Flexibility and Adaptability

Adrian Leaman, Building Use Studies
Bill Bordass, William Bordass Associates

Chapter for MacMillan, S (ed), Quality and Value in the Built Environment

Introduction

This chapter is about design quality viewed from the perspective of post-occupancy evaluation studies. We deal with the rather elusive concepts of flexibility and adaptability which should be an integral part of design quality debates, but rarely feature explictly.

We draw upon the Probe series of post-occupancy studies [Footnote 1]. We also include findings from other building studies which we have carried out but these are not in the public domain, so the buildings are not named.

There is a growing body of literature about Probe, so it is possible to follow up some of the examples and references used here. This includes:

- the original building studies (21 in all at the time of writing), each of these has a short section on implications for design;
- articles based on strategic findings from Probe (another 17);
- third-party rejoinders (7 more).

For an up-to-date list and the opportunity to download some of these, please use www.usablebuildings.co.uk.

The Probe findings are primarily based on detailed analysis of a) technical and energy performance, and b) occupant feedback, backed up by contextual and observational work. For reasons that we have explained elsewhere (Bordass et al, 2002), Probe does not include benchmarked studies of cost, aesthetics or space efficiency / utilisation.

This chapter uses the concepts of flexibility and adaptability as a theme for exploring some of the implications for design that we have discovered in our performance studies. We not not attempt here to give detailed examples (that is project for the future). We are looking for some of the main lessons which we draw from our observations so far. These - seven in all - are in the last section.

Everything that we are trying to say here should be relevant in some way to design decisions, but we are not concerned only with design, but with the total building system that results after handover and occupation. This includes, for example, usability and manageability (which, sadly, are usually absent from mainstream discussion about design), environmental impact, and reference to the underlying social and technical changes affecting buildings, their location and procurement.

We are conscious that the terms "design" and "quality" are both abstract and profound (taken separately and together) with different meanings for different players. For example, unlike architects, building users are frequently only incidentally concerned with the fine points of aesthetics. They have a much more practical bent. "Will the building allow me to carry out my tasks to the best of my ability?" "Will it get in the way of what I have to do?" "Will it make my life easier?" To users, a good-looking but impractical building will not win the day.

We also frequently use the word "design" in tandem with "management". We draw on Bill Allens's aphorism, slightly adapted:

> "Building research should never be more than one step away from a design or management decision".

The myth of self-managing flexibility

One of the most common requirements for a modern building is flexibility. Clients almost always want it and designers usually say they can deliver. But it is all too easy to put gloss on flexibility / adaptability issues and forget the downsides. We obviously need more flexible buildings, otherwise they may not meet occupier needs and may quickly become obsolete, but:

- Will they be too complicated?
- Will the occupants like them?
- Will they require too much routine effort?
- Can they anticipate the unforeseeable?

Evidence from studies of buildings in use show that flexibility / adaptability are inextricably linked with building technology and its manageability. How well a building functions (for e.g. energy efficiency and comfort) seems to be just as much, or even more, about technology-management interactions than design alone.

Figure 1 sums this up. From the data we have so far, the best performing buildings are either Type A or Type D: that is briefed, designed, constructed, used and managed with an "up-front" mandate to deal with technological complexity and manageability. The best buildings have either:

- realistic assessments of their technological complexity and find appropriate levels of management and maintenance skills to cope with the inevitable consequences (e.g. Tanfield House [Bordass et al, 1995], One Bridewell Street [Energy Efficiency Office, 1991];

or

- minimised technological impacts, by making things simple and self-managing where reasonably possible (e.g. Woodhouse Medical Centre [Standeven el al, 1996]. Elizabeth Fry Building [Standeven et al 1997]. As technological side effects are usually also environmental impacts [Tenner, 1996 and Weizsäcker et al, 1997], this makes environmental sense as well.

Unfortunately, many buildings (our data are mainly from Britain, but this applies worldwide) are Type C, that is barely coping with the consequences of technology-driven complexity, usually without adequate management resources to do it.

Unmanageable complexity is the commonest bugbear. Often systems are sold as "flexible" and "fit-and-forget", by implication, seemingly requiring no extra inputs. In reality, management resources are limited. Supposedly flexible systems can become obstacles to adaptability, for example, where "flexible" servicing systems are so congested and pervasive that it is difficult to alter them or insert additions without major surgery.

Therefore it is prudent to:

- avoid fantasies and wish lists (e.g. leading future occupants to think that automation in the new building will be the answer to everything), or parking problems in areas where nobody sees them (e.g. leaving detailed design of lighting controls to the contractor);
- not rely too much on performance specifications (as Alex Gordon said: "Do not be surprised if you get a rubber tube with a clamp on the end when you wanted a tap.");
- do not expect more of the building than it can reasonably be expected to deliver (e.g. over-optimistic modelling of energy performance at concept design stage);
- make sure the right people "own" the problems (e.g. don't expect the managing agent to program the system to meet the changing needs of individual tenants);
- seek robust, generic solutions (see the "safe territory" area of Figure 2);
- consider adaptability (long-term adaptability may be a better and most cost-effective way of meeting unforeseeable future changes than quick-fix flexibility);
- have contingency planning strategies (especially important during periods of volatile technical and environmental change when shifts in one critical parameter can lead to cascading effects elsewhere - e.g. potential to switch from air conditioning to mixed-mode or natural ventilation);
- try to minimise downside risks (especially with the performance of obviously critical systems like airtightness of the building fabric (often leaky in the UK, creating unwanted comfort and other side-effects) or

window design in naturally ventilated buildings [see Standeven et al 1998, Bordass et al 1998]).

Figure 3 summarises some of the side effects as they commonly occur in offices. Two vicious circles result.

Complexity trumps manageability: To avoid altering the building in use, one asks for it to be flexible. Designers respond with over-complex systems which in use demand management time. If not enough resources are devoted, or if response is not fast enough, failures occur directly or indirectly affecting staff satisfaction, comfort, health and productivity; and nearly always with adverse environmental impacts.

Disease claims to be the cure: Enough time and effort is spent on managing the systems but the cost of looking after systems intended to provide flexibility may exceed those of adapting a simpler building to meet new needs as they arise. As demand is relentless, so systems originally intended to be flexible may even obstruct the change that is required, and may prove very ineffective indeed as they begin to become obsolete.

Leaving elbow room

Flexibility is one way of dealing with uncertainty and the vagaries of change, but often unpredictable changes defeat flexibility strategies. Some of the more notorious occurred in the UK in the 1980s when the perceived need for extra cabling and air-conditioning - driven by sales-inflamed scares about accommodating new technical equipment and the unthinking adaptation of buzzwords and quantified but poorly-researched standards by letting agents - led to gross over-capacity of heating, cooling and ventilation plant [Parsloe 1995] and fewer degrees of freedom with floor-to-ceiling heights (because of raised floors and ceiling voids). Added complexity of plant, ducts and controls with less available volume for air created many nasty side effects for occupants as well [Wilson and Hedge, 1987].

Successful flexibility / adaptability strategies anticipate how contextual factors change over time. However, the reverse is one of the reasons why US building strategies are copied worldwide [Van Meel 1998]: globalisation involves destroying context in order to achieve uniformity of product and a form of market flexibility. Its advantages in terms of appropriateness, use value and long-term adaptability and environmental responsibility are more questionable. This has economic advantages - standardisation being one - but ultimately produces cultural and environmental revenge effects which may well be unsustainable.

A crucial question is where to place the needed, but seemingly (but not necessarily) costly, redundancy. Is redundancy best located in the structural fabric (to guarantee structural integrity and weather-tightness), building services (to cope with all conceivable demand fluctuations), extra space (to accommodate growth and change), lower densities (to give managers and occupants more degrees of freedom) or what? We are looking for systems which successfully meet demand, given different requirement profiles for users, managers, owners, developers and designers within contexts in constant flux.

This implies strategies which go further than fit-and-forget technologism or short-termism. We have found Figure 5 useful here. The diagram has physical / behavioural and context-free / context-dependent axes, giving equal weight and importance to all four quadrants.

Four strategies are implied:

1. make invisible (those things which are supposed to work only in the background, with hardly any intervention);
2. make usable (things needing regular attention and/or interaction);
3. make habitual (formal and informal rules which help with safe, comfortable and smooth running);
4. make acceptable (things which are not prescribed and covered by the rules, but allow scope for individuality, innovation and change).

Buildings which are properly flexible and/or adaptable will have included consideration of provision for all four somewhere in the briefing, design and operations thinking, raising issues such as usability, innovation, habit (i.e. cultural norms in the organisation and user etiquette), safety, security, risk, value and uncertainty.

However, the modern tendency is to push as many things as possible into Quadrant A - seek “fit and forget” - and leave the consequences of leakage back out into the other three quadrants for someone else to worry about. Unfortunately for us all, side-effects cannot be forgotten even if they are not immediately foreseeable or includable in cost-benefit equations or risk-value payoff calculations. Examples of some of the consequences are given in Figure 3.

Dependencies and interactions

The temptation to use technology as a get-out-of-jail-free card is often irresistible to designers and managers when faced with problems requiring quick answers. But buildings are interdependent systems with many hierarchic layers, a property which introduces dependencies and interactions, often unwanted, hidden or unforeseen. The shell-scenery-set diagram introduced in the 1970s [Duffy and Worthington, 1972] neatly summarises the hierarchic nature of buildings and their subsystems and can be helpful in separating variables and developing adaptability strategies. However, in the wrong hands such layering can actually inhibit strategic integration.

Our expanded version is in Figure 5, an adaptation from Brand (1997). Systems at the top of the list - site, strategy, shell - tend to set constraints for things lower down (services are determined to some extent by the shell, for instance). Things at the top also tend to be longer lasting - centuries in the case of some sites; minutes for the position of things on desks. The diagram has many virtues, not least of which to emphasise Russian-doll-like complexity (with systems apparently nesting inside each other) and the time frequencies of changes. The implication is that things at the bottom are easier to change than those at the top - more flexible, and perhaps more adaptable. However, this is not necessarily so: a transportable building can be moved to another site, shells and structures can be adapted or replaced; and sometimes, for instance, arrangements can be impossible to change because of their interlocking nature!

Modern businesses are increasingly demanding much greater flexibility throughout the hierarchy, trying to give themselves greater degrees of freedom. Some of the symptoms are:

- rental lease periods reduced from 25 years to sometimes 5 years or less;
- the rapid rise (and volatility) of businesses such as Regus which offer high quality, very short term, office accommodation for rent in major cities around the world, and growing investor interest in fully-serviced suites for temporary or long-term occupancy;
- more stress on property and estate strategies;
- renewed interest in briefing, and further consolidation of business and design targets.

Strategies based on shell-and-core or space guidelines for space planning are no longer sufficient. Space plans must not cut off options for new layouts. Potential for moving cores if necessary may even be required.

Flexibility at one level does not guarantee flexibility elsewhere - often the reverse. For example, buildings which are designed around their space plans often introduce onerous constraints. A fixed furniture system may offer occupants no options to fine-tune their seating position and furniture so that they can try to mitigate adverse effects of eg glare or low winter sun. Any changes may have to be carried out by the facilities managers. In one instance, external consultants had to be called in every time the furniture needed to be moved! It is usually better to avoid dependency of this sort - occupants are capable of making these minor changes for themselves, they are happier and problems and costs for managers are avoided. However, the trend is towards greater dependence, not less. Occupants are increasingly having control and adjustment options taken away from them. This, in turn, places a higher burden on the technical and management systems that are supposed to provide these services - and makes them more vulnerable as well. This is why occupants say they are less comfortable in buildings which relatively good internal environmental conditions have less perceived control options (in the jargon, fewer “adaptive opportunities”) [Brager and de Dear, 1998].

In Britain, commercial and professional pressures have tended to divide and rule so that integration between architects and engineers can be minimal sometimes, even in so-called "integrated" design practices. Parts of the design can easily fall in the gaps between areas of professional responsibility (no-one "owns" the problem). Some of these turn out to be crucial for occupants' welfare, eg the stability of the indoor environment and opportunities to change conditions quickly when required. Anecdotal evidence from Scandinavia and the Netherlands indicates that under global market pressures their previously better-integrated design cultures may be forced down this course as well.

Key considerations are:

- Develop clear strategies for flexibility and adaptability and keep them under review.
- Identify risky constraints at each level of the hierarchy and explicitly flag them up for designers or managers, making sure that they are fully "owned".
- Unless there are circumstances which require specialised optimisation, do not allow any one to dominate the others eg the space plan, or "optimising the irrelevant" servicing considerations [e.g. (Bordass, 1992)].
- Allow for changes at any level, including those that may be seemingly unthinkable, like the shell and structure but don't get carried away - robust simplicity is also most important, but do not forget that many parts of the building may be appropriately permanent.
- Flexibility can be hindered if options are restricted higher up the hierarchy. This can be specially vexing for certain types of building services, for example, building cores obstructing the best routes for ducts or adaptability thwarted by lack of consideration of site constraints. For more detailed treatment, see Geraedts, (1998).

Different standpoints

Flexibility and adaptability take on different meanings depending on your standpoint. Users and occupants often want short-term flexibility, answering specific local needs as fast as possible. Facility managers may be more concerned about occupant control and speedy and cost-effective changes in furniture layouts. Designers may think about possible image changes, and certainly issues like capacity, turnover, space fit, densities and layout types. Corporate managers may be more concerned with how easily they can sell or relet the building if they no longer need it and so get locked in to property market criteria whether or not these actually benefit the users.. All of them will want their needs to be met reasonably quickly, with as little fuss and cost as possible.

For any of them, it makes sense to bring the action as close to the point of demand as possible. The problem, though, is that requirements conflict and it is not obvious:

- what the needs are, especially in the future when contexts may subtly change;
- where priorities lie;
- where risks are greatest.

Specialised buildings tend to become obsolete fastest, while bespoke buildings - specialised or not - are anthema to valuers and letting agents, so stifling innovation. On the other hand there are still many spectacular examples of unlikely function changes inside seemingly specialised structures, particularly if they have become respected parts of the landscape (for example, Brand, 1994).

Does the designer:

- play safe with industry norms (e.g. British Council for Offices, 2000);
- opt for more generic, context-free approaches, gambling on accelerating trends towards convergence of function (e.g. offices and laboratories becoming more similar);
- take a longer term view, attempting to combine this with emphasis on lower environmental impacts;
- place greater faith in promising new technology (e.g. Doxford photovoltaic building, Sunderland, UK) while gambling that accommodating new constraints (the photovoltaic wall) does

not compromise other considerations (such as office layouts forms);

- fit suitable strategies to prevailing circumstances, perhaps giving priorities to costs in use, manageability, occupants' needs, and taking a more pronounced "demand" side perspective?

Our view is that attention to the demand side, minimising environmental impact and carefully reviewing the extent to which generic solutions are appropriate will yield effective results in the longer term; though it may take some time for market valuations to catch up.

Greater account must be taken of needs - and resolving conflicts between them. This implies more emphasis on:

- brieftaking;
- future business and organisational scenarios;
- social, economic and technical changes in the background;

all of which give further colour to demand.

Bringing action closer to need

Bringing action as close as possible to perceived need while minimising the need for vigilance at other levels is usually an important objective. At lower levels of the building hierarchy this can be obvious. For instance, when you switch on a light (action) you want the response to give you the result you require (need). The faster the need is met by the action, the better. Any extra thought required (if the switch's operation is unclear), involvement of others (e.g. ringing a helpdesk) or delay in response adds unnecessary complexity, inefficiency and cost. When action does not meet need, the system is often said to be inflexible or inefficient. When it is difficult to change, it has poor adaptability.

However, things are not so straightforward as you go higher up the building hierarchy. Lags between demand and supply (the demand for space may not be in the same place as spare capacity), geographical inertia (the tendency for organisations to stay rooted to a familiar area) and longevity (only about one per cent of, for instance, the UK building stock is renewed every year and market lock-in (Bordass, 2000)) all conspire to create mismatches and inefficiencies. These inequalities drive fluctuations in property markets, giving them their peculiar character [Investment Property Databank, 1994]. With individual buildings, it is unusual to find a perfect "fit" between preferences and the facilities provided - buildings which in the eyes of their occupants, owners, managers and designers are "just right". But "good enough" is usually sufficient (satisficing rather than optimising). Beyond this, if the building lacks adaptability it may be replaced or abandoned.

Conclusions, with contradictions

Without being too theoretical or technical, what are the main lessons to be learned from this? Seven emerge, but sometimes they contradict each other!

1 *What do you really need to change*?

More uncertainty in the world leads to demands for more flexibility: but how much is really required, and where? Can simpler, more generic, but adaptable building types which get some basic things right actually prove liberating, not constricting? Is it best to adapt the building, to adapt to the building, or to change the building? Flexibility of movement within a diverse and fluid property market could make up for some of the shortcomings of individual buildings in a more static market. And how can we make better adaptive use of the buildings we have already got, a significant portion of which (particularly from the 1950s to the 1970s) are now unloved, but not always owing to a lack of potential, but a lack of imagination, fashionability and market value?

2 Know your timescales

We define flexibility as primarily about short-term changes and adaptability about less frequent but often more dramatic ones. Try not to confuse the two: while ideally they are complementary, in practice they can easily conflict. For example, it is not unusual for air-conditioning distribution systems installed to improve flexibility but also physically obstruct adaptations one would like to make.

3 Hidden costs

Flexible concepts for buildings often provide fewer physical obstacles, particularly to any space plan which fits within the boundary conditions. However, the downside is often much higher dependency on technical and management infrastructures that anybody had anticipated. In addition, the technology has often proved to be less flexible and more prone to obsolescence than one had thought, viz: the amount of nearly-new materials and equipment which are often scrapped when an office is fitted-out or refurbished.

4 *Dependency cultures*

Flexibility concepts (e.g: deep plans), equipment (e.g. interlocked serviced furniture) and technologies (e.g. automated internal environments) can deprive occupants of the ability to make even small adjustments, causing them to be disgruntled, make more demands upon management, or both. The costs of this in terms of the degree to which the quality of the building needs at be improved, together with management and the expensive support services required are often ignored, or at best badly underestimated. But if these demands are not met, occupant dissatisfaction and lost productivity will result.

5 *Hierarchical layering*

The strategic 'layering' of a building (shell, services, scenery etc.) helps to avoid unwanted rigidity by minimising interlocks between elements with different functions or with different timescales for maintenance, alteration and replacement. However, by excessive reductionism, and the splitting of activities into single issues dealt with by narrow specialists (like space planning), it can also get in the way of holistic design and strategic integration. This in turn can destroy context, reduce added value, and increase the loads a building imposes on the environment through unnecessarily wasteful consumption of fuels and materials.

6 *Generic buildings: tonic or tragedy?*

Will we benefit most from more standardised solutions or from rich and chaotic diversity? We see hope in reducing the number of unnecessary variables and seeking out more generic solutions which aim to satisfy better the needs of investors, occupants and the environment. How in practice will this differ from the North American reductionist, standardised approach which tends to destroy context and create widely-accepted, competitive, but often far from optimal, industry standards?

7 *If in doubt, leave it out*

The essence of adaptability is to invest in the outset in the things you are really going to need, and to leave to others the option of adding (or subtracting) things you are not sure about. Of course, this is not easily done in a changing world, but nevertheless it is usually possible to reach some sort of verdict.

Agendas for the future include:

- Briefs which are explicit about need, and try to make hidden assumptions crystal clear for all concerned.
- Adaptable envelopes and structures, at least in parts of the building which can benefit.
- Building shells which are better at selectively moderating the external climate.
- Intrinsically-efficient building services which adopt "gentle engineering" principles and good controls to fine-tune the environment efficiently, only to the extent needed.
- Where necessary, "plug and play" supplementary components which can easily be obtained, installed, and relocated to alter building services provision and capacity.
- More rounded understanding of future scenarios, especially from the perspective of businesses and their progress, and the social, technical and environmental constraints most likely to affect businesses, buildings and their locations.

So what to do?

- Consider all types of risks and constraints affecting buildings, not just the obvious or fashionable ones - acute and chronic, short term and long term - and work on all of them.
- Take a demand-side perspective which starts with revealed needs and preferences especially within the immediate context of business and organisational requirements - and work towards more abstract supply-side issues, rather than the other way round as has tended to be the case.

- Think of potential downsides and their consequences, emphasising the thresholds where action meets the point of need (eg the trigger points when people become uncomfortable and decide to do something about it; or what happens if the building becomes too big or small for you).
- Adopt a perspective which treats constraints in a positive way, so that potential bugs become features. Most great designs - especially the most usable - are like this, apparently making insuperable constraints disappear altogether. Of course, they never do; both potential and constraints have been turned to human advantage - the essence of human adaptability and the hallmark of progress.

Footnote

1 Probe (Post-Occupancy Review Of Buildings and their Engineering) is a research project which started in the UK in 1995. At the time of writing, 20 building studies have been published (19 UK, 1 Dutch) in Building Services: the CIBSE Journal. As well as the original Probe articles, there are many other supporting papers. An up-to-date list may be found on www.usablebuildings.co.uk by following the Probe link.

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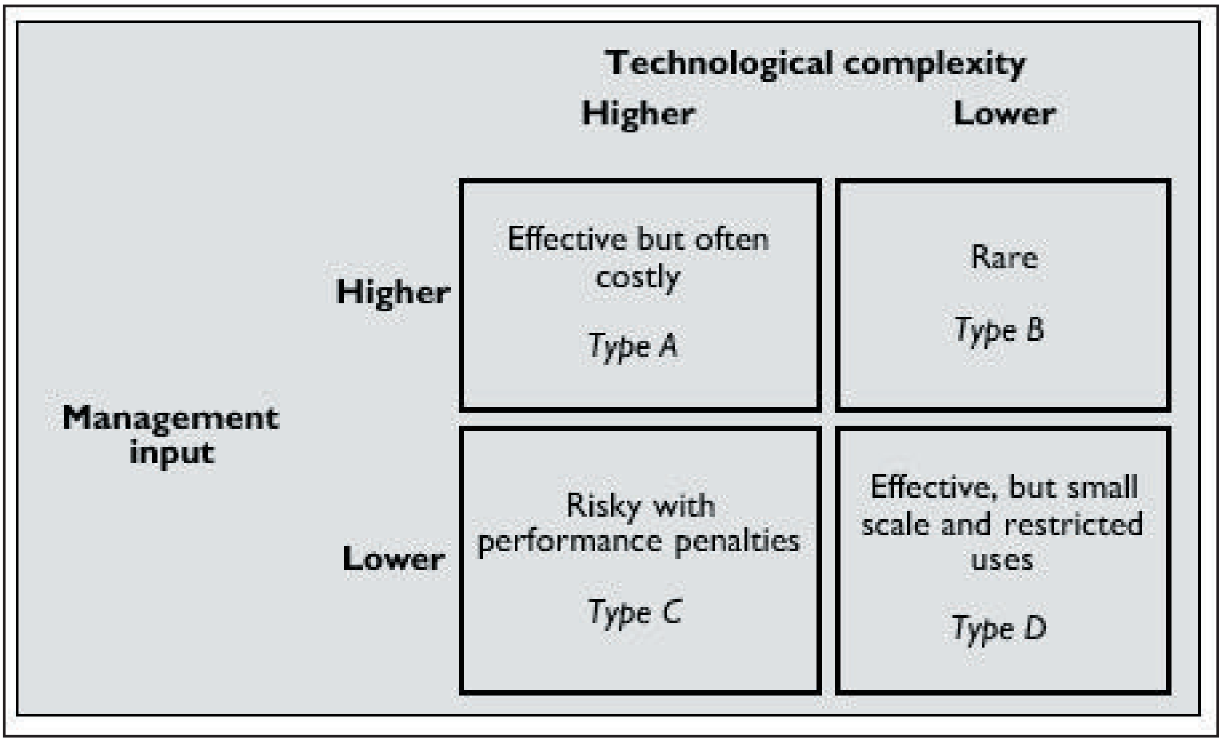
Adrian Leaman runs Building Use Studies, which carries out performance studies of buildings from the users' point of view.

Bill Bordass is principal of William Bordass Associates which works largely on design briefs, and field and desk studies of building performance.

Other work by Adrian Leaman and Bill Bordass may be downloaded from

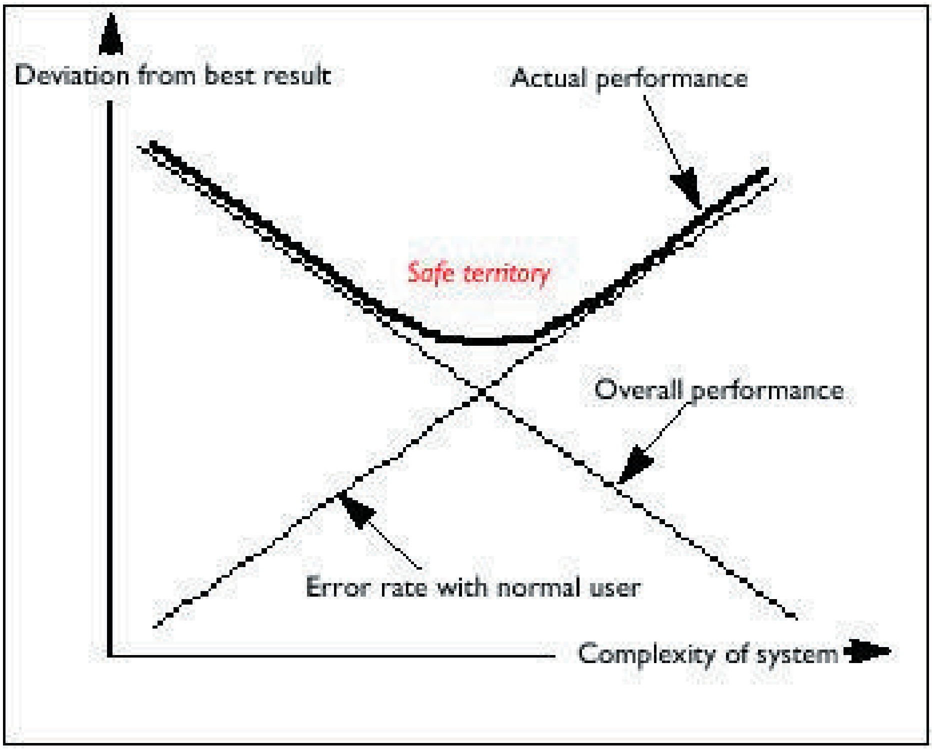
www.usablebuildings.co.uk.

Figure 1: Technology-management interactions



Source: Authors

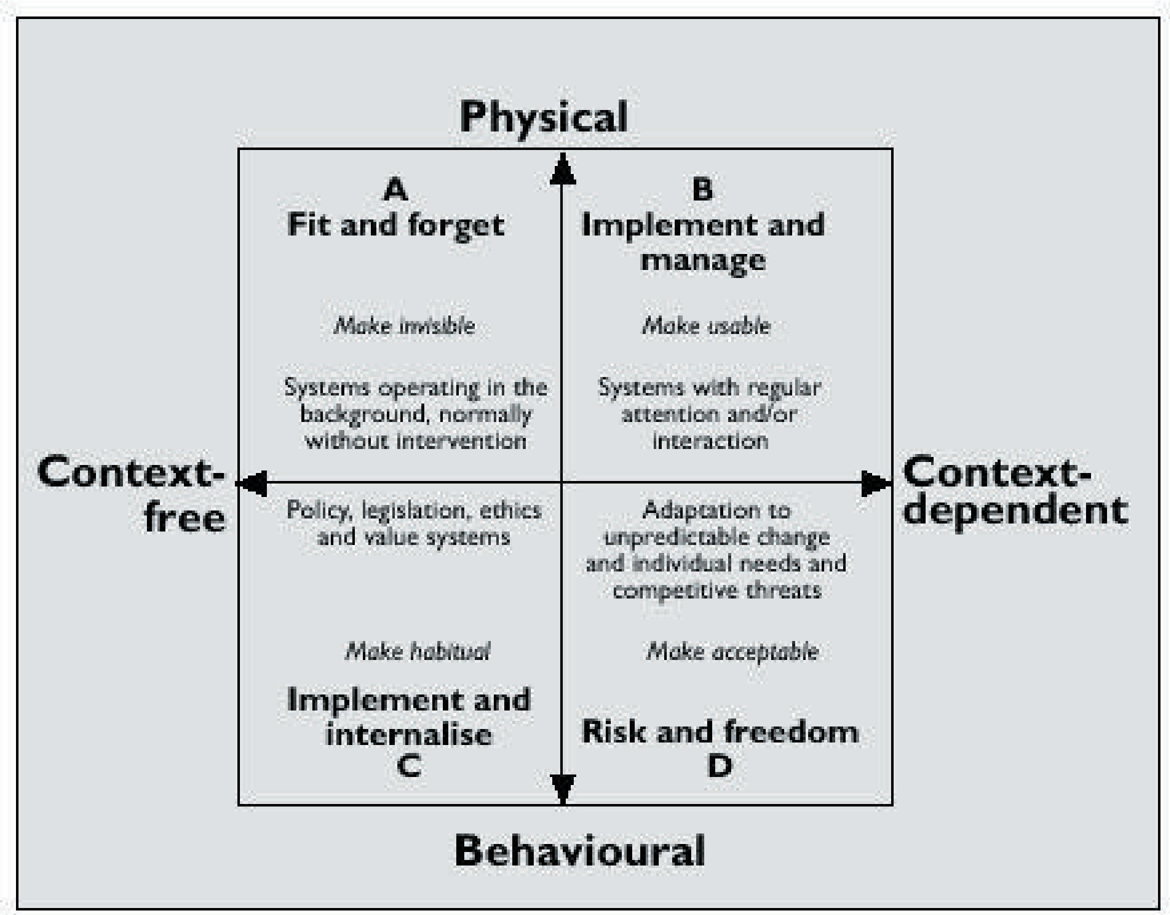
Figure 2: Safe-territory areas



Source: Chapman (1991)

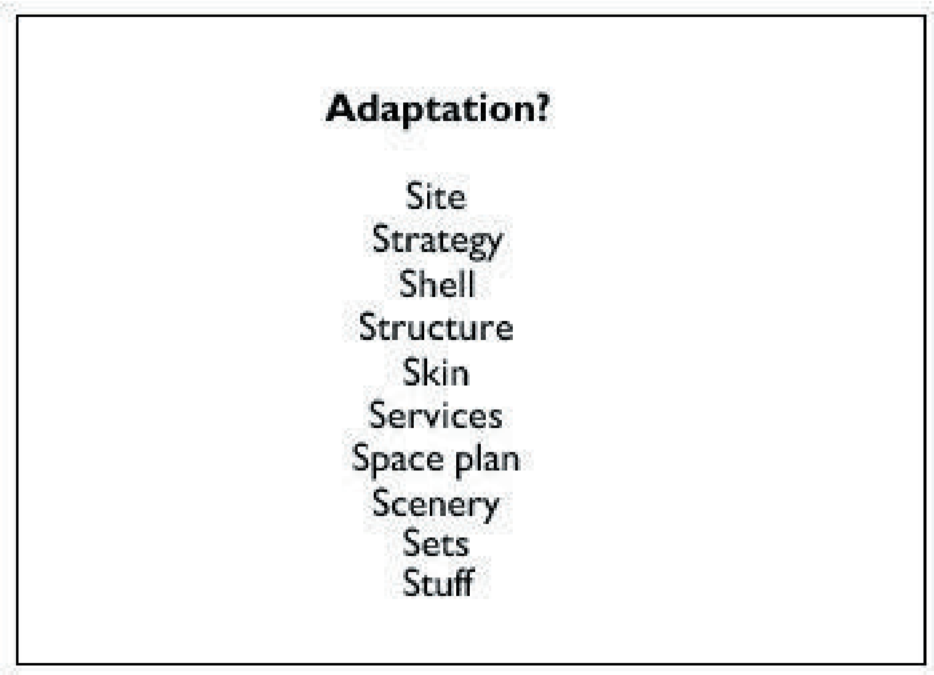
Fig 3: Examples of				
Measure	Intended consequence	Revenge effect	Possible solution	Comments
Improve comfort provision and energy efficiency	Automated windows, blinds, lights etc. can provide optimum conditions.	Reduced occupant tolerance. Increased dependence on management. More complaints.	Include occupant override facilities.	Imposition of a matic control c very irritating. to sacrifice ada opportunity
Increase technology to provide added "flexibility".	Less management input necessary to make alterations from time to time.	More management input to look after the additional systems. Still requires some alterations to	More realism. Better integration between physical and human systems.	Careful discuss of brief and de options to avoi tasies.
Increased BEMS control	Better control and management information provided.	More load for operator, who may not be fully familiar. Local interventions more difficult.	Don't over centralise. Allow for local decisions on overrides etc..	Particularly imp to have local o rides in mult-te buildings.
Outsourced facilities management and BEMS operation. Professional service.	Leaves occupiers to concentrate on their core business.	Business requirements for environmental services not so well understood, so systems run generously, wasting energy.	Tighter contractual requirements or retain in-house control of operation.	Third parties o on site out-of-h when anomalie to occur. Don't source the fee loop!
LIGHTING:				
Occupancy sensed lighting in offices	Lights switched off when people absent.	Lights switch on unnecessarily when occupant does not need it, or for passers-by.	Include manual ON switches, except where lighting is required for safety or convenience. Also include manual OFF switches if possible.	Control lighting circulation rout separately.
Occupancy sensed lighting in meeting rooms.	Lights come on only when required.	Can't switch lights off for slide presentations etc.	Include local over-ride switches.	Local manual plus absence s only may be pr able.
Automatically dimmed lighting	Reduces artificial illuminance level when daylight is sufficient. Increases artificial illuminance level when daylight fades.	Bring on at a low but reasonable level.	Try to leave adjustments to increase brightness to the occupants.	Photocells son confused by re tions.
Local switching of lighting	Greater responsiveness to need	Difficult to switch off lights left on inadvertently.	Absence sensing or 'last out-lights out' facility at the exit.	The switch at t entrance shou activate circula and safety ligh

Figure 4: Strategic imperatives



Source: Authors

Figure 5: Hierarchical 'layering'



Source: after Duffy and Worthington (1972) and Brand (1994)