

Towards Adaptable Buildings: pre-configuration and re-configuration – two case studies

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Abstract

The future is uncertain – the present must be adaptable. The Loughborough University IMCRC Building Brands pilot project has shown that optimum built environment solutions, whether branded or not, must be adaptable. In other words they must be able to be changed over their life cycle to adapt to changing needs of the end users. This is a key component of the sustainability '3-Rs' of reduce, reuse, recycle and responds to the 1:5:35 ratio which drives the need for buildings to remain efficient places to live and work in order to ensure real life-cycle value for money. Adaptability is important pre-construction and re-configurability throughout the life cycle. This paper discusses preliminary results from this pilot project and lays out the challenges to be addressed by subsequent work. The paper develops concepts discussed at the 2006 Adaptables Conference in Delft (Davison et al, 2006).

Keywords: adaptability, sustainability, life-cycle, reconfiguration

Background

Industrial Context

The future is uncertain – the present must be adaptable. A pilot project by the authors, 'Building the Brand', funded by the Loughborough Innovative Manufacturing and Construction Research Centre, raised a number of key issues – one of which is that any built environment solution, whether branded or not, must be adaptable. It must be able to be changed over its life cycle to adapt to the inevitable evolving needs of its end users. Buildings must remain efficient places to live and work to ensure real life-cycle value, driven by the '3-Rs' of reduce-reuse-recycle and responding to the '1:5:35' ratio where value from building use (35) significantly outweighs cost in design and construction (1) and maintenance (5).

The structure and fabric of the built environment is a value generating asset, increasing over time, whereas the internal 'fit-out' is consumable and devalues over time – adaptability would open new ways of owning and managing property. Customisable, standard buildings are also a direct response to UK Government demands for more multi-use developments. The real

challenge is how to make adaptable buildings without creating unnecessary redundancy and, in so doing, significantly increase the first cost.

Problem

The following are the key research issues:

- What future scenarios must the various building types be able to respond to?
 - Issues are external and internal to the end-user of the facilities
- Why have historical attempts at this not been successful? – technology or human failings?
- What building systems and technologies are best suited to provide this level of adaptability cost effectively?
- What implications does this have for the design and build process?
- What implications does this have on the future use and management of buildings and facilities?

Approach

The Building the Brand pilot project was a collaboration between the Loughborough University team and a consortium of Laing O'Rourke (major contractor and construction developer), Buro Happold (engineering consultants) & Reid Architecture (architects and designers). These three industrial partners are leading exponents in the area of branded buildings in the UK construction industry and between them possess a great deal of experience and knowledge in this area. They joined the project (and became a key part of the methodology) because they recognised the need to undertake fundamental research into the concept. The project embraced a range of qualitative and quantitative methods including a **literature review** examined existing schemes in the UK and abroad, existing and potential building systems, barriers to the use of such systems and identified relevant supporting design, procurement and management systems. **Focus group workshops** were held with the project partners and other members of the industry and its customers. It was considered important to capture not only the technological push of the industry but also the market pull, trying to better understand what owners, occupiers and users really want - the former in terms of ownership and responsibility for building management, and the latter from the perspective of business performance and the working experience. Semi-structured and informal **interviews** were used with market leaders in the branding, design, procurement, supply and construction of the types of buildings identified, as well as with existing and potential customers for these systems. The state-of-the-art, as far as it existed, was explored in the housing, multi-occupancy residential and specialised edge-of-town retail and leisure markets through **case studies**, with the assistance of the industrial partners who have involvement in all these areas. This included understanding how components could be simply but flexibly assembled into customised single or multi-use facilities. Lessons from other industries (e.g. the business and car industries) and other countries (e.g. Japan and Europe) were identified to see what ideas or concepts could be transferred to, and used within, the UK construction sector. Similar initiatives which have not succeeded or have been discontinued in the UK (e.g. Mace MB1) were analysed and investigated, to try and learn why these initiatives did not succeed in the UK market place. This paper concentrates on the adaptability issues from this pilot project.

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Analysis

To date, the main geographic focus of existing research into adaptable buildings (open building/agile architecture) has been Japan and The Netherlands although most of this has been limited to residential buildings. Habraken promoted the concept of open building in the 1960's. The term open building covers a number of ideas relating to a building and its environment which Habraken (2006) defines, in part, as ;

- *The idea that, more generally, designing is a process with multiple participants also including different kinds of professionals.*
- *The idea that the interface between technical systems allows the replacement of one system with another performing the same function.*
- *The idea that built environment is in constant transformation and change must be recognized and understood.*

Omi (2005) describes the 'renovation' of 'Tetsu-Chin' apartment houses and Matsumura describes the conversion of offices to dwellings. However, the practical application of open building has been limited to one-off projects utilising a variety of systems, mainly in housing (Schueblin 2006). Very limited new build projects are evident in the residential sector in Japan and The Netherlands. The Next 21 project in Osaka was designed by 13 different architects to offer a wide range of flexible accommodation options to a wide range of age groups. The Molenvliet project near Rotterdam, is promoted as an example of open building due to the fact that every house floor plan in the development was different (Van der Werf, 1980). The theoretical concepts behind open building have been researched but few projects have been built using this principle and even those that have been completed have not used the inherent flexibility as intended (Verweij and Poleman, 2006). Geraedts (2006) and Davison et al (2006) outline features pertinent to the adaptability of buildings but more detailed research into more widely applicable design solutions is required for this emerging technology.

Re-configuration

The most obvious application of adaptability in the built environment is re-configuration of a building or facility during its life-cycle after construction. This is the re-use part of sustainability's 'three-Rs' (Reduce/Re-use/Recycle).

Why should buildings be adaptable in their lifetime?

In a survey of high profile UK property developers and agents by Reid Architecture, 94% saw the need for an adaptable building solution providing associated capital cost increases were minimised (Gregory 2004). The primary argument in support of re-configuration is the change in the needs of society and commerce in a particular location, for instance, changing use from commercial to retail, or industrial to residential. Figure 1 compares the percentage change in sales and lettings of space to occupiers of retail, commercial and industrial buildings for the first two quarters of 2006¹ (developed from data taken from RICS, 2006). This snapshot illustrates the volatility of the market and the trade-off between space requirements for different end-user sectors in certain regions, such as London and Wales as well as a general trend to increase or decrease demand in some regions. Whilst the likely adaptability of buildings currently envisaged would not apply over these short periods, further studies are expected to identify

¹ Industrial sector figures Central London and Greater London were not listed separately in the RICS data.

similar trends over a number of years, thus indicating the desirability of adaptable solutions for the built environment.

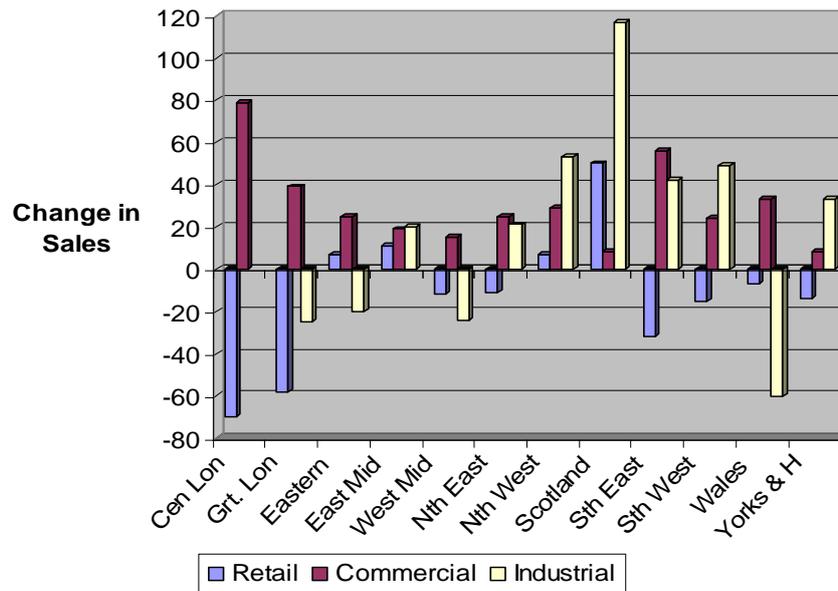


Figure 1 Percentage change in sales for retail, commercial and industrial across UK regions for the first two quarters on 2006

‘Sustained competitiveness in the UK construction sector: a fresh perspective’, or the ‘Big Ideas’ for short, is a government-sponsored collaborative research project between the Innovative Manufacturing Research Centres at Loughborough, Reading and Salford Universities (www.thebigideas.org.uk). The Loughborough University team has been focussing on developing possible future development scenarios for the UK construction industry over the next 10 to 20 years in order to support the industry in delivering the future requirements of society and industry. The central tenet is that a better understanding of the structure of underlying issues, events, barriers and trends through their causal relationships will enable the industry to address the persistent and deep-rooted problems that have hampered its performance for many decades. The initial stages of this work involved reviewing the many construction futures reports which had been published in the last 8 years, the majority from the UK but also some international work (Harty *et al.*, 2007). More than 300 separate issues were identified from this literature and content analysis was used to group these in high-level clusters of related issues (Soetanto *et al.*, 2006). These issues were used as a basis for identifying emerging themes in the data collection exercise, which was aimed to capture people’s perceptions and interpretations of future events in industry workshops, in the form of causal maps (Eden and Ackermann, 2001). One of the key cluster has been the need for adaptability in the built environment. The recent high profile Stern review (2006) clearly promotes adaptability: ‘**Adaptation** to climate change – that is, taking steps to build resilience and minimise costs – is essential. It is no longer possible to prevent the climate change that will take place over the next two to three decades, but it is still possible to protect our societies and economies from its impacts to some extent – for example, by providing better information, improved planning and **more climate-resilient** (crops and) **infrastructure**’.

Multispace case study

Reid Architecture (2005) and Buro Happold have recently completed a research study which investigates the problems of designing, constructing and letting/selling what they describe as the ‘*Multispace adaptable building design concept*’. The aim of this concept was for a single, fundamental customisable, design to be the basis for the design of a variety of mid- to high-quality offices, residential, hotels and retail developments. The study outlines solutions for the

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technical aspects of the proposed concept and highlights possible barriers to the use of the concept from users, developers, funding bodies and planners. The authors are now working with the industrial team to build upon this previous study, by investigating further the barriers identified and recommending solutions to overcome these. Aspects of this case study have been published elsewhere (Davison et al, 2006) and full details are still considered commercially sensitive. Therefore, it is only possible to provide limited information in this paper.

Multispace has developed optimum solutions for the following key parameters to take best advantage of adaptability of building solutions:

- Storey height (this is the crux of the problem)
- Building proximity, form and plot density
- Plan depth
- Structural design
- Vertical circulation, servicing and core design
- Fire safety design
- Cladding design

A summary of adaptable building requirements are shown in Figure 2 and examples of the Multispace concept in Figures 3 and 4..

	Ground floor condition	Upper floor condition
Proximity of blocks	Determined by spread of fire regulations	18 to 21m min. between habitable rooms
Plan depth	13.5m (preferably 15m) to 45m	15 to 21m
Internal ceiling height	3.5m single storey 5 to 7m double height	Approx. 2.7m
Ceiling zone	0 to 500mm	0 to 500mm
Floor zone	Preferably 100 to 350mm	Preferably 100 to 350mm
Structural slab & spans	Min. 7.5m span 260mm slab @ 9x9m; 330mm slab @ 12x9m	Min. 7.5m span; max. 12m span 260mm slab @ 9x9m; 330mm slab @ 12x9m
Design occupancy for fire	1 person per 5sqm	1 person per 6sqm
Travel distances for fire	30m two way (12m one way)	30m two way (12m one way)
No. and size of lifts	N/A	Design for mixed use as the worst case and offices as worst case for single use
Cladding spec.	Maximise glazing within fire, noise and cost constraints	40 to 100% glazing, NR 20-30; 1.5m module & option for opening casements

Figure 2 Summary of adaptable building requirements (Reid 2005 & Davison et al, 2006)

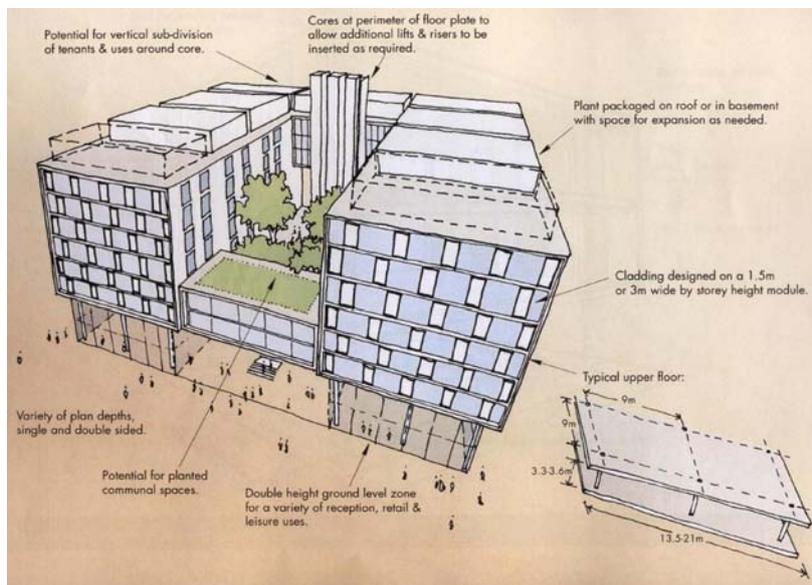
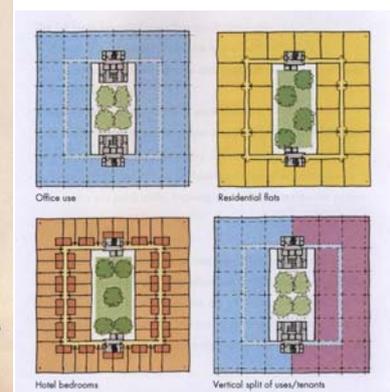


Figure 3

The Multispace concept
(Courtesy Reid Architecture)



Pre-configuration

The second aspect of adaptability is pre-configuration, where building systems are used to maximise the variation in first-build end product. Again, the goal is that this would be achieved at no extra cost, rather that the cost would be significantly reduced through the industrialisation of the process, reduction in variation of parts and so forth. This has long been the ‘holy grail’ for open building systems and has been the subject of numerous research studies and publications.

NewWay case study

GlaxoSmithKline (GSK) have recently ‘launched’ their NewWay initiative. This targets the reduction in design and build time for their facilities from around 24 months to 13 weeks. This is driven by a very clear business need to get drugs to market earlier whilst at the same time reducing the risk element caused by starting the design and construction of a production before the pharmaceutical product is designed. Figure 5 shows the pharmaceutical development programme. A hit is recorded when research produces a new chemical combination which is linked to a health need. This is then developed into a product which is then developed further until it is ready for market. Until the product is produced, GSK do not know for sure what sort of primary or secondary production facility is required (as every one is designed uniquely for a particular drug). Currently, the two year design & construction time for a new facility means that they need to start building prior to fully understanding what will be manufactured – hence the increased risk. Through NewWay, the dramatic shortening of this design & construction period enables them to wait until they really understand the required configuration of the production plants before they start to build. It also allows them to reach the market quicker, which, due to limited life of patents, is a major factor in a drug’s commercial success.

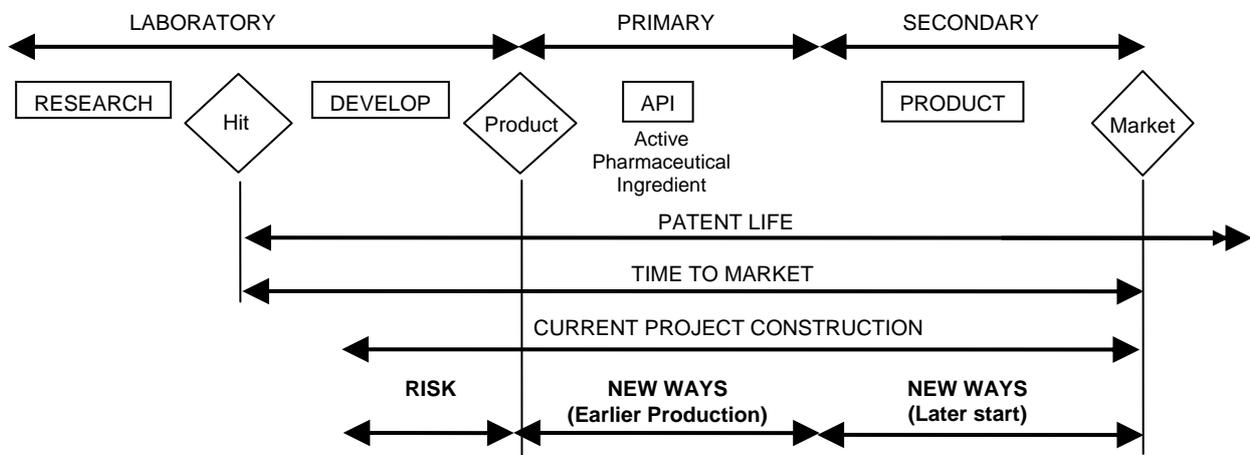


Figure 5 GSK’s commercial drivers for radical reduction in building delivery time
(Adapted from Nigel Barnes, GSK, 2006)

GSK, through their designer Bryden Wood McLeod are developing a configurable ‘kit of parts to facilitate this step-change.

A number of studies have sought to categorise the extent of standardisation, including Fox & Cockerham (2000) and Gann in Gibb et al (1999). GSK’s NewWay target for their 3 types of built environment asset (research laboratories; primary & secondary production facilities) is to reduce their assemblies to 30 variants, components to 90 and parts to 900 (Figure 6). This is currently challenging all the organisations to completely change their way of working. GSK Director, Nigel Barnes, likens this to stopping trying to incrementally improve the propeller engine and, instead, moving to the jet engine. One example of the changes required is that GSK’s

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design consultants, Bryden Wood McLeod (BWM) are employing product designers from a manufacturing background rather than traditional architects.

	Bespoke	Hybrid	Mass Customised	Mass Produced	NewWay target
Parts					900
Components					90
Assemblies					30
Assets					3

Figure 6 Extent of standardisation and GSK targets for NewWay

Challenges to be overcome to achieve adaptable buildings

The authors' research to date has identified a number of significant challenges that must be overcome to achieve adaptable non-residential buildings in the UK. The authors have been shortlisted for a major research project to work with GSK & Reid Architecture in this area.

The first challenge concerns the evaluation of the potential market for adaptable buildings. The impact on the type of new build being undertaken, if this approach was adopted, would alter the balance and structure of the construction industry. However, forecasting market size for radical new products is particularly difficult because everything is so uncertain. It requires the use of more qualitative forecasting techniques based on expert opinion, rather than basing forecasts on more traditional quantitative extrapolation techniques (Wright et al. 1996). Some of the key issues that will need to be explored are: how would adaptable buildings contribute to organisational, sectoral and national economics; how might customer driven requirements drive the revised design process; and how likely is it that these new adaptable buildings will be accepted, or whether they will be seen as 'cheap and nasty' in comparison to traditionally designed buildings. The exploration of this issue will provide an understanding of the market segments that exist, providing valuable knowledge regarding the key segments that the new products could be targeted at. One other important issue that may also need to be considered is the linkage between customers definitions of short and long term needs and the way in which the concept should be sold to the customer (convincing them that they are not getting less than before etc).

A review of the literature highlights that much attention in innovation research has been focussed upon incremental innovation, rather than more radical innovation. This is despite the strategic importance and paradigm-shifting characteristics of radical innovation. Zairi (1995) identifies that radical innovation is an aggressive style of new product development based upon completely new rules. Humble & Jones (1989) argue that radical innovation requires staff to develop new skills and capabilities to develop projects outside of the current core activities of the business. Previous studies around product innovation in construction have failed to investigate the willingness of those working in the industry to embrace the change necessary. Rather, the capacity of those charged with responding to the transformation that innovation requires is taken for granted, and the impact on those actually working within the industry rarely considered (Green, 1998; Green and May, 2003). A second challenge, therefore, concerns the need to support the process of behavioural change necessary to successfully redefine the ways in which buildings are specified and designed (i.e. in supporting the paradigm shift in building specification and design processes from designing to a specified brief, to designing for unknown

future need). This shift is fundamental as it represents a complete redefinition of the basis upon which traditional design decisions are predicated. It calls into question both the efficacy of traditional design protocols and heuristics, and the appropriateness of the performance metrics against which traditional contributions to design are evaluated. Given the redefinition of traditional design parameters that adaptability is likely to encourage, the existing bodies of knowledge, processes and protocols from which designers draw are unlikely to support the radical design solutions required. There is a need, therefore, for design, organizational and human resource management solutions which support designers in the transition to adaptable solutions. Traditionally architects have been trained in the expectation to design for a relatively immediate client need with a specific set of functions identified as the starting point for a building design. This implies that a paradigm shift to adaptable design will bring with it sociological issues in parallel with technical design and build issues.

New technologies and process innovations are malleable - they evolve and mutate *through* the process of adoption (Bijker 1992; 1995). As such, design researchers are increasingly concerned with how designed artefacts are shaped by, and shape, the contexts in which they are used (Shove *et al* 2005). In the case of adaptable buildings, their success and impact is ultimately dependent upon the ways in which the technology is applied by designers with responsibility for configuring future design solutions, and the ways in which the completed buildings are appropriated by end users. Understanding how adaptable technology might become embedded within the industry requires an understanding of how the demands of design practice and utilisation of the built artefact structures the process of innovation through diffusion.

The real challenge is how to make adaptable buildings without creating unnecessary redundancy and, in so doing, significantly increase the first cost.

The UK construction industry aspires to the standards set out by Latham and Egan in the 1990s, yet few innovative breakthroughs have been made in how we design and procure new buildings. According to *Constructing the Future* (DTI 2001), the next 20 years will be an era of unprecedented change for UK construction. As an industry we need to be challenging the traditional ways that we design, procure and construct to respond to this ever changing future.

Results and Business Impacts

Key Findings and Business Impacts

True adaptability in non-residential buildings in the UK currently remains an aspiration. However, a number of leading players are seeking to drive the radical change required to achieve this, both in terms of flexibility in initial, pre-construction configurability of buildings and in lifecycle re-configurability. A major research project is planned to address these issues – further information will be presented at the Manubuild conference.

GlaxoSmithKline, as a leading client of the built environment, have a vision – to build any type of industrial process plant, pharmaceutical manufacturing facility or drug research and development facility, anywhere in the world, within 3 months, instead of the traditional 18 to 24 months which industry currently offers. The GSK criteria includes an increased level of quality, with the same or extended building life expectancy and also an ability or potential to adapt the building use in the future. The need for the latter is driven by frequent alterations to GSK research and manufacturing requirements due to continuous changes in pharmaceutical technology. To achieve such a step change in construction speed and building flexibility involves a product based building construction system, using modern methods of fast assembly and offsite fabrication. GSK's vision is not focused on small, incremental improvements in delivery schedules across industry, instead GSK see a requirement to rethink the entire

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construction methodology and design of buildings. GSK have called the vision “Project NewWay” and are partnering with key designers and suppliers within many areas of industry to develop an idealised product platform for the three main facility types. GSK envisage that on-demand components will be pre-engineered, procured and manufactured to a capacity forecast, delivering the building blocks that can be configured and re-configured, rapidly, to deliver facilities up to eight times faster than present norms

Conclusions

This paper has introduced the Adaptable Futures initiative in the UK, featuring GSK’s NewWay and Reid/Buro Happold’s Multispace concepts. These demonstrate applications of pre-configuration before initial construction and re-configuration during the project’s lifecycle. The commitment of these organisations demonstrates that this is an important area for further work to understand the full technical, business, process and people implications of adaptable building.

Key Lessons Learned:

- There is a movement towards truly adaptability in large, non-residential building which has not previously been evidenced in the UK
- This move provides real challenges: to determine the market and understand the technical, business, process and people implications of this radical change
- Two examples, GSK & Reid/Buro Happold point the way to an adaptable future

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