

# Adaptable Futures: Setting the Agenda

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**Abstract.** Currently the majority of buildings are designed and constructed as bespoke creations to suit a particular use at a certain time, with little thought for the future. The Adaptable Futures project, introduced in this paper, aims to facilitate the development of adaptable buildings in the UK that take account of an often uncertain future. This paper gives a brief overview of the project and then goes on to describe the two industrial case studies being used as the main sources of data collection for the project. These are a pre-configured concept, Newways, developed by Pharmaceutical organization, GSK, and a re-configurable concept, Multispace, created by architects 3DReid. Findings from a recent workshop looking at adaptable buildings are then presented.

**Keywords:** adaptability, pre-configuration, re-configuration

## 1 Introduction

This paper provides a summary of the Adaptable Futures research project being undertaken at Loughborough University. An introduction to the project is presented that includes an overview of the research, the key objectives, a brief description of the context, methodology used and the industrial case studies that form the focus for the project. The initial findings from a workshop<sup>1</sup> with industry partners are then presented and next steps for the project identified. The paper builds on previous publications presented by the research team on the same topic, including *Towards Adaptable Futures* [1] presented at ManuBuild 1<sup>st</sup> International Conference and *The Multispace Adaptable Building Concept and its Extension into Mass Customisation* [2] presented at Adaptables '06.

### 1.1 Overview of the Project

The Adaptable Futures project is a three year multi-disciplinary research project that aims to facilitate the development of adaptable buildings in the UK through academic research and examples from industry. The project involves academics and researchers from the following sectors: construction, architecture, quantity surveying, business, project management and engineering.

The adaptability of buildings is being investigated under two design strategies, pre-configuration, dealing with initial design choices and re-configuration, looking at subsequent changes in use. These design strategies and their definitions are being developed as part of the research and a typology for adaptable buildings will be created to enable their comparison and assessment.

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<sup>1</sup> The authors acknowledge the input to the workshop from other members of the Loughborough research team, namely: Andrew Dainty; Christine Pasquire; Jim Saker; Vicky Story and Cephas Idan.

## 1.2 Context

Currently, the majority of buildings are designed and constructed as bespoke creations to suit a particular use at a certain time, with little thought for the future [3]. The 21<sup>st</sup> century has brought with it economic and environmental drivers that have and will challenge normal practice as well as starting an era of unprecedented change in UK construction [4]. These changes include: faster design and production to reduce client uncertainty and cost; much wider adoption of lean manufacturing approaches (including offsite); and increasing demand for infrastructure reconfigurable to future needs that are usually unpredictable [3]. In a survey of high profile UK property developers and agents [5], 94% saw the need for an adaptable building solution providing associated capital cost increases were minimised. Environmental benefits of adaptable office buildings have been estimated by Larsson [6] as a 15% reduction in (a) air emissions and (b) demolition solid waste. According to DEFRA [7], 24% (70Mt pa) of all waste is construction demolition materials and soil. There is clearly both a business and sustainability case for extending the useable life of our building infrastructure. The real challenge is how to make buildings adaptable without creating unnecessary redundancy and increases in first cost.

There have been few recent attempts to incorporate adaptability into new buildings and those that exist have been almost entirely residential. The move to adaptable buildings requires an industry step-change in the way in which structures are conceived, designed and assembled [3]. The main geographic focus of recent flexible building design research has been Japan and The Netherlands [8]. Japan has lead the way in developing mass-produced housing from a purely cost driven commodity item towards a customisable, high quality product which delivers a significant degree of flexibility to the end client [9]. Habraken promoted the concept of open building in the 1960s. However, the practical application of open building has been limited to one-off projects utilising a variety of systems, mainly in housing [10]. The theoretical concepts behind open building have been researched but few projects have been built using this principle and those that have been completed have not used the inherent flexibility as intended [11].

## 1.3 Objectives

The objectives of the research are to:

- identify future scenarios and design criteria for adaptable buildings to respond to
- understand the success or failure of past attempts, both technological and human
- create novel product architecture models and associated methods of analysis to optimise the configuration of components and systems against customer needs
- invent cost-effective building systems and technologies best suited to provide the required levels of adaptability over their life cycle

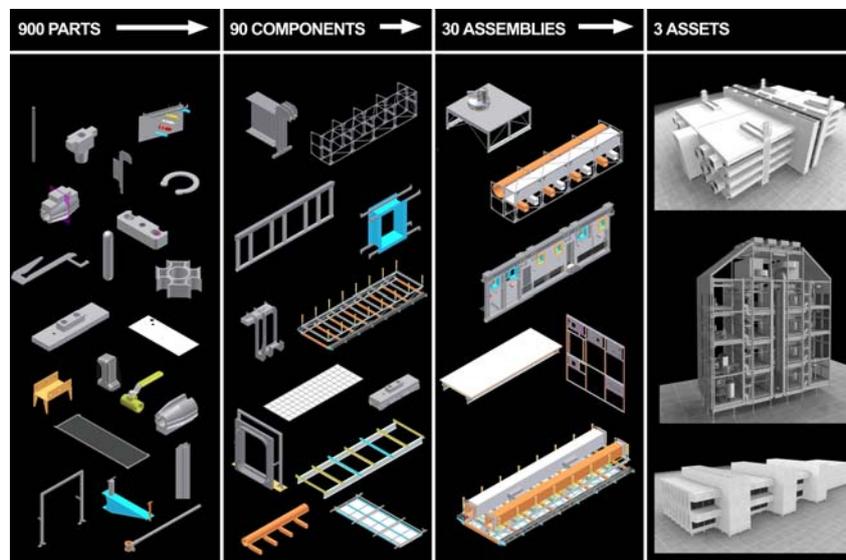
## 1.4 Methodology

The main sources of data collection for the research are two case-study solutions from industry that fit under the two design strategies. These are a pre-configured example, Newways, developed by GlaxoSmithKline (GSK) and Bryden Wood McLeod (BWM) and a

re-configured example, Multispace, developed by 3DReid and Buro Happold<sup>2</sup>. Newways is a pre-configured component building system designed to suit the needs of GSK to create any one of three building types that GSK require. Multispace is a re-configurable concept that is a customisable multi-use building design that can be built as or changed into offices, residential apartments, hotel or retail. These case studies are explained in more detail below. A number of other organisations that make up the reference group are also contributing to the research. A mixed-method approach is being used to collect data from these sources. This approach includes: action research with the industrial case studies; interviews; focus groups; workshops with the research collaborators; scenario modelling; and dependency structure matrix analysis.

## 2 Newways

The main aim of Newways is to reduce design and build time for GSK’s facilities from 24 months to 13 weeks to enable the drugs that they produce to get to market earlier [12] or to enable the delay of the design and construction of buildings until the drug is approved, thus reducing risk of producing sub-optimal buildings and facilities. To achieve this GSK are working with BWM to develop a pre-configured kit of parts used to build three building types: research laboratories; primary production; and secondary production facilities. The kit of parts is shown in Fig.1 and consists of 900 parts, 90 components, 30 assemblies that make up the three building types or assets [1]. GSK see the benefits of the Newways concept as: reduced risk; reduced supply disruption; reduced capital project contingency (10%); reduced cost due to bespoke design; and improved technology transfer [13]. The strategy used to develop the buildings is the 10:80:10 (context: products: enhancement) rule, which means that the majority of the building is standard components, but the site-related elements and the finishes are customised [1].



**Fig. 1.** Newways kit of parts (GSK)

<sup>2</sup> The authors acknowledge the significant contribution of the Adaptable Futures project partners: Nigel Barnes & Al O’Dornan (GSK); Frank McLeod & Martin Wood (BWM); Paul Warner & Chris Gregory (3DReid); Adrian Robinson & Mick Green (Buro Happold).

## **2.1 FlexiLab**

The Newways concept is being driven by the use of FlexiLab that creates flexible open plan laboratory spaces that can be re-configured when necessary [14]. The FlexiLab system consists of modular mobile laboratory furniture on wheels that has been designed to adapt to new laboratory requirements [13]. The services for the laboratory come through sockets in the ceiling that the equipment plugs into. The laboratories can be fitted out very quickly and can be easily reconfigured by the scientists using them. The life-cycle cost was calculated as being lower as although the capital cost is more, the reconfiguration cost is negligible [15].

## **2.2 Services**

At present GSK have standard M&E components for their production facilities, with facilities being designed around these services as they are replicated. The manufacture of the components happens at the same time as the construction of the building and they are brought onto site on the back of a lorry and bolted onto the structure [15]. The Newways concept is to have service ducts around the outside of the building that will contain these M&E components and other services [14].

## **2.3 Components**

At present the parts that make up the Newways components are being developed and rationalised. The fit-out and module elements are in the feasibility stage, cladding and plant are in the concept stage and the structure has gone through scheme design and is now in detailed design. Currently the number of column parts are being rationalised to reduce the number of column types. The floor cassette is the most developed component, with a prototype having been created and tests completed. The floor cassette has been designed to be installed quickly and consists of a pre-cast concrete slab with connections so it can be slotted into place. The grid size currently used came from GSK and the best grid was seen as 12m x 12m as this is the set up of the FlexiLabs. 12m x 4m was chosen for a floor cassette to create these grids, as they can be moved easily on lorries and provide a loose-fit, which is seen as being more flexible. The grids can also be configured with 4x6, 4x8 and 4x10 components. A 0.3% premium will be paid to make sure that all floor cassettes can be used anywhere; it was suggested that this must result in savings overall. The aim is to create a catalogue of Newways components that would include all the parts and how they could go together to form various components and assemblies [14].

## **2.4 Industrial Processes**

To cater for the products that GSK produce a shorter construction time is needed to enable the construction of facilities to be started later to reduce risk and waste and increase efficiency. To do this a continuous process is suggested by GSK that will incorporate: programme management; product development; supply chain management; production of components and assemblies; and production systems. A number of projects would then be produced from this and the process would be able to constantly improve. The process would need to operate in other countries as products moved there for production, this would require control of the supply chain. GSK would need to build up and reconfigure the supply chain as necessary,

identifying what currently exists and how to fill any gaps that appear [16]. This could involve building relationships directly with manufacturers rather than suppliers [14].

## **2.5 Cultural Change**

To enable Newways to be successful, cultural change is necessary. The relationship with subcontractors was seen as the most important aspect of cultural change as these were seen as difficult to control, therefore relationships with suppliers need to be developed. To work with suppliers directly, a base load of work needs to be guaranteed to provide consistency and comfort to strengthen the supply chain. The way in which the connections between parts/components/assemblies are made is very important, this process needs to be controlled, to do so it could be moved off site, which could also increase efficiency. Business and the supply chain need to be reformed to see cultural change. A new way of working is needed, to do that an understanding of the business is important as there is a need to make a market for the product. Simple cultural changes like getting parts, components and assemblies delivered on time and when they are needed on site are crucial to shorten the construction period for buildings [16].

## **3 Multispace**

3DReid, formerly Reid Architecture, conducted a concept study of re-configurable adaptable buildings. The concept developed from this is called Multispace and presents an adaptable, multi-use design that could be the basis of a variety of offices, residential apartments, hotels and retail developments [17]. Mixed-use developments are increasing in popularity and Multispace offers the opportunity for these buildings to respond to market conditions by changing use without significant adjustments to the external envelope. This could maximise commercial return and reduce risks to landlords [2] as well as reducing waste. The aim of the study was to offer some potential solutions to the problems faced by creating multi-use buildings, these were addressed by identifying a set of design parameters [17].

### **3.1 Design Parameters**

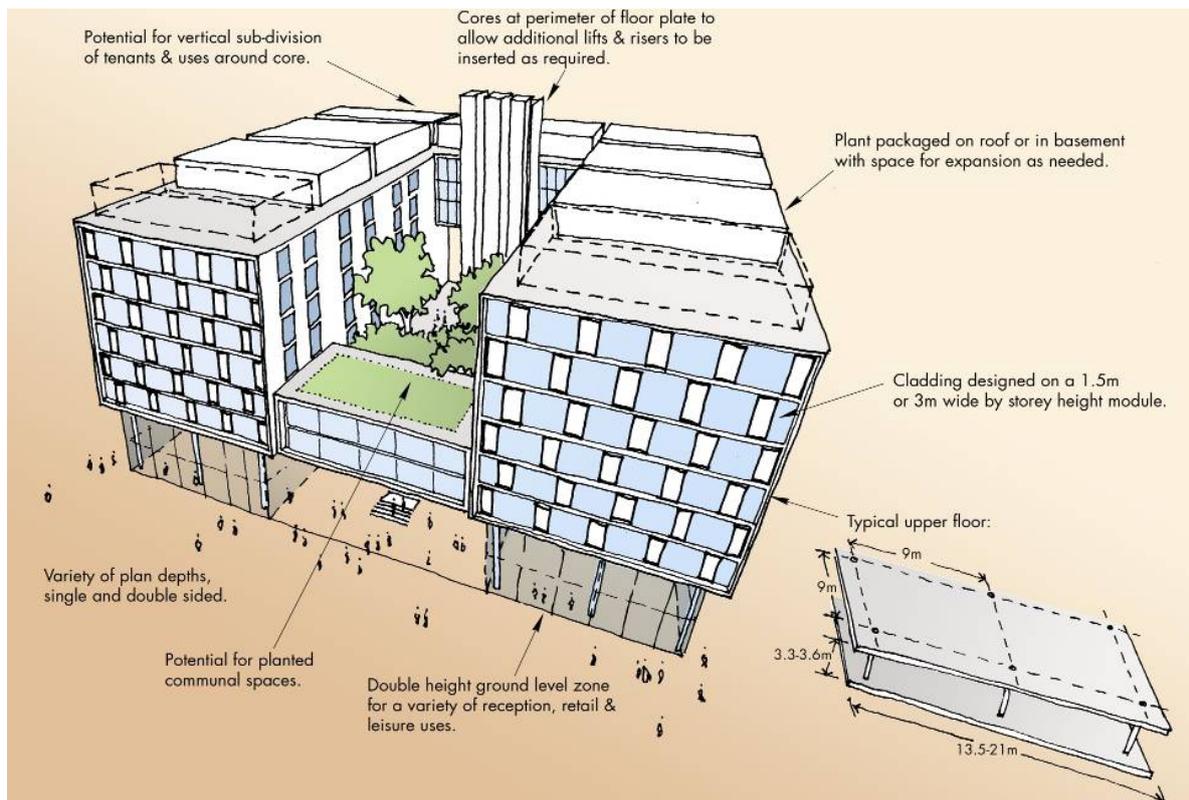
The technical requirements of a set of building design parameters was compared for each building use selected. This enabled acceptable values for each parameter to be proposed to develop a generic specification for an adaptable building [2]. The design parameters were selected to allow a change of use without requiring a significant change in the building envelope. The design parameters included: storey height; building proximity, form and plot density; plan depth; structural design; vertical circulation, servicing and core design; fire safety design; and cladding design [17].

### **3.2 Requirements**

A summary of the proposed specification requirements for an adaptable building from the Multispace concept are shown in Fig. 2. Fig. 3 shows a visual representation of what a building developed using the Multispace concept might look like.

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

**Fig. 2.** Requirements for adaptable buildings [17]



**Fig. 3.** Visualisation of the Multispace concept [17]

## **4 Workshop Findings**

In this section results from a workshop [15] with the industrial collaborators and the reference group are presented. The workshop focused on the two design strategies addressed by the research; pre-configuration and re-configuration. During the workshop participants were asked to document their experience of adaptable buildings that could be categorised under these design strategies. They were then asked to discuss, in small groups, the pros and cons of these examples and the opportunities and challenges for delivering the two types of adaptable buildings identified. In this paper five themes, out of the ten identified during the workshop, are discussed. These include: components, systems, industrial process, flexibility and society.

Data were collected from workshop participants using audio and video recording. The discussion elements of the workshop were treated like focus groups, with specific questions being asked and discussed by each group. Each group was made up of 4-5 industrial collaborators, members of the reference group and members of Loughborough University. Participants were split up according to their backgrounds, which included: industry bodies; producer/contractor; academic/researcher; designer/consultant; and client/developer, this enabled a mix in each group. Each group had a facilitator to guide the discussion and a note taker to allow the facilitator to feedback after the session.

### **4.1 Components**

During the workshop many examples of standardised components used in various systems and buildings were identified. The use of standard components was seen positively as the specification is known. It was felt that components needed to be fit for purpose and so good that people would want to use them. A library of components was suggested as at present they are not used universally. Connections between pre-configured components were seen as the most important part of the design by many of the workshop participants. There was some debate surrounding trying to make as many of the buildings' parts as possible like furniture or 'stuff', as this would enable re-configuration to take place more easily, an example of this is the GSK fume cupboard. It was felt, however, that this approach was constrained by current thinking.

### **4.2 Systems**

Panelised, volumetric, steel frame and modular systems were discussed during the workshop as well as the idea that these can be 'mixed and matched'. It was felt that the systems, rather than the buildings themselves were key to some examples presented, which represented a different approach to design. Due to this, architectural quality was a concern for some systems, but it was stated that bespoke buildings could be created either permanently or temporary as the limitations to the designs were said to be reducing with more experience of the various systems.

### **4.3 Industry Processes**

The supply chain involved in the development of pre-configured buildings was discussed at length by the workshop participants. It was felt that the most benefit comes when a supply chain is in place to deliver the standard components required. The issue of who should pay for pre-manufacture and storage of these components was discussed as this was sometimes an obstacle to pre-configured buildings. The supply chain was described by participants as being an open or closed system, with an open system enabling components to be sourced from various manufacturers, whilst a closed system relies on a particular set of components from specific manufacturers. The scale of the project for which components are required affects this, as if a large volume of components are necessary then benefits can be seen by having a separate supply chain. Another aspect of pre-configured buildings is that much of the work is done offsite, which was highlighted as being faster, less wasteful and more efficient.

### **4.4 Flexibility**

Occupants were thought to need the opportunity to remove or add space, it was suggested that this should be dealt with in the early stages of the design process. Many examples of internal flexibility were presented during the workshop. Hospitals were identified as needing internal flexibility as it was stated that radical change occurred every five years. Several multi-use buildings were discussed which ranged from a 1960s banqueting hall to a science park designed for a very large spectrum of potential uses. There were, however, worries that the optimum solution would not be achieved by these examples and that compromises would always need to be made. Examples of building that were designed to be dismantled and relocated were presented and some had been re-configured as designed, but many others had not and it was envisaged never would be. There were also many examples of buildings that had been designed to be extended and some had been, but many had not been extended in the way they were designed to be.

### **4.5 Aesthetics**

It was outlined that the aesthetics of pre-configured buildings could be bespoke as many could be 'dressed' as necessary. Aesthetics were given as a reason why some buildings were not re-configured as designed, as fashions change. Workshop delegates argued that the aesthetics of some pre-configured buildings had not been very inspiring, but if time and thought was invested it was felt they could be as varied as conventional buildings. It was felt by some participants that the perception of pre-configured buildings was fairly negative, but that this was improving as designers became more involved in the process. 'Second-hand' buildings were also seen to have a negative perception. It was believed that a change in mindset was needed for multi-use buildings and that these should be strived for to help the sustainability agenda. Choice in pre-configured buildings was important to enable developers to put their own mark on buildings and to respond to the local context. It was also felt that there was a massive motivating force for humans to control their environment and have that choice.

## 4.6 Summary

To summarise, the findings from the workshop for adaptable pre-configurable and re-configurable buildings raised the following elements as being important:

- Components must be designed to be fit for purpose
- A library of components should be created to enable universal use
- Connections are a vital part of the design of pre-configured buildings/systems
- Building parts, especially those internally, should be detachable
- Thinking of pre-configured systems rather than buildings will lead to a different design approach
- Architectural quality can be achieved with time and thought
- The supply chain is key to the delivery of components
- Storage of components needs to be addressed
- The supply chain can either be open or closed; depending on the volume of components
- Re-configuration requirements need to be addressed early in the design process
- Solutions created for multi-use buildings may not be optimum
- Many re-configurable buildings are not re-configured as intended
- A change in mindset is needed for adaptable buildings to be successful
- Client or developer choice of building design and aesthetics is necessary

## 5 Conclusions

This paper has introduced Loughborough University's Adaptable Futures project and has presented the two main sources of data collection, the Newways pre-configurable concept being developed by GSK and BWM and the Multispace re-configurable concept created by 3DReid. The paper has also covered issues that are of concern to each of the case studies and provided some findings from a workshop conducted with the industrial collaborators and the reference group for the research.

The next steps in this research are to investigate the two case studies in more depth and conduct action research to enable novel product architecture models to be created as well as to invent cost-effective building systems and technologies. Other case studies will also be examined to aid this process and to identify parameters, materials and technology for successful adaptability. It is intended that aspects of this further work will be presented at the I3CON conference.

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