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Designing for Short Life: The Emerging Need for Packaged Reusable Building Services Components in the UK Healthcare Sector

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Abstract

Current and emerging influences in the general business environment often necessitate that businesses develop dynamic working methods by focusing on their short term function. Such function requires the support of flexible building spaces that can readily accommodate changes in the use of their internal spaces.

Changing the use of space is often accompanied by changes in services requirements. If services installations are to be operated in an efficient, environmentally-friendly manner throughout building life, they must become adaptable at the time of space use change to readily satisfy revised performance requirements. The high cost of adapting services installations using current practices limits the flexibility of serviced usable spaces. The rising extent and complexity of services installations in all types of building further impedes the provision of the flexible buildings increasingly demanded by clients.

This paper identifies the need for a new approach to the servicing of buildings. Packaged reusable building services components are proposed as a method of increasing services installation adaptability by reducing the cost of frequent alteration. Other industries are reviewed to identify aspects of existing reuse practices that may be transferred to construction to implement the reuse of building services components.

Healthcare providers are exposed to influences necessitating their development of dynamic function. As healthcare providers also utilise buildings that are extensively serviced to stringent requirements, this sector is ideally suited for adoption of reusable services components. Successful utilisation in this sector will establish the premise for industry-wide adoption of reusable components.

The paper concludes that the reuse of components or products may be viable, but further work is required to address the technical feasibility and economic viability of the proposal. It is perceived that component reuse will be a viable tool for use by healthcare sector building operators to better satisfy user demands for flexible building space which is likely to increase in the next millennium.

Keywords:
National Health Service; Building Services Components; Functional Obsolescence; Adaptation; Reuse; Reconditioning

1. Introduction

Influences such as rising consumer expectations and technological advancement are increasing the importance of establishing business function flexibility in the short term. The anticipated rise in the number and consequence of these influences will cause business competitiveness to be dependent upon the ability to respond to a continuously changing operating environment.

Many businesses are addressing this evolution of their operating environment by developing new working practices (Gilbert et. al., 1992) that must be supported by buildings possessing usable space that can be readily changed between uses (Duffy, 1993). Changing the use of a space often alters the servicing requirements of that space. Implementing a change in space use often, therefore, necessitates adaptation of the supporting services installation. In the absence of an engineered approach to servicing flexible spaces interim solutions, such as filling open plan office floors with services irrespective of particular requirements or oversizing plant to accommodate future demand changes, have emerged but are detrimental to building efficiency in terms of capital cost, through-life adaptation cost and energy consumption. To achieve efficiency and value for money while minimising environmental impact, services installations must remain closely matched to the demands of supported spaces throughout the life of a building. To ensure that this can be achieved, a new approach to servicing buildings in an adaptable manner must be developed.

The adaptability of services installations is currently limited by the cost of alteration using established practices. As building spaces are predicted to be changed between uses more frequently in the future, the consequences of the short-comings of current practice will become more significant. Given that the rate of change in the use of building spaces is expected to rise in the future, the period of time for which required services performance remains constant will diminish. Many functionally obsolete components that may have only been utilised for a short period of time will possess significant residual physical life and capital value due to their inherently long life. These properties will be recovered by reusing the services component. The alternative to reuse is to design disposable components with a short useful life. When appraised on a life cycle cost basis, however, reusable services components are likely to be more economic than replacing disposable building services components many times throughout the life of a building.

It is therefore proposed that building services components can be developed in the future so that reuse may be facilitated a number of times during their long physical life. As such reuse will reduce the cost of and the opportunity for alteration, services installation adaptability will be indirectly increased. This will increase the flexibility of associated serviced usable building space. Hence the construction industry and building operators will be provided with a means to construct and utilise the flexible buildings that are anticipated to be increasingly required by clients as they operate in the next millennium. The Department of Building Engineering and

Surveying at Heriot-Watt University, Edinburgh is currently studying these proposals in a research project funded by the Engineering and Physical Sciences Research Council.

2. The Reuse Practices of Other Industries

Reuse is prevalent in many industries. Items reused range from prefabricated engineering installations to automobile components. A framework for the introduction of building services component reuse can be developed by reviewing the reuse practices of other industries. The automobile, office equipment and offshore oil industries are considered representative and are reviewed to identify those reuse process attributes considered conducive to the introduction of packaged building services component reuse to the construction industry.

Diversity in the nature of the reuse processes already present in other industries suggests that, as reuse can be successful under varied circumstances, the likelihood of building services component reuse being viable is also high. It is therefore justifiable to further study the proposed building services component reuse.

2.1 Reuse in the Automobile Industry

The automobile industry has remanufactured components for reuse for many years (Bylinsky, 1995; Warnecke, 1985). After recovery, failed "core" components are fully disassembled. Each component part is tested to determine its likely future life and performance. Those passing this appraisal are re-assembled to form remanufactured components. Hence fewer remanufactured components are produced than cores returned. A purchaser of a remanufactured component will usually exchange a failed core component. This allows use of the existing dealer distribution network to recover cores from application. After recovery by the original equipment manufacturer, the core is remanufactured by a specialist organisation and subsequently returned to the original equipment manufacturer for re-sale in his name, using his distribution channels.

Reuse in the automobile industry is driven by economics alone. To create a price differential sufficient to offset consumers' perception that remanufactured components are not as good as new ones, studies have shown that a remanufactured component can not be sold for more than 57% of the price of its new counterpart (Amezquita et. al., 1995). The large installed user base of identical components generates a sufficiently large stream of failed components to facilitate remanufacturing on a production-line basis thereby realising economies of scale.

2.2 Reuse in the Office Equipment Industry

The high capital cost of many office equipment items causes many customers to lease them from manufacturers, usually using performance specifications. Retention of product ownership by manufacturers facilitates their recovery upon lease termination. Recovered products are either remanufactured in their entirety or disassembled to provide parts for the manufacture of new products. The purchase of service provided by an office equipment item, rather than the item itself, facilitates reuse in this industry.

As a high proportion of the component parts of office equipment items are subjected to rapid technological advancement they tend to be designed in a modular format. Upon remanufacture, such product parts can be readily replaced with their current equivalent. Modular design also

facilitates module transfer between products for reuse. A drum unit from a laser printer may, for example, be reused in a small photocopier. Office equipment items such as photocopiers also contain many high value yet technologically inert parts that are ideally suited to reuse (e.g. the optical system). Sophisticated techniques to determine their likely future life and performance have been developed to determine component suitability for reuse (Azar et. al., 1995).

2.3 Reuse in the Offshore Oil Industry

The 'topside' (i.e. above water) offshore installations used by the offshore oil industry are usually constructed from modular, very high value, prefabricated modules. These modules provide either engineering installations or accommodation. The opportunity cost of leaving functionally redundant modules in an offshore installation where space is limited is sufficient to cause such modules to be removed and returned onshore, facilitating their reconditioning or repair for subsequent reuse. The costly and technically difficult recovery process is further justified by the high residual value of the modules. Hence the economic viability of reconditioning high value items on a singular basis drives reuse in this industry.

The large size of offshore operators usually facilitates module reuse within individual organisations. Offshore operators maintain computerised inventories of their modular engineering items detailing location, condition and availability for reuse (Birnie, 1994). Integrated with their maintenance system, these inventories can identify module reuse opportunities within the originator's organisation. If this can not be done, the modules are auctioned and may be purchased by another operator for reuse or purchased by a scrap merchant for disposal. It is observed that market demand is the predominant determinant of the 'scrap or reuse' equation in this industry.

2.4 Aspects of Existing Reuse Practices Appropriate to the Reuse of Building Services Components

The above overview of three representative instances of reuse has identified a number of process attributes that are considered appropriate for use in establishing a framework within which building services components may be reused. The process attributes considered advantageous to building services component reuse are:

- the need to recondition recovered components to ensure that they will be fit for purpose when reused. The stringency of this reconditioning process is dependent upon the nature of the component and its previous application.
- the need to focus on reusing high value components to economically justify building services component reuse on the singular basis necessitated by their diversity.
- the opportunities for reuse created by specifying the performance required from a component or rather than the component itself.
- the need for reconditioned components to be available for reuse at a significantly lower cost that their new counterparts to overcome users' perceptions that reused components are not as 'good' as new components.
- the need for an effective information system to aid identification of reuse opportunities.

It should be possible to introduce packaged reusable building services components to the construction industry, provided that the above attributes are considered for incorporation into the component reuse process.

3. Perceived Component Reuse Implementation Mechanisms

Given the increasing frequency of services installation alteration required by increasingly demanded flexible space, the importance of developing a new approach to servicing such space will become apparent. To effectively manage services installations to satisfy the demands expected in the next millennium, building operators will have to be more concerned with the length of time for which it is appropriate to retain a services component in a building rather than physical component life, which is currently their primary concern. Hence the occurrence of functional obsolescence will determine time period for which a component is utilised in a particular application rather than physical obsolescence which is currently the more common life determinant. The financial consequences of purchasing services components that may be required for only a short time can be offset by utilising reusable components to minimise repeated capital expenditure and to recover residual component value through sale for reuse when functional obsolescence occurs.

The matching of component capacity to initial installation requirements, together with fragmentation of the construction industry, restrict the likelihood of a reuse opportunity for a functionally obsolete component being found within the originating organisation. To implement reuse, therefore, components must be transferred between organisations via open market function. Such inter-organisational component exchange raises the following issues:

- the need for services components to be reconditioned prior to reuse.
- the need for the fitness of purpose of reconditioned components to be warranted in the absence of knowledge of their operating history.
- the need for an effective information system to co-ordinate the transfer of reusable components between buildings.

3.1 The Need for a Building Services Component Reconditioning Industry

If a reused component is purchased from the market place having been previously utilised by an unknown organisation, the recipient organisation has no historical knowledge of that item (reliability, maintenance undertaken, etc.) and therefore requires a warranty of its fitness for purpose. Such warranty can only be provided by a third party carrying out the reconditioning of components prior to their sale for reuse. It is perceived, therefore, that a new industry sector will emerge to perform the reconditioning process. A possible reuse process incorporating this function is presented in Figure 1.

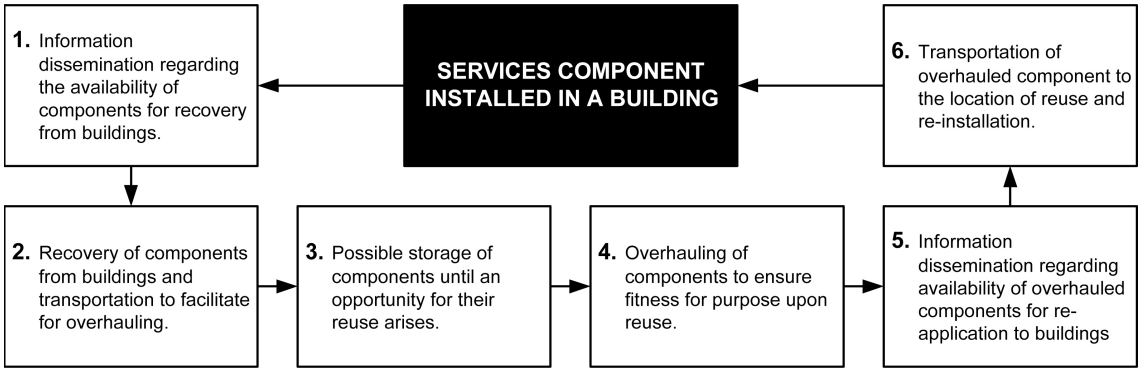

Figure 1: The Role of the Reconditioning Industry in the Perceived Component Reuse Process

Members of the reconditioning industry sector (stage 3 in figure 1) will recover components from buildings, appraise their condition and perform a reconditioning process upon the component appropriate to its nature and condition to facilitate warranty of its fitness for purpose. This process will be undertaken with a sufficiently low cost to enable component sale for reuse at a price significantly lower than the new counterpart.

Organisations ideally suited to establishing the reconditioning sector are those with access to information regarding original component manufacture such as design details and suppliers of component parts (Bollinger, et. al., 1981; Lund, Skeels, 1982). Although the organisations most likely to possess this information are original equipment manufacturers and their certified agents, maintenance contractors or new entrants (perhaps organisations already reconditioning components in other industries) could also form the new industry sector provided the barriers to entry associated with the need for component information can be overcome.

3.2 The Need for an Effective Information System

Communication in the construction industry is often impeded by its fragmented structure and the diversity of the organisations within it. To implement the envisaged component reuse process presented in Figure 1 above, an information system must be established to provide an interface between building operators and the services component reconditioning support industry. This system will perform two functions:

1. to assimilate information from building operators regarding functionally obsolete building services components available for reconditioning and subsequent reuse (stage 1 above). This information would be utilised by members of the component reconditioning support industry.
2. to disseminate information detailing the availability of building services components that have undergone reconditioning for reuse (stage 5 above). This information would be submitted by members of the component reconditioning industry and utilised by building operators sourcing components to alter existing services installations.

As this information system must operate efficiently and effectively to minimise the likelihood and associated cost of storing components at any stage in the reuse process, the Internet is proposed as a suitable delivery mechanism. This communication medium is fast, resilient and readily accessible at reasonable cost. The suitability of the Internet for this task is demonstrated

by the offshore oil industry which currently uses it to identify opportunities for transfer of modular engineering installations between offshore operators. It is proposed that the information system would be operated by a third party on a subscription basis.

3.3 The Need for Warranty Provision

Preliminary discussions with client organisations, based on the assumption that packaged reusable building services components are technically feasible and economically viable, have identified the need for reconditioned component fitness for purpose to be warrantied. This requirement originates from clients' desire to manage their exposure to the risk of component failure, which they perceive to be increased with utilisation of un-warrantied reconditioned components.

As discussed above, this need for warranty of fitness for purpose necessitates the establishment of a new industry sector undertaking component reconditioning. The nature and stringency of required warranties (and the reconditioning process to enable their provision) remains to be established.

4. Applicability of Building Services Component Reuse to the Healthcare Sector

The need for a new approach to the servicing of buildings supporting business activity has been established as a response to multiple trends influencing the likely nature of business function in the next millennium. The case for adoption of this new approach by managers of buildings supporting healthcare sector activity, however, remains to be established. National Health Service guidance (Department of Health, 1996a) has recently identified the need for "flexibility and commitment to achieving value for money" and the creation of spaces that can be used "in a number of different ways without any need for physical alteration" (Department of Health, 1994a) to ensure that buildings can satisfy emerging needs. This need for building flexibility originates from changes in healthcare provider function necessitated by a changing operating environment. The changing nature of the healthcare sector is caused by many influences summarised in Figure 2.

	Component manufacturers' component reuse implementation measure	Proportion of component manufacturers willing to implement measure
a.	Willing to manufacture more reusable building services components	88%
b.	Willing to overhaul components of own original manufacture prior to their reuse	86%
c.	Willing to overhaul components of originally manufactured by others prior to their reuse	43%
d.	Willing to provide guarantee with overhauled components (assuming willingness to manufacture reusable components)	79%
e.	Perceived viability of proposed component reuse supporting industry sector	45%

Figure 2: Summary of Influences on the Provision of Healthcare by the NHS

In recent years healthcare providers have been subject to influences on their function arising from internal reform of the NHS or government policy. These "internal" influences act in addition

to traditional "external" determinants of provider function. It is apparent that, although exposed to different influences than those of the general business environment, healthcare providers must be supported by buildings possessing similar flexible space if they are to develop flexible function in the short-term (Webb et. al., 1997). Problems associated with the steadily increasing cost and complexity of building services installations are particularly onerous in the healthcare sector where building services installations tend to be more extensive and complex and are subject to more stringent performance requirements. Hence the initial application of packaged reusable building services components as a new approach to servicing buildings and managing building space use changes in the healthcare sector is particularly appropriate. If proven viable in this exacting environment, the utilisation of reusable components should also be applicable to the buildings required by other industrial sectors.

Advancements in medical technology are increasing the range of healthcare services that can be provided in the primary healthcare environment (Department of Health, 1996b). By bringing healthcare closer to the patient in the community environment, the size of the estate retained by healthcare providers for the provision of acute services in the secondary environment is diminishing. In recent years this trend, colloquially known as "the secondary to primary shift", has caused the sale of surplus secondary NHS estate. Reduced in size, the residual secondary estate is utilised more intensively, increasing the importance matching function performed to building space used and to supporting building services installations. The healthcare services provided in the secondary environment, by their nature, place more stringent demands on supporting building services. The greater extent and complexity of the services installations required by the secondary estate increases the importance of a new approach to servicing buildings in an adaptable manner.

The operation of Environmental Management Systems (EMS's) in accordance with the ISO 14000 series of standards is common in the general business environment. By auditing their environmental impact these systems help businesses manage the reduction of that impact. This practice can also be economically advantageous (Public Technology Inc., 1996). Many NHS healthcare providers are implementing environment management systems in accordance with management guidance (Department of Health, 1995) to address the following key issues:

- consumption of resources and manufactured goods
- handling and storage of raw materials
- energy management
- air quality standards
- the consumption and disposal of water
- waste management
- buildings, grounds and gardens
- transport

In addition to realising economic benefits, utilisation of the proposed reusable building services components by healthcare estate managers will enable them to address of many of the above issues.

Facilities management practices have recently been introduced to the NHS to assist building operators to better respond to continually changing needs of space users, an ability that will become increasingly important in the future as the rate of change in those needs accelerates. Although the management of space use has traditionally been practised by healthcare providers themselves, management guidance (Department of Health, 1996a, op. cit.) highlights opportunities for outsourcing this function, allowing the healthcare provider to focus on the provision of healthcare services. Such outsourcing, where an external organisation is contracted to operate a healthcare provider's estate in response to its needs, creates opportunities for the introduction of new working methods to the NHS. It may be the case that an external facilities manager will be more willing to introduce new practices if these have proven effective in other sectors. The difficulties in forecasting and quantifying the output required from an outsourced facilities manager at the commencement of a contract often results in contracts being let on a performance basis. In such circumstances, where the performance of space is specified, it is possible to utilised reused services components to service that space provided performance of the services installation is maintained.

The UK government has revised the manner in which all public sector capital projects are procured to necessitate appraisal of the suitability of use of the Private Finance Initiative (PFI), where traditionally public sector projects are financed, constructed and operated by the private sector. The private sector receives a revenue income throughout the life of their operating contract (typically 15-30 years). By developing infrastructure in this manner private sector working practices are introduced where traditionally public sector practice would prevail. In the case of the healthcare estate, although the estate must be developed to satisfy existing NHS guidance, it is possible to introduce new practices to its construction and through-life operation. As the private sector consortiums undertaking PFI projects wish to minimise their risk exposure, they may be willing to utilise reusable components allowing them to better respond to changing building users' needs throughout its life.

Although the PFI has been successfully utilised for a number of low value developments of the NHS estate, successful application to larger projects such as acute hospitals has been limited. At the time of writing, only one acute services PFI project has reached financial closure (Barrie, 1997). There are, however, a large number of projects in development, presenting opportunities for implementation of the proposals.

5. Unresolved Services Component Reuse Issues

The need for a new approach to the servicing of buildings in an adaptable manner to increase the flexibility of usable serviced spaces has been established. The development and utilisation of packaged reusable building services components has been proposed as a solution to this problem, the prevalence and consequence of which is anticipated to increase in the future. By reviewing the practices of other industries, the potential viability of reuse processes has been established. Review of the influences upon and particular requirements of the healthcare sector

has further identified this industrial sector to be ideal for the initial development and application of the proposal.

While the premise for services component reuse has been ascertained, and preliminary requirements of an effective implementation reuse process determined, a number of significant issues remain unresolved at this stage of study and require further address. These issues are embodied in a series of unresolved questions, thus:

1. Will it be technically feasible to manufacture and deploy packaged reusable services components in buildings?
2. Will the process of recovering functionally obsolete services components from buildings and reconditioning them for reuse be economically viable given that reconditioned components must be marketed at a significantly lower price than their new counterpart?
3. Will the life cycle economics of reusable services component utilisation be viable?
4. Will the "packaged" reusable component be physically packaged, or is the term better used to describe revised procurement processes, centred on performance specification, that may enable reusable component utilisation?
5. Will it be possible to develop an objective method of determining whether a functionally obsolete component should be reconditioned for reuse or disposed off as scrap?

6. Conclusions

The need for business organisations to focus on their short term function has been identified as likely to increase in the next millennium. The emergence of new, dynamic working practices have been further identified as necessitating the provision of flexible usable space in the buildings supporting organisational activity.

The rising cost and complexity of services installations in buildings currently restricts the flexibility of usable space as the through-life cost of frequently adapting supporting services installations is often restrictive. The development and utilisation of packaged reusable building services components is proposed to reduce the cost of alteration, thereby increasing installation adaptability. Review of practice in industries other than construction and healthcare has identified instances of component reuse verifying that reuse can be viable under varied circumstance and may, therefore, be applied to construction.

Although the influences determining the function of healthcare providers are greater in number and different to those of the general business environment, their overall effect of increasing the importance of short term function is the same. The healthcare sector therefore provides an ideal vehicle for the initial development of the proposals. Healthcare buildings tend to be intensively utilised and extensively serviced. If packaged reusable building services components can be successfully introduced to the management of buildings used by this sector, it should be viable to also introduce this practice to management of buildings used by other sectors.

As it is anticipated that the reuse of building services components will enable healthcare estate managers to better respond to the needs of their building uses as they progress into the next

millennium, this work is currently appraising the initial response of the construction and healthcare industries to the proposal and probability of subsequent take-up.

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