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Designing for Short Life: A Study into the Development of Reusable Packaged Building Services Components in the Healthcare Sector

R.S. Webb, J.R. Kelly and D.S. Thomson

Abstract

Industry concerns regarding the increasing contribution of services installations to total project cost have highlighted the need to develop new methods of designing, procuring, constructing, utilising and disposing of services components. Additionally, the shift in operational focus of many industrial sectors towards short term requirements for built space to perform a particular function requires a new approach to the recovery of services components.

The UK national health service is illustrative of a construction industry client whose operational need, in terms of supporting built estate, can be met with utilisation of reusable services components. The varied influences on the manner by which healthcare services are provided necessitate a short term approach to functional space provision and therefore frequency of change in the services requirements of internal space.

Packaged reusable services components reduce the cost of services installation adaptation through recovery of residual un-depreciated capital and un-utilised physical life embodied in the functionally redundant components recovered from applications of short term duration.

The paper concludes that reuse has been identified as valid business practice and is considered appropriate for use in the development of the readily adaptable buildings required by construction industry clients. Further work is required to derive methodologies for the design and procurement of packaged services components for reuse.

Keywords:

services components, reuse, short term, adaptable space, national health service, remanufacture, performance specification, cost reduction

1. Introduction

Concerns regarding the increasing contribution of services elements to overall construction project costs have been expressed by both the industry and its clients (MacPherson, et. al., 1991). Methods of providing services installations at lower cost while providing the same levels of quality and function must be developed to address these concerns. In addition to addressing...
the need to reduce the capital costs of such installations, the need to reduce the through-life costs associated with the adaptation of services installations must also be considered.

These concerns regarding the cost of services installations are increasingly relevant within the context of the observed shift in the operational focus of the general business environment towards the short term. This short term focus has arisen out of increasing competitiveness heightening the need for businesses to respond to changing markets for their output by continually adapting their performed core function. This consequentially increases the frequency of change placed upon buildings supporting the core function revision.

An increasing proportion of the capital invested in building is embodied in the services installations associated with the spaces provided. The adaptability of space to change of use can be increased through the simple reuse of services installations, which reduces the impact of the cost of change. Services components arising from applications of a short term duration are likely to be functionally (i.e. not economically or physically) redundant and will therefore possess significant potential for reuse to recover embodied un-depreciated capital investment and residual remaining physical life.

The composition of services installations from inter-connected yet uniquely identified components of construction (in contrast with the more homogeneous nature of most other building elements) assists the implementation of reuse of individual constituent components upon identification of their functional redundancy.

Although current methods of servicing buildings are effective, the introduction of reusable services components needs to be considered to address the need to create readily adaptable buildings. As the shift in the business operation focus to the short term creating the demand for adaptability is observed to be a currently emerging trend it is anticipated that this will continue into the future, increasing the need for adaptable buildings created by reducing the cost of change through the reuse of services components.

It is envisaged that the reuse of services components is possible provided that a reconditioning process to ensure component fitness for purpose is conducted between applications and that procurement methods are developed to specify performance in lieu of uniquely identified physical assets. Additionally, the physical format of the components themselves requires revision to aid physical transfer between installations.

2. **Proposed Benefits Accruing With the Reuse of Services Components**

Utilisation of packaged components designed for reuse introduces potential opportunities to recover remaining un-depreciated capital investment and residual future physical life upon the identification of component functional redundancy. Provided that an opportunity to implement component reuse can be identified, the sale of such components on the open market will realise the value of these residual attributes.

Recovery of functionally redundant component residual value in this manner reduces the cost of adapting services installations as a consequence of changes in the use of serviced built spaces.
This reduction in cost will drive the manufacture of packaged reusable components with greater adaptability.

The use of performance specification for the procurement of services installations creates opportunities to utilise reused components. As individual components are not identified with application of a performance specification components can be reused in this context provided that system performance is maintained. The cost benefits of utilising reused components in this manner will be passed to the building operator.

3. **The Study of Services Component Reuse**

The Department of Building Engineering and Surveying, Heriot-Watt University, Edinburgh, has received funding from the EPSRC to carry out a two year long pilot study to investigate the reuse of services components. It is anticipated that implementation of successful study outcomes will provide the construction industry with a means to address currently emerging and anticipated future client demands to reduce the cost of services installations and create more readily adaptable buildings.

The need to reuse services components arises from observed changes in the use of spaces within existing buildings. If a space is adapted from one use to another the demands placed upon its supporting services installations change which, to ensure system efficiency, necessitates its adaptation. To recover the residual value of functionally redundant (i.e. not physically or economically redundant) components their disposal as scrap must be avoided. The potential for reuse to reduce the financial impact of change is being investigated by this study.

Upon adapting services installations associated with a space whose use has changed, functionally redundant services components can be made available, via market function, for reuse elsewhere by other organisations. Additionally, the purchase of services components recovered from built applications and reconditioned for reuse can provide the required revised system output at a lower cost.

This study presents the healthcare sector as a vehicle for development of reuse proposals by assessing the attitudes of NHS clients, building services component manufacturers, design engineers and services system installing contractors to determine viability of these proposals. This study will address the possible requirement to provide services components in a physical format and utilising procurement methods conducive to their reuse.

Component reuse is proposed for implementation on the macro, inter-organisational, level. Exchange between organisations for reuse introduces concerns regarding fitness for purpose, market function and information availability in addition to technical component design and process economics issues. These concerns will be addressed by this study.

4. **Perceived Opportunities to Implement the Reuse of Services Components**

The construction industry and its clients have established concerns regarding the increasing contribution of services installations to total project cost. Services installation system designers must reduce the contribution of their designed installation to the total construction project cost, without reducing quality or functionality. To allow them to do this, system designers require new
techniques of providing adaptable services installations by focusing on the performance required from installations.

The development of installations utilising packaged services components designed, manufactured, procured and deployed to buildings in a manner to facilitate reuse upon identification of functional redundancy will reduce the through life cost of adapting building services installations necessitated by the continually evolving demands of users upon the spaces serviced. The cost reducing potential of packaged services component reuse should receive support from the construction industry and both its clients and suppliers.

It is acknowledged that both the construction industry and academia are addressing the need to reduce the initial capital cost of building services installations. It is observed that value engineering provides significant opportunities to reduce the cost of such installations without comprising either functionality or quality (Hayden, 1996) (MacPherson, et. al., 1991). However the development of installations to facilitate reuse of their constituent components addresses the cost associated with frequent through life adaptation of these installations.

5. **The Scrap or Reuse Equation**

Although significant opportunities exist to develop recycling of the raw materials generated by construction industry activity, it is proposed that services components are reused with retention of functional output and geometric form. It is postulated that a break even calculation can be made dependent upon whether a reuse opportunity can be identified. If not it is possible that the value of the component will be higher for disposal as scrap (i.e. for materials recycling).

An initial assessment must be carried out to determine component potential for reuse. It is observed that this assessment is typically integrated within the maintenance regime operated by an organisation, or its outsourced maintenance contractors. This process currently lacks structure, and generally comprises an assessment made by a maintenance engineer, based on his personal experience.

Component reuse determination occurs in two stages. In the first instance, if the preliminary assessment of reuse potential by the maintenance engineer indicates that reuse may be viable, the component will be forwarded to the open market in an attempt to realise its residual value. If this is not the case, the component will be offered directly to scrap merchants as scrap.

Determination of component value via market function comprises the second stage of the process. The reuse potential assessment is inherent in the mechanism by which market function price level is determined. If a purchaser intends to reuse the component they offer a price above that of scrap merchants whose intention is only to recover the raw materials contained in the component. If the converse occurs, the component terminates its cycle of utility and is disposed of as scrap. It is therefore observed that the scrap/reuse assessment is embodied in open market function.

It remains to be determined if a standardised equation and associated assessment methodology can be formulated to conduct the component reuse assessment in a uniform manner, abstracted from the varying experiences of individual people.
6. **Validity of Reuse as a Business Tool**

Observation of practices in a variety of industrial sectors illustrates growing acceptance of reuse as a valid business tool. The study of a representative selection of these industries provides an opportunity to identify the characteristics of successful implementations of reuse.

The desire of businesses to focus upon their core activity by outsourcing (externalising) non-core supporting functions has created an environment in which the services provided by assets are procured in lieu of specific physically identified assets.

### 6.1 Illustrative Reuse Instances

The fact that instances of reuse are observed to operate successfully in a number of industries in the absence of legislation illustrates the economic benefits achievable with the implementation of this process.

Reuse instances are observed to occur on a number of levels. In some instances, reuse occurs at product level, in other instances it occurs at component (i.e. product part) level. While some products are reused insitu, typically with the introduction of upgrading of function through a remanufacturing process, the majority of products or components are recovered from application upon redundancy or failure to facilitate their reuse.

In the oil industry modular, prefabricated, engineered systems of components and accommodation modules utilised in offshore installations are reused. As these units are maintained to a high standard in their offshore installation, reuse opportunities predominately arise due to functional redundancy rather than unit failure. Module reuse occurs primarily due to their high residual value and the opportunity cost of leaving functionally redundant components in such installations. The high value of these component systems is illustrated by operator finance of the logistically complex recovery process from offshore application for onshore repair or reconditioning. Reuse typically occurs within single, albeit large, offshore operators although transfer between organisations can occur via open market function. Physical module transfer between locations is managed with the use of computerised information systems (Birnie, 1994).

In the automobile industry, vehicle components have been remanufactured for reuse for many years. The number of failed components arising from the large installed user base of identical components facilitates remanufacture on a production line basis, accruing economies of scale. Remanufactured automobile components are available to consumers at a significantly lower price than the equivalent new product (Amezquita, et. al., 1995). The price differential is required to ensure that consumers will purchase remanufactured components for through-life maintenance of vehicles by off-setting perceptions that reused components are “not as good as” their new equivalents despite implementation of the remanufacture process.

A number of automobile manufacturers are developing methods of designing and manufacturing automobiles to ensure that they are more reusable through the recovery of their constituent components and materials of construction upon their end of life disposal (Bylinsky, 1995). While the automobile is one of the most recycled products in terms of recovery of raw materials (Office of Compliance, 1995), (Bylinsky, 1995), manufacturers are preparing for legisatory extension of
their responsibility for the environmental impact of their products throughout their life, including end of life disposal.

In the office equipment sector, the reuse of equipment items, primarily high value photocopiers, has occurred for a number of years. The use of lease agreements by consumers to secure access to the services provided by these assets creates the characteristics feature of this sector: original manufacturer ownership of components throughout their life. Lease agreements provide original manufacturers with a means to reclaim components at the end of their useful life, or functional application (i.e. upon termination of the lease).

To facilitate their reuse, these components undergo a remanufacturing process. Although the manner in which this process is conducted varies between manufacturers, the objective to ensure fitness for purpose to facilitate reuse remains constant. Canon UK Ltd. defines remanufacture as (Anon., undated):

"the process of totally disassembling and cleaning a product, replacing non-functional or sub-standard parts and then testing and rebuilding that product to the quality, reliability and performance standards of products manufactured from all new parts".

Many office equipment products are manufactured on a standardised, modular basis which facilitates the transfer of component parts between product types for reuse. These products are additionally characterised by the presence of a number of high value, but technologically inert component parts (i.e. the optical system in a photocopier) which aid the economics of reuse through recovery of their embodied residual value.

A comparison of these reuse instance observations is presented in the following table.
<table>
<thead>
<tr>
<th>Industrial Sector</th>
<th>Nature of Reused Item</th>
<th>Reuse Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore Oil Industry</td>
<td>• high value</td>
<td>• functional redundancy of components</td>
</tr>
<tr>
<td></td>
<td>• deployed in modular prefabricated systems</td>
<td>• opportunity cost of not reusing components</td>
</tr>
<tr>
<td></td>
<td>• low number</td>
<td>• opportunities for reuse arising within large offshore operator organisations</td>
</tr>
<tr>
<td></td>
<td>• unique, non-identical</td>
<td>• open market function facilitates transfer of components for reuse between organisations</td>
</tr>
<tr>
<td>Automobile Industry</td>
<td>• low value</td>
<td>• economy of scale accrued by full remanufacture process</td>
</tr>
<tr>
<td></td>
<td>• large installed base of identical components</td>
<td>• remanufactured components available for reuse at significantly lower price than their new equivalent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• development of future automobile designs for greater component reuse in anticipation of legislation</td>
</tr>
<tr>
<td>Office Equipment Industry</td>
<td>• high value</td>
<td>• service purchased by customers through leasing agreements; manufacturer retains through-life ownership.</td>
</tr>
<tr>
<td>(Photocopiers)</td>
<td>• reasonably large installed base of identical products</td>
<td>• high rate of technological advancement in controls accommodated with modular design</td>
</tr>
<tr>
<td></td>
<td>• limited variability in installed user base</td>
<td>• high value, technologically inert components are reused (e.g. chassis, optics, motors, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• standardisation of modular designs facilities module transfer between products for reuse</td>
</tr>
</tbody>
</table>

Table 1: Analysis of Reuse Instances in Industrial Sectors Other than Construction

The above overview of successful reuse instances provides an opportunity to identify best practice and apply these techniques to the development of services component reuse methodologies.

The manner in which assets are reused in the offshore oil industry draws the greatest parallel with the perceived manner by which it is anticipated that services components can be reused. Sizing of services components to suit the spaces served creates an installed user base of components, matched to the requirements of their current application. The process of reconditioning and reconfiguring components for reuse is likely to be economically viable only in the instance of high value components. Reuse process success is dependent upon the effective dissemination of information from a database detailing component deployment.

The most promising technique for the introduction of component reuse is the procurement of service provided by assets via the specification of performance. Office equipment is successfully reused within this context as the function procured remains constant irrespective of the specific equipment item, or its constituent components, providing that function.
Application of production line remanufacturing techniques observed in the automobile industry is not initially considered appropriate for application to the reuse of services components as the majority of components recovered from applications of short term duration will not have physically failed and instead are functionally redundant. Additionally, the non-uniformity of the installed user base may restrict the availability of sufficient quantities of components for implementation of a production line reconditioning process. However, the requirement for a cost differential in favour of the reused component to offset consumer perceptions of reused components being “not as good as” their new equivalent is considered an essential element of the development of services component reuse processes.

6.2 Identified Process Characteristics Applicable to the Development of Services Component Reuse

Analysis of the above examples of reuse identifies a number of process characteristics that are considered representative of best practice and may provide opportunities for the successful development of services component reuse:

- the reuse of high value components (oil and office equipment industries).
- the introduction of reuse within the context of the procurement of service (office equipment industry).
- the need to provide reconditioned components for reuse at a lower price than their new counterparts (automobile industry).
- the requirement to conduct a reconditioning or remanufacture process to ensure component fitness for purpose upon reuse (all industrial sectors analysed).

7. Identification of Possible Component Reuse Application Environments

Although, as discussed above, focus upon short term functions is commonplace in many industrial sectors a search was made for an industrial sector where this mode of operation is especially prominent. Once identified, consideration of the application of the proposed reuse of services component to this industrial sector provides a means to model the implementation process and identify possible restrictions on the development of research proposals.

Currently, the UK healthcare sector exhibits characteristics considered conducive to the implementation of services component reuse, meeting its requirement to utilise long life assets with a predominant operational focus on short term activity. In the case of the healthcare sector, the short term is defined as periods of less than three years duration.

8. Healthcare Sector Demand for Adaptable Built Space

The demand for a flexible (i.e. readily capable of accommodating changes in use) built estate supporting the core activity of national health service healthcare providers is derived from the environment within which these NHS Trusts function. The influences, illustrated in Figure 1, on the provision of healthcare services inter-link to create an environment for the provision of healthcare which is continually changing. NHS Trusts react to this environment by continually adapting the services they provide. Demands placed upon the built estate are continually evolving, requiring the accommodation of changes in the use of spaces in the short term. To
accommodate such changes, the supporting estate must be adaptable. The adaptability of built estate can be increased by reducing the impact of implementing changes in its use. Recovery of the residual value of the components of construction of such spaces through reuse provides a means to reduce the cost of implementing changes, thereby increasing adaptability.

9. The Reuse of Services Components in the NHS Estate

Reuse has been established as a valid business practice where, in the absence of legislation, economic arguments expedites the implementation of services component reuse which is anticipated to reduce the cost of adapting installations. The use of new procurement methods where performance is specified in lieu of physical assets by the NHS further provides opportunities for the implementation of reuse, provided function is maintained.

![Figure 1: Summary of Influences on the Provision of Healthcare by the NHS](image)

Concerns regarding services contribution to total project cost are especially prevalent in the healthcare sector due to the extent and complexity of the services installation required to support the spaces used by this sector. This environment adds further relevance to the selection of building services components as the focus for development of reuse methodologies.

The established NHS practice of market testing to ensure value for money, has prompted the out sourcing of the facilities management function and the provision of some non-core functions such as laundry, catering and cleaning. Recent use of the private finance initiative to develop the built estate takes this further (Department of Health, 1994).

Additional relevance of introducing reuse NHS estate management is provided by application of BS 7750 or ISO 14000 series derived environmental management systems (Department of...
In this context, the benefit of services component reuse is considered to be the reduction in the quantity of waste generated as a consequence of implementing changes in the use of buildings throughout their life.

The introduction of new estate development and utilisation techniques to the NHS is likely to create a management environment more appropriate to the use of the estate in a short term, flexible manner. By reducing the cost of change, the reuse of services components endows existing and new estate buildings with increased adaptability when compared to their counterparts with services installations procured, designed, constructed and adapted in a traditional manner.

10. Opportunities for Reuse Created by NHS Procurement Methodologies
In parallel with wider business practices, the increasing focus of NHS Trusts on their core function increases out sourcing. One function which is observed to be increasingly externalised is the development, operation, maintenance and adaptation of the built estate supporting Trust activity.

Observed increasing occurrences of procurement of services, based upon a performance specification establishes opportunities to utilise reused components for the provision of the required function at lower cost.

It is observed that procurement of functional output occurs at a number of levels within the context of the built environment. Longer established NHS procurement methods, arising out of compulsory competitive tendering originally isolated out sourcing to individual functions such as catering and cleaning. Periodic market testing ensures that performance specifications offer value for money. Many of the functions externalised occur at a higher, more homogeneous level where the performance specification encompasses a number of operational tasks. Introduction of commercial facilities management organisations to NHS Trust’s estates provides an example of this multi-function Trust separation from direct responsibility for assets used (Department of Health, 1996).

Separation of Trusts from assets used occurs on the whole building level within the context of capital investment projects procured utilising the private finance initiative. It is envisaged that utilisation of the PFI to develop buildings for use by the NHS provides the greatest opportunity to implement reuse. In the PFI context, private sector project members are considered to be more willing to introduce new concepts such as reuse to the development of their buildings for NHS use. New techniques will be introduced if they contribute to the development of buildings capable of accommodating changes in use, thereby reducing the risk exposure of these private sector bodies.

It is noted that opportunities for the introduction of reused services components increase with the separation of Trusts from the responsibly for the operation of those assets. This variance in the extent of Trust user abstraction from assets used to support their core function activities is illustrated in Figure 2.
11. **The Development of Reusable Packaged Building Services Components**

Reuse has been established as a valid method to increase building flexibility by minimising the cost of change through the recovery of residual value embodied in services components. In the case of buildings utilised by healthcare providers, the opportunities for services component reuse are substantial given that services installations in this sector are generally more complex and service spaces are adapted for new function on a frequent basis.

The reuse of services components will be aided, and the cost of process implementation reduced, if components subjected to the anticipated reuse process are designed, manufactured and deployed in a manner conducive to the implementation of reuse. It is anticipated that the development of physically packaged components is the most appropriate method to aid reuse implementation, where the term “packaged” refers to the combination of a number of existing design attributes and these procurement methods assessed as beneficial to reuse implementation.

12. **Required Organisational Function Reform to Support Component Reuse**

To ensure component fitness for purpose after recovery from an application, it is proposed that a reconditioning process be introduced prior to reuse. It is envisaged that this process be undertaken by a new industrial sector which will purchase functionally redundant components and recondition them for sale, with value added, for subsequent reuse. This new sector may evolve from the limited industry currently implementing services component reuse. This proposal raises a number of issues regarding the structure of the support industry and the organisational development required to conduct its activity.

The structure and membership of the proposed support industry will be derived from comparative analysis of roles performed by organisations currently reusing components together with development of reuse implementation scenarios to identify organisations and contractual relationships. Comparison with current practices will identify required organisation function reform and requirements for the development of new organisation relationships.

13. **Further Work**

Four reuse implementation process focus groups have been identified as exerting greatest influence on the creation of environments within which the development and deployment of reusable packaged services components can occur. These focus groups are: Healthcare providing NHS Trusts, services component manufacturers, consultant design engineers and installing contractors. To ensure that the development of proposals for the introduction of reusable services components correspond with the needs and concerns of these focus groups questionnaire analysis will reveal their attitudes and concerns for incorporation into proposals.

If project outcomes indicate that the reuse of services components is both economically viable and technically feasible, fully developed economic and technical process models will be required to assist the implementation of reuse proposals.
14. Conclusion
The cost of services installations and the need to create adaptable buildings can be addressed through services component reuse to provide a means by which the construction industry can meet the changing demands of its clients. This would provide opportunities through the implementation of services component reuse for the construction industry to respond to concerns regarding the increasing contribution of services installations to project costs. The need to create adaptable buildings capable of accommodating changes in the use of their internal spaces in the short term would also be met.

Revision of current techniques utilised in the design, procurement, construction and through life adaptation of services installations may be necessary to facilitate reuse. Services components may require revision of their physical format to aid the implementation of reconditioning and physical transfer between built applications for reuse.

The healthcare sector has been identified as a suitable vehicle for investigation of this application of reuse to the construction industry, although it is noted that operation of the internal healthcare market provides a substitute for the open market for products or services in driving operational focus on the short term.

Current perceptions of factors driving the increasing frequency of changes in the use of built spaces supporting business processes indicate the relevance and timeliness of this study. Anticipated successful project outcomes derived from analysis of services component reuse development in the healthcare sector will provide a demonstration of the validity of this approach to the creation of readily adaptable built space to other industrial sectors also wishing to use adaptable buildings to support their core function.

Further work is required to determine the response of construction industry members, clients and suppliers to the services component reuse proposals of this study. Development of detailed technical and economic models illustrating the anticipated viability of these proposals require development upon identification of the support of the above parties to the envisaged reuse process.

15. References


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