VALIDATING DESIGN LIFE THROUGH PERFORMANCE REVIEWS

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**ABSTRACT**

Poor design scopes and poorly executed design and detailing neither contribute to cost effective life quality building or constructed facilities, nor will it lead to a reduction in either CO2 emissions or material waste. In consequence, it is thought that the construction sector’s goal should now be re-focused, ‘to secure product improvement based upon performance criteria and whole life based designs ‘ in order to secure a more sustainable built environment.

In this a wider context of product as opposed to project management, there is a need for both a common language and a greater transparency of what lies behind decisions made if life designs are to be secured. Yet the nature of the current project work break down domain, is such, that the construction sector's products may be seen as an outcome of a coalition of specialist designers, trade contractors and diverse supply chain with or with out a project manager?

This paper addresses the work undertaken and focuses upon examining service life planning, its review and the validating of the life based design input to securing a sustainable construction. The work also discusses the implications of service life configurations and disassembly-deconstructable construction, life care and the importance of the reference documentation domain.

It is believed, that performance and service life reviews should be developed for key stages of the design and project, some of which could be verified at the same time, or later time, through linking up with performance auditing. Further the new ISO 15686 should be adapted to address both an existing building’s relifing, as well as used in the pursuit of a new life designed construction work. These stages can be extended to anticipate future de-commissioning and dismission responses including, what is seen as important sustainable product developments based upon optimising their service life through dis-assembly. To that end it is believed that a schedule of review reference documents should be drawn up at the start of the project and design life briefing.

Performance and service life reviews may take place at all levels of the design life management process and can also be seen as part of the Project’s product management and process information management domain. Such reviews should there for form part of an established project or design management quality system of the originating office procedures.

Finally, the performance review is seen as an essential part of optimising and securing insurable and re insurable sustainable life designs and must interface with the external audit environment.

**KEYWORDS:**

Design life; Performance review; Reference document.
INTRODUCTION

From observing those processes and reliability engineering developments in electronics, aerospace and other engineered and manufacturing industries one may be encouraged to believe design life products are achievable and deliverable in construction. So as construction is itself a processing activity, and is moving increasingly to a component assembly base, one can consider developing a life based designed constructed works with an associated life care management.

In fact the design of buildings and other constructed works is now entering a new phase, both in meeting sustainable criteria and in development projects sense, whole life thinking. This move is particularly evident through the recent private finance initiatives for procuring projects, where whole life has become an agenda item.

Whole life construction, however, spans across a diverse group of ‘interested’ parties, actors and stakeholders -none of who are brought or meet together at any one point in time. Worse still, in their communication there is not an easily recognised or common language, nor is there a common framework and understanding of whole life and the service life that it addresses.

Nevertheless, service life designs for construction is still in its infancy and has yet to secure a project or design life management status.

Despite these difficulties, the recent publication of two parts of a new International Standard concerned with firstly, service life planning principles (ISO 15686 2000a) and secondly, with performance auditing and review (ISO 15686 2000a) is to be welcome.

Indeed, this new International standard will have other parts added to it and may go some way to encourage ‘whole life and relifing thinking’ in constructed works. In short, this generic standard, ISO 15686 may prove to be a significant contributor to the longer term sustainable and ecological constructed works this century.

It will also provide a common lifeline for those in manufacture, research, design, procurement and supply chain. In addition, it could also bring those in waste stream management, insurance and funding as well as regulatory bodies, to a common point-the service life and design life with all parties working together.

DESIGN LIFE

One is unable with certainty to judge a future design life of a portfolio or constructed works state in today's changing domain of mobility of customers and suppliers. Indeed, information management is gradually re-defining how societies, their organisations and processes and people may live and work.

Likewise, the usefulness of a constructed facility or work depends on its ability to support the primary activities of the owner occupier organisation and end user domains of adding value to the products and services they offer. More over, the building's configuration and space quality must also be able to respond to the way its occupier's activities are linked within society and facility and asset management practices. So what life should be designed or planned for?

At the moment, the project or design team determine either a life period based upon what some have called, ‘whole life cost’ or the brief's building-facility life with some time based criteria of acceptability or performance levels. Nevertheless, such life periods appear to be largely notional and tend to be a ‘blanket value’ for example;

- 30-35 years in Privately Financed Initiatives;
- 60 years in some public sectors design work;
- 20 years or less for some ‘crinkly tin shed’ developments;
- 25-40 years for office developments;
• 120 years for some infrastructure work and bridges
• 200 years say occasionally for a state or national building.

Other life design life periods given tend to be by way of stating a minimum design life period for a building, or component, for example, as suggested in Table 1, of Part 1 ISO 15686. Equally, such stated or specified design lives are not by itself, a rational or guaranteed life. One also needs to address the changing building, planning and environmental regulatory bodies requirements and respond to global warming, rising costs of the component and material supply chain and their future uncertain disposal. Finally there is also that realisation that as buildings and constituent parts have lives so do business and other sector activity.

Determining the right design life period before design work for new constructed facilities is also difficult (Lucchini & Wyatt 2001). So the brief life given, is currently left to general values rather than to a portfolio business sense that does itself always think in terms of performance based serviceability despite an interest in life costs. Yet, the performance life scope provides that degree of freedom necessary and in doing so permitting a fuller review of the building’s own life cycle and environmental damage functions.

There is in fact a conflict with a ‘nobler aim’ of optimising the selection of service life based components and materials chosen with their durability and that of the business goals and approaches to asset and facility management.

Finally, those concerned with design, life cycle assessments and life costing need to develop skills in service life planning in order to secure the design life proposed.

SERVICE LIFE PLANNING

The design life may depend as much upon the performance levels set, as to that life management ownership and portfolio practice that can be delivered. Nevertheless, service life planned and engineered designs will lead to more effective performance and space utilisation, more accurate whole life cost predictions and the opportunity to develop a framework for validating the whole life domain set.

To validate the service life planning process there is a need to identify, schedule and document the reviewing activity in varying levels of formality(Wyatt 2000). Here specific and common outcomes can be set down in a systematic way in the reference document schedule (Annexe One).

Such a schedule can be prepared as part of the service life plan and be agreed with the constructed asset portfolio key holder or owner as the case may be. It then remains for the design life management to play a full and proactive part to develop and secure the whole life design within a performance framework and to help to:

• validate a performance based model for a project scope (Figure 2);
• Identify the whole life and dismission process stages (Annexe One);
• determine the scope of the review and reference documentation;
• develop those whole life and performance skills necessary to design for dis-assembly;
• determine optimum service life profiles for those design configurations in question;
• provide that performance life care thought necessary for the design proposed;
• determine the performance life cycle expected and anticipate it's through life costs in the operability phase;
• establish vigorous life cycle assessment review and audit requirements;
• determine the level of risk as well as using establish tools like failure mode effect analysis.

In fact, as intimated in Figure 1, in service life planning, one is striving to address whole life and life cycle costs, through life performance and its associated conditioned based monitoring. At the same
time to respond to the life cycle assessment of the service life profiles of the buildings elements and systems.

Finally, service life planning may be used to determine the design’s performance, reliability, serviceability and space quality. Likewise, its service life profile, dismission and life care plan ready for validating at the design review or its audit.

PERFORMANCE REVIEWS

In most built facilities, clear relationships exist between performance, reliability and serviceability that are readily demonstrated. But in a service life planning and in particular in use, the life sense, such links inevitably suffer an internal tension. Part of this may be attributed to the fact that the performance levels set, do not, or are not as likely to remain over time.

This point may be illustrated, say in an engineering system or component where as they age, their reliability begins to become questionable. Again, the performance of an internal floor surfaces, external roof coverings, or walling envelopes may fall and be no longer serviceable- i.e. they have reached the end of their practical economic or service life!

In essence, operability variations lead to differing levels of acceptability and complicates a building’s life which may be itself also be subjected to periods of misuse, damage, negligence. Indeed the building life is likely to also see a change of use or some other form of modification, which was not part of the original design. So the terms of reference for a performance review can be wide depending upon what stage of the whole life process one is reviewing (Annexe One)

Performance reviews should be related to those key design process stages as well as for project as a whole and scoped at the relevant work breakdown package? Equally, the design, engineering analysis
and its performance and reliability computation is not easily proof tested. In consequence, performance reviews are seen more than just a reiterative process for each of the principle performance levels set, viz. a viz., lighting, acoustics, thermal and fire etc.

When reviewed the implications of the operability performance levels tailing off as the system or element ages, or the building becomes defective or obsolete should also be flagged up. Finally, dismission and the issue of risk and threat to any proposed recovery or disassembly initiative must also be addressed as service life planning starts to contribute to whole life supply chain management and sustainability. (Lucchini & Wyatt 2001)

Finally, validating the designed life proposal has to be based upon objective evidence made available. So again one must stress review requirements must be clearly defined, for all relevant key product design stages within the organisation or practice responsible.

SERVICE LIFE REVIEW

The performance review relates to the whole operability qualities of the design but the service life review requires a different approach. Here the service life review is seen as important process in validating the sub-systems of any design life's construction break down (Figure 3)

![Service Life Review Diagram](image)

The Key
- DL  Design Life
- SL  Service Life
- PSL Performance for System Life
- RSL Reference Service Life
- FMEA Failure Mode
- SLP Service life profile
- ESL Estimated Service Life

**Figure 2 Service life reviews**

The problems of service life break down arise from the complexity caused by bringing together a wide range of different materials and components. Nevertheless, despite the limitations of service life data each system and element's service live ratios and their implications of failure associated life care and recovery and they're cost implications. can be critique to advantage.
Significant variations will be found in the constructed facilities service life ratios of the respective service life profiles of the buildings systems, elements and components. So until software programmes are developed to help determine and refine the ecopoint assessment, life cycle costs and the life care plans patience is needed so one needs to identify and focus upon key areas first. Where necessary a given profile specification or profile or detail may need reworking and in turn the dismission life care plan changed.

Finally, as part of design development and client sustainability strategy for their future - dis-assembly for re-use stresses the importance of the service life review. It may also encourage work in developing new jointing systems, disassembly work sequences and life care management as well as investment strategies for whole life management

VALIDATION

To assist in the mind set believed necessary, Figure 3 is included to indicate something of the inputs in service life planning whose outputs may require validating.

By identifying both the performance operability points and the reference documentation agreed, one may validate those design life decisions made and have confidence in proposal. This means one must establish a service life review and the audit programme (ISO 15686 2000b). Nevertheless, a problem that remains is that the review points do not always coincide with the completeness of the documentation called for.
It is both the derivation and managing of the service life (i.e. *that period of time after installation which a building or its parts exceeds the performance requirements*) along with the context of Figures 2 & 3 which in effect becomes the validation focus. At the same time, the role and requirements of an insured life needs to be kept under review as this field develops and one may insure for a life selectively to drive out quality and cost defects.

Validating may in fact be seen as having two parts. Firstly, the performance review concerned with operability and availability and relating more to facilities management, Secondly, the service life review of the break down of the design life concept's configuration of elements and system service life profiles where the review relates more to the asset management.

In a sense, whilst Figure 2 captures the inputs and outputs, which impinge directly upon the papers title and intent, the life methodology established, ethos, calculations and interpretation whilst not part of this paper nevertheless should be explicit and their limitations made clear.

Finally, consideration to in life experience and associated problems of fitness for purpose, serviceability provision and the ease of access together with the associated operability impacts should be drawn upon. Indeed feed back is seen as a critical aspect of facility and asset management and will in turn help life designs and ownership costs.

Finally, the validating process is an internal opportunity to share and update the life design development, and life based hand over and user life information through the development of service life planning and the reference document.

**CONCLUSION**

One must acknowledge that design life working has not been a central part of the construction sector. Only recently a few buildings have been life crafted and some lessons and problems understood but this has not become part of an established service life design culture. Nevertheless, like other more sophisticated science technical and engineering based sectors, construction is moving to a life engineered domain where optimisation of performance, material usage and more predictable life cycle costs are welcomed outcomes.

What ever the relative merit and demerits of moving to a design life it is clear that to think in life terms will raise building quality, reduce material waste and set in train a product improvement. In short together with other initiatives particularly in life cycle assessment one could also look forward to improved operability quality and the opportunity to move from demolition and destruction at the end of the service life to one of relifing and recovering.

In fact good service life handling will contribute to future decision making and better management of the supply chain and its constructed works. It will also contribute to a reduction in environmental impact damage and open up a life based open system based component building environment.

Concluding, adopting a design service life profile approach and developing skills in life design and engineering will make a significant contribution to the way we manage our future. Extending this line of commentary one could see a time when in an obsolescence sense, service life profiling would become the basis for optimising life costing and form the basis of component supply chain and an integrated life care management. One that will secure the practical ecopoint optimisation of the supply chain in an ecological friendly that is economic to do so.
REFERENCES


### Annexe One

**Table 1  The Reference Document Schedule**

<table>
<thead>
<tr>
<th>Process state</th>
<th>Review</th>
<th>Reference documentation and-or comments</th>
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</table>
| The Project- Client Briefing   | Brief                   | * Proposed reference document schedules  
* Proposed design life + performance levels  
* Space requirements and delimiters  
* Operability and serviceability conditions  
* Plant and equipment requirements-limits  
* Client based specifications requirements |
| Initial Design                 | Concept                 | * Develop and agree review project reference documentation and programme schedules  
Concept CAD Images and GA Drawings  
* Preliminary plant and equipment and coding for asset inventory and DCMA  
* Preliminary design procurement clusters schedules, CDM -RA  
* Breakdown scope elements systems operational areas  
* Preliminary disassembly proposals  
* Outline cost estimate and wlc  
* Outline eco point score and lca schedule |
| Initial Design                 | Preliminary design      | * Reference document schedule identifying parties and programme timing etc.  
* Schedule of proposed design lives  
* Bar code inbound inventory breakdown  
* Schedule of proposed insured life element systems operational areas |
|                               | life cycle and         | *Service life methodologies and techniques proposed for whole design and operability  
anticipated whole life costs  
* Risk analysis of procurement clusters schedule  
* Target service life for design and construction work packages |
|                               | Life method and tools   |                                                                                                                                                                         |
| Initial Design                 | Construction            | *Construction and deconstruction method evaluation and approach for recovery including service life access appraisal  
Deconstruction methods           |                                                                                                                                                                         |
|                               | Work break down Packages| *Schedule of TSL, SLP for the cluster group, codes and dependability delimiters  
Schedule of interface constraints  
* Schedule for the interval for servicing relifing  
* Imaging of bar code inbound identification  
* Evaluation for access needs over time, protection and conditions for operability  
* Serving conflict schedule incl. CDM -RA |
| Initial Design                 | Service life profiling  | *LCA and LCC Ecopoint centres and spread sheet computation  
Inventory break down System, Elements, Component Schedules and list of Plant and Equipment with assigned SLP  
* Serviceability life care requirements  
* Life care interval requirements  
* FMEA for critical areas and systems and components  
* Relifing options appraisal incl. CDM-RA  
* Recovery options and net gain for WLC  
* Performance and reliability reviews  
* Procurement and bar coding inventory review |
<table>
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<tr>
<th>Detailed design</th>
<th>Cluster interface and ESL SL life proposed</th>
<th>Detailed design</th>
<th>Whole life cost</th>
<th>Detailed design</th>
<th>Drawings and specification</th>
<th>Construction Execution</th>
<th>Project construction management and Work package and cluster group</th>
<th>Construction</th>
<th>Commissioning</th>
<th>Commissioning and Hand over</th>
<th>Life care</th>
<th>Post product</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>*Reference document schedules</td>
<td></td>
<td>*Performance validation summary review</td>
<td>*Detailed critique of cluster and details in all WB Packages, RA-CDM and their programme</td>
<td>*Commissioning Sequence and Programme As built Ref. documents</td>
<td>*Performance and setting to balancing values</td>
<td>*Post commissioning systems balancing adjustments schedule and CAR</td>
<td>*Review Repose To The Preliminary Design and Upgrade Of Documentation</td>
<td>*Review of supply chain evaluation and ecopoint</td>
<td>*Check Of All Detail Drawing And Specification and programme</td>
<td>*Performance and help desk and servicing manuals</td>
<td>*Post commissioning systems balancing adjustments schedule and CAR</td>
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<tr>
<td>Life care</td>
<td>Relifting</td>
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|           | •Life care programme with periodic reviews of dismission options for upgrading performance levels including relifting e.g. new fit out, replacement systems.  
|           | •All changes to become part of the WLCA and WLC Monitoring |

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<tr>
<th>Dismission</th>
<th>Recovery Programme</th>
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|            | *Performance-reliability and serviceability as built surveys, review of life design *Notifications and in service logs  
|            | *Response to upgrade-relifting and dismission options and recovery *Eco point LCA and service life and SL profile evaluation with recoverable relifting options  
|            | *MTTR, MTTF Obsolescence and risk reviews  
|            | *Up-down stream service life eco point routes  
|            | *Inventory of supply chains service life profile and dismission routes |

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<th>Deconstruction</th>
<th>Removal and site reinstatement</th>
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|                | *Dis-assembly Ecopoint SLP Programme  
|                | Sequence for fit out components systems- elements  
|                | *DCMA and design documentation-instructions incl. CDM and RA  
|                | *Service life bar code relife schedule  
|                | *Return to sender obligations |

Footnotes

i The reference documents (RD) may be defined as

" The formal review document or documents provided for performance and service life review or auditing purposes that demonstrate those responses to the performance scope of the project brief given has been'  

ii One aspect of the reference documentation is that it could assist in the project planning and procurement focus on whole life and its management whilst addressing sustainable initiatives to benefit. The RD mapping would be the recognition of the information base needs and requirements and those reference document that may be necessary to both review and or audit the design life and its outcomes.