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Maintainability

What is it?
Do we have it?
Does it matter?

What is it?

I tend to be somewhat simple minded here and define maintainability as the choice, design and construction of an asset so that it can be easily, safely and cost effectively maintained.

In this issue **Greg Williams, of Transfield Worley Solutions** takes a more in-depth look at what constitutes maintainability. Greg has a background in aviation.

Do we have it?

Ami Sudjiman-Spinks of Strategic Facility Service PL suggests 'probably not'. She calls on her considerable experience in the building industry.

Does it matter?

In a world of disposable technology, we might say it doesn't matter, but is this true? To explore this issue a bit further I spoke with **Malcolm Winterburn with Infraco SSL**, one of the new companies formed to manage the London Underground Infrastructure and Rolling Stock.

How can we get it?
In Issue 82 we will consider what asset managers can do to improve maintainability

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Maintainability from a Plant Perspective

Maintainability is the result of the trade-of between up-front design costs and lifetime operation and maintenance costs.

Skimp on the first and pay for it with the last.

MAINTAINABILITY - WHAT IS IT?

BY GREG WILLIAMS, TRANSFIELD-WORLEY

Maintainability is the significance of a loss of system availability in terms of maintenance and repair activities. It is a time-based indicator used to measure the adequacy of design and the support organisation, as a function of the time taken to return a system to a serviceable state. It is therefore a measure of system efficiency.

Maintainability is concerned with simple, pragmatic approaches to reducing life cycle costs by considering how equipment is accessed and by whom, the ease of handling, and the affects of improved teamwork.

The assessment of maintainability normally entails consideration of a series of questions, designed to quantify elapsed times for discrete tasks in a series of activities. The answers may be expressed in terms of averages and may be entirely subjective in terms of the description of the task requirements. Maintainability is not an exact science, although some analysis is conducted. It is the pragmatic application of subject matter expertise and quantifiable assumptions to identify the most efficient way of completing a maintenance task.

Maintainability and the Human-Machine Interface

- Maintainability concerns the interface between the human system and the physical system.—can you reach the area to be maintained?
- Maintainability concerns ergonomics in a maintenance environment. - can you lift whatever needs to be lifted without back damage?.

Maintainability and Organisations

- Maintainability concerns *organisational* design—are the processes in place to ensure the task gets done in a timely and efficient manner?
- Maintainability concerns the efficiency of the support infrastructure. - how long does it take to deliver that spare or find that tool?

Maintainability and Equipment Design

- Maintainability concerns detail design—for assets that potentially have a long life span, e.g. a major road, can any shorter-wearing elements be easily accessed and renewed? Is the optimum point for intervention readily determinable? (The point in the asset life cycle where the level of asset maintainability can be significantly enhanced is during detail design. It's often too late after manufacture or construction; the maintainability has been built in, and only minor modifications can be made to gain small improvements. For example, if consideration of access to buried pipes for internal inspection is only made after the pipeline is laid, it is too late to modify the asset or the construction technique. .

Where maintainability has been well developed.

In the Defence and Aerospace industries, the analysis of maintainability has developed to be a rigorous engineering technique against which the adequacy of design is measured. In fact, the Department of Defence contracts for maintainability, generally at the system level. Operators and maintainers of defence and aerospace assets necessarily link the assessment of maintainability to design approval and acceptance. In many cases, maintainability maybe the primary acceptance criteria.

For example, equipment located in confined spaces may be the critical driver in determining the availability of a system. In aeroplanes, equipment that is critical to a mission, be it ferrying passengers or hunting submarines, must be relatively easy to remove and replace to return the aircraft to a serviceable state in the minimum time. This fundamental requirement drives the design of engines as modular units, able to be changed and tested within a matter of hours.

Where down-time costs serious money (eg manufacturing or aircraft maintenance) the value of lost time is usually the parameter that is to be managed rather than the cost of maintenance itself.

Is this true of other areas, eg property management?

See the next article that focuses on property.

Equally, the means by which equipment is removed or replaced is a significant factor and directly impacts design. In one recent example, the specifications for the mean time to repair the total system, in this case a helicopter, were so tight that the installation design had to be revisited before the customer would accept the product. The main problem was that the options for locating an avionics black box in a military helicopter were limited, to the extent that it's final orientation had to be rotated ninety-degree and flipped to obtain a reduction in the removal time of less than one minute. In another example, an installation design for a large heavy unit was revised to accommodate a handle position just 2 cm higher than the original and the re-routing of a wire bundle, to allow easer handling. In this case, the weight of the unit was rather high and removal by a female had to be accounted for by improving the ergonomics of the removal routine. Design standards still discriminate between men and women where strength is a factor in the maintenance action.

Maintainability and Life Cycle Costs

Maintainability concerns trade-offs between the desired and the affordable states for optimum maintenance and support of an asset. If not properly addressed at key stages in the design, commissioning and upgrade of physical assets, maintenance becomes a significant driver of life cycle costs. Small investments in up-front design can definitely result in a reduction of life cycle costs.

Maintainability from a building perspective

What are the concerns at the design, documentation and construction stage?

MAINTAINABILITY—DO WE HAVE IT?

BY AMI SUDJIMAN-SPINKS, STRATEGIC FACILITIY SYSTEMS PTY LTD

Probably not! Here are some of the things that happen 'out there, on site'.

- **Users left out from the design stage**

Early in the design stage, the designers will discuss the concept and idea for the building with representatives of the owner or the users. However, these representatives are not always the ones who will finally occupy the building, nor will they necessarily forward the concept to the future occupiers of the building. The building users are usually the last group to be notified on what they can expect to have in the building.

- **Builder not notified of the original concept or intent of the design**

The builder is usually expected to price and construct the building based on drawings provided, with detailed instructions on how certain things need to be constructed. However, there is very little briefing on the original concept and ideas behind the design itself, so that builders often do not appreciate the design intend or even able to share the vision of the design.

- **Designers chose very special fitting or equipment, which are difficult to maintain**

Particularly for buildings claiming to have the latest use of technology or trend of design features, the designers often choose to use very special type of fitting or model of equipment, for which

  - operating performance is unknown;
  - maintenance requirements are not fully understood;
  - spare parts are difficult/expensive to find (e.g.only available overseas); and
  - no local supplier or organisation is available to maintain or work on it.

- **Users found problems occupying or operating the building**

Consequently, builders often construct the building based on *their interpretation* of the design concept, which by now may be completely different from what the (representatives of the) users originally had requested to have. Any concept of operationability originally discussed between the users and the designers is often lost.

- **Designers opted for styles of design or method of construction that create maintenance problems**
  - Current trend for using flat flush ceiling provides no indication of the exact location nor provision to access the air conditioning equipment installed behind the ceiling.
  - Having tall ceilings or eaves that there is no way of reaching the light fitting and replace the globes.
  - Using many different types of light fittings and consequently light bulbs, each with different life spans. This creates logistic problem of storing spare bulbs and identifying the types. One building has 65 different light fittings throughout.

- Poor detailing of the gap between the treads and the glass panel for a set of concrete stairs and glass balustrades. The gap is wide enough to allow dirty water to enter whilst the cleaner mop the stairs, but not wide enough for rags to clean the stains.

- Tall timber wall panelling that no-one can reach the top of the panels to regularly maintain them to prevent them from drying and splitting.

- Creating roof gardens or patio that constantly leak.

- Having atriums that allow too much sun, causing problems with air conditioning load, glare and fading of finishes and furnishings. The glare often also cause reflections along the floor tiles, showing the portions that the cleaner missed when they last mop the floor.

- The off form concrete finish of the 80s tend to attract dust, grime and marks, making them appear darker over the years, and finally have to be painted, and repainted regularly.

- Designing garden beds directly alongside the building perimeter which does not have its own Building Maintenance Unit to clean windows etc. There is no way for cherry pickers or similar equipment to move close enough to the building to clean or repair windows.

- ***Designers specify awkward position of fittings - hotels***
  - Tight shower recesses with taps located at the far end, risking hands to be burnt by hot water whilst trying to turn the taps on.
  - Positioning toilet paper holder too close to the WC pan
  - Having short mixed water spout in shallow basin, that the kettle cannot fit under.

With building air conditioning, by the time owners specify fancy types of system, they run out of money just prior to completing the installation. They usually cancel the automatic control mechanisms of the system, and opt for the manual operation. However, the manual operation does not have the fine tuning capability that is often demanded during occupancy.

Design Problems may be exacerbated by

Inappropriate Cost Cutting

- ***Desktop Commissioning of the Building***

The builder and installer will provide certificates that all equipment have been appropriately commissioned to be installed correctly. The commissioning process is usually conducted as a desktop process, as the equipment are often never commissioned operationally. *That is no one actually tests how the equipment perform to their full capacity, and in conjunction with other equipment in the building.*

Maintainability Problems experienced at Building Completion time

- ***Users left with no Drawings, Manuals or Instructions from installers***

The builder or installers will usually leave the building without leaving any As Built Drawings, Operations and Maintenance Manual or any relevant instructions behind. The users will move in, occupy the building, and then try to learn how the building operates. The users will engage someone to maintain the building and expect them to know how the building equipment operates and what maintenance tasks are required to keep them operating. The users often become frustrated with the way things are installed or built, particularly if the users were not party to the design process.

- ***Shared occupancy, who pays for the common areas?***

When the power is connected, there are often opportunities to commercially arrange for the power distribution amongst the occupants of a multi tenanted building. There is no guarantee that each tenant is paying for their respective power and lighting allocation. Power connected to the lifts, foyer lighting and similar commonly consumed areas are often 'slipped' into the various tenants' power distribution boards.

- ***Allocating Maintenance Responsibility***

Who should pay for maintenance of equipment? As with the management of risk, costs are best minimised by allocating responsibility for them to those who can manage them best. This is generally the user! Yet it is common practice for the maintenance costs of general purpose equipment to be picked up by the building owner and then passed on to the tenant in rent. This does not give anyone any incentive to manage these costs down.

Maintainability Problems Discovered Upon Occupancy

- ***Access to conduct Maintenance tasks***

There are organisations who have tight security measures and will not allow outsiders to enter their work area easily. They often resent providing any access for maintenance, especially if it involves temporarily disconnecting existing services. However, this type of organisation will also be the type who require certain level of performance of their building air conditioning, and will not tolerate poor performing equipment.. Access to conduct maintenance tasks in these type of areas need to be negotiated early.

- ***Use of Incompatible Items in Replacement and upgrade***

This tends to cure the immediate problem, but causes imbalance to the rest of the system.

SOLUTIONS?

What can be done to overcome these problems and so reduce the life cycle costs of building assets?

Send your ideas to <info@amqi.com'> if you would like them to appear in our next maintainability issue in a few weeks time.

Maintainability from the Perspective of Integrated infrastructure

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The London Underground

MAINTAINABILITY—DOES IT MATTER?

BY MALCOLM WINTERBURN, INFRACO SSL

- **Need for a continuing service**

A major difference between managing buildings and infrastructure such as rail is the requirement to provide a continuing service. For buildings we can decant personnel onto other floors or even into other buildings while the renovation is underway. For London Underground Ltd (LUL) we need to continue the service whilst renewing and closure is a rare opportunity

LUL are confined to doing much of the track based maintenance between 1-4 am. The set-up costs, night rates and the need to pay a full shift for just a few hours of productive work is very expensive. Maintainability certainly matters.

New York uses its double track in places to create a 24 hour railway but the London underground has no space to do this where there is the greatest need to do so, in the central area. Bi-directional signalling ((whereby trains can go in both directions on the same section of track) has been suggested But the trade-offs and the cost of the potential complexities have not y et been fully analysed.

If track maintainability is such an issue, why isn't it more mechanised?

- watch for more on this when we tackle how maintainability can be improved in Issue 83.

These are examples of creating a sort of redundancy to increase maintainability, but they inevitably raise the cost question.

- **Does Maintainability Pay?**

If we put money into maintainability will we get a return? What are the trade-offs between first cost and operational cost?

London Underground has been moving to a knowledge based regime where the old traditions of reliability, simplicity and cost reduction from strongly in-house influenced designs are being replaced by knowledgeable suppliers working to performance specifications including maintainability.

Gut feeling is one thing, obtaining sufficient and reliable knowledge to justify a business case across organizational boundaries is another

Indications are that in some cases you can have your cake and eat it—or almost. Fitting signalling equipment on the tunnel wall rather than under the 4th power in the centre of the track we have on London Underground reduces not only its first cost; it vastly improves the ease of maintenance and saves vital minutes should it ever fail.

- **Factoring in the Customers**

Perhaps surprisingly, the passengers will be just as interested in maintainability. When it comes to those response times to failures, maintainability will get them on their way in half the time—or perhaps better.

The Cost of Delay

London Underground measures the cost of customer delays and has found that the loss is in proportion to the square of the duration

- every reason to get response times and maintainability right

That same need to rapidly respond to failure, so critical in rapid transit, has led to increased automatic fault diagnosis—another strong factor dramatically improving maintainability. The most recent rolling stock has the capability of automatically sending information from on-board back to the depot so that parts can be ready to exchange on arrival of the train—at the same time minimizing downtime costs and increasing asset utilization.

The customer needs don't always work so happily in concert with the driver to improve maintainability. There is ever increasing demand for more information, increasing complexity, increasing cost, and making the packaging of equipment and access that much more difficult in the restricted space of the Underground.

- **Maintenance and Design**

Maintenance knowledge for life cycle management does not happen by chance; it must be adopted as a planned purpose. It is difficult to change once the asset is designed.

Designing in Maintainability

Interchangeable parts can make for good maintainability. Care must be taken though with safety critical systems and detachable parts—to ensure that *dissimilar* parts are *not* interchangeable.

M8 bolts can too readily be fitted instead of the imperial 3/8—only to come out in service.

When cameras on platforms were introduced to monitor door closures from the train cab, their proximity to the track prevented maintenance other than during the small hours. More recent designs have fitted cameras on booms which allow them to be swung down, out of harm's way and to allow 'on the spot' unit change with virtually no disruption to the customer service.

On the other hand inaccessible critical drive shafts on escalators have recently led to months of widespread downtime, literally—a feature avoidable at the design stage.

Modernisation of the stations has benefited from the experience of a knowledgeable maintenance engineer who understood what needed to be done to reduce graffiti and reduce cleaning costs. Requirements, for example, for enamel surfaces at low level, have been introduced into refurbishment specifications. These are challenged however by architectural demands for what are seen as agreeable contemporary materials and surface finishes, which may not have the practical durability, creating real business tensions.

- **Maintainer/Designer Dialogue**

Quality standards call for feedback from user to designer, in practice the designer is not heavily incentivised to obtain that experience, and there can be many organizational blocks in his way

—but more about that in the next edition!