Obsolescence Management

As part of managing the lifecycle

About the Author

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1. INTRODUCTION

Lifecycle Management may look at a number of factors; availability of products, manufacturing lifecycles, costs associated to maintenance & replacements and requirements for the products use. There are also related factors such as; its lifecycle (service/operating life), available products in the commercial market and the approach to designing a through life solution taking in to account technology roadmaps and evolution.

This paper looks to outline issues and recommendations to manage them as part of; Lifecycle Planning, Technology for Life, Design for Life and Whole Life Value. For the purpose of this paper, there is an assumption that everything at some stage or another will become obsolete. The term 'product' will be used a number of times, and for the purpose of this paper a 'product' is defined as any commodity that can be bought or sold (and may be inferred as an 'asset' depending upon the operator or user).

2. LIFECYCLE PLANNING

Lifecycle planning, within the realms of obsolescence management is the activity taken to identify the likely point of obsolescence, by reviewing specifically for the product its; availability, manufacturing lifecycle and its popularity (or share) in the commercial market. This will be looked at in more detail in sections 2.1 to 2.3.

2.1. Availability

There are a number of ways that availability is identified, this paper will not look at comparing these. The following have been summarised as to how this can be identified:

- Known – The manufacturer has issued a definitive statement as to their products availability or remaining availability.
- Forecasted – The manufacturer has given an indication of how much longer they may manufacture (or support) the product for (typically because of sales and demand).
- Predicted – An algorithm using various data provides a possible (or likely) date the product may become obsolete.

So, what could be the possible issues with these ways of identifying a product's End of Life (EOL)? For those having managed or dealt with obsolescence the list is long, I however have chosen the following two:

- Uncontrollable influences – There are influences outside of a manufacturer's control that affect manufacture and sales of their product(s). Manufacturers may give a date (known or forecasted) as to the planned EOL but if the product; suddenly goes out of favour, there becomes an issue with manufacturing (i.e. result of legislation or shortage of resources) or an increase in failures, that date can shift to the left very quickly, the Samsung Galaxy Note 7 is one example of this.

- Accuracy of data – Any data used is only as good as when it was entered and the accuracy of it at the time of entry. We can proceed on the knowledge that some data results will be infinite or near infinite (e.g. availability of a pocket whistle) but the medium of that product is not. I would suggest that the same can be applied (to a certain degree) to a number of products in that the technology remains (or improves) but the medium is obsoleted (e.g. computer monitors, changed from Cathode Ray Tube (CRT) to Liquid-Crystal Display (LCD)).

How do we approach these issues? It is not as simple as saying everything is either black or white so I will choose grey as the answer. It is more about understanding what drives the availability, what influences the changes in availability and being aware of when you need to act. Close relationships with the supply chain can help to mitigate these problems as the end user can be many layers removed from where the issues arises from.

Those responsible for product selection as part of the design will typically adopt those items already in the market place and readily available, some may be newly introduced but the majority will be mature products and sometimes at the peak of their manufacturing lifecycle. Suppliers (and manufacturers) know the products and are best suited for advising on product selection and remaining availability.

2.2. Product Lifecycle

A product may be anything from a; material, mechanical item, liquid, electrical or electronic item. Remember that obsolescence affects everything not just electronics. I have decided to look at three main types of product classes, I will explain in section 2.4 why I have not chosen to look at assemblies or systems, the 3 products classes are;

- Component – A constituent material used in the manufacture of an item (e.g. silicon) or an item used within a part (e.g. processor used on a control board).

- Part – An item that is either whole (e.g. cog wheel) or comprises of components (e.g. switch) to carry out a function.

- Software (including Hardware Description Language (HDL)) – Instructions, codes and other operating information used to perform a task.

As already mentioned some technologies can have a long life but the actual product that uses the technology does not. Component materials are not infinite in their sources and without conducting reclamation activities during disposal of unwanted products they will continue towards obsolescence at an increased pace. The end user generally does not have the capability to reclaim materials but they can put policies in place that support a ‘Circular Economy’ and will help slow the approach to the cliff edge future generations currently face.

Electronic components are seen as the more commonly occurring problem for obsolescence, caused by a number of reasons but mostly associated to market demand and competition (for the next technology generation). As equipment’s operating lives continue to be extended, the availability of the original components and even equivalent components reduces to the point of being unavailable. Though alternatives may exist, the cost to implement varies depending upon the level of technological complexity of the equipment (including the differences between the original and replacement) and any safety or critical functions it is responsible for.

The typical trend of a product lifecycle includes; Introduction, Growth, Maturity, Decline, Phase-Out and Obsolescence as shown in Figure 1. Depending upon the technology, the ‘time’ could be one or two years, or ten years or more and the resulting curve in the peak in the maturity will then be more mountain for short and hill top for longer. An example being that though a product has reached its maturity it could sit at that peak for 5 years or longer if the technology is stable and slow to evolve and its forecasted demand is constant, see Figure 2 for an example view.

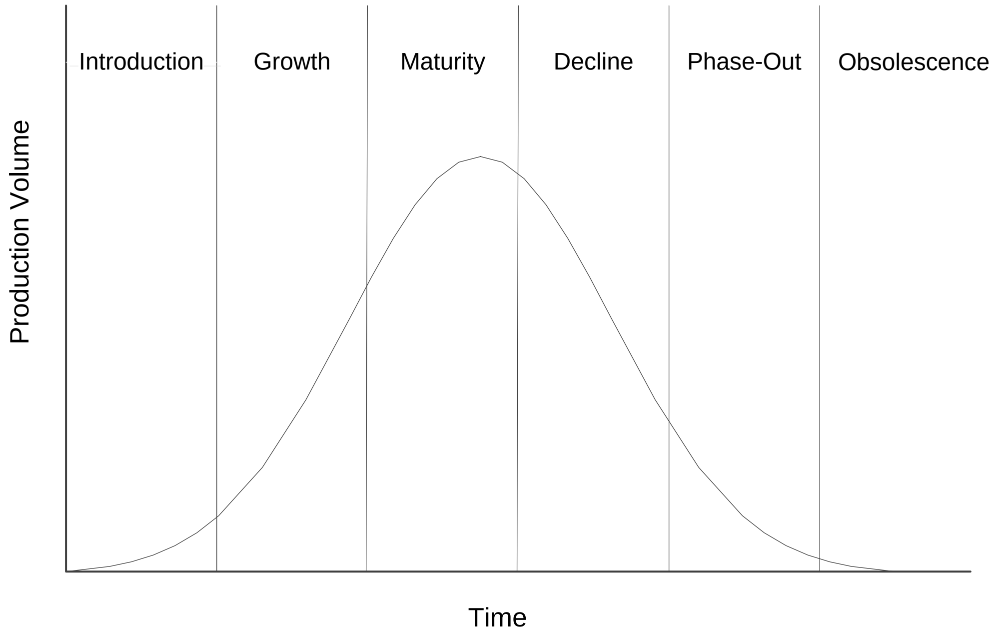


Figure 1: Example of a Product Lifecycle

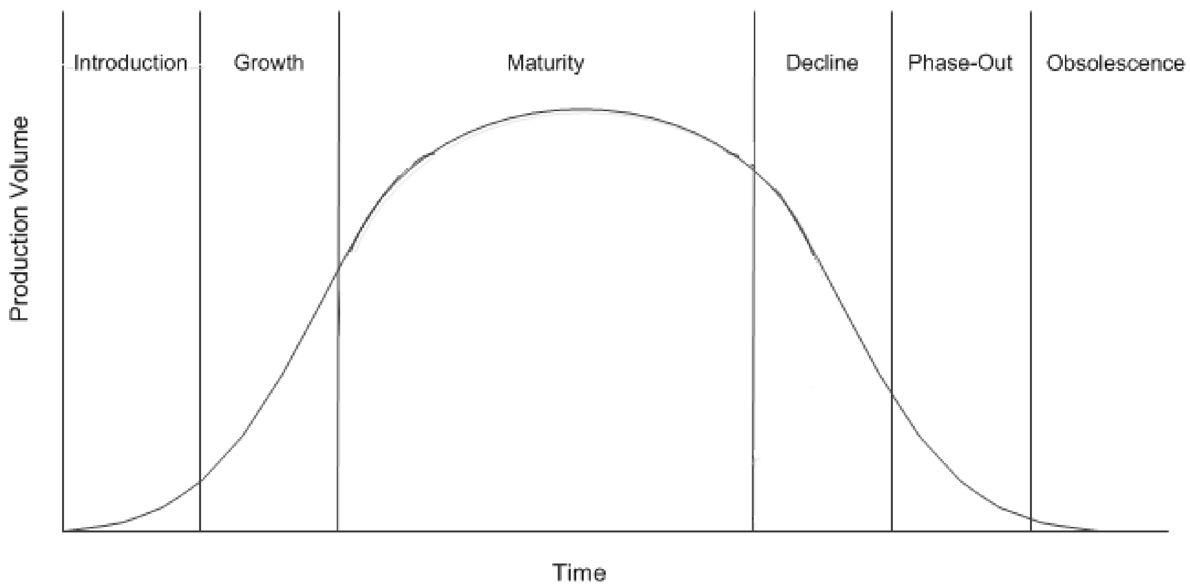


Figure 2: Example of an Extended Maturity Lifecycle

Personally, software is quite likely the most unquantifiable risk and in my opinion, there is a misnomer that software does not become obsolete. This has come about due to individuals believing that as long as they hold a copy of the software (either hard or soft copy) that it is still available and not a problem. There are a number of issues I believe that affect software obsolescence, and I will quickly cover them here:

- Obsolete – No longer made by the original manufacturer.
- Not supported – No longer supported by the original manufacturer, third parties or internally by the user (see also people obsolescence).
- Associated hardware obsolete – Any hardware needed to load, programme and/or operate the software is no longer available.
- Associated software obsolete – Any software needed for the associated hardware to be operated, or to conduct its function is no longer available.
- People obsolescence – The knowledge (and skill) associated to using (including the modification of) the software (and/or hardware) is no longer retained by the user (or other individuals, including the manufacturer).

All these affect the products lifecycle, the product being anything that is using a component, and/or part, and/or software. The user does not have much influence over a products lifecycle no matter how much money they are willing to spend! However, where users have selected products to support their own lifecycle requirements and forecasted their own demands for the life of the product and communicated that to the manufacturer (either component, part or system manufacturer including integrators) then the manufacturer can better plan their own manufacturing demands that may better support the user.

There are three other elements I believe that affect a products lifecycle that will be described in section 2.3, these are; demand, competition and value of the market share.

2.3. Commercial Market

We use the term 'commercial market' as if it applies to every product that can be sold, there are a number of definitions that exist but in its simplest form the commercial market provides a place to sell products (including services) to individuals, public and private companies but not to government agencies (source www.pcmag.com/encyclopedia).

Before discussing the three elements that affects a products lifecycle it is worth identifying the typical sources, which will be described further in section 3.1, these are:

- Original Component Manufacturer (OCM) – The manufacturer of the constituent material used in the manufacture of an item (e.g. silicon) or an item used within a part (e.g. processor used on a control board). Typically large production volume.

- Original Equipment Manufacturer (OEM) – The manufacturer of an item that is either whole (e.g. cog wheel) or comprises of components (e.g. switch) to carry out a function. Typically large production volume.

- Integrator – A supplier who integrates components and parts to form assemblies and/or systems (e.g. computer based control system). Depending upon the type of product this can be small to large production volume.

- Specialist – A company who offers a bespoke service due to requirements that would not interest an OCM or OEM (e.g. moulds & dies, Application Specific Integrated Circuits (ASICs) or aftermarket manufacture (AM)). Typically small production volume (or large one-off production volumes).

These sources are all affected by the commercial market economy and specifically:

- Legislation & Regulations – Restriction of Hazardous Substances (RoHS), Registration Evaluation Authorisation & restriction of Chemicals (REACH), International Traffic in Arms Regulation (ITAR) & Export Administration Regulations (EAR), international, national and supra-national laws and rules that impact on the manufacture and sale of goods (and services).

- Demand & Competition:

    - Demand – Past, present and future demands for the product impact the lifecycle. If previous similar products have been a success and there is interest in the new or next generation of a product, manufacturers will build to that demand including taking a risk on forecasted/predicted demand.

    - Competition – If two or more manufacturers are making the same or similar products then competition over prices, additional novel features offered or takeovers can ensure.

- Value of the Market Share – How companies dominate the market can influence whether they remain, look to offer new and improved products or drop products. Table 1 presents a view of the market share of units sold by the major phone brands (source www.counterpointresearch.com), however this does not show the income from sales. Quantity alone does not derive dominance and a company's value can also be determined by their share price.

Table 1: Mobile Phone Market Share

Global Smartphone Shipments Market Share (%)													
Brands	**2018 Q1**	**2018 Q2**	**2018 Q3**	**2018 Q4**	**2019 Q1**	**2019 Q2**	**2019 Q3**	**2019 Q4**	**2020 Q1**	**2020 Q2**	**2020 Q3**	**2020 Q4**	**2021 Q1**
Samsung	22%	19%	19%	18%	21%	21%	21%	18%	20%	20%	22%	16%	22%
Apple	14%	11%	12%	17%	12%	10%	12%	18%	14%	14%	11%	21%	17%
Xiaomi	8%	9%	9%	6%	8%	9%	8%	8%	10%	10%	13%	11%	14%
OPPO	7%	8%	9%	8%	8%	9%	9%	8%	8%	9%	8%	9%	11%
vivo	5%	7%	8%	7%	7%	8%	8%	8%	7%	8%	8%	8%	10%
Huawei	11%	15%	14%	15%	17%	16%	18%	14%	17%	20%	14%	8%	4%
realme	–	–	–	–	1%	1%	3%	2%	2%	2%	4%	4%	4%
Others	33%	31%	29%	29%	26%	26%	21%	24%	22%	17%	20%	23%	18%

These three sources are inter-related, examples being; breakdowns in international relations resulting in trade restrictions (ITAR/EAR) or tariff's, dumping of products on the market where loss is subsidised by governments, or brand dissatisfaction either as a result of a failure or poor customer management.

By not monitoring the commercial market closely and its changes, some of which can be foreseen (i.e. rise of the electric car and autonomous technology) then reacting to the changes leaves companies behind the curve struggling to catch up, let alone keep up and in some cases resulting in their collapse and/or takeover.

2.4. Lifecycle Relation Summary

Applying lifecycle planning from products to 'assemblies and systems' would need to take into account any modularity (or upgradeability) that has been designed in, see sections 3 and 4 for further details. As much as products will have an expected lifespan, an assembly or system will move left or right of an envisaged end of life date as the products used within them are maintained and replaced (or not). An example being a car, there are a number of historical cars in use today, specialist companies provide original stock (reclaimed from scrapped cars), replacements for obsolete parts with modern alternatives and refurbishment capabilities all of which impact on the lifespan. It is recommended that lifecycle planning with respect to an assembly or system is conducted against the products contained within them and then mapped to the assembly and/or system as necessary.

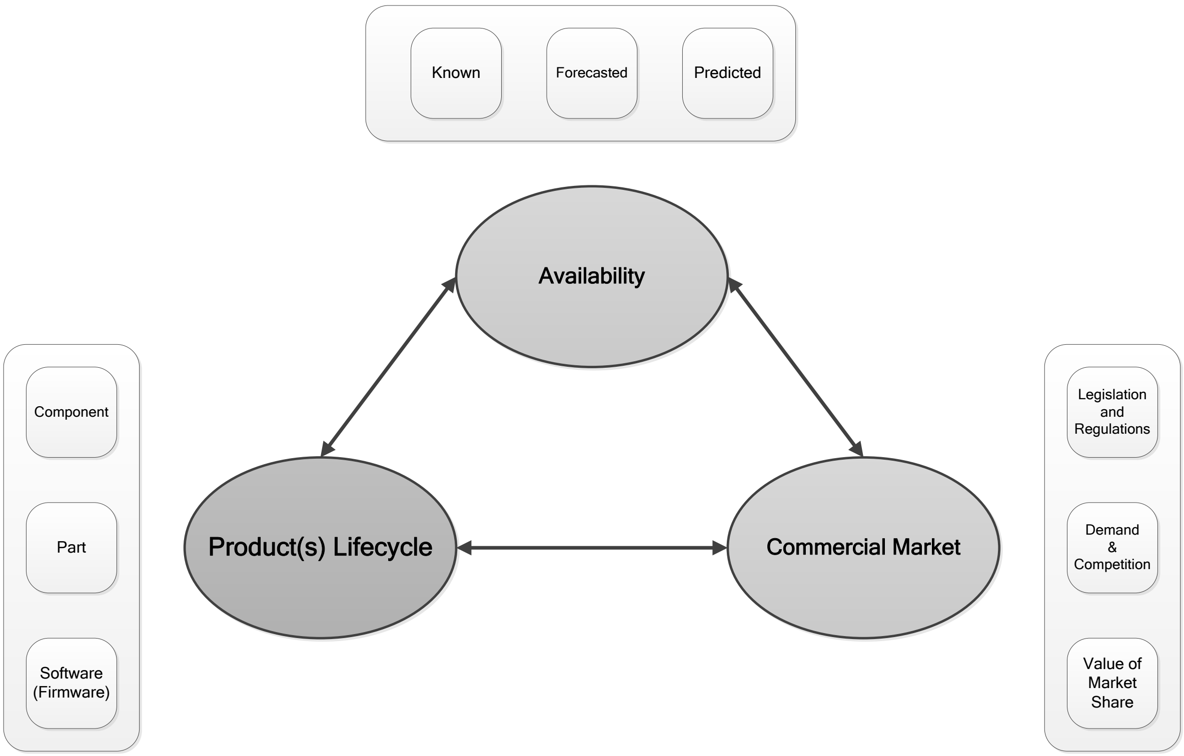


Figure 3: Lifecycle Relation

Figure 3 presents a view of the lifecycle relation and how each of the three parts are interlinked. This can be best summarised as follows:

i. Product Lifecycle & Commercial Market – The life of the product is impacted by its position in the market.

ii. Commercial Market & Availability – Availability of the product (from original manufacturer or authorised channels) is impacted in changes to the market.

iii. Product Lifecycle & Availability – Manufacturing lifecycle (including alternating production runs) of the product (by the original manufacturer) affects its availability.

Applying a calculative method against this triplet would identify those products requiring priority planning.

In conclusion, reviewing just one aspect of a products lifecycle or the factors that affect that aspect will not identify all of the causes of the change to the lifecycle nor where it will impact in the products life.

Availability, Reliability & Maintainability (ARM) will be discussed in section 5, which will look at optimising the resolution point in the lifecycle.

2.5. Lifecycle Planning Recommendation

It is recommended that when conducting 'Lifecycle Planning' that a products lifecycle, its place in the commercial market, and its remaining availability are assessed together and not as unrelated factors. All three are interlinked with both the products lifecycle and commercial market having a direct impact on a products availability.

By having an understanding of those factors will enable individuals to better select technology (section 3) that supports the design (section 4) so that the lifecycle can be managed from 'cradle to grave'.

3. TECHNOLOGY FOR LIFE

As mentioned in section 2.2, technology can have a long life though the product (or its medium) may not. The introduction of the wheel over 5,000 years ago may have been seen as a technological breakthrough at the time though the similarity with the modern day wheel (and its manufacture) is completely different. Over those 5,000 years, the various types of wheels that have existed have been made obsolete though the originating concept or technology has remained.

Over the last 100 years we have seen advancements in technology that have been faster than the previous 1,000 years which is why the impact of obsolescence has been far greater this last century than in the millennium that preceded it. Sections 3.1 to 3.3 will look at factors to be considered when selecting technology (and its medium) to meet the design (requirements) life.

3.1. Commercial Market

Section 2.3 introduced OCM, OEM, Integrator and Specialist sources (or manufacturers) and how these are affected in the commercial market as part of lifecycle planning. When assessing what the future (or likely) lifecycle of items are, there are changes in the market that should be reviewed prior to the selection of a product, these are; the theory of 'Moore's Law', Evolution and Revolution. I have marked in Table 2 where I believe that these impact on the different types of sources of products/items and will explain why in the following points.

Table 2: Link between Technology Changes and Manufacturing Sources

	OCM	OEM	Integrator	Specialist
Moore's Law	√	√	√	√
Evolution	√	√	√	√
Revolution			√	√

- **Moore's Law** – In its simplest term the law (or observation) states, "that processor speeds, or overall processing power for computers will double every two years" (www.mooreslaw.org). There is a demand from users for technology to be easier to use and provide more functionality, but not increasing the size of the product it is delivered by. Elements of this have been achieved where a GPU sits within a CPU package providing dual function without increasing the overall footprint. This is associated to evolution in that there is a general expectation that technology will improve over time.

- **Evolution** – There are number of reasons why technology evolves, I have generalised them as a result of:

  ○ fixing the original or predecessors faults, and

  ○ identifying opportunities for improvement.

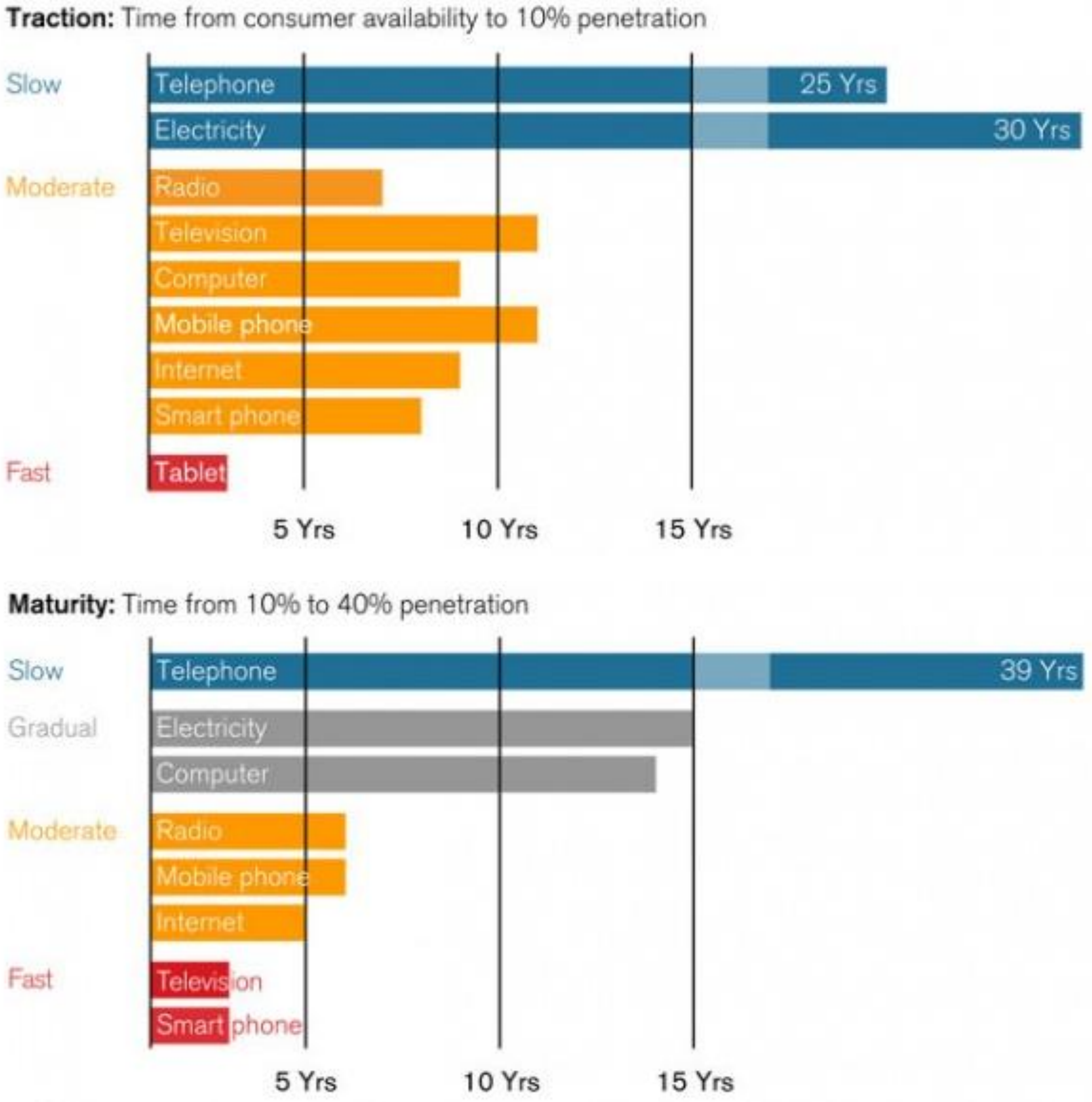
  Though it could be argued fault fixing is not providing an evolution change it is ensuring it is not replicated within the next product and additionally provides an opportunity to improve upon the previous products capabilities.

- **Revolution** – Nick Bostrom wrote, "*we might define a technological revolution as a dramatic change brought about relatively quickly by the introduction of some new technology*". We are currently in the "information and telecommunications" revolution where we have seen some dramatic changes, memory and mobile phones are two that spring to mind, both have obsoleted their respective predecessor within a few years of the introduced change and they are still seeing significant advancements.

The commercial market responds to these changes by adopting the newest and latest technologies available, driven by competition between manufacturers but also by user demand. Figure 4 presents a view of the technology adoption by users, though some appear to be stable, aspects of their technology are broken out which can be mapped to advances in technology (tablets from computers and smart phones from mobile phones).

U.S. Technology Adoption Rates

U.S. market penetration for nine technologies shows the speed at which they gained traction, reached maturity, and achieved saturation. Data through 2010.



Tablets are omitted, having achieved the 10% traction threshold in 2011.

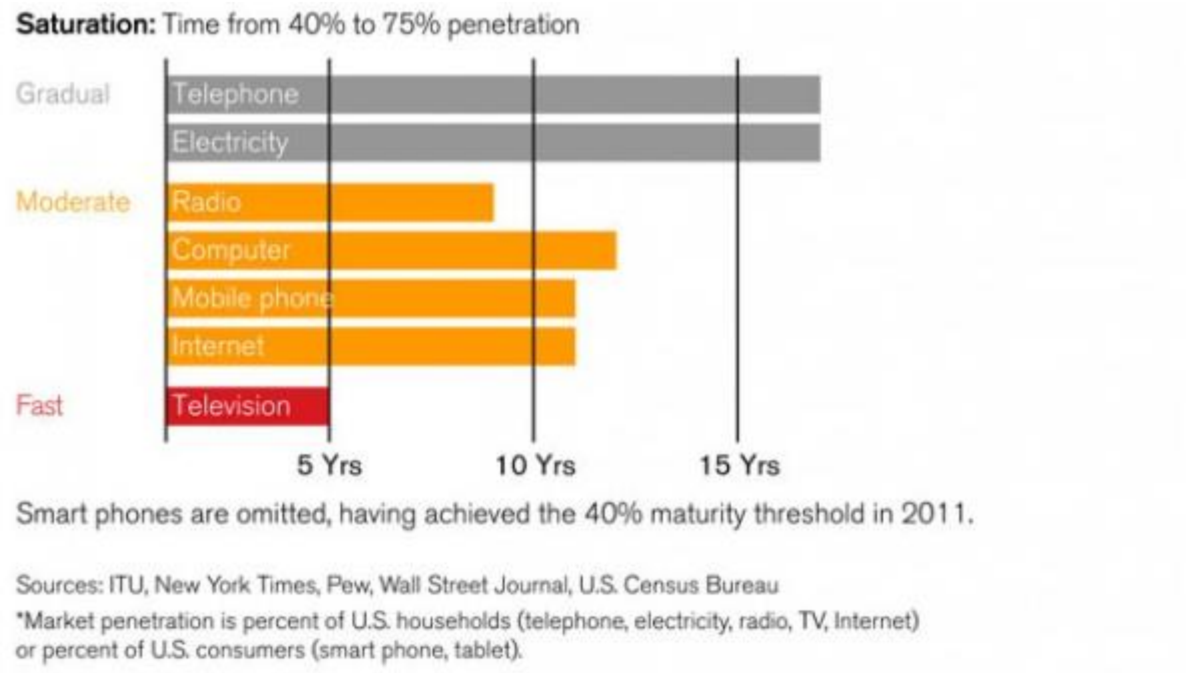


Figure 4: Technology Adoption Rates (source MIT Technology Review)

Tough these product areas are more consumer based the components are still common across; transport, aerospace, etc. and the changes in this commercial market area are affecting the other markets and are resulting in increasing the rate of obsolescence. By not monitoring the fast changing (inter-related) markets there is the risk that technology selected which is expected to be manufactured (or even supportable) for an extended period will not be available (from the original manufacturer) within 5 years of its introduction.

3.2. Technology Roadmaps

We live in a ‘throw away’ culture where once a product (or technology) is no longer required (or used) it is disposed of, sometimes because of ‘Style’ or ‘Aesthetic’ obsolescence (https://en.wikipedia.org/wiki/Obsolescence). Where a product is required to be both repairable and maintainable for upwards of 20 years or longer this can be particularly difficult to achieve especially where there are dwindling supplies. Tied in to this is that there is an unrealistic expectation that a modern product will have an operating life of 40 years or longer without undergoing some form of change either at a component level or at a unit level as part of a system (or assembly) uplift.

As these problems are transferred into design requirements for them to be mitigated or prevented, a number of manufacturers (typically OEM’s and Integrators) address this through the use of ‘roadmaps’. These roadmaps provide an opportunity for users of their products to look at the planned future of products from both a manufacturing and a supportability standpoint. Three areas I suggest that should be reviewed are:

- **Standard or Known Technology** – Where the technology is stable and not likely to be replaced or modified/upgraded (on a regular basis), (the product) has not been changed since its introduction (or not had recent or significant changes) and the technology is universally recognised (i.e. resistor, valve actuator). More common in non-electronic products where their use has had little to no change and will have little to no change in the future i.e. the toilet flush.

- **Mature Growth Product(s)** – In relation to the technology lifecycle, they are at the peak of their lifecycle and are approaching the 'decline' phase of their manufacturing life. Manufacturers will either; be working on its replacement, have already released its replacement, or may have an extended support option for it. Figure 2 presents a view for products that have a longer than normal maturity period during its lifecycle.

- **Advanced or New/Niche Technology** – Technology that has been developed for a specific requirement or its current use is constrained to an industry or commercial area due to its relative age and acceptance in the market place. The technologies reliability is potentially still being developed through modifications or its failure causes whilst in operation are still to be identified.

3.3. Through-Life Solution

Having a 'through-life solution' is not about having one product last for the entire life of the product but about applying a solution principle at the design stages (for the life of the product) that ensures that when the obsolescence occurs the ability to maintain and if necessary replace the part does not result in an inability to operate the product or system, or requires a (major) redesign to replace the part.

The 'solution' may detail a collaborative approach of solutions with a mixture of technologies and service provisions that enables the overarching product or system to operate for the duration of its planned life and possibly longer. This may be by the use of; maintenance policies that enable greater repair rates, increased stocking of spares (including components and reclamation from redundant/removed products) and selection of technologies that support a through-life solution. Whatever the source of the technology is (i.e. the size of the manufacturer), the selection should consider three particular technology types, which are:

- **Bespoke** – The technology (or its product) is designed for a specific task or operation, stereotypically one-off manufacturing as it is built to a customer's exact requirements. This ensures that the product operates as required with little to no change to any of its interfaces. However, it is generally obsolete immediately and the ability to remanufacture is dependent upon availability of tooling, knowledge and cost. Though they would exist for re-occurring manufacturing runs, due to 'bespoke' technology normally being "one-offs", the likely remanufacture could be 15 years (or longer) after the last build and the tooling is either; no longer operable (as a result of not being maintained), no longer available or the operation of it is no longer known.

- **Modular** – The product is designed (generally by a manufacturer) to be replaced by the latest version of its technology product range and ensuring a level of interchangeability that does not affect the overall Form, Fit and Function (FFF) of the system or assembly (unless intending to provide improvements to function). More common for open or transparent system design where the system is expected to evolve or the requirements of its operation change as a result of a (customer/user) requirement change. These can be affected by short manufacturing lives but can be tied in to product roadmaps as manufacturers encourage customers to move to their latest product.

- **Off the Shelf** – Recognised more colloquially as 'Commercial off the Shelf' or COTS, are products that are designed to be easily installed and to interoperate with existing system components (https://techtarget.com/). The prefix 'Commercial' is replaceable with Modified, Modifiable, Industrial, Military, Government, NATO or Niche depending upon the user and its use, though this then means the product potentially is customised and 'bespoke' rather than truly "off the shelf". Though typically the product is designed to be used across the different industries with little or no changes (such as software), depending upon its use and quantities sold (market demand) will determine its availability in the market and its manufacturing life. PC's (including laptops), displays and lighting are examples of common COTS products.

3.4. Technology Relation Summary

Consumer demand of products within the commercial market and the trends of its use, acceptance and demand (year on year) may impact on the manufacturer's decision to continue manufacture, make changes, develop next generation products or cease making it. The level of technical complexity or uniqueness of the product can also determine its acceptance and demand, and how manufacturers plan the products manufacturing life. These factors affect product (including next generation) selection to meet the requirements for a whole-life (supported) system and the level of design control from the user/owner to the manufacturer.

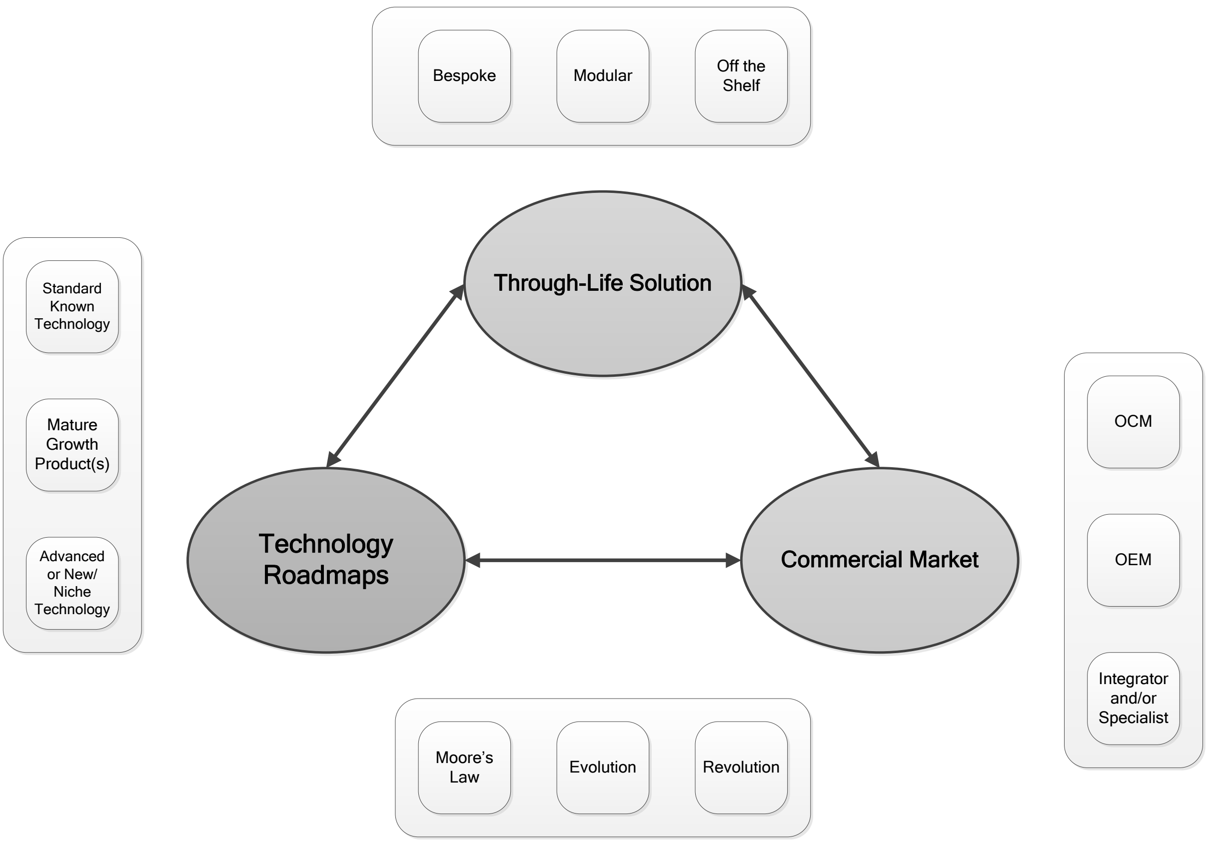


Figure 5: Technology Relation

Figure 5 presents a view of the technology relation and how each of the three parts are interlinked. This can be best summarised as follows:

i. Through-Life Solution & Commercial Market – The level of technical complexity (and/or uniqueness) impacts the products use in the market.

ii. Commercial Market & Technology Roadmaps – The product adoption (and success) in the market impacts design and selection of the next generation (or iteration) of products.

iii. Technology Roadmaps & Through-Life Solution – The availability (and option) of next generation products influences the selection of products that meet the requirements of a through-life solution.

In conclusion, selecting a product that only suits or meets the operating requirements can result in a dependence upon that product (or its supplier/manufacturer) and force users to implement a redesign or significant design change whereas selecting an open or transparent technology can reduce or mitigate this likelihood.

3.5. Technology for Life Recommendation

It is recommended that when reviewing the selection of products to meet a 'Technology for Life' concept that the products commercial position (with respect to the current and expected technology progression), its technical complexity and the design concept are assessed together and not as unrelated factors. The selection of products that meet the short term (or delivery) requirements of a project but do not take into account the longer term (or support) requirements of the product/system and will more than likely result in earlier than planned costly upgrades and/or redesigns.

4. DESIGN FOR LIFE

A products design is normally a result of the (minimum) requirements it must meet, which typically looks at function and reliability. Its life is generally an after-thought with a requirement that it lasts for a set period and varies from product to product (i.e. electrical, electronic, mechanical). At a system level there is an overarching design or service life but little to no understanding of the obsolescence challenges to overcome in achieving this (by the customer or end user). As a result, there is an expectation that the product will operate reliably for a given period of time, with an increase in failures or degradation of function over time, or a sudden failure at the end of the designed life and that spares remain available during this time.

Obsolescence becomes an increasing issue where the product remains in use beyond its planned design life and the spares required to support it are no longer available. Additionally, with an emphasis on organisations to reduce their carbon footprint a sustainable design that achieves this can become more desirable, sections 4.1 to 4.3 will review a number of elements that should be considered to reduce the impact of obsolescence and potentially enable an extended life post design life.

4.1. Through-Life Solution

At the design stage there is an opportunity to plan for obsolescence, determine how the selection of the product may counter the obsolescence and whether additional measures are needed to resolve it. This 'mapping' activity highlights any risk of obsolescence during manufacturing and in-service lifecycles and how the application of a solution or solutions provide a 'through-life solution' that could be replicated should the design life require extending further. An example of how this might look is presented in Figure 6 where green shows little to no obsolescence transitioning to red with a high degree of obsolescence, and as a result of an action to manage the obsolescence, has extended the life of the product and potentially the system, in some cases being referred to as a technology refresh or insertion.

The selection of technology types (e.g. bespoke, modular or off-the-shelf) will be a determining factor as to when an action is required, as the complexity to resolve/mitigate the obsolescence may mean dealing with the issue individually at a component or part level or jointly with other parts. Other factors such as reliability of the product and availability of spares may mean that action is not required or can be postponed to a later date. This can present a problem in planning when to deal with the obsolescence for manufacturers, especially when there is more than one customer using the product and their requirements as to when to resolve the obsolescence differ.

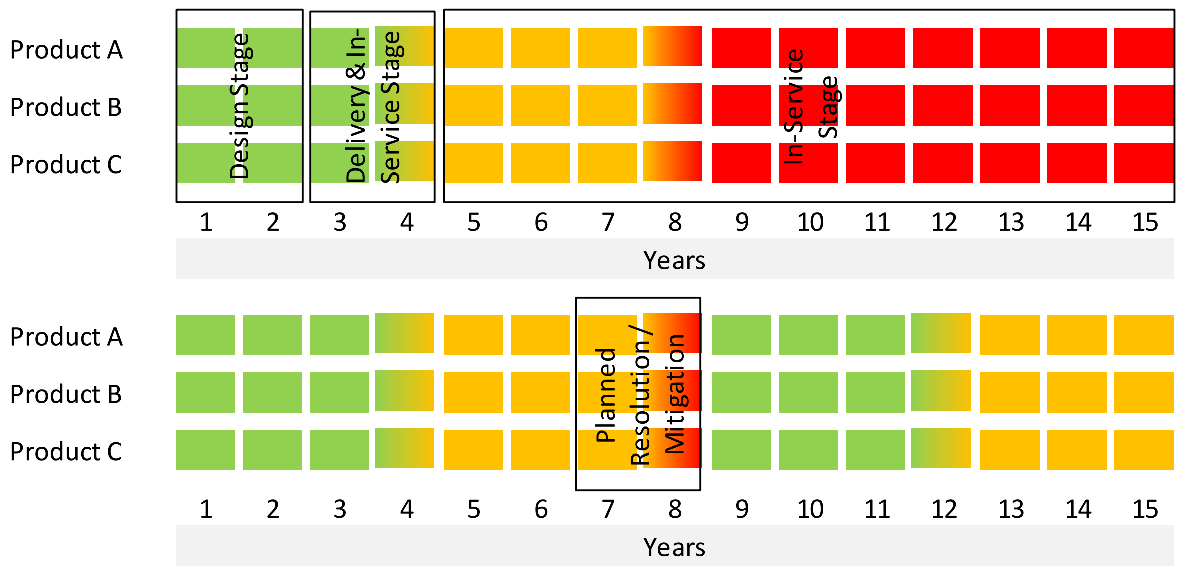


Figure 6: Through-Life Solution Mapped to Product Lifecycle

At the design stage, the following should be considered:

- the risk of obsolescence during the products lifecycle stages (see Figure 1),
- the point obsolescence is likely to occur,
- the resulting impact (if nothing is done),

- the resolution or mitigation required and when they are to be enacted by, including the technical complexity of the product and that of the solution, and
- the resulting change in the products remaining life (i.e. reduced or increased).

Cost is another factor for consideration and is covered in section 4.3 and wider in section 5.

4.2. Product Design Requirements

Stakeholders (i.e. designers, customers, users) requirements vary accordingly to how that individual or group interface with the equipment, all of which can create obsolescence for the installed product(s) whether it is aesthetic, functional or economic. Each of these obsolescence types should be considered during the design, as they may not be an immediate impact but as a result of a change may mean the product no longer meets the evolving requirements during the equipment/system lifecycle. I have broken the requirements down to three types of groups, these are:

- **Customer**. Depending on the product, the customer could also be the operator though this is would be more in the commercial market (e.g. televisions, and other privately owned goods). For the purpose of this document, the customer is the 'Contracting Authority' (i.e. company or business) who purchases the product. Their design requirements would normally be as a result of a tender process with the technical aspect originating from an engineering function (e.g. Design Engineer). This may either be; from a new need, where the company has identified a gap in their business model/service or where an existing product is no longer suitable or is obsolete and requires replacing.
- **Maintainer**. Technicians and equipment maintainers responsible for servicing, repairing and maintenance activities of the equipment. These may be the customers own maintainers or contracted maintainers (from the OEM or third party specialist). Their requirements can sometimes be overlooked in the design requirement phase, where the focus is primarily on the ease of maintaining the equipment/system and availability of spares, and not the risk of obsolescence, which may result in engineering changes and possible configuration control issues (i.e. parts installed different to the spares held).
- **Operator**. Either a direct or indirect user of the product, whether it is standalone or integrated within a system. The user or operators requirements are generally centred on the products ability to perform the tasks as required whilst providing maximum usability (https://en.wikipedia.org/wiki/Usability) with little to no awareness of the obsolescence risk.

These three groups can unknowingly contribute to obsolescence risk for the product or even the system/equipment the product will be used within. Each has a differing set of requirements but all should be addressed as practicably as possible within the design. The design requirements should also take into account the likely evolution of the requirements over the lifetime of the equipment by those three groups and whether the design can meet them or not.

There are a number of lifecycles where the risk of obsolescence should be considered and planned for, especially where there are overlaps. The product lifecycle has been described in section 2.2 and presented in Figure 1, additional there is the CADMID (Concept, Assessment, Demonstration, In-Service and Disposal) lifecycle and the relationship of obsolescence management during the lifecycle phases that should be considered within the design (see Figure 7).

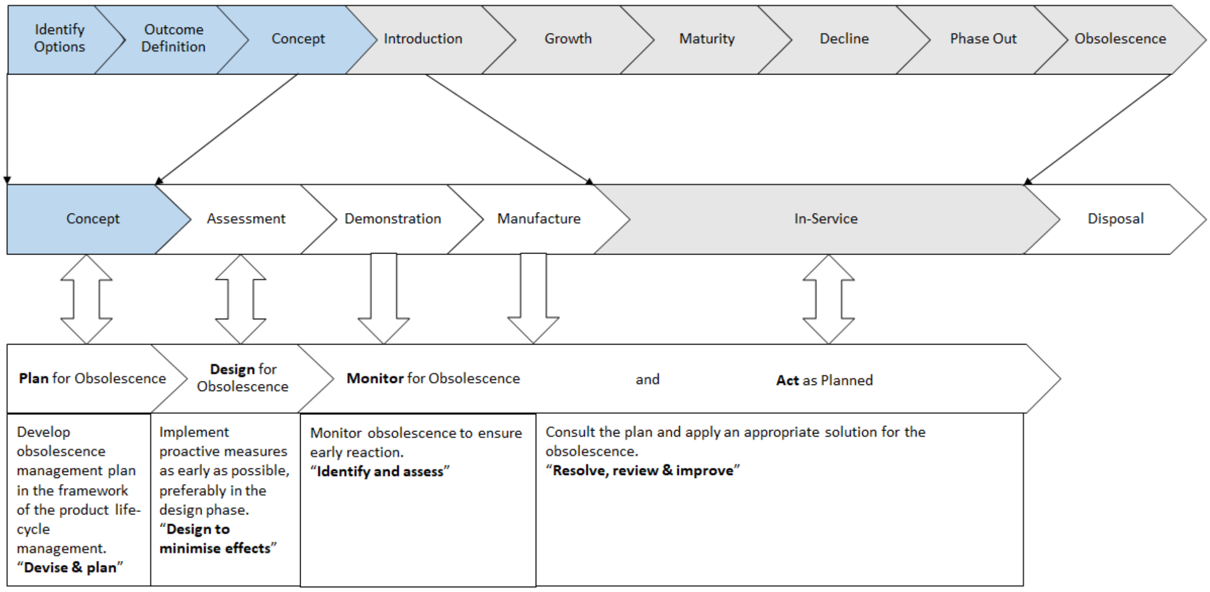


Figure 7: Overlapped Lifecycles with Obsolescence Management Timeline

Obsolescence is for life and the integration of an Obsolescence Management Plan (OMP) at the beginning of a products life will help to prevent if not mitigate the impact of obsolescence for the remaining life. There are a number of different process approaches to determine the strategy selection and implementation at the design stage and most follow a similar 'Plan-Do-Check-Act' approach that can be tailored to the company, product and product service life. The Obsolescence Management standard BS EN IEC 62402:2019 outlines a recommended process.

4.3. Costs

The cost of managing and resolving obsolescence has been a topic of conversations since the 1930s and will likely continue to be an area of constant challenges for project and product managers, and customer asset managers. A number of tools have been developed to help calculate resolution costs during a products lifecycle and scenario planning for when to implement. This section will not be looking at the tools (though the use of them is recommended) but the various aspects that make up obsolescence costs that should be considered at the design stage.

The cost of obsolescence is not always considered during the design stage and normally becomes realised where there is either a long design and/or manufacturing period (e.g. several years, especially in the case of large or many system builds), or as a result of sufficient materiel being available during manufacture and then becoming an un-planned cost during the in-service stage. At the design stage, the following three costs should be reviewed and planned for:

i. **Resolution Costs** (Stock/Replacement/Redesign) – The selection of the technology type (bespoke, modular, OTS) can determine the likely or expected cost to resolve which is generally on a sliding scale of low to high for stock-to-replacement-to-redesign. The design stage should take into consideration:

a. Availability of stock for manufacturing and production of spares (both initial and in-service). Where components used for the product have become obsolete and their procurement only achieved through the use of aftermarket sources (i.e. Brokers/Vendors) their costs can be far higher than originally planned, and there is a risk of counterfeit parts being supplied (see Figure 8).

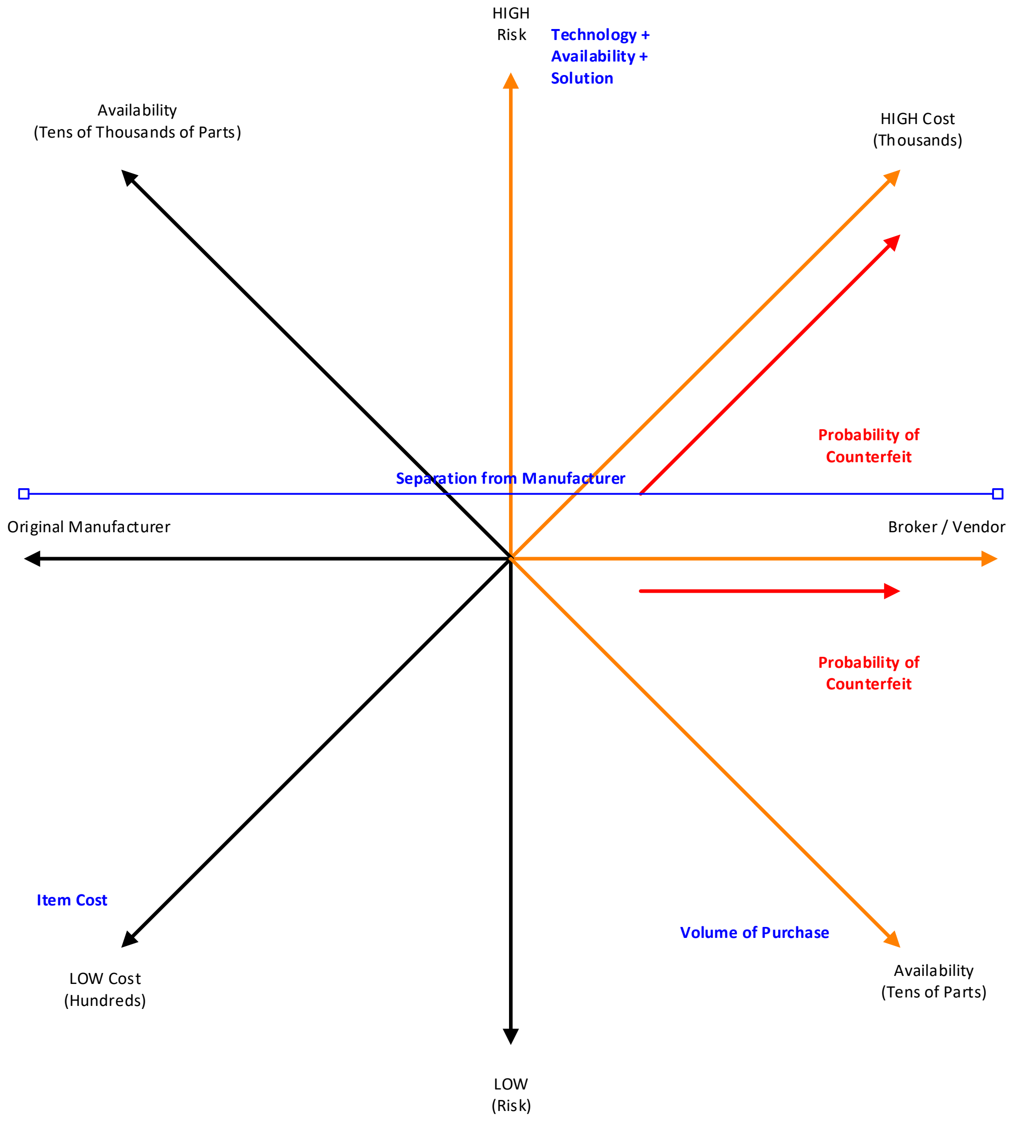


Figure 8: Obsolescence Availability & Cost Star

b. Use of FFF or near equivalent components. Minimising configuration changes and maintaining compatibility of built systems through the use of modular or transparent technologies. This can minimise the impact of obsolescence through an evolving product design and reducing costs of holding obsolete components, however, there is a risk over an extended timeframe that the design diverges to a point that iteration ‘A’ is not compatible with iteration ‘Z’.

c. Planned technology refreshes or insertions. At the design stage identifying points in the products lifecycle, especially where there is a likelihood it will be extended, or where a redesign or uplift can address a large portion of obsolescence as well as addressing any changes in requirements or adding an improved functionality is key to addressing long-term obsolescence. Though these costs can be significant, identifying them within the design stage will enable sufficient cost planning should they become necessary.

ii. **Support Costs** (Service/Repairs/Spares) – Resolving obsolescence during the products service life has not always been a consideration during the design stage and as a result, the ability to conduct servicing and repairs can be hampered because of a lack of spares caused by obsolescence. The forecasting of spares normally done during the design stage should also forecast the likely impact of obsolescence on their availability and the increase in costs associated to; procurement of components from the aftermarket and Non-Recurring Engineering (NRE) costs for replacement and redesign solutions.

iii. **Product Unit Costs** (Fixed/Variable/Market Driven) – As identified in points i & ii above, obsolescence can affect the planning of costs throughout the product lifecycle (see also 5.1). Planning for these likely cost fluctuations at the design stage especially for the manufacturing and in-service stages should enable more accurate cost profiling of spares with any increases in unit price(s) as a result of obsolescence being clearly identified. The provision of ‘service support’ or similar type contracts can help to mitigate variation of costs as long as proactive obsolescence management is being employed, if not there is a real likelihood that costs will fluctuate upon each request for quote (RFQ) as they will be driven by the market availability of the components.

4.4. Design Relation Summary

The selection of product types to meet the initial design requirements may not be suitable where the product has a longer than normal lifecycle or where the products life is extended beyond its original design life and as a result there are evolving design requirements not originally planned for. Not designing for obsolescence results in hidden costs and latent issues that will have an increasing cost to resolve the further the issue is away from the originating obsolescence cause.

Figure 9 presents a view of the design relation and how each of the three parts are interlinked. This can be best summarised as follows:

i. Product Design Requirements & Through-Life Solution – The design selection influences the products longevity and its continued use if the service life is extended.

ii. Product Design Requirements & Cost – The selection of components and products to meet the design will impact the cost to resolve obsolescence at a later point.

iii. Through-Life Solution & Cost – Planning for the implementation of solutions at the design stage will reduce the impact of obsolescence costs and identify where risks exist for cost may increase.

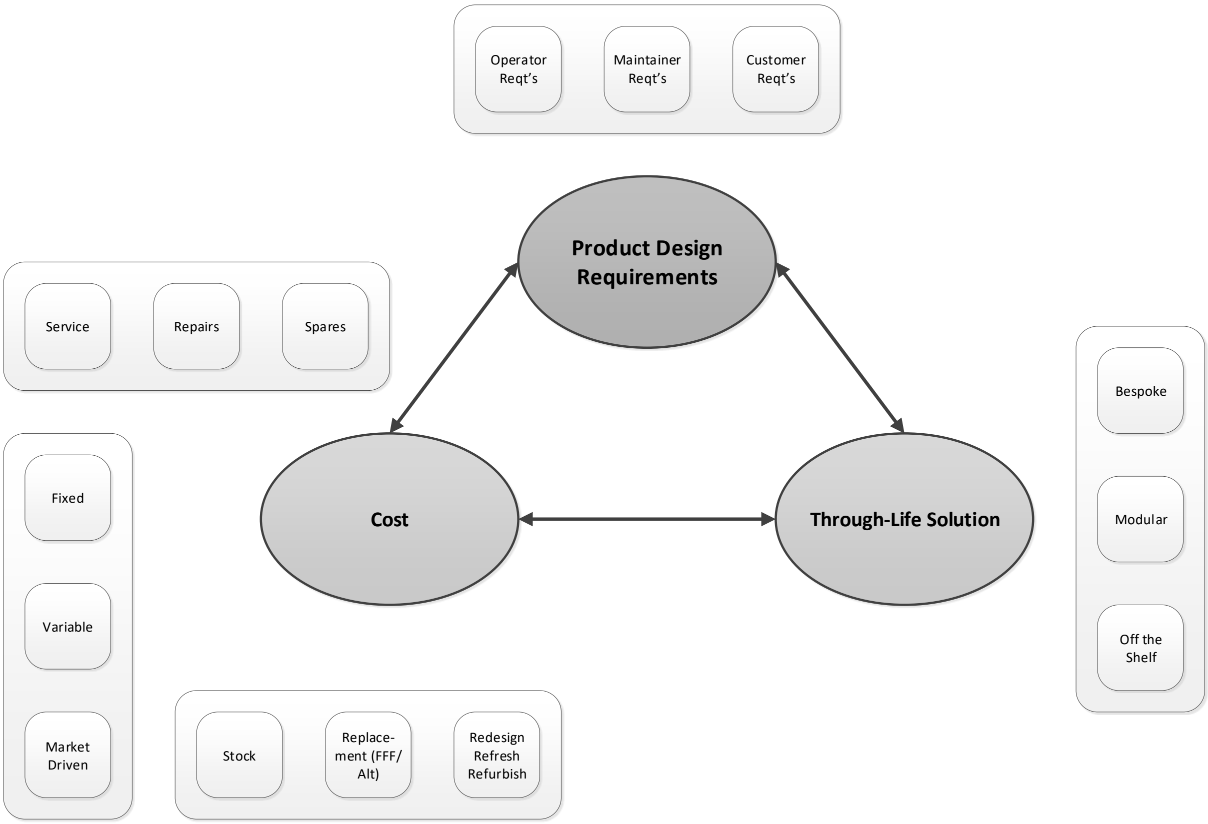


Figure 9: Design Relation

In conclusion, designing a product that meets the minimum or contracted requirements without evaluating the potential longer term need of the product will likely result in unplanned costs to resolve and no longer meeting the new requirements of its use.

4.5. Design for Life Recommendation

It is recommended that the management of obsolescence should be implemented as early as possible within the design stage. An obsolescence assessment would then determine if the selection of products meet a 'Design for Life' concept, if any resolution approach is required to resolve or mitigate the obsolescence, when it is likely to be required or implemented by and its estimated costs.

This approach can help in determining the viability of the product, especially where the cost to resolve the obsolescence is proportionally more than the design costs or other determining cost measure.

5. WHOLE LIFE VALUE

There are different interpretations of what Whole Life Value (WLV) is and sometimes being confused with Whole Life Cost (WLC). My interpretations are:

- WLC looks at the expenditure of the product throughout its life such as; its design, manufacture, qualification & acceptance into service, operation & maintenance, spares and eventual decommissioning.
- WLV looks at the products ability to meet key areas (some being more measurable than others) as a return on the costs incurred over the life of the product (or asset), more typically referred to as Value For Money (VFM).

Whole life value can include; the products ability to continually meet functional requirements, quality of the product (is maintained), product performance (is maintained), no lost time (because of spares non-availability) and in some cases lifecycle costs remain within acceptable limits. Sections 5.1 to 5.3 will look at aspects of these in helping to determine if the product provides value for money.

5.1. Costs

Obsolescence costs can appear at any point of the lifecycle so identifying and understanding the origins and impacts of them can help to determine the strategy to be implemented in countering the obsolescence in as cost effective manner as possible whilst ensuring an optimum balance of the investment and the products remaining life.

An analysis of the lifecycle costs should take into account the different stages of the product lifecycle to determine if the product is cost effective. I have identified three main points to focus on as follows:

i. Production – Section 4.3 outlined issues associated to varying unit costs as a result of obsolescence and sourcing of components from the aftermarket to support manufacture. The manufacturing phase (production of the product and (initial) spares) should analyse the cost of procuring the components necessary for the manufacture but also if there are any tranche builds and the procurement of components tied to them. Obsolescence is more likely to be an issue where there are delays to tranche builds and can result in either additional NRE to replace obsolete components or increased material costs. Figure 10 presents a view where obsolescence arises on two occasions. The first impacting procurement for Tranche C and spares for Tranches A & B, and the second impacting procurement for spares for Tranche C. Potentially this could result in configuration changes to the builds with Tranche A & B different to C, and potential issues of compatibility of spares for Tranche A, B and C.

ii. Support – It is recognised that once a product moves from production to in-service, the cost to support is further impacted by managing and resolving the obsolescence. Figure 8 presents a view of decreasing stock availability with increasing cost of purchase the further right the product moves in its life away from the point of obsolescence and a similar increase can be applied to managing the obsolescence, though this typically declines nearer the end of the products life. Though support costs are normally built into service support contracts the forecasting of obsolescence, the resolution type and its cost to resolve and when to resolve can be problematic to plan in, and are more often covered as a risk rather than the real and actual cost they will be. The costs should not be bounded to contract periods but analysed against the service life of the product for a number of reasons, some of which being; (1) It can generate incentivisation of the customer/end user to fund obsolescence resolution, (2) the costs are not hidden and allow for forward planning, and (3) can help to determine whether the product is no longer economically viable (either manufacturing of new builds, spares or support) or the future point it will no longer be viable.

iii. Resolution – A number of studies and papers have been done for forecasting and modelling obsolescence costs by industry and academia with tools available to provide indicative costs. I will not be commenting on them but do recommend their use, I will however highlight areas that should be considered which are:

a. Resolution Type – Broken down to three main types:

- Stock. Various terminologies used such as Life of Type Buy, Last Time Buy, All Time Buy, Bridge Buy or Reclamation/Salvage, but all associated to the sourcing of stock to mitigate or resolve the obsolescence. Seen as the easiest way to maintain configuration of the product but issues with shelf life, ageing effects and resulting degradation, stock lost/misplaced/damaged, quantities over/under calculated, and remaining operating life where reclaimed. Though suitable for supporting manufacturing, the stock may not be required for a number of years as a result of reliability of the product and low user demands. This can present as an excess of stock incurring additional costs to manage, inspect, maintain and in some cases dispose of.

- Replacement. Whether this is the use of an equivalent, alternative or use of specialist manufacturers to emulate or remanufacture the original component, there will be a varying level of costs. This may increase with the level of difference (to the original part), any necessary qualifications, NRE and likely Minimum Order Quantities (MOQ) / Minimum Order Value (MOV) costs for emulation and aftermarket manufacture and any costs associated to the manufacturing time.

- Redesign/Refresh. Generally seen as the more expensive and time-consuming solution, however this can provide a wider solution especially where there are multiple obsolescence issues (including any not yet impacting). Though there is normally a preference to veer away from these types of solutions, if properly planned they can provide an extension to the products life.

- Resolution Implementation – Not all obsolescence needs to be resolved, and not all obsolescence needs to be resolved straight away, especially where there is a proactive obsolescence management programme in place. Additionally, resolution costs can influence the resolution type and when it can be implemented. Obsolescence resolution planning as part of the lifecycle with cost profiling can help to determine whether a short or long-term solution is applicable (sometimes the use of both) and whether the cost expended allow for a Return Of Investment (ROI) and as a result the decision being either; Do-Nothing, Postpone, Mitigate or Resolve.

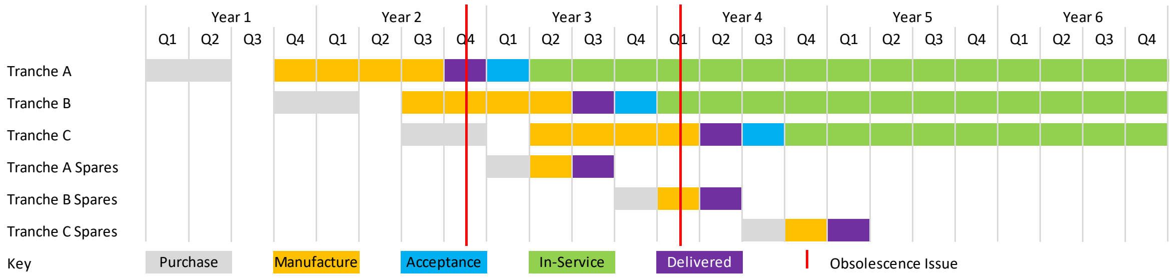


Figure 10: Manufacturing Timeline with Obsolescence

The value of managing the obsolescence is not just measurable by how much or how little has been resolved, but by a number of factors that should be agreed with stakeholders. These can be for example, set around availability of the product, On-Time-Delivery (OTD) of spares, Turn-Around-Times (TAT) of spares and repairs, management (& resolution) of obsolescence within agreed budgets to name but a few.

5.2. Lifecycle

Section 4 discussed aspects of the products 'Design Life', which is not always transferable to its lifecycle as presented in Figure 7. There are a number of influences to the lifecycle which have already been covered in this paper. For a number of large operators, there has been an increase in extending the lifecycle of their assets and the products that comprise them. Where there has been little to no obsolescence management, or where the product is already at the end of its designed life with no previous plans to extend, the challenge of resolving the obsolescence has becomes far harder.

Though there is value in extending the operating/service life as there is no initial design & manufacturing costs to incur, there will be other costs that arise such as; refurbishing/overhauling equipment, resolving the obsolescence (which can be over 30% of the Bill of Materials (BoM)) as well as implementing additional or increasing maintenance and surveillance programmes and may not always provide the extended timeframe desired. Obsolescence can affect the following areas that have an impact on the lifecycle and decision to extend or shorten it.

- Testability – Special to Type Equipment (STTE), Automatic Test Equipment (ATE) and other test equipment (including test benches) are commonly built specific to the product or are COTS equipment. All are prone to obsolescence, commonly overlooked because of their function and for the STTE's normally difficult to replace. Any activity that is looking to extend the lifecycle should take into account the availability of the test equipment that supports it, without if of course reduces, if not prevents accurate fault investigation.

- Maintainability – In the case of built systems or products that have replaceable components the ability to maintain it by repairing or through the use of replacement spares is paramount. Lifecycle planning should take into account the forecasted maintenance activities, the usage of spares (and any other material) to achieve it including whether removed component can be repaired and returned as a spare. Other options for consideration are changes to the maintenance activities that reduce or remove any unnecessary maintenance activities that could induce failure or damage.

- Reliability – Though products have Mean Time Between Failures (MTBF) or Mean Time To Repair (MTTR) rates, the actual failure or repair point can vary as a result of the environment the product is used within, its actual use (i.e. hours run versus OEM recommendation) and the maintenance schedules employed by the user. As a result, forecasting the level of component or product spares required and their costs are not always accurate. This can often lead to minimum spares being held which is insufficient because of product age there is an increase in failures. The use of condition monitoring and/or Failure Recording, Analysis and Corrective Action System (FRACAS) can be used to identify where there may be an increase in demand and enable implementation of an obsolescence resolution in a timely manner so that there is no loss or reduction in availability of the product.

The lifecycle can be increased or decreased depending upon the quantity, technical complexity of the obsolescence and cost to resolve. The value in managing the obsolescence within the products lifecycle can be realised as a result of; reduced obsolescence costs over the timeframe, maintained or improved reliability of the product (as a result of obsolescence resolution), and number of years the extension achieves (versus cost expenditure). Figure 11 presents an example of a basic view of incorporating obsolescence stock buys, repairs and implementation of a refresh to extend the product life.

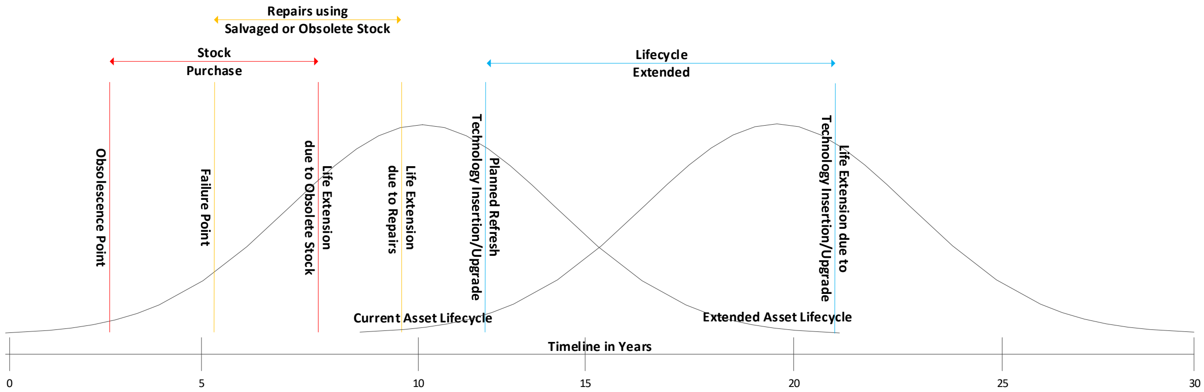


Figure 11: Lifecycle Extension

5.3. Availability

Section 2.1 introduced availability in association to lifecycle planning and the start of section 5 outlined my interpretation of WLV and that "*the products ability to continually meet functional requirements, quality of the product (is maintained), product performance (is maintained), no lost time (as a result of spares non-availability) and in some cases lifecycle costs remain within acceptable limits*".

Investment of a product either by the manufacturer, as part of their product portfolio or by a contracting authority is reliant upon the ROI. The manufacturers interest in the product sales and the resulting profit (which support future Research & Development (R&D)), and the users interest in the product remaining operational (or available) for its designed life. As previously mentioned, as a result of poor quality the product can be quickly dropped and replaced.

Obsolescence impacts all levels of the supply chain from the constituent part supplier, to the component manufacturer, to the product manufacturer up to the end user (though the supply chain can be far more extended and diversified) and the availability of the respective materiel is tied to that end demand, which can be:

- Known – The demand has been agreed through contracts or purchase orders. Unless contracts for service support/availability are at least 5 years (the longer the better), there are still risks to the availability of the product especially where the product is for a small market area/customer base.
- Forecasted – There are two aspects to this, (1) the product is replacing an existing (earlier) version and sales are forecasted against a similar market adoption, or (2) the forecast is based on repairs and future demand of spares (based on failures). There is still an element of risk associated to this in that the product is more reliable than planned, or not used to the original specification by the customer and the demand numbers erratic.
- Predicted – Similar to the forecasted demand but more of a risk for a new concept being introduced to the market and where the adoption is gradual and by the time the product is widely accepted (growth stage of the lifecycle) it is already suffering from obsolescence.

By managing the demands for the product in that it continues to meet the customer availability requirements (i.e. functional, maintainable, spares available), and in the case of a commercial market the product remains competitive and profitable, its position within the maturity phase of the lifecycle can become extended (see Figure 2). As a result, its return on the costs incurred over the life of the product (or asset) continue to provide value for money.

5.4. Whole Life Value Relation Summary

Value is not just about cost but all of those parts that make up the cost, the product achieving or exceeding its planned lifecycle and the availability (repairs, spares and other support functions) guaranteed over that same period. Obsolescence becomes a factor of those parts and needs to be planned for and addressed so that the product achieves its return on the costs incurred whilst meeting stakeholder requirements.

Figure 12 presents a view of the whole life value relation and how each of the three parts are interlinked. This can be best summarised as follows:

i. Cost & Lifecycle – The cost of the product (including any support/service arrangements) remain economical over the lifecycle providing a return on investment.

ii. Lifecycle & Availability – The longer the product remains within the maturity phase of the lifecycle the greater the likelihood of it remaining available increases.

iii. Cost & Availability – As long as the product remains economically viable and there are assurable demands managed through the entire supply chain the availability is more likely to be stable over a longer period of time.

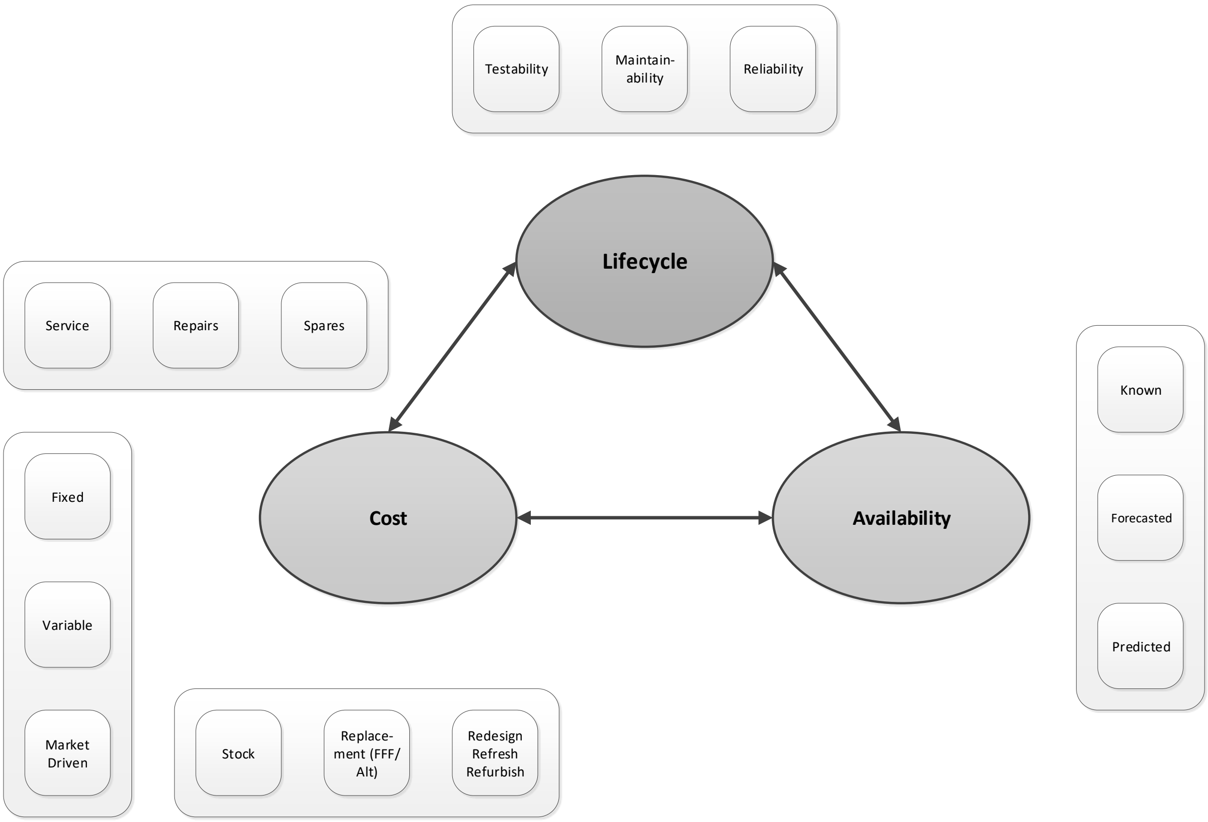


Figure 12: Whole Life Value Relation

In conclusion, when assessing the whole life value the focus should not just be on cost but those elements that give indication of how its lifecycle targets can be achieved and possibly exceeded whilst maintaining its functional objectives.

5.5. Whole Life Value Recommendation

It is recommended that when analysing the whole life value of the product, that the likely effect of obsolescence, the solution approach to resolve it and resulting influence that the obsolescence has on the cost, lifecycle and availability of the product also considers the benefits that arise as a result of the obsolescence being managed.

The long term planning of practicable product life extensions that ensure the products continued availability and in some cases improved functionality, by addressing the obsolescence proactively and systematically whilst remaining cost effective (no unnecessary resolution cost or those that do not bring benefit) for the whole life of the product is achievable with a pragmatic approach to investment.

6. PAPER CONCLUSION

The management of obsolescence should be an integrated approach throughout the whole lifecycle of the product (whatever it may be). Figure 13 presents a view to those aspects covered in this paper, showing the overlap which each other, their relationships and in some cases inter-dependencies with one another. Obsolescence is a major factor in every part of a products lifecycle and the management of that lifecycle from its concept through to its end of life, and is a major driver in deciding the continued manufacture and support of the product or not.

Obsolescence management is not a single user or group's responsibility but that of everyone involved in the various aspects of the products lifecycle whether they are the requirements specifier, design engineer, supply chain manager, manufacturer, supplier, customer, user or maintainer. Each can provide valuable insight and knowledge in how and when to address the obsolescence.

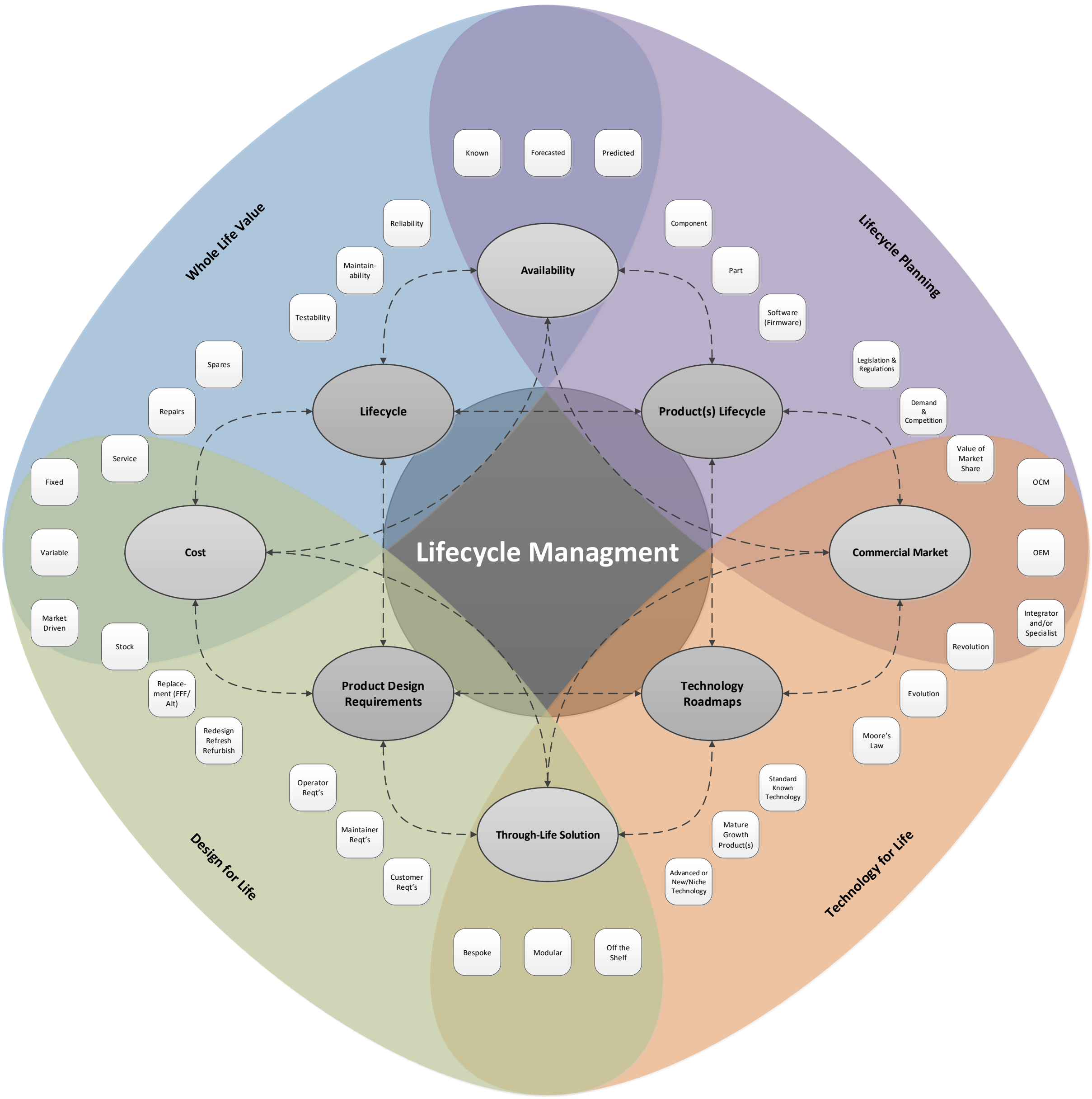


Figure 13: Lifecycle Management Systemigram