Strategic Life Cycle Management

Measures for Minimising Obsolescence

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Purpose of this document

This document is intended to define general instructions for the minimisation and partial avoidance of the impact of obsolescence in the railway industry.

Target readership

This document is intended for the entire supply chain in the railway technology industry, in particular the energy, IT, control and safety technology and telecommunications systems on both an infrastructure and vehicle level. It is aimed specifically at operators, system suppliers, integrators and hardware and software manufacturers, as it contains general guidelines for all levels as well as detailed instructions for design and procurement, for example.

Evolution of the document

This document is under ongoing development to incorporate knowledge gained from, in particular, guidelines, such as the VDI Guideline 2882, which were drafted simultaneously to this document.

The next planned update is for September 2016.

Terms and definitions

Life cycle management

- Includes, among others, measures for the avoidance and minimisation of the impact of obsolescence from the development to the phasing out of a product;
- Role: LC Manager (LCM).

Obsolescence management

- Encompasses all measures for the avoidance of obsolescence issues and for the handling of occurring obsolescence issues;
- This is a part of LC management;
- Role: Obsolescence Manager (OM).

Product life cycle (manufacturer's perspective)

Delivery period

- The duration of an original manufacturer's ability to deliver a product, from its introduction to the market to its phasing out of the market.

Repair period

- Repair period after the end of the supply period, including any limited supply of spare parts.

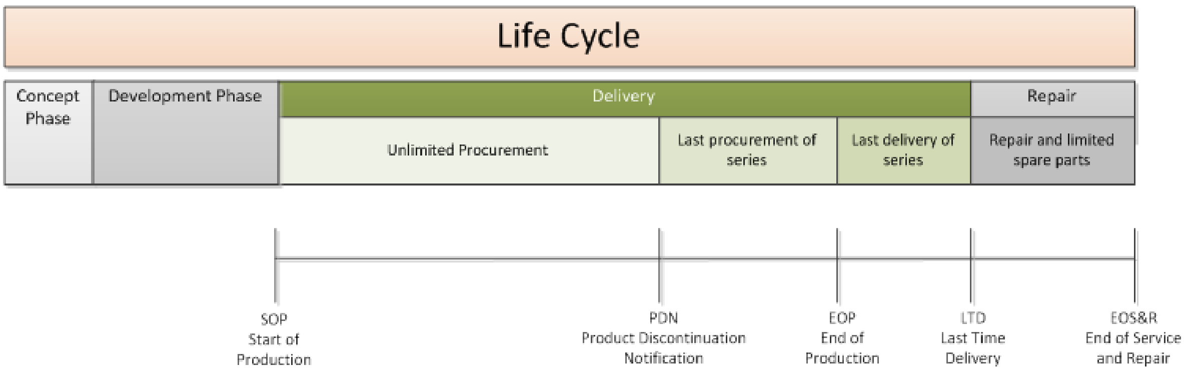


Figure: Definition of terms from a manufacturer's perspective

Product life cycle (user's perspective)

Reliability period

- The reliability of a product from its delivery until it becomes defective or is replaced.

Usage period

- The desired usage period for a product.

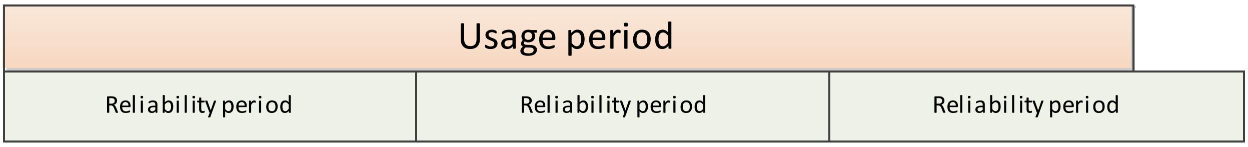


Figure: Definition of terms from a user's perspective

Examples:

- Consumer electronics (e.g. a mobile phone): Reliability period > usage period;
- Railway electronics (e.g. brake control): Usage period > reliability period.

The following sections address cases in which the usage period > procurement period.

A new life cycle management parameter

Up to now, life cycle planning for technical devices was based primarily on procurement costs, operational service costs and the usage period of a device. These parameters could be used to determine which device accrued low costs, considering the sum of these factors, over the duration of the planned usage period. Associated “LCC” calculations have been a standard in the railway industry for many years.

Recently, it has become clearer that one, broad parameter – the obsolescence of components, meaning that they cease to be obtainable – has fundamentally changed life cycle planning. This does not only include the well-known obsolescence of electronic components, but also of various other components, from the elements of a device all the way to software, which are becoming obsolete more and more quickly, as demonstrated by news in the smartphone industry, where software is, at times, only serviced for a period of two years.

At the moment, the response to this trend is being handled primarily within the framework of obsolescence management. Even so-called “proactive” approaches are often limited simply to a user's own early detection of obsolescence as opposed to it coming as a surprise – which is still often the case.

In response, the CNA/Cluster Bahntechnik obsolescence management task force has investigated other concepts which can be used to determine the impact of obsolescence on life cycle costs from the very start and develop ways to avoid these costs.

An initial theoretical analysis by the experts involved produced the three following areas of focus:

- An analysis of the actual state of a device’s obsolescence at the time of the purchase decision;
- Life cycle planning of obsolescence influences during the usage period of the device;
- An analysis of the robustness of a device's design in terms of obsolescence influences.

The actual-state analysis primarily provides a technical overview of the current state in terms of the future deliverability of components at the time of a device's procurement. Life cycle planning, on the other hand, projects the expected obsolescence-based costs during the planned usage period of a device. Finally, the robustness analysis of a device indicates how sensitive to obsolescence the device is.

Actual-state analysis in terms of obsolescence

This analysis is based on a device’s hierarchical bill of materials (see the example in Annex 1). For example, if a device is made up of assemblies, which, in turn, are made up of modules and components, the planned remaining delivery period (series delivery) is determined and recorded for each component on each of these hierarchical levels.

To keep this process simple, only the more complex components, which are delivered by a limited number of suppliers, are considered. Simple electronic components such as resistors and capacitors are normally not considered – as long as they have not already been flagged in terms of their discontinuation criticality – if they have a wide range of replacement options.

Typical complex components are, for example, various types of integrated circuits or even coils and relays if they are only available from a few select suppliers.

As a general rule, for railway vehicles, only components with a life cycle model which includes a clearly-defined availability period should be used. Furthermore, components which have a roadmap with a compatible successor shall be prioritised.

In addition to hardware components, the actual-status analysis must also consider the availability of the software installed on a device, as displayed by the example in the introduction. In most cases, the use of a software is usually limited to the service period planned by the software manufacturer. After the expiry of this period, the software is usually still functional, but safety updates or adaptations to hardware changes, for example, are no longer executed, which limits the software’s use.

For all cases, life cycle transparency is essential on all levels, as the shortest sub-component life cycle defines the time at which the first obsolescence issue will occur.

- Definition of the life cycle on all levels (e.g. component, building block, assembly, board, system, vehicle / infrastructure-related equipment);
- The life cycle must comprise LC phases and LC data which must be diligently kept up to date on all levels;
- Life cycle data and phases should be harmonised to “speak the same language” (definition of EOS&R, PDN / PCN, ...).

Sub-component / sub-system LC data should be transmitted to (and requested from) various participants in the supply process via “standardised LC information”.

Minimum information:

- SOP – Start of Production;
- PDN – Product Discontinuation Notice/Note/Notification /
  PCN – Product Change Notice/Note/Notification;
- EOP – End of Production or, alternatively, EOS - End of Sales;
- LTD – Last Time Delivery;
- EOS&R – End of Service and Repair or EOP - End of Production or, alternatively, EOS - End of Sales.

Component	SOP	PDN	EOP / EOS	LTD	EOS&R
System	12-2015	12-2022	…		
Sub-Com.A	01-2012	12-2025	…		
Sub-Com.B	06-2009	12-2016	…		
Sub-Com.C	09-2014	12-2024	…		

Figure: Example of minimum life cycle information and table presentation to be forwarded to the next instance

An example template for hierarchical life cycle information across the various levels of the supply chain can be found in Annex 1.

Please also refer to the VDI Guideline 2882 and, in particular, Section 5.2.1 on life cycle and risk analysis.

Life cycle planning under consideration of obsolescence influences

In addition to the actual-state analysis, measures in response to expected future obsolescence scenarios should be planned in order to achieve the goal of ensuring the availability of a device for the planned usage period. As with the actual-state analysis, this plan not only illustrates a technical situation; it also facilitates a cost evaluation of various strategies.

Life cycle planning for project-related (one-time) investments

Project-related one-time investments are characterised by time-limited procurement (usually one or only a few delivery lots for a limited procurement period) and known / limited quantities:

- Usage period: Usually several years (5-10);
- Procurement period: Usually short (1 year).

Example: Equipping of the project "Infotainment displays for tram route 8 in Munich" with a total of 120 displays to be delivered within an equipping period of 5 months.

This updated type of life cycle planning is based on the traditional process, which primarily considers the costs for

- Procurement,
- Repairs, and
- Consumables

for the planned usage period.

The repair costs are the failure rate in the usage phase at a constant error rate (the flat portion of the so-called "bathtub curve").

The costs for consumables (e.g. energy costs) vary widely depending on the device type. As these costs typically do not play a role in the illustration of the impact of obsolescence, they will no longer be considered in the following sections for the sake of model simplification.

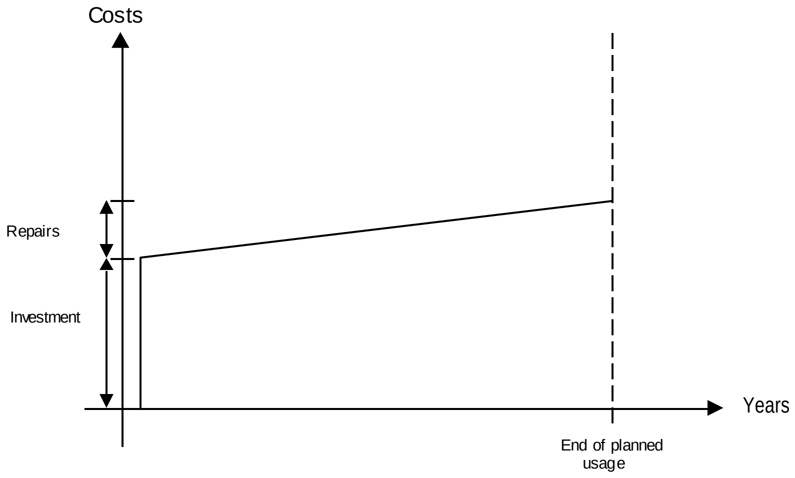


Figure: SOM – typical life cycle cost progression with procurement and repair costs and without a need for action

In some cases, an additional factor must be considered in traditional life cycle planning, namely

- The end of a component's usability caused by wear during operation,

which is often calculated as the end of a component's service life. Television tubes represent a typical case, where the glowing phosphorous on the glass at the front of the tube gradually wore down over the course of the device's operation, causing the brightness of the television tube to decrease proportionally.

If one of a device's components can no longer be used before the end of the planned usage period due to this operational wear, the component must be replaced during the usage period of the device.

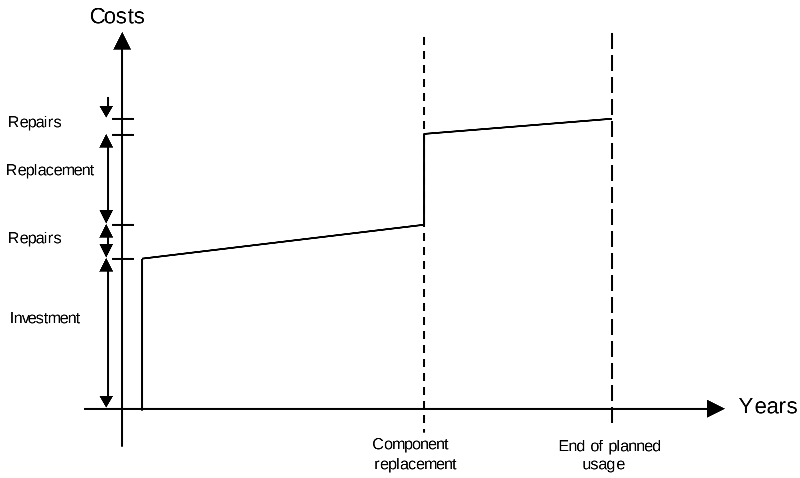


Figure: SOM – typical life cycle cost progression for the strategy variation "component replacement due to wear"

In association with the obsolescence of components during the planned usage period, additional costs for the warehousing of

- Spare parts for repairs, and
- Replacement parts for the end of the service life of components

apply, as the components needed from the time of obsolescence must be kept in stock.

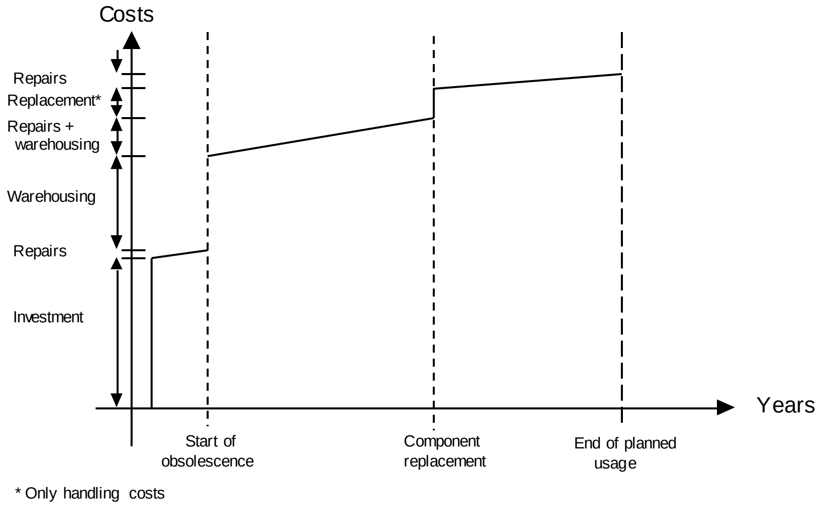


Figure: SOM – typical life cycle cost progression for the strategy variation "warehousing of components due to obsolescence"

This chart illustrates the need to stock the components which will be required after the start of obsolescence for repairs during the remaining usage period or replacements after the end of the service life. Costs at the time of replacement and for regular repairs sink accordingly after the start of obsolescence, as the required components will have already been procured at this point in time. New are the costs for warehousing after the start of obsolescence.

Two fundamental types of warehousing, the costs of which differ significantly, must be distinguished from one another:

- Conventional warehousing "on the shelf";
- Long-term warehousing with measures to preserve usability.

With the first type of warehousing, components are stored – sealed in film, for example – in a typical storage space. For several components, however, this type of warehousing is only possible for a limited period of time, as chemical decomposition, among other effects, is soon detected.

For a longer storage period, many components must undergo special treatment to preserve their usability for an extended period of time. With this so-called "long-term warehousing", components are, for example, stored in special climatic conditions and activated at regular intervals. These additional measures significantly increase warehousing costs.

For some components, the maximum possible warehousing period is too low in comparison to the usage period of the device, or warehousing is too expensive for the required period of time. This makes it necessary to

- Redesign the device (please also refer to VDI 2882, Section 5.1.6)

at the time of the required replacement, instead of pre-emptively warehousing the required components. This device redesign replaces the component which is no longer available with a similar component which can be obtained at that point in time. In such a case, further (generally not insignificant) costs for the redesign of the hardware and, possibly, the device software associated with the component are accrued in addition to the costs for the replacement parts. More details on this issue can be found in Section 5.3.5 (redesign decision model) of the VDI Guideline 2882.

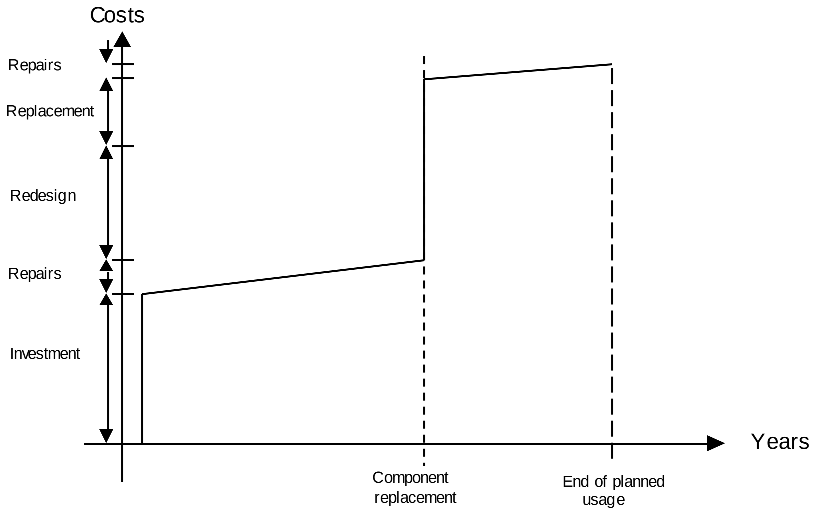


Figure: SOM – typical life cycle cost progression for the strategy variation "replacement of a component due to wear with an alternative component and device redesign"

Annex 1 includes an example which uses a simplified device model to illustrate how to generally implement this kind of life cycle planning.

Life cycle planning for product-related investments

Product-related investments are characterised by a long procurement period focussed on the use of unchanged products for an entire life cycle without the ability to quantify the total number of components at the start of procurement:

- Usage period: Usually several years (15-30);
- Procurement period: Unchanged over several years (often up to 10 years).

Example: A system integrator or train equipper integrates a product (e.g. "driver's cab display") in its standard product portfolio and uses this product in all future project requests and calls for tender.

Since, in the case of product-related investments, the total production number is not known during the life cycle (it depends on a customer's acquisition success in their projects), measures need to be implemented to ensure that the system life cycle remains intact, even in cases of component or sub-component obsolescence. A simple warehousing strategy is not sufficient in this case, as the quantity to be kept in stock cannot be adequately determined.

Schematic examples which illustrate the dependency of the system life cycle on the sub-components are presented below:

System LC: Option A

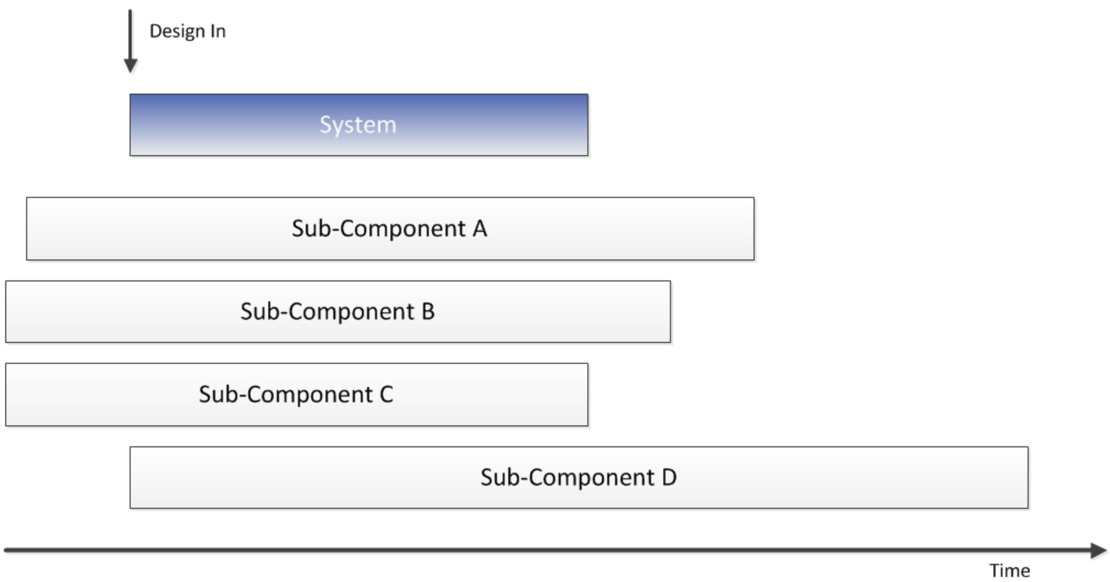


Figure: Ideal status: All sub-components are available for longer than the required system LC

Advantages:

- No obsolescence expected during the system LC;
- A stable system, no changes, no maintenance or replacement costs;
- Spare parts only need to be considered for the time following the system LC.

Disadvantages:

- The shortest sub-component LC defines the system LC;
- Usually does not meet what is expected of the system LC.

Conclusion:

- Ideal for systems with shorter life cycles (e.g. infotainment displays, e.g. 5 years) → Use of embedded components.

System LC: Option B

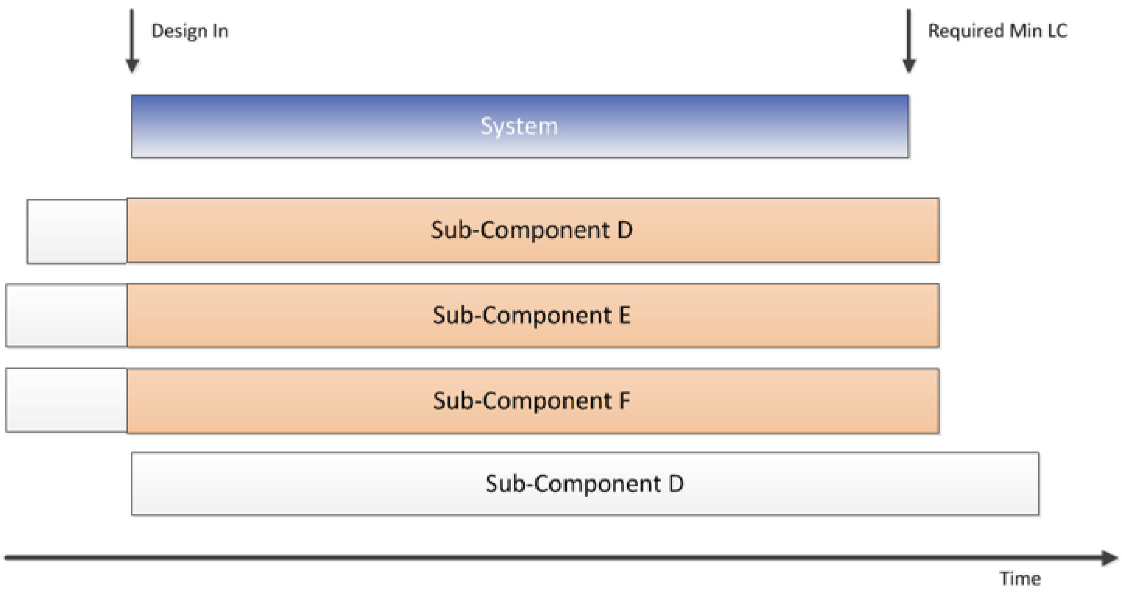


Figure: Solution with a redesign of all sub-components at the start of the system LC

Advantages:

- No obsolescence expected during the system LC;
- A stable system, no changes, no maintenance or replacement costs;
- Spare parts only need to be considered for the time following the system LC;
- The system LC may be longer.

Disadvantages:

- High development costs at the start of the project, long implementation time frame;
- The system LC is limited to the LC of the sub-components; extension is barely possible.

Conclusion:

- This option is usually not acceptable due to the high initial investment costs and long design-in phase.

System LC: Option C

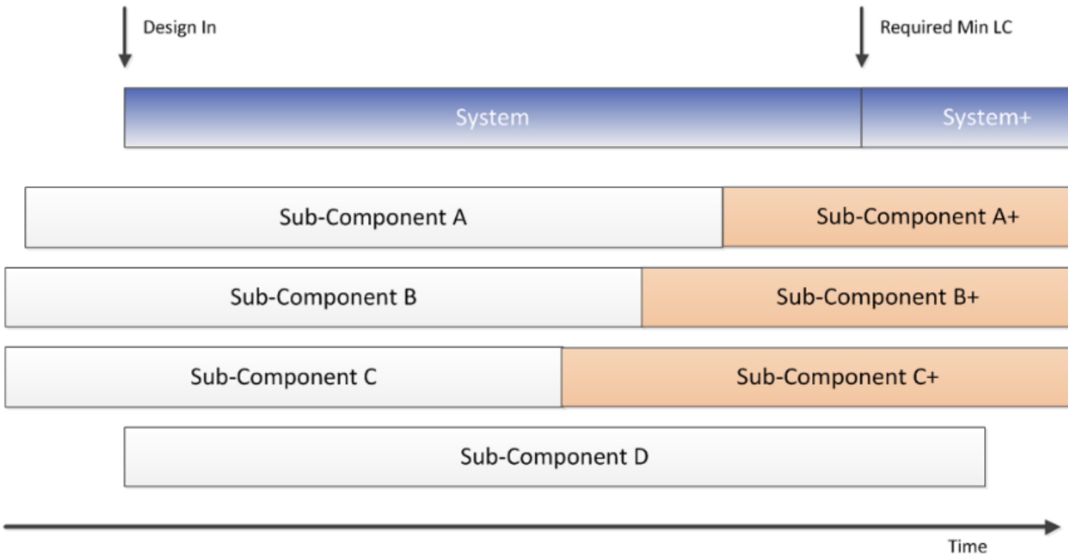


Figure: Pragmatic solution: FFF successor of necessary sub-components to extend the system LC

Advantages:

- No system obsolescence;
- Possible to extend the system LC “indefinitely”;
- Function is always intact – FFF;
- No special consideration and warehousing of spare parts;
- Low development costs at the start of the project (components already available).

Disadvantages:

- Changes to sub-components (redesign / replacement) during the system LC need to be managed (documentation or re-qualification).

Conclusion:

Because of the limitations affecting the investment decision and the preference for a long system LC, option C is the only executable approach.

The chart below schematically illustrates the typical life cycle costs for a complex system comprising modular sub-components for a product-oriented application – i.e. no transparency regarding the total quantity. As described above, the system life cycle is only sensible if implemented in a modular fashion and with FFF replacement types.

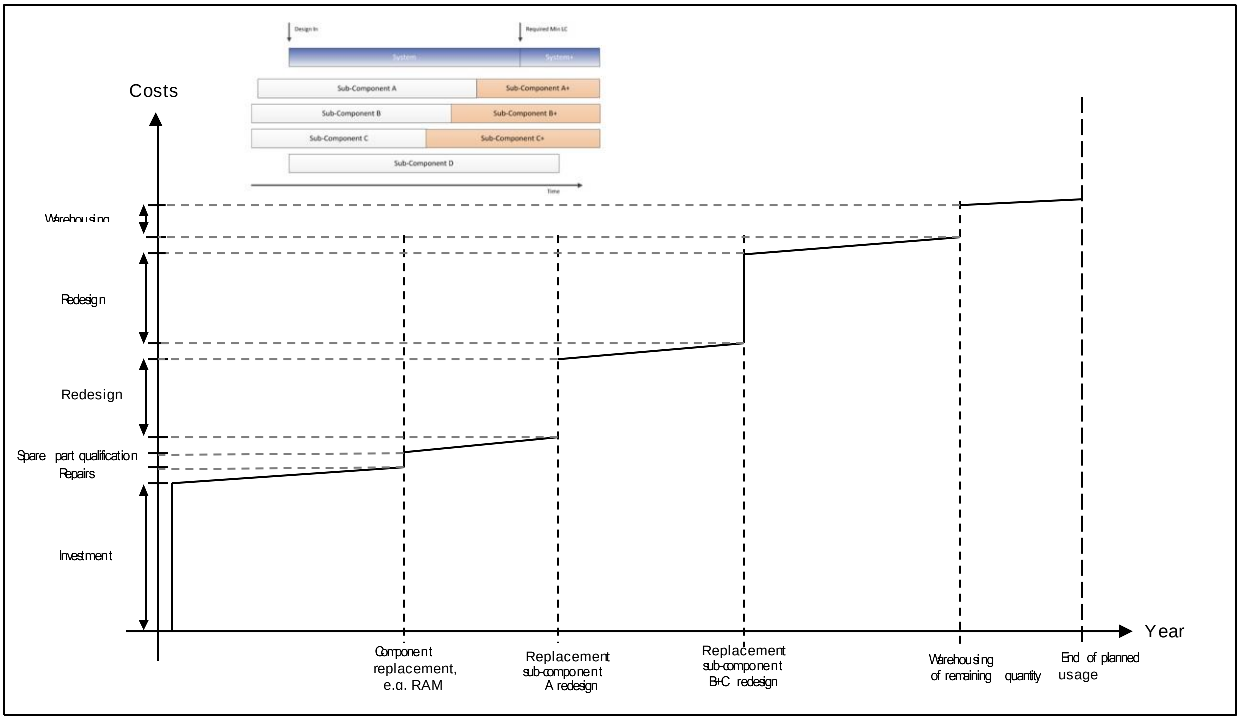


Figure: Typical life cycle cost progression for complex products with a long life cycle and an undefined quantity under consideration of the Form-Fit-Function replacement

To sum up, the following recommendations for product-related investments can be made:

- Systems should be designed in a modular fashion (to make sub-components easier to replace);
- Systems should be equipped with standardised interfaces (to more easily introduce multi-source sub-components as replacements);
- Before the use of sub-components, the LC of such components needs to be clearly identified and evaluated;
- The use of sub-components with an LC shorter than that of the system LC shall be avoided;
- If this is not possible, a replacement scenario shall be established for the affected sub-component;
- Through modularisation and standardisation, only sub-components with a Form-Fit-Function roadmap should be selected (to make an FFF successor available).

Robustness analysis

Here, a distinction is made between the analysis of a component to be procured at the time of procurement and the analysis of robustness at the start of the design phase.

Robustness analysis at the time of procurement

In many cases, electrical systems are not newly developed at the beginning of a project but are rather adopted and integrated from existing products or platforms. This means that sub-components with varying remaining life cycles are being used. To avoid and minimise the impact of future obsolescence, the task force recommends already performing a robustness analysis at the time of the procurement of a solution, system, platform, hardware or software.

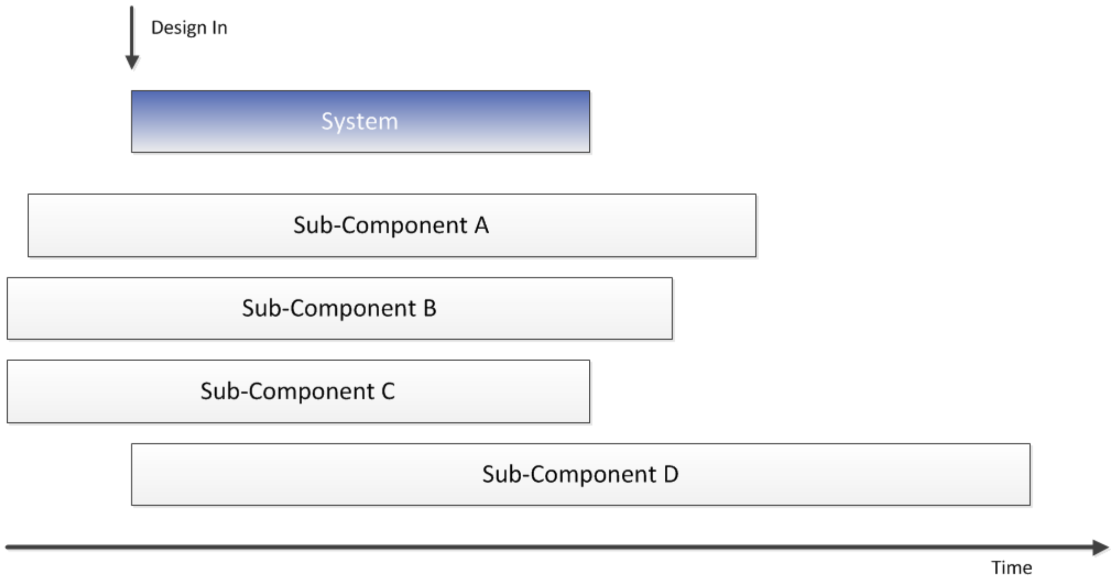


Figure: Varying life cycles of sub-components define the system life cycle

Criteria like modular design, the use of standardisations or the avoidance of exotic solutions should have an impact on calls for tender and their evaluations and can be assessed using checklists for example.

Assessment criteria regarding hardware modularisation / standardisation

- Defined building blocks – reusable, well-maintained circuit components which do not have a life cycle end;
- The use of widely available components and second sources;
- No use of exotic components (e.g. to reduce costs);

- Knowledge of life cycle drivers during the selection of components (e.g. automotive / industrial components);
- The use of standardised interfaces (e.g. Ethernet, MVB, CAN, EtherCAT);
- The use of standardised electrical connectors;
- The use of standardised form factors (3U / 6U Europe card, PCIe MiniCard, COMExpress ...);
- The use of widely available, standardised system solutions accepted by the market (e.g. CPCI, VPX, VME, TCA).

Assessment criteria regarding software modularisation / standardisation

- The use of standardised software solutions and operating systems which are serviced and maintained (POSIX-based OS); this affects the OS and required tools;
- The use, where possible, of OpenSource components (Linux); the avoidance of exotic software products for which maintenance cannot be guaranteed (e.g. QNX and PPC);
- The use of standardised communication protocols (IP, FSoE ...);
- A clear separation of responsibilities when it comes to hardware/software design;
- Independence of application software via abstraction;
- Abstraction of hardware and software using middleware layers;
- A clear and unique interface definition of the middleware layer used;
- Service and maintenance of the middleware layer by the responsible party (e.g. the hardware supplier).

These aspects are based on the foundational recognition that the adaptation of a device to modified environmental conditions is always successful if a device is not designed as a monolithic block but rather has individual areas isolated from one another and connected via well-defined interfaces. When this is the case, the impact of obsolescence is generally limited to one of these isolated areas. A single area is much easier to repair than an entire device.

The most sensible degree of modularisation for any given device must be evaluated individually for each case, as modularisation – as opposed to a monolithically designed device – initially incurs additional costs during acquisition which are amortised successively over the course of the usage phase.

Robustness measures at the start of the (re)design phase

New solutions or partial solutions are often developed at the start of the (re)design phase. To avoid and minimise the impact of future obsolescence, the task force recommends designing the life cycle of the sub-components based on the minimum required system life cycle.

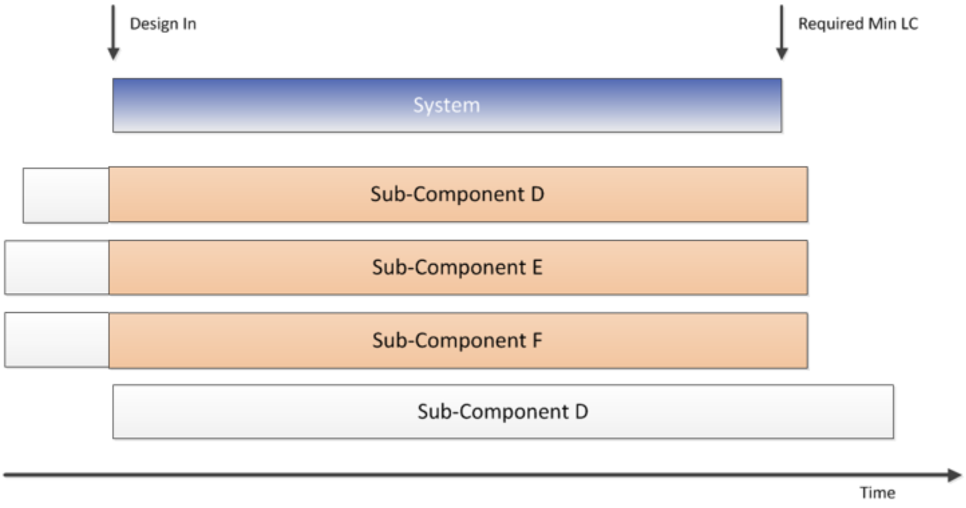


Figure: Development of sub-components at the start of the project

Guidelines which facilitate a robust (re)design to avoid obsolescence are presented below. These guidelines are aimed at solution, system, platform, hardware and software manufacturers:

- The exclusive use of components with an embedded roadmap;
- Exclusion of exotic components;
- The exclusive use of components with a second source (a second or third manufacturer of the same component if possible) (not possible for processors, for example);
- Transparency regarding components with a single source (making active management possible);
- The use of processor architectures which are supported by standard OS (e.g. Linux Mainline) on the software end (software maintenance more probable in such cases).
- The use and selection of components after an equal evaluation of the following criteria:
    - Life cycle / availability;
    - Function;
    - Price.
- Components which do not meet all of these criteria should not be used (important: selection should not be based solely on price and function);
- The selection of components must always be a joint decision by the development and purchasing departments (to consider the criteria above in the same capacity during introduction);
- A uniform component database used by all departments;
- Active obsolescence management for critical components (that is why it is important to identify critical components);
- Assignment of component statuses based on the criteria “proper function” vs. “availability” vs. “optimum cost”.

- Example:
    - P05: Introduction in redesign;
    - P10: Price enquiry;
    - P20: Low quantity, for short-term requirements;
    - P30: Approval for series procurement;
    - P40: Preferred components (e.g. second sources available);
    - P50: Discontinued in due time: Obtainable but no longer “recommended for new designs”;
    - P6x and higher: Remaining coverage, warehousing, reservations etc.;
    - X00: Blocked.
- Maintenance of components in the database using these statuses as a guideline;
- If a criterion is not met → “not recommended”;
- Replace preferred components with new components early; do not apply 6-8 years for redesigns.

Component classification based on the life cycle in the database

When it comes to the selection of components, the use of higher-quality components generally results in associated additional costs as well. Deliberation is essential here, too, to establish which additional costs are sensible, considering whether or not they will produce an optimised result for the entire usage period.

The robustness analysis provides design transparency regarding the approximate effort required to compensate for the impact of obsolescence. This together with the procurement costs for the respective design produces a clear selection criterion.

Annex 4 illustrates a detailed obsolescence robustness analysis procedure.

Process model for minimising obsolescence

The application of a life cycle management process model has proved itself as a method for minimising obsolescence. This model is based on a manufacturer's perspective.

Annex 3 contains an example of an independent process model illustrating the collaboration between the relevant functions of a manufacturer.

Conclusion

The following core insights were established at the obsolescence management workshop by CNA/Cluster Bahntechnik and described in the elaboration above:

Life cycle (LC) information – in particular regarding obsolescence – must be made transparent and communicated with all parties involved.

Investment decisions must take “total cost of ownership” into account – including the impact of obsolescence. Follow-up costs and maintenance costs must be taken into account (LC-optimised products generally appear to be more expensive based purely on the required investment, but the planning of the entire life cycle often results in cost advantages).

Life cycle management is a holistic approach which must not be viewed exclusively at a manufacture or integrator level; all parties involved along the supply chain must be included.

Life cycle management must play a much larger role in contract award systems and calls for tender (so that lower procurement costs are not prioritised).

Life cycle information must be transparently communicated with and requested from all parties involved to avoid life cycle transparency gaps.

Furthermore, life cycle management must be understood as a unit and department overarching process within organisations – collaboration between all departments, such as purchasing, development, marketing, production, sales etc., is absolutely essential.

The roles of obsolescence and life cycle management should not be viewed separately. Coordination between the roles is essential. A joint role is recommended.

List of abbreviations

EOP / EOS	End of Production / End of Sales
EOS	End of Service and Repair
FFF	Form Fit Function
LC	Life Cycle
LCC	Life Cycle Cost
LTD	Last Time Delivery
PDN	Product Discontinuation Notice/Note/Notification
OM	Obsolescence Manager
OS	Operating System
SOM	Strategic Obsolescence Management
SOP	Start of Production

Annexes

Annex 1: Actual-state analysis in terms of obsolescence

The following Excel excerpt illustrates the LC data analysis for complex systems in hierarchical form broken down to a sensible sub-component level.

In the proposal phase, the LC situation can be transparently requested and substantiated with measures which have already been planned using a template like this one.

Hierarchie	Artikelnumme	Beschreibung	Menge	ME	PDN	EOP/EO	LTD	EOS&R
190100-10-00006R	190100-10-00	System XYZ	1,00	Stk	30.12.2017	30.03.2018	30.06.2018	2024-06-30
190100-10-00006	02F011S02-02	CPU 1 Atom1.3GHz,1GB,12TE	1,00	Stk	31.12.2017	30.03.2018	30.06.2018	
190100-10-00006	02F011S03-02	CPU 2 Atom 1.3GHz,1GB,12 TE	1,00	Stk	31.12.2017	30.03.2018	30.06.2018	
190100-10-00006	02F301-01-01	CPCI 3U,6xLAN switch	1,00	Stk	30.12.2015	30.03.2017	30.06.2017	30.06.2022
190100-10-00006	02F401-00-01	Multi I/O 3U CPCI Board	1,00	Stk	30.12.2015	30.03.2016	30.06.2016	30.06.2018
190100-10-00006	180029-03-00	Comm F206-4+4xSA02-11+1xSA02-15Kom	1,00	Stk	31.12.2014	30.03.2015	30.06.2015	30.06.2017
190100-10-00006	17PU20-01-02	PSU: PU20,3U 6HP DC, 120W	1,00	Stk	30.12.2024	30.03.2025	30.06.2025	30.06.2027
190100-10-00006	08AF33-00-00	PSU: 3U 6HP H15 con-panel	1,00	Stk	30.12.2026	30.03.2027	30.06.2027	30.06.2029
02F011S02-02015	08AE43-02-01	Adapt mSATA+Batt.Sock	1,00	Stk	30.12.2017	30.03.2018	30.06.2018	
02F011S02-02015	08SA02-11-01	Adapter 1xRS422,isol.	1,00	Stk	31.12.2020	30.03.2021	30.06.2021	
02F011S02-02015	08SA03-02-01	Adapter 1x RS232,isol.	1,00	Stk	30.12.2016	30.03.2017	30.06.2017	30.06.2019
02F011S03-02011	08AE43-02-01	Adapter mSATA+Batt.Sock	1,00	Stk	30.12.2017	30.03.2018	30.06.2018	
02F011S03-02011	08SA02-11-01	Adapter 1xRS422,isol	1,00	Stk	31.12.2020	30.03.2021	30.06.2021	
02F011S03-02011	08SA03-02-01	Adpater 1x RS232,isol	1,00	Stk	30.12.2016	30.03.2017	30.06.2017	30.06.2019

Annex 2: Life cycle planning under consideration of obsolescence influences

Here, a simplified model of a device serves as an example to illustrate the impact of the new life cycle parameter: obsolescence. A so-called infotainment display, which is common in trains these days, was selected for this example due to its simple design.

Figure: Infotainment display in a train

An infotainment display like this one consists primarily of a TFT flat screen (hereinafter referred to as a TFT panel) and a control computer. The DC/DC converter provides power supply to both of these components. An enclosure (usually made of metal) with a robust front screen houses the two components and their cabling.

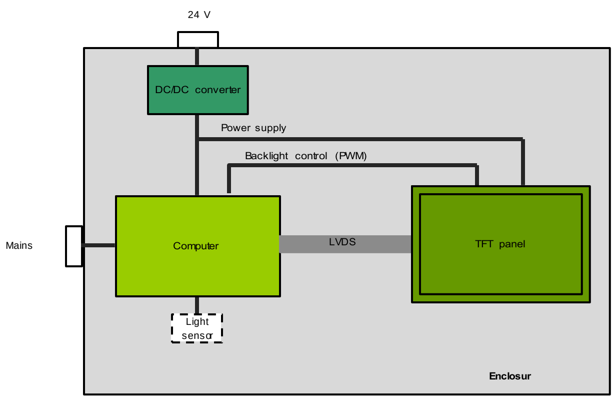


Figure: Design of the infotainment display

Since the enclosure and the cabling are components with long life cycles and long-term obtainability, the following analysis concentrates on the electronic components.

There are two significantly different versions of the main components – the TFT panel and the computer. On the one hand, they are offered as industrial components with long life cycles, but, on the other hand, they are also available on the market as common consumer products.

The main difference between these two versions is the duration of their availability on the market. While consumer components are often replaced by a newer version every six months these days, the obtainability of industrial components is ensured for a significantly longer period of time. This model assumes an obtainability of five years for both of these components.

To place a special focus on the impact of obsolescence in this example, other parameters such as a possibly longer usage period, which many industrial components possess, are not taken into consideration. Both versions were given the same usage periods: 10 years for the TFT panel and 15 years for the control computer. The failure rate was also set at 1% per year for both versions.

This example assumes the procurement of 100 devices in one lot. The devices should be used for a period of 15 years and then replaced by up-to-date versions.

The first segment of the table compares the procurement costs for the industrial and consumer versions of the components. Here, one can see that the two versions are set apart primarily by cost of procurement for the electronic components. In total, the consumer version in this model has a cost advantage of approx. 20% compared to the industrial version in terms of procurement.

The costs used here are based on the average cost of typical designs over the past few years which were then generalised for this simplified model. For example, the warehousing costs for conventional and long-term warehousing were assumed as a whole in relation to the value warehoused. For this reason, deviations from this model are possible and even expected for actual designs depending on their specific version.

At the time of procurement, the consumer version displays a clear advantage, as already described above. This changes, however, at the latest after one year if the significant consumer-version components are discontinued. Since there is generally no roadmap with compatible replacement products in the consumer market, all of the units required for the remaining life cycle of the devices must be purchased and warehoused at the time of the last call.

In addition to the repair requirements for all components, this primarily affects the number of TFT panels which will be needed for replacement after the usage period has expired.

Industrial components also need to be stocked, but only after five years rather than immediately. This somewhat reduces the number of components that need to be stored for repairs, but it is the TFT panels which only need to be warehoused for five years instead of the nine years required for consumer devices.

Since it is generally not possible to warehouse many components for longer than five years without the need for additional measures such as annual activation, it is not only the duration of warehousing that increases for consumer components due to their early discontinuation; the additional effort associated with their warehousing goes up significantly as well.

This already starts, for example, with the complicated research necessary at the start of warehousing which will then be used to evaluate in detail which measures will be required during warehousing.

The alternative to warehousing is a partial redesign of the device at certain points in the device's life cycle. After the redesign, currently available components can be used once again.

The ideal time for a redesign is, for example, the time at which all TFT panels need to be replaced due to their age. If the redesign is done at this time, long-term warehousing – and the associated, not insignificant pool of costs – of these components is no longer necessary.

This model assumes that the control computers will also need to be updated along with the TFT panels during the redesign, as this is the only way to adapt the computers to the new panels.

Finally, keep in mind that this model is only a simplified example used to illustrate basic relationships.

If the procedure illustrated here is applied to real devices, a detailed analysis must be performed in different areas. The development of such refined criteria will be part of the future investigations of the obsolescence management task force at CNA/Cluster Bahntechnik.

TFT-Display - Gesamtkosten

Grunddaten		
geplante Lebensdauer	15	[Jahre]
Anzahl Geräte	100	[Stück]
Lagerkosten "im Regal"	5%	[des Lagerwertes]
Lagerkosten "Langzeit"	20%	[des Lagerwertes]
Handlingsaufwand Einbau Austauschteil	100	[€]
Redesign	50.000	[€]

Anz.	1 Variante Industriekomponenten Bezeichnung	Lebens-dauer [Jahre]	Ausfall-rate pro Jahr	Design Life [Jahre]	max. Lager-dauer [Jahre]	Einzel-Kosten [ca.]
	Zentrale Komponenten					
1	TFT-Panel	10	1%	5	5	250,00 €
1	Computer	15	1%	5	5	300,00 €
1	DC/DC-Wandler	15	1%	5	5	100,00 €
1	Kabel	20	-	-	-	100,00 €
1	Gehäuse	30	-	-	-	200,00 €
	Gesamtgerät					**1.400,00 €**

Bezeichnung	Jahr 1	Jahr 2	Jahr 3	Jahr 4	Jahr 5	Jahr 6	Jahr 7	Jahr 8	Jahr 9	Jahr 10	Jahr 11	Jahr 12	Jahr 13	Jahr 14	Jahr 15
Anschaffung	140.000 €														
Ersatzteile für Reparaturen															
TFT-Panel	250 €	250 €	250 €	250 €	250 €	250 €									
Controller	300 €	300 €	300 €	300 €	300 €	300 €									
DC/DC-Wandler	100 €	100 €	100 €	100 €	100 €	100 €									
Einbau Austauschteil nach Lebensdauerende (nur Handling ohne Material)											10.000 €				
Bevorratung nach Ende des Design Life															
Ersatzteile für Reparaturen															
TFT-Panel						2.250 €									
Computer						2.700 €									
DC/DC-Wandler						900 €									
Komponenten zum Austausch nach Lebensdauerende der Komponente															
TFT-Panel						30.000 €									
Computer															
DC/DC-Wandler															
Lagerkosten initial						5.000 €									
Lagerwert "im Regal"						30.000 €	30.000 €	30.000 €	30.000 €	30.000 €	0 €	0 €	0 €	0 €	0 €
Lagerkosten "im Regal"						1.500 €	1.500 €	1.500 €	1.500 €	1.500 €	0 €	0 €	0 €	0 €	0 €
Lagerwert "Langzeit"						5.850 €	5.200 €	4.550 €	3.900 €	3.250 €	2.600 €	1.950 €	1.300 €	650 €	0 €
Lagerkosten "Langzeit"						1.170 €	1.040 €	910 €	780 €	650 €	520 €	390 €	260 €	130 €	0 €
Redesign															
	140.650 €	**650 €**	**650 €**	**650 €**	**650 €**	**44.170 €**	**2.540 €**	**2.410 €**	**2.280 €**	**2.150 €**	**10.520 €**	**390 €**	**260 €**	**130 €**	**0 €**
Summe		141.300 €													**208.100 €**

Figure: Life cycle planning for a device based on industrial components

TFT-Display - Gesamtkosten

Grunddaten		
geplante Lebensdauer	15	[Jahre]
Anzahl Geräte	100	[Stück]
Lagerkosten "im Regal"	5%	[des Lagerwertes]
Lagerkosten "Langzeit"	20%	[des Lagerwertes]
Handlingsaufwand Einbau Austauschteil	100	[€]
Redesign	50.000	[€]

2 Variante Consumerkomponenten

Anz.	Bezeichnung	Lebens-dauer [Jahre]	Ausfall-rate pro Jahr	Design Life [Jahre]	max. Lager-dauer [Jahre]	Einzel-Kosten [ca.]
	Zentrale Komponenten					
1	TFT-Panel	10	1%	1	5	150,00 €
1	Computer	15	1%	1	5	150,00 €
1	DC/DC-Wandler	15	1%	5	5	50,00 €
1	Kabel	20	-	-	-	100,00 €
1	Gehäuse	30	-	-	-	200,00 €
	Gesamtgerät					**1.100,00 €**

Bezeichnung	**Jahr 1**	**Jahr 2**	**Jahr 3**	**Jahr 4**	**Jahr 5**	**Jahr 6**	**Jahr 7**	**Jahr 8**	**Jahr 9**	**Jahr 10**	**Jahr 11**	**Jahr 12**	**Jahr 13**	**Jahr 14**	**Jahr 15**
Anschaffung	110.000 €														
Ersatzteile für Reparaturen															
TFT-Panel	150 €	150 €													
Controller	150 €	150 €													
DC/DC-Wandler	50 €	50 €	50 €	50 €	50 €										
Einbau Austauschteil nach Lebensdauerende (nur Handling ohne Material)											10.000 €				
Bevorratung															
Ersatzteile für Reparaturen															
TFT-Panel		1.950 €													
Computer		1.950 €													
DC/DC-Wandler					500 €										
Komponenten zum Austausch nach Lebensdauerende der Komponente															
TFT-Panel		30.000 €													
Computer		5.000 €													
DC/DC-Wandler															
Lagerkosten initial		20.000 €													
Lagerwert "im Regal"															
Lagerkosten "im Regal"															
Lagerwert "Langzeit"		38.900 €	38.600 €	38.300 €	38.500 €	38.150 €	37.800 €	37.450 €	37.100 €	36.750 €	1.400 €	1.050 €	700 €	350 €	0 €
Lagerkosten "Langzeit"		7.780 €	7.720 €	7.660 €	7.700 €	7.630 €	7.560 €	7.490 €	7.420 €	7.350 €	280 €	210 €	140 €	70 €	0 €
Redesign															
	110.350 €	**67.030 €**	**7.770 €**	**7.710 €**	**8.250 €**	**7.630 €**	**7.560 €**	**7.490 €**	**7.420 €**	**7.350 €**	**10.280 €**	**210 €**	**140 €**	**70 €**	**0 €**
Summe		177.380 €													**249.260 €**

Figure: Life cycle planning for a device based on consumer components with warehousing

TFT-Display - Gesamtkosten

Grunddaten

geplante Lebensdauer	15	[Jahre]
Anzahl Geräte	100	[Stück]
Lagerkosten "im Regal"	5%	[des Lagerwertes]
Lagerkosten "Langzeit"	20%	[des Lagerwertes]
Handlingsaufwand Einbau Austauschteil	100	[€]
Redesign	50.000	[€]

2 Variante Consumerkomponenten

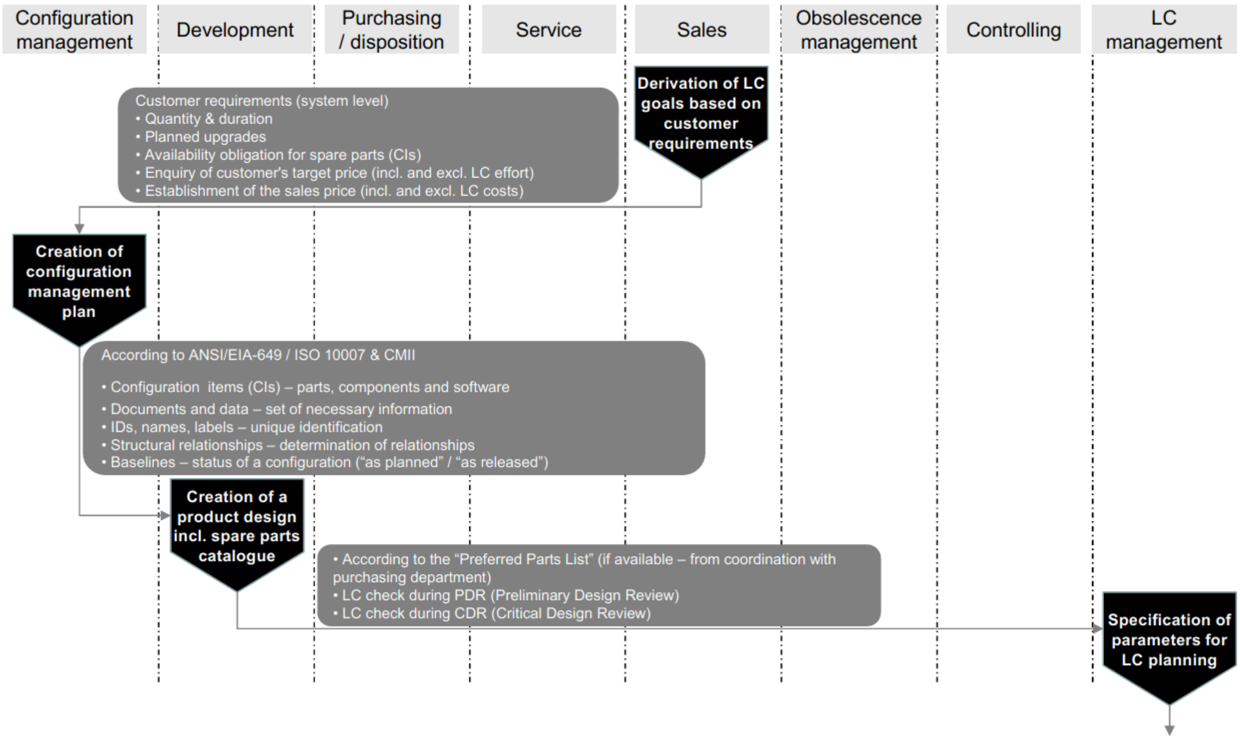
Anz.	Bezeichnung	Lebens-dauer [Jahre]	Ausfall-rate pro Jahr	Design Life [Jahre]	max. Lager-dauer [Jahre]	Einzel-Kosten [ca.]
	Zentrale Komponenten					
1	TFT-Panel	10	1%	1	5	150,00 €
1	Computer	15	1%	1	5	150,00 €
1	DC/DC-Wandler	15	1%	5	5	50,00 €
1	Kabel	20	-	-	-	100,00 €
1	Gehäuse	30	-	-	-	200,00 €
	Gesamtgerät					**1.100,00 €**

Bezeichnung	Jahr 1	Jahr 2	Jahr 3	Jahr 4	Jahr 5	Jahr 6	Jahr 7	Jahr 8	Jahr 9	Jahr 10	Jahr 11	Jahr 12	Jahr 13	Jahr 14	Jahr 15
Anschaffung	110.000 €										30.000 €				
Ersatzteile für Reparaturen															
TFT-Panel	150 €	150 €									150 €	150 €			
Controller	150 €	150 €									150 €	150 €			
DC/DC-Wandler	50 €	50 €	50 €	50 €	50 €										
Einbau Austauschteil nach Lebensdauerende (nur Handling ohne Material)											10.000 €				
Bevorratung															
Ersatzteile für Reparaturen															
TFT-Panel		1.200 €													
Computer		1.200 €													
DC/DC-Wandler					500 €										
Komponenten zum Austausch nach Lebensdauerende der Komponente															
TFT-Panel															
Computer															
DC/DC-Wandler															
Lagerkosten initial		20.000 €										5.000 €			
Lagerwert "im Regal"												900 €	600 €	300 €	0 €
Lagerkosten "im Regal"															
Lagerwert "Langzeit"		2.400 €	2.100 €	1.800 €	2.000 €	1.650 €	1.300 €	950 €	600 €	250 €	200 €	150 €	100 €	50 €	0 €
Lagerkosten "Langzeit"		480 €	420 €	360 €	400 €	330 €	260 €	190 €	120 €	50 €	40 €	30 €	20 €	10 €	0 €
Redesign											50.000				
	110.350 €	**23.230 €**	**470 €**	**410 €**	**950 €**	**330 €**	**260 €**	**190 €**	**120 €**	**50 €**	**90.340 €**	**5.330 €**	**20 €**	**10 €**	**0 €**
Summe		133.580 €													**232.060 €**

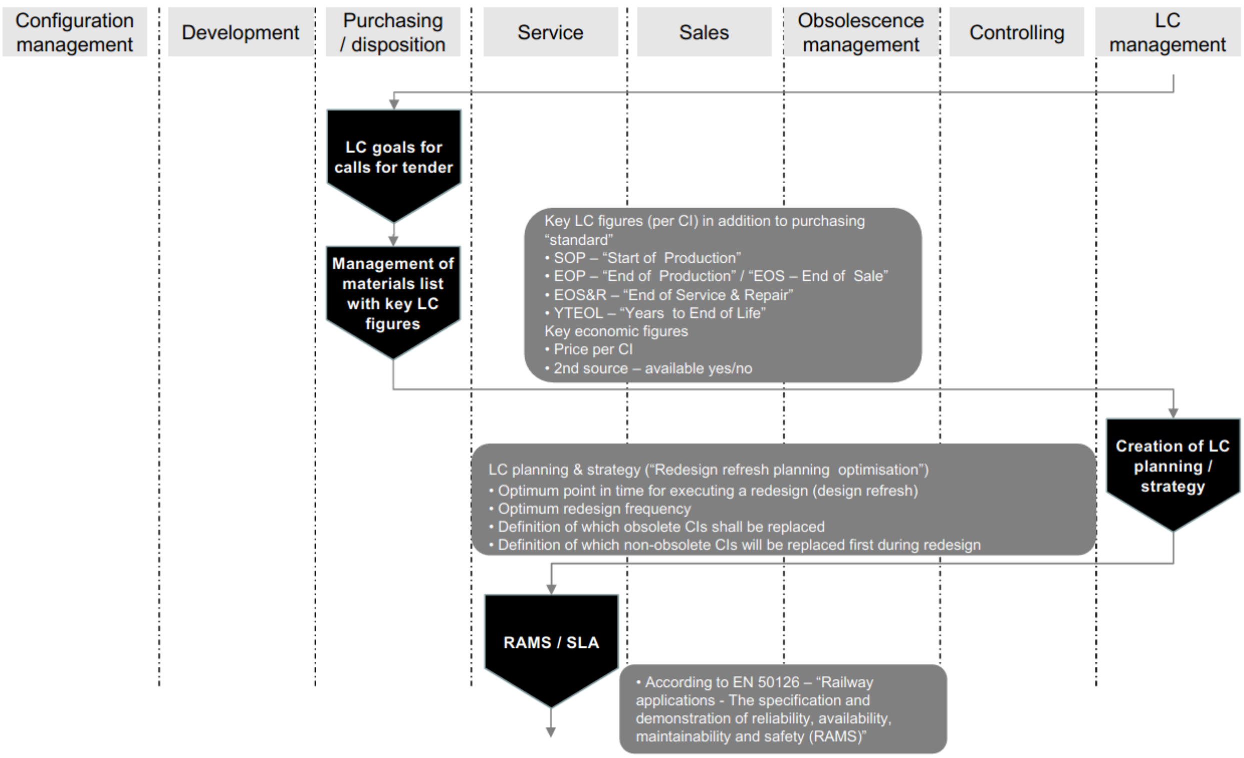
Figure: Life cycle planning for a device based on consumer components with redesign

Annex 3: Process model for minimising obsolescence

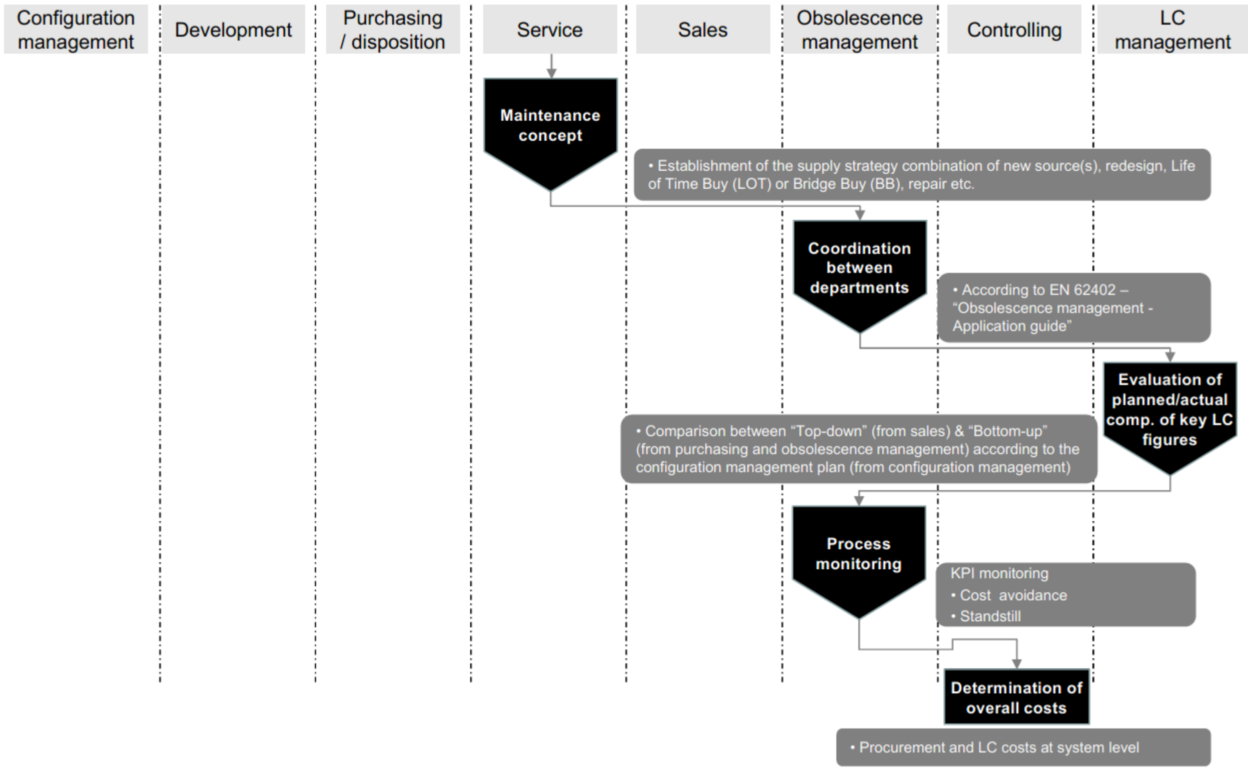
Life cycle management considering obsolescence minimisation from a manufacturer's perspective



Life cycle management considering obsolescence minimisation from a manufacturer's perspective



Life cycle management considering obsolescence minimisation from a manufacturer's perspective



Annex 4: Detailed obsolescence robustness analysis procedure

Cyclical redesigns are done for reasons of (technical) modernisation and for the reworking of worn components and structural parts of a system and ultimately for the stabilisation of technically-critical systems.

These redesigns should also be used to identify sub-components which are obsolete or at risk of becoming obsolete and to find appropriate solutions. To identify risks, an obsolescence robustness analysis should be performed which will identify these risks and form a basis for the development of solutions.

The robustness analysis is primarily done according to the process below. The following figure organises the process according to a milestone concept.

Creation of an obsolescence robustness analysis
Milestone 1 – Identify OM risks
System delimitation and definition
Coordination with partners in the supply chain
Data mining
Identification of affected sub-components
Data analysis
Observation of the maintenance situation
Answering of the maintenance question catalogue
Clarification of repair and rework situations, including an estimation of the availability of documentation, software, test systems, manufacturing procedures/complexity
Estimation of the ageing condition
Creation of an overall picture
Milestone 2 – Develop solution approaches for obsolescence-critical components
Evaluation of the risks of limited reworkability, availability and warehousing ability
Assessment of possible system maintenance solutions
Establish measures for long-term repairs
Identify supply sources for new parts
Analyse recovery potential
Investigate re-engineering / reproduction possibilities
Assess use/cost refurbishment
Assess the substitution of the entire system
Investigate the certification-relevance of changes
Put together a package of measures
Milestone 3 – Coordinate OM strategy
Financial effort estimation per measure
Evaluate the sustainability/efficiency of individual strategies

Create an implementation plan for OM solutions with a procurement strategy
Establish the OM strategy

The analysis results can be viewed as an obsolescence strategy which must be implemented. The redesign can be used if a substitution of the entire system was determined to be beneficial. In all other cases, such as, for example, long-term repairs and the stabilisation of spare parts supply, redesign provisions do not need to be planned, as the system and its sub-components will not be changed.