OBsolescence Management

A “White Paper”

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SUMMARY

Obsolescence Management is not a traditional ‘Asset Management’ concern but in terms of maximising the return on deployed electronics assets it will be one of the most important categories in the years to come.

The best way to protect against Obsolescence is to consider it right at the start of a new project.

This doesn’t happen often enough. Obsolescence is generally considered for the first time when it’s no longer possible to repair a system because the parts are already obsolete!

If an existing electronics system asset has an expected life of 10 years, this can be extended it by at least a further 10 years. On a typical trainborne system costing circa £10M for a fleet of 100 trains, this can mean saving a complete replacement cycle of £10M for around 5% of the cost (i.e. £500k spread over 10 years)

The question is no longer “How to mitigate the risk?” but “How to estimate the cost and manage it?”
ELECTRONICS LIFETIME

In the context of a whole life plan, electronics is one of the most challenging commodities for deployment in the Rail or Military Industrial sectors.

![Component life evolution](image)

In the 70’s it was considered that the electronics components lifecycle would be at least 20 years. By the time we arrived in the 21st century, the product lifecycle had reduced to around 5 years. Today, that timeframe has reduced to – in some cases less that 1-year!

The challenge is how to embrace and manage within these constraints. Nothing individual companies can do is likely to alter global technological advances.

There are several other important characteristics to consider:

- Suppliers no longer design specific components for military or commercial programmes. They are too expensive.
- Component development is driven by telecom & computer industries:
  - This favours rapid innovation and low costs rather than long-term availability and robustness.
- Rail system suppliers are small sized consumers with limited leverage
- Components manufacturers continue to merge and leverage scale factors
- Technical & environmental evolutions: Voltage (5V → 3.3V → 2.8V → 1.06V→...), Miniaturisation, lead free terminals, Surface mount technologies...
- All components are impacted (including connectors, heatsinks, transformers, etc.)

Most products on trains today use ‘First Generation’ technology, utilising ‘leaded components’ with minimal (but growing) use of Surface Mount devices.

This is both good and bad:

Its ‘Good’ because it is still possible to ‘repair’ damaged or obsolete systems as the tools and techniques to achieve this are well know and widely available.
These processes are also ‘affordable’ in terms of local company budgets.

Its ‘Bad’ because unless provision has already been made, the chances of obtaining ‘fresh’ components or sub-systems to repair those in service, are slim at best or non-existent as a norm\(^3\). This lack of foresight, or lack of whole life planning is typical of the industry response in general.

The only solution in many cases is to reproduce the existing function with modern components --- at, enormous additional cost. Existing system reproduced with new components still need the design, development and exhaustive testing demanded by the safety related nature of the industry.

This process is hugely wasteful of enterprise and opportunity. Industry could be developing new products for new customers but is instead dissipating time and resources putting right the failures of poor whole life planning.

**Electronics systems Reliability**

The main difference between electrical and mechanical reliability is that generally electronic systems do not wear out (with some exceptions). While there are debatably some wear out mechanisms such as electromigration and component parameter drift, electronic systems behave in a fundamentally different manner to mechanical ones.

To aid understanding of these issues, let me introduce the classical visualisation of reliability: The Bathtub curve:

![Bathtub Curve Diagram](image)

The curve can be broken down into 3 basic sections:

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\(^3\) Transform Technology Ltd provides obsolescence audit and assessment for a wide range of electronic systems.
The first section is characterised as ‘Early life failures’ and a decreasing failure rate as the new system is ‘bedded in’. In the second section we can consider the component as operating in the ‘mature’ region of its whole life curve, where it tends to exhibit ‘Constant or Random failures.’ The final part of the curve depicts the expected ‘Wear Out’ characteristics of the system or component.

Modern electronic equipment is largely constructed from semiconductor devices that have no real short term wear out mechanism, hence the existence of a wear out element of the curve is not particularly well understood. For most electronic components, this wear out section is still relatively flat. What designers really need to understand is how electrical systems fail so they can take this into account in the design, and mitigate the effects.

Not all electrical components follow an exponential failure rate. Electrolytic capacitors break down over time, generally due to the ‘drying out’ of the ‘wet’ electrolyte contained in their manufactured structure. This reducing volume of ‘wet’ electrolyte eventually prevents them from operating as capacitors and the system in which they were operating, fails. It is not safe to say therefor to say that electrical system cannot wear out. It would be fair to say we don’t understand all the failure mechanisms and so wear out prediction is difficult and a first order estimate at best.

In simple terms, the designer needs to recognise the existence of the ‘Obsolescence Factor’ and plan designs to mitigate it. Obsolescence is a fact of life.

**Whole Life Reliability**

- Electronic components don’t wear out in the traditional sense of the word. Instead, they can undergo parameter drift. Some components do wear out, such as electrolytic capacitors and optoelectronic isolators.
- Reliability cannot be an afterthought. It must be a goal from the beginning of the design phase.
- Subsystems most commonly wear out from environmental exposure such as corrosion, fracture of connectors, etc. This can be a result of extreme temperatures, humidity, salt spray, moisture, dust, sand, vibration, shock and electromagnetic interference.
- Care must be taken not to expose designs to conditions outside their rated specifications.

Reliability improvement is achieved by being data-driven. Without the data on the components, subsystem or system being designed, reliability cannot be guaranteed. There is little point in trying to ‘test’ reliability into a completed design. This leads to wasted effort and significant additional expense.

Whole Life Reliability needs to embrace the obsolescence requirements of a system. The designer need certain parameters at the beginning:

- When you start?
- How long the system is required to perform its function?
- Whether any levels of degradation can be tolerated?

Without this information, the wrong system will be designed --- it will be either over engineered and too expensive or under engineered and fail within its expected lifetime.
‘A STRATEGY FOR ELECTRONICS SYSTEMS MAINTENANCE’

‘Proactive Refurbishment’: A Fundamental change in maintenance strategy

For many years, the conventional wisdom has been to replace so-called ‘life expired’ Electronics components at an interval similar to that of their mechanical counterparts. It has already been argued\(^4\) that electronic systems don’t in general suffer the same ‘wear out’ characteristics of their mechanical counterparts.

Having collected a large amount of failure data as part of a specific Metro Train Reliability Project, it can be confidently predicted that with the exception of three component types\(^5\), the Electronics systems deployed today as part of the Passenger Information System can be refurbished to function effectively for at least a further 10 years. This enabled the Customer to save two thirds of the costs of a complete system replacement for the investment of around 3% of the planned replacement system budget.

Electronic Systems can be categorised into two basic categories. These are:

- High Power Electronics (Category 1)
- Low Power Electronics (Category 2)

**Category 1 systems** include items such as the Traction System Power Electronics and any High Power systems (which dissipate in excess of 200 watts)

**Category 2 Systems** include: The Passenger Information System, CCTV and Communications systems and any of the TMS related systems etc, (generally which consume less than 100 watts of power.)

Category 1 products need to continue with a regular replacement strategy, as they become ‘life expired’ from operating in high stress environments (combined high temperature and vibration.)

Category 2 products will generally have a useful life of more than 20 years providing certain ‘exception’ components are considered in more detail.

These ‘exception’ components include:

- Electrolytic capacitors,
- Internal ‘PCB-type’ connectors,
- Opto-electronics components (opto-isolators).

The remaining components require obsolescence planning, procurement and customised component retention\(^6\).

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\(^4\) Electronics components don’t generally ‘wear out’

\(^5\) Electrolytic Capacitors; Internal Connectors; Opto-isolators.

\(^6\) Customised Component Retention includes the packaging of components in environmentally stable conditions with regular testing and annual audits of component parametric function to ensure that if a component were actually needed, it would perform to its original specification.
**CATEGORY 1 SYSTEMS**

Category 1 systems include, in the main, Power related Traction Systems, Subsystems and components. These systems are usually house in areas of relatively high thermal and vibrational stress. On many Metro Train installations, the Electronics are house affixed to the wheel bogies or slung under the train body in Traction Cases purposefully designed to house the electronics in as benign an environment as can be arranged, give the usual space constraints.

Many category 1 systems are used in the conversion and transformation of voltage levels of kilovolts together with drive motor current requirements of hundreds of amps. These systems need very careful and specific maintenance and renewal.

Because of the propensity of these systems for catastrophic and sometimes spectacular failure mechanisms, the System coping strategy is usually one of ‘Redundancy’ where the temporary loss of one subsystem in normal service does not mean the asset or vehicle needs to be taken out of useful service immediately.

**CATEGORY 2 SYSTEMS**

Category 2 systems include:

- The Passenger Information Systems and its components
- Track to Train CCTV Systems
- Saloon CCTV Systems
- Platform CCTV Systems
- Train Management Systems
- Radio and Communications Systems
- Radio Communication Systems, etc.
- Station based systems in general
- Track mounted Signaling systems

They are characterised by being ‘low power systems’ which are usually contained in relatively benign environments (in the Drivers Cab or Passenger Saloon areas on rolling stock) and they are not generally associated with vehicle traction.

Theses systems can be safety critical – like the Track to Train CCTV systems, which the Train Operator uses to determine whether there is any obstruction in any of the Saloon doors prior to moving off from a station, or the systems can be ‘support’ systems providing Passenger Information on destination and progress throughout the journey.

A further point of commonality of such systems is that they use first or second generation electronic components and assembly techniques (leaded components with double sided Printed Circuit boards) and are now approaching obsolescence if they have been on the trains for up to 10 years.

When these systems were first designed 20 years ago, Surface Mount techniques were becoming established in the Consumer Electronics sectors and certain Automotive Suppliers were deploying them in vehicle systems for the first time.
The advantage that the Rail industry has today is that these installed systems are repairable. It is possible to remove and replace components without compromising the integrity of the circuit board or the reliability of the system.

**The biggest problem today is that few companies have made provision to obtain and retain the obsolete components from which these systems are constructed!**

The next generation of components and systems will be much harder to maintain and virtually impossible to reverse engineer by third parties. It is therefore vital that systems designed with today’s components are fully documented and that the Customer has access to that documentation via an ESCROW agreement.

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7 Reverse Engineering is the technique of recreating the design documentation and functional specification of a system, subsystem or component by knowing what it does and measuring it functional and physical parameters. This information can then be used to reconstruct a functionally equivalent device using present day techniques and technology. The difficult arises today from the use of multilayer Printed Circuit boards, which make the task of tracing the interconnectivity between components virtually impossible or at least prohibitively expensive!

8 ESCROW is “An account established by a broker, under the provisions of license law, for the purpose of holding materials on behalf of the broker's principal or some other person until the consummation or termination of a transaction or agreement.” Transform Technology Limited offers this facility for Design Documentation and Software code.
OBsolescence Management: TranTech’s Approach

From the diagram below, the Product lifecycle phases are matched by the clear need for parallel Obsolescence Management. Nothing should be left to chance and nothing missed from the analysis.

Obsolescence is a fact of life. It needs to be treated with the same seriousness as any other business metric.

Investing in Obsolescence Management is as important as planning the next project or the next item of capital investment. It’s as important as running the monthly Profit and Loss calculations or VAT returns.

Adopting a Proactive Obsolescence Management Process is crucial to minimise project. This is a continuous process, not something that is ‘done once’ and forgotten about.

Components and systems go obsolete all the time so it’s important that the business is protected by a regular component audit.
CONCLUSIONS

A properly constructed system design should take into account the realities of obsolescence.

Everything goes obsolete in time, however with due consideration the effects of obsolescence can be mitigated to the point where the effect is nullified.

The earlier ‘Obsolescence’ is considered in a Project, the greater the project's likelihood of continued success.

Remember:

The earlier the identification of a part obsolescence problem, the more options are available

Trantech can help identify Obsolescence issues
APPENDIX A: COMPONENT STORAGE

One of the most challenging aspects of managing obsolescence is how to guarantee you have the necessary components needed to repair your system many years into the future?

Many traditional ‘Stores’ organisations, be they internal or external to your business, are not set up to store electronic components (or anything else for that matter) for the long term.

In these days of ‘Just In Time’ (JIT) ‘Stores space’ is generally unsuited for long-term storage of critical and sensitive components. Too often, having supposedly identified and ‘quarantined’ parts, when they are required, they have fallen foul to the latest ‘stock check’ or Stores ‘tidy up’.

Invariably they are not where they were left!

STORAGE CRITERIA

Long-term storage of sensitive electronics components requires something more than just assigning them to a cardboard box and leaving them on the shelf.

Electronic devices are variously sensitive to extremes of temperature, vibration and humidity. They are also sensitive to Ultraviolet Light, Radio Frequency Energy (RFE), and Static Electricity.

Any long-term storage of such devices should be considered with these criteria in mind.

Electrolytic Capacitors of both the ‘wet’ and ‘dry’ constructions need ‘reforming’ during their storage life otherwise when you come to use them, they won’t exhibit the characteristics they had when they were factory fresh.

Certain semiconductor devices are sensitive to UV light – by design. Early generations of EPROMS in particular could have their memory ‘erased’ by being exposed to UV light.

Don’t forget those ‘hard to find’ connectors and transformers. They also need to be stored and kept in a similarly benign environment to ensure they function when you need them to.

Components should be tested prior to storage and that included parametric testing of any Integrated circuits to ensure that those you have stored can be used in your circuits. There is no point in storing devices that are untested – and maybe even empty plastic packages as one of our customers discovered when we began to test his components!

Your provider should be capable of a continuous audit and test the stored components. Nothing lasts forever, but better to find that out before they are needed.

Your provider must also be able to advise of future obsolescence risks. Just because sources were checked this year doesn’t mean those sources will still be available in 12 or 18 months time.
Our Offering

Transform Technology Limited offers expertise that assists Customers achieve an obsolescent-free future.
APPENDIX B: ESCROW

Escrow Agreements are a tri-partite agreement under which a system or software developer agrees to deposit a copy of the software source code or design documentation with an escrow agent.

The escrow agent undertakes to the developer and the developer’s customer that he will deliver a copy of the source code or critical documentation to the customer in certain circumstances (as set out in the agreement). These circumstances include in their basic form the developer’s insolvency.

Increasingly agreements are being drafted to include additional triggers for release where a developer fails or refuses to provide maintenance / support in a timely manner.

MATTERS TO CONSIDER WHEN THINKING ABOUT ENTERING INTO AN ESCROW AGREEMENT:

WHAT ARE THE OPTIONS?

There are many options to consider when choosing Escrow as a means to secure documentation and Software that might be needed:

• How much would it cost to go to a third party to reverse engineer the system or write the support software?
• Are third party providers prepared to run with proprietary software or designs generated by another company?
• What will be the transition time?
• What are the migration costs?
• What are the initial and ongoing costs?
• Who will pay for the costs - the developer or the customer?
• What will happen if there is a dispute between the software developer and the customer?
• How will the escrow agreement be policed if there is a problem or dispute?
• Is the developer required to regularly deposit fresh up-to-date code or documentation? Old documents or code that is out of date will be of little value to the customer!
• Is the escrow agent independent?
• Will the agent allow for the deposited escrow material to be tested or verified?
• Who will pay for the cost of this?
• What exactly will be deposited? Whatever it is it needs to be in the correct form / format necessary to enable a skilled practitioner to understand it and to run with it.
• Can Escrow deposits be reviewed without added costs?
• Does the Agent provide online access to at least the Escrow list of material?
• What is the procedure for release of the escrow material? How long will it take and what are the costs associated with it?

Any third party tools required to maintain the Escrow material, ought to be considered and costed in the proposal.
APPENDIX C: ELECTRONICS SYSTEM FAILURE MODES

Electronics systems have different failure modes and life considerations compared to their mechanical counterparts.

The ‘killers’ for electronics are ‘high temperature’ and ‘vibration’

There are 3 major failure modes for such systems:

1. The electromechanical interface: anywhere a ‘mechanical’ connection is made between the components, systems and their external environment
2. Electrolytic capacitors ‘dry out’ over time, losing their function.
3. Optoelectronic devices become ‘dim’ and progressively lose their function.

The average life of a correctly designed ‘Electronics System’ in a Metro Train is between 20 and 30 years depending on:

1. The Environment regarding high temperature and vibration
2. The Power consumption/dissipation of the unit
3. The ability for a Train Operator to physically interact with the system
4. The susceptibility of the system to vandalism

The other indeterminate failure mode results from particular component ‘obsolescence.’ This is invariably the final ‘killer’ of an electronics system in the rail sector.