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TITLE: Future Initiatives for Obsolescence Mitigation Strategies

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Future Initiatives for Obsolescence Mitigation Strategies

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Abstract The accelerating pace of technology change requires new approaches to the design, manufacture and through life support of military and long life cycle commercial platforms to minimise the effects of short-term technology obsolescence. The purpose of this paper is to describe medium and long-term strategies for the mitigation of obsolescence currently being considered in the UK. All complex military equipments are at risk from the effects of unmanaged technology obsolescence before and after they enter service. A systems engineering approach is described for the evolution of strategies that would involve co-operation between users and manufacturers to produce affordable through life solutions

Introduction Technology obsolescence in military and commercial long life cycle systems is now occurring at a far faster rate that at any other time in contemporary history. The gradual demise of military qualified parts and the availability of state of the practice Commercial off the Shelf (COTS) technology requires smart technology obsolescence management and technology insertion techniques to achieve and maintain military and commercial advantage.

The average rate of change of technology for semiconductor-based components available to meet future military requirements is expected to continue to decrease from its present three year term to less than two years by 2005. Components, which are presently being designed into new systems, have a high probability of being obsolete when the equipment enters service and unavailable when subsequently required.

Today the major thrust of electronics technology development is almost entirely dominated by high volume commercial requirements to satisfy the rapidly expanding market opportunities for video games, personal computers, mobile communications systems and new developments in the automotive industry. The computer and communications industry alone accounts for more than 70% of the market share. Although the military requirement for semiconductor products is now far greater than it has ever been, its actual share of the market has dropped from greater than 90% in the 1970's to less than 0.5% today. The projected growth and viability of these markets is such that satisfying the military requirement takes a low priority with the major semiconductor manufacturers many of whom have now withdraw completely from this market sector.

The military is increasingly not the instigator of the design process for products that it requires in weapons platforms and has to react and respond to the imperatives that drive the process of change in the commercial market place.

The introduction of COTS components into military systems enables new technology to be incorporated quickly and at a fraction of the cost of traditional MOD funded research. These benefits are however accompanied by concerns of inadequate environmental robustness, the lack of traditional military screening processes and short-term commercial technology life cycles. Commercial product life cycles in turn create problems of accelerating functional and component obsolescence, resulting in the requirement to deliver frequent technology upgrades into systems that have not been designed

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to accommodate new technology insertion on a regular basis.

Whilst semiconductor technology obsolescence is a cause for long-term concern in the support of electronic components, other areas of technology obsolescence ranging from mechanical components to software are beginning to impact cost and operational through life support issues. Many of these technologies are inextricably linked within an equipment requiring a systems engineering approach to obsolescence management and not the conventional components based discrete technology solutions.

Research in DERA is showing that in future systems there is a growing interdependency between obsolescence solutions, reliability concerns and COTS insertion. Future obsolescence solutions have to ensure that all these areas of technology are addressed if the goal of effective low cost through life support is to be met.

The Present Management of Obsolescence: Within many organisations obsolescence management, if it is done at all, is done reactively. It is very rarely part of the design, development and sustainment policy and certainly the costs of reactive obsolescence management are generally unknown.

Within the military and most defence contractors obsolescence problems are generally solved serially within projects, on an ad hoc basis, with no lessons learnt feedback to other parts of the system or across the organisation. This situation arises as a direct result of the reactive nature of obsolescence management with the problems mainly being discovered during repair in response to equipment failure. At the time the parts status is discovered it may be to late for last time buys and the part is no longer available. Considerable cost may then be involved in finding an equivalent part or in the worst case having to redesign the system. The fact that an equivalent part can be found may only provide a short-term solution since the total parts obsolescence status of other components on the board or other boards within the equipment is not known.

The DERA approach takes a proactive systems engineering view of obsolescence management encouraging a “no suprises” culture that provides time to devise affordable solutions which can then be implemented across multiple platforms.

Obsolescence Management Tools: The DERA obsolescence management tools allow the customer to minimise future obsolescence at the equipment development phase, determine the obsolescence status before procurement, plan the most cost effective timescales for in service technology updates and manage obsolescence in legacy equipments to extend their service life.

The tools consist of a relational database, EPIC 2000, and ITOM an equipment configuration tool that allows the total parts distribution to be viewed at any level of indenture in a system.

The Electronics Parts Information Centre (EPIC 2000) contains information on over 1.2 million semiconductor devices consisting of:

- Original Component Manufacturer
- Full Parametric Information
- Availability Information
- International Parts Reference Numbers
- Possible Equivalents

The Integrated Technology Obsolescence Manager (ITOM) is a configuration management tool that can identify all the hierarchical levels in a military platform and populate them with data imported from the EPIC 2000 database. The functionality of ITOM is such that it is possible to obtain obsolescence information at discrete device, board, assembly, cabinet, LRU, system or platform level. It also has the ability to address any combination of multiple platforms and build standards.

The operation of the ITOM tool is via user friendly screens that follow logical paths to determine the current and projected availability of components at any level of indenture in a system or system of systems.

An availability code on each component indicates the timescales to obsolescence up to a maximum predicted value of 8 years. The predicted obsolescence timescales are derived from life cycle algorithms, which are continuously reviewed against expert opinion and knowledge of technology trends.

Methodologies The EPIC2000 database can be used as a stand alone tool that can be addressed by the user with single or multiple enquiries. This approach is however not recommended since it does not provide an overall view of the total obsolescence problem and can lead to increased cost of ownership with time.

For Military and Defence Contractor requirements, obsolescence is generally addressed on a project by project basis. Using the ITOM tool the system configuration is populated from customer furnished parts lists and then managed, on behalf of the customer through out the equipment life cycle. The customer is provided with regular obsolescence health check reports and priority alerts to inform of unexpected component non-availability. At any time the customer can receive suggested equivalents or alternatives to obsolescent parts to enable decisions on the most cost effective solutions to be reached.

The Evolution of Obsolescence Management:
At present in most legacy systems military grade qualified parts are still the norm. Obsolescence is managed via a combination of available military equivalents or best case commercial parts. Many of these systems however still have predicted future in-service lives in excess of 30 years or more with the result that the management of obsolescence at component level will become increasingly more difficult as the original military and equivalent commercial discrete devices become obsolete.

The accelerating rate of commercial technology and the proliferation of short lifetime COTS components in military systems will inevitably have an effect on the way technology obsolescence management evolves. Conventional component level obsolescence management tools will themselves become obsolete as new innovative semiconductor packaging and board level technologies move the lowest levels of system integration from discrete components to integrated board level assemblies.

Before this point is reached it is possible that functional obsolescence will demand a technology insertion which will increasingly be at board or subsystem level. It is most likely that the board level insertion will be a COTS component or a custom design containing COTS components.

The evolution of high density packaging techniques [1] for IC products is mirrored by new developments in board level technology that can take maximum advantage of Direct Chip Attach (DCA), Flip-Chip, Multi Chip Modules (MCM), Chip Scale Packaging (CSP) and Systems on a Chip technologies. These technologies are not designed to be repaired and attempts to do so will have unpredictable effects on reliability. The market for these new technologies is increasing very rapidly and future predictions show that as soon as 2002 they may account for about 8% of the total worldwide IC market.

It would seem probable therefore that obsolescence management will have to be delivered in a number of parallel ways in time scales determined by the availability of discrete device technology and the introduction of new integrated board level components. Conventional component level obsolescence management will have a window of opportunity after which the emphasis will change from delivering parts availability information, providing solutions bases on equivalent or alternative components, to that of advising on the time scales for the most cost effective new technology insertion at board level.

The period of twenty years or more that characterises the evolving obsolescence management strategies will be one were Military/Industry partnerships are vital and lessons learnt are widely disseminated across the stakeholder base.

National Obsolescence Centre Concept:
The concept is based on combining the resources of DERA and Industry to address present and future obsolescence management on a national scale and leverage this holistic advantage to provide a fast comprehensive low cost service to all the stakeholders.

The goal of the National Obsolescence Centre is to globally manage tri-service obsolescence problems in new and legacy equipments and play an active role in devising future obsolescence mitigation strategies jointly with MOD, DERA and Industry.

At present obsolescence is managed with a scattergun approach throughout MOD and industry. The cost penalties of this uncoordinated approach could eventually impact the defence budget to the detriment of R&D and new systems procurement. The formation of a focussed national obsolescence centre would enable a system engineering approach to be adopted for the global management of obsolescence over the total MOD inventory. The single focus for all obsolescence information holds the promise of rapid response, economies of scale, and the elimination of duplication across the supplier and customer base.

The eventual requirement for the Centre would be to maintain a range of component databases, with current availability databases that would include:

- Semiconductors
- Passive components
- Connectors
- Cables
- Electrical components
- Relays
- Batteries
- Electro-optical components
- Microwave components
- Mechanical components
- Software
- Lessons Learnt

The lessons learnt database is a generic concept for describing the repository of solutions for obsolescence problems. For most of the component databases solutions such as equivalents, are an integral part of the individual technology database structure.

A physical lessons learnt database would contain information on custom solutions to electronic and mechanical problems including the future provisioning of sole sourced devices such as ASICS. It will address many of the "learnt from experience solutions" to COTS procurement and insertion problems throughout the equipment life cycle.

For most major defence contractors a large proportion of their output is dependant on the added value provided by Small to Medium size Enterprises (SMEs) who are finding it increasingly difficult to carry the financial burden of obsolescence management. Whilst the initial thrust of the National Obsolescence Centre will therefore be to provide an affordable obsolescence management service to small and medium size companies it the capability to service any level of stakeholder involvement.

Total Inventory Obsolescence Management: If the total hierarchical structure and component population of all MOD equipments were lodged at the Centre a health check of all equipments could be performed on a regular basis and the customer informed of component alerts and the timescales in which they need to be addressed. In this way the total costs of managing obsolescence across MOD would be dramatically reduced since there would be no suprises and adequate time would be provided to determine the optimal remedial actions.
The same service could be provided for long life cycle commercial platforms in the aerospace, oil and medical industries where economies of scale could significantly reduce through life costs.

The alternative is to continue the present trend and create a series of unique solutions to a single problem across the total customer base with increasingly large cost and deployment penalties to the customer.

Built for Life Electronics
A Research project has started in FY 99/00 that will specifically address the development of Built for Life Electronics based on the principles of Physics of Failure [2]. Physics of Failure technique have shown that failure mechanisms are far from random and it is becoming possible to predict failure times of electronic assemblies with a degree of accuracy that promises the capability of invoking the concept of a guaranteed life. The technologies for guaranteed life or maintenance/failure free operating periods (M/F-FOP's) are currently being funded by MOD, DERA and many of the major defence contractors in the US and Europe through the CALCE initiative at the University of Maryland. The DERA programme will investigate the applicability and impact of these techniques at system level and the possible future direction of this type of research within DERA and industry.

Physics of Failure (PoF): Physics of Failure is an approach to develop reliable products that uses the knowledge of root cause failure mechanisms to prevent product failures in the field by incorporating PoF at the product design stage.

The PoF approach incorporates reliability into the design process by establishing a scientific basis for evaluating new materials, structures and electronics technologies. An important aspect of the technique is the ability to predict the time to failure of specific failure mechanisms throughout the system geometry.

The Physics of Failure approach involves:

- Identifying potential failure mechanisms including, chemical, electrical, physical, mechanical, structural or thermal
- Identifying failure sites including component interconnects, board metallisation, or external connections
- Failure Modes including electrical shorts, opens or problems associated with failure mechanisms resulting in electrical deviations beyond specification.
- Identifying failure mechanism models and their input parameters including materials characteristic, relevant geometry at failure sites, manufacturing defects and environmental and operating loads.
- The provision of information to determine electrical, thermal and mechanical stress margins.

Physics of failure models can be applied to accelerated life testing of electronic components to assess the reliability and lifetimes under normal stress conditions. As the use of the PoF approach increases this method may become a routine process during the design and evaluation phase of the product lifecycle

M/F-FOPS: Physics of Failure techniques can be used to design a system for maintenance and failure free operating periods. Maintenance free operating period (M-FOP) is defined as a period of time during which a system is operational and is able to carry out its required functions without maintenance and without encountering failures. A failure free operating period (F-FOP) is defined as a period during which no failures resulting in a loss of system functionality occur

The M/F-FOPs approach is the basis of the concept of built for life electronics when used in a defined operational envelope.

When built for life electronics is used to describe a disposable or throw away item it could be described as an F-FOP. A system containing multiple built for life units could be an M-FOP which contains units with known remaining life and hence known maintenance schedules.

Health Unit Monitors: Health unit monitors (HUMs) are required to monitor built for life equipments to ensure that excursions outside the agreed operational envelope are observed. New DERA initiated research in the CALCE programme is designed to enable the HUMs to perform the dual function of Event Monitoring and Life-Consumption monitoring by mapping event data into damage accumulation models to provide indications of remaining life.

Open Systems [3]: To obtain the maximum cost and operational advantage from built for life units they should be compatible with an open systems approach to equipment design.

An open system is a system that implements sufficient open specifications for interfaces, services and supporting formats to enable properly engineered components to be utilised across a wide range of systems with minimum change. The success of open systems, in future military systems, lies in the choice of commercially supported specifications and standards for interfaces. Interface standards generally have long lifetimes, some as long as 25 years, and can outlast any particular product, vendor or technology.

The attraction of open systems is due to:

- Portability-The ease with which a system, component, data or software can be transferred from one hardware or software environment to another.

- Interoperability-The ability of two or more systems or components to exchange and use data

- Scalability-The capability of hardware and software to accommodate changing workloads

- Vendor independence-Products available on a commercial basis from multiple vendors

- Supportability- easy upgrades or technology insertion

An open systems approach to future designs promises to solve many of today’s problems and specifically to allow maximum advantage to be taken of the availability of state of the art COTS technologies in an incremental acquisition process.

DoD as far back as 1994[4] recognised the problem and issued a directive that instructs programme managers to employ open systems as a design consideration in defence systems engineering.

Open systems provide an opportunity to achieve lower cost affordable designs which can readily accommodate new technology insertion over the whole life of the system with the additional advantage that upgrade technologies can be state of the practice technology from multiple suppliers. The approach also mitigates against the risks of obsolescence by using commercially supported interface standards permitting upgrades and new technology insertion at relatively low cost.

A Possible Future: The prospect of maintenance and failure free operating periods for electronic components in open architecture systems promises to provide a neat low cost solution to the obsolescence problem as well as addressing the short term technology upgrade problems in military and commercial equipments.

The incorporation of low cost life consumption monitors based on highly integrated environmental sensors holds out the promise of predicting in real time the remaining life of electronic assemblies.

The advantages of no obsolescence problems, known reliability and seamless technology upgrades coupled with a faster development timescale, a better product at lower cost with a fast time to market will satisfy the requirements of both military and commercial customers.

Conclusions: Proactive obsolescence management will require a culture change in both Military and Defence Contractors. It is not difficult to see that if obsolescence was managed on a tri-service basis considerable insight into major problem areas and valuable lessons learnt could be fed back into research, development and procurement cycles.

Obsolescence could be managed to greater advantage if the Military and Defence Contractors teamed jointly to form a National Obsolescence Centre that could address obsolescence on a global basis across the total customer inventory. The concept of teaming offers many areas for cost reduction within MOD and Defence Contractors whilst adding to the overall knowledge of the participants. It would have the added advantage that work was not duplicated and solutions could be disseminated to all the participants across multiple platforms in real time. Defence Contractors who also address the commercial market could gain possible commercial advantage by predicting reduced levels of through life maintainability.

It is now possible, albeit with some difficulty, to manage semiconductor component obsolescence, that is to maintain the equipment to its originally specified functionality throughout its service life. In most cases however this may not be sufficient since the rapid acceleration in technology innovation will make the original equipment itself functionality obsolescent. A systems engineering approach to obsolescence management is required to determine the most effective solutions for equipment modifications, upgrades or new technology insertion at any point in the equipment life cycle.

The increasing use of commercial off the shelf (COTS) components in military and long life cycle commercial equipments will exacerbate the problems of component obsolescence management. COTS components undoubtedly save front end costs through the development and procurement stages when compared to traditional military components. They also carry the risks of technology development being driven by commercial requirements rather than to provide enhanced capability in a military scenario

The solutions to component obsolescence, commercial technology insertion and reliability are increasingly inter related as new technology evolves. Cost effective solutions, based on open systems design, with the availability of guaranteed life COTS components, must address these areas simultaneously over a wide range of technologies to achieve the optimum performance/cost benefits.

References

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John Hopkins Applied Physics Laboratory
Technical Digest Vol20 Number 1 (1999)

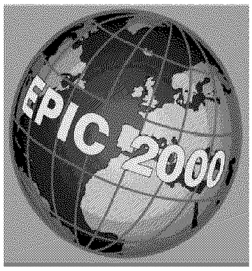
2 Pecht, M., Dasgupta, A., Baker, D. and Leonard, C.T.
The Reliability Physics Approach to Failure Prediction Modelling
Quality & Reliability Engineering Vol. 6, p267 – 274, 1990

3 Practical Open Systems Engineering
http://cosip.npt.nuwc.navy.mil/POSE/Introduction/intro.html

4 Acquisition Information Memorandum
Open Systems Approach
http://www.acq-ref.navy.mil/opensyst.html

EPIC 2000

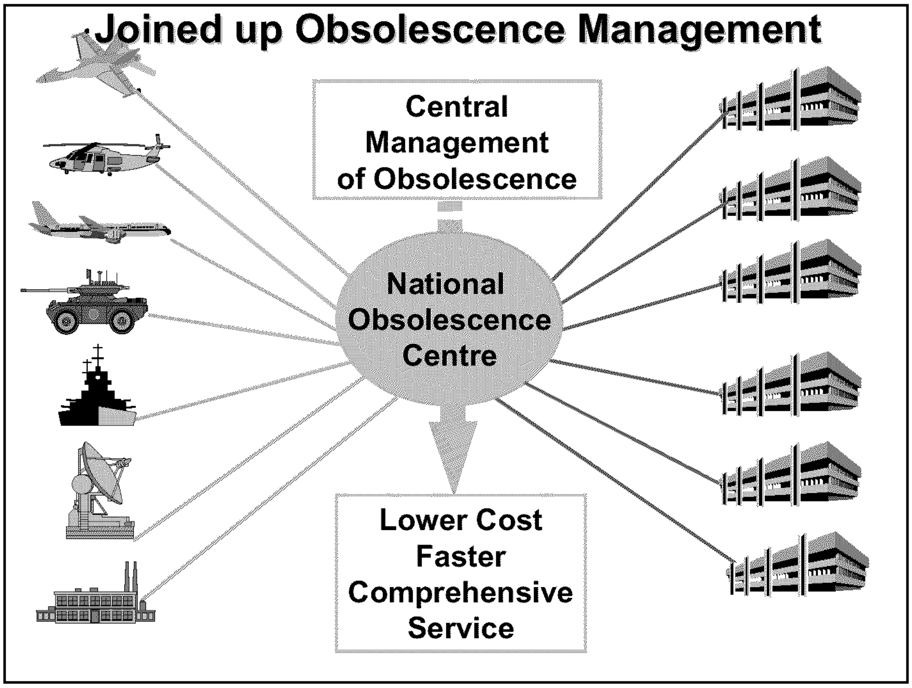
- Relational Database
- Data Currency
- Parts Description
- Parts Equivalence
- Obsolescence Predictions



What we require is to

+ **Turn <u>Reactive</u> Obsolescence Management**
+ **into <u>Proactive</u> Obsolescence Management**

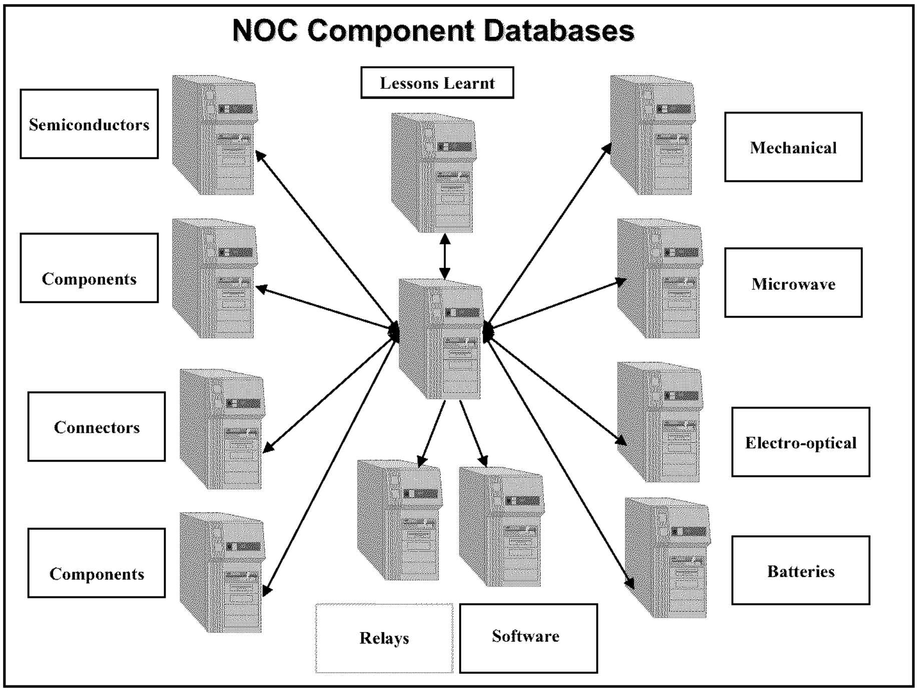
- Continuous real time health checks of the total component count across multiple platforms from multiple users
- Simultaneously inform every user who has a problem the location and extent of the problem
- Solve the problem once only and inform all the owners

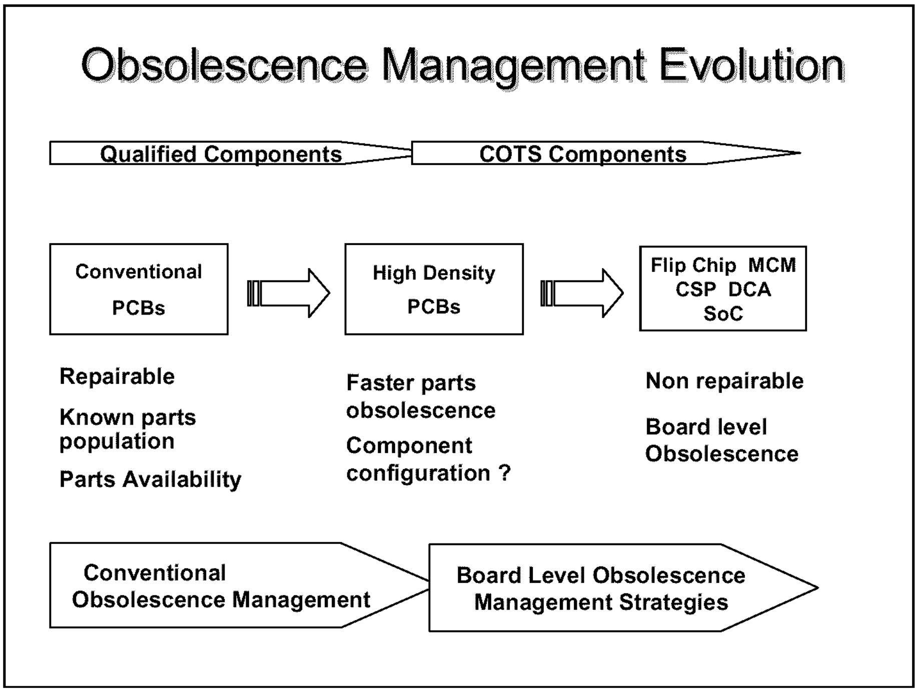


National Obsolescence Centre

DERA COG

Department of Trade and Industry


NOC Component Databases
Lessons Learnt
Semiconductors
Components
Connectors
Components
Mechanical
Microwave
Electro-optical
Batteries
Relays
Software


Obsolescence Management Evolution
Qualified Components
COTS Components
Conventional PCBs
High Density PCBs
Flip Chip MCM CSP DCA SoC
Repairable
Known parts population
Parts Availability
Faster parts obsolescence
Component configuration ?
Non repairable
Board level Obsolescence
Conventional Obsolescence Management
Board Level Obsolescence Management Strategies

Physics of Failure

A Probabilistic Science Based Approach to Reliability Prediction

- Identification of Failure Modes, Mechanisms and Failure Sites prior to Build
- Reliability Predictions at Design Stage
- Virtual Reliability and Qualification
- Software and data for Circuit Board and Device Level Analysis

Maintenance/Failure Free Operating Periods M/F-FOPs

Maintenance Free Operating Periods M-FOPs

A period of time during which a system is able
to carry out its required function
without maintenance activity
and without encountering failures

Failure Free Operating Periods F-FOPS

A period of time during which no failures
resulting in a loss of systems functionality can occur

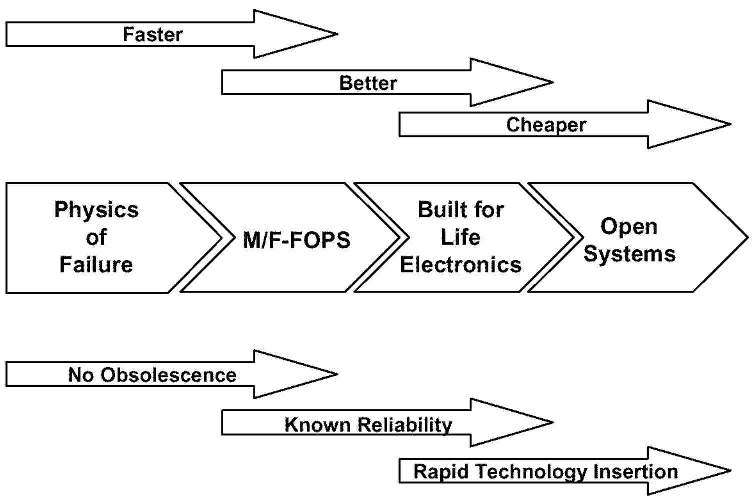
Open Systems

An Open System is a system that implements sufficient open specifications for interfaces, services and supporting formats to enable properly engineered components to be utilised across a wide range of systems with minimal change

Characterised by

Commercially supported specifications and standards for system interfaces

Future System Concept



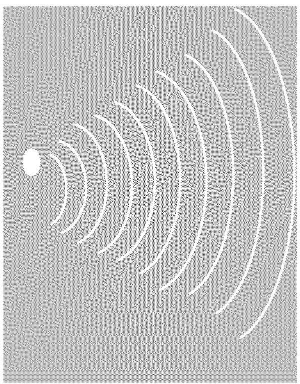
Built for Life Electronics

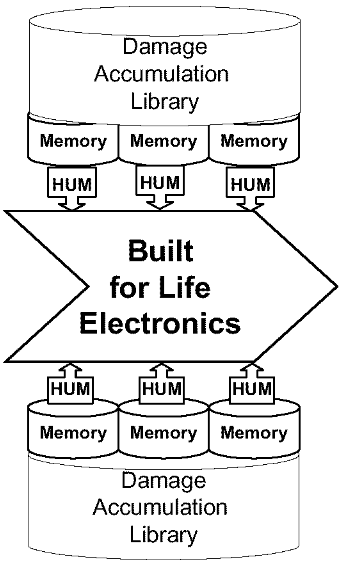
What does the user want to know

Remaining useful life

Difference between manufacturers guaranteed life and that lost due to wear out and out of specification excursions

Built for Life Electronics
Life Consumption Monitoring





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