Electronic Part Obsolescence – Life Cycle Optimization and Cost

Life Cycle Optimization

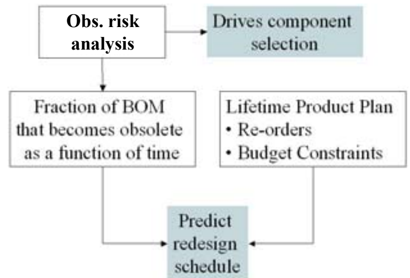
Given some ability to forecast part obsolescence (and potentially forecast functional upgrade opportunities), how can this information be used to optimize the lifecycle of the product?

- Lifetime buy vs. design refresh tradeoffs (Boeing, Raytheon)
- Design refresh optimization - MOCA (University of Maryland)*
- Resource allocation decision support system – RADSS (Litton-TASC)*
- Reengineering tools (synthesis)*

*Ongoing development through Air Force Electronic Parts Obsolescence Initiative (EPOI)

Conventional Use of Obsolescence Data During the Design Stage

- The majority of the military, avionics and automotive community either ignore obsolescence risk or use it only during the component selection process at the design stage
- Some organizations use obsolescence risk information to predict redesigns



- Conventional methods of predicting the economic impact of obsolescence take into account the obsolescence risk, but **do not** account for part-specific obsolescence mitigation strategies
- The analysis is usually restricted to lifetime buy vs. redesign trade-offs

Last Time Buy vs. Redesign

Basic Concept:

- If a redesign can be deferred to a future year, the net present value (NPV) of the redesign cost decreases as the redesign is postponed
- As the redesign is deferred, more parts need to be purchased (last time buy) to support production and repair of the current design, thus increasing the sustainment cost
- The optimum year for redesign is the minima in the sum of the two curves

Note, this modeling approach does not account for the performance or maintenance "value" of the redesign

Net Present Value (NPV) of Redesign Costs

NPV = Net Present Value is a way of comparing the value of money now with the value of money in the future. A dollar today is worth more than a dollar in the future, because inflation erodes the buying power of the future money, while money available today can be invested and grow.

$$\text{Present Value} = \frac{V_n}{(1+d)^n}$$

Present value of an investment worth V_n, n years from the present with a constant discount rate (rate of return on investment) of d

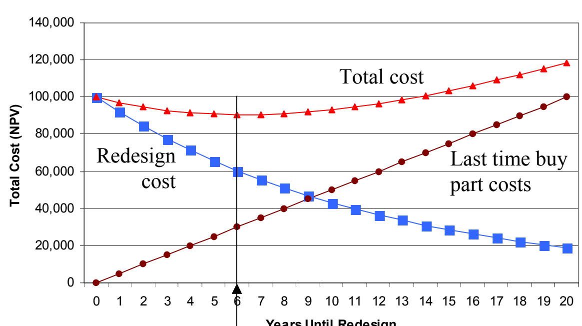
$$\text{Net Present Value} = \sum_{i=0}^{n} \frac{B_i - C_i}{(1+d_i)^i}$$

Present value of an annual value V_i=B_i-C_i, n years from the present with an annual discount rate of d_i. B_i and C_i are the benefit and cost in the ith year.

$$\text{Redesign Cost (NPV)}_i = \frac{\text{Inflation adjusted redesign cost}_i}{(1+d)^i}$$ in the ith year

Last Time Buy vs. Redesign

(A Very Simple Example)



Redesign in year 6

Total cost = redesign cost + last time buy part costs

Assumes one part goes obsolete in year 0

Example Analysis Data:

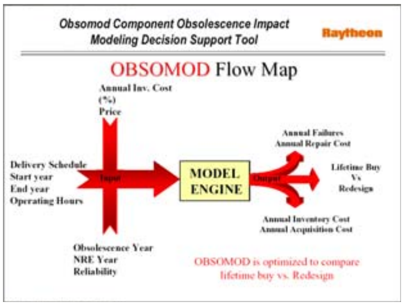
Return on investment via some other use of the money → Discount rate (%)

Redesign cost (year 0)	100,000
Inflation rate (%)	3
Discount rate (%)	12
Number of the obsolete part needed per year	500
Obsolete part price at last time buy (year 0)	10

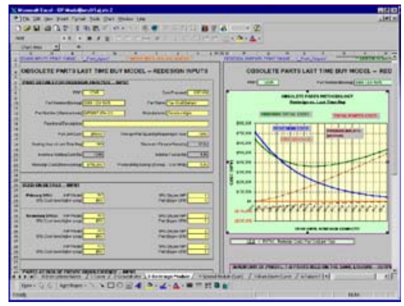
Last Time Buy vs. Redesign

The simple analysis can be expanded to include:

- Multiple obsolescence events
- Annual inventory costs
- Reliability models to predict annual product quantities



Raytheon Tool:
J. Mainwaring, “Technology Obsolescence and Sustainment,” Lower Voltage Technology Initiative Government/Industry Workshop, July 1999.



Boeing Tool:
Z. Porter, “An Economic Method for Evaluating Electronic Component Obsolescence Solutions,” Boeing Corporation.

Price-Based vs. Cost-Based

Cost-Based Model:

- Incentive for the prime contractors and OEMs to defer a redesign as long as possible and let the customer pay for the both the obsolescence-driven upgrade and the performance improvements concurrently
- A lifetime buy vs. redesign analysis is a valuable tradeoff of this approach

Price-Based Model:

- Prime contractors and OEMs are allowed to “pocket” recurring cost savings that result from redesigns, thus providing an incentive to redesign as soon as it makes sense.
- Different analysis needed…

Design Refresh Planning

Design refreshes (redesigns) of electronic systems are performed to update functionality/performance/ technology, <u>and</u> to mitigate electronic part obsolescence problems.

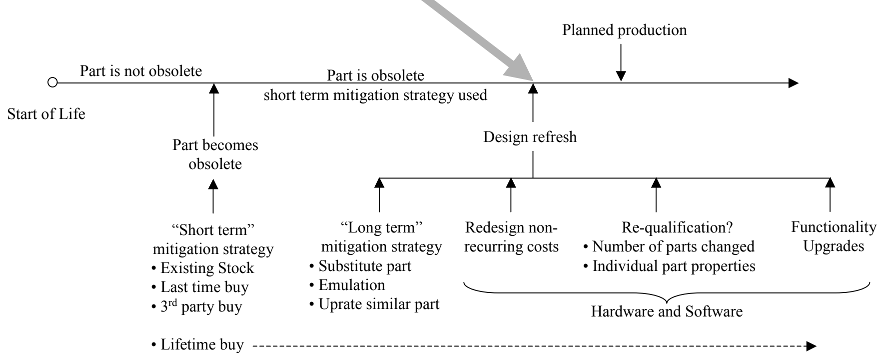
However, design refreshes of avionics systems, potentially require large expenditures for re-engineering and re-qualification.

The challenge is to determine the optimum design refresh plan that balances obsolescence mitigation with the expense of redesign.

Software tool and methodology for refresh planning:
MOCA = Mitigation of Obsolescence Cost Analysis

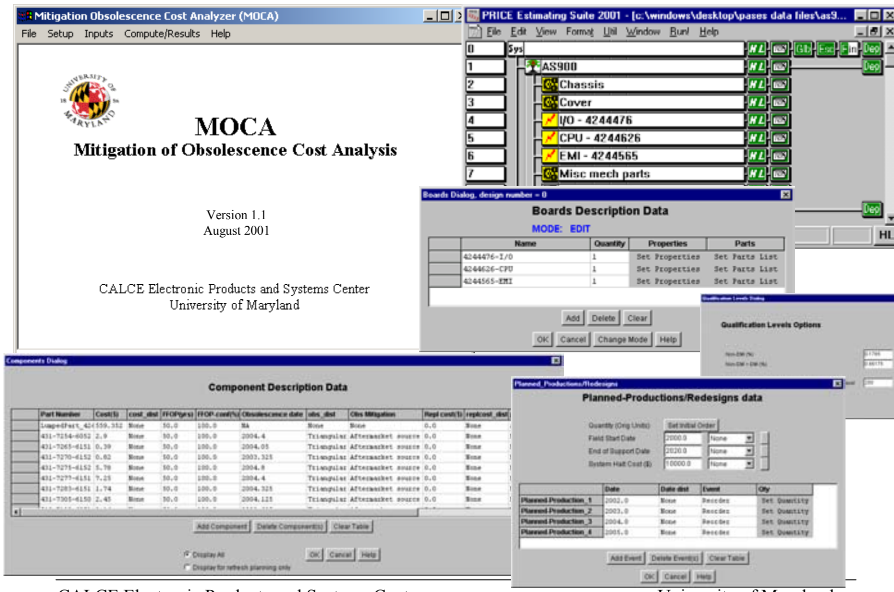
MOCA Design Refresh Optimization Landscape

Optimum location(s) of these refreshes depends on:
• which part(s) become obsolete
• when they become obsolete
• how the obsolescence is mitigated
• resulting system re-qualification requirements



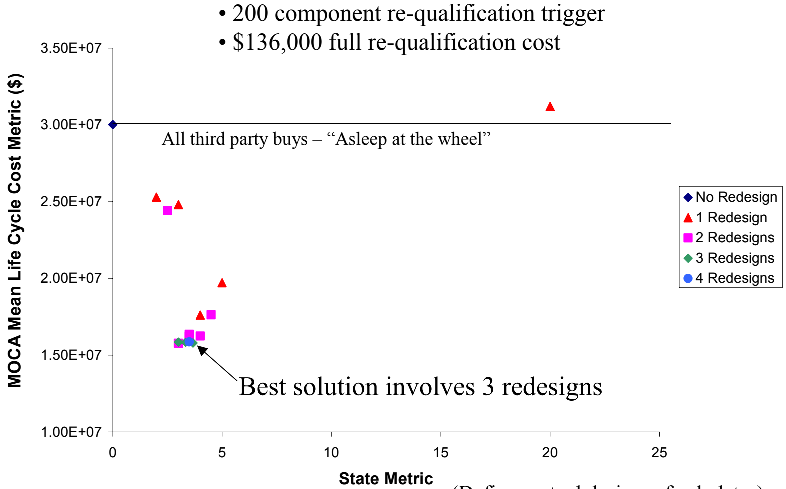
CALCE Electronic Products and Systems Center
Obsolescence/Technology Insertion
University of Maryland

The MOCA Tool



Example MOCA Design Refresh Result

- 1 year look ahead
- 20 year product life (3200 units manufactured)
- 200 component re-qualification trigger
- $136,000 full re-qualification cost



(Defines actual design refresh dates)

RADSS (Litton TASC*)

Part obsolescence management system based on commercially available Resource Allocation Decision Support System (RADSS)

RADSS makes optimum part obsolescence management decisions (based on known part obsolescence and discontinuance) in a resource budget constrained environment

The primary purpose of the tool is to aid the user in making financial management or investment decisions

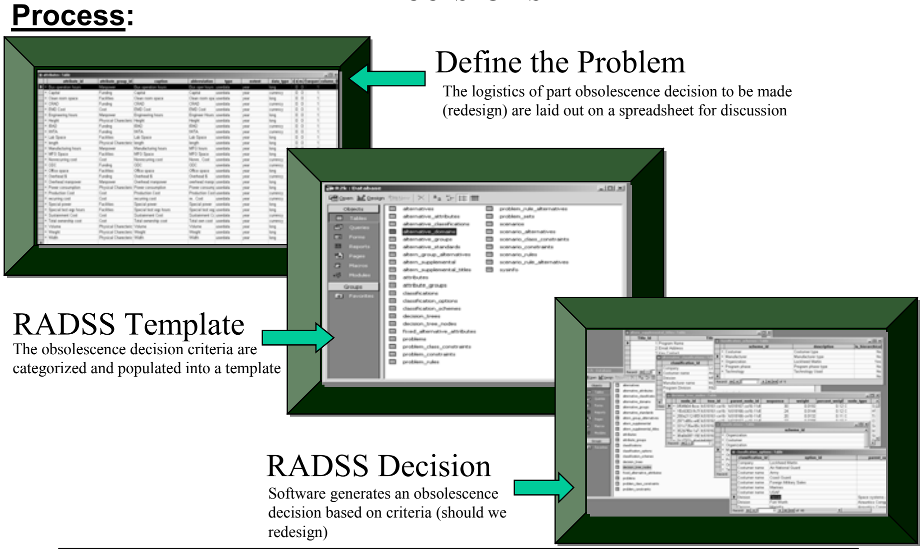
> This tool may enable "best value" decisions, i.e., value = financial, performance, customer requirements satisfaction

(http://www.tasc.com)

*Now part of Northrop Gumman

RADSS - Model for Complex Obsolescence Decisions

Process:



Reengineering Tools

Objective: provide automated VHDL model generation tools, libraries of simulatable and synthesizable virtual components, and legacy software modeling:

1) Design extraction from an obsolete platform
2) Architectural design tradeoff analysis
3) Synthesize new hardware and software to replace the obsolete portion of the system
   - Redesign advisor (VP Technologies, www.vptinc.com)
   - Behavioral product reengineering tool (Synopsis)
   - Design verification test generation tool (University of Cincinnati)

These are essentially ASIC-based obsolescence mitigation solutions and thereby suffer from the ASIC problems previously discussed

Publicly Available Life Cycle Costing Tools
(Used for Military and Avionics Products)

None of the following tools model the cost impacts of obsolescence, however, all provide critical elements of the calculation

Hardware Development and Production:
- Price-H/HL/M
- SEER-H/I

} Complexity based parametrics

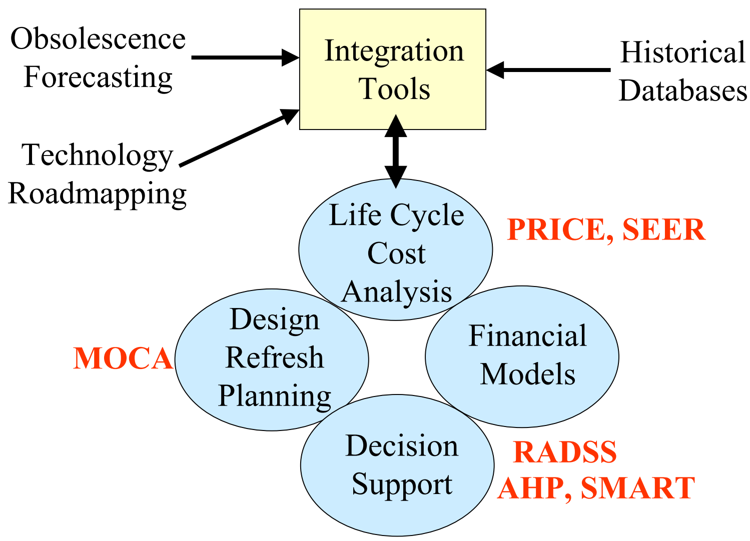
Software Development, Maintenance and Testing:
- Price-S
- SEER-SEM
- COCOMO

} Source lines of code based parametrics

- SAGE Development team based parametrics

- ICE (Frontier) Tool/data integration environment

A *High-Altitude* View of the Design Tool Space



Software Obsolescence

When the system hardware is modified via a design refresh, the system software and/or the system's software qualification may have to be refreshed too.

Challenge:

- Determine what software needs to be refreshed
- Figure out the cost of the software refresh
- Determine if the software needs to be re-qualified
- Figure out the cost of the software re-qualification
- Include these effects within the design refresh optimization

Standards and Specifications/ Requirements Obsolescence

The standards, specifications, and/or requirements used when designing and manufacturing a system may change or be obsoleted during a system's sustainment life, i.e., a system can no longer deliver the required performance to meet the customer's need (e.g., insufficient memory or processor).

This type of obsolescence may result in obsoleting an electronic part's applicability to for use in the system, i.e., the part itself is not obsolete, but its performance or reliability no longer satisfy the new system requirements.

Mitigating Standards and Specifications/ Requirements Obsolescence

Standards, Specifications, and Requirements changes are expected by difficult to predict.

There are system-level strategies that allow us to mitigate the the impact of unexpected changes (e.g., "encapsulation" of the standards as much as possible so that changes in standards are transparent to the system)

This is what "upgradability" is all about, i.e., the capability to accommodate and exploit new technologies with minimum impact in order to meet evolving performance requirements

ROI/Cost Avoidance Associated with Obsolescence Management

The best (only) actual data on costs associated with electronic part obsolescence management is from a DMEA study in 1999:

J. McDermott, J. Shearer, and W. Tomczykowski, "Resolution Cost Factors for Diminishing Manufacturing Sources and Material Shortages," ARINC, February 1999. (http://smaplab.ri.uah.edu/dmsms98/papers/trunnell.pdf)

This study lays out the following items associated with obsolescence mitigation alternatives:

1) Non-recurring cost factors
2) Recurring cost multipliers
3) Cost avoidance values

Comment:
This data assumes maintaining only a legacy performance capability, i.e., does not figure in functional upgrades

Non-Recurring Cost Factors for Obsolescence Resolutions in Avionics

Resolution	Low ($)	Average ($)	High ($)
Existing Stock	0	0	0
Reclamation	1000	2000	3000
Alternate	4000	7000	9000
Substitute	15000	19000	24000
Aftermarket	41000	50000	59000
Emulation	55000	72000	89000
Redesign – Minor	82000	117000	153000
Redesign – Major	361000	433000	505000
Life of Type Buy	*	*	*

(2001 Dollars)

* The LOT buy resolution is program specific and should be calculated by individual programs

J. McDermott, J. Shearer, and W. Tomczykowski, "Resolution Cost Factors for Diminishing Manufacturing Sources and Material Shortages," ARINC, February 1999. (http://smaplab.ri.uah.edu/dmsms98/papers/trunnell.pdf)
Supplemental Report, "Resolution Cost Factors for Diminishing Manufacturing Sources and Material Shortages," ARINC, December 2001.

Additional NRE Costs

The previous chart does not include the following additional NRE costs:

- New source qualification - $20,000 to $161,000
- Radiation hardening qualification
  - Dose rate $15,000-$20,000
  - Total dose $5,000-$12,000
  - Single event upset $15,000-$20,000 (microprocessors up to $50,000)
- PEM qualification
  - Acoustic microscopy $1,800-$1,890
  - 100% screening $13,250
  - package qualification $27,150-$32,200

J. McDermott, J. Shearer, and W. Tomczykowski, "Resolution Cost Factors for Diminishing Manufacturing Sources and Material Shortages," ARINC, February 1999. (http://smaplab.ri.uah.edu/dmsms98/papers/trunnell.pdf)

(1999 Dollars)

Recurring Cost Multipliers for Obsolescence Resolutions in Avionics

Resolution	Low	Average	High
Existing Stock	1.0	1.0	1.0
Reclamation	Not available	Not available	Not available
Alternate	1.0	2.5	4.0
Substitute	1.6	5.8	10.0
Aftermarket	5.0	7.5	10.0
Emulation	10.0	20.0	30.0
Redesign	1000.0	5500.0	10000.0
Life of Type Buy	Not applicable	Not applicable	Not applicable

J. McDermott, J. Shearer, and W. Tomczykowski, "Resolution Cost Factors for Diminishing Manufacturing Sources and Material Shortages," ARINC, February 1999. (http://smaplab.ri.uah.edu/dmsms98/papers/trunnell.pdf)

Cost Avoidance for Obsolescence Resolutions in Avionics

Resolution	Low ($)	Average ($)	High ($)
Existing Stock	629	1884	3249
Reclamation	2121	4500	13251
Alternate	2250	11727	33776
Substitute	10390	29249	64606
Aftermarket	1610	20652	35118
Emulation	5400	43022	100000
Redesign – Minor	177600	299118	520000
Redesign – Major	0	0	0

Determined by subtracting the NRE cost resolution from the next highest NRE cost resolution

(1999 Dollars)

J. McDermott, J. Shearer, and W. Tomczykowski, "Resolution Cost Factors for Diminishing Manufacturing Sources and Material Shortages," ARINC, February 1999. (http://smaplab.ri.uah.edu/dmsms98/papers/trunnell.pdf)

Obsolescence Management

Reactive mitigation approaches:

- Existing stock
- Substitute part
- Aftermarket supplier
- Life of type buy
- Uprate commercial part
- Emulation
- Reclamation (salvage)
- Reverse engineer
- Design refresh

ROI = 3:1
R. Stogdill, "Dealing with Obsolete Parts," IEEE Design & Test of Computers, April-June 1999

Proactive management approaches:

- Reengineering tools
- Obsolescence mitigation decision making tools
- Obsolescence forecasting
- Design and lifecycle optimization tools

ROI = 18:1
Design capture as executable specification/simulation objects (Northrop E3 AWACS)

ROI = 100:1