An Economic Method for Evaluating Electronic Component Obsolescence Solutions

Background

Obsolescence of electronic components is an issue affecting avionics suppliers and airframe manufacturers throughout the aircraft/aerospace industry. Component obsolescence has been a subject of many industry papers, addressing primarily: the magnitude of the problem faced by our industry, where the microprocessor industry is going, and availability of resources to aid in predicting component life and potential risk of part obsolescence.

This paper addresses the problem faced by the avionics supplier in the selection of an obsolescence solution, and the economic trades that will identify decision points in a buy vs. redesign solution.

Obsolescence Resolution

When confronted with notification that an electronic component has been declared obsolete, the avionics supplier is faced with a series of alternatives. The basic decision is whether to make a "last-time buy" of components necessary to last thru the life cycle of the product, or to initiate redesign of either the LRU (line replaceable unit) or printed circuit assembly in order to design the component out of the product. In complex avionics, especially those involved in flight-critical systems, redesign can be very expensive, requiring extensive engineering, qualification testing, and certification of the LRU. Revisions to software necessitated by the new components can also involve significant engineering effort, sometimes exceeding that required for hardware design.

Avionics Redesign

LRU redesign should be explored only after evaluation of the following alternative solutions:

- Selection of an interchangeable replacement component
- Alternate source for component (requires requalification)
- Use of "upscalable" parts, or alternate components suitable following selective screening to meet higher performance requirements
- Die banking, which involves use of a 3rd-party source to hold the die and package the component at a future point in time
- Part emulation, using newer-technology components that are packaged in the same form factor as the original part, that will emulate the component's functionality
- Use of ASICs for replacement of the component, or component group.

If one of the above alternatives is applicable to resolving the obsolescence event, the cost of non-recurring engineering is relatively small. If not, re-engineering cost can be significant. Whether a minor design change involving a replacement component or a major redesign to the LRU,

non-recurring engineering activity will be required to some degree. In evaluating the redesign effort, the engineering team (consisting of design, manufacturing, and support personnel) must make sure to include all costs associated with the change, including elements such as:

- Definition of all requirements associated with incorporation of the new component in the LRU, including architecture changes where appropriate
- Impacts to the aircraft system or subsystem, including potential architecture changes
- Hardware synthesis, analysis, and verification testing
- Functional test requirements definition
- Functional test implementation, including ATE software and hardware
- Software design, coding, and verification
- Design drawing and documentation updates
- Qualification testing
- Impact to supporting deliverables, including
  - Component Maintenance Manual
  - Airplane level documentation
  - Support and test equipment
  - Revisions to other supportability analyses/support products
- Lab testing in system environment (hardware, software, integration testing)
- Flight testing
- Certification
- Procurement support, stores impact, incoming inspection/receiving revisions

Last-Time Buy of Obsolete Parts

The avionics supplier usually has prior notification from the component manufacturer of an obsolescence event, providing the opportunity to make a last-time buy of parts from the component manufacturer or distributor before they are no longer available. Except when dealing with a direct substitute part, a continuing inventory of parts is required to maintain production until a redesign or alternate part is available.

If a redesign is planned that will not allow direct use of the new design solution in previously manufactured LRUs, sufficient inventory must be available to support repairs of the product currently in the field throughout its remaining life.

When faced with a last-time buy decision, other corporate influences need to be overcome -- principally, the conviction by inventory management personnel that "inventory is evil". This may be true in a dynamic manufacturing environment where high inventory turns are paramount, but takes on new perspectives when faced with the inability to procure a part in the future. If the component is not available when needed in the future, LRU production will cease, or the LRU will become unrepairable / unsupportable -- until a re-engineering activity is completed. This can take up to 12 to 24 months if design changes are significant.

Costs associated with a last-time buy need to address the following considerations associated with holding and management of a last-time buy inventory:

- Inventory holding cost
  - Cost of capital invested in inventory
  - Warehousing
  - Material handling
  - Insurance/taxes on inventory
  - Counting/auditing inventory
  - Cost of reporting on inventory
  - Cost of spoilage, damage, and pilferage
- Increased protection/security of this irreplaceable inventory
- Receiving/inspection of last-time buy inventory
  - Special testing
  - Special packaging

Companies typically have a factor used to cover the above costs, called an "inventory holding cost factor", usually expressed as a percentage of the dollar value of the inventory. The inventory holding cost factor can range from 10% to 30% depending on the company. Special testing, packaging and security for items placed in long-term storage may add to the standard factor that would generally be applied to manufacturing inventories.

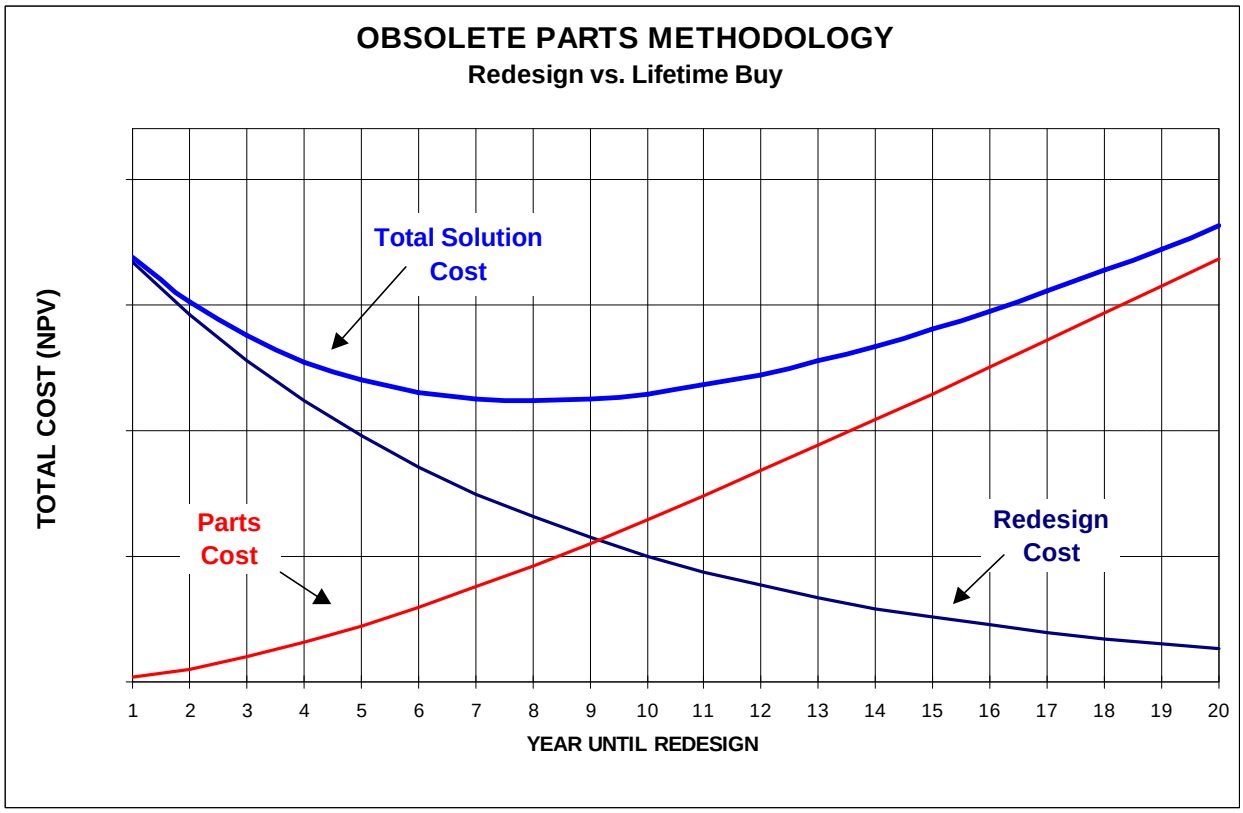
The Decision Process

If a substitute component can not be used as a replacement for the obsolete part, the engineering team is typically faced with the decision of whether to perform a redesign or make a last-time buy. The decision is greatly affected by whether the LRU is in current production, or has been superseded by another design; in the latter case, the decision applies only to the quantity of affected LRUs that are in the field.

For LRUs in current production, the best solution may be to procure enough parts to support continued production until a "block-point redesign" can be made in a future year. The engineering team needs to look at the overall product line strategy affecting the future requirements for hardware in question. Factors affecting the decision process include:

- Continued market for the product
- Manufacturability of the LRU
  - Potential for producibility enhancement
  - Risk of current manufacturing processes going obsolete
- Risk of other obsolete parts in the LRU
- Other LRUs affected by this obsolete part
- Impact to airlines (users) of a redesign, such as
  - lack of spares commonality
  - costs associated with having a "second" LRU in their inventory
  - retrofit costs (if the new LRU is not form-fit-functionally interchangeable)
- **Economics of the decision**

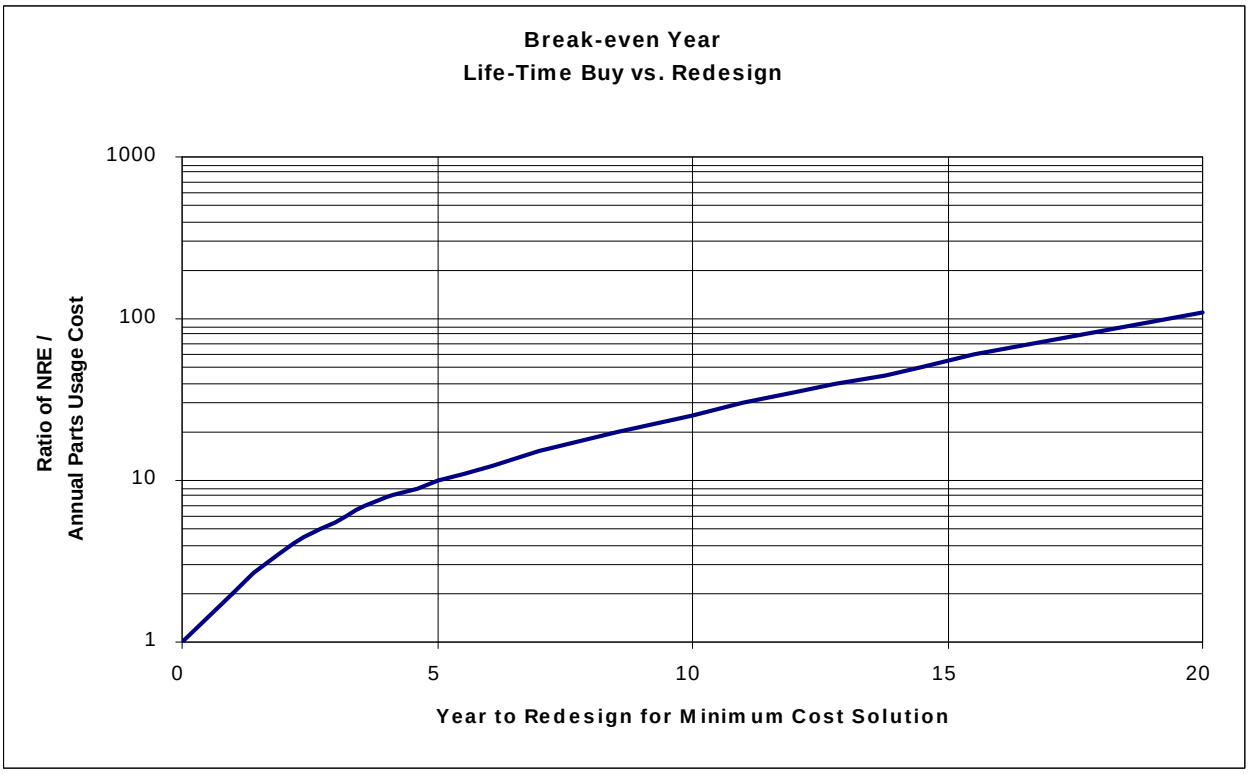
Data for most of the above factors are available to the engineering team thru technical analysis, or from the marketing department. Economic decisions, however, are often foreign to the engineering community and can be somewhat complex in nature. Simple to use rules-of-thumb need to be made available to the engineering team. Boeing Electronic Products has developed a simplified methodology that allows the engineering team to determine the appropriate time point for any redesign that will minimize cost to the company. Net Present Value (NPV) cost analysis techniques are used to determine the cost effectiveness of trades between multiple solution options. The following curves show the relationships between a redesign and a last-time buy solution:



The "Redesign Cost" curve is established based on the principle that if the redesign can be deferred to a future year, the net present value of the redesign cost decreases as the redesign is postponed. The NPV analysis recognizes the time value of money, and uses a "rate of interest" equal to the discount rate minus inflation, recognizing that money can be invested elsewhere and earn a return for the company.

As redesign is deferred, more parts need to be purchased to support production and repairs of the current design. The "Parts Cost" curve shows the increasing cost of holding the increasing number of parts over time. The sum of the two curves is the "Total Solution Cost" for a redesign in a particular future year. The optimum year for redesign, based solely on cost, is the year where the total solution cost is a minimum.

By plotting the locus of the years in which the minimum cost solution occurred for varying ratios of "Total non-recurring engineering (NRE) cost" divided by "Annual parts usage cost", the following relationship was obtained:



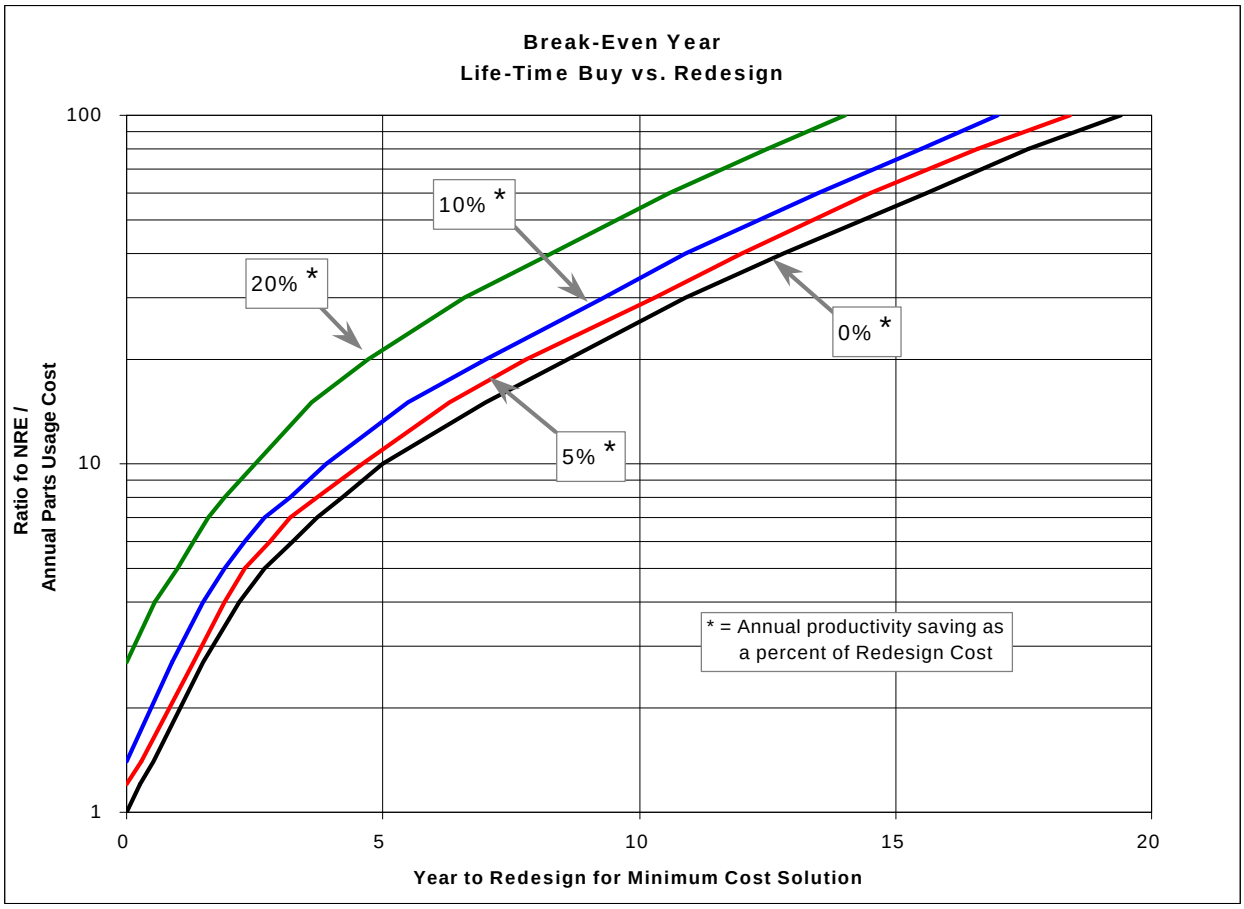
The above relationship, simply stated, says that if the non-recurring engineering cost is less than or equal to the annual parts usage cost, a redesign should be initiated immediately. Conversely, if the NRE is very expensive and yields a ratio of 200 or greater, a life-time buy is the more cost effective solution. In between these two cases, the curve shows the optimum year for redesign to yield the minimum-cost solution; a "block-point redesign" is indicated, with sufficient last-time buy parts inventory procured for production (until the revised design is available) plus those parts required to support repair of the total installed base (total of the old configuration product built) for the planned lifetime of the product.

Inherent in any decision that makes a commitment for a 10 to 15 year period is the risk that unforeseen changes will occur that invalidate the current solution, say, 10 years down the road. Conversely, deferring the design means that you will have a better understanding of these unknowns prior to committing redesign funds.

The Break-Even Year chart can be tailored to the specifics of a given company, using only the following variables:

- Inventory holding cost factor
- Discount rate to be used
- Projected inflation rate

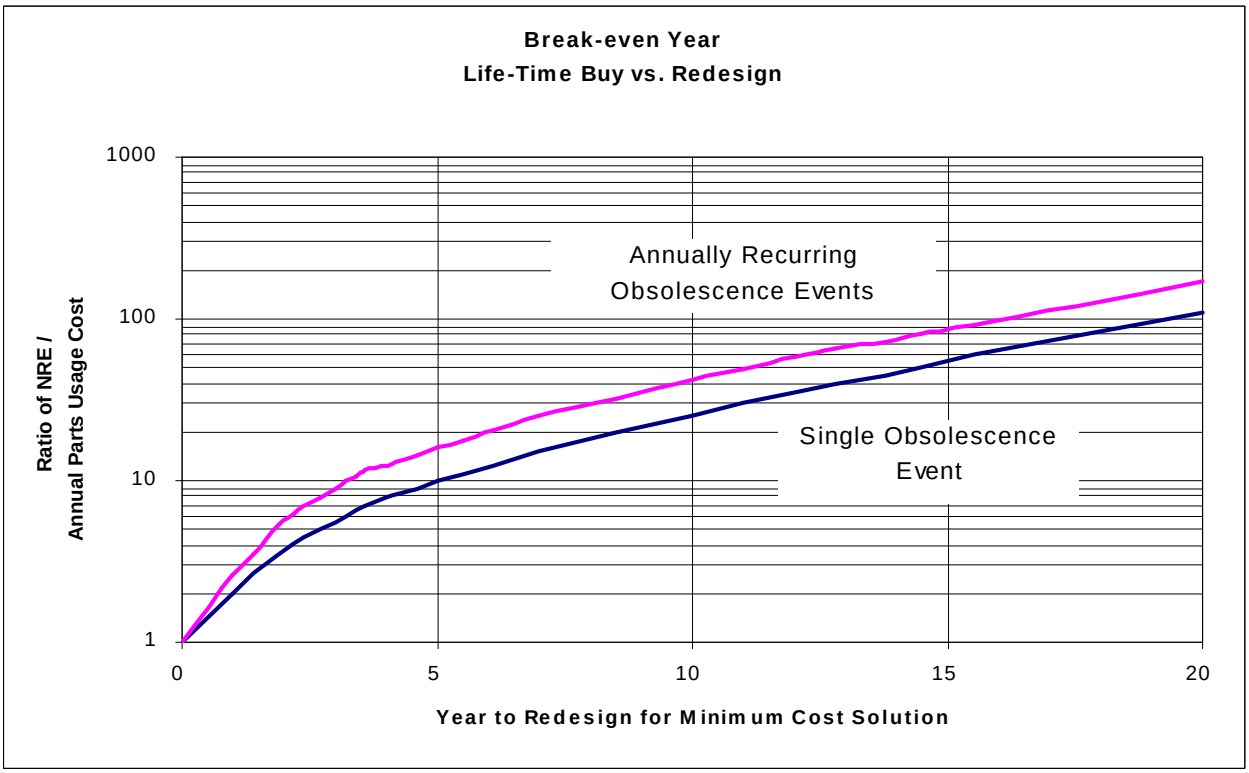
The Break-Even Year chart can also consider the effect of changes in overall product manufacturing cost as a result of a redesign. Using "annual production cost saving as a percentage of the non-recurring engineering cost" provides a measure that will continue to allow use of the dimensionless cost relationships for determining an optimum redesign year. As shown in the figure below, this yields a family of curves, progressing left (parallel to the existing curve) as the annual production cost decreases.



Decisions Involving Multiple Obsolescence Events

The above relationships show optimal timing for redesign considering obsolescence of a single component. In reality, the engineering team is faced with defining solutions involving multiple components anticipated to become obsolete over the life of the product. Exact solutions require use of fairly complex modelling, using detailed data on all of the components within the LRU.

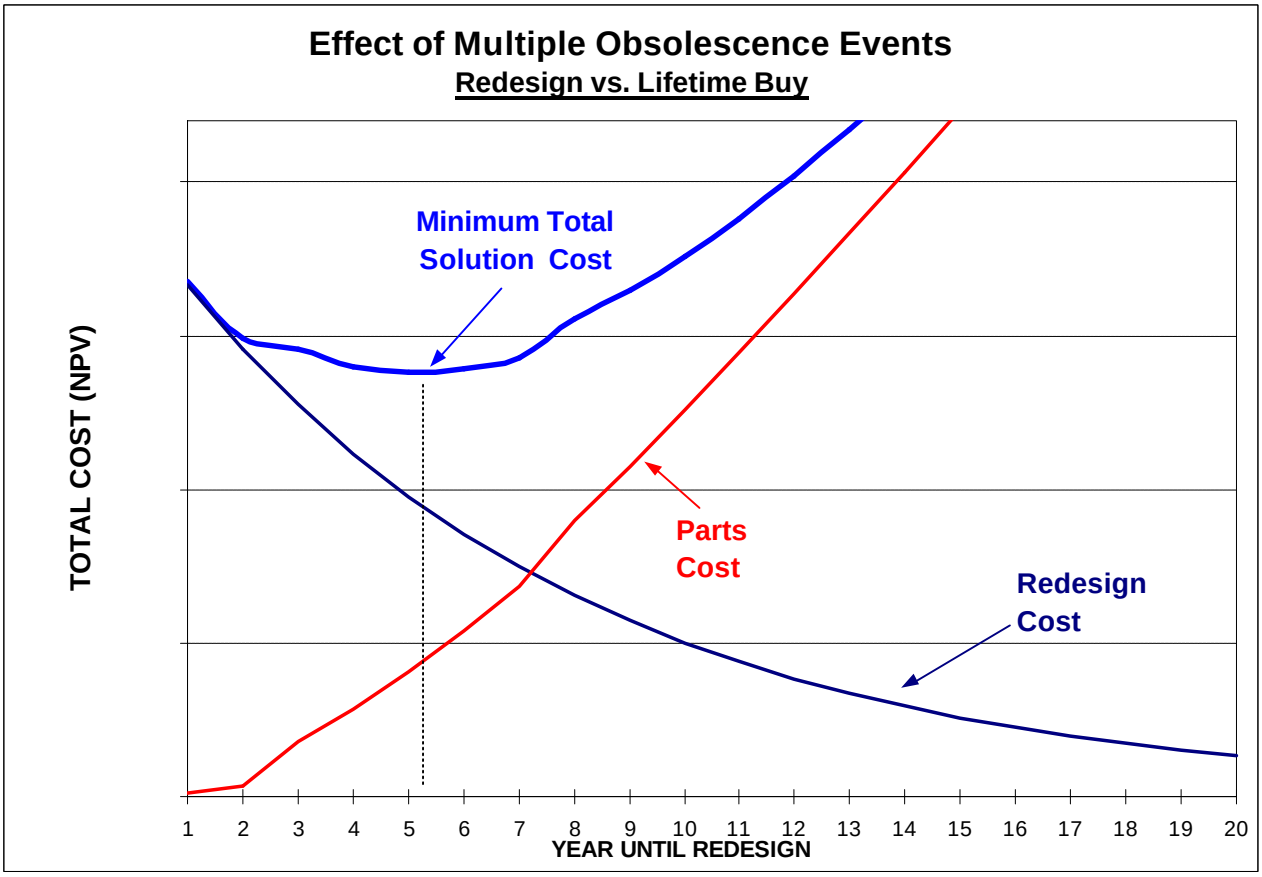
To provide the engineering team with additional guidance for multiple component obsolescence events, Boeing Electronic Products has expanded the above relationships to show the effect of annually recurring component obsolescence. We set the "annual cost" of parts projected to become obsolete (based on production usage) as constant, assessed the minimum cost solution for these annually recurring obsolescence events, and superimposed on our "Break-even Year" chart a plot of the locus of the year for the minimum cost solution using the same ratio of NRE divided by "Annual parts usage cost". The following figure shows the results: the cost-effective time point for redesign is moved forward, typically 2 to 3 years. From this data, approximations for redesign timing can be made.



If the engineering team has detailed data on expected production availability of all components in the LRU, a more in-depth analysis can be performed. The following table shows the type of data required for an in-depth cost analysis.

Part No.	Part Cost	Qty/LRU	Year Part Going Obsolete	Annual LRU Production Vol.	NRE $ to Redesign

Given this data, a more exacting solution can be obtained for the timing of a redesign solution. The time point yielding a minimum cost solution is identified in the following graph:



Iterations of solutions involving the paramenters described above can lead to optimization of solutions for obsolescence events.

Summary

The Break-Even Year charts provide quantitative guidance to the engineering team in developing a solution for component obsolescence. It is important to have tools that will allow the engineering team to understand the economic factors involved in the determination of the optimum year for planning a redesign. Detailed models can be developed that consider anticipated production life of all components within a LRU. When using any of the above data, the engineering team must assure that they have accounted for all potential obsolescence events that can be projected for the production and support lifetime of the product in question.

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