Return-on-Investment (ROI) for Electronic Prognostics in High Reliability Telecom Applications

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Abstract **– This paper defines the approach and methodology for the deployment of prognostics in Telecom power supplies. With 100% up-time being the ultimate target, prognostics can be effectively utilized to provoke early actions to avoid costly potential down-time events.**

An example will be provided using a common telecom power supply. Further analysis will be provided to demonstrate the return-on-investment that prognostics adoption can achieve.

INTRODUCTION

For many years, commercial telecom systems have adopted many forms of reliability enhancements all intended to improve system "up" time. While these changes have been effective, the "surprise" factor is still prevalent in systems carrying vitally important traffic over the network.

Providers and technicians alike often wish there was some signal or other indicator of an upcoming problem in order to take some action in advance of a system shutdown.

In military and aerospace systems prognostics have been adopted to improve operational readiness, reduce cost of provisioning and spares, and significantly increase operator safety.

Early implementations were focused exclusively on mechanical prognostics essentially targeted at detecting airframe fatigue and other wearout mechanisms. Electronic prognostics were the next frontier. Now well along in development, there are many forms of electronic prognostics all intended to detect early life failure and wear-out signatures.

Mechanical prognostics as implemented by the military is hardly a problem for the commercial telecom world, however there are extreme environments where packaging and connector reliability are problematic.

PROGNOSTICS

Prognostics is defined as, "Predictive Diagnostics which includes determining the remaining useful life or time span of useful operation for a component". [1] It is best understood by reviewing a standard reliability "bathtub" curve, as shown in Figure 1.

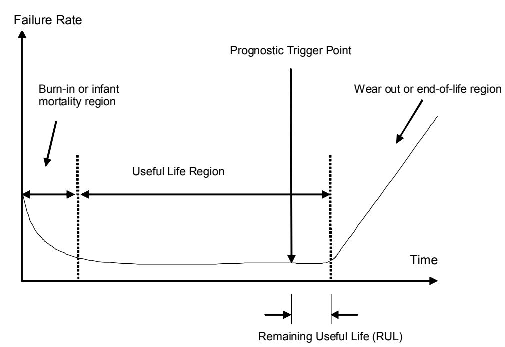

Figure 1 – Reliability Bathtub Curve and Prognostic trigger point, and Remaining Useful Life (RUL)

For a system, the RUL is a key parameter that drives ROI analysis. The concept can be extended to Prognostic Health Management (PHM) and provide a more holistic view system engineering. [3]

ELECTRONIC PROGNOSTICS

In a commercial telecom system there is significantly greater need for electronic prognostics over mechanical prognostics in that there are far more electronic components that can contribute to the failure rate as opposed to the number of mechanical items. Moreover, there is relatively short time between the difficult to detect precursor "signature" and the actual failure.

For each component on a system PC board, it is necessary to follow a methodical process of determining the highest failure rate components. This is often the cause of debate between system engineers. Predicted failure rates supplied by component vendors are often misleading and are not influenced by the application, environment, care of use or installation.

The recommended technique is to use a blended approach considering all of the reliability factors combined and applying a weight to each factor and then apply an algorithm to produce a composite indication of the electronic module's health.[2]

RETURN ON INVESTMENT

As in any other investment proposal, the return on investment for the adoption of electronic prognostics consists of an analysis of the savings associated with the planned implementation, less the entire cost of the implementation, divided by the investment required. Restated the formula is as follows:

ROI = (Savings – Implementation Costs)/(Investment Required)

In a telecom system, the identified sources of savings are as follows:

- Financial consequences of customer dissatisfaction as a result of unexpected system interruption
- Litigation resulting from critical missed communications
- Reduced capital expenditures for planned redundancy
- Moving spares, if available, to the proper location (logistics)
- Expediting suppliers and freight companies to obtain replacement parts

COSTS OF APPLYING PROGNOSTICS

The costs of applying prognostics are typically contained in one of three of the following categories:

- Non-Recurring engineering (NRE) cost of adding the prognostics to the system power supply
- The per unit costs of the prognostic components themselves
- False alarm costs (if the failure rate of the prognostic circuitry approaches the failure rate of the component being monitored)

The NRE costs are quite variable depending on the complexity of the supply. Adding a suitable sensor array to a redundant kilowatt power supply could be quite complex. On the other hand, adding a few sensors to a low voltage DC/DC converter is very inexpensive. Considering a 300 Watt multi-output Compact PCI power supply, the cost to implement prognostics is estimated to be 15% of the development cost of the supply itself. Doing the math, prognostics would add $15K to a $100K development project.

The per-unit cost of components is estimated to be as low as 10% in the simpler implementations of prognostics. Using the example of a 300Watt power supply, prognostic implementation might result in an additional $10 in component costs.

False alarm costs are assessed exclusively in terms of maintenance as traffic is considered to be "divertable" during an intentional system shutdown. This diversion of system traffic is often referred to as failover and when the diversion is intentionally induced by the action of a systems engineer, it is referred to as forded failover. False alarm costs would increase dramatically if system traffic were not diverted onto other hardware.

Conservative calculations indicate that predicted reliability of a 300W system power supply is 200,000 hours (MTBF) False alarm rate of Prognostic Circuitry for the Power Supply is estimated to be 5 fpmh but again, the system's failover architecture is expected to mitigate these costs.

The total cost to replace the system power supply is estimated to be $5k. This includes the total average cost to isolate, remove and replace the failed hardware.

SYSTEM ASSUMPTIONS

- 1000 unit deployment of a 300 Watt power supply in a given system implementation
- Useful service life is 5 years (Technology advancements usually pre-empt the life of the hardware)
- Operating 24 hours per day/7 days per week/365 days of the year
- Approximately 50,000,000 hours of system operation over the useful life
- $15,000 in additional NRE cost to "prognostics-enable" the power supply.

PRACTICAL APPLICATION OF PROGNOSTICS

Using readily available public information, we can now examine a practical application indicating the financial benefits of Electronic Prognostics.

The BladeSwitch deployment began 2 years ago in Malaysia as a small voice-only infrastructure model serving a small number of users somewhat typical of a North American based Central Office. In the past years the system has blossomed to serve thousands of users.

Facts for Financial Calculations:

- 1,000 power supplies were deployed in a non-redundant architecture
- 10 power supplies are contained in each BladeSwitch unit totaling $3,250 ($325 per supply)
- MTBF of the power supplies in this specific application is 250,000 minimum as a result of environmental controls and loading considerations
- Through proper design, Prognostics for the power supply does not degrade the MTBF more than 10%
- The incremental cost of the Prognostics components per power supply is estimated at $12
- Cost of each power supply with prognostics is $337
- Cost to replace a system supply is $5,000 including the cost of hardware and labor

Savings estimate for BladeSwitch

For this system, the benefits can be viewed in two categories, hard costs, and soft costs.

Over the 5 year service life of the telecom system, 3 unplanned power supply failures at an expected cost of $5000 each would payback the cost to implement electronic prognostics within the power supplies.

Soft costs, or the variable cost of the loss of reputation etc., associated with an untimely system failure have the potential of driving up the ROI even higher.

Implementation Cost Estimate

The Non-Recurring Engineering (NRE) cost to implement prognostics in this application is estimated at $15,000 which includes all of the sensor design, implementation, prototyping and layout. In a small deployment such as this one, the amortized one time charges amount to $15 per supply. Obviously the Prognostic design is scaleable and portable such that it can be mirrored in other designs significantly reducing the unit cost.

Return on Investment Estimate for BladeSwitch

Assuming hard cost savings of system failure avoidance exclusively:

ROI = (Savings – Implementation Costs)/(Investment Required)

ROI = ($5,000 – ($15+$12) / $15,000

ROI = 33%

CONCLUSION

The purpose of this document was to provide a basic framework for the calculation of ROI for electronic prognostics. It has been shown that implementation of prognostics can have a very favorable rate of return. Hard costs were used in this example so as to use real out of pocket costs in the calculations. However, soft costs during a system malfunction can be significantly higher. Clients experiencing a malfunction may penalize potential hardware suppliers for extended periods as a result of a single event. Even more dramatically are penalties and fine which might be levied on a supplier as a result of system downtime. Although the conservative hard cost estimates here prove Prognostic implementation to be a worthy investment, real life returns should be much greater.

REFERENCES

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