Reducing Maintenance Costs Using Beyond Economic Repair Analysis

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Introduction

A Beyond Economic Repair (BER) analysis compares the cost of repairing a part or assembly with the cost of replacing it giving a company information to help determine if repairing a product is more economical than replacement. Using information from a BER analysis, repair procedures can be written so that once a pre-determined amount of time has been spent on repair without success, a product can then be replaced, spending the additional time on replacement rather than further attempts at repair. A BER analysis starts out as a prediction using anticipated repair costs for a new product to establish the amount of hours spent to attempt repair before stopping repair work and replacing the product. As individual product units are returned to the company for repair, actual repair hours can be recorded and incorporated into the repair procedures as well as the economical repair yield (the percentage of failed assemblies of each type that are successfully and economically repaired) for a product.

A BER analysis is developed initially for the lowest level repairable components in a product, once actual repairs have been attempted a BER cost threshold for the top level product can be established as well. Establishing a BER threshold cost is valuable for the initial determination of a product warranty, and once actual repairs have been accomplished the repair cost information will inform a company if their warranty program has been profitable. Once a product passes beyond its warranty a BER repair cost threshold will also help determine the cost for non-warranty repairs. This paper will demonstrate how to perform a Beyond Economic Repair analysis and how to use the analysis to reduce maintenance costs, manage a products warranty and non-warranty repairs.

Data And Cost Elements of the BER

A maximum economical repair cost can be calculated using the following data and Cost Elements, developing the calculation is described in the Calculate Max Repair Labor Hours Section:

Repairable Parts and Assemblies: Identify the Parts and Assemblies or Repairable Assemblies (RAs) that will be analyzed for economical repair cost, these are the parts and assemblies that are identified as failed by testing the top level assembly. To repair an RA means to fault isolate the RA, replace the faulty component(s), test the RA and return it to service. All costs (material and labor) associated with these subtasks make

up the Material and Repair Cost which is compared to the BER Threshold Cost to determine if an RA is economically repairable.

Unit Cost of RAs: This is the average purchase price for a RA. An RA may be available only during the manufacturing phase so a prediction of the number of expected failures should be performed so that a decision can be made about how many of an RA should be purchased while they are still in production. Once an RA is out of production, the cost of procuring them could become prohibitive since their manufacturer would have to re-start a production line in order to manufacture the item.

Labor Rates: Touch (repair technician) and Engineering Support – includes all administrative or clerical services.

Average Material Cost of Repair: Historically 20% of a part or assemblies unit cost is added to repair cost for materiel. The 20% figure can be adjusted for specific parts or assemblies, for instance parts or assemblies with a long repair history may have a predominant failure mode that requires more or less materiel than the initial 20% of unit cost. The cable in row 6 of the Sample BER Analysis Spreadsheet is an example.

BER Threshold Cost: Many models use a repair cost of 70% of unit cost as the threshold for economic repair cost. Some models go as high as 100% of unit cost, in other words spend as much on repair as the unit costs before replacing it. If the part or assembly cannot be repaired then the labor to replace the part is added to the unit cost making for a more expensive repair. The rationale for replacing an RA when repair costs reach 70% of its unit cost is that it is more economically beneficial for the service life of the entire product to have a new RA rather than the used RA which has cost more than 70% or more of its unit cost to repair. The new RA will have a longer expected service life than the repaired one.

Economic Repair Yield: The repair yield, successful repairs of an RA that require less time than the Max Repair Labor Hours expressed as a percentage of attempted repairs, must be greater than the BER threshold in order to be economically repairable. Once a stable repair yield has been determined a Service or Depot Manager (Service Manager) has information to help decide if repair should be attempted rather than replacement. Other factors affect this decision; if a part or assembly is obsolete (no longer being manufactured) then repair will have to be attempted. If a part or assembly is currently not in stock and a supply will take some time to secure, the Service Manager must determine if repair should be attempted or replacement of the part delayed until a supply of new parts is in stock at the repair facility. This determination is especially important in a commercial environment where customers may expect a quick turn-around on repairs.

	A	B	C	D	E	F	G	H	I	J	K
1	BEYOND ECONOMIC REPAIR (BER) REPLACEABLE ASSEMBLY (RA) MATRIX										
2	**Top Assy Serial Number**										
3	**Replaceable Assembly (RA)**	**Part number**	**Unit Cost**	**Max Repair Labor Hrs**	**Recorded Labor Hrs**	**Remaining Labor Hrs**	**Repair Labor Cost**	**Repair Material**	**Material and Labor Cost**	**BER threshold**	**Economic Repair Yield**
4	Cover	XXXXXXX-X	$165	0.33		0.33	$0	$33	$33	$116	70%
5	Harness, Wiring	XXXXXXX-X	$1,550	3.10		3.10	$0	$310	$310	$1,085	65%
6	Cable	XXXXXXX-X	$3,360	9.27		9.27	$0	$34	$34	$2,352	65%
7	Cryoengine	XXXXXXX-X	$11,050	22.10		22.10	$0	$2,210	$2,210	$7,735	50%
8	Heatsink	XXXXXXX-X	$190	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9	Circuit Card Assy 1	XXXXXXX-X	$2,020	4.04		4.04	$0	$404	$404	$1,414	50%
10	Circuit Card Assy 2	XXXXXXX-X	$2,710	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11	IMU	XXXXXXX-X	$14,150	28.30		28.30	$0	$2,830	$2,830	$9,905	95%
12	Bulkhead	XXXXXXX-X	$85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	DC\DC Conv	XXXXXXX-X	$3,690	7.38		7.38	$0	$738	$738	$2,583	TBD
14	Filter	XXXXXXX-X	$1,590	3.18		3.18	$0	$318	$318	$1,113	TBD
15											
16	Hourly Touch Labor Cost:	$70.00									
17	Hourly Support Labor Cost:	$120.00									
18	Total Repair labor "hour"	$250.00									
19											
20	Data input cell										
21	Always replace										

SAMPLE BER ANALYSIS SPREADSHEET

Developing The Model

Assumptions

The Sample BER Analysis Spreadsheet was developed by following these steps:

Identify The Replaceable Assemblies

If a BER analysis is being performed for a new product identify the lowest level parts and assemblies that can be replaced or repaired. Testing the Top Level Assembly must be able to identify these parts and assemblies as the failed item. These parts and assemblies, or Replaceable Assemblies (RA) will make up the initial spares candidate list.

If a BER analysis is being performed for a product that has been in use for some time a list of failed parts and assemblies should be available, or a list can be developed by talking with the appropriate repair facility personnel. Parts and Assemblies that have a failure history may also have repair information such as how much time has been spent on individual repairs and the Economical Repair Yield. Economical Repair Yield is the percentage of a particular failed part or assembly that have been successfully repaired economically. Once the BER has been completed repair times and repair yield can be used to determine if repairing an RA is economical, this is discussed further in the Review, Implementation and Revision section.

Determine a Unit Cost For Replaceable Assemblies

Determining a Unit Cost (Column C) for the RAs is critical to the output of the BER analysis since the economical repair threshold is defined as a percentage of Unit Cost. A cost estimator will determine the unit cost for an RA using such factors as: if the RA is still being manufactured, can a purchase for spares be made along with a purchase for production to take advantage of volume discounts. RA Unit Costs may fluctuate; they should be updated as part of the BER revision cycle.

Determine Touch and Support Labor rates

Touch and Support Labor (cells B16 and B17) are charged at different rates. Touch and Support Labor rates need to be fully “burdened” that is, all costs that add up to the price the customer is charged for the labor need to be included, this information can be obtained from a financial analyst.

The amount of Support labor to charge is a ratio of how much Support labor is charged for each hour of Touch labor. The ratio of Support to Touch labor can be calculated from total Support hours charged divided by total Touch hours charged for the repair of

a particular Top Level Assembly. If the BER analysis is being performed for a new product establish a ratio of Support to Touch labor by comparison with comparable products then adjust every 6 months as Touch and Support hours begin to be recorded. Once the ratio of Support to Touch labor is established a Total Repair Labor Hour (cell B18) can be determined. A Total Repair Labor Hour is what will be used in the equation to determine the max repair labor hours (for an economical repair) in column D. In the example BER spreadsheet Support labor is 1.5 times Touch labor so the equation to calculate a total labor hour in cell B18 is: = B16 + 1.5 * B17.

Determine Repair Materiel Cost

Using the standard rate of 20% of an RAs Unit Cost for the repair materiel cost the equation used for cell H4 is: = C4*.2 and so on for the rest of the cells in Column H.

Calculate BER Threshold for the RAs

Using the standard rate of 70% of unit cost as the BER economic repair threshold the equation used for cell J4 is: = C4 * .7 and so on for the rest of the cells in Column J.

Calculate Max Repair Labor Hours

The Maximum Repair Labor Hrs for an economical repair is calculated by subtracting the Repair Materiel Cost from the BER threshold which leaves the cost of labor, divide the cost of labor by a Total Repair Hour (cell B18). The equation in cell D4 is: = (J4 - H4) / B18 and so on for the rest of the cells in Column D. An assumption of this model is that repair hours are those hours spent repairing the RA, repair hours do not include re-installation of the RA into the Next Higher Assembly (NHA) or product. Those repairs are accounted for at the NHA level or product level, whichever is applicable.

Remaining Labor Hours and Repair Labor Cost

Remaining Labor Hours provides information for the repair technician about how much time remains for an economical repair of the RA, the equation in cell F4 is = D4 – E4 and so on for the rest of the cells in Column F. The spreadsheet can be formatted so that If the recorded labor hours in Column E are greater than the Max Repair Labor Hrs in Column E the Remaining Labor Hrs in Column F will be red. Repair Labor Cost shows how much money has been spent on labor, the equation in cell G4 is = E4 * B18 and so on for the rest of the cells in Column G.

Material and Labor Cost

Material and Repair Cost is the entire cost of repairing the RA, the equation in cell I4 is = G4 + H4 and so on for the rest of the cells in Column I. The spreadsheet can be formatted so that if the cost in column I is equal to or exceeds it's corresponding BER threshold value in Column J the cost in Column I will be red.

Determine Economic Repair Yields of RAs

Another factor that can be considered in determining whether or not to repair an RA is the historic repair yield of the RA. If repair yield and repair time information is available combine the information to determine the Economic Repair Yield (Column K). First, for all RAs with recorded repair times use the repair times for successful repairs that are less than the Max Repair Labor Hrs. Do not use an average repair time for all successful repairs to determine a repair yield percentage, a few high or low times could move the average above or below the BER threshold. Divide the number of successful repairs that required less than the Max Repair Labor Hrs by the number of attempted repairs to get a repair yield in percent. Record the percentage in column K.

The repair yield of an RA needs to be greater than the percentage of unit cost used as the BER threshold in order for repair to be economical. The spreadsheet below shows the repair\replace cost of a wiring harness from the Sample BER Analysis Spreadsheet as it relates to repair yield, 100 attempted repairs are used for the analysis. The equation in cell F2 is = ((D3 * 68) + (C3 + D3) * 32) / 100. If 100 repairs were attempted a 68% economical repair yield means that 68 out of 100 wiring harnesses were economically repaired, the remaining 32 had to be replaced after an unsuccessful repair attempt. So the average cost for repairing or replacing each of the 100 harnesses is $31 more than the Unit Cost meaning the least expensive repair option is to replace all harnesses rather than attempt repair. Once the BER threshold has bee reached and a repair technician has decided to stop repair work and replace an RA the costs for reassembly and testing the assembly are the same so those costs are not included in this analysis.

	A	B	C	D	E	F
1	**Replaceable Assembly (RA)**	**Part number**	**Unit Cost**	**BER threshold**	**Economical Repair Yield**	**Repair\Replace Cost per unit (100 units)**
2	Harness, Wiring	XXXXXXX-X	$1,550	$1,085	68%	$1,581
3	Harness, Wiring	XXXXXXX-X	$1,550	$1,085	69%	$1,566
4	Harness, Wiring	XXXXXXX-X	$1,550	$1,085	70%	$1,550
5	Harness, Wiring	XXXXXXX-X	$1,550	$1,085	71%	$1,535
6	Harness, Wiring	XXXXXXX-X	$1,550	$1,085	72%	$1,519

REPAIR COST AS A FUNCTION OF REPAIR YIELD

Since not all economical repairs will require the Max Repair Labor Hrs (Column D of the Sample BER Analysis Spreadsheet) the analysis is conservative, a Service Manager may choose to attempt repairs at lower economical repair yields depending on repair history for a particular RA.

Using The BER Spreadsheet

Enter the RAs and their part numbers in Columns A and B respectively. Enter Unit Costs in Column C, Repair Material costs (column H) and BER threshold costs (Column J) will be calculated when Unit Costs are entered. Enter Hourly Touch Labor Cost in cell B16 and Support Labor Cost in cell B17. The Total Repair Labor "hour" will be calculated in cell B18 and the Max Repair Labor Hrs will be calculated in Column D. If Economic Repair Yields have been calculated enter them in Column K.

The BER spreadsheet may show that some RAs will not be economically repairable either because their Unit Cost is so low that even the minimum time necessary to repair them exceeds their Unit Cost or their repair yield is so low that attempting repair is not economical. A useful cost threshold for Unit Cost is one Total Repair labor "hour" (cell B18 of the Sample BER Analysis Spreadsheet). The Heatsink in row 8 of the BER Spreadsheet and Bulkhead in row 12 both have Unit Costs below the Total Repair labor "hour" of $250 so they are marked as Always replace. The Circuit Card Assy 2 in row 10 is shown as Always replace due to a low repair yield.

Before a repair technician begins repair work on a particular RA he (she) looks at the Max Repair Labor Hrs (column D) allowed for an economical repair of the RA. As repair work proceeds the technician can enter the amount of time spent repairing the RA in column E, the Repair Labor Cost will be calculated in Row G and the remaining time allowed for an economical repair is calculated in Column F. The repair technician may decide, after consulting with manufacturing engineering, to end repair work at any point because additional repair work not result in a successful repair, a new RA would be re-installed at the NHA. If the amount of time spent repairing an RA exceeds the Max Repair Labor Hrs in column D the Remaining Labor Hrs in Column F and the Material and Repair cost in column I will turn red meaning the repair work has exceeded the economical threshold. This is an indication that repair work on the RA should be stopped and a new RA used for the NHA.

Model Review, Implementation and Revision

Review

A peer review should be conducted on the model before submitting it to program management for implementation.

Implementation

Once the BER model has been developed it should be reviewed by others in the company responsible for product repair, people with such as the Program Manager, Sustainment Manager and Service Manager before implementation. The Sustainment Manager or Program manager may modify the recommendations of the model due to supply chain issues. For instance an RA that the model determines is not economically repairable may have to be repaired due to the component no longer be manufactured or is not available at an economical price (the cover in row 4 of the Sample BER Analysis spreadsheet is an example). The Service Manager may have depot or labor related issued that affect implementation of the BER tool, getting the buy-in of the Depot Manager is critical to the successful implementation of the BER tool.

Revision

Once the Service Manager accepts the BER model for use in the depot a revision cycle should be established to update such information as Repair and Support Labor rates, Unit costs and Repair Yields. Repair and Support Labor rates and Unit costs affect the amount of time that can be economically spent repairing a component or assembly. Repair yield can affect the decision as to whether or not a part or assembly should be repaired or replaced; repair may be necessary for a part with a low repair yield if there are no spares in stock.

Conclusion

A Beyond Economic Repair Analysis is a recommendation used to determine if repairing a product is more economical than replacement. The BER along with other factors such as reparability of the Replaceable Assembly, parts availability and repair facility factors are used by a Sustainment or Repair Manager in determining the most economical means of supporting a product.