Assessing Warranty Cost

John A. Long
PRICE Systems, L.L.C.

On 19 October 1984, Congress passed the Department of Defense (DoD) Authorization Act of FY1985. That Act included Section 2403, also known as Public Law 98 - 525, which established warranty policy for the Department of Defense. Section 2403, entitled "Major Weapon Systems: Contractor Guarantees," consists of definitions, requirements, and waiver procedures for weapon system warranties. The law requires that each prime contractor provide written guarantees that an item provided under the contract, at the time it is delivered to the Government, will 1) conform to design and manufacturing requirements specifically delineated in the production contract, 2) be free from all defects in materials and workmanship, and 3) conform to essential performance requirements (EPRs) of the item, as specifically delineated in the production contract. If the item fails to meet the warranty requirements, the contractor, at the discretion of the Contracting Officer, shall be required to take corrective action or pay for Government correction of the defect.

The distinguishing feature of Title 10, Section 2403 is its inclusion of EPRs in warranty clauses. According to Title 10, EPRs are "operating capabilities and/or reliability and maintenance characteristics of a weapon system that are determined by the Secretary of Defense (or delegated authority) as necessary for the system to fulfill the military requirement for which it was designed." For each system, there are numerous EPRs and the meeting or not meeting of these parameters can mean the difference between success or failure of the mission. Thus, the EPRs affect the system throughout its life cycle. Therefore, EPRs targeted for warranties must be carefully chosen and the warranty constructed so as to assure their compliance.

Section 2403 mandated that the military services implement weapon system warranties (WSW) for all programs which cost more than $ 100,000 per unit or $ 10,000,000 total buy. Waivers to this policy are possible if the warranty is not in the National Interest (as determined by the Secretary of Defense) or is *not cost effective* (as documented by the weapon system program office and approved by the Secretary of Defense). Congress does not intend that the DOD should purchase warranties that are not cost effective. To show cost effectiveness, a warranty cost benefit analysis (CBA) must be performed.

WARRANTY COST BENEFIT ANALYSIS

The warranty CBA requirements of the Federal Acquisition Regulation (FAR) are stated in FAR Subpart 46.7 - "Warranties:"

> 46.702 (c) The benefits to be derived from a warranty must be commensurate with the cost of the warranty to the government.

If the contracting officer considers a specific warranty not cost-effective, a waiver request is initiated. Warranty cost effectiveness is determined by comparing the benefits derived from the warranty to its acquisition and administrative costs. A CBA must be done, even though the contractor may propose a "no-cost" weapon system warranty, to compare the government's cost of administering and enforcing the weapon system warranty to the potential benefits to be derived from the proposed weapon system warranty.

According to the Defense System Management College Warranty Guidebook, the methodology used to conduct a warranty cost benefit analysis may vary depending on the type of warranty selected, the type of weapon system, the terms and conditions exercised by the contracting officer, the essential performance characteristics of a weapon system, and the identification and measurability of various types of costs. DoD regulatory guidance requires program offices to compare life cycle cost with and without a warranty to determine the cost effectiveness of the warranty. If the difference between the life cycle cost without a warranty and the life cycle cost with a warranty is positive, the warranty is considered cost effective. (DSMC 1986)

Performing a warranty CBA is a process, a systematic series of six progressive and interdependent steps consisting of: 1) planning, 2) groundrules and assumptions, 3) methods and approaches, 4) data collection and analysis, 5) estimate development, and 6) documentation. (Long 1993)

WARRANTY COST ESTIMATING

An essential part of the warranty CBA is the determination of the warranty cost. The cost is normally decided by the contractor and relayed to the Government as part of the CBA. Warranty costing for the contractor begins with a determination of the repair costs for failed items. In addition, according to Air Force Manual 64-110, “the contractor’s warranty price may include reasonable administration and data costs.” Further, the WSW “does not include profit.” (AFM 64-110, 1994) With the repair costs in hand, the contractor adds its administration cost, along with any travel costs to estimate the full cost of the warranty. The key to determining the repair costs is the warranty item’s mean time between failure (MTBF). Secondary to the MTBF, mean time to repair (MTTR) is critical in determining warranty cost. MTBF or MTTR or both may be EPRs for the system being warranted. With there two parameters, MTBF and MTTR, in hand, the contractor can then proceed to apply labor rates and transportation costs to arrive at the repair cost. On the Government side, once the contractor provides the warranty cost, the Government adds its internal administrative cost to arrive at a total cost to the Government. This process may sound simple, but it practice it can be very complex due to warranty item's deployment scenario and utilization rate along with other complicating factors.

In order to perform the process effectively and efficiently, computer-aided estimating models are required. The PRICE HL model with its interactive Microsoft Excel interface is ideally suited for this purpose. Driven primarily by MTBF and MTTR, the model quickly and accurately estimates the cost to repair a failed item. A contractor can use the model to price a warranty and the Government can use the model in performing a warranty CBA to determine the cost effectiveness of the proposed contractor price. With reference to the six steps in the warranty CBA process, the model guides the analyst in the drafting of groundrules and assumptions and forms the basis for the methodology and approach of the analysis. Further, it assists in defining the required data and aids in the analysis of that data. Lastly, the model forms the core of the estimate development and then assists the analyst in preparing the documentation. This paper details the warranty CBA process and, particularly, warranty pricing using the PRICE HL model. It clearly shows how the model can be used to determine the price of a warranty and how to evaluate that price for reasonableness and cost effectiveness.

WARRANTY PRICING

Warranty pricing may actually begin with the PRICE H Model. The PRICE H model estimates the development and production cost of the item being considered for warranty. When used with calibrated manufacturing data, the PRICE H model develops three critical parameters that may not be available from empirical data. These critical parameters are MTBF, MTTR, and the average cost for assemblies, subassemblies, and parts. These parameters along with other pertinent data are then automatically fed to the PRICE HL model where the repair costs are estimated.

At this point an example will help clarify the process. The SecCom Corporation has been contracted by the Air Force to build and deploy a new internet secure radio for transmission of classified information. The radio can be either air or land based. It takes classified data, scrambles it, and then transmits it to a nearby ground station. The ground station then sends the encrypted data over the internet to another ground station near the data recipient. There it is once again transmitted by radio to the recipient who has an internet secure radio. The Government would like a three-year "failure free" warranty on the new radio. Under the warranty, the contractor is responsible for all repairs to failed radios. The contractor will have one full-time representative at each of four operational sites in the United States. The contractor representative will false isolate to the module and then send failed modules to the contractor plant for repair. Fault isolation will be by built-in test (BIT). The contractor will pay the transportation cost and will furnish all required spares. At the end of the warranty period, the spares will be the property of the Government.

The Government intends to purchase one hundred (100) of the new internet secure radios and deploy them at four sites in the United States. Each radio, on average, will be operated forty-five (45) hours per month during the three-year warranty period.

PRICE HL requires a minimal number of parameters in order to estimate the repair costs for the warranty. However, in order to use PRICE HL as the warranty pricing vehicle, several of these parameters must be properly set. Some of these are located in the Miscellaneous Globals as shown in Figure 1. DPEC (Delete Production Equipment Cost) and DPSEC (Delete Production Support Equipment Cost) are set to unity to delete Production Equipment cost and Production Support Equipment cost respectively. This assumes that the contractor will use test equipment employed during the production process to repair radio failures. If this is not the case, the cost of support equipment should be included as part of the warranty price. In addition, the parameter AOFF (Availability Shut-Off Control) is also set to unity to eliminate readiness from the spares calculation, thereby increasing the number of spares and guaranteeing a readiness of one hundred percent. (Rotz 1985)

Further, the parameters PCTS (Percentage For Annual Test Set Upkeep), CEN (Cost to Enter an Item Into the Supply System), CAD (Annual Cost to Retain an Item in the Supply System), and FNGF (False No-Go Fraction) are all set to zero. PCTS is the fraction of the support equipment acquisition cost used to compute the annual maintenance and upkeep costs of the test sets over the support period. If there is no support equipment cost, as mentioned previously, this parameter is not applicable. CEN is the cost to catalogue an item in the Federal stock systems and CAD is the yearly cost to maintain an item in the system. If the internet secure radio is eventually maintained organically, these costs will be applicable at that time. For the warranty, however, they are not applicable. The FNGF is used to model removals of items from the equipment level which, after check-out, are found not to require any repair work. These items are then placed back into service. Under the warranty, all items are treated as failures. If the BIT gives a false indication, then it has failed and the radio has incurred a failure. (Rotz 1985)

In addition to the Miscellaneous Globals, other Globals must be set to accommodate the warranty scenario. These include the Provisioning and Labor Globals and the Shipping Cost Factors. The Provisioning and Labor Globals are shown in Figure2. The depot labor rate was set to reflect a fully burdened or loaded rate for the

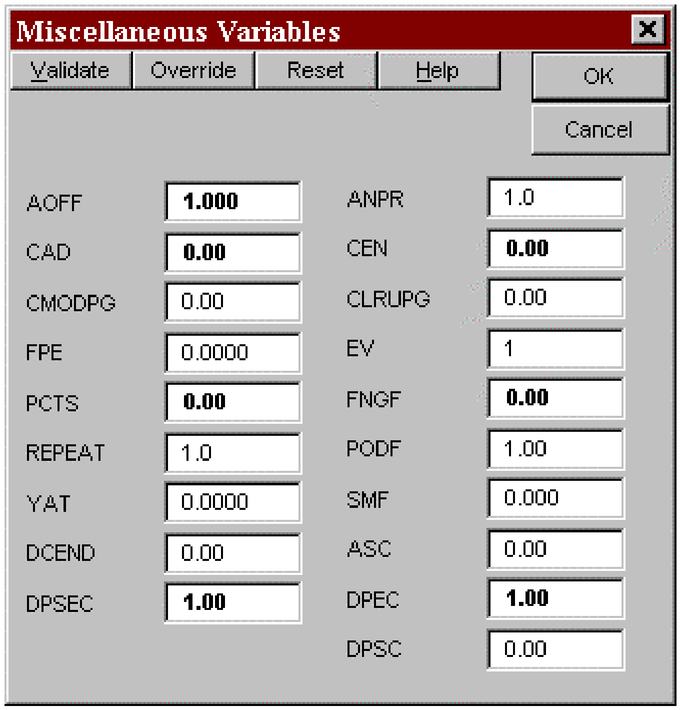


Figure 1 PRICE HL Miscellaneous Globals

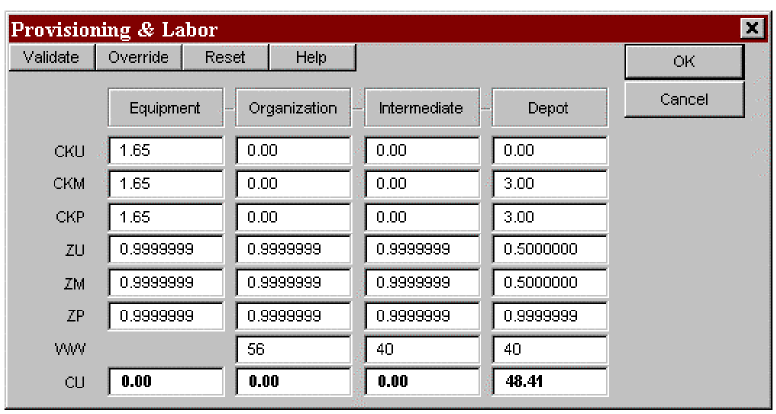


Figure 2 Provisioning & Labor Globals

contractor repair facility. This is known as a “wrap rate”. A wrap rate is a total rate per hour that covers direct labor, overhead, fringe benefits, and other costs. All other labor rates were set to zero. At the same time, the Shipping Cost Factors were set to reflect the contractor’s cost per pound for shipping failed items between the operational sites and the contractor repair facility. These rates are shown in Figure 3.

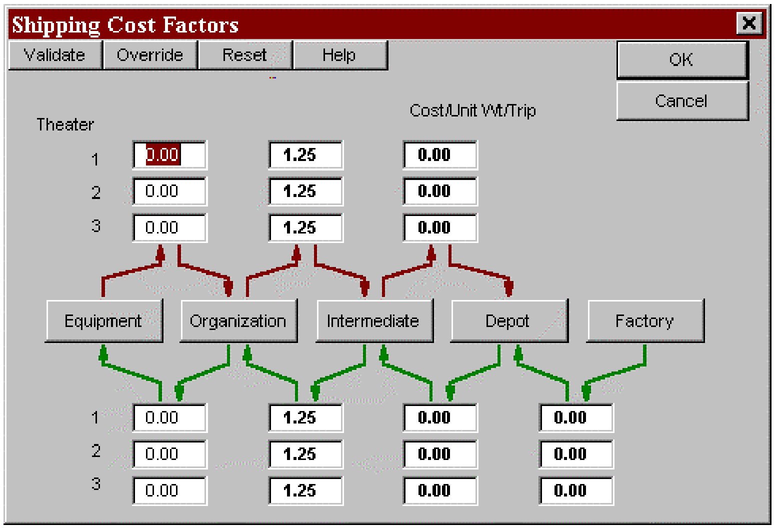


Figure 3 Shipping Cost Factors

Aside from the Globals, the Deployment sheet must be set to reflect the radio deployment scenario. The warranty Deployment sheet is shown in Figure 4. The Deployment sheet indicates the number of years that the warranty will be in effect, the number of deployment supply and maintenance locations, the number of systems deployed (ED), and the amount of time each system will be operated a month (OTF).

The next step in the process is to build the Estimating Breakdown Structure or EBS. EBS is the PRICE term for cost breakdown structure that is aligned to the hardware configuration structure to provide for more effective cost estimating. The EBS for the internet secure radio is shown in Figure 5. This EBS can be built either in PRICE HL or in the PRICE Excel Interface. The recommended procedure is to build the EBS in PRICE where there is visual reference to aid the analyst. The EBS shows the four components in the radio: a chassis, transmitter, receiver, and modulator. There are two identical transmitters per radio. A sample EBS element input sheet is shown in Figure 6. The input sheet contains cost driving EPR parameters such as MTBF and MTTR (TD), as well as item costs and the maintenance concept.

At this point, the process transitions to the PRICE Excel Interface. It is here that the remainder of the warranty cost calculations and analysis will take place. The Interface is shown in Figure 7. For this warranty example, there are three worksheets as illustrated by the three tabs at the bottom of the figure. The Builder worksheet is shown in the figure and is the direct link between Microsoft Excel and the PRICE HL model. PRICE input parameters can be changed in the Builder. These changes are then fed to the PRICE model, the model is run, and the output is updated. This occurs while PRICE is running in the background, unseen but very much an active part of the analysis. Thus for example, the MTBF for each component, as shown in column C of the worksheet, can be

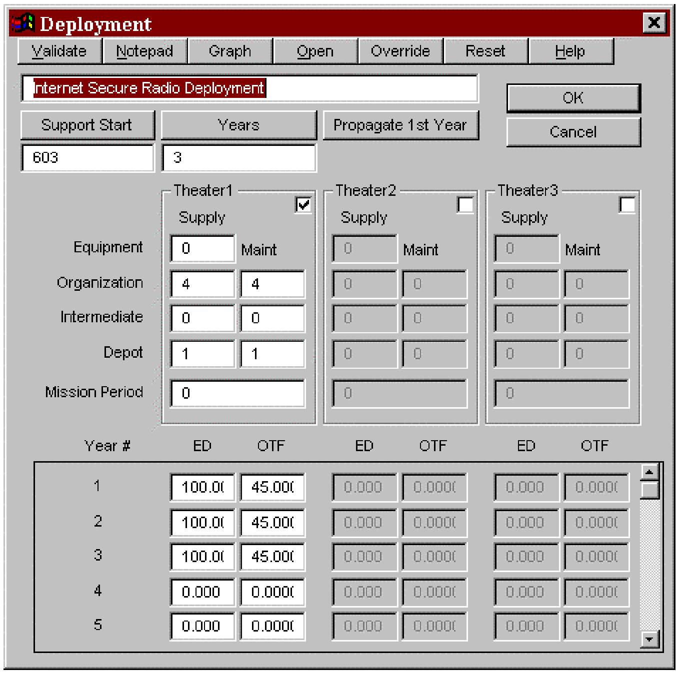


Figure 4 Internet Secure Radio Deployment Sheet

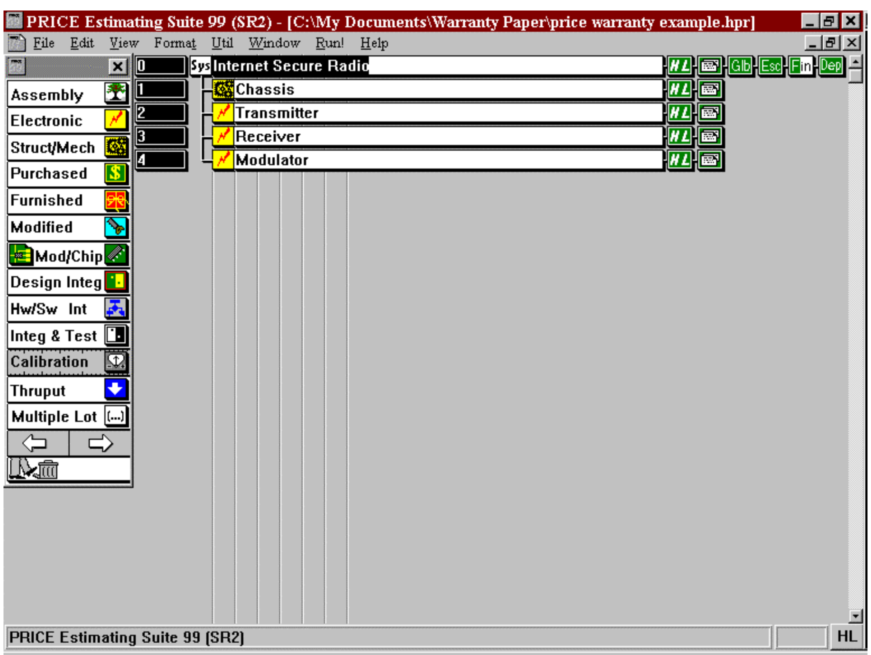


Figure 5 Internet Secure Radio Estimating Breakdown Structure

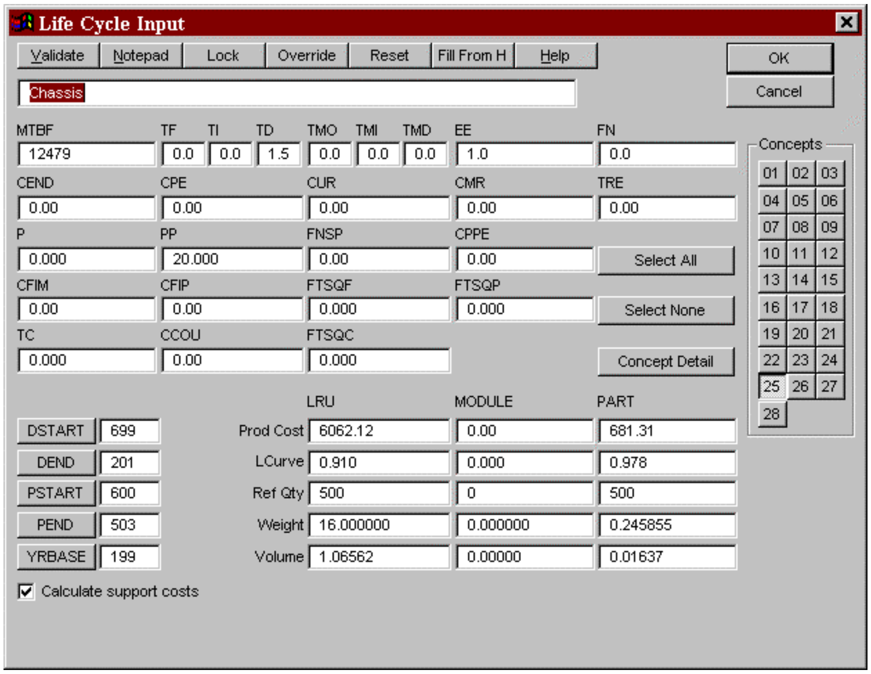
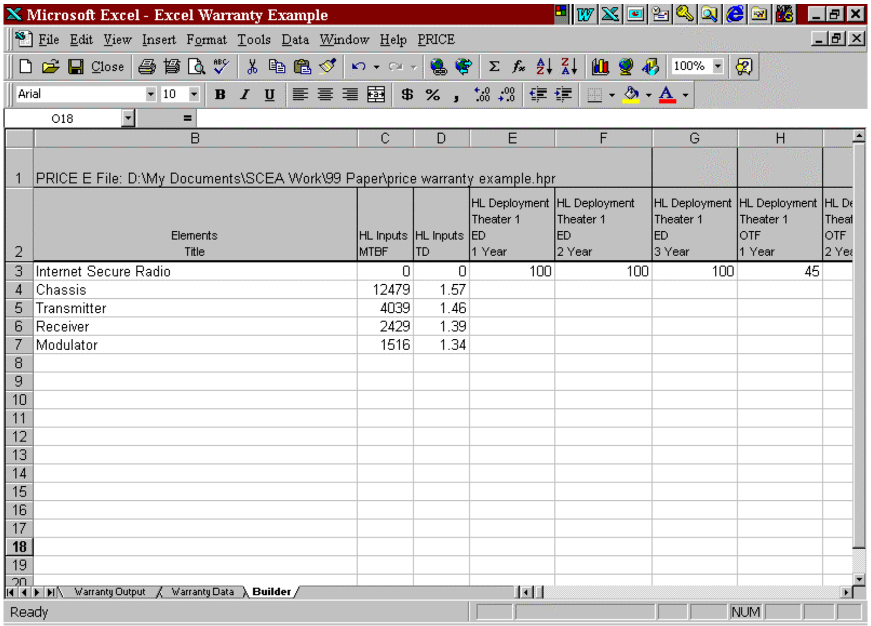


Figure 6 Internet Secure Radio Sample Input Sheet

doubled and the new cost is reflected in a Builder output column (not shown). The analyst has complete control over which PRICE inputs and output are contained in the Builder columns.

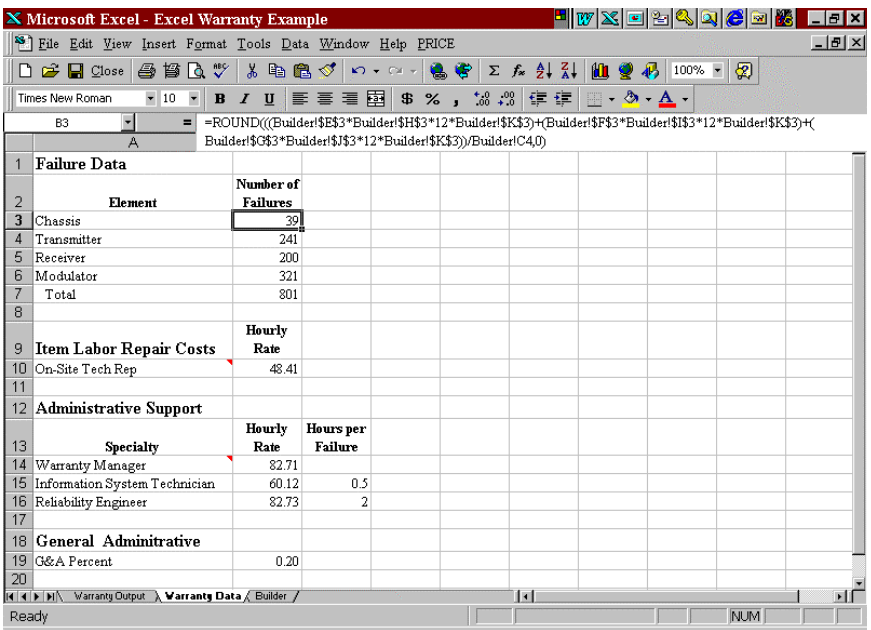
The Warranty Data worksheet, referenced by the tab to the left of the Builder in Figure 7 and shown in Figure 8, contains data to feed algorithms to estimate warranty costs not calculated by the PRICE HL model. For example, the number of failures is needed because the cost of the Information System Technician and Reliability Engineer is predicated on a set number of hours per failure. These people are not dedicated to the internet secure radio. The formula for computing Chassis failures is shown at the top of Figure 8. The calculation for the number of chassis failures is directly linked to the Builder, which is directly linked to the PRICE HL model. If a PRICE HL parameter that affects the number of failures, such as MTBF, is changed, the number of failures on the Warranty Data worksheet will in turn change and the cost is thereby updated.

The Warranty Output worksheet, accessed through the tab to the left of the Warranty Data tab in Figure 7, contains the warranty cost information. Its content is shown in Table 1. This worksheet is linked to the Builder worksheet and the Warranty Data worksheet. The item labor repair costs at the top are directly linked to the Builder



	B	C	D	E	F	G	H
1	PRICE E File: D:\My Documents\SCEA Work\99 Paper\price warranty example.hpr						
2	Elements Title	HL Inputs MTBF	HL Inputs TD	HL Deployment Theater 1 ED 1 Year	HL Deployment Theater 1 ED 2 Year	HL Deployment Theater 1 ED 3 Year	HL Deployment Theater 1 OTF 1 Year
3	Internet Secure Radio	0	0	100	100	100	45
4	Chassis	12479	1.57				
5	Transmitter	4039	1.46				
6	Receiver	2429	1.39				
7	Modulator	1516	1.34				

Figure 7 PRICE Excel Interface (Builder Worksheet)



	A	B	C
1	Failure Data		
2	Element	Number of Failures	
3	Chassis	39	
4	Transmitter	241	
5	Receiver	200	
6	Modulator	321	
7	Total	801	
8			
9	Item Labor Repair Costs	Hourly Rate	
10	On-Site Tech Rep	48.41	
11			
12	Administrative Support		
13	Specialty	Hourly Rate	Hours per Failure
14	Warranty Manager	82.71	
15	Information System Technician	60.12	0.5
16	Reliability Engineer	82.73	2
17			
18	General Adminitrative		
19	G&A Percent	0.20	
20			

Figure 8 PRICE Excel Interface (Warranty Data Worksheet)

and are a function of the number of failures, the MTTR, and the depot labor rate. The cost of the on-site tech reps is a function of the number of deployment locations and the hourly wage rate. Recall that the tech reps are dedicated to the internet secure radio and are paid based on 2,080 hours per year.

As with the item labor repair cost, the spares cost is linked to the Builder and is a direct output from PRICE HL. The cost of spares is a function of the MTBF, pipeline times, number of deployment locations, the maintenance concept, and individual item cost. Just as with the spares cost, the transportation cost is directly linked to the Builder and to PRICE HL. It is a function of the number of failures, the weight of the items, and the shipping cost per pound found in the PRICE HL Globals. The warranty administration cost is linked to the Warranty Data worksheet that is, in turn, linked to the Builder. The General and Administrative (G&A) cost is a set percentage of all other costs. The G&A percent is located on the Warranty Data worksheet.

From the previous description, the power and versatility of the PRICE Excel Interface is quit evident. Through the Builder, PRICE HL inputs and outputs are tied directly to the estimate. If an input changes, the dependent output(s) will likewise change and the warranty cost is automatically updated. Through the Warranty Data worksheet, items of cost not computed by the PRICE HL model can be easily added to the warranty estimate and these can be linked to changes in PRICE HL inputs or outputs.

Now that the spreadsheet structure has been built, it is quite easy to perform sensitivity analyses on the cost driving PRICE HL input parameters. For instance, what if the Government decides to purchase a two-year, rather than three-year, warranty. This contingency is easily accommodated by changing the HL deployment number of years from three to two, as shown in Figure 9, updating the PRICE HL model, and observing the result in the Warranty Output worksheet, as shown in Table 2. Other sensitivity analyses, such as changes to MTBF or MTTR, can be just as quickly and easily calculated.

As an analyst, attention should be directed to the cost drivers, items of cost that contribute most substantially to the total cost. The spreadsheet format assists the analyst in isolating the cost drivers. In the warranty example case, the cost driver is the tech reps. Perhaps part-time tech reps or Government personnel at the operational sites would be more colt effective. PRICE HL with the Excel Interface would require minimal changes to facilitate this change in maintenance concept.

Table 1 Warranty Cost Output

Warranty Estimate

Internet Secure Radio

(FY99$)

Item Labor Repair Costs

Element	Repair Labor	
Chassis	987	
Transmitter	5,670	
Receiver	4,488	
Modulator	6,932	
On-Site Tech Rep	1,208,314	
Sub-Total		1,226,390

Spares

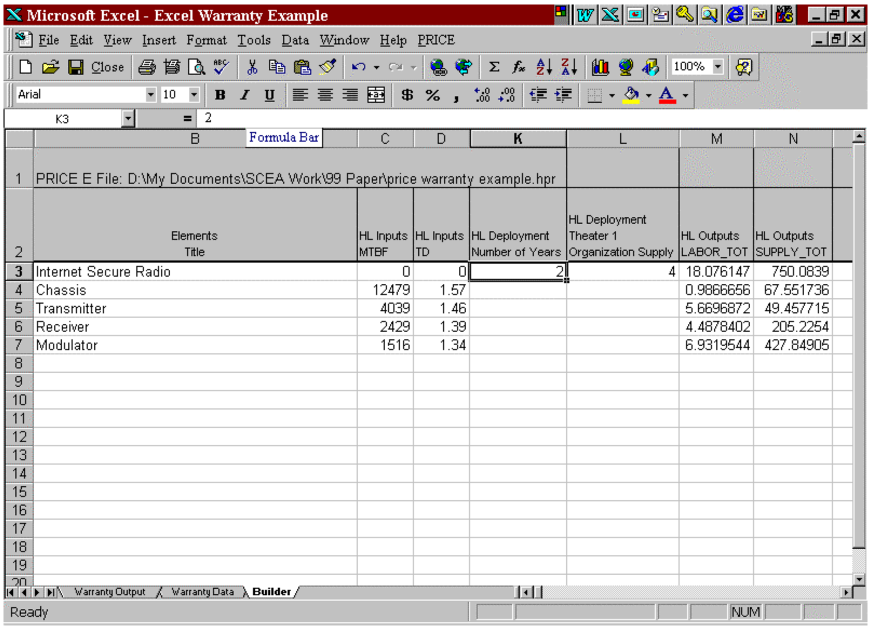
Element	Spares Cost	
Chassis	67,552	
Transmitter	49,458	
Receiver	205,225	
Modulator	427,849	
Sub-Total		750,084

Transportation		5,060

Warranty Administration

Warranty Manager	516,110	
Information System Technician	24,078	
Reliability Engineer	132,533	
Sub-Total		672,722

General and Administrative		530,851
Total		3,185,107



Microsoft Excel - Excel Warranty Example

	B	C	D	K	L	M	N
1	PRICE E File: D:\My Documents\SCEA Work\99 Paper\price warranty example.hpr						
2	Elements Title	HL Inputs MTBF	HL Inputs TD	HL Deployment Number of Years	HL Deployment Theater 1 Organization Supply	HL Outputs LABOR_TOT	HL Outputs SUPPLY_TOT
3	Internet Secure Radio	0	0	2	4	18.076147	750.0839
4	Chassis	12479	1.57			0.9866656	67.551736
5	Transmitter	4039	1.46			5.6696872	49.457715
6	Receiver	2429	1.39			4.4878402	205.2254
7	Modulator	1516	1.34			6.9319544	427.84905

Figure 9 Builder Worksheet with Input Change

CONCLUSION

As long as Public Law 98-525 is effective, Government and industry will have to consider warranty pricing as a normal business practice. The warranty pricing process is greatly facilitated through the use of computer-based models. PRICE HL with the Microsoft Excel Interface affords the opportunity to tailor the estimate and include all pertinent costs. The Interface allows the analyst to concentrate on the EPRs and facilitates analyses that previously would have been quite laborious and time consuming. In short, the Interface produces better, more complete estimates with less time and resources.

Table 2 Warranty Output with Input Change

Warranty Estimate
Internet Secure Radio
(FY99$)

Item Labor Repair Costs

Element	Repair Labor	
Chassis	658	
Transmitter	3,780	
Receiver	2,992	
Modulator	4,621	
On-Site Tech Rep	805,542	
Sub-Total		817,593

Spares

Element	Spares Cost	
Chassis	67,552	
Transmitter	49,458	
Receiver	205,225	
Modulator	427,849	
Sub-Total		750,084

Transportation

Transportation		3,374

Warranty Administration

Warranty Manager	344,074	
Information System Technician	16,022	
Reliability Engineer	88,190	
Sub-Total		448,286
General and Administrative		403,867
Total		2,423,204

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