PRICE HARDWARE MODEL

INTRODUCTION AND OVERVIEW

INTRODUCTION

The PRICE Hardware Model is a computerized method for deriving cost estimates of electronic and mechanical hardware assemblies and systems. It was developed by and for RCA in the early 1960's. PRICE H was first used rigorously in the mid to late 1960's and early 1970's, especially to estimate avionics and space system costs. Interest in the model grew to the extent that arrangements were made for leasing PRICE H by analysts outside of RCA. Commercial operations began in 1975, with an average of over 175 new users of the model trained each year.

The PRICE H Model offers many benefits over manual systems: reduces the probability of accounting errors, faster operation, added capability, and greater facility for sensitivity analysis. The essentials of operating the Model are easy to learn and provide speed, quality and accuracy in lieu of grass roots estimating. The key ingredients are:

- Interactive operation with conversational input and output.

- A parametric approach derived from experience and supported by empirical evidence.

- Efficient problem description with a small set of easily comprehended input factors. Internal self-checking to test the consistency of input data sets.

- Flexibility in adapting to local definitions and accounting procedures.

- Performance calibration that relates current estimates to actual achievements on prior projects.

PRICE H permits rapid and early "probable cost" evaluations based on project scope, program composition, and demonstrated organizational performance. Operational and testing requirements are incorporated, together with technology growth and inflation.

In addition to cost, the Model derives typical schedules for the work to be accomplished. Schedule constraints which have been imposed are examined within the model, and costs are adjusted to account for apparent acceleration or stretch-out.

PRICE H is equipped with many features designed to facilitate the model's use and extend its power. Input parameters may be modified at any time to answer "what if" questions. Risk and/or Sensitivity Analysis will be introduced at a later time. Off-the-shelf, customer furnished and vendor supplied hardware elements may be described and integrated. Special supporting elements are provided for Calibration, Modification, Hardware/Software integration, element integration, and system level integration.

PRICE H is applicable to all aspects of hardware acquisition, from development, production, purchased, furnished, or modification of existing equipment. PRICE H estimates the costs associated with design, drafting, project management, documentation, sustaining engineering, special tooling and test equipment, and of course material, labor, and overhead. Costs to integrate sub-assemblies into a system and to test the system for required operation are also estimated by the model. Costs for field test, site construction, and software are not estimated by the PRICE Hardware model but can be included in the overall estimate if known.

The underlying principle of PRICE H is that all estimates involve comparative evaluation of new requirements in light of analogous histories. PRICE H has been designed for use by managers and analysts to assist them in translating experience and judgment into reliable, timely cost estimates. PRICE methodology provides a convenient way of reducing empirical data to a few principal variables which describe the significant technological and cost differences between individual projects and organizations.

OVERVIEW

PRICE H has been designed to estimate cost and schedule for both commercial and government hardware development and production efforts. An example of a PRICE H Basic Estimate output is shown in Figure A-1.

Basic Estimate

Assembly #1
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Assembly Cost — Costs in ($1000 Constant 193)

Program Cost	Development	Production	Total Cost
Engineering			
Drafting	573.3	60.3	633.6
Design	1757.2	169.0	1926.2
Systems	289.2	-	289.2
Project Mgmt	239.2	627.4	866.6
Data	97.2	195.0	292.2
SubTotal(ENG)	2956.2	1051.7	4007.9
Manufacturing			
Production	-	7200.4	7200.4
Prototype	742.5	-	742.5
Tool Test Eq	13.2	350.4	363.6
SubTotal(MFG)	755.7	7550.8	8306.5
Total Cost	3711.9	8602.4	12314.3
Purch Items	196.9	4921.8	5118.7
Software	400.0	200.0	600.0
Total (Thru Put)	400.0	200.0	600.0
Total w/Thru Put	4308.8	13724.2	18033.0

System Weight	551.00	System WS	356.00
System Series MTBF Hrs	88		
System Quantity	0	Avg System Cost	246

Figure A-1. PRICE H Basic Estimate Output

WHAT INFORMATION IS REQUIRED TO USE PRICE H?

The major objective in developing PRICE H has been to provide a methodology by which experience from apparently unrelated projects could be correlated for use in cost estimation. The character and structure of PRICE H inputs have been designed to permit rapid calibration of unique user conditions. Most companies having development experience will find familiar terms and descriptors. The values associated with the variables and parameters are relatively simple to determine. PRICE H inputs are normally less detailed than information needed to estimate hardware costs by other methods. Alternative forms of project description are permitted.

The principal PRICE H inputs may be grouped into seven or more categories as follows:

Project Magnitude - The number of development and/or production units. Included in this category is the weight, volume and/or the electronic weight or packaging density of the assembly.

Customer Specification and Reliability Requirements - The specification level, operating environment, and the reliability requirement associated with the end use of the product.

Complexity of Design - A measure of the efforts technology, producibility (material, machining and assembly tolerance difficulty, etc.) yield, platform and all labor required to produce the structural and/or electronic part of the assembly.

Complexity of Engineering - The experience, skill, and know-how of the assigned individuals or team, as applicable to the specified task. Is a measure of the complicating factors of the design effort.

New Design and/or Design Repeat - How much new work is required. The amount of design that can be taken from existing design drawings and the amount of structure repetition.

Schedule Impact - The relative impact of known and unknown scheduling conditions on the normal time required to complete the project.

Other costs - Pertinent escalation rates and mark-ups for General and Administrative charges, profit, IR&D, cost of money and purchased element handling.

The fundamental characteristic of the parametric input is that of interrelationship. A change in any one parameter is usually not localized to one cost element, but rather, may have a direct effect on a few cost elements, and an indirect effect on many more. Consider the impact of a change in quantity. Certainly this would cause a change in manufacturing cost. But, it might also affect the fabrication process and, hence, the cost of tooling equipment. In addition, a change in quantity would probably have a schedule effect and so the cost due to escalation would differ. A filtered impact on integration and testing, sustaining engineering, and project management would almost certainly result from a change in quantity. This dynamic effect is characteristic of most input variables.

The PRICE H model contains thousands of mathematical equations relating the input variables to cost. Each specific set of input parameters uniquely defines the hardware for cost modeling. The resultant cost output is determined from the mathematical equations alone. PRICE H does not perform the function of a table look-up model.

PRICE H has been designed to estimate costs with a minimal amount of hardware information. This feature makes it a legitimate tool for cost estimation of programs in the conceptual stage of development, since the model uses its internally generated values for any missing input variables in order to estimate cost. Of course, it is always preferable for you to supply the inputs, when their values are known. In this way, the statistical uncertainty of the parametric model is reduced.

The following provide more detailed descriptions of the principal input groups plus others.

PROJECT MAGNITUDE

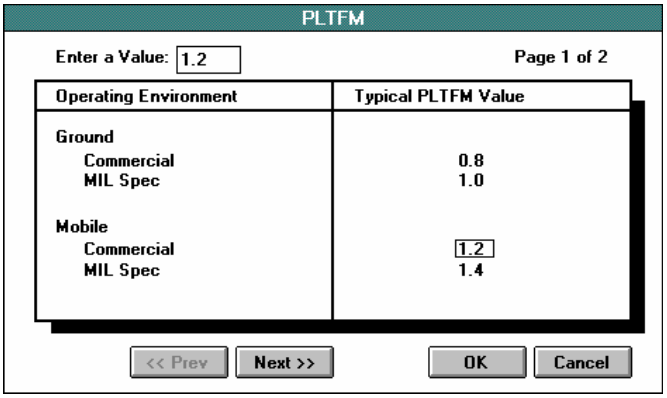
The project magnitude is described to the model by the number of Development and/or Production units. Additionally the total weight and volume of the element being modeled must be described. Weight is considered a paramount input variable which has a direct impact on the total cost of the effort. If the element being modeled is an electronic element, then the Electronic Weight/Electronic Density must be described which serves as a very significant check value on the design parameters.

CUSTOMER SPECIFICATIONS AND RELIABILITY REQUIREMENTS

Hardware programs have many and varied uses. The requirements of the operational environment can significantly affect the process of hardware development. As conditions become more demanding or sophisticated, reliability testing, configuration control, documentation and time to complete the job all increase, with commensurate increases in project cost.

The variable called 'Platform' (PLFTM) summarizes the operational requirements in terms of specifications and testing reliability. It plays a major role in the computation of costs, indirect cost ratios and performance schedules. There may be instances when it is necessary to develop and test an element in one environment, knowing that it will be installed in another.

In general then, PLTFM relates the cost of hardware development to the requirements of the environment in which the hardware must operate. It is a measure of the transportability, reliability, testing and documentation which must be provided for acceptable contract performance. Typical values are summarized in Table A-2



PLTFM

Enter a Value: 1.2 Page 1 of 2

Operating Environment	Typical PLTFM Value
Ground	
Commercial	0.8
MIL Spec	1.0
Mobile	
Commercial	1.2
MIL Spec	1.4

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Table A-2. Typical PRICE H PLTFM Values

The key in each case is not so much the location of the hardware, but the specifications it must meet. For example, it is entirely conceivable that ground-based hardware could have PLTFM values considerably greater than 1.0, if the hardware is to be used to control airborne or space operations.

NEW DESIGN AND/OR DESIGN REPEAT

Hardware projects may not require a total new design effort. Some of the required subelements, assemblies, procedures and/or peripheral devices may be available in part from previous completed projects. Hardware cost estimates must reflect this availability, and PRICE H addresses this requirement by allowing you to specify the amounts of New Design and/or structural repetition employed.

COMPLEXITY OF DESIGN

The organization capabilities or measure of the assemblies technology, its producibility, yield, platform, and all labor required to produce the asset are expressed in two input variables identified as:

Manufacturing Complexity of the Structure (MCPLXS); and
Manufacturing Complexity of the Electronics (MCPLXE)

Although typical (table) values are provided, you are encouraged to make use of the specially designed calibration feature which permits characterization of individual organizational performance. This feature, called ECIRP, is the ability to run PRICE H 'backwards' with actual costs and schedules of past projects as inputs. The result is a customized MCPLXS/MCPLXE value which can be applied to describe the anticipated performance of the same (or similar) organization on future hardware developments.

COMPLEXITY OF ENGINEERING

The organizational experience, complicating factors and individual talents of the activity that will accomplish the work are among one of the significant considerations of any method of estimating costs. The variable called "Engineering Complexity" (ECMPLX) has been designed to compositely reflect all such factors. Engineering Complexity values are empirical measures of relative performance and experience of the design team. Table values are provided. ECMPLX and the development schedule are significant cost drivers. It is important to remember that a direct relationship exists between these two input variables. As the engineering difficulty level increases, the schedule will probably increase to accommodate the additional effort. More on this topic may be found in the chapter on Functional Relationship.

TECHNOLOGY GROWTH?

The technology of hardware production is continually changing. On-going innovations lead to more efficient manufacturing processes, materials, support tools and management practices. Even with increasing requirements for reliability, productivity does seem to be improving. The magnitude of the factor is controlled by the input variable YRTECH and PLTFM, which are used to determine the maturity year for a specific complexity. The model automatically adjusts the status of technology to the date the project starts.

SYSTEM INTEGRATION

Many large hardware developments involve the merging of two or more related hardware products into a single unified system. The individual products often have widely varying characteristics, and they may even be developed by different organizations or companies.

Resources and time are required to accomplish total system integration. PRICE H develops cost and schedule estimates for this activity, just as it does for individual subsystems. It does this by relating the level of integration required for each individual subsystem to the normal amount of engineering effort accomplished in bringing subsystems together into a total unified operation.

WHY PRICE IS DIFFERENT

Two questions are often asked by those unfamiliar with the PRICE approach to cost modeling:

- What is your equation?

- What is your data base?

These questions are closely related. Both are based on the assumption that the PRICE modeling approach is the same as that customarily used in developing classical cost estimating relationships (CERs). This is not the case. The customary approach is first to gather as much relevant data as possible, then screen the data for consistency, reduce the data by formal statistical procedures (typically, regression analysis), and present the results in the form of one or more CERs.

In contrast, the PRICE approach is more process oriented than data base oriented. The model has been designed to emulate the processes by which experienced managers, engineers, and estimators assess the impacts of key cost and schedule drivers. As much as possible, actual recorded data is used to formulate, test, and verify those assessment processes, and, it is those formulations that compose the algorithms of the PRICE model. However, in some cases, data cannot exist for formula building. For example, the impact of schedule variations on cost cannot be statistically processed. This is due to the simple fact that there is only one schedule that can occur for a program, we can't know for sure what the impact would have been had that schedule been shorter or longer. However, knowing that actual schedules frequently differ from those originally planned, we can study the processes employed to manage the differences and thereby model the cost impact.

The strength of the classical approach is that it enables investigators to test hypotheses and identify significant factors that have affected past hardware developments, PRICE has not ignored these results. Indeed, similar procedures were often used in preliminary model development. As a consequence, there is nothing in the PRICE model that is inconsistent with classical results. The difference is that these results are not an end in themselves. When blended with quantification of the subjective but no less valid perceptions of experienced people, they contribute substantially to PRICE methodology.

The principal reason for the success of the PRICE model is that it does not depend on a single CER or on a single data base. By focusing on the process of rational cost estimation, it preserves for you the flexibility to tune the model to the estimate in question. Normally, cost histories of previous projects within the your own company or product line will provide the best reference. Our experience has been that within-group scatter of these data is much less than the across-industry scatter present in classical CER approaches.

The effect of all this is that the central data base in each case is yours. The calibration process ensures that special factors present in the development environment are included. New project descriptors can then be evaluated in light of accumulated industry-wide experience scaled to your own data base. There is no single cost equation in practice, the PRICE model develops a new family of CER's to fit each specific application.

THE MODEL

The PRICE H Model is not one single model but, actually a group or system of cost estimating and evaluation models and auxiliary programs. In addition to estimating costs to develop, produce, modify, integrate, and test hardware the hardware model also includes methods for:

- Calculating complexity factors from any known cost
- Thru-put costs not estimated by PRICE H

- Estimating the costs of multiple lot productions
- Calculating the costs for design integration of purchased and furnished equipment
- Calculating the costs for hardware/software integration (HSI)
- Calculating the manufacturing complexities of non-homogeneous assemblies
- Calculating field reliability
- Measuring the cost effect of a reliability upgrading
- Expertly deriving input parameter values.

In summary, PRICE H offers a parametric cost estimating model that is versatile, easy to implement, rapid at producing results, and adaptable to most any situation.

TECHNICAL SUPPORT

PRICE Systems takes great pride in our customer support policy and our ability to respond to our customers needs. Experienced Customer Support Representatives are available twenty-four hours a day, seven days a week. A PRICE representative brings to each customer the benefit of his or her individual experience and knowledge of Computer Aided Parametric Cost Estimating. The PRICE goal is to provide Speed, Quality and Customer Satisfaction to all.

To reach any PRICE Systems office call:

1-800-437-7423