How to Successfully Construct Life-cycle Costing

Parametric models exist for estimating the life-cycle cost of hardware, software and information technology. When it comes to estimating life-cycle costs, the challenge is not the cost modelling, but the data gathering. The life-cycle is defined as the procurement (development and production) plus the in-service (Operating and Support) phase.

This paper introduces the concept of simple data gathering for Operating and Support cost models. It was developed out of a recognized need by a cost model vendor: a need for information and data on Operation and Support costs. The challenge was not to develop a more sophisticated cost model, but simply to obtain the data necessary to run a cost model – detailed analysis is not a substitute for lack of data.

Methods of Data Gathering

The literature survey resulted in a number of different methods of data gathering, as listed below:

- *interrogating existing databases* – a review of the resources contained in databases in current projects and existing equipment databases;
- *questionnaires* – gathering information in a standard format using a form, either hardcopy (paper) or softcopy (electronically);
- *interviews* – using experts who have subject matter knowledge;
- *literature search* – searching through past studies, supplier documentation and other third party sources;
- *simulation* – it is possible to generate Operating and Support data from acquisition data (development and production) with the use of mathematical relationships which have been researched based on previously gathered records. This is particularly useful when predicting the cost of future systems which are many years away from being produced, let alone operated in the field;
- *field tests* – the ultimate means of obtaining the Operating and Support data required by a model involving the measurement of repair and failure times in the field.

What is most important about the Operating and Support data that you gather? What are the attributes that distinguish between a good method and poor method of data gathering? Let us consider the criteria that can be used to evaluate the different methods.

RESOURCE EFFICIENT

The most efficient data gathering method should not be resource intensive. In the modern economic climate, organizations cannot afford a huge team of staff devoted to data gathering. The methodology needs to be efficient in terms of both cost and schedule.

CURRENT

The data provided to the cost model needs to be current and up to date. It is of little interest that the data is plentiful and easy to gather if it relates to a prior technology that will not be employed. The data relating to diesel electric submarines can be of little use to Cost Engineers considering the cost of modern nuclear submarines.

ACCURATE

The data needs to be close to the original source and should be accurate. If other analysts have interpreted the information prior to you obtaining the data you cannot be certain of its validity. The result of a cost model will only be as good as the information fed into it. If it is impossible to validate the data or to have confidence in it, then the cost estimate that results will be equally unreliable.

VALIDATED

The data needs to be validated and verified or reliable. It needs to be provided by a credible source which can be relied on. You would not ask a motoring organization for the Operating and Support cost data related to aircraft.

COMPREHENSIBLE

Data is of little use if it is not understandable. A data dictionary is important to enable the person providing the data to have a complete understanding of the needs for which the data is being used, in terms of the data that they provide.

TIMELY

The Operating and Support cost data needs to be gathered in the timeframe available for the estimate. It is absolutely no use gathering the best data in the world, only to complete the exercise two months following the decision to procure a system that will not have the optimum life-cycle cost.

The sources of Operating and Support data are considerable; it should not be difficult to identify them in an organization. However, problems can sometimes arise due to internal politics, for example, when a project team is embarrassed about their statistics on reliability or cost. The list below provides an aide-mémoire for the sources of Operating and Support cost data:

- records from similar past projects;
- accounts and field data from similar in-service equipment;
- reliability and maintainability experts;
- suppliers' documentation;
- maintenance technicians;
- Integrated Logistics Support (ILS) Engineers;
- Failure Modes and Effects Criticality Analysis (FMECA);
- Logistic Support Analysis Record (LSAR).

Types of Data Required by Operating and Support Cost Models

When reviewing various Operating and Support cost models, it is possible to identify a trend in the types of cost data that these models require. In general terms they are split between parameters to describe the equipment to be operated and supported, the infrastructure to operate and support the equipment and a means of describing the Operating and Support policy.

- equipment description (weight for transportation costs, volume for storage costs);
- corrective maintenance data (Mean Time Between Failures [MTBF], Mean Time to Repair [MTTR]);

- scheduled maintenance data (frequency of the maintenance);
- deployment data (1st line/organization, 2nd line/intermediate.);
- maintenance policy/concept (contractor support or Government
- support);
- manpower (crew cost, support cost).

Advantages and Disadvantages of Different Data Gathering Techniques

Table 1 compares the different methods of data gathering. In terms of resource efficiency the simulated data is obviously the best. It requires little time and effort; however, although it might approximate to the correct data and need to be used in early concepts studies, it will be incorrect in most parts. Conversely, the interview, literature search and field tests will potentially consume large amounts of resources and require funding.

⊠ ⊠ ⊠ = Good, ⊠ ⊠ = Average, ⊠ = Bad

	Resource efficient	Current	Accurate	Reliable	Understandable	Timely
Interrogate Existing Databases	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠	⊠ ⊠
Questionnaires	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠ ⊠	⊠ ⊠ ⊠
Interviews	⊠	⊠ ⊠	⊠	⊠	⊠ ⊠ ⊠	⊠ ⊠ ⊠
Literature search	⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠	⊠
Simulated (Created by modelling)	⊠ ⊠ ⊠	⊠	⊠	⊠	⊠ ⊠	⊠ ⊠ ⊠
Field Tests	⊠	⊠ ⊠ ⊠	⊠ ⊠ ⊠	⊠ ⊠ ⊠	⊠ ⊠ ⊠	⊠

Table 1— Advantages and disadvantages of data gathering methods

The current nature of the data will best be served by the field tests. As the tests are conducted for the cost estimate, they will provide an existing record of the equipment Operating and Support data. The simulated data is created from mathematical expressions. When these were researched and whether they are still current can only be answered by the suppliers of those routines. As described earlier, the use of simulated data can be extremely important when considering the Operating and Support cost of future systems. In this scenario there is no field data to gather, and the accuracy of the Operating and Support cost phases is perhaps less important to a current decision between design options. Operating and Support cost for the future system is many years away, providing an opportunity to refine the costs at a later time. The problem with interviews lies in the anecdotal nature of the data being presented. People tend to be optimists or pessimists; depending on whether they have had a good or bad experience with that piece of equipment, different maintainers will provide different answers. The best accuracy is going to be achieved by measuring the necessary parameters in the field.

Data reliability is low for interviews and simulation and high for field testing for the reason described above. But understanding the data introduces a range of new influences. A good understanding of the data is essential; a data dictionary is a good starting point for defining the immediate boundary of the data. As such, existing databases and literature surveys are not a particularly good technique for obtaining data: someone else will have gathered the data and will have made their own assumptions in the process. Indeed, if the data has been processed, it is not (by definition) raw data. Conversely, questionnaires, interviews and field tests will provide an opportunity to clarify the boundary, assumptions or definitions of the data being gathered.

Finally, the field test and literature survey are not likely to produce results within the necessary timeframe. If the Operating and Support cost is required to influence a decision in the near term, the best methods would be the simulation, interview and questionnaire to ensure the data is available when it is needed.

Taking all of these criteria into consideration, the technique that has the fewest drawbacks whilst providing greater than average performance is the questionnaire.

Life-Cycle Questionnaire

It is important to distinguish the roles involved when designing a questionnaire. There will be a group of users who are interested in the gathering of the data. This group requires the data to populate a cost model; we will label them the Customers. This group is looking for ways to make their budget stretch over more programs.

There will also be the organizations that are responsible for providing the Operating and Support data. These are staff who will not benefit directly from the data gathering, therefore, their task needs to be as undemanding as possible to enable them to provide the Operating and Support data. We will label this organization the Suppliers.

Looking more closely, two types of Suppliers can be identified. Those that reside within the Customer's organization and those that will probably lie outside the management structure of the Customer organization. Examples of the external suppliers include:

- subcontractors;
- equipment suppliers;
- support organizations;
- current legacy projects.

Examples of internal suppliers include:

- project teams;
- Integrated Logistic Support (ILS) departments;
- Integrated Project Team (IPT) staff;
- future projects departments.

The example Life-Cycle Questionnaire that will be used here has been developed by PRICE Systems and was released in the PRICE Cost Estimating Framework. It is a Microsoft Excel workbook that contains several worksheets. In summary the various worksheets are self explanatory:

- Instructions for Customer;
- Instructions for Suppliers;
- Example;
- Questionnaire;
- Builder.

The purposes of the different sheets are contained in the following sections.

INSTRUCTIONS FOR CUSTOMERS' SHEET

This sheet contains different embedded file formats (including rich text format and ASCII Text format) of the same document. This ensures that most people will be able to access the files even if they do not use a Microsoft product for their word processor. It is important when creating a questionnaire that it is as user friendly as possible. Any difficulty, like problems opening a file, can be used as an excuse to return the document unpopulated.

These files are provided to give guidance on how the Customer will use this Life-Cycle Questionnaire. Following a brief introduction the topics covered in the customer guidance include sections on:

- how to prepare a questionnaire to be sent to the supplier;
- what equipment deployment data is required;
- what needs to be done when the supplier populated questionnaire is returned.

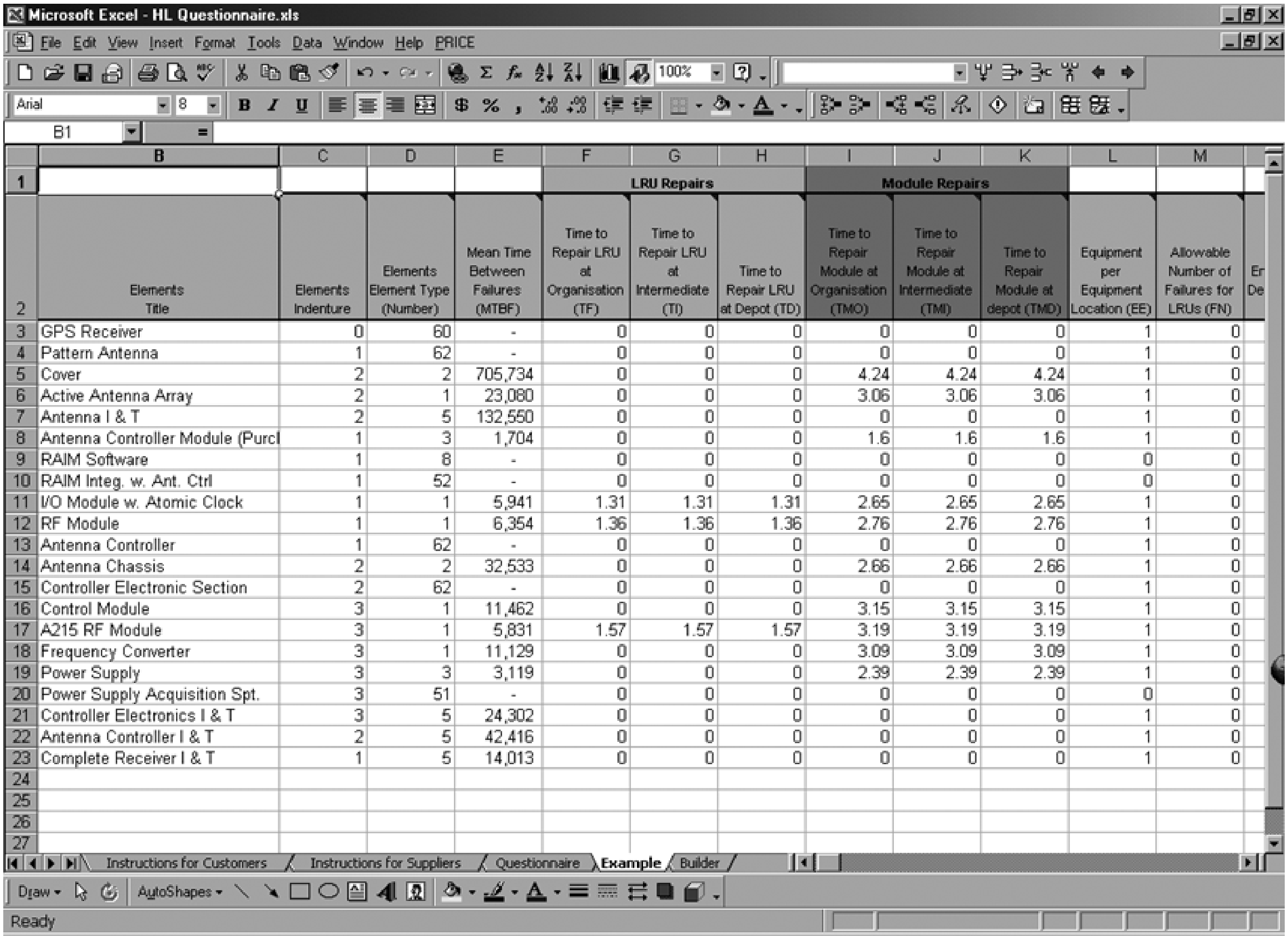
INSTRUCTIONS FOR SUPPLIERS' SHEET

This sheet again contains different file formats (including rich text format and ASCII Text format) of the same document. Each file is identical and is provided to assist the Supplier in completing the Life-Cycle Questionnaire. In this case the topics covered include:

- introduction providing explanation of why the data in the questionnaire is requested and what will happen to it;
- the deployment data regarding the project;
- how to create an Estimating Breakdown Structure (EBS);
- what Operating and Support costs are needed and their definitions;
- overview of the cost model which will be employed to calculate the costs when the questionnaire is returned.

'EXAMPLE' SHEET

The Example sheet contains a set of data for a 'GPS Receiver system'. This is an example of a completed Questionnaire sheet. As can be seen in Figure 1, this example can be used to guide the Supplier through the process of completing the questionnaire – the type of inputs required and the detail desired.



Elements Title	Elements Indenture	Elements Element Type (Number)	Mean Time Between Failures (MTBF)	LRU Repairs: Time to Repair LRU at Organisation (TF)	LRU Repairs: Time to Repair LRU at Intermediate (TI)	LRU Repairs: Time to Repair LRU at Depot (TD)	Module Repairs: Time to Repair Module at Organisation (TMO)	Module Repairs: Time to Repair Module at Intermediate (TMI)	Module Repairs: Time to Repair Module at depot (TMD)	Equipment per Equipment Location (EE)	Allowable Number of Failures for LRUs (FN)
GPS Receiver	0	60	-	0	0	0	0	0	0	1	0
Pattern Antenna	1	62	-	0	0	0	0	0	0	1	0
Cover	2	2	705,734	0	0	0	4.24	4.24	4.24	1	0
Active Antenna Array	2	1	23,080	0	0	0	3.06	3.06	3.06	1	0
Antenna I & T	2	5	132,550	0	0	0	0	0	0	1	0
Antenna Controller Module (Purcl	1	3	1,704	0	0	0	1.6	1.6	1.6	1	0
RAIM Software	1	8	-	0	0	0	0	0	0	0	0
RAIM Integ. w. Ant. Ctrl	1	52	-	0	0	0	0	0	0	0	0
I/O Module w. Atomic Clock	1	1	5,941	1.31	1.31	1.31	2.65	2.65	2.65	1	0
RF Module	1	1	6,354	1.36	1.36	1.36	2.76	2.76	2.76	1	0
Antenna Controller	1	62	-	0	0	0	0	0	0	1	0
Antenna Chassis	2	2	32,533	0	0	0	2.66	2.66	2.66	1	0
Controller Electronic Section	2	62	-	0	0	0	0	0	0	1	0
Control Module	3	1	11,462	0	0	0	3.15	3.15	3.15	1	0
A215 RF Module	3	1	5,831	1.57	1.57	1.57	3.19	3.19	3.19	1	0
Frequency Converter	3	1	11,129	0	0	0	3.09	3.09	3.09	1	0
Power Supply	3	3	3,119	0	0	0	2.39	2.39	2.39	1	0
Power Supply Acquisition Spt.	3	51	-	0	0	0	0	0	0	0	0
Controller Electronics I & T	3	5	24,302	0	0	0	0	0	0	1	0
Antenna Controller I & T	2	5	42,416	0	0	0	0	0	0	1	0
Complete Receiver I & T	1	5	14,013	0	0	0	0	0	0	1	0

Figure 1—The example questionnaire

'QUESTIONNAIRE' SHEET

The sheet in Figure 2 is the Life-Cycle Questionnaire itself. It contains the hardware parameters that need to be populated in order to run the parametric cost model. Each column has a header that provides a brief description of the parameter including its units (hours, currency and so on) and its parameter abbreviation (MTBF, DSTART, etc.).

Each row needs to be completed for each element in the Product Breakdown Structure (PBS). This will be specific to the Supplier's product or equipment.

The column headers contain comments that perform the function of a data dictionary. They define the interpretation of the input for the Supplier. As can be seen, the Mean Time Between Failures (MTBF) has been defined and exemplified in the screenshot.

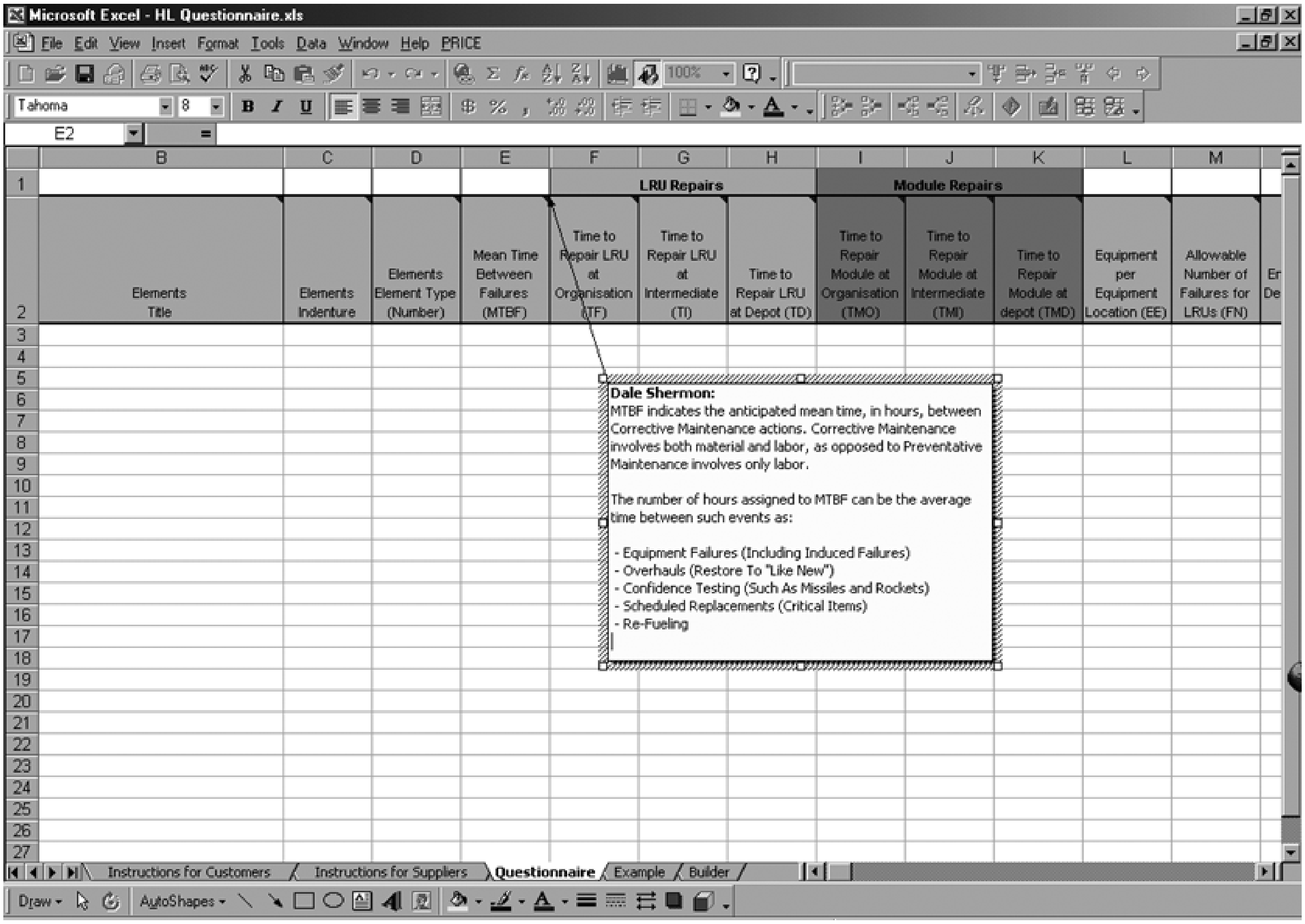


Figure 2—The questionnaire

COST MODEL INTERFACE— 'BUILDER'

A simple mechanism is needed to transfer the questionnaire data to any parametric cost model. In this example a Builder sheet is the key to creating a parametric model Product Breakdown Structure (PBS). This sheet has the ability to interface with this particular cost model. As the Supplier will not necessarily have the parametric model, this Builder sheet will not be provided to them.

The Data Gathering Process

The questionnaire is relatively simple once the roles of the Supplier and the Customers have been identified. Figure 3 provides a summary of the process and the responsibilities of the Customer and Supplier.

To start the process the Customer must have a good understanding of the system that is to be subjected to life-cycle cost estimating: the system architecture, the contractual work share and make / buy decisions of the equipment that constitute the system. Once determined, these provide the key system attributes. The

Customer is in a position to prepare a Supplier's Questionnaire: the Life- Cycle Questionnaire, Example and Suppliers Instructions.

Two parallel activities then take place. The Customer needs to continue preparing the information around Deployment and Employment and the maintenance concepts. The Supplier is probably not able to contribute to the Deployment and Employment decision part of this process as the final recipient of the cost estimate and the Customer have that contractual relationship. The Supplier may have opinions on the most effective way to support and maintain their equipment, but the (ultimate Customer) may be constrained by a fixed or restricted capability for support and maintenance.

Meanwhile the Supplier, either internal or external, may populate the questionnaire. They have been identified as the best source of data, but may only have part of the information required. For example, the maintenance data may derive from one source and the spares data from another. Alternatively, some sub-systems may come from one Supplier (possibly internal – 'Make') and other sub-systems might come from another separate Supplier (possibly external – 'Buy'). Eventually, the completed Supplier Questionnaire, containing the Operating and Support data, will be collected by the Customer and used in the Operating and Support cost model.

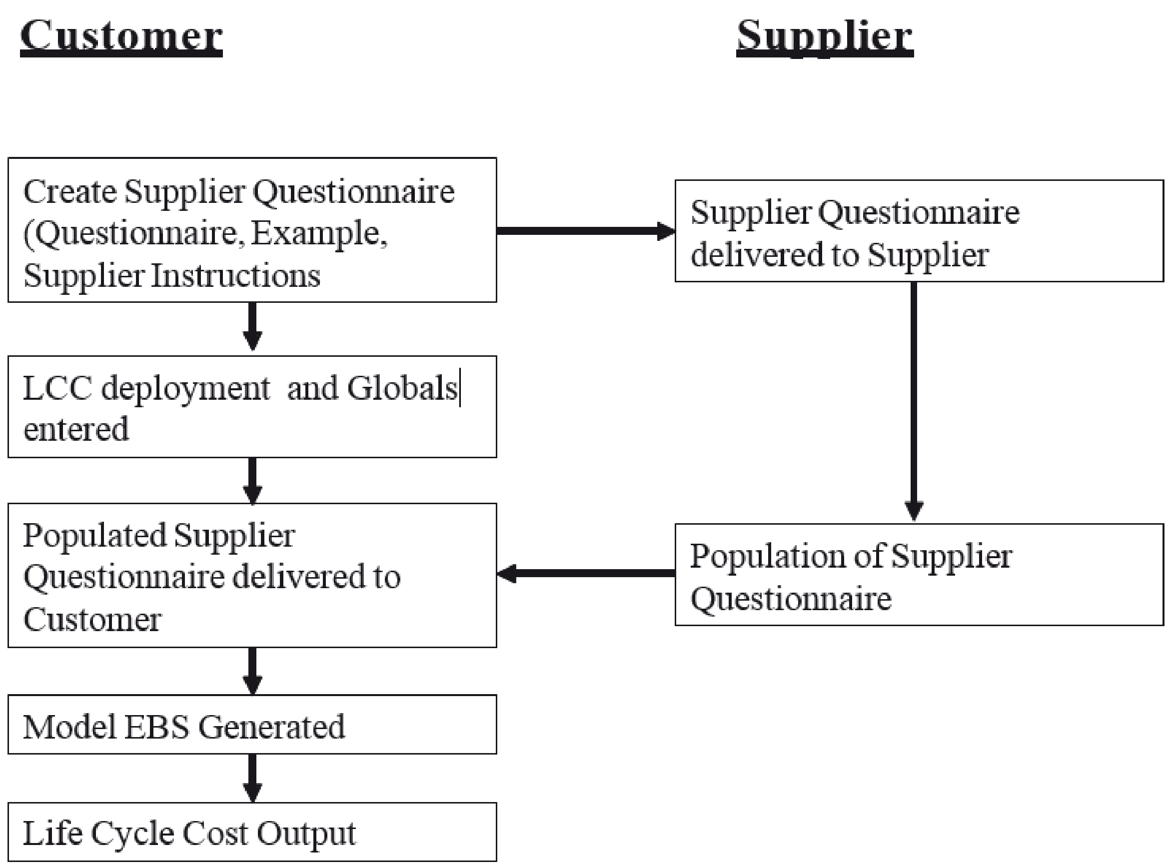


Figure 3—Questionnaire process

CONCLUSIONS

- *Consistent methodology for data gathering* – A questionnaire provides a method of gathering Operating and Support cost data that complies with the criteria that were stipulated.
- *Simple interface for non-parametric trained users* – The questionnaire, being a Microsoft Excel solution, explains the model parameters such that non-LCC trained engineers can understand and gather the data.
- *Accelerated process for data transfer* – If the questionnaire is used in conjunction with the parametric cost model, it will result in speed and ease of Operating and Support costs modelling.
- *Improved quality of data* – As the solution complies with the criteria of the data gathering requirements, it will result in more timely, consistent, accurate, current and understandable data to feed the cost model resulting in improved cost predictions and lower LCC.

About PRICE® Systems, LLC.

PRICE® Systems, a world leader in predictive cost analytics solutions, enables our clients to significantly improve the speed and accuracy of cost analysis and estimation in support of many key processes. PRICE® delivers cost estimating, cost analysis and knowledge capture tools, combined with expert consulting in predictive cost analytics and best practices, to help customers better predict and manage costs and schedules throughout a project's lifecycle, ensuring program affordability.

PRICE®'s value to you is rooted in 40 years of predictive cost analytic experience, a dedicated cost research team and comprehensive cost models with the most recent, relevant benchmark data. Established in 1975 with offices in the United States, Europe and Asia-Pacific, PRICE Systems serves more than 300 customers worldwide. More than 20,000 project professionals have been trained in the company's cost estimating and analysis methodologies.

We have achieved and maintained this leadership position in the industry by growing a team of seasoned professionals with a track record of success and putting our focus on customer success and satisfaction. The people at PRICE® include experienced cost estimators and cost analysts, model builders, project leaders, mathematicians, logisticians, hardware and software engineers, computer scientists, and consulting professionals – all committed to your success.