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PARAMETRIC COST MODEL FOR GROUND VEHICLES

A model is being developed to facilitate quick, detailed cost estimates for ground vehicles. This model will contain a logic structure to catalog the particular equipment being costed in broad categories, each of which will have its own parametric relationship. The model will also involve a feedback module that will compare predicted costs with actual costs to test the model accuracy and update the cost estimating relationships when the accuracy of the model falls below a threshold value.

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A Concept Paper : Parametric Cost Model for Ground Vehicles

Symposium Theme : New/Innovative Techniques in Parametric Cost Estimating

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INTRODUCTION

This concept paper discusses an idea that could change the way that a large amount of cost estimating work is performed. The amount of resources required for certain classes of cost estimates will be drastically reduced, estimates developed within the cost analysis units will be more consistent with each other than in the past, and the validation process will be improved. At the moment, this is only a concept, but the Army's Tank-Automotive Command (TACOM) is beginning development of a variation in a parametric cost model that will accomplish these goals.

The model will be ideal for situations when past Life Cycle Cost Estimates (LCCEs) need to be updated due to changes in production schedule, fleet densities, or operating tempo. In a matter of two hours a revised estimate could be developed. In addition, an entire LCCE for a system that has not previously been costed could be developed by parametric methods. This model will contain databases that contain all LCCEs developed by the cost office and still considered valid, along with a Cost Estimating Relationship (CER) library. The validation process would also be improved by the use of two different methods.

BACKGROUND/SDB

In 1989, the Tank-Automotive Command developed a model called the Sustainment Data Base (SDB). Sustainment estimates for a few wheeled vehicle systems were developed and integrated into a single spreadsheet model. Once this basic database was assembled, the relations between each cost element and the corresponding fleet density and operating tempos for the vehicle were determined and introduced into the spreadsheet. The SDB allowed the cost office to respond quickly to requests for cost data on existing systems by simply entering the fleet density being studied and the operating tempo and allowing the model to automatically adjust each cost element.

The SDB was expanded in 1991. The spreadsheet was automated to a larger degree, the format was revised and some rudimentary documentation was included for users. More importantly, the revised version (SDB 2.0) also included all of the sustainment cost estimates prepared by this office from 1987 - 1991. It retained the relations determined between cost, density and operating tempo from the original version. The amount of time needed to perform a sustainment estimate on a wheeled vehicle was drastically reduced. An estimate that would have taken about two days to perform prior to SDB was replaced by a single phone call to get information from the requesting office, a spreadsheet update, and a fax or hand delivered cost estimate. The new estimate could be provided in writing within two hours of the request.

This was the first attempt to compile all similar estimates into a single summary database. The benefits of this should not be overlooked. Usually, the data gathering process is rather difficult because of the overwhelming number of sources and the apparent contradictions between the sources. Having all of the old estimates available in a single location and in a single format proved to be an invaluable aid in responding

quickly and accurately to requests for estimates. Another, unforeseen, use of SDB surfaced after analysts developed trust in the results produced. Since all past estimates were included, the database could be used as a validation tool. Comparing the costs being validated to the costs included in the database, the validator could determine if the costs were comparatively accurate.

The success of SDB 2.0 provided the seed for the model that this paper outlines. The model will be similar in structure to the SDB 2.0, but the scope will be much larger. The model will include a database of Life Cycle Cost Estimates (LCCEs), a CER library, and a generalized form of the internal parameterization used in SDB 2.0. (Internal parameterization in SDB 2.0 is the implementation of the relation between cost, density and operating tempo. This would be generalized to account for other additional factors in the larger life cycle model.)

OVERVIEW OF LIFE CYCLE MODEL

This model, while a parametric cost model at its core, will actually involve a much larger realm of estimating. The following types of cost activities could be developed within the framework of the model;

- (1) Parametric Estimate
- (2) Analogy Estimate
- (3) Sensitivity Analysis
- (4) Comparative Validation

A parametric cost estimate usually consists of applying a relation between the cost of a system and other non-cost parameters, such as gross vehicle weight. This relation is derived through statistical analysis of analogous weapon system. If the analysis shows a strong correlation, then a CER has been developed. The cost can then be developed for any similar vehicle from a knowledge of the relevant system parameter. For this model, only the major cost drivers should have CERs developed. There will be a few classes of CERs. For example, for wheeled vehicles, there will be CERs developed for light, medium and heavy vehicles. The different classes of CERs will allow for a wide class of vehicles to be estimated by the models.

Another form of CER that is often used is a simple cost factor. The cost for a particular cost element is determined by multiplying a different cost by a factor. For example, it may be determined that, in general, the cost for testing a single vehicle is equal to ten percent of the vehicle unit manufacturing cost. Therefore, once the unit manufacturing cost is developed, the testing costs can be found by multiplying the unit manufacturing cost by .10. While the major cost drivers will have CERs that apply to them, the rest of the cost elements will be developed through the use of cost factors.

Analogy estimating usually involves estimating costs for a weapon system by comparing it to another similar system. The estimate then becomes a task in

adjusting the costs for the old system to account for the differences. Oftentimes, the differences are accounted for by the method of factors. This method of analysis is really just another form of parametric estimating, but the relations aren't usually examined statistically. That being the case, the analyst has more flexibility, but must use good judgement in the application of this method. The model will allow for a factor that will adjust costs.

Sensitivity analyses involve examining the effect of particular parameters on the overall cost of the system. It is usually implemented by simply increasing or decreasing a cost element and all costs affected by that cost element, then examining the change in total system cost. It could also (more correctly) be applied by changing a particular parameter (say, production rate) and examining the change in the total cost. This type of analysis will be carried out easily in the model by the internal parameterization method. In the concept of the model, sensitivity analyses and revising old estimates to account for a new production schedule, fleet density or operating tempo are virtually identical processes.

Comparative validation consists of comparing the estimate being validated to the estimates that appear in the LCCE database. There are two type of comparisons that could be applied. The first one would be external comparison. The estimate being prepared would be matched up with other similar vehicles and costs for each cost category would be compared. IF a certain element is out of line, then the estimate being validated should be examined further to explain the difference.

The second type of comparison validation is called internal comparison. It consists of comparing the ratio of certain cost elements and determining if they are in line with the cost factors previously developed. If a specific cost element is out of line, again, the estimate being validated should be examined in greater detail to determine the reason for the variation.

MODEL DEVELOPMENT

The basis of the model will be three separate databases - the collection of LCCEs, the CER library, and the cost factor file. The first two should be developed independently, while the third will be created from the first.

The LCCEs assembled should be arranged into the cost structure defined in the Department of the Army Cost Analysis Manual of Aug 92. Included in the LCCE should be the production schedule, operating tempo and the fleet density. These parameters will be necessary for the internal parameterization portion of the model and will be necessary in updating any LCCE. In addition, technical, non-cost data on the system should be collected for such items as vehicle weight, payload, engine HP, etc. A basic set of these elements should be defined and collected for all vehicles which have LCCEs included in the LCCE database. These would come in handy in developing CERs in the future.

The CER library should include a set of formulae that relate cost elements to other non-cost parameters. Ideally, these would use contract costs and not estimated costs, but it is up to the analyst to use good judgement in determining the validity of any CER. The CERs developed should concentrate only on the major cost drivers of the weapon system, such as manufacturing cost. A thorough analysis on the major cost drivers will result in a more accurate estimate than would result from a less thorough analysis on all of the cost elements. In developing the costs for the lower dollar costs, cost factors should be used instead. While, technically, a cost factor is a CER, they are handled in the context of this model through the concept of internal parameterization.

After the LCCE database is assembled, a statistical analysis should be performed to determine the relation between the minor cost elements and the cost drivers. These are the cost factors that will then be used in conjunction with the CERs to develop a complete parametric cost estimate.

The last step in creating this model would be to create the internal parameterization. Each cost element in the Department of the Army Cost Manual that is included in the model should be examined and its relation to the program variables such as operating tempo, production rate, fleet density would be defined. These relations will be assumed relations based upon experience. For example, the manufacturing cost-production schedule relationship may be a power law function (learning curve). On the other hand, the relation may be a simple linear function (as would be the case when no learning is assumed, or the lot number is well out into the flat portion of the learning curve). The SDB 2.0 assumed linear relations between several cost elements and the fleet-density. The internal parameterization in SDB 2.0, therefore, was based upon the ratio of the old variable to the new variable. This means that if the fleet density is doubled then those cost elements would double.

MODEL EXECUTION

As mentioned previously, this model has four uses;

- (1) Prepare new estimates using parametric methods
- (2) Revise old estimates
- (3) Sensitivity Analyses
- (4) Comparative Validation

The new estimates would be prepared by using a combination of a few methods. The estimate would be based upon a parametric cost estimating method. The major cost drivers would be developed using the CER library. The most appropriate CERs for that particular weapon system would be applied. This would form the majority of the cost. Cost factors would then be applied to complete the rest of the cost estimate. This would be a complete parametric estimate. An alternative estimate would be based, not upon a CER, but on a analogy factor. The estimate then would not technically be called a parametric estimate, but would instead be an estimate based upon analogy.

That is not to say that an analogy estimate is less accurate than a parametric estimate. analogy is more appropriate in some situations, while CERs are more appropriate under other circumstances.

The advantage to preparing the new estimates in the model is that the speed with which the estimates could be performed with very little information. The disadvantages are those that are always associated with a parametric estimate. If the system being estimated is a unique system (as they all should be to some degree), the costs that result from applying the CER will not be accurate. The more unique a system is, the less appropriate a CER application becomes. However, the analogy estimating method would be appropriate for the unique systems if some sort of connection could be developed between an existing system and the system being estimated.

The model is particularly well suited for the purpose of updating old estimates for new production schedules, operating tempos or fleet densities. In fact, this is the original purpose of the model. Internal parameterization accounts for the relation between the cost elements and the above mentioned quantities. After the relations are incorporated, a change in any of the quantities could be accounted for and a revised estimate could be prepared extremely quickly.

This method of updating old estimates was proven to be successful in SDB 2.0. However, the disadvantage to this method is a false sense of security that is instilled in the analyst. There are two assumptions that are inherent in this method. The first is the relation between the different cost categories and the quantities being altered. The relations may be accurate for small changes but may diverge from reality as the changes become large. The second assumption is that no other factors change in the estimate. Only the production schedule, operating tempo and fleet densities are assumed to vary.

A sensitivity analysis is quite easily carried out in this model. Any cost can be changed and the end effect can be found quickly. Also, the internal parameterization of the production schedule, operating tempo and fleet densities can be used to determine the sensitivity of the estimate to these important quantities.

In the validation process, the model would be useful as it is the only all inclusive set of LCCEs available. One of the most important characteristic of an estimate is how consistent it is with other estimates for comparable weapon systems. The integrated LCCE database would be invaluable for this purpose. The alternative would be to search through old files and track down past estimates. Oftentimes, the amount of time required to track down the old estimates would make it unfeasible. This is the only reasonable method available to assure consistency across all estimates of ground vehicles.

The other method of validation that could be used in the model would be the cost element comparison method. This consists of examining the ratios of different cost

elements. For example, it may happen that the cost for data collection is, in general, ten percent of the systems manufacturing cost. The validator would have access to these ratios and the present estimate would be checked to make sure that these ratios are not out of line with the general ratios. If they are, the difference should be justified by the analyst.

CONCLUSION

This model, when fully developed would prove to be an invaluable instrument in maintaining consistency in the LCCEs that are produced by the cost office. It would drastically reduce the amount of resources required for preparing revisions to past estimates that are required when the operating tempo, fleet densities, or production rate changes. It would provide an environment that would aid in preparing new estimates using the parametric or analogy approaches. Lastly, the model would improve the efficiency of the validation process. As the data processing hardware becomes more capable, models such as the one described in this report will become quite common and valuable.