This manuscript defines a step-by-step philosophical analysis approach on how to evaluate the costs of product development and product manufacturing. By performing this process, the costs of development and product manufacturing can be estimated. This estimation allows for determination of project viability.

KEYWORDS: Product development cost, product production cost, product concept, alpha/beta prototype, market risk analysis.

INTRODUCTION

This manuscript provides a disciplined format that describes steps that should be performed in any small to medium product development project as well as the parameters that should be considered and met at the onset of the development process. After completion of the evaluation portion (Phase I) for the product concept, an alpha/beta prototype (Phase II) is generated that propels the initiation of an estimate for the development cost, market risk analysis, performance evaluation, and product cost estimation. Figure 1 provides a schematic representation of the product concept evaluation steps with the corresponding phases.
Upon successful completion of Phase II, an evaluation process (Phase III) is initiated whereby the various industrial design concepts, the mechanical design, the customer interface design, the electronic design, software development, options design and the estimated manufacturing cost are considered. If Phase III meets the predefined acceptable criteria then the actual product design and tooling can commence. Phase IV (the actual product design) will not be addressed in this manuscript.

LITERATURE REVIEW

To the best of our knowledge this manuscript is novel in that it provides an evaluation of three essential phases of a product design process. Related literature mainly addresses singular parts of the design process and these are included in this study. In terms of studies dealing with product development costing, the literature offers a large variety. However, the majority of this related research focus on individual components of product development elements and costs, while information on an algorithm for the whole entire process is lacking.

This manuscript focuses on a small medium electronic based product that requires operator interface which allows the user to communicate with the product. Communication can be by touch screen, pendant or RS 232 computer interface, a data transmission equipment. The product design process can be performed entirely within the company or, alternatively, parts of the process can be outsourced to more experienced firms if the designing company lacks
experience or expertise in an area. The process begins with the design specification of the product which derives from the product concept as depicted in Figures 1 and 2.

Design specifications are pre-determined by the market need that is gauged from a sales perspective. In collaboration with the engineering department, a design outline is established. The outline is then evaluated by a larger group comprised of sales and marketing specialists as well as the engineering department, manufacturing, and quality control.

Once the design specification is complete, a market analysis must be performed. This is best accomplished by personal one on one meetings with existing and potential customers. The goal is to establish that the new proposed product meets the needs of the market and is not lacking any desired attributes. In order to properly conduct a market evaluation, a product cost and selling price must be estimated. A preliminary cost analysis is performed and a market price point (selling price) is evaluated to confirm that the product of interest will meet the market need at a price that seems appropriate. Cost analysis is followed by a market survey designed to evaluate features versus cost, size, appearance, options, operational parameters, design concepts, and final cost.

The research for this project will consist of a survey of past customers and potential customers of the products being considered for design. The surveys will include specific design considerations, features, costs, options, performance parameters and input/output features. The research method will be mixed, both qualitative and quantitative will be employed.

This research is necessary to establish what the market desires in the product performance and to establish the price that the market is willing to pay for a range of performances evaluated. Without this research, the product design will be based on the internal opinions of the company personnel and could miss certain critical performance issues.

The survey results are then evaluated and the design specification is modified accordingly. The modified design is evaluated again for cost and market price point.

Upon completion of the market survey, a market risk analysis is performed. This can be accomplished simultaneously with the market survey. Is the product fulfilling a significant need or a marginal need? Is the product development cost justified by the sales potential? If the results of this query are positive a technological evaluation must be performed. Are we pushing the state of the art with this product? What are the chances that this design approach will not succeed? Is there a better approach? If these questions return acceptable responses, then Phase II can proceed.

The first step in Phase II is to decide what type of proof of concept prototype one wishes to develop: an alpha (bare bones) or a beta (fully developed) prototype. After that decision is made it is important to estimate the development cost, determine the return on investment (ROI) potential, evaluate the performance expectation and estimate the product manufacturing cost.

If all of these evaluations are positive, Phase III can commence. Otherwise the design approach must be reevaluated until all of the results are acceptable.

Figure 2 shows the inter-relationship between variables and how they affect product development cost. By understanding these relationships, one can control the time-to-market, product cost, product quality and ultimately market acceptance of the product. Each highlighted
variable has an impact on the others thus making each of them an independent as well as a dependent variable.

Once the final design specification is agreed upon, the product design engineering begins. Various industrial designs are generated and a final concept is approved by the contribution of sales, marketing, engineering and manufacturing and quality control.

The engineering department then generates a block diagram of the product design that allows for the generation of an estimated bills of materials. Simultaneously, the mechanical design is in progress and decisions are made as to the appropriate tooling required to manufacture the prototypes as well as the beta (pre-production) and production models. In a parallel effort, the bills of materials (BOMs) are priced out in the appropriate quantity ranges and the parts are ordered for manufacturing the prototypes.

The customer interface design is an important step in the development process. The type of interface should be pre-determined from the potential customer surveys described earlier. The execution of the interface will have a significant bearing on the ease of use of the product, the minimization of input errors, the ease and accuracy of repetitive use, and the ease of use of the program libraries. The effectiveness of this process is best determined by allowing the unit to be tested and used by individuals that are not associated with the product development. These individuals should be comfortable with using the product and any questions they raise, should be evaluated to determine if the input process should be modified to eliminate obstacles.

If options are to be designed, the purpose and use of the options have to be evaluated to the same degree as the original product. All of the previous steps must be performed, evaluated and modified to attain acceptable results.

The final step in the design process is to reevaluate the product cost. Does it meet the original goals? If not, what can be done to reduce cost without sacrificing any of the attributes that all of the previous efforts determined were desirous?

This is the critical junction that determines outcomes. Is it feasible to proceed to the final product design? Should the project be scrapped? Should the product be modified and repeat some or all of the previous steps?

Figure 2 illustrates the inter-relationships of the variables and how they ultimately affect the product cost. By understanding these relationships, you can control the time-to-market, the product cost, the product quality, and ultimately the market acceptance of the product. Each one of the variables has an impact on the others thus making each of them both an independent variable as well as a dependent variable.

Figure 2: Inter-relationship of variables to the product development cost
Prototypes are manufactured and tested to confirm compliance with the design specification. When the appropriate adjustments are performed, a complete test program is conducted. These tests will be operational (functional) and environmental, including high and low temperature, high and low voltage input, noisy power input, etc.
CONCLUSIONS

There are many steps to a product design. All of them must be considered although some steps are more important than others. If steps are eliminated a proper risk assessment should be performed and the results evaluated. If all of the steps are performed and deemed acceptable, the product and the project will have a high probability of being successful. If after performing these steps it is determined that the project should be scrapped, then the significant cost of developing and tooling a product will have been avoided and that in itself is a healthy business outcome.

REFERENCES