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Learning Based Total Vehicle Development

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ABSTRACT

The complex task of Total Vehicle Development (TVD) has been a major challenge for automobile developers since its inception. The current approach to TVD is primarily resource based planning and execution. General Motors' Vehicle Engineering, with the help of MCA, has developed a fresh new approach to TVD. The new TVD approach is a planning and execution philosophy that is focused on learning and prioritizing the learning. In this paper, the authors will explain the fundamental philosophical and technical differences between the two approaches and illustrate the advantages of the new approach. The new approach relies heavily on usage of:

1. Zero Based Learning
2. Risk Prioritization and Sequencing
3. Mathematical Models and Problem Solving
4. Rapid Learning Cycles
5. Rapid Engineering Prototyping

This paper will describe the scientific application of Learning Based Total Vehicle Development. It will show examples of planning and execution, which will enable the product developing organizations to use the existing knowledge and reduce risk of new uncertainties.

INTRODUCTION

There are more than fourteen thousand parts that must be integrated into a vehicle during TVD. The conventional approach has been to develop each part separately and then have the development group to integrate the parts into a working system.

This approach works under two conditions:

1. Breakthrough technology
2. Unlimited markets and available time-to-market (TTM)

The breakthrough technology approach requires top down identification of system, subsystem and component specification. Practical application of this method is limited to unique scientific projects such as airspace.

The unlimited markets and long product life-cycle will also enable a product developing company to design and engineer their products part by part, since the product can be improved during its years in the market. Unfortunately, the luxury of unlimited markets and therefore long product life cycles are no longer the reality of today's vehicle manufacturers.

In a multi-year investigation and implementation, General Motors Corporation vehicle engineering, with the help of MCA, has been able to redesign the processes of product development. The redesign resulted in impressive improvements in Time, Cost and Quality of the products. Time and cost savings in excess of 20% were achieved. The methodology used to get these results is called "Learning Based Total Vehicle Development."

PRODUCTION ENGINEERING AS A SYSTEM (3)

The Value Added Workflow of product engineering is depicted in Figure 1. Product needs are the existing gaps between current product performance and the customer requirements. Application of Quality Function Deployment (QFD) helps to translate the customer needs into technical requirements. At this stage, the design and calibration of the product starts. Development adds value by making sure that the design will satisfy the customer's functional requirements. Validation is the phase of product development, which will enable the product's testing, simulating the customer environment. This process by itself is not very complicated; the complexity is added to this process when the integration of the parts requires a plan, which will enable engineering to achieve their goals. Limited resources and time have the highest impact on the company's process of creating the first plan. This limitation has forced many product developing companies to focus their planning on resources rather than the learning necessary to reduce the gap. During the busy years of work, engineers and managers focus on resource firefighting and in order to develop products, they rely on templates and requirements driven product development. This process further alienates them from a product-oriented organization and pushes them towards a resource and process-oriented organization. This, in turn, creates bureaucracies hampering the speed needed to get the product to market.

Several years of research were conducted to understand the fundamental differences in product development processes. The final conclusion was that most of the processes of product development look alike. What distinguishes the companies is not their use of tangible tools in the processes of product development; it is their Management's Philosophy of Operation.

BUSINESS LEARNING SYSTEM

Not unlike manufacturing, the process of product engineering has a product, which needs to be measured on its merits in regards to time, cost and quality. The product of engineering is "Information" which will be delivered in various forms, such as drawings, specifications and assembly documents. To avoid the resource based planning anchor, and produce high quality engineering products; General Motors' vehicle engineering conducted worldwide benchmarking. The results of the benchmarking all directed the managers of GM to Learning Based Product Planning. Figure 2 /2/ was developed to depict the processes of Learning Based Planning.

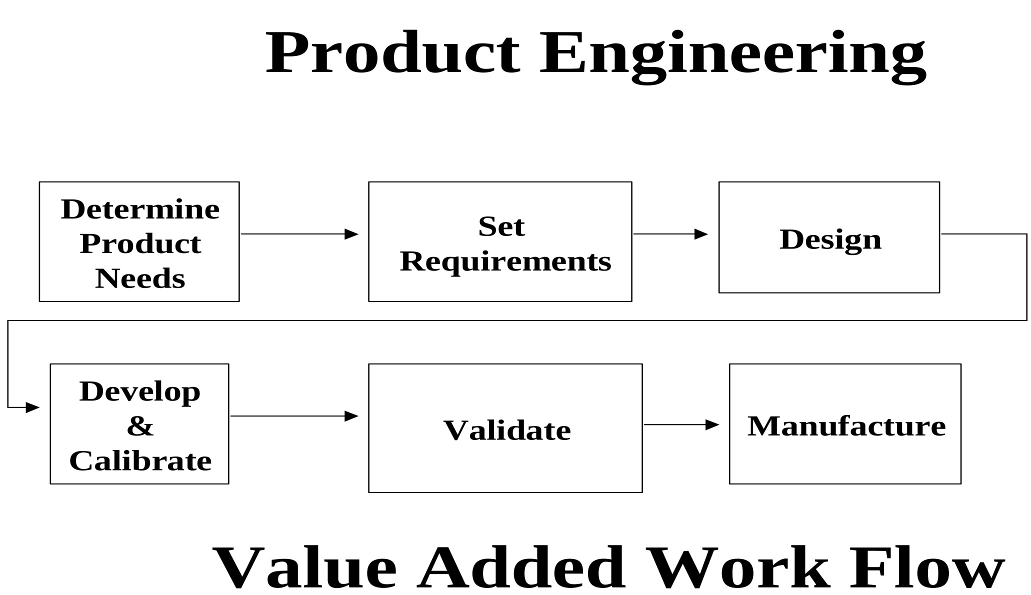

Figure 1

This process is fundamentally different than the traditional resource based process. It starts with identification of the opportunities and gaps of the current market needs. Once the gaps have been identified, they are then divided into:

1. Technological
2. Integration
3. Business

Technological gaps are those opportunities that the introduction of new technology to the market creates. Integration gaps are defined by the current product's performance opportunities measured by the consumer advocates and other market measures and the resulting performance opportunities. The business gap is the measure for product profitability, warranty costs and Product Development's (PD) allocated cost of the total product cost.

The learning based PD starts with management taking an active role in prioritizing the risk and therefore the "Learning Objectives." The steps of management's input on "Learning on Demand" are:

1. Zero Based Learning
2. Prioritization of Learning Objectives (LO)
3. Sequencing of LO
4. Resource balancing
5. Reduction of Risk

Where most of these steps are self-explanatory, the zero based learning requires a more detailed analysis. The fundamental difference between the resource based and learning based product development comes from this step. In the resource based process, all tests are run for all the products. There are no reference points to start with. Every program starts with a clean sheet of paper. In contrast, in the learning based process, the historical knowns and unknowns are identified and only the real program risks are investigated. The secondary differences between the two processes are the prioritization and sequencing of the program risks.

Common tools and processes are naturally a necessary threshold of product development. However, these tools by themselves will not ensure a product's success in the market place. The true measurements of the product's performance is gauged by the market's prevailing forces such as:

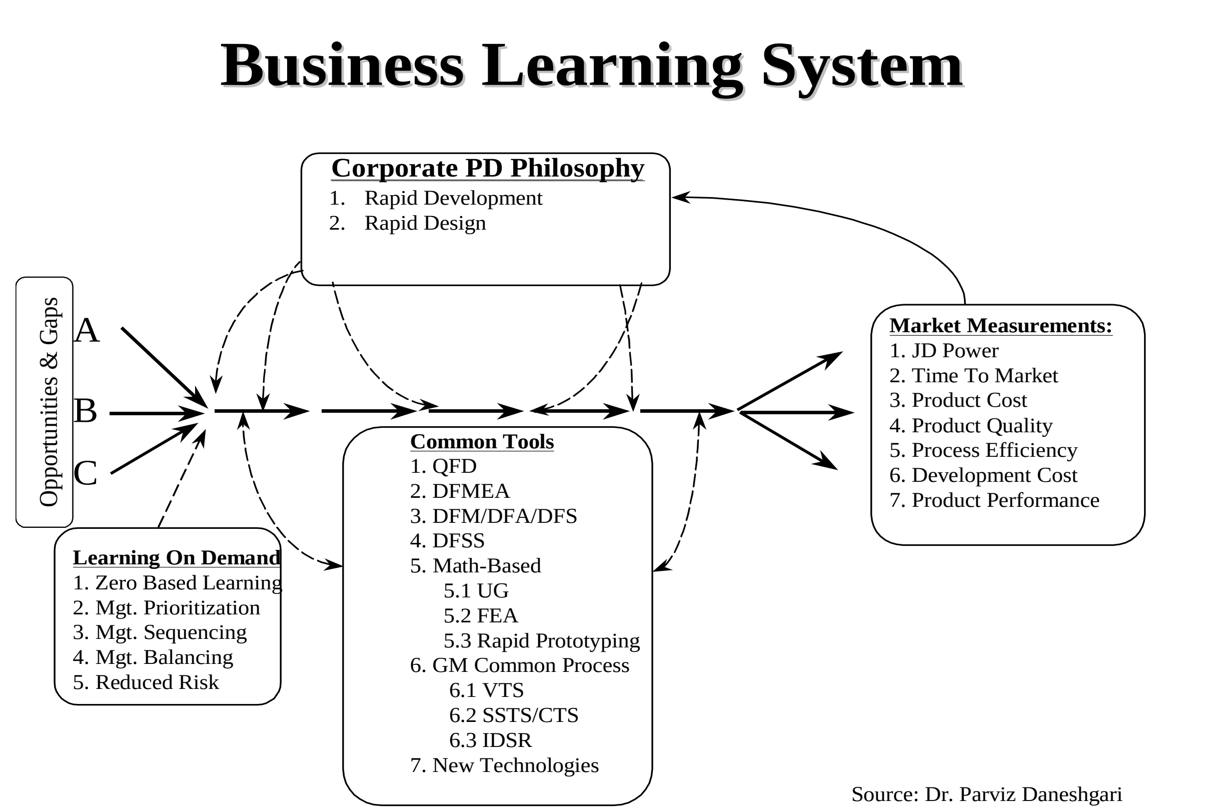

Figure 2

1. JD Power
2. Time to market
3. Product cost
4. Product quality
5. Process efficiency
6. Development cost
7. Product performance

The main factors distinguishing various companies are their abilities to implement Rapid Product Development, which is enabled only by the correct management philosophy. Thus, it is management's philosophy and not their tools that matter.

BASIC ENABLERS

The application of Learning Based Product Development requires some fundamental shifts in the corporate engineering infrastructure. One of the major changes in the infrastructure needs to be in the pre-production area. Southeast Michigan's traditional approach has been a batch production system, that is, in most cases, decoupled from engineering needs. The Learning Based Product Development requires a more nimble process that can support rapid learning loops. In this process, the major engineering build events are no longer necessary during the early development phases. The learning happens in smaller and more focused mule events. Figure 3 /1/ shows the differences between these two operations. Based on the learning objective priorities, the allocated test vehicles will be used to solve the problems and reduce the risk as they go. Figure 3 is also depicting the typical learning cycle time differences between the two processes.

Other enables, such as:

1. Creation of "Knowledge Bins"
2. Content reduction
3. De-coupled technology development
4. De-coupled subsystem development
5. Subsystem learning cycle reduction

Most companies have tried one or the other of these enablers. General Motors' vehicle engineering had to make all these organizational changes to enable rapid product development.

CONCLUSION

By using this philosophy General Motors and MCA were able to reduce vehicle development cost by better than 20%. It is imperative to note that the Learning Based Product Development is not a process, but rather is a

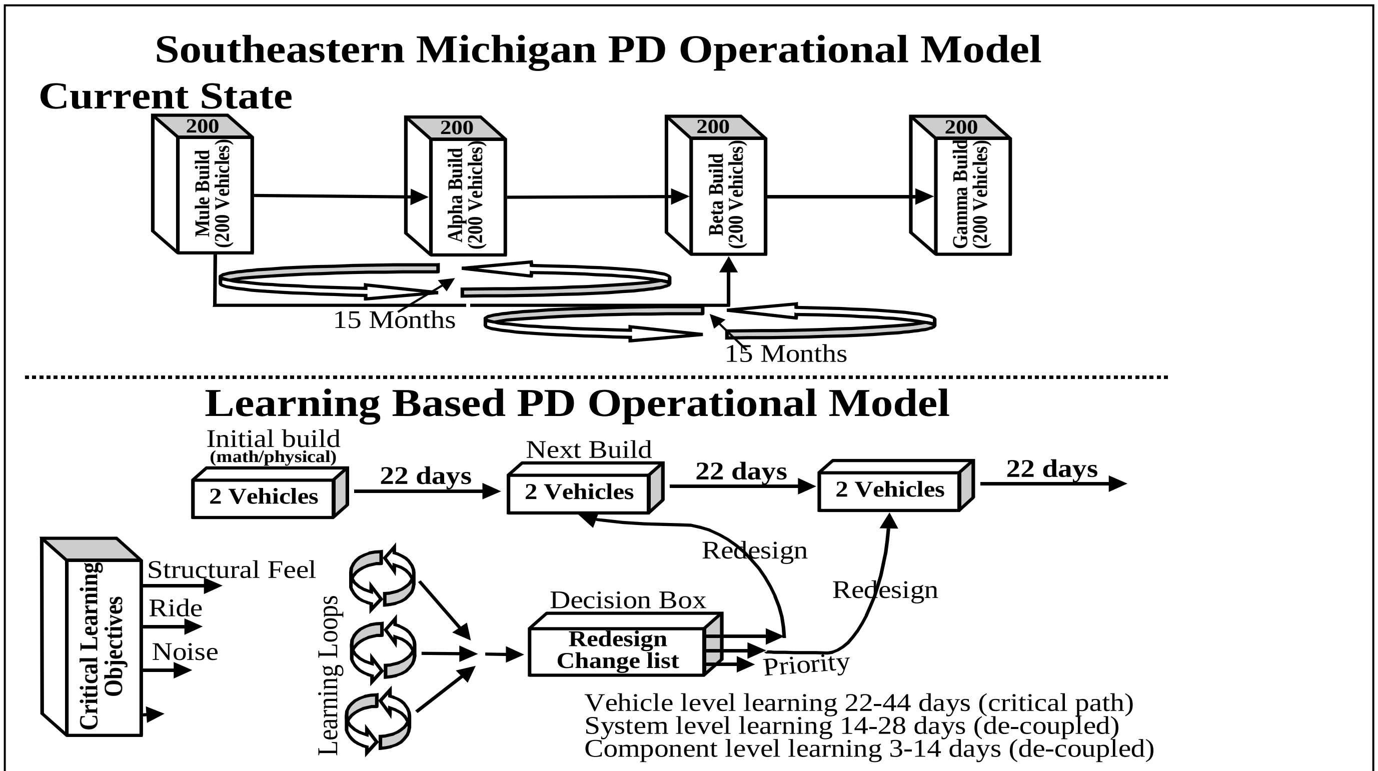

Figure 3

Philosophy of Operation, that needs to be decided and supported by the highest level of management of the corporation. In summary, the “Learning Based Total Vehicle Development” can be summarized as:

1. It is a Management Philosophy.
2. It consists of multiple quick learning cycles.
3. Managers set and prioritize the “Learning Objectives,” and lead the vehicle development.
4. Managers sequence the learning based on risk.
5. Manufacturing variation is part of the early risk assessment.
6. Vehicle technical specification is simplified and used as a statistical process control tool.
7. Mathematical and hardware tools are used simultaneously to reduce risk.
8. Infrastructures must support rapid learning and the reduction of risk activities.

REFERENCES

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

TVD: Total Vehicle Development

LO: Learning Objectives

PD: Product Development

QFD: Quality Function Deployment

DFMEA: Design Failure Mode and Effect Analysis

UG: Unigraphics

FEA: Finite Element Analysis

VTS: Vehicle Technical Specifications

SSTS/CTS: Subsystem Technical Specifications / Component Technical Specifications

IDSR: Integration Design Specification Requirements

ADV: Analysis Development Validation

PIT: Performance Integration Team

SMT: Systems Management Team

DFM: Design Firm Manufacturing

DFSS: Design for Six Sigma

DFS: Design for Service