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QCT OPTMISATION IN NEW PRODUCT DEVELOPMENT - DETAILED STUDY ON INTER-LINKS AND ANALYTICAL APPROACH FOR TRADE-OFF DECISIONS

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ABSTRACT

In the highly Competitive and demanding Global Automotive Industry, it is necessary to ensure High Quality, Low Cost & Quick to market, in any Product or Service being offered. It is obvious that major portion of these elements is embedded and controlled in Design and Development stage. This paper explains why it is not possible to optimize all objectives simultaneously due to the strong Inter-relationships between each objective. Also it goes further it detail to offer an systematic and Data driven approach, to help Trade-off decisions.
Keywords: NPD, Rapid Product Development, Cash-flow constraints, Optimization, Trade-off decisions, Profitability analysis

1.0 INTRODUCTION

In the past decade or so, every Top Management and Project manager in Automotive Industry, have given more emphasis to optimize Quality, Cost & Timeline during New Product Development. This requirement or the urge has stem from the concept of Quick to Market, with a better Quality and at Right Cost. Also this is being considered as Need of the Hour, to stay alive and competitive in Global market. In an attempt to accomplish this ambitious target, various tools and approaches were tried and adopted by companies spread across the globe.

Though we intend to optimize simultaneously Quality (Q), Cost (C) and Development Time (T) by tweaking the way a Product is designed and developed, is it really possible to optimize all at a time? The answer seems clear “No”. The reason is all these 3 elements are

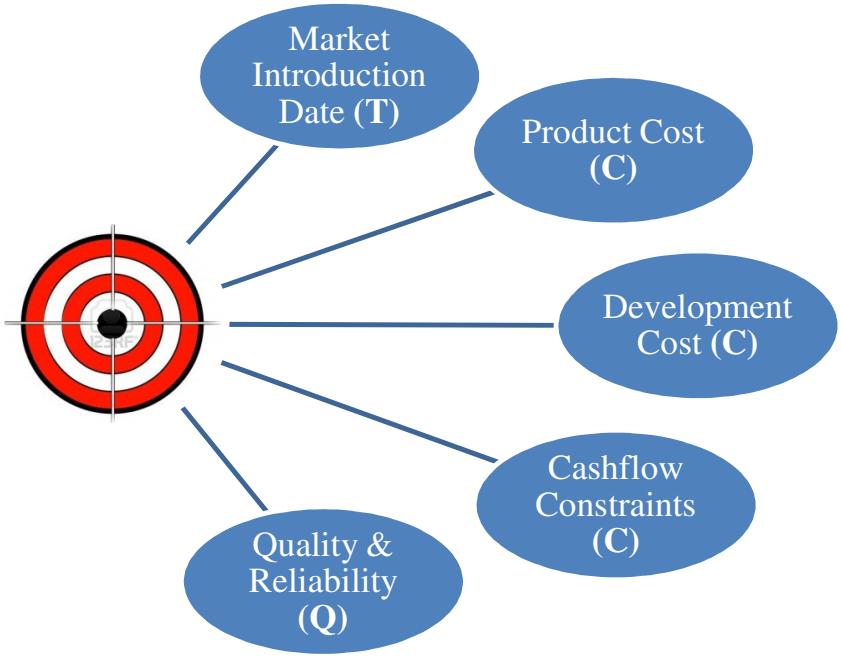
strongly inter-associated, hence often we end-up in a situation where we will be forced to go for a Trade-off. On the other Hand this Inter-relationship is specific to Company or Product or even the Project. Hence it is practically not possible to generalize the Optimization model.

However if we have a Systematic Analytical approach to assess and Quantify Inter-relationship, it would be really useful to apply in during any Trade-off decision making process [1]. The subsequent chapters will explain one of such methods in detail, covering Key objectives of New Development Projects, explanation of each objective and methods to arrive a Model specific to each Project considering all objectives.

2.0 KEY OBJECTIVES OF NEW DEVELOPMENT PROJECT

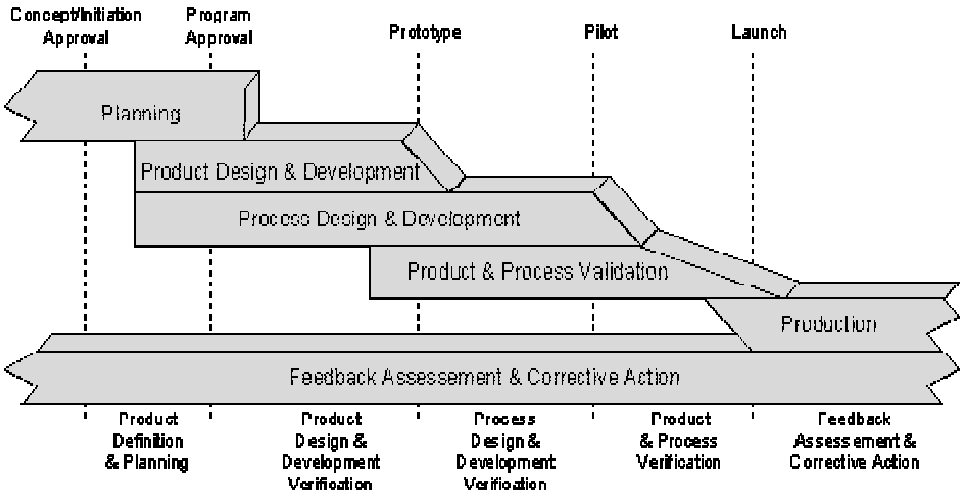
Typically any Development Projects will have following five key Objectives;

Fig 1: Key Objectives or Targets of Development Project [2]



The first objective, "Market Introduction Date" means the date at which Product is available for sale to an End customer. This also implies that the Project Development phase is completed and the Final Product goes in to Mass production. Basically the Duration between Start of Project and Market Introduction Date is commonly known as "Development Lead time", also referred as "T" in this Paper. Typically Automotive Development lead time is the duration comprising of phases namely; Planning, Product Design & Development, Process Design & Development and Product & Process Validation [3]

Fig 2: Typical Automotive Development Phases



The second objective, "Cost" also called as "C" is the Unit cost of a Product. Normally Unit Product cost is arrived based on Development cost, Direct Material, Direct labour, Conversion cost, Depreciation & Overheads [4]. In the recent past, Automotive suppliers prefers to charge their Development Cost to Vehicle manufacturers Up-front. On the other hand, vehicle manufacturers want to pay it on Part price amortized over a period of time. This will help vehicle manufactures to avoid up-front payment and thus controlling the Cash outflow during the Development stage of a Product. Following table can briefly summarize key elements of Product Cost;

Table 1: Elements of Product Cost

Development Cost	Design & development cost of both In-house and Suppliers, amortized over a period of time (Or volume)
Material Cost	Further classified as Direct & In-direct material. Material that can become part of a certain manufactured product is called as Direct Material [5]. Example: Casting used in Engine In-direct material is not a part of Product, but essential to make the final Product [5]. Example: Oil used in machineries
Labour	Further classified in to Direct & In-direct Labour [5] Direct labor - Employees who directly work on Product manufacturing line Indirect labour – Involved in Inspection, maintenance
Overheads	Cost of Supervision, Maintenance, Insurance, etc.,
Depreciation	Depreciation of Fixed Assets [6]

The third objective, Development Cost is normally one-time cost incurred for Development expenses. Money spent on Manpower, Prototype, Testing, Projects specific Investments on machineries, Equipment's are included in Development Cost. In some projects, Investments are excluded from Development Cost and considered as Long-term strategic Investment. For example Car manufacturer entering in to a new country's market needs huge investment for their Manufacturing plant and Service network. All these expenses cannot be loaded as Development cost of the 1st project, as these facilities would be used even for upcoming projects. Hence only the Investments specific to a project, can be considered as a part of Development Cost. Below table can explain the typical elements in Project Development Cost, taking an example of Passenger Car;

Table 2: Typical Elements of Project Development Cost [7]

Content (In-house & at Suppliers)		**Brief Explanation**
Product	Workforce	Cost of workforce used for Product Design, Development, Testing, Trials, etc.,
	Design & Validation	Cost of Design, Digital & Physical tests
	Prototypes	Cost of Proto parts, Engines & vehicles that will be used for physical testing of Design
	Tuning & Certification	Cost of Software, Tuning Development and Certification costs as a part of Regulatory requirements
Process	Workforce	Cost of workforce used for Process Design, Facility Installation, Testing, Trials, etc.,
	Design & Validation	Cost of Design, Digital & Physical tests
	Investments	Cost of Machinery, Tools, Equipments that are specific to the Project
	Launch	Cost of Production trials, Lower Efficiency during initial days of production, Training cost, etc.,

The fourth objective, "Cash flow constraints in Organization" is very essential considering recent Global Economic crisis. Though every company would be interested to invest in new projects to capture new market, it is necessary to weigh company's Cash flow constraints, so as to secure long term objectives of the company. For example, considering Company's financial situation and Global Economic situations, Top management may ask the team to avoid any Cash Outflow during the year. Now it's a tough target to the team, to work on the strategy to delay the Cash outflow means possible impact of Development time and Time to Market [7]

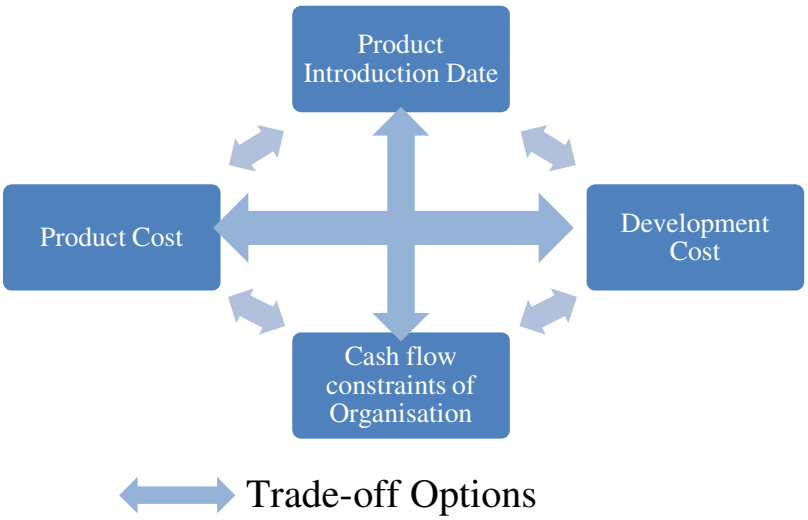
Preferably Quality and Reliability has to be taken out of Optimization scope. The reason being, this is already included and hidden within other four elements. For example, Rework in the Development stage will increase Development cost and Introduction date. Low manufacturing yield will increase Product cost. Warranty cost arising out of Poor Reliability will show-up in Product cost, thus affecting Profit. Also today Quality & Reliability is

considered as a "Must" for any product. Under the stiff competition in any Industry, it is not viable to put Quality as one of the elements to Trade-off. Hence further chapters in this paper will not treat "Quality & Reliability" as a separate objective by itself.

3.0 INTER-RELATIONSHIP BETWEEN OBJECTIVES & POSSIBLE TRADE-OFFs

Once we remove Quality & Reliability from the New Development projects' Objectives, for the purpose of Trade-off study, we will have 4 key objectives which are strongly inter-linked with each other. The same can be pictorially explained as below. Note that the magnitude of relationship varies Project to Project.

Fig 3: Key Objectives & Trade-off Options in Development Projects [1]



You can see in Fig 3 that there are six Trade-offs between four Key Development objectives. This concept of Trade-off is important because Development projects have multiple objectives which must be balanced. In practice, we usually cannot achieve the earliest possible Introduction and the lowest possible Unit cost at the same time [7]. We will discuss few examples to understand how the movement of one objective on positive or negative side, impacts the other objectives.

By utilizing Innovative Development processes like Early Supplier Involvement, we may be able to optimize the Development time and ensure Design for Manufacturability which can help us later stage of Development [8]. But it will have an impact on Cash Outflow, as Company has to pay to supplier in Advanced stage of Development which otherwise comes at later half of Development. By following the concept of Value Engineering, we may be able to achieve better Product Cost in the Development stage itself, however it may not be possible to stick on to the same Development lead time, thus increasing the Development cost and affecting the Market Introduction time as well.

Development lead time can be shortened by enhancing the overlap the Product and Process Design [9]. This will allow the Product design to take vital inputs from Process design, similarly Process Design period can be shortened thus helping us to optimize Market

Introduction date [10]. Usually this approach can increase the Development cost due to usage of more resources at the same time and additional verifications to ensure effective Product-Process interface.

By strong negotiation a manufacturer may succeed in convincing the supplier to pay Development Cost amortized on Product price over a period of time. This will help the company to optimize the Development Cost and reduce Cash outflow during the development phase. However this will obviously increase the Product unit cost.

Thus the necessity of Trade-off in Optimization of Development objectives can be explained with many more situations and examples.

4.0 PIVOT POINT FOR TRADE-OFF DECISION – PROFITABILITY

As we have seen above there are many Trade-off options to choose but how to decide the Trade-off? One way can be, to decide the Trade-off considering Company's or Projects' objective, taking in to account of current situation. But normally this is short term or Specific objective. To keep in mind the Long term Objective of any Business, we need a Pivot point on which the Trade-off can be studied. "Profitability" is that Pivot point which can also act as a criterion to decide on Trade-off options [11]

Profitability is too generic in terms of definition, hence we shall consider following Metrics, to assess the profitability. However the Rules of minimum level of this metrics varies company to Company and Project to Project.

4.1 Profitability Index

Profitability Index is the Present value of a Project's future Cash flows divided by Initial Investments. It can be expressed as;

$$PI = \frac{PV\ of\ future\ cash\ flows}{Initial\ Investment} = 1 + \frac{NPV}{Initial\ Investment} \quad (1)$$

PI is very closely related to NPV (Net Present Value). Whenever NPV is positive, PI will be greater than 1 and conversely when NPV is negative PI will be less than 1. Normally the Investment decision rule is [5]

Invest if PI >1 [12]. Some companies follow 1.2 as minimum criteria

4.2 Payback Period

Payback period is usually expressed in years. Start by calculating Net cash flow for each year. Net Cashflow for Year 1 = Cashflow year 1 – Cash outflow year 1. Then cumulative Cash flow = (Net Cashflow year 1 + Net Cashflow Year 2+etc.,). Accumulate by year until cumulative Cashflow is positive, that year is the Payabck year It can also be calculated using the formula [13]

$$Payback\ period = (p - n) \div p + n_y \quad (2)$$

Where;

p = Value of cash flow at which the first positive value of cumulative cash flow occurs

n = Value of cash flow at which the last negative value of cumulative cash flow occurs

n_y = Number of years after the Initial investment at which the last negative value of cumulative cash flow occurs

Since, Payback period doesn't take in to account "Time value of Money" another metric used is "Discounted Payback period"

Criteria for Payback period varies company to Company, from 1 year to 3 years

4.3 Net Present Value – NPV

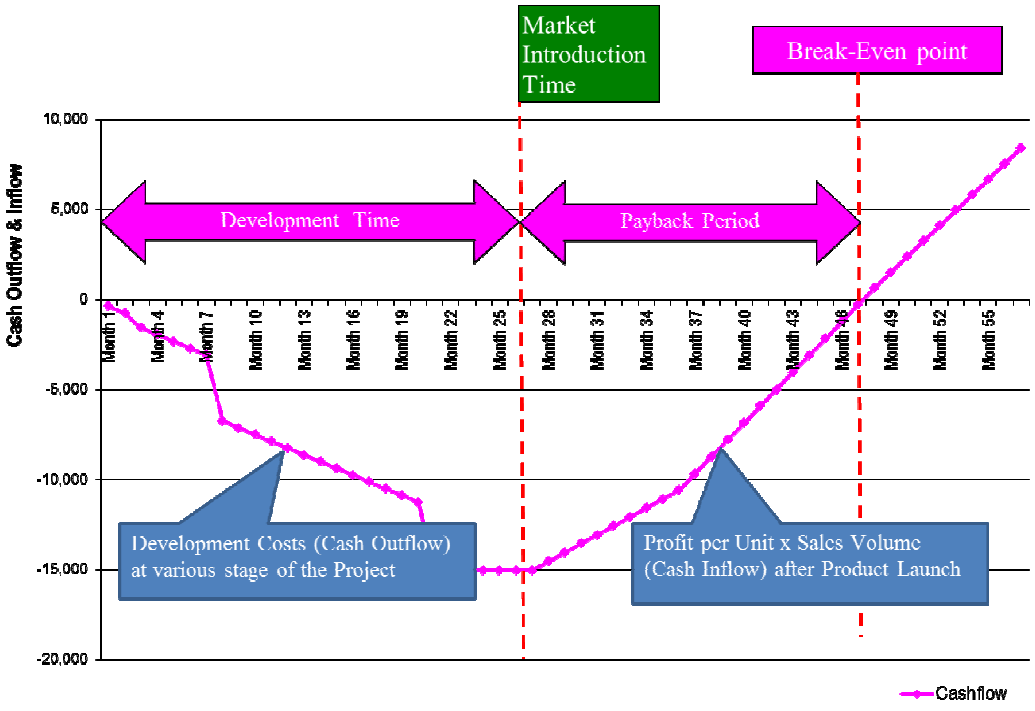
NPV can be described as the "Difference amount" between the sums of discounted Cash inflows and Cash outflows. It compares the present value of money today to the present value of money to the future, taking inflation and returns in to account. It can be expressed using the following formula [13]

$$NPV\ (i,N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t} \qquad (3)$$

Where;
t = the time of the Cash flow
i = the discount rate (the rate of return that could be earned on an investment in the financial markets with similar risk) the opportunity cost of capital
= the net cash flow ie, cash inflow-cash flow, at time t

4.4 Example to explain a Development Projects' Cash flow & Profitability:

Figure 4: Cash flow analysis



Typically any Development project's Profitability can be assessed by calculating PI, NPV & Payback period using the formulas. And graphical representation of Cash flows [14] as shown in above example will help to assess the Trade-off, subject to the limits of Profitability set by the specific Project.

5.0 CONCLUSION

The approach used in this paper can be universally used for any project. However Trade-off model has to be developed for each Project, as the priority of objective cannot be kept same for each project, it is Project Specific.

Any Trade-off decisions have to be data driven; consciously taking in to account Company/Project specific rules on Profitability level which is normally influenced by company's strategy on specific Project. Also it is essential to have keen watch on the market to understand the Technology trends, Fluctuation in market size (Volume), before any Investment decision

The success of Optimization lies in minimizing the trade-off effect by Innovative Development Processes

REFERENCES:

[1] Preston G. Smith, Donald G. Reinertsen (1998), "Developing Products in Half the time" John Wiley & Sons INC,

[2] Preston G Smith and Donald G.Reinertsen (1992), "Shortening the Product Development cycle", Reserch-Technology Management, May-Jun 1992, pp 44-49

[3] AIAG (Automotive Industry Action Group), "Advanced Product Quality Planning manual 4th edition"

[4] Edward J. Vanderbeck (2012), "Principles of Cost Accounting 16th Edition", pp 83-99

[5] Susan V. Crosson, Belverd E. Needles (2010), "Managerial Accounting" pp 45-67

[6] Helene Personnier, Marie-Anne le Dain, Richard Calvi (2012), "Failures in Collaborative Design with suppliers: Literature review and future research avenues", 21st Annual IPSERA conference

[7] Kenneth B. Kahn, Gloria Barczak, John Nicholas, Ann Ledwith, Helen Perks, (2012), "An Examination of New Product Development Best Practice", Journal of Product Innovation Management 2012:29(2):pp1 80-192

[8] Daniel Capaldo Amaral, Henrique Rozenfeld, Jose Carlos Toledo (2002), "Early Supplier Involvement: a review and proposal for new directions in research", Journal of Product Management & Development Vol 1 no. 2 pp 19-30

[9] Marcus Vinicius Pereira Pessoa, Geilson Loureiro, Joao Murta Alves (2008), "A method to Lean Product Development planning", Journal of Product Management & Development, Vol 6, No 2, December 2008, pp 143-155

[10] Nicolas Maranzana, Nathalie Gartiser, Emmanuel Caillaud, "From Concurrent Engineering to collaborative learning of design", International Journal of Design and Innovation Research (IJODIR) , Volume 4, No 1, pp 39-52

[11] Regiona C. Mcnally, M.Billur Akdeniz, Roger J.Calantone (2011), "New Product Development Processes and New Product Profitability:Exploring the Mediating Role of Speed to Market and Product Quality", Journal of Product Innovation Management" 2011:28(S1) pp 63-67

[12] Michelle R. Clayman, Martin S. Fridson, George H. Troughton (2008), "Corporate Finance: A Practical Approach", John Wiley & Sons, pp 35-56

[13] Williams JR et al (2012), "Financial Management And Accounting", McGraw hill, pp1117

[14] Ronald Mascitelli (2011), "Mastering the Lean Product Development", A Practical Event driven process for Maximizing Speed, Profits and Quality