Performance Measurement in the

Product Development Process

Doctor of Engineering in Automotive Engineering

Research Project 2

EVALUATION OF PERFORMANCE MEASUREMENT TECHNIQUES IN THE AUTOMOTIVE PRODUCT DEVELOPMENT PROCESS

by

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A thesis submitted in partial fulfilment of the requirements of the

University of Hertfordshire for the degree of Professional Engineering

Doctorate in Automotive Engineering

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ETHICS APPROVAL PROTOCOL NO: 1011/340

ABSTRACT

This thesis incorporates report 2 of the submission of the authors Engineering Doctorate. The intention of the programme was to evaluate and compare the performance of product development processes and to identify areas in which improvements can be made. The research is principally concerned with the automotive industry but can also has wider implications within similar industries.

EVALUATION OF PERFORMANCE MEASUREMENT TECHNIQUES IN THE AUTOMOTIVE PRODUCT DEVELOPMENT PROCESS

CONTENTS

1 Introduction

Project 2 of this research programme aims to evaluate the current use of performance measurement techniques in automotive product development (PD). Research has shown that the PD process is one of the underlying factors of why car programmes fail in the market (Hanawalt & Rouse, 2010).

1.1 Research Background and Project Context

As described in project 1, PD is a source of competitive advantage in the automotive industry. Traditionally, vehicle design projects have ranged from being completely developed in-house at the OEM to totally outsourced i.e. turnkey projects performed by suppliers. Between these two extremes discrete aspects of projects are also outsourced but managed by the OEM. The aim of project 2 will be to develop a system of measuring the efficiency of new PD projects.

1.2 Research Hypothesis

From the research background it is proposed that current PD processes in the automotive industry lack effectiveness and efficiency. That is, the right product for the customer is not always delivered (effectiveness) and that too many costly resources are used to deliver the result (efficiency). Current performance measurement techniques do not measure effectiveness and efficiency well enough.

Definition of the research problem:

> How to measure the performance of the PD in the global automotive industry.

The Product Development & Management Association (PDMA) Success Measurement Project: Recommended Measures for Product Development Success and Failure (Griffin & Page, 1996) concluded - "Success is not just elusive; it is also multifaceted and difficult to measure."

An initial literature review (Teresko, 2008) found that, at a corporate level, the top ten PD metrics have been proposed as:

- PD Spending as a percentage of sales.
- Total patents filed/pending/awarded.
- Total PD headcount.
- Percentage sales in year due to new products released in the past x years.
- Number of new products released.
- Number of products/projects in active development.
- Percentage of resources/investment dedicated to PD.
- Number of products in defined/planning/estimation stages.
- Average project ROI – return on investment or average projects payback.
- Percentage change in PD headcount.

These measures, whilst a useful starting point, are too high level and do not give an indication of actual project performance. A method of measuring the PD project efficiency is required.

1.3 Aim and Objectives

As informed by project 1, successful actors in the automotive industry of the future will have effective product development processes that will be more efficient in their use of company resources than those of today.

1.3.1 Aim

The originally stated aim of project 2 in the initial research design was:

To critically assess automotive PD and identify specific areas where advances could be made to improve the process.

With the focus of performance measurement identified in project 1 this now becomes:

> To critically assess automotive PD performance measurement techniques and identify specific areas where advances could be made to improve the process.

1.3.2 Objectives

Similarly objectives 3 to 5 in the original research design are evolved and expanded to;

3. To establish best practice and effectiveness of performance measurement techniques in PD and compare an engineering service supplier's process documents with automotive industry best practice to identify the strengths and weaknesses of their documentation or processes.

4. To explore and critically evaluate the current application and effectiveness of performance measurement techniques in PD projects in the global automotive industry.

5. To identify deficiencies and opportunities in the current automotive PD process where new measures/ratios/metrics/indicators are needed.

1.4 Structure of the Report

This research project will undertake a literature review to identify techniques commonly used in PD, project management and performance measurement. The project will then comprise a review of the project management processes used at RLE and as applied to four PD projects at different OEMs in the automotive industry. These four projects and the processes employed are representative of those used commonly within the industry and will be critically compared with findings from the literature review.

From this research, an evaluation of the suitability and effectiveness of the performance measurement techniques currently employed will be made. Deficiencies in processes currently used will be identified.

This procedure will inform project 3 to identify, propose and evaluate a revised process for the management of the PD process that is appropriate to the future requirements of the automotive industry.

Chapter 2 contains an evaluation of current PD processes and project management techniques.

Chapter 3 investigates project performance in four automotive PD projects and includes an exploration of performance measurement techniques.

Chapter 4 includes a critical analysis of processes at RLE in comparison to industry prescribed APQP and TS 16949 standards.

Chapter 5 describes the critical outcomes and discusses causality and implication for business.

Chapter 6 draws conclusions and discusses contribution.

Chapter 7 describes future work and the research programme for the part 3.

2 Project Management of Product Development

Effectiveness is a measure of doing the right job (Drucker, 1967), i.e. stakeholder expectations are met. Efficiency is a measure of doing the job right (Drucker, 1967), how economically resources are utilised.

2.1 Product Development

Product Development can simply be defined as the development of new products. However, many definitions are available in the literature (Cedergren, 2011). Within the context of this research project the author prefers "the set of activities beginning with the perception of a market opportunity and ending in the production, sale and delivery of a product" (Ulrich & Eppinger, 2008).

The PD process in most major organisation follows a systematic process. The waterfall model, figure 2.1.1 (Leffingwell, 2011), is often credited to Winston Royce of TRW (Royce, 1970) shows PD as a process where progress cascades or flows over time.

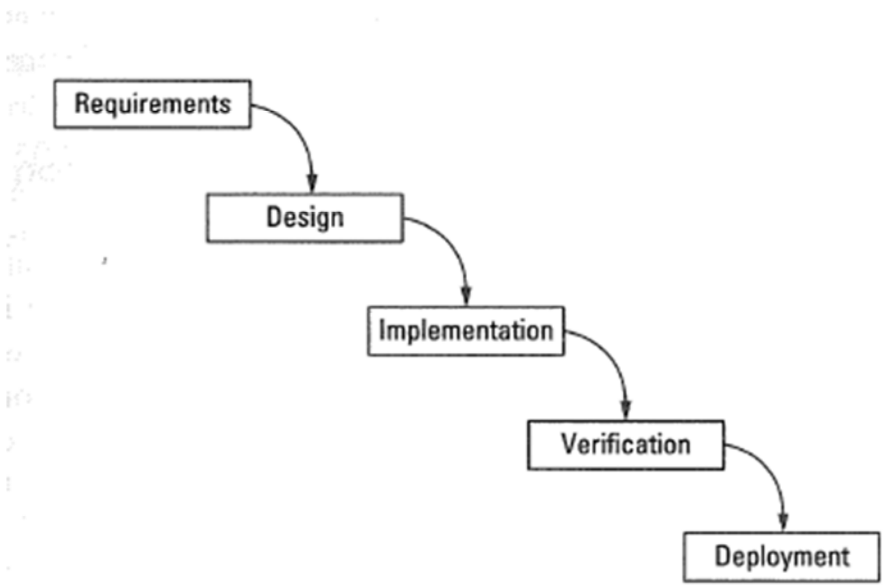


Figure 2.1.1 – Waterfall Model of PD

(source: Leffingwell, 2011)

Alternative, more complex approaches have been developed, e.g. design activity model of Pugh (1991), figure 2.1.2.

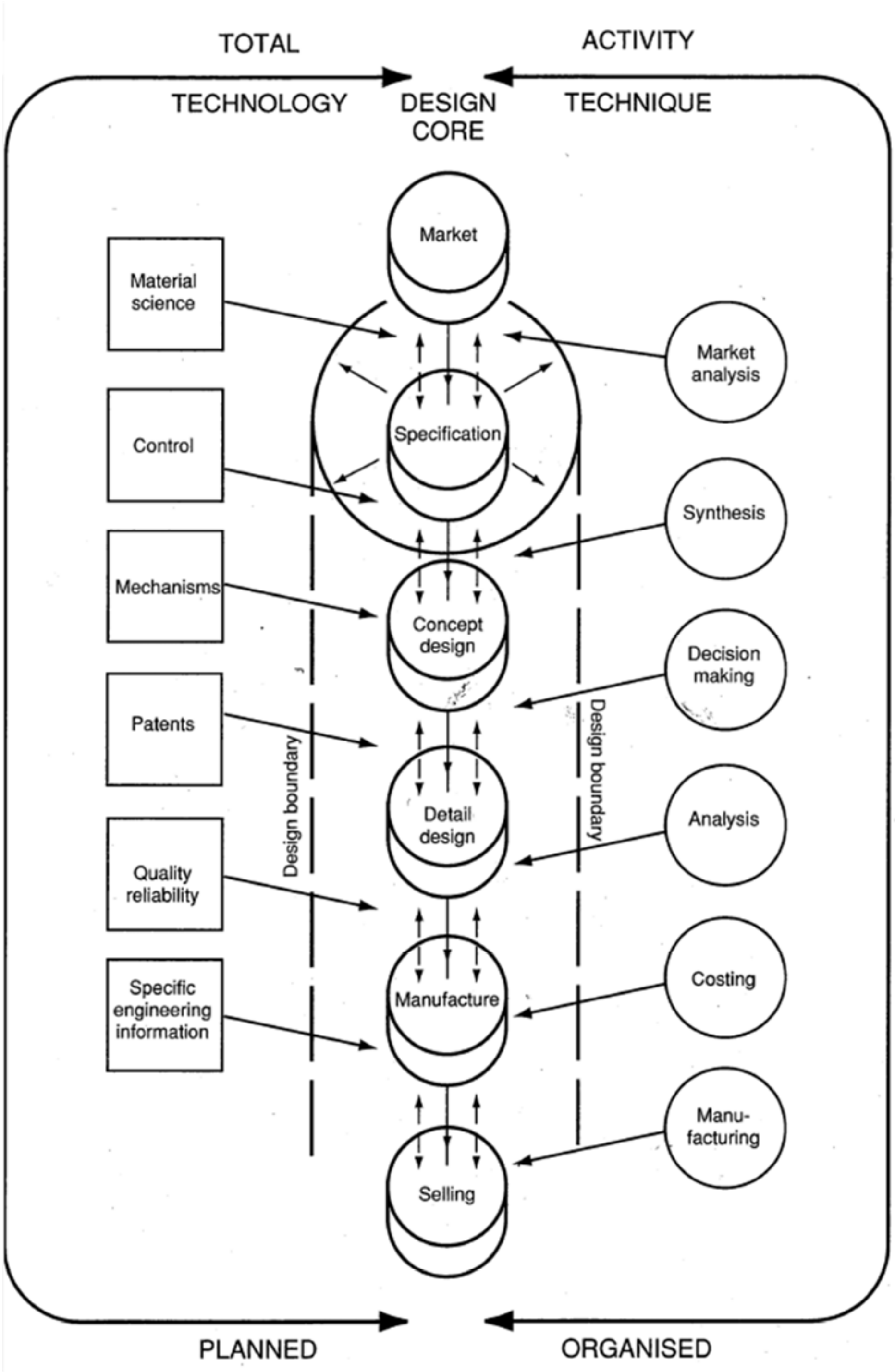


Figure 2.1.2 – Design Activity Model

(Pugh, 1991)

The stage-gate model, Figure 2.1.3 (Cooper, 1994), has a similar breakdown of phases but prescribes a formal review or 'gate' between stages.

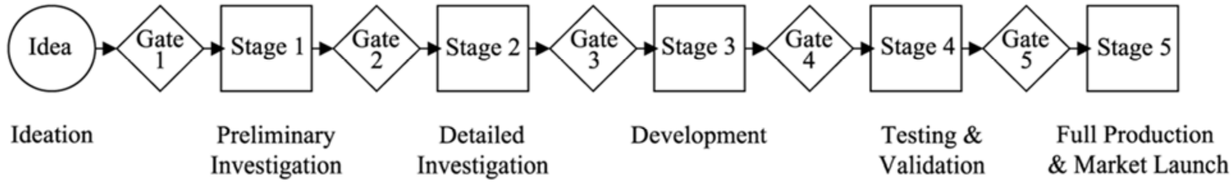


Fig. 2.1.3 – Stage-Gate Process (source: Cooper, 1994)

Initial idea generation, ideation, is often called the "fuzzy front end" is followed by preliminary investigation where the business case is justified. This research project is concerned with the subsequent phases and in particular the development stage where the detailed design and engineering is performed and verified by computer aided techniques prior to confirmation testing on physical prototypes.

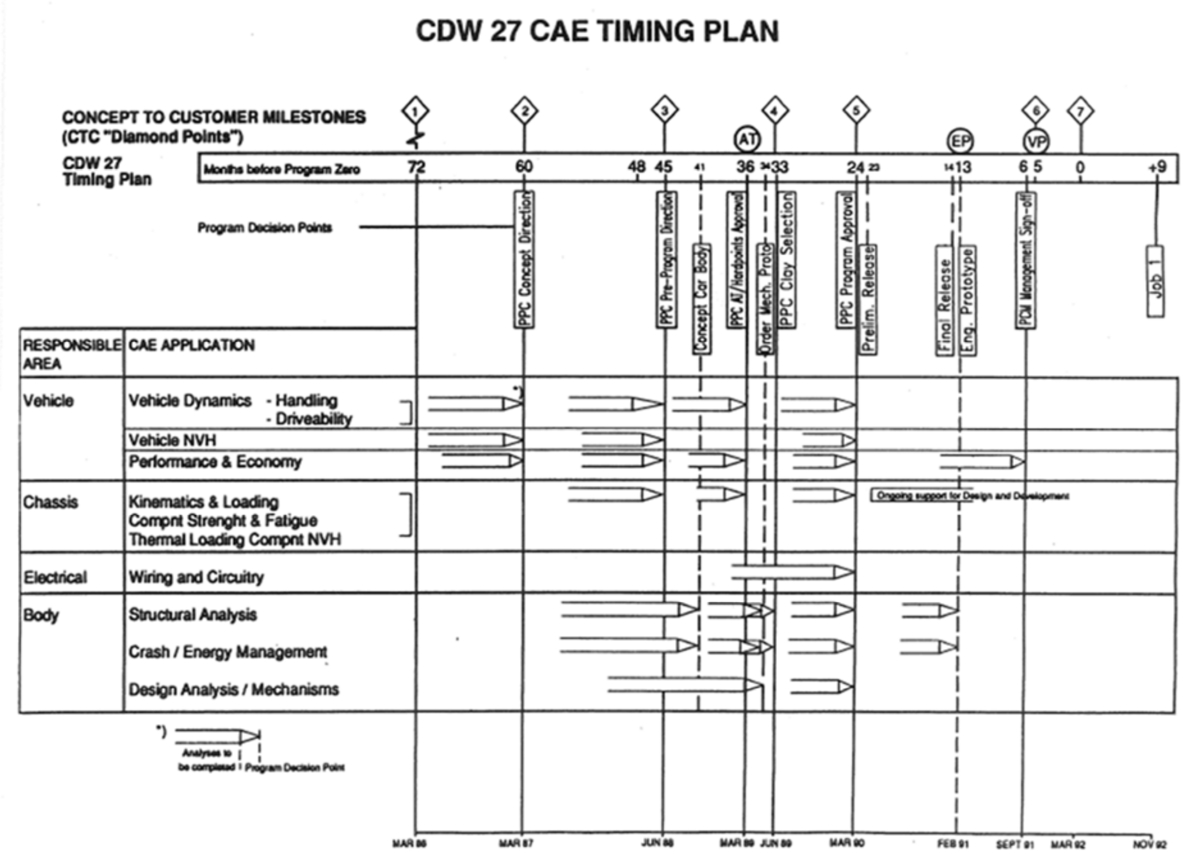


Figure 2.1.4 – Ford Motor Company 1980's Concept to Customer PD Process

(source: RLE)

In the Ford Motor Company Concept to Customer (CTC) model, figure 2.1.4, the gateways are termed milestones or diamond points. Models prevalent in other development industries include the the spiral model (Boehm, 1988) shown in figure 2.1.5 which is common in the computer software industry.

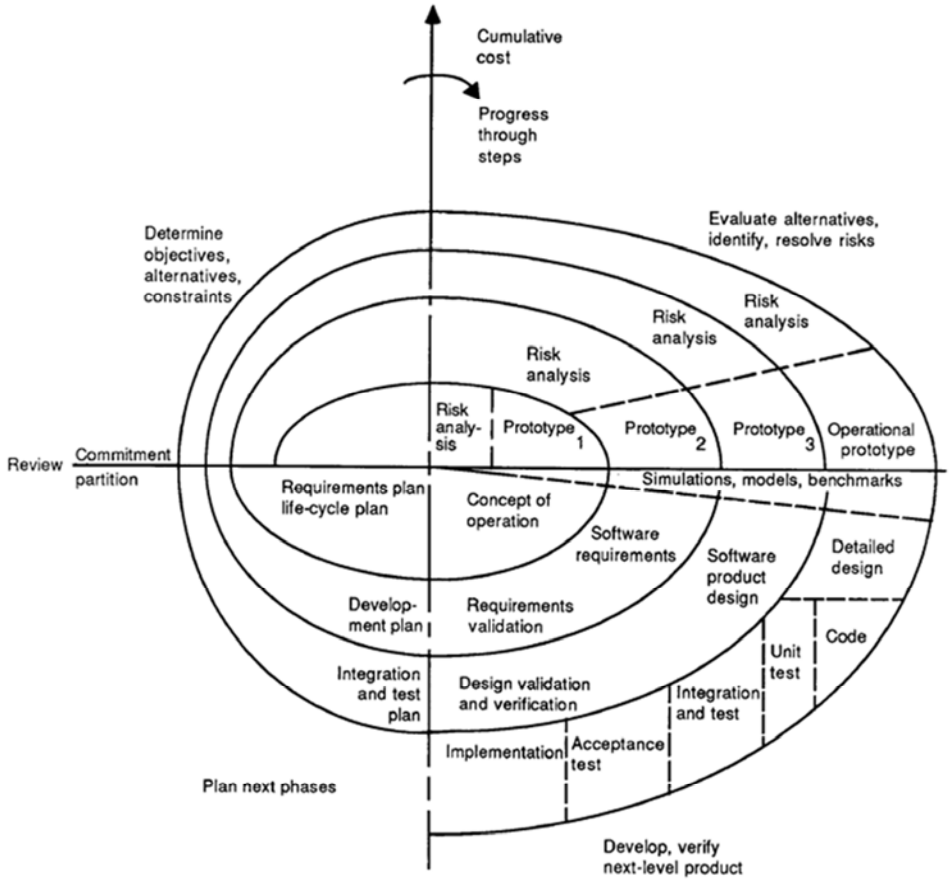


Figure 2.1.5 – Spiral PD Process (source: Boehm, 1988)

As discussed in research project 1, modular design plays a key role in modern PD. The systems engineering approach splits a product into modules or systems and assigns attributes to sub-systems. The V-Process is used to cascade and decompose attributes from the product level to the sub-systems and individual components, figure 2.1.6.

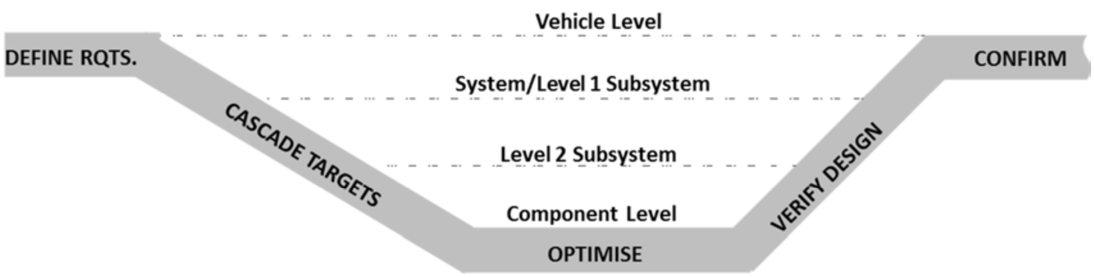


Figure 2.1.6 – V-Process from Systems Engineering (source: RLE)

2.2 Project Management

The Project Management Institute's published body of knowledge (PMBOK) provides the following definitions:

1. A project is a temporary endeavour undertaken to create a unique product, service or result.
2. Project management is the application of knowledge, skills, tools and techniques to meet project requirements.

Alternatively, PRINCE2 definitions are:

1. A project is a temporary organisation that is created for the purpose of delivering one or more business products according to an agreed business case.
2. Project management is the planning, delegating, monitoring and control of all aspects of the project, and the motivation of those involved, to achieve the project within the expected performance targets for time, cost, quality, scope, benefits and risks.

The original version of the iron triangle or triple constraint (Phillips, et al., 2002) has been represented in many forms since first presented by Dr. Martin Barnes in 1969. The usual version shows time, cost and scope (figure 2.2.1).

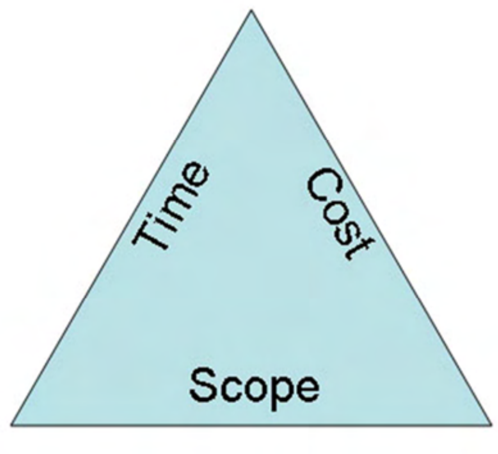


Fig. 2.2.1 – The Iron Triangle or Triple Constraint (source: RLE)

The PRINCE2 definition of project management recognises this has evolved over the years and the PMBOK list of project constraints is now in 2011 represented as star (figure 2.2.2).

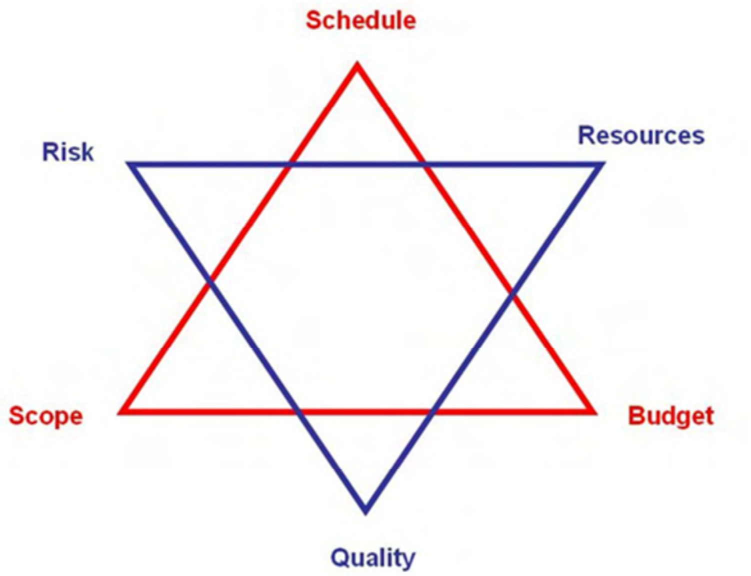


Fig. 2.2.2 – The new 'Triple Constraint' (source: PMBOK)

A project is typically divided into a Work Breakdown Structure (WBS) with sub-projects and tasks. The timing and linkages of tasks can be represented on a Gantt chart as shown in figure 2.2.3. Software such as Microsoft Project and Primavera can be utilised to prepare Gantt chart as well as other depictions of the project.

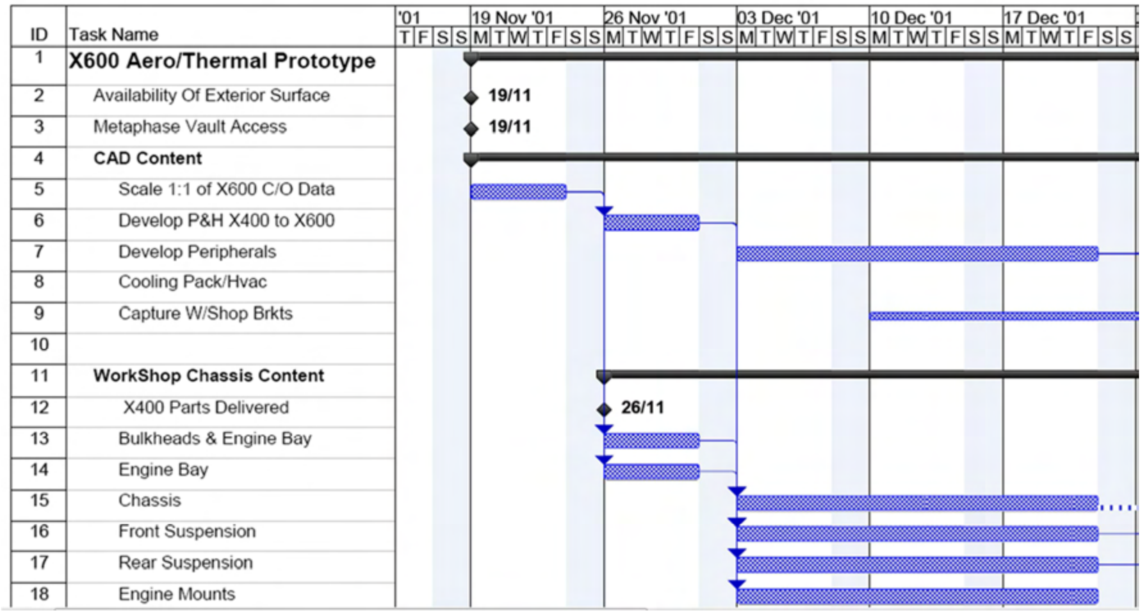


Fig. 2.2.3 – Gantt Chart generated in Microsoft Project (source: RLE)

Microsoft Project also allows resources to be assigned to tasks and overall resource requirements for the project or multiple projects to be calculated. A basic Gantt chart with resource requirement is shown in Figure 2.2.4.

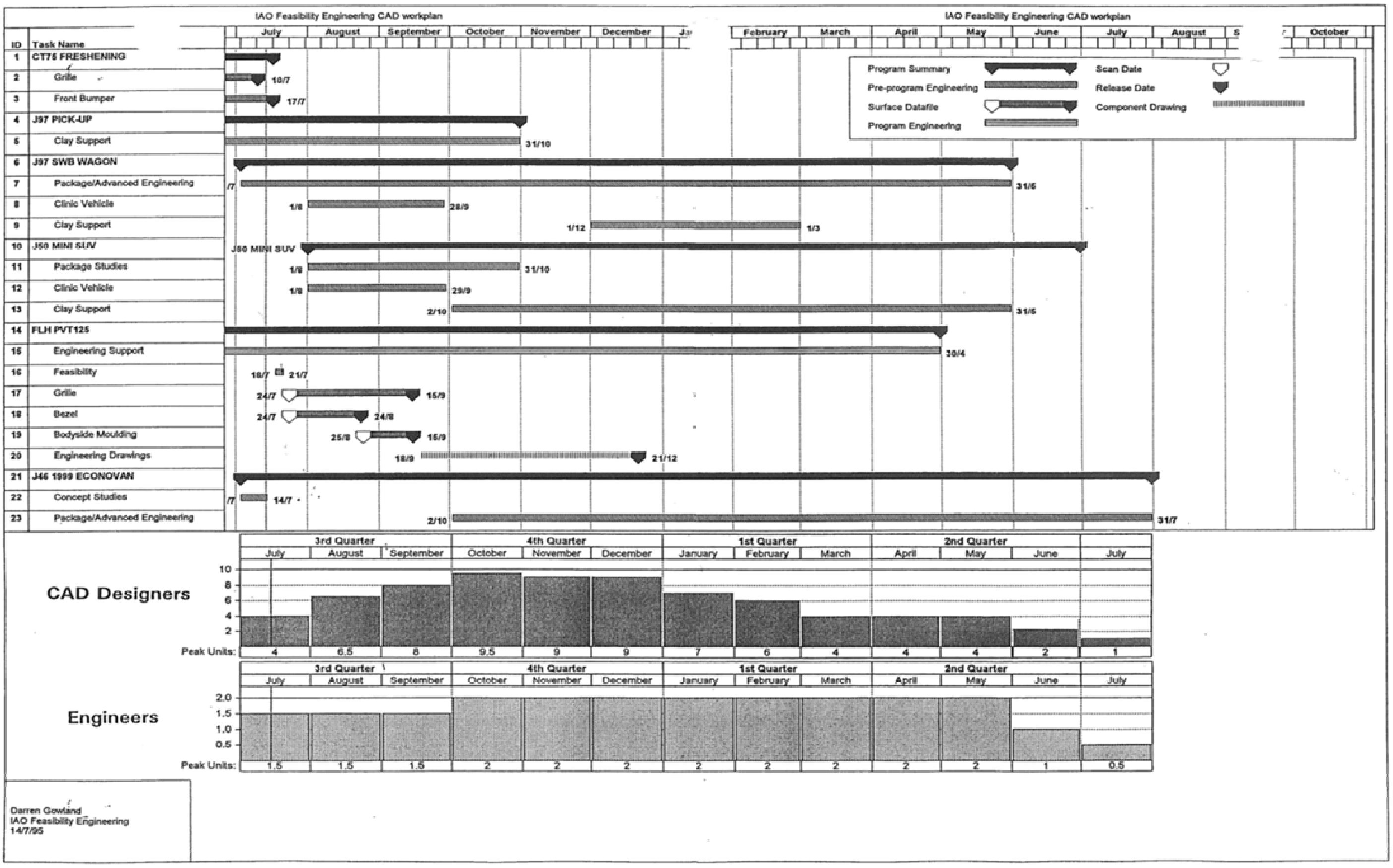


Fig. 2.2.4 – Gantt Chart showing Resource Histogram (source: RLE)

The Gantt chart is the most popular project management tool (Lyneis, et al., 2003) but does not explicitly show relationships between tasks. Browning and Ramasesh (2007) describe how interactions in the PD process are as important as the actions or tasks that are shown on a Gantt chart, but are rarely considered in the actual process.

This identification of the importance of interfaces and the inclusion of additional criteria such as resources and risk recognise the growing complexity in project management. This complexity has led to many organisations setting up departments to define and maintain standards within the project management process. These departments are often referred to as the Project Management Office (PMO).

2.2.1 Project Evaluation and Review Technique (PERT)

The PERT approach, developed in 1958, comprises tasks or activities shown as nodes or on an arc (Lyneis, et al., 2003), figure 2.2.1. PERT originally was an activity on arc network. When the tasks are represented by arcs the nodes can represent the state of a project or milestones.

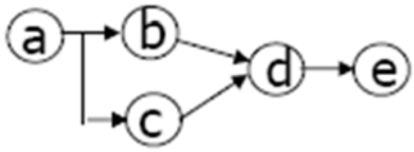


Figure 2.2.1.1 – PERT Network Chart (source: Lyneis, et al., 2003)

2.2.2 Critical Path Method (CPM)

The critical path method, invented by Dupont Corporation in 1960, links together project tasks to show the shortest possible project duration. The tasks on the critical path have no float and any delay in their performance will impact overall project timing.

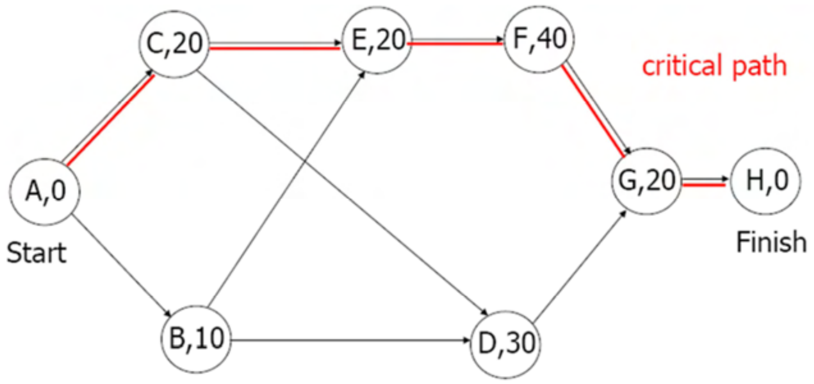


Figure 2.2.2.1 – Critical Path Method (source: Lyneis, et al., 2003)

2.2.3 Earned Value Management System (EVMS)

Developed in the 1970s this method allows the project management team to monitor the value creation of the whole project with a targeted budget at completion based on the budgeted cost of work scheduled, figure 2.2.3.1. Reserves can be applied to timing and costs and actual estimates at completion are extrapolated throughout the project.

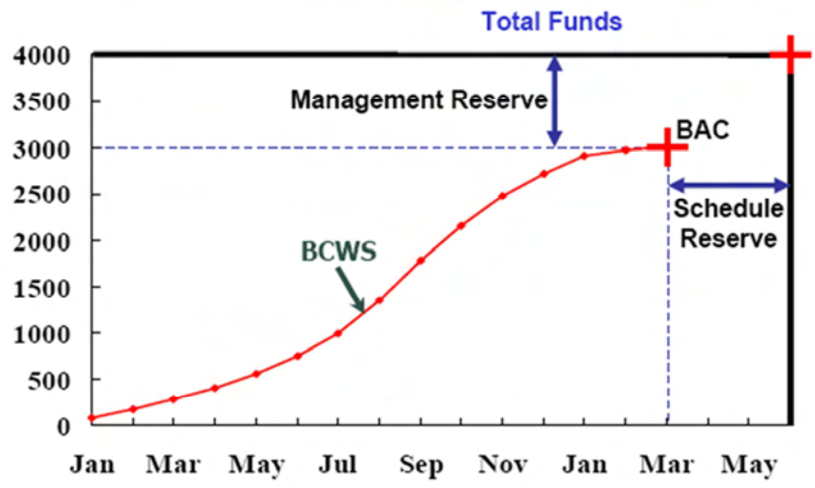


Figure 2.2.3.1 – Earned Value Management (source: Lyneis, et al., 2003)

2.2.4 Critical Chain Method (CCM)

The critical chain method is based on the Theory of Contraints (TOC) (Goldratt, 2004). In this approach individual task buffers are removed and an overall project buffer is created for control by project management. However, critical tasks that could cause bottlenecks and delay the project are recognised. Feeding buffers are then put in place to ensure these tasks are always busy thus preventing further delays, figure 2.2.4.1.

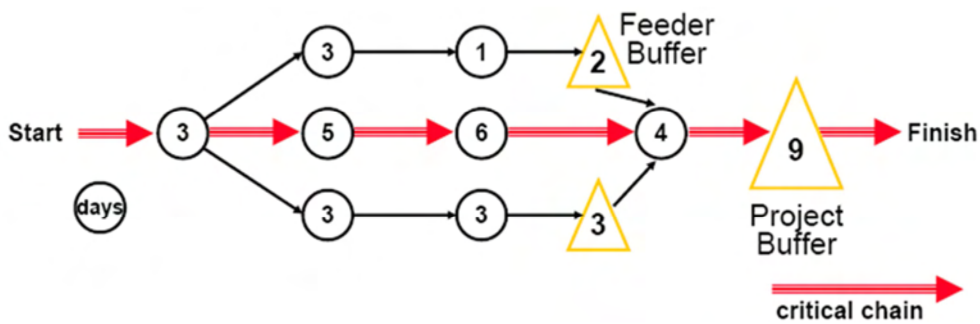


Figure 2.2.4.1 – Critical Chain Method (source: Lyneis, et al., 2003)

Despite the benefits that are conveyed by using PERT, CPM, EVMS or CCM, the most popular project management tool by far, at 80% usage, is still the Gantt chart (Lyneis, et al., 2003). This is certainly true of the automotive industry PD process, where the Gantt chart is ubiquitous.

2.2.5 Simultaneous Engineering / Concurrent Engineering

Simultaneous or concurrent engineering is a systematic approach to the integrated concurrent design of products and their related processes including manufacturing planning and support. This approach is intended to consider all elements of the product life from conception through to production, figure 2.2.5.1

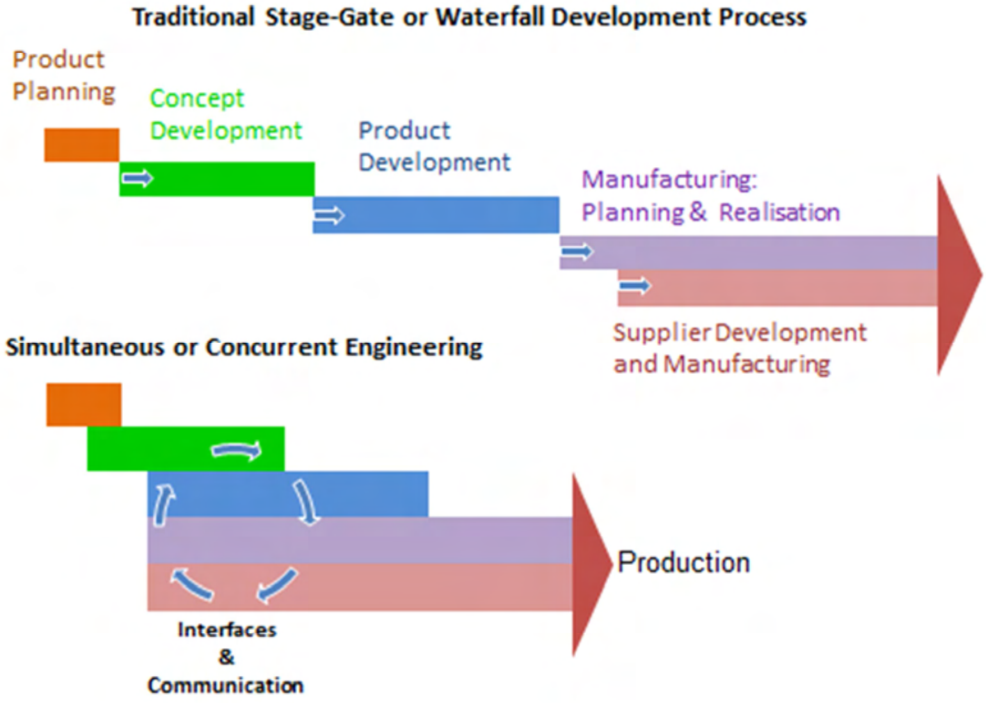


Fig. 2.2.5.1 Simultaneous Engineering Communication (source: RLE)

This is an over simplification and does not recognise or consider the level of interaction necessary between the different departments responsible for each of the activities. These multiple interactions can give rise to conflicts of interest between departments that are discussed at cross-functional meetings to find resolutions. Prior to the use of virtual design and simulation techniques, these meetings and discussions often took place around physical prototypes.

Within the PD process, interactions between activities have been identified as more important than the actions themselves (Bicheno, 2008). Wheelwright & Clark (1992) provided templates for interaction in the concurrent engineering scenario, figure 2.2.5.2.

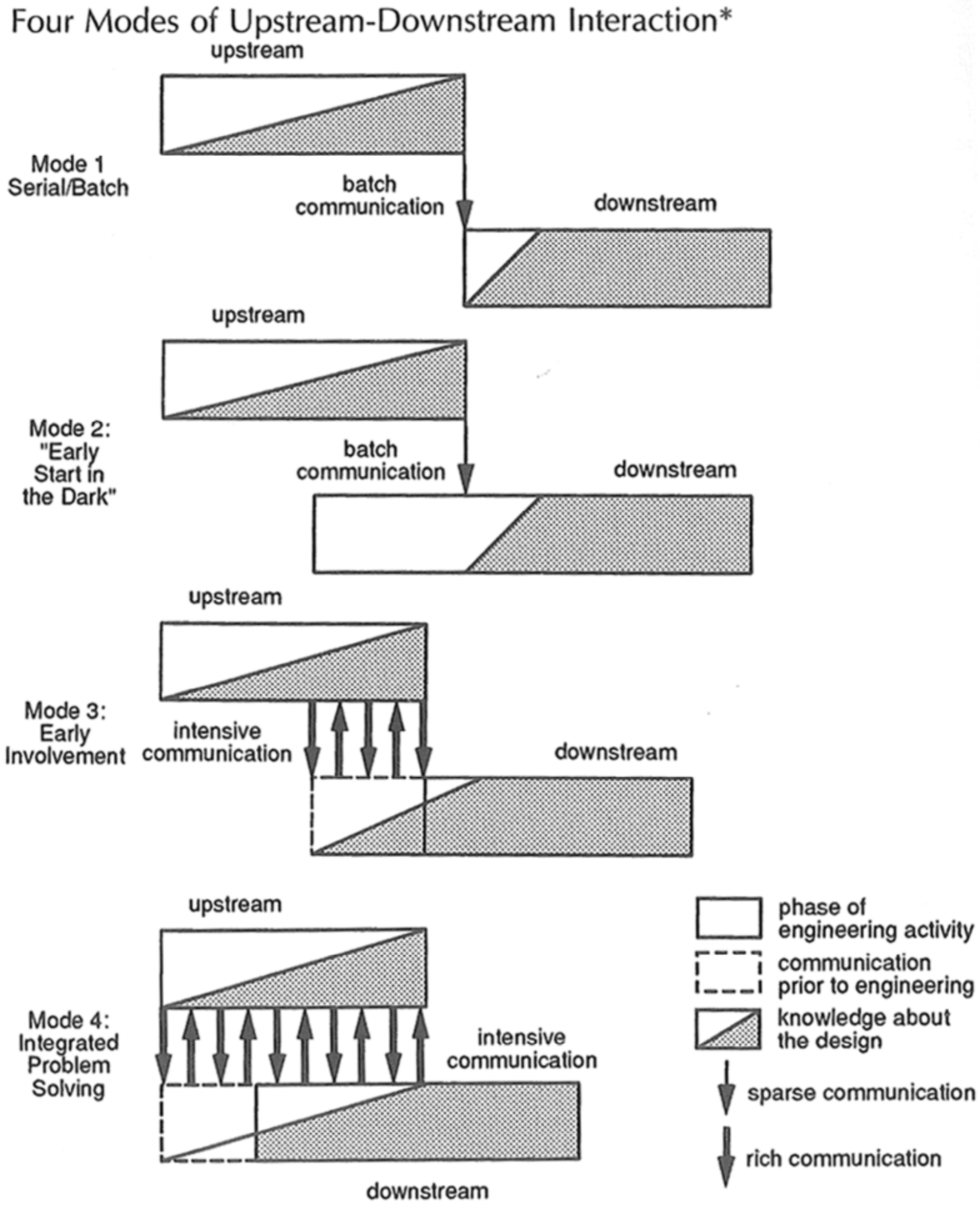
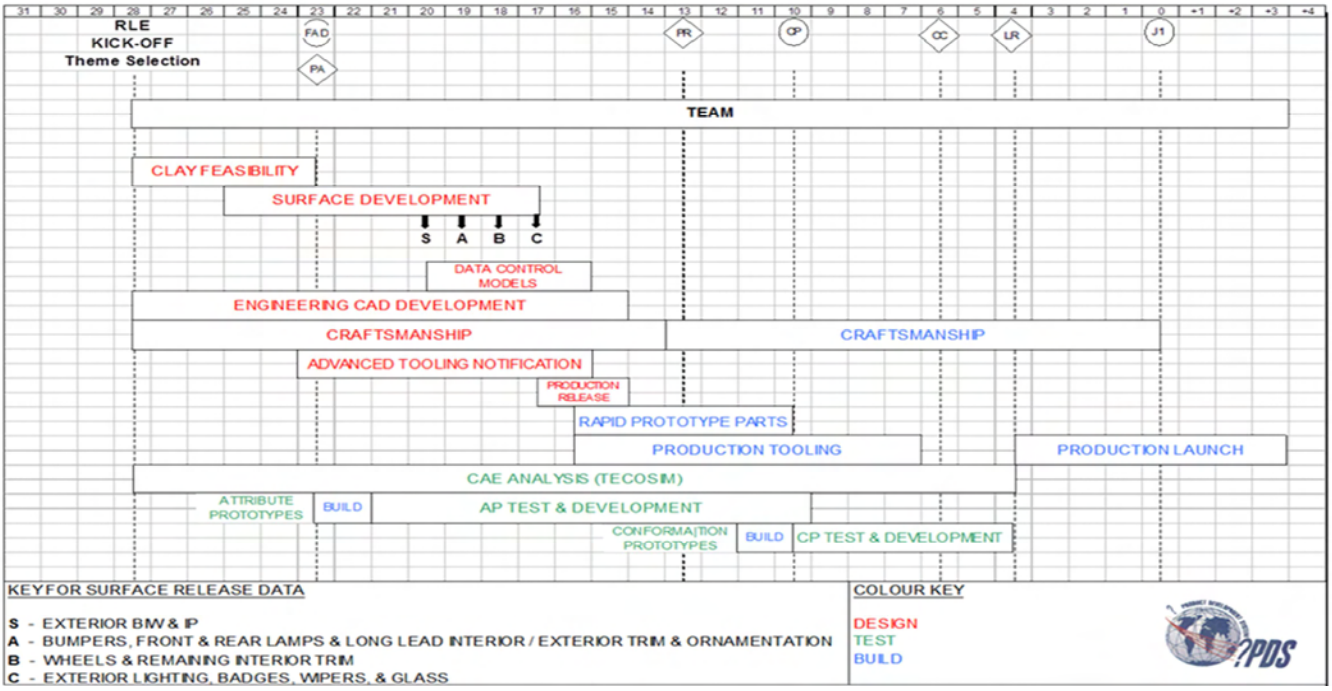


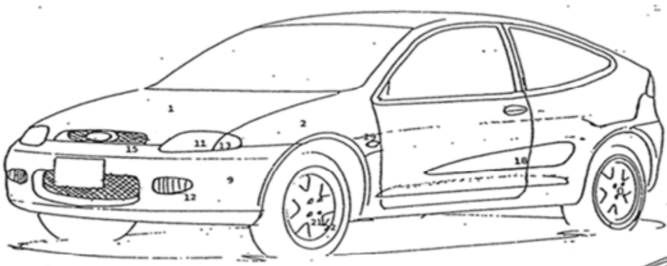
Figure 2.2.5.2 Four Modes of Interaction
(source: Wheelwright & Clark, 1992)

In 2000, the author of this report proposed a similar model to mode 3 of the Wheelwright and Clark (1992) template, to the Director of Product Development at Ford of Europe, under the guise of '?PDS'. This model utilised sequential releases of surface data (shown as S,A,B,C) as per the Mazda product development system the author had been exposed to whilst working in Japan in the mid-nineties (figure 2.2.5.3). The '?' in the name '?PDS' referred to the question of what the system would be called.

Co-location of teams also improves project communication levels but this does not work for multiple projects in the same period.

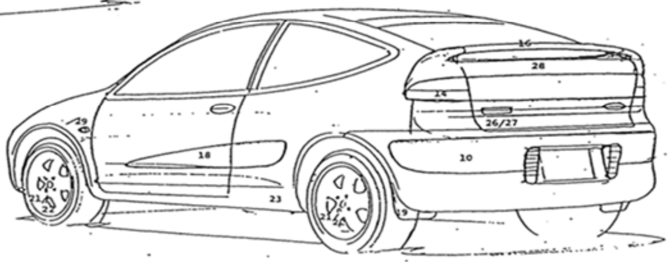
[Vehicle Timing Plan]





CT75 DESIGN PARTS LIST

EXTERIOR		BODYSTYLE	RANK
1. SHEET METAL	– HOOD	4DR/3DR	S
2.	– FENDER	4DR/3DR	S
3.	– RR. QTR	5DR	S
4.	– TAILGATE	5DR	S
5.	– ROOF	5DR	S
6.	– RR DOOR FRAME	5DR	S
7. GLASS AREA	– RR DOOR	5DR	S
8.	– TAILGATE	5DR	S
9. FRONT BUMPER		4DR/5DR/3DR	A
10. REAR BUMPER		4DR/5DR/3DR	A
11. HEAD LAMP		4DR/3DR	A
12. FOG LAMP		4DR/3DR	A
13. F. COMB. L.		4DR/3DR	A
14. RR. COMB. L.		4DR/5DR/3DR	A
15. GRILLE/FINISHER		4DR/5DR/3DR	A
16. R. SPOILER		4DR/5DR/3DR	A
17. WINDOW MLDGS.		5DR	A
18. B.S.P.M.		4DR/3DR	B
19. R. MUD FLAP		4DR/3DR	B
20. RR. APPLIQUE		4DR/5DR/3DR	B
21. WHEEL COVER		I/II/III	B
22. ALLOY WHEEL		I/II	B
23. ROCKER MOULDING		3DR	
24. CERAMIC PAINT		5DR	C



EXTERIOR	BODYSTYLE	RANK
25. RR. SCREEN HEATER LINE	5DR	C
26. BADGE		C
27. NOMENCLATURE	I/II/III/IV	C
28. H.M.S.L.	5DR	C
29. SIDE REPEATER	ALL	C
30. RR. WIPER	5DR	
31. SHEET METAL-DECK LID OUTER	4DR	S

Figure 2.2.5.3 – RLE Proposal for Sequential Surface Releasing (RLE, 2000)

2.3 Project Management in Automotive Product Development

The majority of the global OEMs have developed their own PD processes and all generally follow the basic stage-gate framework. These processes or systems are typically adapted via Gantt chart type templates to suit individual project scope and are used to determine timing of stages and gateways (Figure 2.3.1) and, together with the vehicle's Bill of Materials (BOM), are used as a basis to calculate project resource requirements.

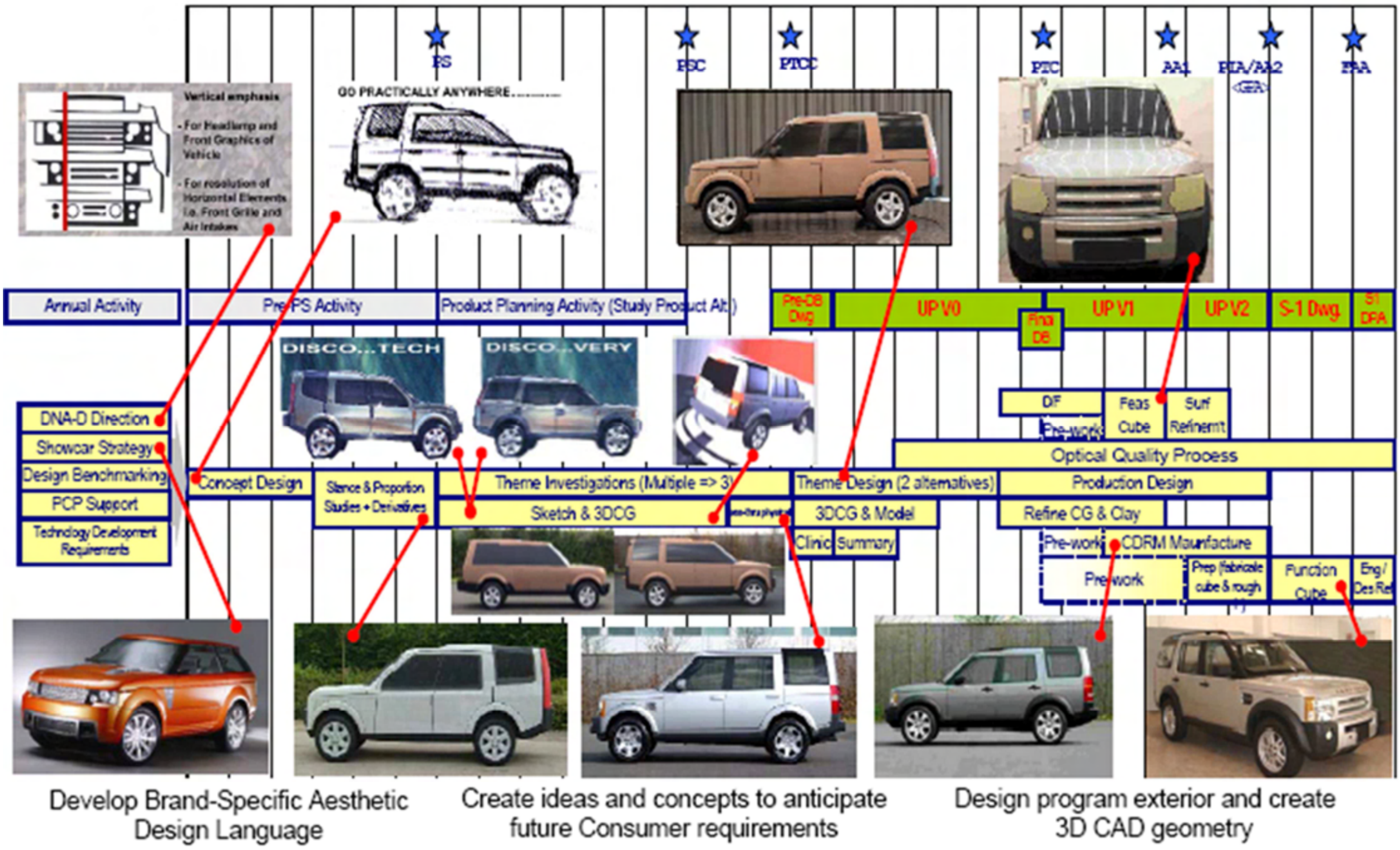


Fig. 2.3.1 – Typical OEM Product Development Stage-Gate Process showing the Evolution of an Exterior Design over Time (Source: RLE)

These PD process templates are often developed in corporate headquarters, e.g. Detroit and applied differently in other regions. For example, when Jaguar was owned by Ford many processes were adopted from Ford North America and these differed from Ford of Europe processes.

As described in project 1 of this research programme, OEMs have reduced PD lead time over the last two decades. The performance based study of PD in the automotive industry (Clark & Fujimoto, 1991) is considered a seminal text on the subject and identified shorter product development lead time as a significant competitive advantage of the Japanese OEMs. Clark and Fujimoto (1991) identified three aspects of PD that impact an organisation's ability to attract and satisfy customers with its products:

1. Total product quality

2. Lead time

3. Productivity

Total product quality consists of two aspects; the level of design quality of the product, the artefact, and the organisation's ability to produce the design.

Lead time is the time taken to go from a concept to a saleable product.

Productivity is the level of resources used to take the project from a concept to a saleable product. This includes hours worked (engineering hours), materials used for prototype builds and any equipment and services the organisation uses. Whilst productivity has a direct effect on the final cost of the product it also determines the number of projects an organisation can deliver given a fixed level of resources; human, material or financial.

Figure 2.3.2 shows the reduction in PD lead time (MBJ#1) at Ford Motor Company since the introduction of the Concept to Customer process introduced in 1985 until the roll-out of the Global Product Development System (GPDS) in 2004.

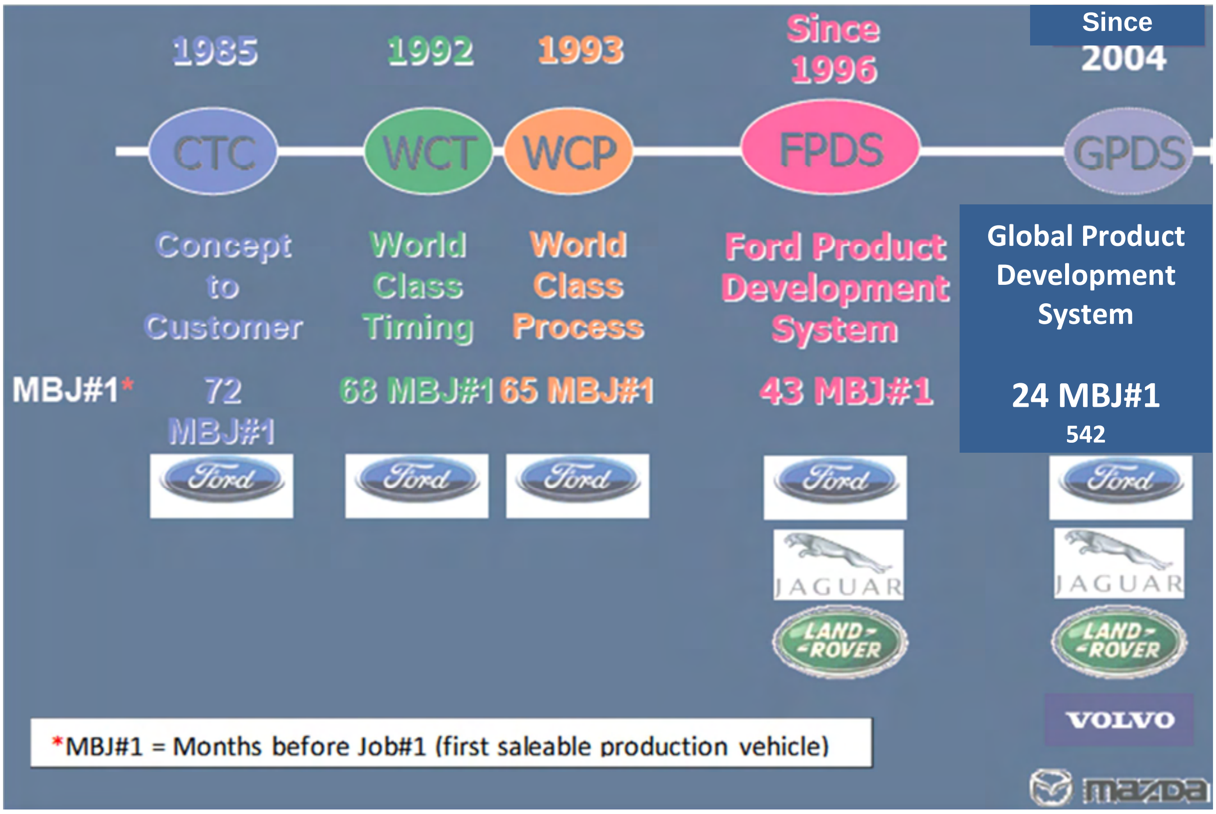


Fig. 2.3.2 - Reduction in Development Timing at Ford Motor Company

(Adapted from: UGS, 2007)

The platform and modular strategies described in project 1 have resulted in the OEMs developing scalable timing plans, dependent on the levels of use of common platforms and new parts, figure 2.3.3.

Scale	<SI>	Vehicle Change(s)
6	42	All New Vehicle
5	41	New Exterior, modified lower structure (floor pan, rails, dash)
4	37	New Exterior, c/o lower structure
3	32	Moderate Freshening
2	24	Minor Freshening
1	18	Trim

Figure 2.3.3 – OEM PD Timing Scale Dependent on Levels of Carry Over Parts

Going beyond this scale approach, some OEMs have further refined project definitions based on levels of under-body (platform), upper-body (top hat) and powertrain re-usability versus new module development.

3 Investigation of Performance Measurement in Automotive PD

The primary research investigates performance measurement in automotive PD projects in the global automotive industry via a case study of four real life projects. Yin (2009) states that for case studies, five components of a research design are important:

1. a study's questions.
2. its proposition.
3. its unit of analysis.
4. the logic linking the data to the proposition.
5. the criteria for interpreting the findings.

Components 1 to 3 are covered in section 3.1 and components 4 and 5 in section 3.2.

3.1 Research Questions, Proposition and Unit of Analysis

Overall Research Questions:

1. How to define success in PD?
2. How is PD performance measured in the global automotive industry?
3. Are there additional measures we should consider?

O'Donnell & Duffy (2005) postulate that performance in PD consists of two aspects: performance of the design, i.e. of the artefact, and performance of the design activity. The design activity, i.e. the PD process, uses resources over a period of time resulting in costs being incurred.

Additionally, O'Donnell & Duffy (2005) define:

- Efficiency of an activity is seen as the relationship between what has been materially gained and the level of resource used.

- Effectiveness of an activity is the degree to which the result of output of meets the original goal.

The proposition for this case study is that automotive PD processes need to be more efficient in their use of company resources.

The unit of analysis is the design activity rather than the design itself, i.e. this research project is about the PD process and the dynamics of the engineering team, not the artefact.

3.2 Methodology

Project 2 sought to achieve objectives 3, 4 and 5 by comparing RLE's processes to current industry PD standards and assessing specific aspects and techniques of current PD processes on actual projects.

In order to evaluate current practice in the use of performance measurement techniques in the global automotive industry a case study of discrete four projects was conducted. The participants were experienced engineers working on comprehensive automotive PD projects. The case study research in project 2 involved empirical investigations in its real life context using multiple sources of evidence. Methods for this qualitative research included survey by questionnaire, interviews and documentary analysis in the form of assessment of project performance. Additionally, the general case study is tested by secondary documentary research into the project management processes employed by an Engineering Service Supplier (ESS) in the automotive PD business.

Qualitative methods are those by which the researcher can create knowledge assertions based primarily on constructivist perspectives. Hypotheses can be constructed from engagement with participants and exploration of emerging themes. Project 2 gave rise to the development of a theory based on the similar experiences of participants working on four discrete projects.

A questionnaire was used in research project 2 to assess performance and performance indicators on four real life automotive PD projects. Guidance was sought on questionnaire design prior to the actual exercise (Munn & Drever, 2004) to avoid leading questions and ambiguity.

Document review in the form of content analysis was used in research project 2 to analyse the project management documentation in the projects in the case studies.

The action research (Coughlan & Coghlan, 2002) in projects 2 also included participant observation in the form of complete observation, i.e. the author was not a member of the project teams but attended review meetings. These observations enabled the author to witness first-hand the issues arising on the projects, to log these and analyse for emergent common themes.

3.3 Sources of Data - Case Study Projects

Whilst all four projects in the case study were performed by RLE teams a set of criteria was developed to ensure a broad analysis. The four projects all had to be different in terms of:

- Geographic location
- Customer
- Engineering scope
- Predominant team culture

From a range of development projects performed by RLE in 2010 a selection of four projects was identified that met the criteria:

Project Location	Customer	Engineering Scope	Culture
1. Germany	Valmet	Electric vehicle show car	German
2. India	Maruti	Steel tailgate for new model	Indian

3.	Sweden	Volvo	Scalable platform for new vehicle	English
4.	USA	Chrysler	Aluminium door for current model	USA

The author was involved in all four projects at a steering committee level, had full access to all project documentation and was able to observe the process and progress over the projects' duration. In order to survey the case study projects, a questionnaire was designed and trialled with a pilot group at the UK office of RLE prior to being sent out to all team members. In all, twenty-four respondents completed questionnaires which represented a fifty-one per cent sample of the total teams' headcount. In all four cases the project manager was included in the respondents.

3.3.1 Questionnaire

Based on understanding gained in the literature review and based on the author's observations and documentation review, a structured questionnaire was developed in support of this research programme.

The questionnaire was developed using standard research guidelines (Munn & Drever, 2004) and piloted with a group of RLE UK employees to test understanding. The questionnaire was then sent to the RLE project team members.

The questionnaire contained twenty-four questions arranged in six sections as follows:

1. General Information & Project Management – to clarify respondent PD experience and assess project hygiene factors.
2. Project Performance Measurement – to test for use of metrics or KPIs from literature survey.
3. Interfaces and Interaction – to understand level of complexity in communication with other departments.
4. Time Usage – to test the amount of time spent on planned activities.
5. Project Information – to test the quality and flow of information.

6. Project Delivery and Satisfaction – to test delivery against original plans in terms of effectiveness and efficiency.

3.4 Research Findings

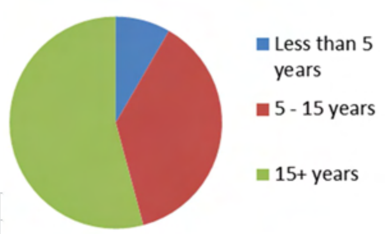
Out of forty seven questionnaires sent to the complete project team headcount twenty four responses were received in the allotted timescale, figure 3.4.1. This represented a fifty-one per cent response rate that the author judged sufficient for this research.

Analysis

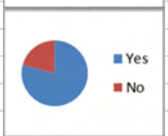
		Volvo	Maruti	Chrysler	Valmet
Total Team Size:	47	13	9	10	15

		Volvo	Maruti	Chrysler	Valmet
Total Responses:	24	7	5	7	5
	51%				

Figure 3.4.1 – Questionnaire Responses Received



Section 1 - General					
1	How many years of experience do you have in product development?	Less than 5 years	5 - 15 years	15+ years	
		2	9	13	
2	Which project did you work on in 2010?	Volvo	Maruti	Chrysler	Valmet
		7	5	7	5
3	Was the project manager identified to you at the start of the project?	Yes		No	
		23		1	
4	Was a project organisation chart provided?	Yes		No	
		18		6	
5	Did you attend a project kick-off meeting?	Yes		No	
		19		5	
6	Were the project objectives explained clearly?	Yes		No	
		23		1	



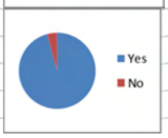


Table 3.4.2 – Questionnaire Section 1 Responses

Section 2 - Project Performance							
7	At project initiation, how was project success defined? Please specify in your own words.	weight(x 9)	platform.	customer.	low cost.	objectives.	partnership
		low cost tooling.		address issues.		win next phase.	
		demonstrate capability					
8	Which metrics were used to measure performance? Identify as many as you wish.	Time	Cost	Scope	Resource	Quality	Risk
		19	21	18	8	16	5
9	Were any other measures used? Please specify.	Methods.	Teamwork.	Iterations.	Innovation.	Issues.	
		Client Satisfaction.		Documentation.		Weight (x4)	

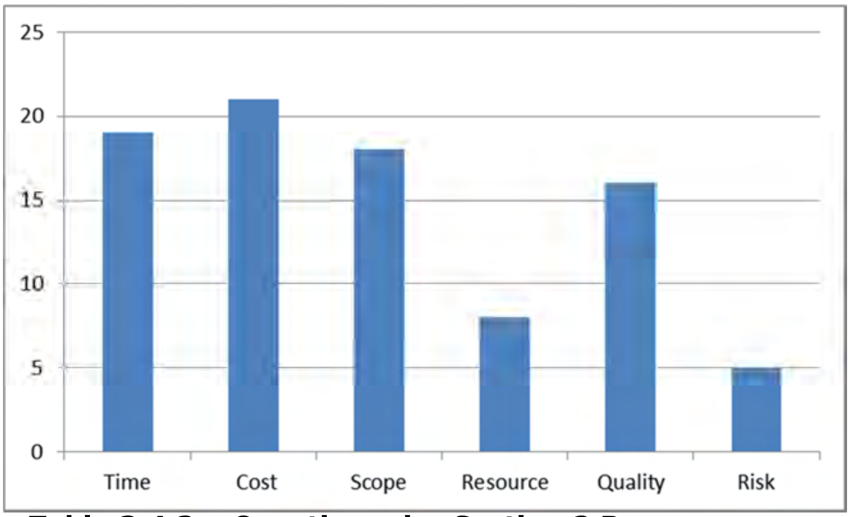
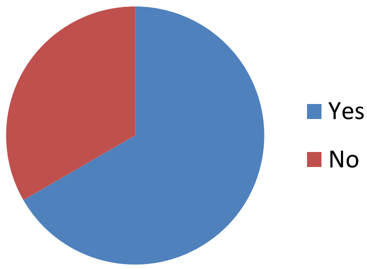
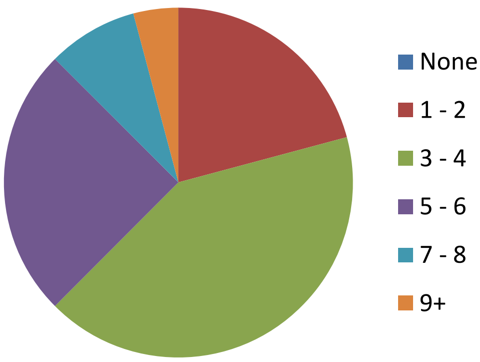


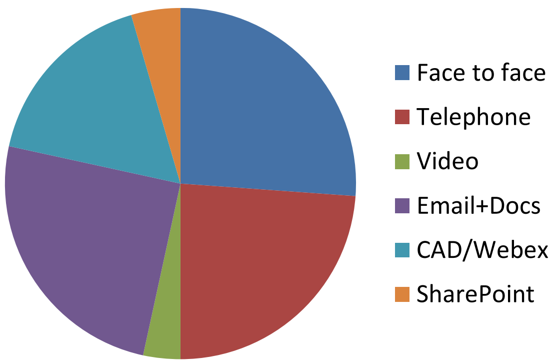
Table 3.4.3 – Questionnaire Section 2 Responses

Section 3 - Interaction with Other Departments			
10	Were you co-located with the majority of the project team?	Yes	No
		16	8



11	How many interfaces did you have on the project e.g.Studio,Manufacturing?	None	1 - 2	3 - 4	5 - 6	7 - 8	9+
		0	5	10	6	2	1



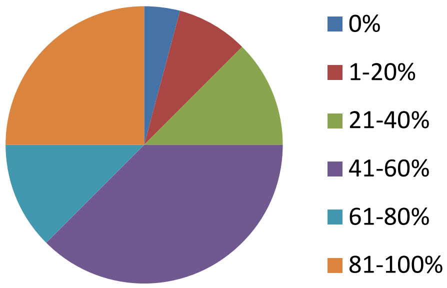


12	How did you communicate with other project team members?	Face to face	Telephone	Video	Email+Docs	CAD/Webex	SharePoint
		23	21	3	22	15	4

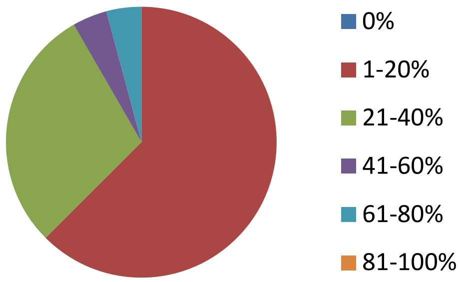
Table 3.4.4 – Questionnaire Section 3 Responses

Section 4 - Your Time on the Project

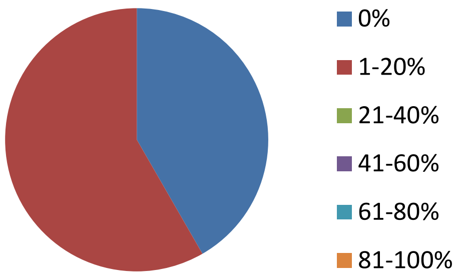
		0%	1-20%	21-40%	41-60%	61-80%	81-100%
13	How much of your time did you spend doing design or engineering tasks?	1	2	3	9	3	6



		0%	1-20%	21-40%	41-60%	61-80%	81-100%
14	How much of your time did you spend in meetings during the project?		15	7	1	1	



		0%	1-20%	21-40%	41-60%	61-80%	81-100%
15	How much of your time did you have nothing to do, e.g awaiting a response?	10	14				



		0%	1-20%	21-40%	41-60%	61-80%	81-100%
16	How much of your time did you spend doing other activities, e.g. on the phone?	1	18	2	3		

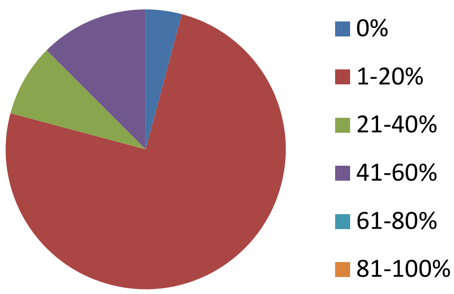
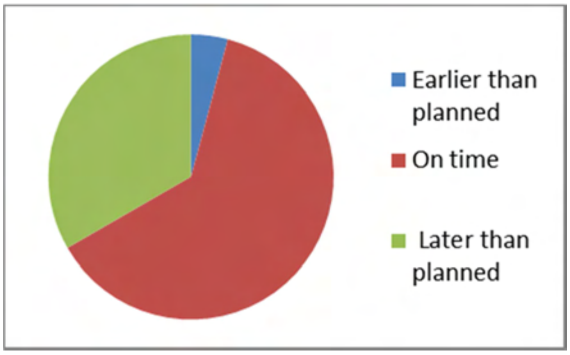


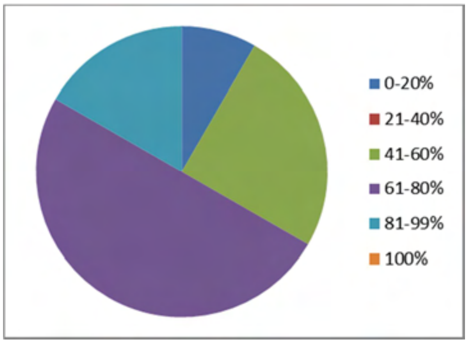
Table 3.4.5 – Questionnaire Section 4 Responses



Section 5 - Project Information				
17	When did you generally receive information that you required to perform your project tasks?	Earlier than planned	On time	Later than planned
		1	15	8

18	When you received information, how complete was it when judged against your expectation?	0-20%	21-40%	41-60%	61-80%	81-99%	100%
		2	0	6	12	4	0

19	When you received project information from another department how did it arrive?	Small batches over time	A large batch at once
		16	8



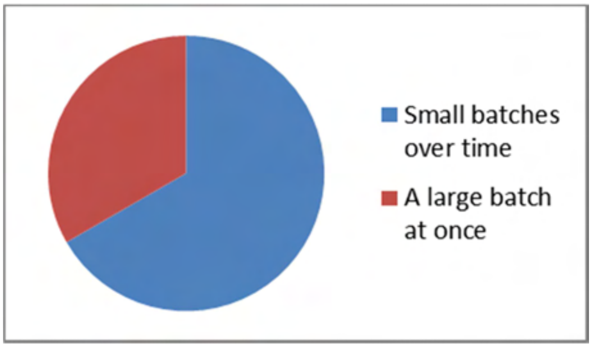
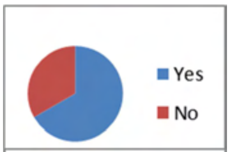
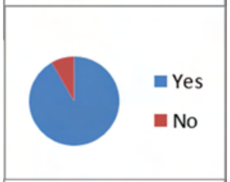


Table 3.4.6 – Questionnaire Section 5 Responses

Section 6 - Overall Project Delivery			
20	Was the project delivered as originally planned?	Yes	No
		16	8
21	Would you say the project was effective?	Yes	No
		22	2
22	Would you say the project was efficient?	Yes	No
		17	7





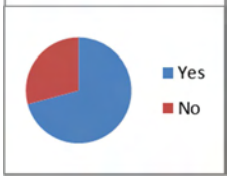
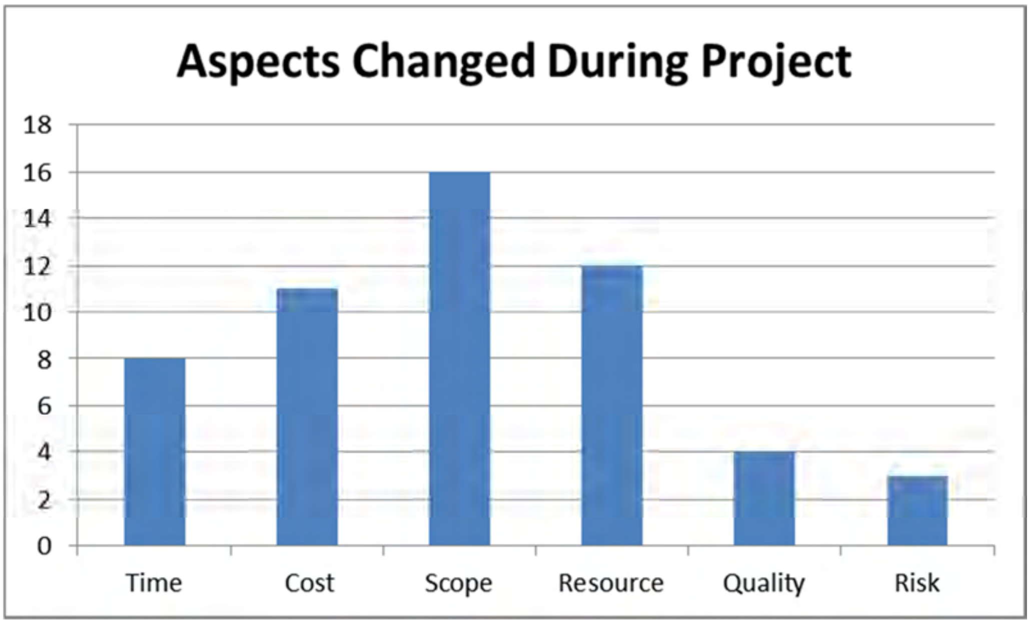


Table 3.4.7 – Questionnaire Section 6 Responses (questions 20-22)

23	Were any aspects of the project changed as it progressed?	Time	Cost	Scope	Resource	Quality	Risk
		8	11	16	12	4	3



24	How would you rate customer satisfaction on this project?	0-20%	21-40%	41-60%	61-80%	81-99%	100%
		0	1	1	1	19	2

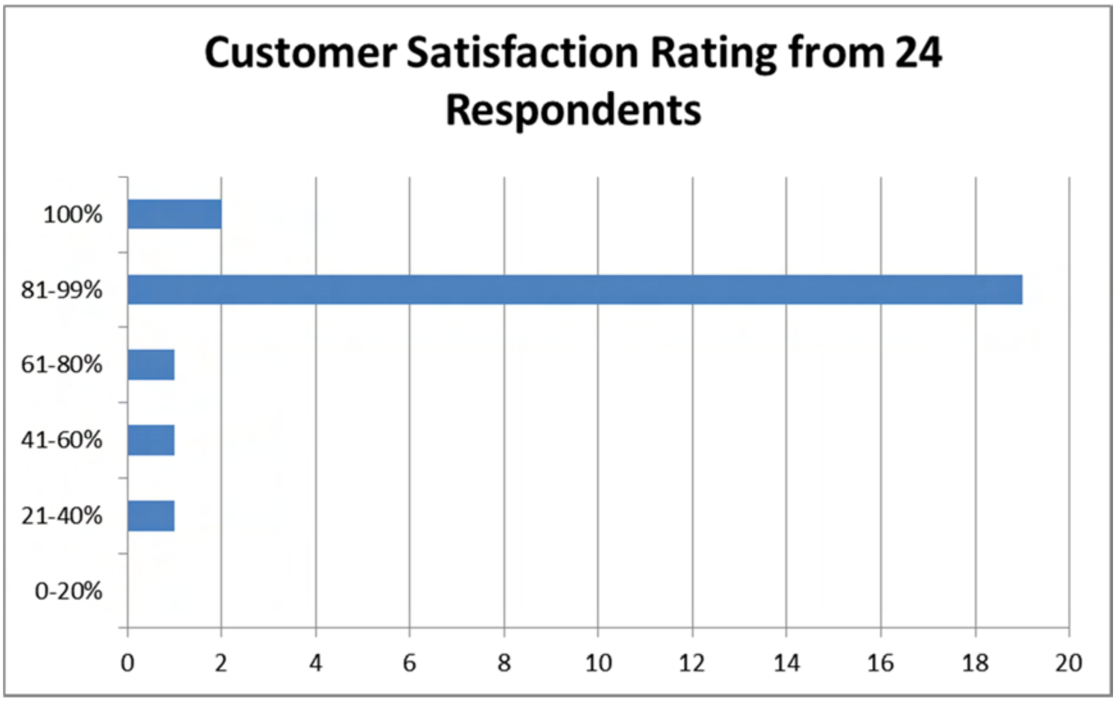


Table 3.4.8 – Questionnaire Section 6 Responses (questions 23-24)

3.4.1 Initial Analysis

Outcomes of the survey by questionnaire were:

1. Initial data analysis highlighted that basic project management methods were employed appropriately in all four cases. However, six respondents stated that they did not receive a project organisation chart and five did not attend a project kick-off meeting.
2. The three main performance measurement criteria were those previously identified as the original triple constraint; time, cost and scope. Quality was ranked fourth with two thirds of respondents identifying this criterion. Resource usage was identified by one third of respondents and risk by five. When asked if any other criterion were used for performance measurement nine responded with weight.
3. Two thirds of the respondents were co-located with their project team and three to four interfaces with other departments was the most common during the projects. Communication methods were predominantly face to face, telephone and email with CAD/Webex meetings fourth with fifteen respondents having utilised this method. Video conferencing and Sharepoint technologies were little used with three and four positive responses respectively.
4. With regard to time usage during the projects, the majority of respondents stated that they were performing design or engineering tasks less than 60% of the time. Fifteen respondents were in meetings up to twenty per cent of their time and seven in meetings up to forty per cent of their time. Fourteen respondents highlighted that they had nothing to do up to twenty per cent of their time spent on the project. In addition, eighteen were on the phone or emailing for up to twenty per cent of their time.
5. Fifteen respondents received information on time but one third stated that information arrived later than planned. Fifty per cent of respondents judged that

the information they received was 61-80% complete against their expectation and one quarter of respondents rated it 41-60%. Two thirds of information from other departments was received in small batches with one third arriving in one large batch.

6. In terms of overall project delivery, two thirds responded that their project was delivered as originally planned and twenty-two respondents rated their project as effective. However, in two thirds of responses the project scope was modified and in fifty per cent the resource usage was different to the original plan. Seven respondents stated that their project was not efficient. Twenty-one respondents rated customer satisfaction as over eighty per cent including two at one hundred per cent.

3.4.2 Follow-up Interviews

Project Managers and a few other key team members were selected for follow up interviews to further explore the factors identified by the survey.

Follow up interviews were conducted with the four project managers and other selected team members to discuss specific responses and factors identified. These interviews were deliberately of a non-structured nature to allow the interviewees to give their opinions and talk freely about their project experiences. However, five questions were asked to provoke the discussion:

- What did the RLE team actually do?
- How did the RLE team ensure customer satisfaction?
- How did the RLE team plan and manage costs, timing and deliverables on these projects?
- Did RLE get anything out of the project other than revenue and profit?
- Did RLE quantify and document these?

3.4.2.1 Responses during the Non-structured Interviews

Direct responses to questions:

- What did the RLE team actually do?
  - Analysed customer requirement and expectation.
  - Agreed Deliverables with Customer.
  - Created a method of delivery on each occasion.
  - Put a team together and provided the necessary tools – CAD, office etc.
  - Delivered a solution to meet customer requirement –
    - Engineering solutions – Design, Materials, Feasibility etc.
    - CAD data/drawings
    - On time & on budget

- How did the RLE team ensure (and predict) customer satisfaction?
  - By understanding customer requirements.
  - By building relationships.
  - By using the RLE customer satisfaction form.

- How did RLE plan and manage cost, timing and deliverables on these projects?
  - Gantt charts – MS Project and Excel.
  - By project control – Excel.
  - By managing resources.
  - Meetings / Review processes

- Did RLE get anything other than revenue and profit?
  - Other values: Learning / Knowledge
  - Reference project for the future
  - Customer praise or reference
  - Follow up projects
  - Did RLE quantify and document these?

- Did RLE employees benefit in any way?
    - Experience
    - Customer exposure
    - Country / Cultural exposure
    - Team atmosphere

During the follow up interviews with the project managers and other members, the following key themes emerged;

- At the start of projects waiting for infrastructure and systems to be put in place "we're always late as soon as we start".
- Objectives and customer value not always defined clearly and reviewed regularly.
- Too much wasted time during projects waiting for information.
- Support of non-project activities – warranty/quality/purchasing etc.
- Meetings – info, updates.
- Staff travelling in some projects.
- Too much information at some times.
- Too much to do at certain times, particularly 'Panics' leading up to at gateways.
- Pre-meetings requested weeks in advance – up to 12 weeks in one case.
- Project manager strength is key to getting the job done.

The main outcomes of the interviews were:

1. The project teams endeavoured to deliver the projects as defined in the original Statement of Work (SOW), on time and on budget.
2. Project control was generally by weekly review of Microsoft Excel documents showing actual status versus project targets.
3. At the start of projects it was common that team members would be waiting for infra-structure and systems to be put in place. As one interviewee stated "we're always late as soon as we start".

4. It was also evident that information needed to begin a project was not always available from the customer at the start point.
5. Project objectives and customer value were not always defined clearly and reviewed regularly.
6. Project manager strength was viewed as a key determinant of project success, i.e. the character of the project manager in dealing with cross-functional issues is central to delivering the project within the predetermined targets. This was observed by all the key informants as well as the author.
7. There is much wasted time during projects waiting for information. Wasted time was defined as time when the engineers were doing tasks that did not contribute directly to project delivery. Whilst this wasted time was not quantified on the engineers' timesheets, this perception of the participants was also observed and noted by the author.
8. Too much time spent waiting, caused by the lack of flow of information.
9. Project engineers spend too much time in meetings discussing status, reporting on issues and resolution plans rather than implementing these.
10. Engineers spend too much time travelling in some projects. This time is generally non-value adding in terms of project delivery.
11. There is too much to do at certain times, particularly at 'panics' leading up to gateways or project milestone events. In some cases pre-meetings to gateways were requested weeks in advance so management could prepare their arguments.
12. When information arrives in large batches from other departments it is difficult to manage.

3.4.3 Documentary Analysis and Observations

Results from the analysis of records showed all four projects were delivered in terms of scope of delivery, or Statement of Work (SOW), and as per the original timing. However, the Chrysler project over-ran in terms of costs and resulted in very little profit for RLE.

This was as a result of excessive resource usage in the project. The project manager had hoped to recoup this expenditure on a follow up project but this never materialised. Investigation determined that in the first phase of the project not all the data required from the customer and other project members was available as planned. However, the RLE team was in place and continued to book time to the project despite the fact that there was insufficient work to do.

Participant observation also logged the frustration and wasted time as a result of information not being delivered on time. Records kept by the author noted team members chasing information from other departments and excessive meetings discussing project status and unachieved tasks. It was also noted that in the Volvo project the project manager had to direct his engineers to stop attending customer meetings as so much of this time was un-productive.

The significance of these findings is, that despite careful planning, project managers had to review and adjust timing plans and resource usage to match the flow of work to be done. In the Chrysler case, where this did not happen, significant cost penalties were incurred.

3.5 Secondary Research

3.5.1 Exploration of Performance Measurement Techniques

Performance Measurement research literature dates back to the 1950s (Neely, 2007) and it is a diverse subject including contributions on accounting, operations management and marketing. This research programme is concerned with performance management of the PD process and as such it is viewed as a sub-process of project management of the PD process.

Griffin and Page (1996) stated - "A firm can assess the success or failure of a development project in any (or all) of many terms, including customer satisfaction, financial return and technical advantage":

1. Customer-base success:

- Customer satisfaction
- Customer acceptance
- Market share goals
- Revenue goals
- Revenue growth goals
- Unit volume goals
- Number of customers

2. Financial success:

- Met profit goals
- Met margin goals
- IRR or ROI
- Break-even time

3. Technical performance success:

- Competitive advantage
- Met performance specs
- Speed to Market
- Development cost
- Met quality specs
- Launch on time
- Innovativeness

These measures are lagging indicators, i.e. they are retrospective in that they consider if targets have been met. Leading indicators, i.e. predictive measures, of project performance and customer satisfaction are required. Whilst some of the technical performance measures do consider the development process, models of performance measurement in PD tend to be focused on the artefact, i.e. the product itself, rather than the development process. Attempts have been made to adapt the balanced scorecard model of organisational performance (Bremser & Barsky, 2004) and to develop a project management scorecard (Phillips, et al., 2002).

Browning and Ramasesh (2007) state that deliverables (information) create the value in PD and the effectiveness of creating this value can be measured. Leading indicators need to be developed that provide timely feedback on project performance during the project period.

3.6 Summary of Findings

Whilst acknowledging that the success of a car programme is unquestionably influenced by the effectiveness of the PD process (Hanawalt & Rouse, 2010), i.e. the degree to which the result or output meets the original goal (O'Donnell & Duffy, 2005), this research programme has identified an issue with the efficiency of the process, i.e. what can be delivered with a specific level of resource? Attending meetings and communicating via email may be necessary to share information in the course of a project but this research suggests that too much time is dedicated to these activities. Less than sixty per cent of time doing design or engineering tasks is too low and this is particularly the case if the project team members are simply waiting for information.

Non-value added time (Morgan & Liker, 2006), accounts for too high a proportion of the lead time in PD. When considering lead time, a holistic view should be taken as simply reducing the time for one aspect of the process may not deliver improvement to the whole. This is because value-added time is only a small percentage of the lead time (Figure 3.6.1).

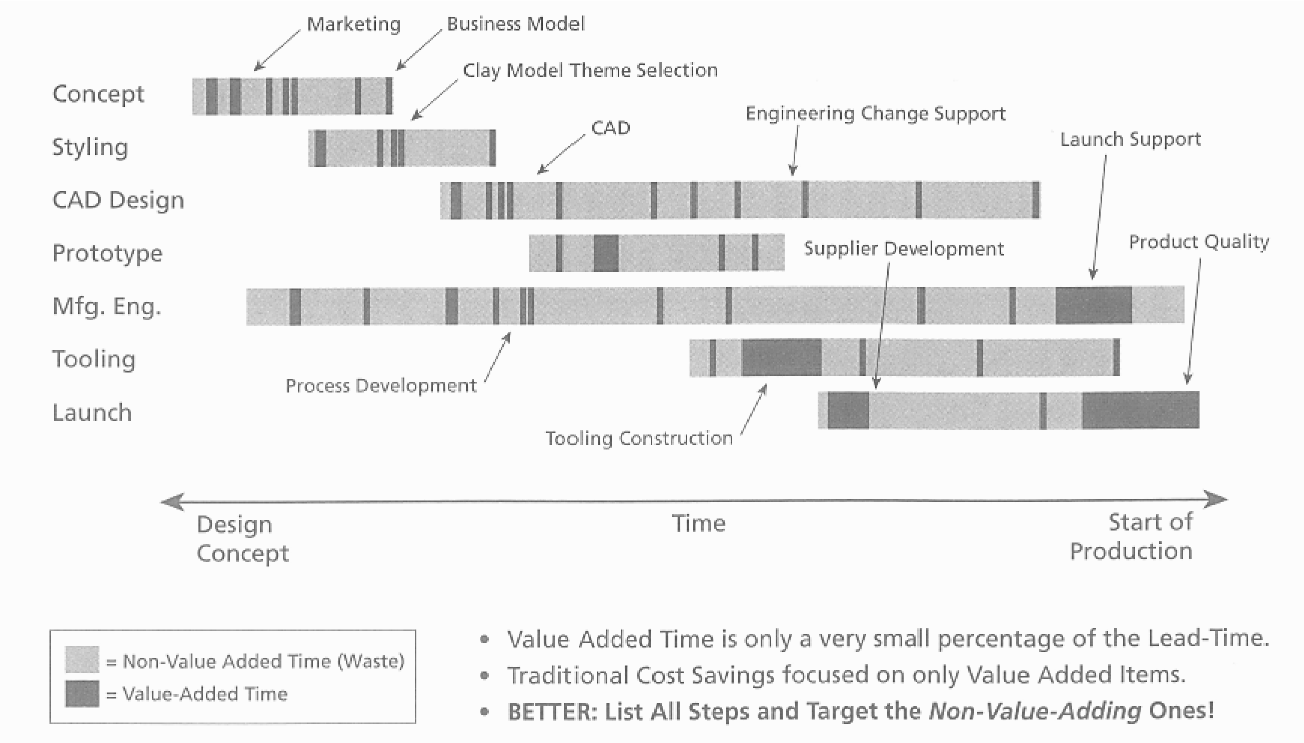


Fig. 3.6.1 – Value Added Time as a % of Lead Time

(Source: Morgan & Liker, 2006)

The OEM PD processes provide a template but not a method visualising actual progress other than at gateways. At gateways, a tick box approach to project mangement and the use of traffic light (green, yellow, red) measuring systems over simplifies many issues with actions marked as complete when in fact they are not. In the digital age, it is difficult to visualise the status of a project in terms of progress towards a finished design.

The primary research of this project has identified that during PD projects the team members are not fully utilised in design and engineering tasks for up to forty per cent of their time because they are on the phone, in meetings, emailing or waiting for information. Further investigation highlighted that all of these activities take place because project information is not flowing in an effective manner. If information does not flow as required, assessments of time and cost the other normally prescribed measures will only confirm that planned targets are not being met.

4 Critical Analysis of Project Management of Product Development at an Engineering Service Supplier

This section contains critical assessment of current processes at RLE in terms of PD processes and project management techniques. These are compared to processes identified with best practice within the automotive industry, i.e. APQP, TS 16949 etc. and from this analysis shortcomings are demonstrated in order to identify areas for improvement and contribution.

4.1 Project Management in Automotive Suppliers

Whilst the majority of the OEMs have developed their own PD systems, at a sector level one of the most widely prescribed frameworks in the automotive industry for product development and manufacture is APQP, Advanced Product Quality Planning. APQP, figure 4.1.1, is a structured method for defining and executing the actions necessary to ensure a product satisfies the customer.

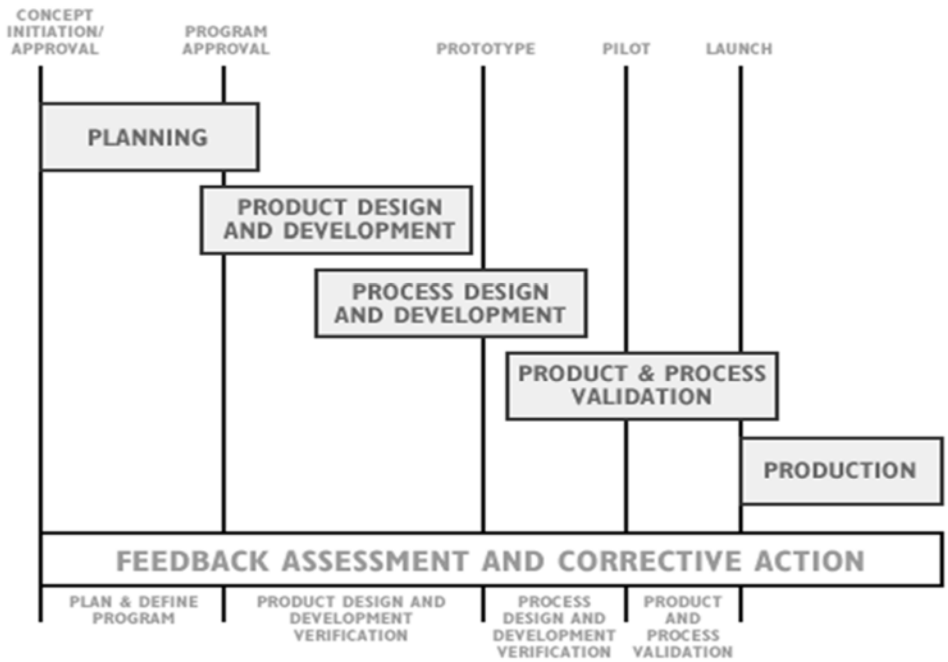


Fig. 4.1.1 – APQP Phases (source: RLE)

APQP was developed by the AIAG (Automotive Industry Action Group) in the 1980s. The AIAG was founded by the three largest North American OEMs; Ford, General Motors and Chrysler, but membership now includes Japanese companies such as Toyota, Honda and Nissan, as well as component suppliers and services providers.

APQP consists of five phases:

1. Plan and Define Programme
2. Product Design and Development Verification
3. Process Design and Development Verification
4. Product and Process Validation
5. Launch, Feedback, Assessment & Corrective Action

Here process refers to the production or manufacturing process. Phase 2 includes guidelines on FMEA, DFMA, design verification, design reviews, material and engineering specifications.

Suppliers are typically required to follow APQP procedures and techniques and are also required to be audited against ISO/TS 16949.

The global automotive industry had developed many quality standards over its history and this led to suppliers having to conform to multiple requirements. In 2002 ISO/TS 16949 was first published which aligns American (QS-9000), German (VDA6.1), French (EAQF) and Italian (AVSQ) quality systems standards for the global automotive industry. ISO/TS 16949 is an ISO technical specification that specifies the quality system requirements for the development, production, installation and servicing of automotive related products. In terms of PD, the standard requires the organisation to control design and development. This does not mean controlling the creativity of designers and engineers, but rather it means controlling the process by which designs are produced (Hoyle, 2005).

According to Hoyle (2005) the organisation should set:

- objectives for the process
- measures for indicating achievement of these objectives
- a defined sequence of sub-processes or tasks
- links with the resource management process so that human and physical resources are made available to the development process when required
- review stages to establish that the process is achieving its objectives
- processes for improving the effectiveness of the development process

The standard requires "the interfaces between different groups involved in the design and development process to be managed to ensure effective communication and clarity of responsibilities." This requirement responds to the leadership principle embodied within the standard (Hoyle, 2005).

Management of interfaces, associated trade-offs and complexity are important issues in the performance of automotive PD (Clark & Fujimoto, 1991).

4.2 Project Management at an Engineering Service Supplier

RLE has historically generated the majority of its revenue from simply supplying human resources to the OEMs and sending invoices on a monthly basis detailing the number of hours spent at the customer. These resources are normally purchased by the OEMs in terms of Full-Time Equivalent heads (FTEs). This term is used to specify the number of people needed for a project. For example, Jaguar might determine that 16 FTEs are required to deliver a particular piece of work in a prescribed period of time. They would then order these people from RLE at an agreed hourly rate. The orders are typically for a three to twelve month period and the customer pays for every hour RLE employee works.

In addition to this labour leasing business, small projects involving five to twenty people have been undertaken but this has not been a significant part of the business. However, a strategic review in 2006 identified the need to move into broader project support activities. Figure 4.2.1 shows the relative importance of having in-house competence areas as the company moved forward.

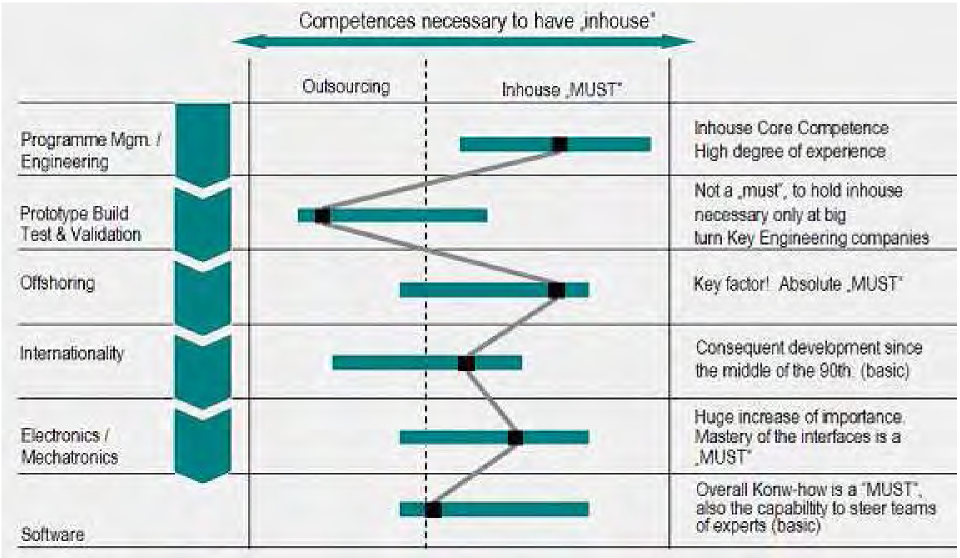


Fig. 4.2.1 – Strategic Evaluation of Future In-House Competences (source: Pallis)

4.2.1 RLE Project Management Process Model

In support of this strategy in 2008 RLE implemented a project management system at its headquarters in Cologne, Germany. The RLE project management system is based on the approach and techniques outlined in the second edition of Hab & Wagner (2006).

In Hab & Wagner (2006) four phase project mangement process (Figure 4.2.1.1) is specified:

1. Quotation and Project Definition
2. Initiation and Planning
3. Steering and Changing
4. Close Out

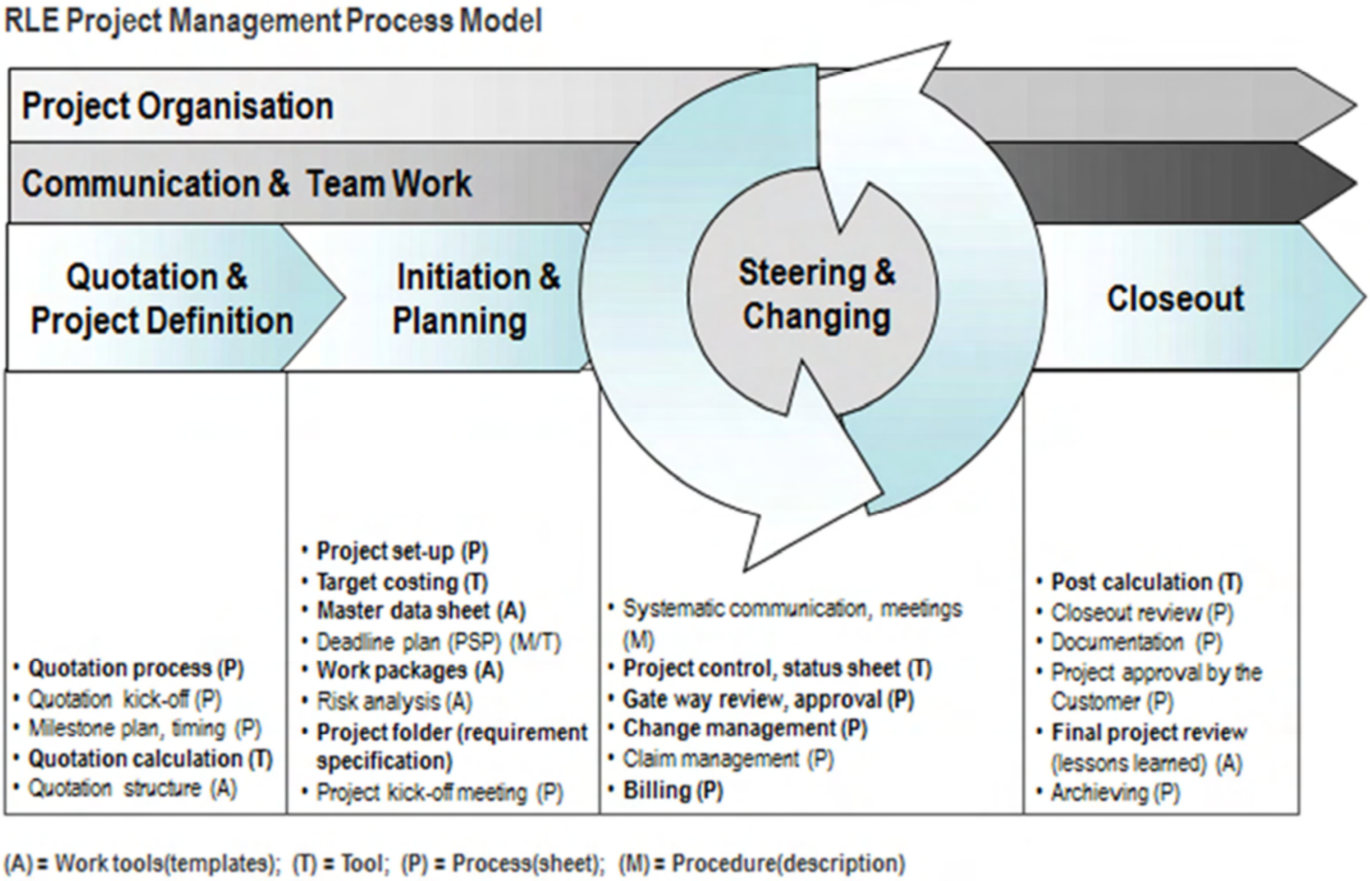


Fig. 4.2.1.1 – RLE Project Management Process Model

4.2.1.1 Quotation and Project Definition

The quotation process starts with a Request for Quotation (RFQ) from a customer. The process involves the detailed review of technical content and customer expectations, the appropriate calculation of resources over the project duration and the description of a requirement specification in the form of a responsibility chart. Comparative analysis of existing quotations and formats is a helpful tool to save time.

During the quotation phase, the coordination between the responsible sales manager and the quotation technical leader is extremely important. The overall target for the company must be clearly specified, in order that the detailed targets for the project can be broken down.

4.2.1.2 Initiation and Planning

As soon as an order is placed phase 2, initiation and planning, starts. If the purchase order value deviates from the quotation value, a target costing with individual departments must take place. This determines the distribution of the budget available, and identifies the cost limits for work packages. The work packages also specify the targets, requirements and timing for individual sub-projects. Of particular importance is to highlight the interdependence and sequence of the individual sub-tasks. As a result, the total timing and the milestone plan can be determined, including the scope of delivery and the responsibilities.

When all sub-projects are specified, the responsible manager appointed and the total timing with milestones established, all data is filed in one master project folder. This folder also presents the requirement specification agreed with the customer at the kick-off meeting. This project folder forms the basis of project status and closeout reports.

4.2.1.3 Steering and Changing

A project starts when all the targets and timings (at least until the next milestone) are communicated and accepted. The projects must be completely set up in the ERP system in accordance with the check list for a project set up. Thereby project resources can be specified by corresponding work orders.

It is important to manage tasks in a timely manner and to identify and communicate discrepancies as early as possible in order to coordinate counteractions. Discussions, solutions and project progress are recorded in writing in meeting minutes with a list of open items and part history documentation.

Changes determined by the customer that result in additional workload are recorded via change management templates; change request and change list. In addition, these work packages are recorded on a separate ERP project and, after coordination with the customer, invoiced accordingly.

4.2.1.4 Final Project Review

The final project review is an internal review where the attendees are the project members, leaders of the sub-projects and the line management. Positive and negative experiences of the project are presented and discussed. Due to these experiences permanent improvement actions of project management methodologies and tools are defined. The main focus is on aspects of project management (organisation, cooperation, planning, regulation, etc.). Items of minor interest are the technical issues.

4.3 Document Review - ISO Certification

This section contains a discussion and evaluation of project management at RLE versus industry best practice, i.e. ISO/TS 16949 and APQP.

The RLE group of companies certified to the necessary ISO and TS standards and has implemented an Integrated Management System (IMS) to ensure the quality of the product and the service supplied to its customers along with occupational, safety, health and environmental protection.

RLE recognises that its long-term success is vitally tied to providing world-class quality and value. Quality, Environmental and Health & Safety is a continuing process, a never-ending effort to improve value, turnaround time, efficiency and customer satisfaction.

A Quality & Environmental Statement is shared and expressed throughout the worldwide organisation, at new employee orientation, training, project review meetings. The IMS manual and its associated procedures, instructions, controlled forms and other support methods ensure that quality & environmental objectives are established and reviewed for effectiveness.

Annual Management Quality, Environmental and Health & Safety Review meetings are held within the RLE Group worldwide at each location to review RLE's IMS.

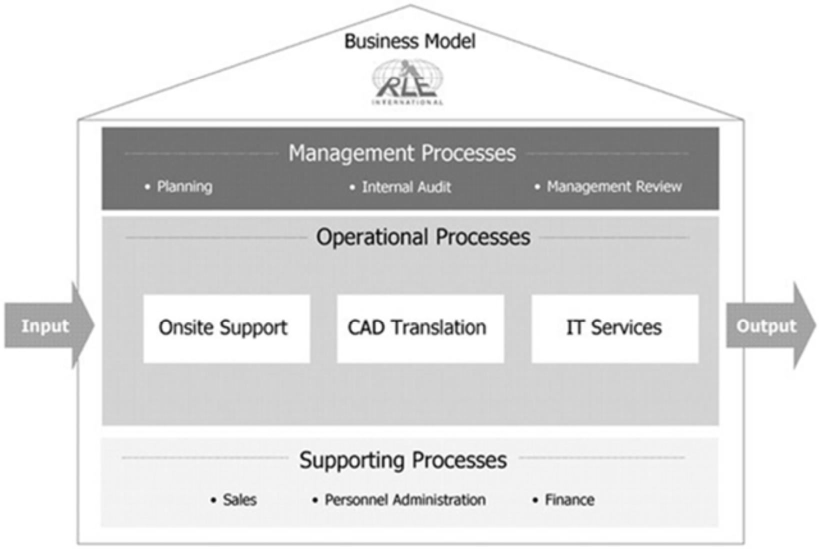


Fig. 4.3.1 - RLE UK for ISO

Figure 4.3.1 shows that the RLE UK operational processes are limited to onsite support, CAD translations and IT services. Figure 4.3.2 shows that the RLE USA processes are a Customer Oriented Process (COP), commonly referred to as a turtle chart.

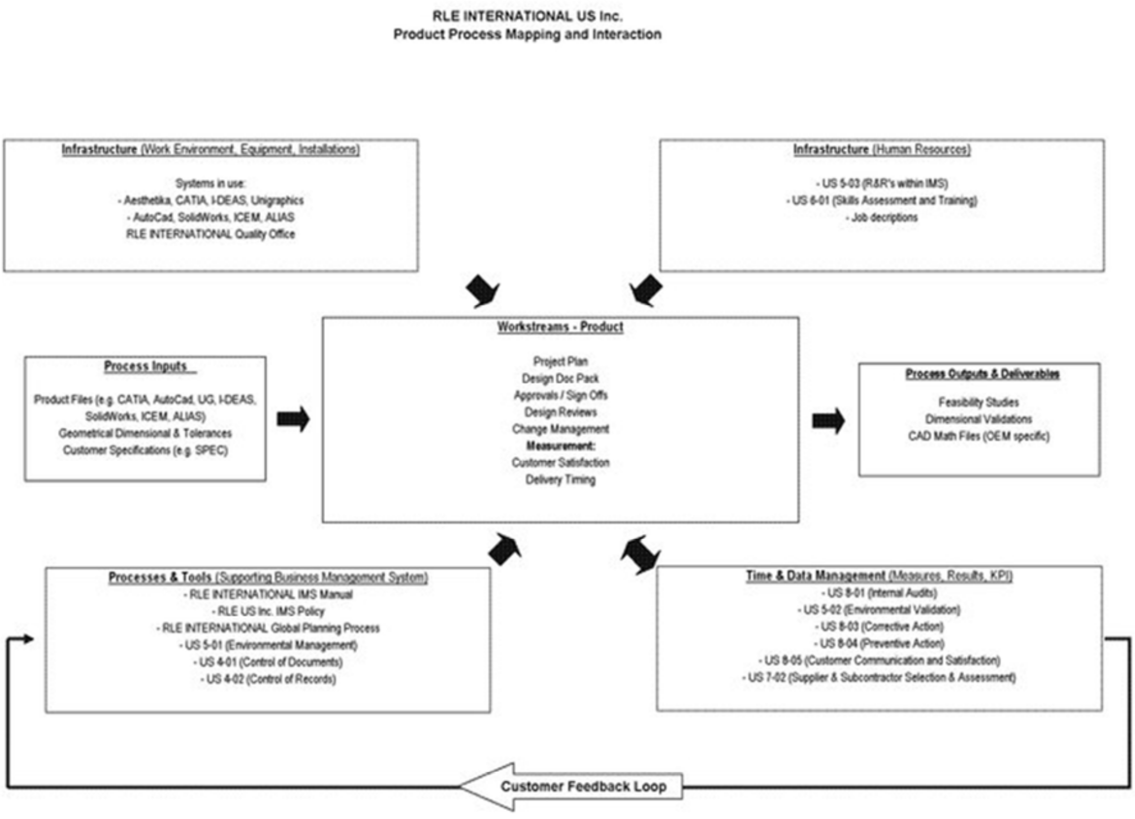


Fig. 4.3.2 - RLE USA Customer Oriented Process (COP) for ISO

Figure 4.3.3 shows that the original project management template from Hab & Wagner 2010 identifies the APQP process in the planning phase. This is a critical omission from the RLE project management process as APQP specifically defines the PD process.

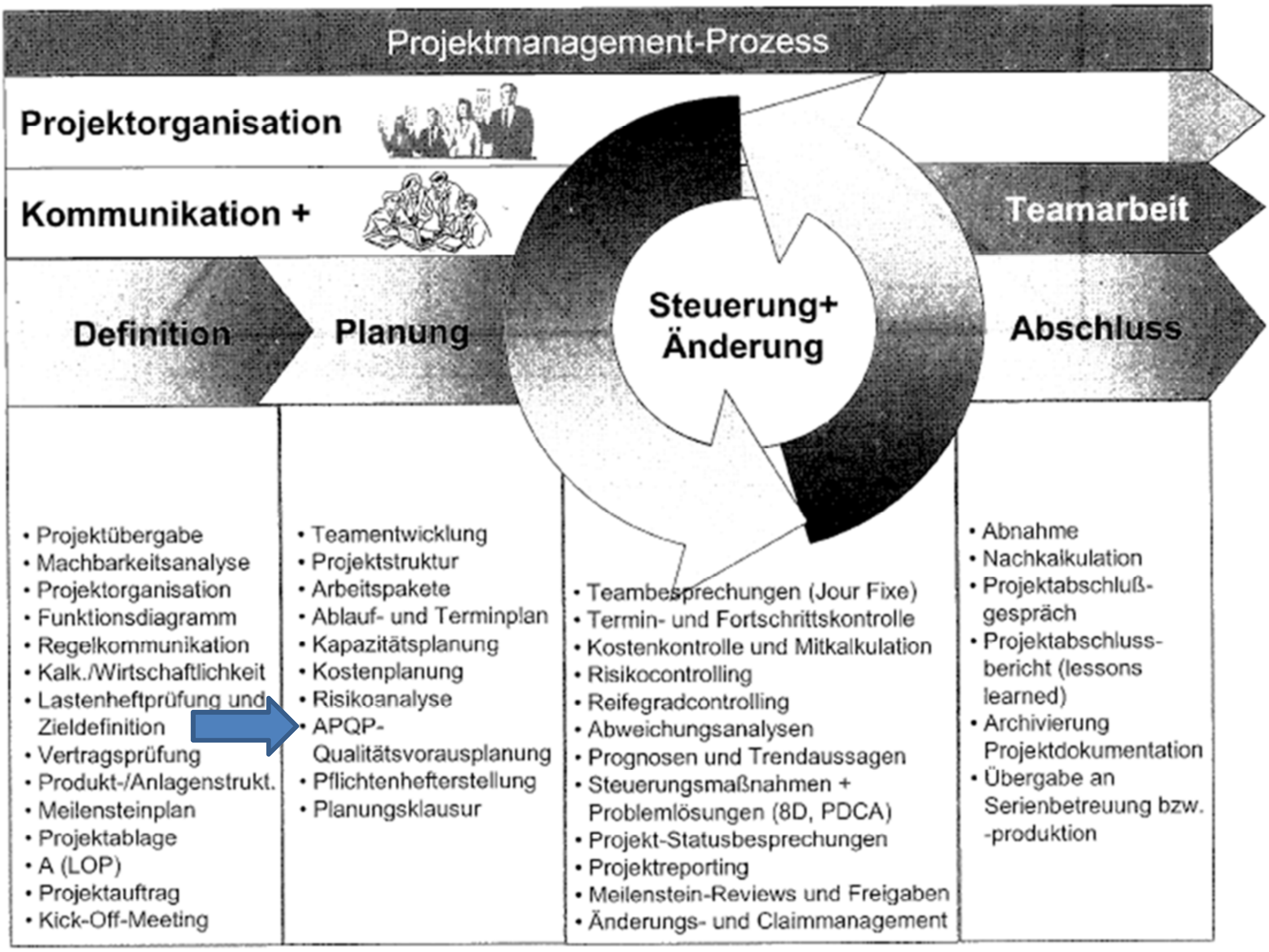


Fig. 4.3.3 – Original PM Template (Hab & Wagner, 2010) Includes APQP

4.4 Observations

- RLE has a Project Management process model that is not widely used within the company
- RLE Project Management process model does not describe the Product Development process
- The RLE Group has an ISO approved Integrated Management System (IMS)

- RLE UK uses a sub-set of the IMS but does not have an ISO Process for Product Development Projects
- RLE USA has a Customer Oriented Process (COP) and a Turtle Diagram

The RLE Group locations use different Enterprise Resource Planning (ERP) and financial accounting systems that are not used to track projects in detail:

- Sage - UK
- Agresso – Germany
- Solomon – USA
- Tally - India

Microsoft excel based systems are used in most locations but in different ways and with different methods.

4.5 Summary of Findings

The RLE approach to project management is fragmented with the three different offices in Germany and all of the international locations adopting different approaches. Whilst to a certain extent it can be argued that this is because they have different customers that bring with them their own product development and project management templates it does not convey a RLE corporate strength.

The RLE situation replicates two of the traits described by Hino (2006) when considering a company that does not match the Toyota philosophy of corporate learning and growth; the RLE teams consist of very competent engineers but with different work methods rather than adhering to one corporate process that is being constantly improved.

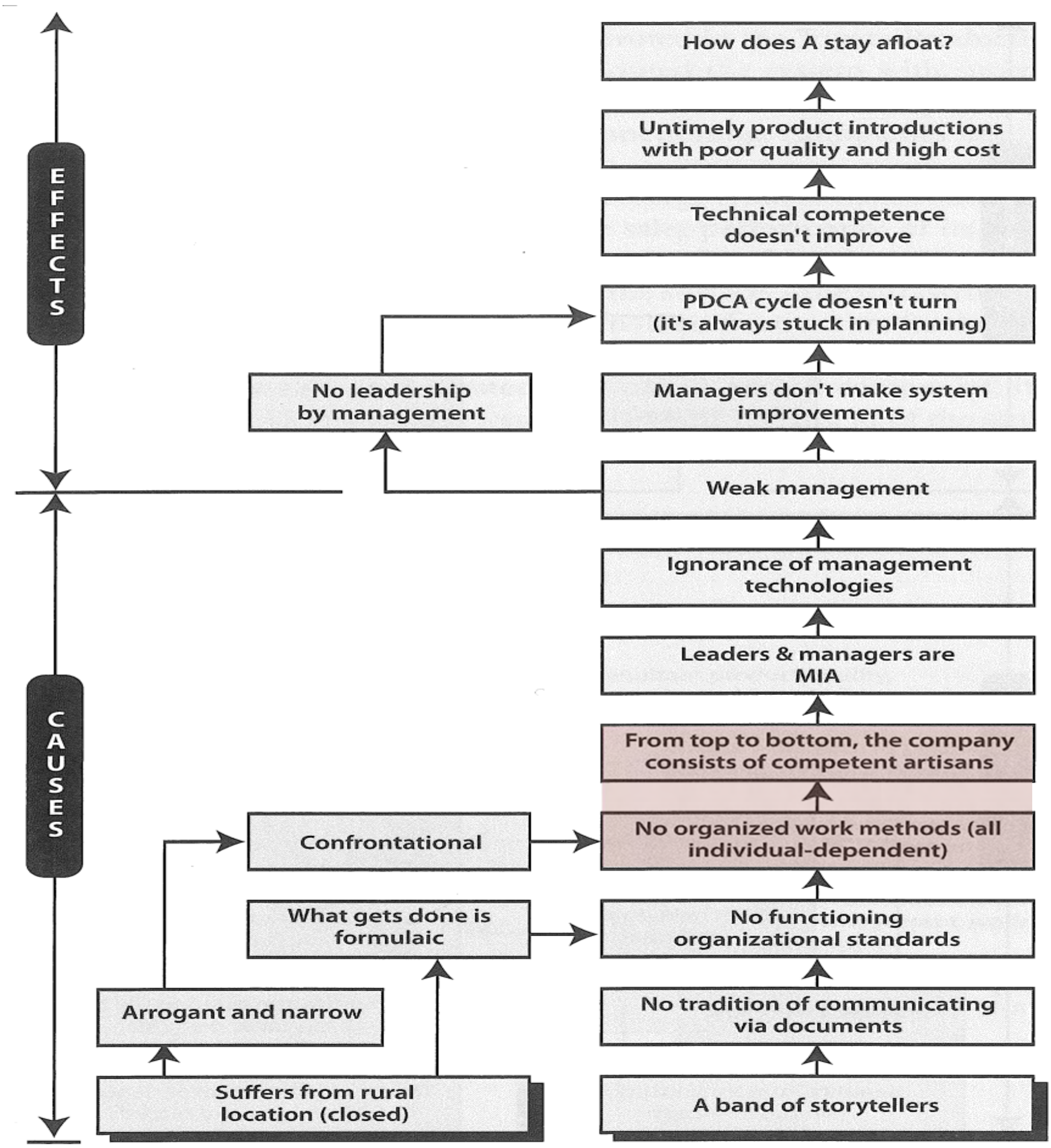


Fig. 4.4.1 – Company Traits from Inside the Mind of Toyota

(source: Hino, 2000)

5. Discussion of Performance Measurement in the Automotive Product Development Process

To be useful to PD executives and practitioners a leading Key Performance Indicator (KPI) is necessary that identifies and communicates how a project is performing as it is happening. This should provide:

1. Value definition and measurement throughout a project.
2. Flow measurement and levelling.
3. Resource allocation – control mechanism.

5.1 Discussion of Performance Measurement from the Empirical Research

The primary research of this project has identified that during PD projects the team members are not fully utilised in design and engineering tasks for up to forty per cent of their time because they are on the phone, in meetings, emailing or waiting for information. Further investigation highlighted that all of these activities take place because project information is not flowing in an effective manner. If information does not flow as required, assessments of time and cost the other normally prescribed measures will only confirm that planned targets are not being met.

5.2 Implications for the Product Development Process

RLE PD processes are generally customer based however, the people are controlled by RLE. However, if RLE is responsible for the project delivery the flow of information within the process needs to be controlled.

Achieving flow is one of the five key principles of lean thinking (Womack & Jones, 2003):

Measure	**What (The Unit)**		**Lean Thinking Concept**
Effectiveness	The Product	(The Design or the Artefact)	Value
Efficiency	The Process	(The Design Activity)	**Flow**

A study at MIT looked at lean principles in automotive PD (Garza, 2005). Flow was not considered so important in the initial phase; product planning and concept development in the design studio (figure 5.2.1).

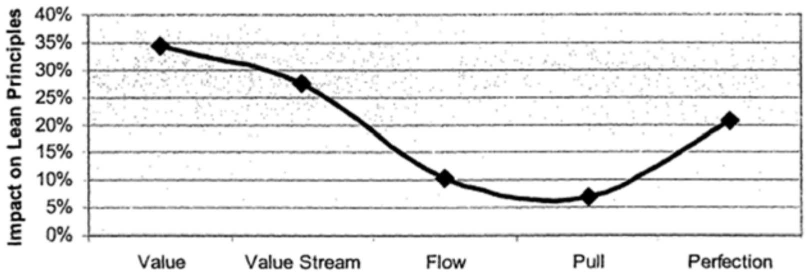


Fig. 5.2.1 - Early Phase Lean Impacts of Lean Principles

(source: Garza, 2005)

The value created in this early stage was judged to be more important. This observation is justified as there are numerous examples of early decision-making mishaps (e.g. the Pontiac Aztek) in the automotive industry whose effects have carried through to the launch phase and the car programme has failed (Hanawalt & Rouse, 2010).

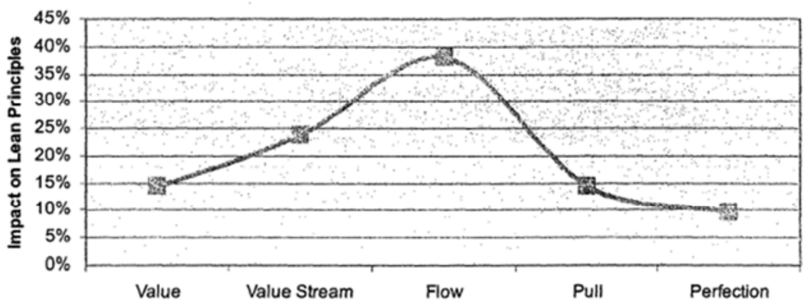


Fig. 5.2.2 - Middle Phase Impacts of Lean Principles

(source: Garza, 2005)

Flow in the second, or middle, phase of PD (figure 5.2.2); "The effects of not achieving flow in manufacturing can be seen on the plant floor. Idle machinery and high reject rates can be measured, modified and watched for improvement. In product development, the flow is informational and is much more difficult to analyse. Often, the issue is found much too late to correct without delaying key milestones" (Garza, 2005).

This is a key unresolved issue that has been identified in project 2 of this research programme. Additionally, in figure 5.2.3 (Garza, 2005), performance metrics are identified as being pursued aggressively, rather than ensuring proper data flow, and the tick the box mentality causes loose project control.

Middle Phase Lean Inhibitor	Description	Value	Value Stream	Flow	Pull	Perfection
Interaction	Cross functional teams can take an excessive amount of time to establish and there is often poor meeting attendance and inadequate communication.		✓	✓		
Feedback	Timely response and interpretability of data are key factors in receiving effective feedback. It is common for data to take an unnecessary long time to be communicated and understood by the associated activities.			✓	✓	✓
Discipline	Previous programs set a precedence for progressing through milestones without meeting all of the requirements which can lead to failures downstream or in other functional activities. Or worse, mistakes are hidden with the rationale that they can be fixed quickly in order to catch up to the next milestone. Either way, programs are often delayed as a result.		✓	✓		✓
Coordination	Processes, prototypes, test facilities and meetings all need to step to a cadence in order to fulfill the requirements. There are repeated instances of overlapping processes, conflicting prototype schedules, lack of test facilities and excessive meetings that generally worsen issues.	✓	✓	✓		
Asking for Help	There is generally a weakness in asking for help by engineers. There are multiple reasons for this issue including fear, negative consequences and management interference.	✓	✓	✓		
Rules Change	Changing the rules is often a result of not following the process. Since the official deliverable can not be met, an agreed method is utilized that may completely change the course of action for an engineer.		✓	✓	✓	
Metrics	Metrics are aggressively pursued in this core development stage rather than ensuring proper data flow. This check the box method causes a program to be progressed loosely.			✓		
Management Drives	During the core development phase of a program, the process calls for planned management drives. This practice acts as a built-in guarantee that there will be late changes.	✓		✓	✓	

Fig. 5.2.3 - Middle Phase Lean Inhibitor Effects of Lean Principles

In summary, this MIT paper recognises the importance of data flow in the automotive PD process, but offers no proposal for measuring or indicating this flow.

5.3 Business Implications

RLE cannot define the PD process as it normally has to follow a customer template even in off-site fixed deliverable case. Likewise cadence of project launches is difficult for RLE with multiple independent customers.

RLE PD processes are generally customer based however, the people are controlled by RLE. However, the flow of information needs to be controlled. RLE's profitability in PD projects is derived from the productivity of engineering hours (Clark & Fujimoto, 1991).

The use of Full Time Equivalents (FTEs) (Valiris & Glykas, 2004) as business analysis metrics for business process redesign is recognised. However, not all engineers are the same. An engineer can be a:

- Research Engineer
- Breakthrough Engineer
- Platform Engineer
- Derivative Engineer

Cooper and Kleinschmidt (2007) state human resources supply is a most significant factor in high-quality product development. RLE needs a model of better resource utilisation in PD projects. To achieve this it needs to develop designers and engineers capable of moving from one project to another. An interesting concept is Overall Professional Effectiveness (OPE) (Bicheno, 2008) applied to the service industry in an adaptation of Overall Equipment Efficiency (OEE) from lean manufacturing.

T-shaped professionals, figure 5.3.1, a concept introduced by the IDEO design consultancy in the USA, possess an ability to collaborate across disciplines and to apply knowledge in areas of expertise other than their own (Oskam, 2009).

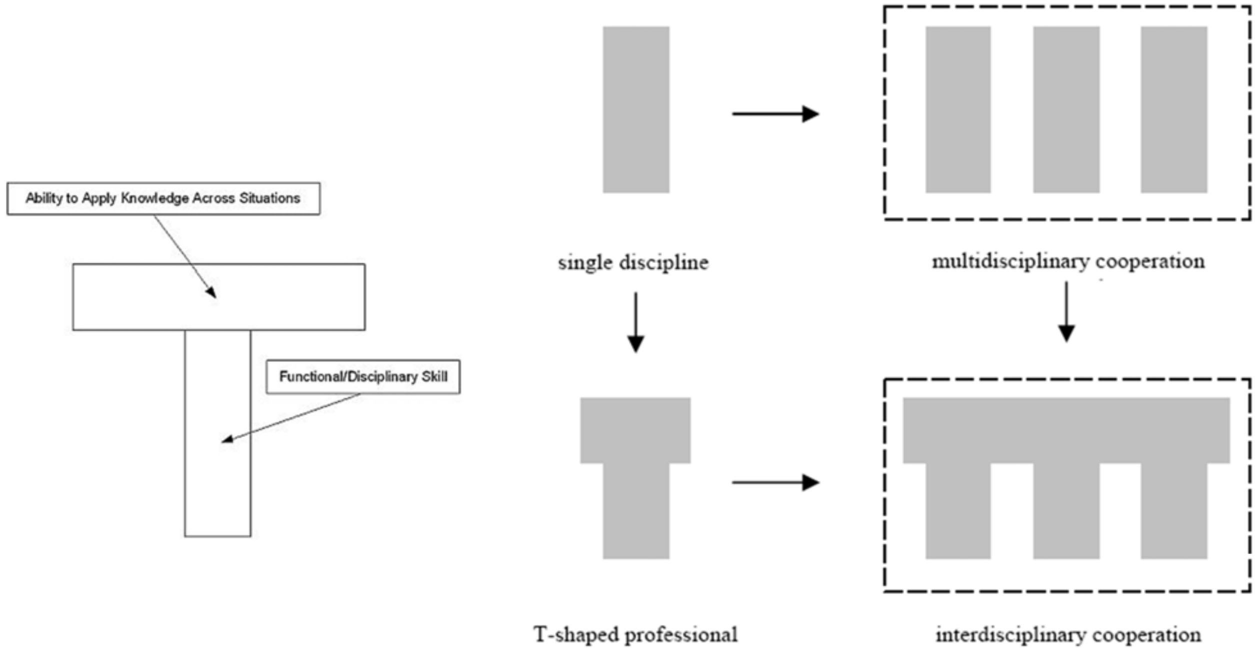


Fig. 5.3.1 – T-Shaped Engineers (source: Oskam, 2009)

Other research has shown (Wheelwright & Clark, 1992) that engineers are more efficient when they have two projects to work on (figure 5.3.2).

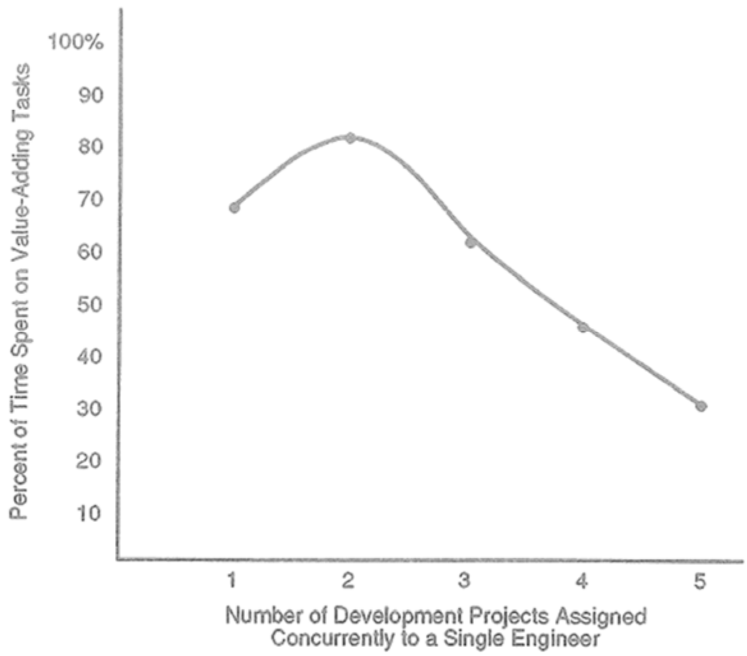


Fig. 5.3.2 – Productivity of PD Time (source: Wheelwright & Clark, 1992)

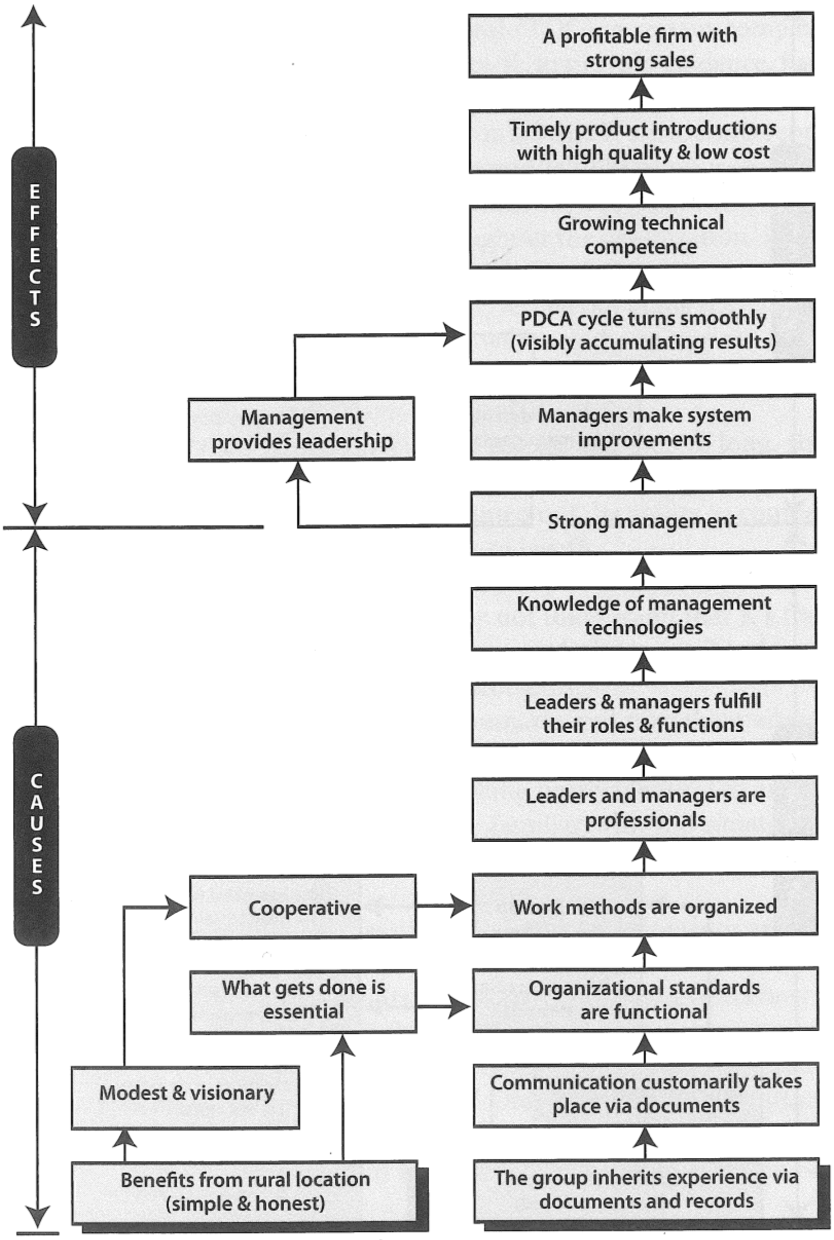


Fig. 5.3.3 – Sources of Growth at Toyota (source: Hino, 2000)

Figure 5.3.3 describes a company that is well organised and adhering to corporate standards and processes. This is the model RLE must strive to achieve.

5.4 Definition of Future Requirements for Performance Measurement in the Product Development Process

What is important, and the key outcome of research project 2, is that measuring or indicating the flow of information versus that prescribed by the original project plan is a leading Key Performance Indicator (KPI) that is not currently recognised by the automotive industry's PD process.

6 Conclusions

Project 2 set out to evaluate performance measurement in PD with particular emphasis on RLE and its projects for global OEMs.

The objectives of this research project have been achieved to the stage of proposing appropriate performance measurement improvements for future methodologies.

What is highlighted is that for a high percentage of their time engineers and designers are not fully utilised as they are waiting for information.

The overall timing plan and gateway process is generally provided by the OEM. What is important in all cases is measuring or indicating the flow of information versus the prescribed plan. The importance of interactions and communication identified as key in modular design (Baldwin & Clark, 1997) applies to the PD process itself also.

Flow of information is a key leading indicator of project success and facilitates:

- Being able to modify resource allocation.
- Identification of bottle necks and constraints to be eliminated.

Indentifying and visualising the information flow in the PD process forms the basis of project 3 of this research programme.

7. Future Work

The remaining work to be undertaken in project 3 of the research programme includes:

1. Measuring information flow.
2. Visualising progress and performance.
3. Flow workload levelling.
4. Resource allocation.

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Appendix 1 – Questionnaire and Interview Questions

RLE International - Product Development Project Questionnaire

Darren Gowland - RLE International

The following information is requested in support of my Doctorate research programme. All responses will be kept confidential.

Your Details:

Name: ………………………………… Department / Location: …………………………………………………………….

Job Title: ……………………………. Contact Phone: ………………………… Email: ……………………………

The purpose of this questionnaire is to evaluate the level of performance measurement in automotive product development projects. I am interested in your evaluation of one of the projects you worked on in 2010. Thank you for your time.

Section 1 - General

1	How many years of experience do you have in product development?	Less than 5 years	5 - 15 years	15+ years

2	Which project did you work on in 2010?	Volvo	Maruti	Chrysler	Valmet

3	Was the project manager identified to you at the start of the project?	Yes	No

4	Was an project organisation chart provided?	Yes	No

5	Did you attend a project kick-off meeting?	Yes	No

6	Were the project objectives explained clearly?	Yes	No

Section 2 - Project Performance

7	At project initiation, how was project success defined? Please specify in your own words.	

8	Which metrics were used to measure performance? Identify as many as you wish.	Time	Cost	Scope	Resource	Quality	Risk

9	Were any other measures used? Please specify.	

Section 3 - Interaction with Other Departments

10	Were you co-located with the majority of the project team?	Yes	No

11	How many interfaces did you have on the project e.g. Planning, Studio, Manufacturing?	None	1 - 2	3 - 4	5 - 6	7 - 8	9+

12	How did you communicate with other project team members? Identify as many as you wish.	Face to face	Telephone	Video	Email+Docs	CAD/Webex	SharePoint

Section 4 - Your Time on the Project

13	How much of your time did you spend doing design or engineering tasks?	0%	1-20%	21-40%	41-60%	61-80%	81-100%

14	How much of your time did you spend in meetings during the project?	0%	1-20%	21-40%	41-60%	61-80%	81-100%

15	How much of your time did you have nothing to do, e.g awaiting a response or information?	0%	1-20%	21-40%	41-60%	61-80%	81-100%

16	How much of your time did you spend doing other activities, e.g. on the phone or emailing?	0%	1-20%	21-40%	41-60%	61-80%	81-100%

Section 5 - Project Information

17	When did you generally receive information that you required to perform your project tasks?	Earlier than planned	On time	Later than planned

18	When you received information, how complete was it when judged against your expectation?	0-20%	21-40%	41-60%	61-80%	81-99%	100%

19	When you received project information from another department how did it arrive?	Small batches over time	A large batch at once

Section 6 - Overall Project Delivery

20	Was the project delivered as originally planned?	Yes	No

21	Would you say the project was effective?	Yes	No

22	Would you say the project was efficient?	Yes	No

23	Were any aspects of the project changed as it progressed? Identify as many as you wish.	Time	Cost	Scope	Resource	Quality	Risk

24	How would you rate customer satisfaction on this project?	0-20%	21-40%	41-60%	61-80%	81-99%	100%

Please return this questionnaire to:
Darren Gowland, RLE International Product Development Ltd, No 1 Endeavour Drive, Festival Business Park, Basildon, Essex, SS14 3WB, UK.
Email: dgowland@rle.co.uk

Questions asked in non-structured interviews:

1. What did the RLE team actually do?

2. How did RLE ensure customer satisfaction?

3. How did RLE plan and manage cost, timing and deliverables on these projects?

4. Did RLE get anything out of the project other than revenue and profit?

5. Did RLE quantify and document these?