Analysing organisational issues in concurrent new product development

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Abstract

Organisation analysis and improvement techniques have been a field of study for many years with the result that there are a number of different methodologies ranging from purely mathematical models of analysis to heuristic models using simulation. This paper presents an overview of research carried out towards the development of a methodology and tool aimed at assisting in the reengineering of the processes and organisation deployed in Concurrent New Product Development (CNPD) (NPD within a Concurrent Engineering (CE) environment). The focus is on the analysis of the operation of multifunctional project teams throughout the NPD process lifecycle, using process modelling and analysis techniques. The methodology and tools developed identify low value adding tasks and poor value adding ability of the performers, using both quantitative as well as qualitative information. This enables the company managers to reduce lead times, remove weak functions or links, move towards a more flatter organisation, and improve performance of the process and consequently organisation. The methodology and tool were originally developed within the European BRITE-EURAM (No. BE-8037-93) project PACE – a Practical Approach to Concurrent Engineering © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

New Product Development (NPD), is an interdisciplinary activity requiring contributions from nearly all the functions of a firm, whether it is an upgrade/improvement of an existing product or a new concept either to the company or the market. Traditionally NPD has been viewed as an organisational activity, which was the result of various functional activities performed in stages from concept development to product delivery. The sequential operation of these functional stages resulted in long development times and many quality problems due to the lack of communication and understanding of the different product design, manufacturing and above all customer requirements. To avoid these problems Concurrent Engineering is being used by many companies and has resulted in companies making new products better and faster [1–4].
CE or Concurrent NPD (CNPD) comprises two basic thrusts: parallelism or overlapping of different but hitherto sequential activities, and early involvement of all enterprise functions that contribute to a successful product [5]. This requires changes in the organisational structure, culture and new approaches to management and control, with a focus on human resource management and process management. The overlapping of activities requires those activities to be managed in a different way. Overlapping requires that the different actors involved communicate and collaborate more vigorously than in the past situations. Multifunctional Teams are often set up to achieve this. The successful implementation and management of Multifunctional Teams hence is of paramount importance. These teams cause strains on the organisation structure and processes within the product development function, in terms of resource availability, information flow and decision making. Methods within Organisation Theory (e.g. [6]) can be used to investigate and improve the structures and processes. However extant organisation theories such as those of Thompson [7], Galbraith [8] and Mintzberg [9] allow aggregated analysis and predictions about the organisational performance of engineering teams under given circumstances. Their aggregated view of organisational behaviour prevents them from providing specific prescriptions for organisation design in a CE context [10]. There is also a lack of focus on the processes, which run through the structures. In CE in order to manage or improve the overlapping of tasks an explicit understanding of the NPD process is needed. There is hence a need for a framework in which organisational issues of CE and the NPD process can be explicitly analysed.

To improve the performance of any action or entity we need to understand how and why given situations and behaviours are generated [11]. To understand behaviour we need to measure or analyse in some way the behaviour over time, which requires that we have some model representing our current belief about the content and causal dependencies of different elements of the entity or action, and which gives insight and understanding of the way organisations work. Thus modelling together with an analysis framework provides us with an understanding, which may be used, for improvement.

The most popular model of organisations is that organisations are fundamentally information processing structures (as seen in the work of March and Simon [12]; Simon [13]; Galbraith [8]. In this view, an organisation is an information processing and communication system, structured to achieve a specific set of tasks, and composed of limited information processors termed ‘actors’-individuals or undifferentiated specialist subteams [14].

Modern literature (such as [15–17]) supports this thinking. According to Levant Orman [17] the solution to the problem of organisation design is to take a prescriptive and analytical approach to re-optimisation of organisational processes and structures. An information processing/decision-making paradigm of organisations should be adopted [18–20].

2. Research questions

Engineering teams are composed of different and specialised participants working on complex design tasks with different values, interests, and capabilities. Developing an analysis methodology together with a graphical computational model representing the state of the organisation for CE (in product design/development) was difficult because of the complexity of human organisations and the requirement for detailed predictions of team behaviour and performance. In most medium sized companies developing medium complexity electromechanical products the NPD process is fairly long and complex involving many different functional expertise. From a computer based process modelling and analysis point of view, there were four basic issues that had to be addressed:

1. How to model product development activities – detailed or abstract;
2. How to break down or dis-aggregate the NPD process so that problems can be analysed in their true context;
3. What should be the units of analysis for studying organisational behaviour or performance – the team or the actors; and
(4) How to validate the model?

The research methodology [21] describes how we achieved these objectives.

3. Research methodology

The research methodology comprised the following six (6) steps.

3.1. Step 1 – Industry survey (case studies) and literature review

The aim of the industrial survey was to establish the structure, the issues, and problems in NPD. This would help enable us in defining the needs and requirements of the new framework for analysing the NPD process (step 2). Four companies and one management consultancy across Europe took part in this study. A total of 30 managers and engineers/specialists were involved in NPD. The survey was carried out using both structured interviews in the form of questionnaires and semi-structured interviews targeting specific areas of interest. The structured questionnaires focused on a wide variety of areas such as organisation structure; organisational effectiveness with regards to NPD; problems in NPD process activities and events; recent changes in the NPD process, their drivers and change enablers; performance measures; use of decision support techniques for analysis and problem solving; and decision drivers. The semi-structured interviews just focused on organisational issues in NPD. This dual approach was adopted because each organisation had its own peculiarities regarding mode of operation, which was not possible to detect clearly in generic questions in structured interviews. For example the main organisational issues for one company were more to do with the problems associated with global communication, because its manufacturing and product design and development were in different countries. Whereas these issues were not present in another company whose design and manufacture were on a single site. The results of the survey revealed that even within a company there are many different issues, which are individualistic, or function related and not found in the organisation as a whole. However, these issues cause serious problems at the business level in terms of delayed product launches and dissatisfied customers. Only a few issues showed over 50% agreement. The issues that emerged (as identified by majority of respondents) in all companies as causing major difficulties were:

(1) strength of the functional organisation,
(2) lack of true integration due to inadequate communication and collaboration between internal functions and external partners (suppliers, etc.),
(3) weak advance planning of projects – lack of co-ordination,
(4) poor estimating and planning of human and other resources,
(5) lack of human engineering resource,
(6) lack of standardisation, particularly at process level (weak process understanding across functions).

These only represent approximately 25% of the issues. The other 75% of issues were related to specific departments or functions. This indicated the requirement for an analysis methodology, which would detect these issues. Individual issues can be solved using specialised solutions, e.g., the issue of communication is being investigated under a separate project at Nottingham University [22].

In one of the structured questions on organisational effectiveness the authors used the factors described by Charles Handy’s [23] fish-bone diagram in his book ‘Understanding Organisations’. The factors affecting organisational effectiveness according to handy can be categorised as under:

- issues relating to the individual, such as level of aspiration, need for hierarchy, training, personality etc.;
- issues relating to the organisational and external environment, such as resources, capacity, job layout, competition, location, economy etc.; and
- issues relating to the organisational leadership, groups, systems and procedures, such as type of lead people, leadership task, group goals, group age and size, control systems, administration structure, power structure, etc.

The interviewees were asked which of the factors or issues were problems in their organisation.
Fig. 1. Analysis of factors relating to the ‘individual’, influencing organisational effectiveness in NPD.

Figs. 1–3 aggregate the results for all four industrial participants, under the above-mentioned three organisational effectiveness categories defined by Handy. The ‘response’ indicates the percentage of people identifying that issue or factor as a problem. One can see that this survey too shows the widespread nature of organisational issues. The authors hence realised that they had to develop a methodology, which identified all issues relating to organisational performance. According to Handy, “Reductionalism”, as it is called, the disentangling of each variable in turn, may suit some academics and analysts but will not do for the manager who has to put the lot together and make it work”. It should be noted that initially in our development of the methodology we concentrated only on the key issues.

On the survey relating to the use of tools for decision support in analysing the organisational aspects of NPD the authors discovered that the concept of using process modelling, particularly in NPD, was still alien to most companies. The most common approach to identifying such problems was through meetings and discussions.

The literature review in addition to covering the above also looked at tools and techniques available to analyse the process especially from an organisational perspective.

3.2. Step 2 – Needs/requirements for new framework/methodology and tool

Based on the conclusions and knowledge gained from the literature reviews and industrial survey (step 1) it was possible to investigate and develop the requirements for a methodology and tool, which addressed the weaknesses identified in existing approaches; and provided the necessary decision support for addressing the real life industrial problems in CNPD organisational and management issues. The requirements in terms of what, where and when (context), and how were: What to model and analyse.

To achieve an analysis of organisational issues or processes the following need to be modelled and analysed:
actors, activities and individual behaviour; functions, teams and team behaviour; and communication links and behaviour.

The ability to calculate the performance of teams, individuals, and communication links, in terms of value adding activities and the ability of the resource to add value, is also required.

Note that the focus is on the softer issues, i.e., human resource and communication behaviour and performance. This is because the central theme of CE is integration, and the main problems are related to people and the way they communicate and collaborate. This will result in the evaluation of CNPD process performance that in turn will verify if the organisational structures and processes are working or not, i.e., organisational effectiveness. The combination of functional analysis and process modelling will result in a balanced and comprehensive approach to organisational diagnosis and analysis. The use of process models which are analysed using analysis criteria reflecting the issues of concern (as identified through the literature reviews and industrial survey) will allow for an explicit diagnosis of the CNPD organisation.

3.2.1. Organisational and process context of analysis (where and when)

It was deduced that dis-aggregation of analysis is required. The framework and tools should allow for different levels of organisation hierarchy to be analysed. Consequently different views and forms of analysis were required.

3.2.2. How to model and analyse

The aim was to develop a process modelling approach as the foundation upon which to analyse and hence model the organisation. The earlier field studies and literature review identified that the process modelling methodology should be highly structured allowing for detailed analysis, of tasks, actors, team based activities and communication links. A corresponding structured analysis approach was required, with clearly defined cri-
Fig. 3. Analysis of factors relating to the ‘organisation’, influencing organisational effectiveness in NPD.

The output should be in the form of:

- index values/benchmarks/performance measures (scores)/rating or scoring system;
- process variables (the process map, cycle time, process loops, number of activities, value-added activities, identification of problem areas etc); and
- representation of a change in score due to a change in an organisational or process metric (assessment criteria).

Process modelling and analysis should focus the thinking towards the NPD process and not functional constraints. The tool should be within the reach of an industrial manager’s budget for such activities.

Another requirement of this research, which came out of the industrial survey, was that any methodology or tool developed should allow for practical implementation in industry. The final solution should be part of an implementation framework highlighting the new or adapted elements in their correct context. This ‘integrated implementation framework’ was also lacking in research literature and commercial tools.

3.3. Step 3 – Develop prototype methodology and tool

Here the development of the framework/methodology and software tool was carried out. It was decided to start developing a modelling and analysis methodology for micro level processes within new product development. A way to model the process was defined. It was based on various diagramming techniques such as IDEF0, Role Activity Diagrams, etc. Initially the focus was on ‘actors’ performing the tasks. A process within the design and development engineering stage was chosen as a test case. This was because it involved a number of different roles within the organisation. The in-
Industrial survey and literature had given a good indication of the issues that needed to be analysed. Consequently, questionnaires and assessment methods were developed as part of the analysis methodology. Gradually the development moved forward by looking at higher level processes, i.e., ones that involved ‘teams’ and eventually departments or functional groups. Analysis frameworks (criteria) were developed for each organisational unit.

In order to develop a computer-based tool a detailed review of software tools and possible architecture scenarios was carried out. The criteria for selection were: should be easy to develop, short development time, low cost, practical to use for end user, and functionally adequate, i.e., able to support the methodology. There were two main elements to the proposed tool, (a) process modelling and (b) data collection and analysis. For Process Modelling, there were two possibilities – build own process modeller or buy an off the shelf process modeller. Based on the selection criteria above it was decided to purchase an off the shelf process modeller which could be customised to suite our methodology. For data collection and analysis there were also two possibilities: (a) use a database such as ACCESS or spreadsheet such as EXCEL; or (b) buy a special purpose data collection and analysis (graphing and charting) tool. The first option was chosen because of the freedom to expand the analysis functionality.

3.4. Step 4 – Initial testing of methodology and tool

The initial testing was carried out at a couple of sites to gauge the end users response to the basic methodology and software tool and also help finetune the implementation methodology. This was carried out over a one-year period. The implementation took place during live ‘New Product Introduction’ projects. The project manager at one company gave the task of using and implementing the methodology and tool to two design engineers, one of whom was also the team leader. At the other company, which was a comparatively much smaller company, the project manager himself took the responsibility of implementing the methodology and tool. Lessons learned from this were used to further develop the methodology and try it out on selected processes.

3.5. Step 5 – Improving the methodology and tool through continuous testing and literature review

One site [24] was then chosen for longitudinal development and testing of the methodology and tool. Improvements to the corresponding software tool were also noted. Again additional literature review was required to meet changing user requirements and to keep up with latest developments in this area. Additional industrial sites were also involved for continuous validation purposes but at a lesser scale than the main site.

3.6. Step 6 – Framework for analysing the NPD process

Once the development phase is complete the methodology and corresponding requirements for software implementation will be finalised. The methodology, tool, and accompanying implementation framework and as they currently stand are discussed in Sections 4–6 respectively.

4. The NPD analysis methodology

We have looked at the NPD process at three levels: primary, secondary and tertiary. Fig. 4 illustrates the process hierarchy and how it relates to the organisation hierarchy and it’s various units (‘resources’ and ‘tasks’). For each level and organisational unit we have developed a mechanism for analysing it and obtained some scores for its performance. This has been illustrated in Fig. 5.

The primary process represents the main stages of the NPD process. For example at one company the stages were (1) Feasibility, (2) Design and Development, (3) Implementation, (4) Production, (5) 90 Day Review and (6) 12 Month Review. The primary process is analysed by the functional and project managers. To analyse the process at this level we propose an input–output type of analysis. A two part table (inputs–outputs) has been developed which is filled out for each primary stage by each
contributing department/functional head or manager. Each functional head lists the following:

**Inputs**: Requirements or ‘Inputs’ to their function; the information provider; and difficulty in obtaining the information (score between 0 and 10).

**Outputs**: ‘Outputs’ or contribution from their department; difficulty in completing (a score between 0 and 10); and reasons for difficulty.

This type of analysis we have labelled Level 2 and provides us with a top level view of the problems as seen from the functional managers point of view. This view can help us in establishing which secondary or lower level processes need to be modelled and analysed. Alternatively we could process model in detail a particular stage, carry out analysis and then compare the results with the results of the primary level assessment.

For the secondary and tertiary processes we use our Organisational Modelling Methodology, which is described below. This has been labelled as Level 1 in Fig. 5. Note that Level 1 consists of three further sub-levels a, b, and c, as discussed below.

### 4.1. The organisational modelling methodology (OMM)

The OMM views the NPD organisation in terms of ‘Functions’ communicating with other ‘Functions’ (Fig. 6). Essentially we build a process model and populate that model with organisational relevant data as described below.

A Function is a work discipline such as design or marketing. A Function is made up of the following elements:
**LEVEL 1**

**Organisational Modelling Method (OMM) and Analysis**

1a- Aggregate / General Analysis of NPD/IPD Team (Questionnaire for Teams)

- **NPD TEAM**
  - various members with a team leader

- **NPD CORE TEAM**
  - core members including team leader

- **SINGLE FUNCTION TEAM**
  - with various members and leader.

1b- Analysis of Tasks (Questionnaires for Individuals and Teams)

- **FUNCTION TASK**
  - a single task performed by a person, team or machine

1c- Analysis of an Actor, Functional Discipline or Actor Role

- **THE ACTOR (INDIVIDUAL OR TEAM)**
  - Performance of the person or team based on its performance in tasks (aggregation of task scores).

- **FUNCTION OR ACTOR ROLE**
  - Performance of a functional discipline or actor role through aggregation of task scores.

**LEVEL 2**

**Analysis of NPD Stages** (input-output analysis using spreadsheets)

- analysis of functional requirements and contributions
- key activities and decisions

**NPD STAGE**

- Functional Requirements For the Stage
- Functional Contributions To the Stage

**Event/Activity Identification** – a number indicating the position, in terms of time, of a task in relation to other tasks in any sequence of operations or tasks. This enables modelling and hence identification of tasks which are totally parallel as they will have identical event numbers. Tasks which are parallel and share or exchange information can be modelled by either decomposing them into their sub-activities and showing the interactions through iterative loops, or by combining the tasks and simply representing them as a team based activity when the interactions are undefined or too complex model.

To represent the NPD organisation we model it in terms of its processes. The ‘OMM’ models the process flow in terms of ‘function tasks’ and ‘links’. *Links* allow information and material flow. The flow process is triggered by a decision, which defines how the information and material flow should be handled. To represent hierarchy in the process, the links can be defined as being either horizontal (same hierarchical level) or vertical (changing hierarchical level). Links can either be inter-organisational or intra-organisational (customers, suppliers, etc.); feed-forward or feed-backward.

The methodology also enables representation of partial overlapping. When two tasks are overlapped, as mentioned earlier, there is a lot of interaction and the activities are essentially carried out collaboratively in a team based environment. By defining the function type for such activities as being a team, identification of parallelism is possible. The detailed interaction can be modelled.
separately by decomposing the team-based activity.

The behaviour and performance of the functions and links is defined by the criteria such as resources, skills, quality etc. shown in Fig. 5, which allows the process model to be used or transformed into an organisational model. These criteria are used for analysing the organisational aspects of the process.

So, as mentioned above we model the NPD processes in terms of functions, where the function tasks are performed by either an individual, team or a machine. Currently our focus is on the human resource. So to obtain a figure for the performance of the NPD processes and structure we need to analyse two things:

(a) the tasks performed by these people or teams, and
(b) the performance of the individuals or teams.

The main characteristic of these secondary processes in CE is that the individual tasks are carried out mainly by the multi-functional NPD team in conjunction with the occasional single person or single function team. This makes analysing these processes complex. The tertiary processes are usually not NPD Team based and the tasks are the responsibility of a single person. Before we discuss how the secondary and the tertiary processes are analysed let us look at what we mean by ‘analysis’.

Analysis is done through questionnaires. Various questionnaires have been built to analyse each process element and organisational unit. These questionnaires use a scoring mechanism to achieve a performance indicator (a score) for the functional-task, performer of the task, and link performance. The scores given are multiplied by a ‘Question Weighting Factor’. The question weighting factors indicate the importance of the question in relation to the other questions within the relevant segment. This weighting factor reflects the CE policy, i.e., which areas are considered of primary importance for CE success. Total performance of the function or link is calculated by summing up the scores for the various questions or analysis criteria.

From an organisation performance point of view whether a ‘function’ is adding value depends on two things:

(a) the number of value adding tasks it is performing and
(b) its ability to add value, i.e., how capable is the person or team in delivering the value adding.

The ability to add value is quite important and is the focus of this methodology. Tasks are assessed for their value adding by asking questions, which have been developed in consultation with the process managers or leaders. The individual or team performing the tasks is assessed for its ability to modify a given piece of information, decision or material and add value from the input to the output. This ‘Value Adding Ability’ is assessed through questions relating to the following criteria:

- *Personal Behaviour* – which is influenced by factors such as motivation, empowerment, attention, environment, and rewards, etc.;
- *Skills* – which are dependant on experience, aptitude, education, training, etc.; and
- *Resources* – which are related to issues such as quality, quantity, centralisation versus decentralisation, etc.

For tasks performed by a multifunctional team we have further questions under the heading of *Team Issues*. A penalty for time delays when evaluating functions or links has also been employed. This type of analysis we have labelled *Level 1b*. 

Fig. 6. Modeling overview.
The function task performance is given by:

**Function Task Performance**

\[
= \text{when Individual Performer}
= [\text{Task Value Adding} + \text{Personal Issues Score} + \text{Skills Score} + \text{Resource Issues Score}] \times \text{Time Delay Ratio};
\]

when performed in Team

\[
= [\text{Team Task Value Adding} + \text{Average Sub Member Task Value Adding} + \text{Multifunctional Team Issues Score (Ave.)} + \text{Personal Issues Score (Ave.)} + \text{Skills Score (Ave.)} + \text{Resource Issues Score (Ave.)}] \times \text{Time Delay Ratio}.
\]

(Ave. = each member answers the questions and the scores are aggregated.)

The tertiary process analysis uses mostly Level 1 Individual performer questionnaires. The secondary process (Stage Level) uses Level 1b (both types – individual and team) and an additional set of questionnaire analyses designed for the establishing the overall performance of the NPD multifunctional team for each stage. This questionnaire set is labelled Level 1a. All team members answer the questions and the scores are aggregated to produce a final NPD Team Score.

Analysis of Links provides additional ‘value adding’ related information in terms of their quality and functionality. Links are assessed by analysing Information/Material (for awareness or decisions) – for importance and usefulness, frequency of change, number of iterations for feedback loops, quality, timeliness, format, etc.; and Decisions only – for urgency, criticality, amount of information added, etc. So the link performance is given by

**Link Performance**

\[
= [\text{Information Score} + \text{Material Score} + \text{Decision Score}] + \text{Time Delay Ratio}.
\]

The Total Performance for the secondary process is

\[
\left[ \frac{\text{Average Task Score}}{\text{Maximum Possible Task Score}} + \frac{\text{NPD Team Score}}{\text{Maximum Possible Team Score}} \right] \times 100.
\]

For the tertiary processes it is as above but without the Team Performance scores.

This leaves us with Level 1c analysis – see Fig. 5. Level 1c was developed from an organisational structure point of view. Level 1c aggregates the scores of tasks analysed through Level 1b into their relevant functional total and provides a figure for the performance of a particular departmental function or for a particular person. In other words the analysis for a group of function tasks, when aggregated form a function or discipline, e.g., the design function. We can also aggregate function tasks performed by the same person and evaluate the performance of that person in addition to the aggregated performance of a function role again by aggregating the different tasks.

So the overall process and hence concerned organisation segment performance is calculated by summing up the performance scores for the functions and links and comparing them with the maximum possible scores. Once the detailed analysis is complete the total process can be analysed additionally by looking at for instance the number of tasks performed in teams, the number of feedback loops, the number of external links, the number of changes in hierarchical levels, etc. Hence various constituents of the NPD process and structure can be evaluated at various levels of aggregation.

5. Structure of the process modelling and analysis tool

The tool developed under the PACE project was called the PACE OM tool [25] and was divided into three sections; a process modelling tool, a data
analysis tool and a training tool. The process-modelling tool was a commercial product called ‘FlowModel’ which allowed icon customisation and the setting of attributes to process nodes and links. An application specific template had been designed with the necessary attributes already set up for the functions and links. Preliminary data was entered using the template and when complete could be exported as an ASCII file. The data analysis tool (ACCESS database application) could import the process modelling data and also provide the analysis questionnaires to complete the data capture. Performance analyses could then be carried out. The modelling and analysis tool will be modified to take into account recent developments in methodology and software support. The training tool was aimed at providing some background information on organisation diagnosis and design, the requirements for it in a concurrent engineering environment and details on how to use the PACE Organisational Modelling tool and the implementation framework.

6. Implementation framework

The implementation framework for applying the modelling and analysis methodology and tool at companies has been developed at two levels. Firstly a macro level framework giving an indication of the main phases a ‘Process Re-engineering’ exercise goes through and the time scales and resources required. Secondly a micro level framework describing the (what and how) steps which can be performed to achieve certain goals relating to the macro level phases. The macro level framework is described briefly below:

Planning phase (duration: 1–3 months): This stage addresses the prerequisites of organisational modelling and the out come of which is the ‘decision to go ahead’. Making sure that the goals of process and organisation improvement are in accordance with business strategy and what support is needed is addressed here. A model of the target process to be improved is made at this stage.

Introduction phase (duration: 3–6 months): This is where the first pilot projects come into action. Here the OM Tool/Methodology is put to test. Problem solving teams are set up to deal with the various issues that have been identified by the tool. The teams need to be trained and the progress monitored.

Working phase (duration: up to 1 year): Having completed the first pilot project and gained considerable experience and knowledge the next stage is to upscale the efforts and ideas and introduce them into other areas and functions in the organisation. The full scope of the introduction phase now comes into action.

Improvement phase: This is to do with continuous improvement. Here the performance measures that have been introduced are monitored and remedial actions taken on a regular or continuous basis.

7. Results to date of longitudinal testing

Testing took place on a live NPD project in a Collocated1 project team environment. Initially a rough cut process map of the test case company’s six stage New Product Development process was produced. This provided input for discussions and a specific stage and one of its sub-stages were targeted and then modelled and analysed in detail using the OMM. As a result weaknesses in both process and organisation were identified and remedial actions taken.

Analysis of a tertiary input process identified weaknesses in communication between the design and purchasing functions: issues in the purchasing department functional setup and unnecessary duplication of information. The ‘design–purchasing’ issue was resolved by purchasing having a stronger commitment through more active participation in the Collocated Team. The issue of information duplication was resolved through the use of improved IT. The purchasing structure issue requires further investigation.

Analysis of a Collocated NPD Team revealed that the following were major issues of concern: allocation of time to the team, number of tasks

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1 Collocated Teams or Collocation, meaning that functions contributing to a new product must be physically located close to each other, is commonly used as one of the main tools for enabling Concurrent Engineering.
performed in a team environment, stability of the team, i.e., too many changes in functional representation, rewards, and modifications to parts. All of these issues and others identified but not mentioned here are being resolved. As an example the issue of too many modifications to released parts is being solved by the introduction of various design specification reviews, and Six Sigma\(^2\) quality targets.

Analysis of various stages using both Levels 1 and 2 are currently under way. Already we have found how the perspective gained from Level 2 analysis (input–output analysis) differs from the perspective gained at a more operational levels in within Level 1 (secondary and tertiary processes). However, there are clear cause and effect relationships being highlighted through our analyses.

The analysis at Level 1 was done through questionnaires, which have been developed by consulting relevant literature in organisational analysis (such as [26,27]), and CE (such as [28,29]; and discussions with industrial partners. These questions have then been subsequently refined through the longitudinal testing process. The questions have been tried with different people on the same activities. Additionally the results have been cross-checked with the input–output analyses carried out at a different level. This process ensures the validity of the questions. The results have identified issues which managers have found quite useful. However, some members of the companies involved have raised concerns about the amount of effort required to go through the analysis process. Further testing across different organisations needs to be carried out in order to ensure general applicability of the analysis criteria and efficiency of the analysis process.

8. Conclusions

In this paper we have attempted to describe how the NPD process can be modelled and analysed using the methodology developed by the authors. The methodology addresses two elements of CE- multifunctional teams and process flow. The organisational modelling and analysis methodology attempts to model and analyse the NPD process and organisation in terms of the tasks, individuals or teams (actors), roles, and communication links. By identifying low value adding tasks and poor value adding ability of the performers (actors), investigations are initiated and where appropriate remedial action is taken. Additionally there is substantial qualitative information, in the form of comments from interviewees, which are gathered by the user of the tool and used in paper and discussion based approaches to finding solutions to the problems identified by the tool. The company benefits from this tool in terms of factual decision support information for:

- reducing lead times;
- removing weak functions or links;
- a move towards a more flatter organisation;
- improving performance of functions, links, process and organisation.

The development of the methodology (modelling, analysis and implementation) is an on-going process at the University of Nottingham in collaboration with selected industrial partners. Lessons learnt from the trial projects will be incorporated into future versions of the computerised tool.

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\(^2\)The Six Sigma concept developed at Motorola Inc. [30], is a quality control target which focuses on process capability rather than product defect (e.g., zero defects).
References


