A GUIDE TO INTRODUCING

CONCURRENT ENGINEERING

IN YOUR ORGANISATION

The National Institute of Manufacturing Management/Smartlink

This guide has been published by Australia's National Institute for Manufacturing Management / Smartlink based on research conducted at the Centre for Advanced Manufacturing Research (CAMR) at the University of South Australia. Smartlink is a unique partnership, bringing together education and research resources, industry and regional associations, and modern diffusion techniques.

Smartlink aims to enhance the capability of the Australian manufacturing sector by:

- improving management skills through the diffusion of best practice in manufacturing management;
- encouraging the managers of small and medium enterprises (SMEs) to aspire to a level of management competency consistent with international best practice in comparable firms;
- being aware of the trends in global manufacturing, working with industry and researchers to adapt the best management techniques for Australian SMEs and making them accessible.

For more information about the National Institute for Manufacturing Management visit our website www.smartlink.net.au.

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The thesis included a survey of Australian firms to obtain critical industrial input regarding the issue of adoption of best practices by SME's. Additional research and work by Dr. Sev Nagalingam and Mrs. Saadia Carapiet of the International School of Business, University of South Australia, has led to the publication of this guide. The team sincerely thanks work carried out by Fast CE research team at Cranfield University, United Kingdom, and Professor Stephen Evans - Principal Investigator on Fast CE project for granting permission to use their work in this booklet.

This guide is meant to be a starting point for companies contemplating the adoption of a world best manufacturing practice i.e. Concurrent Engineering in order to enhance their competitiveness. We wish all companies' success in their endeavour to use Concurrent Engineering.

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Is this for me?

Concurrent Engineering (CE) is a management philosophy and is not restricted to manufacturing companies only. Company size may affects how CE is adopted and implemented, however SMEs as well as large companies can use CE. It involves systematic and simultaneous approach in developing a product or process while bringing up all the people who need to be involved in at the first place. In small companies who have very highly skilled and experienced people, Concurrent Engineering can be practised without computer support or by using any formal techniques.

To ascertain whether the Concurrent Engineering is for you, ask yourself the following questions:

1. Does my company face any of the following problems in product development?
   - Increasing competitive pressure to develop new products
   - Product launch delays
   - Higher costs in processing and developing products than acceptable
   - A predominantly internally focused product development process
   - Little or not direct knowledge of customer requirements
   - No or low involvement by the marketing in early stages of product development
   - Shift in responsibility for product development from one function to another as the project progresses and transfer points often characterised by conflict
   - Poor transferral of learning from one product development project to the next.

2. Am I able to provide the necessary enablers to this process? / What is the state of my organizational readiness?
   - Willingness to change for improvement
   - Senior management commitment
   - Ability to encourage teamwork

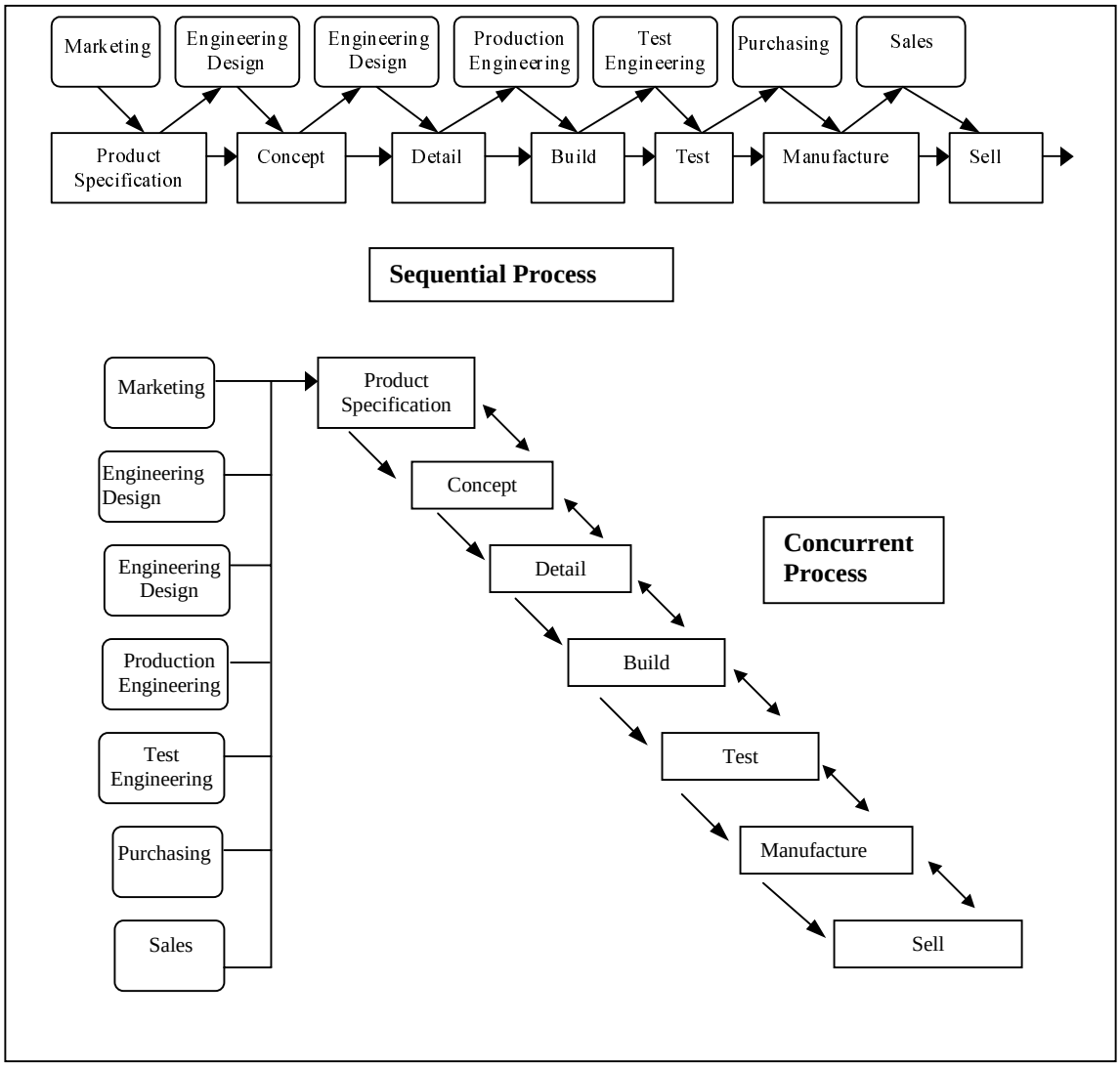

Figure 1 Sequential and concurrent development of new products, adopted from Brookes [20]

A Short Exercise

Come up with some ideas [5]

- How could implementing Concurrent Engineering be useful in your organisation?

- How will you form teams?

- How will you open communication?

- How will you change processes?

- How will you implement technology?

Key features of Concurrent Engineering

Definition of CE

"Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. Typically, concurrent engineering involves the formation of cross-functional teams, which allows engineers and managers of different disciplines to work together simultaneously in developing product and process design. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from concept through disposal, including quality, cost, schedule, and user requirements." [1]

Description of CE

A Systematic approach
to integrated product development that emphasizes
response to customer expectations
and embodies
team values of cooperation, trust and sharing
in such a manner that
decision making
proceeds with large intervals of parallel working by all life-cycle perspectives,
synchronized
by comparatively brief exchanges
to produce consensus. [2]

Concurrent Engineering involves:
- Doing things simultaneously
- Focusing on the Process, being open to change
- Converting hierarchical organizations into teams
- Balancing and prioritising needs of customers, suppliers, quality control, marketing, sales and manufacturing

Goals of CE

- Greater competitiveness
- Improved profitability
- Raise sales and profits from new products
- Reduce new product time-to market
- Reduce human and capital costs
- Maintain or increase product quality
- Leverage knowledge and experience
- Close integration between departments and promotion of team spirit [3,4]

Scope of CE

- Implement process changes within 1-2 years
- Involve people with stakes in new products
- Focus on business process improvements [3]

Understand the Advantages- Industry Experience

CE has led to dramatic benefits for a large number of companies from various industries. Some of the findings are presented here as a pointer towards the potential benefits of this best practice.

Benefits Obtained from Concurrent Engineering [7]

Benefits and Metrics	Results
Decreased lead time	
Development time	30-70%
Time to market	20-90%
Improved quality	
Engineering changes	65-90% fewer
Scrap and rework	up to 75% less
Overall quality	200-600% higher
Reduced Cost	
Productivity	20-110% higher
Return on assets	20-120% higher
Manufacturing costs	up to 40% lower

By executing design in parallel, improvements occur in many areas such as communication, quality, production processes, cash flows, and profitability. The reductions of time to market, which has strategic importance, allows companies to increase their market share and reduce design changes and iterations. Product designs are more easily manufacturable, serviceable and are of higher quality. Once the designs are released to manufacturing, production progresses quickly to full volume because the process is well defined, documented and controlled [8].

World-class companies have achieved remarkable performance using concurrent engineering. Boeing's Ballistic System Division [9] achieved the following improvements.

- 16% to 46% in cost reduction in manufacturing
- Engineering changes reduced from 15-20 to 1-2 drafts per drawing
- Materials shortage reduced from 12% to 1%
- Inspection costs cut by a factor of 3

NCR [10] used CE to develop a new cash register and achieved the following benefits:

- reduction in parts and assembly line;
- 65% fewer suppliers;
- 100% fewer screws or fasteners;
- 100% fewer assembly tools;
- 44% improvement in manufacturing costs;
- a trouble-free product introduction.

Other examples are: Rolls-Royce reduced the lead-time to develop a new aircraft engine by 30%; McDonnell Douglas reduced production costs by 40%; and ITT reduced their design cycle-time by 33% for its electronics counter measuring systems. Intel-Pentium development team reconciled conflicting requirements in semiconductor development [2]. Many other cases which corroborate the benefits of adopting concurrent engineering have also been reported [11,12].

Understand the Advantages

Strategic benefits of concurrent engineering:

Concurrent Engineering (CE) is a management philosophy dedicated to the improvement of customer satisfaction through improved quality, reduced costs and faster product development [6]

Concurrent Engineering leads to:

- Improved customer satisfaction
- Improved quality
- Reduced cost
- Reduced new product development time
- Reduced time to market
- Reconciliation of conflicting requirements in product development

Understand the Difficulties

The reasons for failing to implement CE successfully are repeated in most companies. However, substantial positive results have been obtained by many companies with poor CE implementations [13].

- Implementation of CE is a major challenge for management.

- Many cross-functional change initiatives have high rates of implementation failure [14]

- Concurrent engineering is a particularly problematic cross-functional initiative as it involves, for its implementation, a radical cultural change in an area that is extremely complex and highly pressurised.

- Overall finding from the cases that firms often underestimated the difficulties of implementing new approaches.

- Barriers exist in organisations that inhibit the successful implementation of CE. The two types of barriers are organisational and technical [15]
  - Organisational barriers include lack of management support, protective functional managers, inadequate reward systems, lack of customer involvement, lack of supplier involvement, and fear of loss of creativity. As an illustration rewards based on departmental goals rather than organisation-wide objectives can lead to sub-optimisation of the organisation's performance.
  - Technical barriers include availability of proper computer-aided design/manufacturing and communication tools.

- Implementing concurrent engineering principles in an industrial context often gives less than satisfactory results in practice because of practical problems such as:
  - Inadequate training and expertise in the concurrent development process
  - Difficulty in synergising cross-disciplinary labour functions
  - Difficulty in managing or controlling technical processes in the concurrent development process [16]

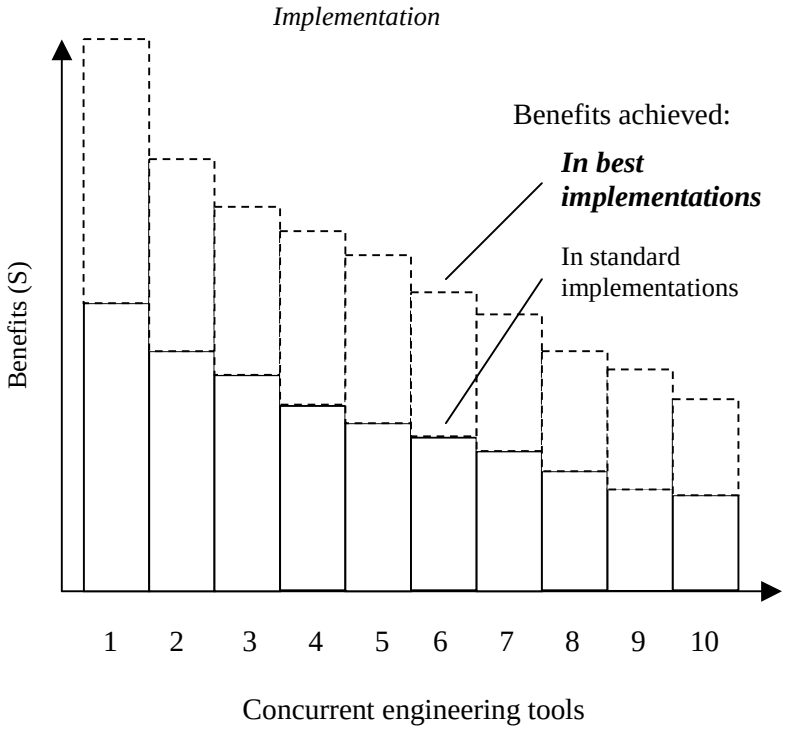

Figure 2 Variability in benefits achieved from CE tools under best and norm conditions [17]

Note: The X axis refers to the general number of concurrent engineering tools being used in the implementation and not refer to any specific tool

Dominant Success Factors In Implementing CE

Factor 1: Pilot Projects

Factor 2: Change Agents

Factor 3: Team Enrolment

Factor 4: Team Engagement

Factor 5: Team Empowerment

Factor 6: Gaining Commitment of Functional Managers

Factor 7: Realignment of Organisational Processes and Structures

This section describes the seven dominant success factors identified primarily through the Best Practice data collection activity with CE practitioners in North America and Europe, using 20 multiple case studies under the EU funded FAST CE research. The material has been extracted from the website outlining the FAST CE project, with Fast CE project teams' approval.
http://www.cranfield.ac.uk/sims/ecotech/projects/fastce1/fastceintro.htm

FACTOR 1: Pilot Projects

Pilot projects were a popular way of achieving radical changes to current working practices on a small scale, in relatively controlled conditions, managed closely by senior management and project leaders. The purpose of a pilot project appeared to be to reduce the scale of initial changes within the organisation and evaluate the potential impact of the desired large-scale changes. This approach sheltered the organisation from experiencing high levels of implementation cost, risk and time, because the pilot created a controlled experience from which learning could take place. This learning was used as a basis to plan and implement large scale changes with the benefit of hindsight. For example the necessary infrastructure on appraisal systems or organisational structure required to support and institutionalise the desired changes at a later stage.

Detailed observations also identified two important sub-components to the pilot project approach. They were related to senior management's need to exercise control over the pilot project to ensure its success. The first sub component was concerned with the selection of the right pilot project. It seemed appropriate to select a project that would be easier to demonstrate as a success. However in some organisations senior management were under time constraints and the next contract into the organisation was automatically classified as the pilot. Nevertheless 12 out of 19 organisations selected pilot projects that were of low risk to the organisation. The purpose was to reduce the overall failure and blame on Concurrent Engineering programme by deselecting projects with unknown technologies or markets.

The second sub component was associated with the visibility and promotion of the pilot project within the internal organisation. In 16 out of 19 organisations the pilot project was considered to have a high profile. These perceptions stemmed from a range of beliefs including its importance to the organisation's profit margins, its newness to the markets, its importance to the Concurrent Engineering implementation, senior management's efforts in internally symbolising the project using posters, newsletters, and so on. Such activities demonstrated to the wider organisation that senior management considered it to be an important project to the organisation's overall competitive market position.

FACTOR 2: Change Agents

The use of internal change agents was prevalent in 15 out of 19 organisations. They appeared to demonstrate senior management's understanding of the amount of time and effort required to implement Concurrent Engineering successfully. Once again it was seen to be a clear and visible projection of senior management commitment to the change process, which is visible to the whole organisation.

Internal change agents took various forms that included senior executive sponsors, Concurrent Engineering champions, product champions, organised change teams of individuals from different levels of the organisation and/or senior management steering committees and included both full-time and part-time members. The size of the change agent body and the scope of their role varied across the sample. Some organisations contained a hierarchy of internal change agents. Senior management viewed it as being a long-term role that formed an important part of managing the change process when implementing Concurrent Engineering. Their primary role was extremely demanding as they were often broadly tasked with helping senior management to drive the Concurrent Engineering implementation process and trying to change people's values, attitudes and behaviours.

FACTOR 3: Team Enrolment

Multi-disciplinary teams were at the centre of all the Concurrent Engineering implementations studied, bringing together knowledge and expertise from different organisational functions during the early phases of the product development process. They were presented as being an efficient and effective way of improving informal communication and functional integration within the organisation and thereby improving product development lead-times, costs and quality.

Involving all the necessary functions (or as many as possible) in the product development process at the appropriate times was reported to have ensured productive team working and hence successful product development. This process has been termed team enrolment. It includes the decision-making processes associated with the issue of functional team representation.

During the earlier pilot projects the selection of team members and leaders was often carried out in an informal and unstructured manner. There were no formal selection processes in place to match the skills of the team members and leaders to the requirements of new product development projects.

A further two important processes were identified as being closely related to the effectiveness of multi-disciplinary teams. Senior management's involvement appeared to be instrumental in their successful implementation. The first process has been termed team engagement and incorporates senior management's main considerations regarding the set up of multi-disciplinary teams. It includes how team members and leaders were selected and the length of their assignment to the teams and where and how they were located to work as a team unit. Complementary to engaging the team, was the second process of empowering it to carry out its product development activities successfully. This process was seen to consist of two main elements which were the assignment of new roles and responsibilities for team members and leaders and ensuring they were given a collective challenge for which they felt ownership.

FACTOR 4: Team Engagement

Tenure of Team Leader and Team Member

In many cases the functional representation of teams varied during the course of the project as it moved from one product development phase to another, requiring different types and levels of expertise for specific tasks. As all functional skills and expertise was not required at a consistent level throughout the project, most teams comprise a combination of full-time and part-time team members. A popular approach adopted by many organisations was the use of full-time core teams and leaders, supported by part-time extended teams.

Collocation

Many organisations had moved their project team members physically closer together from their different functional departments to a new location. This was observed as being an attempt to improve informal communication by encouraging team members to shed their functional sub-cultures to focus more freely on the whole product development process.

The permanent collocation of core team members from different functional departments and the team leader and dispersion of the extended team members was the most prevalent method of improving multi-disciplinary interaction.

FACTOR 5: Team Empowerment

Clarifying Team Leader and Team Member Roles and Responsibilities

Devolving product development decision making power and authority through the assignment of new roles and responsibilities was mainly initiated through the mediation of informal and/or formal discussions, involving senior management, functional management, team members and leaders at different times. Their purpose was seen to help clarify to the team members and leaders their roles and responsibilities within a team working environment. Although it was shown to be an important activity, in many cases it appeared to be one that was poorly administered and caused significant confusion.

In some cases the team leader's roles and responsibilities had been generated through more formal methods including workshop discussions. They were then documented and incorporated into the organisation's operating manuals. However they appeared to be generally used as a check point at times of conflicting interests, due to the adjustments people were making to the new way of working. There was no evidence to suggest they were re-negotiated and re-constructed formally as the project progresses to reflect the changing requirements of team leaders and/or senior management's expectations as their experience of Concurrent Engineering developed. This construction of collective roles and responsibilities tended to occur informally between the team members and team leaders during the course of the project.

Ownership Of Collective Challenge

In every organisation senior management had given a collective challenge to the teams and they were encouraged to always keep sight of it. It appeared to be an effective way of giving them a common purpose and getting them focused on what they had to achieve. The collective challenge was generally explicitly stated within the product specification and/or business case documents. It referred to the product development performance criteria, usually based on product cost, quality and/or time to market attributes. In most cases there was a strong emphasis on improving time to market performance, as the means by which the organisation could improve its competitive position.

The collective challenge manifested itself in the context of two early product development activities, namely the development of the product specification and project plan. The teams' level of involvement in these activities appeared to be associated with the level of ownership they felt for the collective challenge. Although senior management encouraged teams to participate in the development of the project plan this was less apparent in the development of the product specification. Their encouragement appeared to be founded on the belief that greater participation in these activities would help to build the team's commitment to the project.

FACTOR 6: Gaining Commitment of Functional Managers

In most organisations it appeared that functional managers were not actively involved during the early stages of planning and executing the implementation of Concurrent Engineering. They were however generally invited to participate in the early Concurrent Engineering awareness and educational presentations given by senior management and the internal change agents. In some cases they were assigned as educators and informants of Concurrent Engineering within their home functions. Nevertheless insecurities about their role were apparent, as senior management did not fully explain their future role in a Concurrent Engineering working environment.

Senior management and internal change agents tended to use functional managers to gain information sporadically rather than actively involving them in the Concurrent Engineering planning and execution activities. Consequently their commitment to change appeared to be weak.

FACTOR 7: Realignment of Organisational Processes and Structures

Some organisations that had completed or were near completion of their initial pilot projects began to analyse their organisational structures and business and functional processes. The purpose of this activity was to discover ways in which they could be best aligned with the new way of working. In this capacity changes were being planned and implemented in the following areas:

- Consolidating a matrix (or hybrid) organisational structure
- Introducing process improvement teams
- Introducing an incremental improvement product strategy
- Elaborating the concurrent engineering awareness,
- Education and training for teams
- Introducing team based performance measurement and
- Reward & recognition systems
- Introducing methods of transferring team knowledge

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IMPLEMENTATION METHODOLOGY

- Demonstrate the importance for Concurrent Engineering
- Select a Pilot Project to Introduce Change
- Assign Resources
- Identify Strategies and Objectives
- Demonstrate the Benefits and the Need
- Enhance Knowledge
- Organisational Culture and Group Participation
- Continuous Improvement
- Document the Output

This section draws heavily from the key requirements that guided the development of the Fast CE implementation methodology of Cranfield University, UK, and the work carried out by two Masters students at CAMR, University of South Australia.

IMPLEMENTATION METHODOLOGY

As most changes in SME's, Implementation of Concurrent Engineering (CE) involves a top-down-approach. The initiative of implementing CE in an SME should be taken by the top management. By doing so implementation processes in the organisation will have wider acceptance and participation.

Demonstrate the Importance for Concurrent Engineering
Even if top management is directly involved in the implementation process, they need to demonstrate the importance of the implementation of CE. Assigning resources for the CE project and initiating a pilot project to test the viability in the organisation can demonstrate the importance.

Select a Pilot Project to Introduce Change
A Concurrent Engineering pilot project team should be launched as soon as possible. By starting small, a degree of comfort can be generated and the risk of making costly mistakes minimised.

Effort should be placed in selecting the right pilot project. This should be an important project to the company, for example the introduction of a new product rather than smaller, less complex projects requiring only incremental improvements or enhancements to existing product lines. The team should be provided with a clear product specification, product development target and distinct boundaries for making product development decisions. The pilot project team should then begin product development activities as soon as possible to encourage the company to learn fast through experience.

Assign Resources
Setting up a task force to implement CE in the organisation, and assigning human resources and financial support for the taskforce will help the pilot project to move forward. The task force should be accountable for the budget and that was allocated. Very often resources are one of the biggest obstructions for introducing projects in SME's.

Identify Strategies and Objectives
CE is not to be implement for the sake of implanting it. CE should only be implemented if there is a clear need for a change and improvement. This need should be aligned with the company's visions, strategies, objectives, and the underlying reasons for the change. CE is not a quick fix for persistent problems in the organisation and short-term view will not help the implementation of CE, since most of the benefits through changes flows into the organisation after two to three years.

Success of a pilot project can clearly demonstrate the benefits to all involved. The implementation methodology should therefore initially concentrate on early, positive actions that senior management and the pilot CE project team can take to increase the likelihood of a rapid and successful launch of CE implementation.

Demonstrate the Benefits and the Need
If possible, the taskforce should select a new product development or re-design of a product that have really good chances to be a success as a pilot project. This will assist in avoiding the resistance to support, and will facilitate a complete incorporation of CE. Only people with

open minds and who have willingness to challenge old paradigms should be selected in the pilot project.

In order to win support from as many as possible for implementation CE process in the organisation, it is essential everybody understand the need for a change. Whether the reason is proactive (market will change), reactive (market is changing) or crisis (market has already changed) the full understanding by employees the motive for change will help expedite the process. Therefore, it is advisable to give more specific information about CE to enhance the knowledge on CE.

Enhance Knowledge

There are several possible ways to enhance knowledge about CE in an organisation. If any of employees are knowledgeable or have experience in CE, he or she can train and lead the pilot project; otherwise someone with the experience on CE outside the organisation can be brought in to train for the taskforce. A third way is to hire a knowledgeable consultant as a CE mentor. The mentor can participate during the whole pilot project as a provider of necessary knowledge. The mentor need to asked to make sure that everybody in the organisation understands the principles of CE and their roles in the project. The mentor will also try to create the right culture within the team to facilitate the teamwork.

Organisational Culture and Group Participation

A good organisational culture supports teamwork. Teamwork relies on positive attitude of people and organisational culture. In an organisation, facilitating interactions where they share and transfer knowledge and information will improve the team sprit. The team needs to have the commitment to make CE a successful process. Selecting and training leaders in new leadership skills, training employees in team member skills, conducting few meetings with employees to generate commitment and establishing a cross-functional implementation team with expertise in all relevant disciplines are some of the techniques which will enhance the teamwork and the organisational culture. Managing a change is more effective if those required to change have a high level of ownership for the changes required and feel that their ideas and opinions have been accounted for.

Concurrent Engineering is a cross-functional change process, as employees need to be drawn from all parts of the organisation into multifunctional product development teams. For Concurrent Engineering to be successful, it cannot be driven from just one department within the organisation, and must be supported by the managing director or chief executive officer. The implementation methodology should bring together the managing director and senior managers from all functions to work together to plan the changes.

Once selected, the pilot project team members should be actively involved in the early implementation activities. They should work along side senior managers to ensure that a cross-section of views on the change process are represented and ownership for the implementation is widespread. This will help break some of the hierarchical barriers that exist as well as the more traditional focus of CE on breaking down barriers between departments. It will also introduce a process of negotiation between managers and the team.

Continuous Improvement

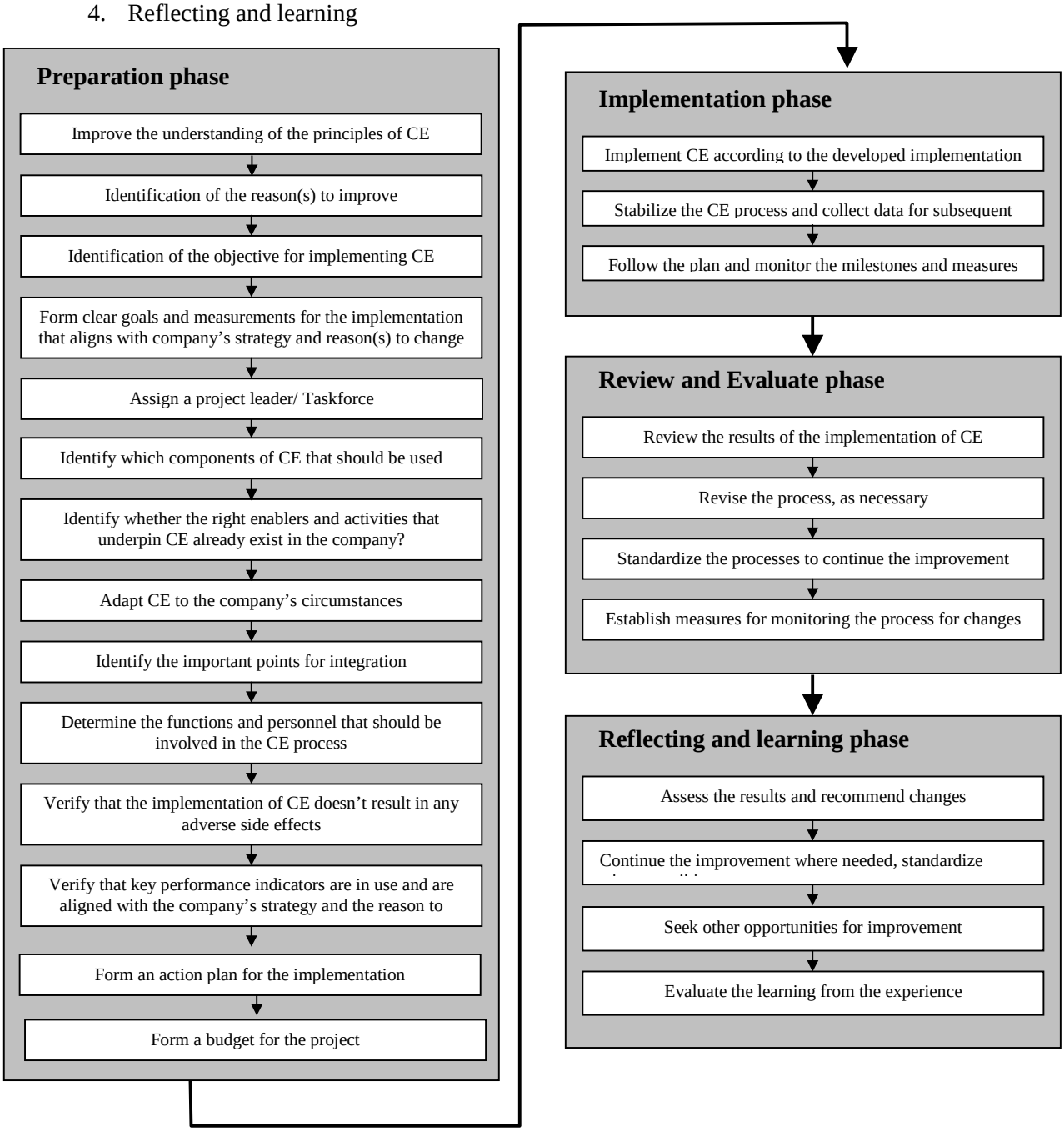
The objectives, strategies and underlying reasons for the implementation of the project should be carefully examined and decided in the planning phase of the pilot project. A pilot project followed by a continuous improvement drive provides a lower risk approach and minimises the number of changes and the amount of training that would have to be accomplished if a more ambitious start is taken. It also enables the organisation and its members to learn gradually and adjust their behaviours and actions to meet the changes occurring in their environment.

Documenting the Output

Documentation is an important part of the implementation process as it ensures that a permanent record of decisions and actions is kept for future reference. Earlier decisions can easily be referred back to as the implementation progresses. The implementation methodology should provide a method for easily capturing and recording important decisions.

Implementation of Concurrent Engineering can be considered along the following four phases:

1. Preparation
2. Implementation
3. Review and Evaluate
4. Reflecting and learning



Preparation phase

Improve the understanding of the principles of CE
Before any further work is done the principles of CE need to be understood by everybody involved in the organisation.

Identification of the reason(s) to improve
What are the reasons to implement CE?
- Strategy driven (proactive)
- Identified through the use of benchmarks (reactive)
- Highlighted by the occurrence of problems (crisis)

Identification of the objective for implementing CE
Based on the reason to improve, one must know what the objective (s) is/are. The possible goals for implementing CE are given in Section 3

Form clear goals and measurements for the implementation that aligns with the company's strategy and the reason(s) to change
This information has to be considered while identifying strategies and objectives.

Assign a project leader
In this stage assign a project leader who can provide necessary knowledge, skills and experience about CE to others..

Identify which components of CE that should be used
The components and activities in the list below is a selection of the most common used, it is mainly based on Salomone's (1995) summary of the basic concepts of CE.

Collaboration:
- Organisational support
  - Support of the top management
  - Support from the functions
  - Elevation of the project
- Multi-functional teamwork
  - Collective team responsibility
  - Team autonomy
  - Elimination of barriers to integration
- Leadership required for the whole project
  - Project staff dedicated for life of project
  - Elucidated and clear objectives
  - Elucidated and clear strategies
  - Team contract
  - Budget responsible
- Knowledge
  - Using existing knowledge
  - Training personnel for the task

- Experience
  - Take into account the effects of the firm's organisational culture and prior experience
- Skills
  - Talented and competent employees, managers and team members
  - Willingness to collaborate and learn
  - Ability to recognize one's own strengths and weaknesses
- Mentor to support CE implementation

Technology

- Information technology
  Client/Server hardware and networking software
  Database software
  Analysis and simulation software
  Communication technology
  Environment/desktop software
  Computer aided tools
  Co-location of personnel

Identify whether the right enablers and activities that underpin CE already exist in the company?

The enablers can be:

a. Culture of change
b. The positive attitude
c. Good communication between different units/functions associated with the product life cycle
d. Open organisational structures such as matrix management and teamwork
e. The knowledge and skills to understand the company's own needs and potential solutions
f. Supplier and customer involvement
g. Knowledge about CE and its components

Adapt CE to the company's circumstances

Explore if there are any specific circumstances that need to be considered. A SWOT analysis can be very helpful in this stage to ensure that the company's circumstances are considered.

Identify the important points for integration

Explore what activities can be performed in parallel? The priorities for the project need to be considered when deciding this issue.

Determine the functions and personnel that should be involved in the CE process

Below are the most common functions that are involved in a NPD process.

- Product development
- Manufacturing engineering
- Marketing
- Sales
- Service
- Purchasing
- Finance
- Specialist vendors (e.g. machine tools and other key components)
- Main suppliers and customers

Verify that the implementation of CE doesn't result in any adverse side effects

When implementing CE one must make sure it matches with all the other concepts and strategies already existing within the enterprise. If there is a mismatch somewhere it has to be solved before the implementation process begins.

Verify that key performance indicators are in use and are aligned with the company's strategy and the reason to change
The CE process should not be measured by the same measurements as of the departments/units but have separate NPD measurements. Below are some examples of suitable measurements for the CE process [18]:

- Project schedule/Shipment date
- Market penetration goal
- Revenue goal
- Product cost goal
- Development cost goal
- Functionality
- Expected volumes

Form an action plan for the implementation

Form a budget for the project

Implementation phase

Implement CE according to the developed implementation plan

Stabilize the CE process and collect data fore subsequent assessment

Follow the plan and monitor the milestones and measures

Review and evaluate phase

Review the results of the implementation of CE
Did the concurrent engineered processes produce the desired effect? Did any unintended consequences or adverse side effects result?

Revise the process, if necessary

Standardize the processes to continue the improvement

Establish measures for monitoring the process for changes

Reflect and learning phase

Assess the results and recommend changes

Continue the improvement where needed, standardize where possible

Seek other opportunities for improvement

Evaluate the learning from the experience

Resources for Implementing CE

Organisations in Australia

- National Institute for Manufacturing Management/Smartlink: www.smartlink.net.au
- Centre for Advanced Manufacturing Research (CAMR): http://www.camr.unisa.edu.au
- Centre for Innovation, Business and Manufacturing (CIBM): http://www.cibm.com.au/help/improvement.htm

Tools

- Guidebook/ Workbook developed by researchers at Cranfield University:
  Lettice FE, Evans S and Smart P. 1999. "Using concurrent engineering for better product development: A resource for implementers", Cranfield University, ISBN 1 87131 575
  Available to order from l.buckley@cranfield.ac.uk Price: £95

- Best Manufacturing Program, Centre of Excellence www.bmpcoe.org includes free online guidelines, tools, and database of cases.

- Software based tools e.g CEPRA (Concurrent Engineering in Practice) co-ordinated by CE-Consulting is an innovative computer-based support environment for Concurrent Engineering adoption, targeted to SMEs in Aeronautics . It is being pilot tested currently. www.biba.uni-bremen.de/projects/CEPRA/results.html

Information on the worldwide web

- Society of Concurrent engineering www.soce.org
- FAST CE research http://www.cranfield.ac.uk/sims/ecotech/projects/fastce1/fastceintro.htm
- Concurrent Engineering Research Centre www.cerc.wvu.edu

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