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Decision Engineering

Global Product

Strategy, Product Lifecycle Management and the Billion Customer Question

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Preface

This book has two main subjects. The first is Global Products. The second subject is the method for identifying, developing, producing and supporting Global Products.

Global Products are manufactured products that can be purchased and used worldwide, and are maintained and supported worldwide. The range of Global Products is wide. It includes industrial goods such as trains, aircraft and machine tools, as well as consumer goods such as cars, food, apparel and consumer electronics.

Chapter 1 introduces Global Products, giving examples of both consumer products and capital goods, and explaining their increasing importance. It shows the opportunities that Global Products offer, the questions that they raise, and the challenges that they set.

Chapter 2 describes the factors that have led to the emergence of Global Products. It highlights more than 20 issues, some of which create opportunities for Global Products, some of which create problems, and some of which do both. An understanding of these issues helps one understand how to respond to challenges rooted in the past, how to benefit in the future from the opportunity of Global Products, and how to identify and avoid related risks.

Chapter 3 shows, using documented cases, how a serious problem with a product will be investigated. The effects will be described, the causes understood, and necessary measures identified and implemented to prevent the problem recurring. By taking a similar approach, companies can identify potential problems with Global Products and take measures both to avoid them before they occur and to improve performance.

Chapter 4 includes examples from individual companies in various industry sectors. It shows the type of issues they face in the product environment, the steps taken to address them and the results.

The situation in every company is different. There are many reasons for these differences, such as different products, different markets, different managers, different employees and different organisational structures. Due to these differences, there is not a single common solution that will be applicable in all companies. However, Chapter 5 proposes Best Practices for Global Products that can be applied in many companies.

Chapter 6 brings together many of the subjects addressed in the previous chapters, and positions them in an overall framework. The framework helps to show how the various components of the product environment are related, and how they are positioned in the different phases of the product lifecycle.

Chapter 7 introduces the Product Lifecycle Management (PLM) activity that allows a company to manage its products across their lifecycles, maximising the value of current and future products for customers and shareholders. PLM is the enabling business activity for Global Products.

Chapter 8 briefly describes the many applications, processes and techniques that are used to manage a product at different times of its life. These are components of PLM.

Chapter 9 shows how to build a Vision and Big Picture of the future product environment in the company that will allow it successfully to identify and deploy Global Products.

Building an environment for successful management of Global Products is, for companies of all sizes, a long-term task. Chapter 10 describes the current situation in typical companies.

Chapter 11 looks at some potential future influences on Global Products and PLM.

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1

Global Product: Opportunities and Challenges

1.1 Global Products and You

Global Products are of great importance to you, your family and friends, your company, your country and Mankind.

You will be interested in Global Products if you work for, or invest in, a company that develops, manufactures, sells, supports or recycles products. The company's revenues result from sales of the products and related services. Get things right with Global Products and the company will succeed. Get them wrong and the company will have problems.

Even if you don't work or invest in a company, you should be interested in Global Products. Maybe, like billions of other people, you use them every day. You probably have ideas about how they could be improved. You may have ideas for new products. Sometimes you may wonder about the thousands of new products that will appear in the next few years, bringing you even more pleasure and comfort.

Maybe, though, like billions of other people, you live in a country where many people don't have access to products such as clean water, enough food to prevent starvation, life-saving drugs, electricity, basic education and decent housing. If so, you may look forward to increased availability of Global Products enabling your family and friends to escape from ignorance, squalor, poverty and disease.

1.2 What is a Global Product?

A Global Product is a manufactured product that:

- Can be purchased and used worldwide
- Is maintained and supported worldwide

and has probably been:

- Developed and engineered in many locations
- Assembled from materials and parts manufactured in many locations

A Global Product is usually available in many options or variants, for example, in different colours and different sizes. New versions are launched frequently. There may be a new version each year or each quarter. There may, as in the fashion industry, be a new version each season. There may be special versions for special events such as the Olympic Games and the World Cup.

Global Products may be consumer products, in which case they usually have a brand name known to consumers worldwide, or they may be industrial goods (also known as capital goods) such as civil aircraft, machinery, telecom equipment, power plants and chemical products.

If they are industrial goods, their brand name is known throughout the world to companies and other organisations in their particular industrial sector. And the customers and users of these organisations' products and services may also know their brand name. For example, aircraft brand names are known to their customers (*e.g.* airlines) and to air travellers (the customers of the airlines).

The range of Global Products is very wide. It includes trains, tractors, cars, aircraft, tyres, food, beverages, clothes, watches, office equipment, white goods such as cookers and refrigerators, pharmaceutical products, soap, toothbrushes, machine tools, computer software, computer games and consumer electronics products, such as PCs, television sets and mobile telephones.

You probably use many Global Products. You probably even like many of them. There are probably many in your home, where you work, where you study, where you relax and where you holiday. You probably travel in them, eat them, drink them, wear them, read them, watch them and listen to them. When you are not well, they help you get better.

1.3 Why are Global Products Important?

Global Products provide huge opportunities. They allow billions of people to benefit from products to which they previously had no access. They allow companies to offer products to a global market of more than 6 billion customers and users. The resulting opportunities for sales and profits are enormous. So are the potential risks.

For most companies it's only recently that such opportunities have been available. In the 1990s, although many companies were international, or multi-national, only a few were able to offer a product throughout the world. Others were limited, for one reason or another, to smaller markets. There are several reasons for the changed situation, including the end of the Soviet Union in 1991, economic reforms in China that started in 1978, economic reforms in India that started in the

1980s, reduced trade barriers, and improved travel, transport and telecommunications.

As a result of the changes, the potential market for most companies is no longer a few hundred million customers for the product in a local regional market, but over 6 billion customers worldwide. Which means that, for many companies, the potential market is already more than 20 times larger than before. And the market is expected to grow to 7 billion by 2012, 8 billion by 2025, and 9 billion by 2040.

The unit of measure for use of consumer products is now the billion. There are more than a billion PCs in use. There are billions of mobile phones in use. There are more than a billion Internet connections. In 2006, the world's airlines carried more than 2 billion passengers. Billions of items of clothing and footwear are sold each year. There are more than a billion vehicles (cars, trucks, buses, motorcycles, and bicycles) on the world's roads. More than a billion people wear a watch. There are more than a billion copies of word processing software.

One Laptop per Child, a non-profit association, developed a $100, robust, low-power-consumption computer that connects to the Internet. There are billions of potential users throughout the world.

There are more than 10 billion embedded systems in products. These are the very small devices – usually with computing, control and communication capability – that are built into more and more products, such as mobile phones, cameras, elevators, cars, medical devices and robots to provide new functionality.

There's nothing to stop your company taking a slice of the billion-customer market. For example, in the early 1980s, US manufacturers dominated the world market for large civil aircraft. Yet 20 years later, Airbus, which is part of the European Aeronautic Defence and Space Company (EADS N.V.), had taken a 50% share. The most successful Airbus product family is the A320 family (which includes the A318, A319, A320 and A321). By the end of 2006, nearly 5000 aircraft of the A320 family had been ordered, and nearly 3000 delivered. With a catalogue price of about $50 million, that's trillions of dollars of sales.

In 2006, sales of the BMW brand, at nearly 1.2 million vehicles, were close to double the figure of about 700,000 recorded in 1998. BMW's home is in Munich, Germany. It only started producing vehicles in the US in 1992. By 2006 it manufactured at 22 sites in 12 countries on 4 continents.

Toyota's annual vehicle sales in the 1970s were about 3 million. They grew to 4 million in the 1980s, and 5 million in the 1990s. Production is planned to rise to over 9 million vehicles in 2007. Toyota began exporting to the US in 1957. In 2006, Toyota had manufacturing companies in 28 countries, design and R&D centres in 5 market regions (North America, Europe, Australia, Asia and Japan), and marketed its vehicles in more than 170 countries and regions of the world.

There are similar examples from other industry sectors. In 2005, sales of The Coca-Cola Company reached 20.6 billion unit cases – nearly 500 billion servings. The Coca-Cola Company sells more than 400 brands in over 200 countries. The geographical sales split in 2005 was 28% North America; 6% Africa; 9% East, South Asia and Pacific Rim; 16% European Union; 25% Latin America; 16% North Asia, Eurasia and Middle East.

The opportunities of Global Products aren't limited to just a few large companies with thousands of employees. The opportunities are also there for small and medium companies, with tens or hundreds of employees, of which there are millions throughout the world. The smaller company may sell its product direct to end users and consumers worldwide. Alternatively it may supply its product to a larger company, operating worldwide, that will include it in the products it offers to its customers.

1.4 The Challenge of Global Products – Customer View

As a potential customer of a global consumer product you probably see it first on the Web, or on television, or in a magazine. It's probably being used by happy, healthy, beautiful people and you want to share the experience. You want that product, and you are going to pay good money for it. It goes without saying that you want a product you can use. You want a product that you can use where you live, in your country. And you want product documentation and instructions in a language you understand. You don't want, for example, a car built for people in a country where the average height is 15 cm less than in yours. You don't want a product – or product packaging or product labelling – that is offensive to your religion or national culture. You don't want a product that you can't even use in your own country because it falls foul of government regulations.

Similarly, if you are a user of an industrial product, you want it to be easy to use and safe. You want understandable operating instructions. You don't want to work all day at a machine that was built for a country where people are on average 15 cm taller. You don't want to strain your arm and leg muscles all day long to work the machine.

As a customer or user of a Global Product, you may not even realise that it is a Global Product. You probably don't think about how it was developed, manufactured and made available to you. That's not your concern. You just want it to work the way you like.

1.5 The Challenge of Global Products – Company View

However, if you work for a company that develops, markets, produces and/or supports products, you can probably think of a few questions that your company needs to answer if it is looking at the opportunity of Global Products.

For which geographical markets could we offer such products? The whole world? One continent? Several continents? Just a few countries? If so, which ones? Would we introduce a new Global Product everywhere in the world at the same time, or introduce it first in one market, then in the others?

Should we sell direct to the customer everywhere, or should we sell through third parties? Should we sell direct in some countries, and through third parties in others? Should we provide support directly to customers everywhere, or should we provide support through third parties? Should we sell over the Web?

Should we have the same price everywhere, or adjust the price to each market? Should the price be quoted in our Head Office currency, or that of the customer? If we have the same price everywhere, should we quote it in dollars, or euros, or yen? And what happens when exchange rates change? Which prices do we change?

Should we have one product for customers throughout the world? Or should we have a different product for each continent, or even a different product for each country? Maybe we know what a potential customer in Columbus, Ohio wants, but how about customers in Seoul and Bogota? Will the same product satisfy customers in Vostok, where the temperature can drop to -129 °F, and in El Azizia, where it can rise to 136 °F? Should we have one product for everybody, or different products for women and for men?

What architecture should we have for our Global Products? Should the product be modular? If so, how do we decide on the modules? How do we define the interfaces between modules? Will interfaces be country-specific? Will we have product platforms? How do platforms relate to modules? Should we have a core product that we can sell world-wide with local customisations? If we are able to make a product that we can sell world-wide, how can we retain market leadership over other companies in the world that, presumably, can do the same thing? Which of our competencies really set us apart from competitors? Which of our product features and functions set us apart?

Where will we develop our Global Products? In a single location where we can bring our best people together and give them the best tools in the world? Or, to be closer to the market, should we develop in several regional locations, even though this implies limited resources at each location? Should we develop the product in one location and then offer the same version worldwide? Or should we develop in one location, and then localise that development in different locations round the world? Or should all the locations work together to develop a common product that can then be produced with local variations? How will we know what to develop for customers in faraway places? How will we know on which development projects we should work? How will we manage development projects that involve companies in different locations with different management structures?

Will we manufacture in-house? Or should we just assemble in-house? Should we move all our manufacturing to a new subsidiary that we build up in a low-cost country? Should we outsource manufacturing? Should we always work with our "preferred suppliers", or should we always select on the basis of lowest-cost? And what happens if, as a result of exchange rate changes, another supplier becomes lower-cost than a previously preferred low-cost supplier? And what about design? And development? And marketing? And IS? And finance? Should we outsource them? What should we outsource, what should we keep in-house? What should we offshore, what should we keep at home?

How will we inform customers around the world about our products? In which language? Over the Web? On television, in magazines, in journals, in newspapers, on billboards? Should we have the same message in all countries?

How will we address regulatory issues? Should we specifically aim to meet regulations country by country? Or should we aim to have a product that will meet the toughest regulations in all countries so that we are sure we can meet all country-specific regulations?

Which business processes should we use? Which IS applications? Should we use the same processes and applications everywhere in the world? If not, what must be global, what can be local? Should we use a set of IS applications from just one vendor, and hope that will eliminate integration problems between applications in different application areas? Or should we use best-in-class applications in each area, even if they are from different vendors and do not integrate well? And where should we store the data that defines our products? How can we keep it safe from envious prying eyes?

How will we train our people? Should everybody get the same training, or should training be country-specific? Should we speak the same language everywhere?

1.6 Practical Considerations and Potential Risks

Global Products offer the opportunity of billions of customers, greatly increased sales and vastly increased profits. But, from the above questions, it appears that developing and supporting products worldwide may not be as easy as talking about billions of dollars. There's an awesome number of questions to answer.

Apart from all those questions, what if something goes wrong? If something does go wrong, billions of potential customers could hear about it, billions of dollars could be lost, and large numbers of people could lose their jobs.

For example, the whole world seemed to hear that, in 2006, Airbus had a problem with the development of its A380 aircraft. In June 2006, the share price of EADS, which had been close to 36 euros in March 2006, dropped under 20 euros. The problem was the delivery date for the A380. In July 2000, Airbus had announced that first deliveries to customers would take place in the last quarter of 2005. In October 2006, Airbus announced that the first Airbus A380 series aircraft would be delivered in the second half of 2007 – two years late. The A380 is a Global Product. At first glance, Airbus looks European. EADS is headquartered in Schiphol, The Netherlands. Airbus has major facilities in Toulouse, France and Hamburg, Germany. However, in 2005 the US was the leading supplier country to Airbus – with $8.5 billion of parts, components, tooling and services. And the first A380 delivery was expected to be for an Asian airline, Singapore Airlines. And an Australian airline, Qantas, was near the top of the delivery list.

The problem with the A380 occurred well into the development project. However, problems with global products can occur even earlier in their lives, for example during their specification. An example is the Airbus A350. Its commercial launch was in December 2004. At that time, it was expected to enter service in 2010. The initial specification was based on an extension to an existing aircraft, which implied rapid availability and a relatively low development cost. However, in view of limited interest from potential customers, an aircraft with a new design, the A350 XWB (Extra Wide Body), was proposed in 2006. Entry into service was announced for 2013, three years later than previously expected.

Problems can also occur during product manufacture. For example, in 2006, computer makers such as Apple Computer, Dell, Hitachi, Lenovo and Toshiba announced the replacement of Sony-made lithium-ion batteries that could overheat in certain circumstances and pose a safety risk.

Problems with products can involve big numbers. In October 2003, Nissan Motor Company said it would recall 2.55 million cars at an estimated cost of 15–16 billion yen ($138–148 million) due to an engine defect. In November 2003, Chrysler recalled 438,000 Jeep Libertys due to a suspension problem.

Problems can also occur at product end-of-life. For example, the French Ministry of Defence had problems in 2005 and 2006 with Q790, previously known as the Clemenceau, an aircraft carrier launched in 1957 and taken out of service in 1997. Dismantling the hull for scrap was never going to be easy. It was known that there was a large amount of asbestos on board — variously estimated at between 50 and 250 tons. (Asbestos has interesting properties — long fibres, strength, resistance to heat and fire, *etc*. It was widely used in the early twentieth century until it became clear that inhaling it was dangerous, and could lead to mesothelioma and other diseases.) A failed attempt to dismantle Q790 in Turkey was followed by a decision to dismantle it in India. As a result, Q790 left Toulon in France at the end of 2005 to be broken up at Alang in India. Several weeks later it was refused entry to India. Q790 was then towed 10,000 miles back to France. It berthed in Brest in May 2006, awaiting a decision about its future.

At the other end of the scale from an aircraft carrier are all sorts of shapes, sizes and colours of solids, liquids and vapours produced by the pharmaceutical industry. Merck voluntarily withdrew VIOXX, an arthritis and acute pain medication, in September 2004 because a trial had shown an increased relative risk for cardiovascular events. There were millions of users worldwide. VIOXX had been launched in 1999 and marketed in more than 80 countries.

If products don't meet the rules and regulations laid down by government and international authorities, there can also be problems. For example, in 2001, authorities in the Netherlands found that some peripherals for a game console contained cadmium levels above the Dutch limits. Sony Corp. temporarily halted shipment. The estimated impact on sales was about 100 million euros.

Coca-Cola rates high on most lists of corporations with Global Products. Another type of product-related problem was highlighted in 2006 when it was announced that the FBI had thwarted an attempt to steal and sell Coca-Cola's trade secrets, apparently including information about a new product.

While the above examples of problems with Global Products got widespread publicity, others may only be noticed by a few people. I experienced the following example in 2003, when I went through Gatwick Airport several times in quick succession. The first time, I noticed an "up" escalator was not working. It had a maintenance sign on it. As I walked up the nearby stairs to the bookshop, I wondered why the partner "down" escalator hadn't been switched to "up" to help people with their luggage. Four days later, on my way home, it was in the same state, so I walked up the stairs again. Four days later, going through the airport again, it was in the same state, so I walked up the stairs again. And four days later it was in the same state, so I walked up the stairs again. According to the nameplate, the escalator had been supplied by one of the world's leading global escalator manufacturers. I wondered why product maintenance took so long.

I travel a lot, so I get the opportunity to see a lot of Global Products at work. Quite a lot don't work well – coffee machines in hotel rooms, hotel elevators, electronic keys for hotel room doors, sensor-operated doors on buses, toilet-door locks on trains, vending machines, rental cars that unexpectedly stop working, aircraft that don't start, aircraft that hit another object while being towed to take-off, jetways that don't extend, aircraft seats that should recline but don't, *etc.*

But those are trivial problems compared to some others. For example, you probably saw the pictures of NASA's Columbia Space Shuttle breaking up during re-entry on 1 February 2003. That was the second Space Shuttle disaster. If you were born before 1980, you may remember seeing the first disaster, on the morning of 28 January 1986, when the Challenger Space Shuttle was destroyed 73 seconds after launch. The crew included Christa McAuliffe, who was to have been the first teacher in space.

In 1999, NASA's Mars Climate Orbiter got too close to the planet Mars before entering orbit, and was destroyed. In November 2003, officials at the Japanese space programme announced that a rocket carrying two spy satellites had to be destroyed after lift-off from Tanegashima Island because of an unspecified technical failure.

On 25 July 2000, the crew of an Air France Concorde noticed a loss of power and a fire under the left wing soon after take-off from Paris. The aircraft went out of control and crashed onto a hotel. Two years earlier, on 2 September 1998, not long after take-off from New York, the flight crew of Swissair Flight 111, an MD-11, noticed an abnormal odour in the cockpit. Their attention was drawn to an area behind and above them, but whatever it was apparently then disappeared. They decided it was smoke and decided to land, unaware of a fire above the ceiling in the front area of the aircraft. The fire spread, degrading aircraft systems and the cockpit environment. The aircraft crashed into the Atlantic Ocean near Halifax, Nova Scotia.

Problems don't just occur with high-tech products such as aircraft and space shuttles. They also occur with apparently basic products such as cattle feed. It's thought that the BSE (bovine spongiform encephalopathy) epidemic in the UK in the 1990s originated when an animal developed BSE in the 1970s. The carcase of the animal was mixed into cattle feed. Animals that ate the feed were infected. In turn, their carcases were mixed into cattle feed and infected others. The deaths went more or less unnoticed until 1986 when the disease, also known as Mad Cow Disease, was identified. BSE cases in the UK rose from a few hundred in 1987 to over 35,000 in 1993. Millions of animals were slaughtered, and the European Union banned UK exports until 1998.

Some of the examples mentioned above are high profile and got global publicity. Many others are only known to a few people. For example, one company I worked with wanted to buy a batch of machines. The order was worth a few million dollars, and it took more than a year for the project team to decide exactly what they wanted. Eventually they ordered. "Sorry", said the manufacturer, "we can't deliver from that two-year-old product catalogue. We adopted Japanese manufacturing techniques and have Kanban and Zero Stock of machines. We don't even have the parts to make the machines you want. We purchased them, and the supplier doesn't make them any more."

Another company I work with did receive the brand-new high-tech machine it ordered from another continent, only to find that it didn't work. Somehow there had been a mix-up concerning the hardware components of the machine and the software controlling them. Apparently, the version of the software that was delivered didn't work with the hardware that was delivered. By chance, in a restaurant one evening, I met the service engineer sent to fix the problem. He told me that he was on the road every week fixing similar problems. The customers wanted customised products, but his company hadn't implemented the systems to make sure all the parts for a specific order fitted together. What worried him even more was that, when he filed an error report about a part, it took more than a year before the problem was fixed. During that time, the plant went on making the wrong parts and Logistics delivered them to customers. And he had to go and fix them and pretend he didn't know what was wrong.

The above examples show that problems can occur at any time in the life of a product. Sometimes the problem occurs while the product is being developed, sometimes while the product is being manufactured, sometimes while it is being used. Sometimes the problem occurs while the product is in conception, just an idea. Sometimes it happens at the end of the product's life. Making sure that such problems don't occur for Global Products is a major challenge.

The product problems mentioned above are just a few of the many that occur. You can see others at the website of the U.S. Consumer Product Safety Commission. The CPSC is charged with protecting the public from unreasonable risks of serious injury or death from more than 15,000 types of consumer products. Each month it lists about 30 recalls of products such as drinking glasses that can break during use, cameras that can overheat, stools that can become unstable, lawn sprinklers that can crack, candle packaging that can ignite, and sweatshirt hood drawstrings that pose a strangulation hazard to children. Similarly, each month the U.S. Food and Drug Administration lists about 20 recalls, market withdrawals and safety alerts of products such as frozen strawberries, eye drops, blood glucose test strips, wet wipes and pharmaceutical drugs. And the Office of Defects Investigation of the National Highway Traffic Safety Administration lists about 20 Vehicle Recall Reports each month addressing parts such as automatic transmissions, fuel tanks, wiper motors, hoses, connectors, nuts and bolts.

1.7 Mixed Fortunes

Some companies have already benefited from the opportunities of Global Products, and many more will benefit in the future, but not everyone will be a winner.

Airbus sales grew in a market against competition from aircraft such as the Boeing 747, the McDonnell Douglas DC-10 and MD-11, and the Lockheed L-1011. In 1997 McDonnell Douglas became part of The Boeing Company. MD-11 production stopped in 2001. The L-1011 was the last large civil aircraft built by Lockheed. In 1995, Lockheed became part of Lockheed Martin. Boeing is now the only US producer of large civil aircraft.

Sales of BMW and Toyota vehicles more or less doubled in a decade. Ford Motor Company's worldwide vehicle unit sales of cars and trucks stood at 6.6 million in 1995, 6.8 million in 2005.

The opportunities of Global Products are similar for all companies. The achievements of different companies will be very different, ranging from great success to the opposite.

1.8 Global Products: Good News, Bad News and Best News

The Good News about Global Products is that they offer companies the opportunity to address larger markets, to develop a great product, sell it to billions of customers and users, and rack up huge profits.

The Bad News about Global Products is that they are not easy to develop, sell and maintain. There are a lot of questions to be answered, a lot of choices to be made, and a lot of decisions to be taken. Once these decisions have been taken, all sorts of problems can occur. Products can take a lot longer to develop than planned. The wrong product can be developed. Problems can occur during manufacturing. When the product is in the market, a competitor may bring out a better product that will eat into sales. And problems can occur during use, all the way through until the product's end-of-life, where there can be even more problems waiting.

However the Best News — for some — is that their companies will understand the opportunities, questions and potential problems of Global Products. And then they will develop appropriate responses for their products and for their capability to deploy those products to customers throughout the world.

1.9 Global Product and Product Deployment Capability

If a company wants a product to be a Global Product it will need a corresponding global capability to deploy it. The two are distinct. There's the product and there's the product deployment capability.

Sometimes it is useful and even necessary to consider the product and the product deployment capability separately. Sometimes it is useful, even necessary, to consider them together.

The problems of the A380 provide an example of the need to consider the product and the product deployment capability separately. The problem wasn't the product, the A380. The aircraft's maiden flight was on 27 April 2005. FAA and EASA approval was achieved in December 2006. Showing its confidence in the product, Singapore Airlines increased its order in December 2006. The problem was that Airbus didn't have the deployment capability to produce, at the agreed time, the series aircraft with the various cabin and seating configurations specified by its customers.

The A380 example shows the need to consider the product and the product deployment capability separately. In other cases, it's important to link them together. For example, Coca-Cola ran a promotion that lets customers enter the number engraved on the inside of the Coca-Cola bottle cap at a special website to get a free MP3 download. It's a win-win situation. The customer gets free music. CocaCola gets information about product usage, and builds a barrier against competitors without the capability to deploy such a product.

A company has much more freedom in defining its product deployment capability than in defining its product. The product has the constraint that it must meet customer requirements. Two competing companies could offer a very similar Global Product, but they could have very different deployment capabilities.

Once a company has defined an effective product deployment capability, it can use it to deploy many Global Products. For example, once Airbus has the capability to deploy the A380, it can use it for the A350.

1.10 Global Product: A Missed Opportunity

For a variety of reasons, companies can be slow to respond to new opportunities. As a result, it can be expected that many companies will be slow to respond to the opportunities of Global Products.

In some companies, managers will claim that they already have Global Products and a corresponding product deployment capability, so they don't need to take action. In most cases this will not be the case, and the opportunity will be lost.

In other companies, management will feel that business is fine – and not take the opportunity to make it even better.

Sometimes, executives will be busy with a high-priority corporate initiative and not want to be distracted from it. Having defined their plan, they intend to work to it.

In some companies, Global Products will be considered to be the responsibility of a single organisation, such as the Engineering or R&D department. Several years may be wasted before it becomes clear that a company-wide approach is needed.

Sometimes, companies will spend heavily on hardware, software and consultancy services for their product development capability, but it will underperform as they invest nothing in changing their working methods or in training their employees.

As the next chapter shows, the environment of Global Products is characterised by many pressures and drivers, and high levels of complexity and change. In some cases, managers may fail to see or understand all the implications. Instead of addressing the overall issue, they may focus on an individual driver such as cost reduction and miss the opportunity of increased revenues.

2

Global Products: Change and Complexity

2.1 Change

Understanding the opportunities and potential problems of global products, and then developing appropriate responses, is not as easy as it looks. A good way to start is by trying to understand the product environment. This is a useful first step towards overcoming the problems and taking advantage of the opportunities.

Among the reasons for the difficulty of getting the required understanding are the high levels of complexity and change in the global product environment.

A lot of companies would be happy if there were no changes anywhere in the world in the product environment. They could then organise themselves, as well as possible, to provide customers, as efficiently as possible, the same product day after day, year after year. They would not need new products and, over time, would probably be able to eliminate many of the problems with existing products. They could plan exactly how many products to produce and sell. Everyone would be happy. There would be no need for anything to change. As the global population increased, market sizes would increase. As companies went down the experience curve, they would reduce costs and increase profits.

However, the situation in the twenty-first century isn't anything like that. The world environment for manufactured products has changed a lot over the last ten years, and the changed environment continues to change.

As an example of the real world, one company that I work with now renews about 75% of its products each year. It's a medium-sized company in the food industry. Of the 300 or so products it had in 2005, only about 70 were taken forward into 2006. Of the 300 products in the 2006 product range, more than 200 were newly developed. Compared to ten years ago, another company I work with has operations in 20 more countries than before. That gives the company lots more opportunities, but each new country has brought new challenges.

Among the changes that companies face are increased complexity, globalisation, geopolitical developments, social and health issues, changing business models, improved telecommunications, transport and travel, new technologies, new IS applications, new company structures, new customer requirements, changes to products, shareholder influences, financial market influences, regulation, deregulation, environmental concerns and sustainable development issues (Figure 2.1 and Figure 2.2). In such an environment, it's best to have a clear understanding of objectives and capabilities, otherwise the result can be disastrous.

- Globalisation
- Outsourcing, multi-site activities
- Corporate restructuring
- Multi-cultural, multi-lingual environments
- Increasing product/solution/service complexity
- Shareholder demands to increase value
- Mass customisation and personalisation
- Mobile communications
- Product traceability
- Sustainable Development
- Recycling directives
- Evolution and complexity of information systems
- Collaborative product development
- Process focus and reengineering
- Toolbox Information Systems
- Large volumes of data

Figure 2.1. Some challenges facing product companies

2.2 Complexity

Not only are companies affected by many different changes, but the changes are often intertwined. As a result, the product environment is becoming increasingly complex with many interwoven components and numerous interdependencies being affected by many overlapping changes. The resulting environment is so complex that it is often difficult to see what the changes are, and what is really driving them, or to understand how they will affect a particular company and a particular product (Figure 2.3).

Among the changes, some create opportunities, some create problems, some lead to the need to change, some are the source of more changes. The resulting changes can also be a source of change. Unexpected events resulting from changes can be a source of further change. All these changes snowball, making it difficult to know how to respond.

In addition, changes have associated risks, and changes in one area may lead to enhanced risks in another area. If the risks were only related to one component or change in the environment, it might be easy to manage them. Unfortunately though, they are often related to many changes, making their management difficult.

- Improved communications
- Improved supply chain
- Open Source software
- World Wide Web and Internet
- Product lifecycle focus
- Product development performance
- Parallel world of software development
- Effective product innovation
- Products with very long lives
- Knowledge Management
- Retirement of knowledge workers
- Regulatory requirements
- Accidents
- Multiple versions of processes
- High cost of training new employees

Figure 2.2. More challenges facing product companies

2.3 Globalisation

Globalisation can have many effects on a company, even a small one. One positive effect is that, because of globalisation, it now has the opportunity to sell its products and services worldwide. It has the opportunity to find many new customers and increase sales. Another effect of globalisation is that even small and medium-sized companies now have competitors all over the world. And they may find that these competitors bring out similar products, but with better cost/performance than their own models. The increased competition means companies have to be more innovative, develop better products, develop them faster and develop them at lower cost. Globalisation also implies companies have to be close to customers in many places, and understand customer requirements and sell products in many environments. A presence in many countries may be necessary. However, the situation in different countries is different. Companies have to take account of these differences. They have to get pricing right in many different environments. They also have to provide technical information, parts, products and service in many locations – and meet regulations in many countries. They have to coordinate the launch of new and modified products for the global marketplace.

Globalisation is a change that has affected many products. The word 'globalisation' describes the increasing economic interdependence of countries. Harvard professor Theodore Levitt used it in 1983 in an article called 'Globalization of Markets'. In the 1990s, globalisation became noticeable well beyond academic circles. A wave of imports from low-cost countries led to the price of goods dropping in advanced industrial countries. Globalisation isn't something that happened with a single ‘Big Bang’. If it had, it might be easier to address because everything would have changed – and then everything would have settled down. Instead, globalisation is an on-going long-term process, with new effects continuing to appear and nobody being sure what will happen next.

Often the changes described in this chapter may be seen as reasons for change or as effects of change. For example, ‘increased competition’ could be seen as a reason or an effect. For a particular company, increased competition may be seen as an effect of globalisation. However, for that company, increased competition may also be seen as a reason for changing the way it operates.

2.4 Geopolitical Developments

Geopolitical changes, for example those resulting from the end of the Soviet Union, affect the product environment. The end of the Cold War led to many countries taking different roles in the global economy. For example, in 2005, more than half of Poland’s exports went to Western Europe. In 2005, more than 20% of China’s exports went to the US.

Political change in China, and its high availability of low-cost workers, have led to investment by foreign companies and the emergence of China as a large market for consumer and capital goods, a major manufacturing country and a major exporter of manufactured goods. For example, the leading steel-producing countries worldwide in 2005 were China (about 350 million metric tons), followed by Japan (about 100). China’s use of steel rose from about 120 mmt in 1999 to over 300 mmt in 2005.

Russia has become a leading producer of oil and gas, second only to Saudi Arabia in oil production, and the world leader in gas reserves. Russia’s Gazprom had sales over $30 billion in 2004. In early 2007, only Exxon Mobil and General Electric had larger market capitalisations than Gazprom. In 2006, there were nearly as many billionaires in Moscow as in New York.

India has emerged as a leading producer of software, software developers and IS companies. For example, Infosys, headquartered in Bangalore, has become a global IT solutions company with revenues over $2 billion in 2006.

The end of the Cold War enabled many countries that were in the Warsaw Pact to withdraw and join the European Union. By January 2007, the European Union had expanded to include 27 countries, with an internal market of about 487 million people.

The population of China is over 1.3 billion, that of India more than 1 billion. More than 900 million people live on the continent of Africa. Indonesia, Brazil, Pakistan, Russia, Bangladesh, Nigeria, Japan and Mexico all have populations of more than 100 million. These key future markets provide the opportunity of a lot of customers for some providers of global products, although many of the countries appear to be in faraway locations.

2.5 Social and Health Problems

Perhaps it would be easier to provide global products if so many potential customers weren't so far away. Perhaps it would be easier to sell global products if so many people didn't live in poverty. In 1999, according to Human Development Reports from the United Nations Development Programme, 2.8 billion people lived on less than $2 a day and 1.2 billion lived on less than $1 a day.

And, in the West, the rich are getting richer, the poor are getting poorer and the middle classes are becoming relatively poorer. The situation is similar in many ways to that at the end of the nineteenth century and the beginning of the twentieth century, with beggars on the streets of many Western capitals.

The world population is expected to rise from 6.3 billion in 2002 to 9 billion in 2050. Worldwide, the average age is expected to increase by over 50% by 2050. By then, it is expected there will be more people over 60 than under 14. As the world's population grows and ages, the demand for healthcare will increase. In 2006, more than 11% of Germany's GDP was spent on health, and the percentage is expected to grow. Population ageing will lead to a demand for new types of products in areas such as medical equipment, home help robots, pharmaceutical drugs, replacement body parts and geriatric cosmetics.

More people now live in cities than in rural areas. As the world's population grows, and even more people move to cities, the need for decent housing will increase. In 2000, about a billion people lived in slums, but according to current trends, the number will rise to 3.5 billion by 2050. An opportunity for providers of homes and home products.

AIDS was first recognised in 1981. In 1983, its cause, the HIV retrovirus, was identified. It led to a new market for pharmaceuticals. It's estimated that, in the most affected countries, there will be 46 million excess deaths because of AIDS in the first decade of the twenty-first century. According to an UNAIDS report, 38.6 million people worldwide suffered from HIV in 2005. Many of these people live on less than $1 a day, and can't afford high-cost pharmaceutical drugs. An opportunity for providers of low-cost drugs.

2.6 Changing Business Models

The changing environment provides opportunities for new business models to be developed, making life difficult for companies with more traditional models.

Some companies no longer manufacture their products, but outsource all production so that they can concentrate on product marketing, development and sales. Suppliers may bid for outsourced work at an online auction.

Some companies lease their equipment and facilities rather than purchase them.

Some companies offer their products for lease rather than for purchase. Aircraft, trains and cars can be leased. Some software is offered on a pay-for-use basis over the Web rather than for purchase.

Some companies offer guaranteed product performance. They guarantee that their products will run for a certain number of hours per month, or that a certain percentage of products will still be in service after 10 years.

Some companies cut out the traditional sales force by only selling over the Web. Others allow customers to set the price they will pay for a product at an online auction.

Some companies offer products free over the Web, with their income coming from Web advertising.

Low-cost product and service providers often cut out non-essential functions, and get customers to carry out some activities themselves, or to pay for them separately.

Fast-food eateries eat into the restaurant market by offering reduced choice, standard menus and no waiter service. Other companies compete by providing ready-to-eat food and drink products that are sold in shops for customers to eat on the street or next to you on public transport.

Some pharmaceutical companies focus on providing low-cost generics that have the same effect as existing high-cost brand-name drugs.

New microfinance institutions are emerging, such as Grameen Bank, founded by Muhammad Yunus. Their products have billions of potential customers.

Non-governmental organisations and non-profit foundations are starting to develop and produce products, and own their intellectual property, to ensure that products can get to the billions of people in the world who can't afford the prices demanded by multi-nationals based in high-cost countries.

2.7 Improved Travel, Transport and Telecommunications

Improved travel services offer the opportunity to be closer to customers and suppliers in faraway locations.

Improved freight services ease part and product transport, providing the opportunity to be closer to customers and suppliers in faraway locations.

Improved telecommunications offer the opportunity to interact closely with customers and suppliers without being in the same room.

2.8 Revolutionary New Technologies

New technologies have appeared and caused such massive change that they are frequently referred to as revolutions – the Digital Revolution, the Electronics Revolution, the Computer Revolution, the Communication Revolution, the Biotechnology Revolution, the Internet Revolution, *etc*.

Each one of these revolutions leads to change and opportunities. For example, mobile telephony has provided a variety of opportunities to carry out activities in new ways. Billions of text (SMS — Short Message Service) messages are sent each day. Service workers can connect to a central database from the customer site where they are working. On-the-move patients involved in trials of new drugs can send performance data rapidly to researchers. Designers of fashion goods can travel worldwide, yet be creative and deliver new designs within minutes of their conception.

2.9 New IS Applications

In recent years, many new Information Systems have been brought to market. They have provided companies the opportunity to work more effectively internally, and, externally, to get closer to customers, suppliers and partners.

Application systems have evolved. More and more of the activities related to product marketing, development, sales and support have been automated. The cost of functionality has dropped. Applications with functionality that used to sell for hundreds of thousands of dollars now sell for hundreds of dollars.

Database management systems have evolved to manage product data distributed on multiple sites in different countries around the world.

New applications are often implemented as Islands of Automation that are not closely integrated with other applications. Many are not interoperable with existing applications. Often they duplicate or triplicate the functionality of existing applications. Often they have separate databases, duplicating information that is already in other databases and raising questions as to where the "master" is. Time is lost, and errors introduced, as information is transferred manually from one application to another.

Once an application has been implemented in a company to address a particular requirement, it tends to expand and be used to address other activities of the product environment. This on-going expansion of applications raises questions for IS Departments (CIO organisations) as to which applications they should provide to support the company's activities.

Enterprise-wide solutions are becoming ever more complex and time-consuming to implement. These solutions can be so complex that no single vendor can supply all components – leading to numerous partnerships among application vendors and system integrators. Many implementations of enterprise-wide IS solutions fail – some surveys claim failure rates as high as 50%. Increasingly, many small and medium manufacturing companies don't have the in-house resources to implement such complex enterprise-wide systems, so outsource these activities.

IS applications used in R&D, engineering and product development are often developed to address the widest possible market. They tend to be "toolboxes", rich in technical functions and features, but not focused on the specific needs of a particular company or industry. This approach helps minimise their cost, but results in the need for each company to work out how best to use them in their particular industry environment.

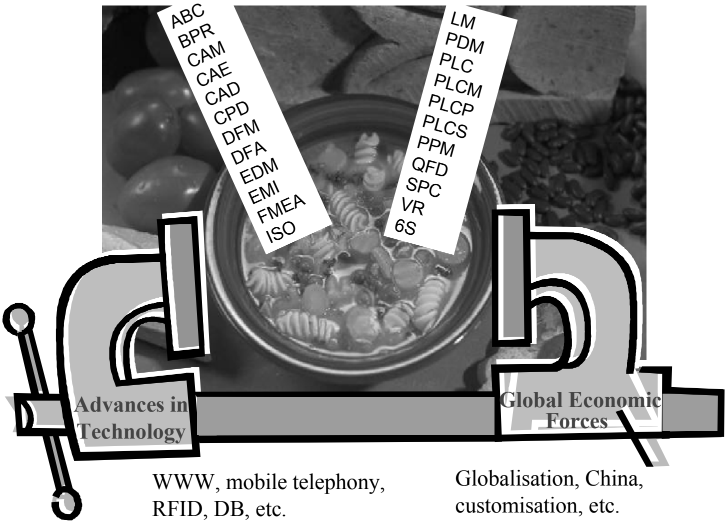


Figure 2.3. More pressure on the product environment

The Web and the Internet have provided the basic technology to allow many activities to be carried out faster and/or at lower cost. They enable information to be transferred faster. For example, engineering drawings can now be sent by e-mail or over the Web, instead of by post. Product requirements can be collected through questionnaires on the Web. Cars and other products can be configured and ordered on the Web. Development data in a Web-based project workspace can be shared between workers on several sites. Developers at different locations can review product designs together. Maintenance staff working on customer sites can get product data over the Web. New Web-based sales channels (B2C, B2B, trading exchanges, *etc.*) remove waste from the supply chain and get products to customers faster. Web-based developments are often relatively simple to implement, and provide companies with new opportunities. However, due to the freedom provided by the Web and the Internet, it is not easy for companies to manage the use of such functionality. It can be difficult to make sure that information remains coherent, and that competitors are not able to break in and browse through confidential know-how, looking for new ideas and gaps to exploit.

With new IS applications, more products are modelled and analysed, more information is developed about product models, and more analysis and simulation is carried out. As a result, the volume of product definition and product-related data that is generated is enormous. Whereas developers once thought in terms of megabytes of data, they now think more of gigabytes – and organisations think in terms of terabytes (10^{12} bytes), petabytes and exabytes (10^{18} bytes) of data. The high volume of data is needed to develop better products, but it also increases the difficulty of managing and keeping control of data. When applications are upgraded, it is often difficult to know exactly which data does not need to be transferred to the new application, so all the data is transferred, including that which is not needed. Moves towards the "Paperless Office" often have the opposite effect to that intended, with each worker creating an unofficial and poorly managed archive of thousands of pages of paper-based information.

As IS applications and databases have evolved, the value that users try to draw from data has increased. Information is more valuable than data, knowledge more valuable than information. Companies want to make sure that the data that is entered into computers can be easily and correctly interpreted, and is available as knowledge.

2.10 New Company Structures

Company structures have changed in response to the changing environment. Many products are now the result of the concerted effort of an Extended Enterprise made up of a manufacturer and a chain of suppliers. The automotive industry has been accustomed for decades to these chains of car manufacturer, Tier 1 supplier, Tier 2 supplier, Tier 3 supplier, *etc.* The concept became widespread in the electronics industry in the 1990s. In the aircraft industry, Boeing adopted it at the beginning of the twenty-first century for the 787 Dreamliner. The concept is now found in most other industries.

In the automotive industry, parts and products are developed round the world. As an example, in 2006, Ford Motor Company gave Gold and Silver World Excellence Awards to 45 global suppliers for exemplary performance in 2005. Among the award winners were companies from Australia, Brasil, Canada, China, Denmark, France, Germany, India, Japan, Korea, Mexico, South Africa, Spain, Taiwan, Turkey, the UK and the US.

A few years ago, suppliers of parts and components used to be referred to as Original Equipment Manufacturers (OEM), as they were the original manufacturers of the equipment included by another company in its products. In recent years the meaning has changed, and the company that incorporates parts and components from suppliers is now referred to as the OEM. Many OEMs put in place different chains for different products, or even for different product derivatives. Participants in the chain may be located in different time zones, with different business processes and different application systems. The long, widely dispersed chain necessitates better planning and control, better communications and well-defined business processes and information use.

In the early 1990s, globalisation led to imports from low-cost countries causing the price of goods in industrialised countries to drop. In response, companies in industrialised countries reduced their costs by outsourcing production to low-cost countries. In addition to outsourcing of production, companies then started outsourcing product development and service. Outsourcing provides the opportunity for a company to focus its efforts on the activities it considers most important and/or provide its competitive advantage, while getting other companies to carry out activities it considers less important. The companies it outsources to can usually do these activities either better or at lower cost. In other cases, the outsourcing company may not even have the resources to carry out these activities.

Outsourcing modifies a company's flow of information and materials — leading to the need to realign processes and applications. Product development and support activities are complex and difficult to control even when they are in one company and on one site. When they are spread over many companies in many locations, their complexity increases, as does the danger of loss of control. Outsourcing has led to long design, supply and support chains with the result that product development, manufacturing and support activities are spread out over different organisations, often over different continents. Managing them when they were in one company in one location was difficult enough, managing them across an extended enterprise is many times more difficult.

Since the mid-1990s, many development and manufacturing organisations have moved away from the model of a single R&D or Product Engineering department in one location. For various reasons, they found this was not the most effective approach. In particular, companies have found that research is often carried out faster by small organisations operating without the overheads and bureaucracy of large organisations. As a result, in some cases, a company's researchers and developers are now located in several places round the world. In some companies, much of the R&D work is outsourced to suppliers. In others, research is carried out through partnerships with other companies. Carrying out research on multiple sites offers an opportunity to bring new products to market faster. However, relocating R&D activities changes the organisation of work.

Although the Extended Enterprise may sometimes appear as a convenient way for large companies to reduce headcount and increase shareholder returns, it also provides small and medium companies with the opportunity to increase their sales and to grow their profits. Initially, a small company may just supply one component to a large company. Later it can develop and produce more components for that company, supply it in more regions, and then supply similar products to other large companies. It can also move from supplying individual components to supplying sub-assemblies and assemblies.

Skilled professionals are sought by companies regardless of their nationality or culture. Their diverse skills are seen as an opportunity by companies looking to provide innovative new products. However, as product-related tasks are increasingly carried out by people from different countries working on different sites of different companies in different countries on different continents, the potential for misunderstanding due to different understandings of words, phrases, processes and behaviour increases. Translation increases costs, and the result may not convey 100% of the meaning. Product development projects can slow down as cultural differences between different sites lead to difficulties in finding common solutions.

Many of the first generation of product developers that worked with computers, and implicitly or explicitly defined their companies' information and activity structures and elements, are now reaching retiring age. Born between 1945 and 1950, these Baby Boomers were among the first users of computers at the end of the 1960s and the beginning of the 1970s. By the year 2000 they were in management positions at the heart of their companies' product environments. When they retire, they take with them the knowledge of why and how many activities in their organisations are carried out, and why particular design and other decisions were taken for specific products.

Most companies developing products have the two basic processes of New Product Development and Product Modification. The New Product Development (or New Product Introduction) process is fairly similar in every company, with the same input (requirements for a new product) and the same output (the new product). The Product Modification process is fairly similar in every company, with the same input (requirements to change an existing product) and the same output (the modified product). However, each company has developed its own processes separately, with the result that all companies have different processes. Managing a company-specific process takes a lot of effort. Implementing an IS application to support a company-specific process takes a lot of customisation effort. And, because there are no standard processes of New Product Development and Product Modification, universities and technical schools can't teach students a standard process. So when students join a company, a lot of time is wasted as they learn and understand all the details of the company's specific processes. And time is wasted when an OEM wants to work with several new suppliers, each with its own activities, applications and documents.

Increasingly, companies are offering products that contain a mixture of mechanical, electrical, electronic and software modules. They develop mechanical, electrical and electronic components in a similar way, with similar processes and applications. However, the processes and applications used for software development are generally very different. Using two separate sets of processes and applications creates all sorts of problems, and can lead to customers receiving control software that doesn't correspond to their product hardware.

Companies recognise that future profits will not come from the manufacture of commodity components and products in developed countries. Companies in countries where wage costs are 10% or 20% of those in the US will be able to carry out manufacturing activities at a much lower cost. To survive, companies in developed countries are restructuring to create revenues in other ways. They are, for example, developing ideas for new environment-friendly products, providing customised products, providing advanced products that less competent competitors can't offer, providing services to support product use and improve the customer experience, refurbishing existing products, or taking financial and environmental responsibility for products produced in low-cost countries.

Corporate cultures change frequently with some companies empowering workers to enable them to make better use of resources to meet customer requirements. Other employers offer increasingly insecure part time and flexible employment conditions leading to workforces with little knowlege or understanding of the company they work for – or its products.

2.11 New Customer Requirements

Consumers want a product that corresponds to their requirements. They don't want the standard product imagined by a marketing specialist, or a customer focus group, on another continent. This leads to increasing pressure for mass customisation — the provision at a mass production price of products and services meeting the specific requirements of individual customers. Mass customisation provides a company the opportunity to increase the number of satisfied customers. However, customised products are more difficult to develop, sell and support than standard products. For mass customisation to become a reality, processes and applications have to be adapted to meet the new requirement.

Some customers also want more services offered along with the product. Sometimes it seems as if the services are more important than the product. Developing and supporting these services often requires additional skills and is not easy for companies that only used to sell products.

There are increasing demands for product traceability from regulators and consumers to provide and assure safety. Product traceability is important in industries ranging from food and pharmaceutical to automotive and offshore. If an airbag fails, a car manufacturer wants to find all the others from the same batch as soon as possible. If an oil rig collapses, any steel parts at fault need to be identified so that similar problems can be avoided on other rigs. Organisations that can successfully track products and parts are at an advantage compared to competitors that cannot. Recalls of millions of parts, or millions of products, are very expensive, and may cost millions of dollars.

Consumer market segmentation and the prioritisation of target segments becomes more complex as the potential market becomes larger and more diverse.

The demands of New York's Baby Boomers and Generation X, as they search for a deeply satisfying connected new experience from a customised product with the latest design from a globally recognised brand, may be relatively easy to understand. But what about the need of Grey Wolves, Generation Y and the Millenium Generation for digital pets, camera phones and domestic robots in Paris, Tel Aviv, Chongqing, Tokyo, Auckland, Soweto and Mexico City?

Consumers want to identify with their sport, fashion, music and screen heroes, from wherever they come. As these activities and industries become increasingly global, brands and products also become global. Crossover products, such as the Nike+ iPod nano, or a mobile phone that is not a high-tech product but a fashion accessory, emerge, intertwining features and functionality previously only available in separate product areas.

2.12 Products

Many new products are launched each day.

The functionality of products goes on increasing, complicating their development and support. In many industries, onboard electronics amd embedded software are major areas for innovation. For example, cars now have functions to help drivers find the right direction, park, steer, avoid other cars, *etc.* The value of the electronic components in a car may represent about 25% of the total value.

Products are becoming increasingly complex with more and more parts and functions. Although more complex products are proposed, they still need to be easy to operate, otherwise customers will not buy them. Cars contain more and more electronics, but are not more difficult to use. Cameras have much more functionality, but are easier to use. Since many people are unable even to operate the controller of their VCR, companies have to make products that are easy to use, even though they are actually more complex.

The support of products with very long lifetimes, such as aircraft, power stations and telephone exchanges, is complicated by the many changes in data media and formats that occur during their lifetimes. The IS applications that create this data evolve through many versions. Application vendors mature and disappear. Even the company that made a product may disappear during the product's lifetime. For example, Concorde was developed by the British Aircraft Corporation and Aerospatiale, but by the time of the Paris crash, neither of these companies existed. However, customers and regulations may require companies to produce documentation about products they, or predecessor companies, developed 50 or more years ago.

Lifetimes for some products are approaching 100 years. The B-52, for example, first flew in 1952, and is expected to fly beyond the year 2040. On the other hand, the lifetime of some products is now so short that the development of a future generation has to start before the development of the previous generation has been finished.

Many companies now offer complete solutions, rather than individual products. This adds a new layer of challenges. Solutions are more complex to develop and support than single products. It's also more difficult to sell a solution than a product. For a product, the price and features are usually clear, and the sale often involves mainly bargaining to find an acceptable price. For a solution sale, a key step in the process is to understand the specific functions, features and performance that a potential buyer is looking for in the solution.

2.13 Shareholder Value

In the 1990s, there was a strong trend for companies to increase shareholder value and thereby appear more attractive to current and potential shareholders. The desire to increase the pay-out to shareholders usually led to pressure to reduce costs. Cost reduction was usually achieved through headcount reduction, outsourcing and offshoring in the expectation that profits would increase as costs dropped and revenues held steady. The effect on products was a secondary consideration.

2.14 Market Mentality

In the market economy, the value of anything at any particular time is defined by what a buyer is prepared to pay for it. In 2006, the market value of a barrel of oil ranged between $44 and $76, even though it contained exactly the same product and the same volume. Market values of other natural resources used in products – such as cocoa, steel, and platinum – are also subject to change. Between 2002 and 2005, the value of $1 fluctuated between 0.75 euros and 1.13 euros. The continual changes in the relative values of currencies, and in the prices of raw materials and semi-finished products, make it difficult for a company to know how much it will have to pay for these in the future, and what price it should propose to customers. It can hedge the risks of changes, but this adds an additional cost to the business, and hence to the product. As hedges are hedged, and hedged hedges hedged, huge volumes of financial transactions are generated. In 2005, exports of goods and services of the 30 OECD member countries amounted to $8.5 trillion, yet annual global currency dealings are estimated to be close to $500 trillion.

The need for shareholders and traders to know the value of a company as precisely as possible leads to companies producing their financial results within a few weeks of the end of the financial quarter. If the company has failed to meet its guidance on earnings, the stock price may drop sharply in a few minutes. To avoid this, a lot of effort goes into setting up a company's systems to collect and manage financial data as effectively as possible. A lot of management time goes into working on the figures to ensure they meet market expectations. A Stock Exchange mentality can develop, with managers more interested in quarterly results than in the long-term well-being of their products and services. The rewards for getting the figures right have greatly increased in recent years. According to the Economic Policy Institute's report, "The State of Working America 2006/2007", in 2005, U.S. CEOs of major companies earned 262 times more than an average worker. In 1965, U.S. CEOs in major companies earned 24 times more than an average worker.

Within companies, with financial figures being so important, product-related activities have been getting increasingly low priority. The main focus of most business managers is now the financial processes and the money flowing through them. Rightly so, some would say, since without positive cash flow, nobody will be paid for long – and workers will lose their jobs. Second priority goes to the sales process, which produces money from customers in the short term. Then come the production processes, as customers often won't actually part with their hard-earned money, or their hard-earned credit, until they are sure the product exists. As for product development, this has a much lower priority. Unless products can be developed in a few weeks, the financial results of product development will be long-term, and not apparent on the top line, or the bottom line, in the next quarterly report. In the rear are the product support activities.

Financial markets want transparency about a company and its products so that investors can take decisions on the basis of full and current information. However, the company's long-term stakeholders may consider much of the information in a company, particularly about its products, to be confidential and a source of value, and will want to keep it secret. Intellectual property management becomes increasingly important at the same time as pressures rise for increased disclosure by companies.

2.15 Regulation and Deregulation

Deregulation and regulation lead to different types of changes.

In 1979, Margaret Thatcher became UK Prime Minister. Aiming to reduce the role of government and increase individual self-reliance, her programme included privatisation, deregulation, and the introduction of market mechanisms into education and health. Many of her ideas were implemented worldwide with little thought as to what they would imply for the details of product development, manufacturing and support. Deregulation led to the break-up of large organisations – often with well-defined responsibilities, but bureaucratic and inefficient behaviour, and offering poor service to customers – and their replacement by numerous companies, contractors and subcontractors with unclear relationships.

Companies in all industries are faced by an increasing number of regulatory requirements. These are often voluminous and subject to frequent change. Just managing the regulations and linking them to different products and services in different countries is a time-consuming task. Many regulations are specific to particular industries or types of products. Others, such as those resulting from the Sarbanes-Oxley Act, have a wider scope.

Regulations lead to requirements for analysis of everything from food and beverages to cosmetics and chemicals. Regulations are often introduced with the intention of doing good for mankind. The European Union, for example, introduced the Restriction of Hazardous Substances (RoHS) directive to address use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ether. The EU's Waste Electrical and Electronic Equipment directive was aimed at preventing waste electrical and electronic equipment (WEEE). The EU's End of Life Vehicle directive is aimed at getting manufacturers to dispose of vehicles in an environmentally sensitive way.

In 2006, the European Commission enacted new legislation, known as Reach (Registration, Evaluation and Authorisation of Chemicals), to force companies to disclose basic data on the chemicals they produce. The long-term effect of many chemicals is unknown. CFCs (chlorofluorocarbons) were thought for many years to be safe refrigerants and solvents. In the 1970s it became clear that they create holes in the ozone layer, especially over Antarctica. Reductions in ozone levels in the upper atmosphere lead to more Ultraviolet B (UVB) getting through to the earth's surface. UVB causes nonmelanoma skin cancer and has a role in the development of malignant melanomas. In the 1930s, DDT (dichlorodiphenyltrichloroethane) was seen as a good insecticide, particularly effective against malaria-spreading mosquitoes. However, by the 1950s, problems were appearing. Many insects developed resistance to DDT, and it was found to be highly toxic for fish. DDT has a half-life of about eight years, so it stays in the body for a long time. In the early 1970s, countries such as Sweden and the US banned its use. It is now thought to be carcinogenous, and to damage the liver, the nervous system and the reproductive system.

Regulations often add costs. In 2006, the ex-Oriskany, a decommissioned aircraft carrier, became the largest ship intentionally sunk as an artificial reef. The US Navy spent $13.29 million to complete the environmental preparations and scuttling in conformance with Environmental Protection Agency (EPA) guidance.

Many product recalls are due not to a problem with the product itself, but to the labelling not corresponding exactly either to the product or to the labelling regulations.

Accidents can lead to new regulations that change the environment of manufactured products. In 1989, the Exxon Valdez oil tanker struck Bligh Reef in Prince William Sound, Alaska, spilling over 10 million gallons of crude oil. In the aftermath of the accident, Congress passed the Oil Pollution Act of 1990, leading to the phase-out and replacement of single-hulled oil tankers navigating in U.S. waters by double-hulled tankers. In 1976, an explosion occurred in a reactor in a chemical plant about 20 km north of Milan, Italy. A toxic cloud of dioxin was accidentally released into the atmosphere and contaminated an area of about four square miles. The Seveso disaster, named after the town most affected, led to many changes in regulations.

2.16 Environmental and Sustainable Development

Since the 1960s, in response to the rising recognition of the potential dangers of products and production to mankind and the planet, politicians and ecologists have influenced business behaviour, forcing companies to think about environmental issues, waste products and recycling.

As global consumption increases, supplies of oil, water, and elements such as iron, are put under pressure. There's widespread concern, for example, about the future lack of petroleum products. The world currently uses about 25 billion barrels of oil per year, and total world reserves of oil are estimated at about 1,000 billion barrels. At current consumption rates, there'll be none left in 40 years. If consumption rates remain unchanged, the increase in the world's population will result in the reserves being exhausted in just over 30 years.

In 1987, the Brundtland Commission defined Sustainable Development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It's a holistic concept that aims to unite economic growth, social equity, and environmental management. Sustainable development and related ecological/environment activities represent a major business opportunity. There are many product-related activities that can help achieve sustainable development targets. They include: reducing the quantity of energy and materials used in a product and in its production; reducing the quantity of energy and materials wasted; finding new ways to re-use materials; finding new ways to recycle material; improving the energy-recovery rates of incineration; improving landfill productivity. Aiming for sustainable development often implies a 90% reduction in the use of new resources for a product. Sustainable development and related activities represent a major business opportunity that can provide opportunities for faster growth and profitability through improved current products and services, and innovation of new products and services. Areas to address include improving air quality, reducing greenhouse gas emissions, enabling waste to be recycled or composted, improving the heating and insulation of homes, improving energy efficiency, implementing more efficient low carbon technologies, using renewable energy, restoring contaminated soil and groundwater, monitoring and preventing pollution, treating waste water, ensuring that housing is of a decent standard, managing energy consumption, *etc.*

In 1997 at Kyoto, Japan, delegates from all over the world agreed on the need to reduce emissions of greenhouse gases, especially carbon dioxide. A lot of these emissions come from products such as cars, aircraft and power plants driven by petroleum products. A report on the cost of global warming published in 2006 by economist Sir Nicholas Stern suggested that, if action is not taken on emissions, global warming could shrink the global economy by 20%. That would affect the sales of many global products. The report suggested 1% of global gross domestic product should be spent on tackling climate change. That could be an opportunity for many global products.

2.17 Changing Roles

Historically, universities had roles of storing knowledge (the library), transmitting knowledge to the next generation (teaching), certifying that a student has reached a certain level, and carrying out research. Many universites have existed for centuries; the University of Bologna was founded in 1088, Harvard in 1636, William and Mary in 1696, Yale in 1701. Today, the Web provides more knowledge than a traditional library, and the best professors in the world can offer webinars to students throughout the world. Collaborative virtual classrooms, running on the Web, enable an unlimited number of students, and both human and virtual tutors. Staff and students can participate from any location. E-learning applications include course management, interactive assessment, role-playing and simulation. Students like e-learning and its ease of use, 24/7 availability, access from any location, possibilities to rerun a lecture, electronic course material, *etc.*

In many companies, there is a feeling that because they have been forced to respond quickly to global changes – or go out of business – their know-how is now years ahead of that available in many universities, where there has not been such pressure. Some large companies even set up their own 'Universities'.

In the past, universities offered a once-in-a-lifetime teaching environment. The university staff taught the student for three years at the university. Then the student left, and usually never returned. Today, a lifelong learning environment is needed in which the student learns to learn, and then continues to learn and develop knowledge assets.

Historically, the industrial revolution brought thousands of workers together in factories. Hundreds of white-collar workers were brought together in offices. Today, as a result of the Communication and Computer Revolutions, many people work alone, or in a small group, in a "Small or Home Office (SOHO)" environment. They may be working for a large company, or as an individual, or for a small company. They need products such as portable computers and mobile telephones to be effective, and are supported by e-working tools such as email, instant messaging, video-conferencing, webinars, collaborative workspaces, communities and blogs.

2.18 Inertia

Many organisations, whether companies, public institutions or countries, suffer from inertia. For example, more than half a century ago, many countries in the West introduced a retirement age of 65 years. At the time, life expectancy wasn't much longer. Families were large, most work was manual, and health care was basic. The cost of retirement pensions was met by monthly contributions from workers. Even though life expectancy has increased by more than ten years since then, and birth rates have fallen, resulting in fewer young workers to fund pensions, these countries find it difficult to change the retirement age. It's difficult to get people to think differently. For example, it's not until 2029 that Germany plans to have raised the retirement age from 65 to 67.

In a start-up, or green-field company, it is much easier to introduce new technologies than in a more mature company with workers accustomed to doing things the old way. It can be difficult to teach some dogs new tricks.

2.19 Free Trade

In recent years, the World Trade Organisation was established (1995), the North American Free Trade Area, linking Canada, Mexico and the United States, was established (1994), other free trade regions have expanded, and there have been reductions in trade barriers. This helps companies to offer global products.

2.20 Communities

Internet and the World Wide Web have enabled the development of many communities. These groups of people have, and share, knowledge and experience of a particular subject. Sometimes linking thousands of people, they have collective knowledge and experience greater than that of most companies. Such resource reservoirs didn't exist in the twentieth century. They offer companies many opportunities. Companies can work with communities to find ideas for new products and processes and ways to improve existing products and processes.

2.21 Low-cost and Lean

Many manufacturing companies run programs to become leaner, reducing waste in areas such as:

- Transportation
- Inventory
- Motion
- Waiting
- Overproduction
- Non-value-adding processing (*e.g.* features that aren't essential)
- Defects

As a result, they can offer products at a lower price, and compete in low-cost markets with high-quality products.

Lean Manufacturing approaches are similar to low-cost approaches adopted in other industries, for example by low-cost airlines.

2.22 The Result and the Requirement

The result of the many changes mentioned above is a complex, risky, continually changing, uncertain, highly competitive, global product environment. This is characterised by demanding customers, horizontal integration across the Extended Enterprise, many small and medium companies in the design, supply and support chains, few layers of management, globalisation, mass customisation, ubiquitous computing, fast technological evolution, a focus on electronics and information, and small numbers of knowledge workers from different functions working together in collaborative teams. There's growing competitive and legislative pressure, such as that concerned with product liability, deregulation, health, safety and the environment. There are technology issues to be faced, including the effect of the increasing amount of electronics and software in products, the possibilities offered by widespread communication networks, and the rapidly decreasing cost of computer power. Multi-technologies in the product make things more complex.

To be successful in this environment, a company must be able to supply and support the products that customers require, at the time required by the customer. The company must have great products. It must have a great product deployment capability. Customer expectations are rising. With so many manufacturers proposing products, why should a customer settle for a second-rate product or late delivery? Customer demands imply better products and services, a wider product range, customisation and market niches, but there's also increasing consumer resistance to price increases. Product costs must be trimmed so that they correspond exactly to customer requirements. Product functionality must be improved to match these requirements. Customer service must be improved with on-time documentation delivery, reliable delivery times, prompt complaint handling, and easy product repairability. Products must be brought to market faster. Technology is evolving fast and products are becoming obsolete sooner. The reduced time between product launch and product retirement erodes sales revenues. As product lifetimes get shorter, significant market share is lost if a product is not brought to market at the earliest possible moment. A company that gets to market first can capitalise on late market entry by other companies.

The complex, risky, continually changing, uncertain, highly competitive, global product environment makes life difficult for companies that develop, produce and support products. In such an environment, they need to have great products that leave competitors far behind and a great product deployment capability. They need to be continually in control of their products. If they aren't, and for one reason or another, they take their eye off the ball, unpleasant consequences can occur.

2.23 The Risks of Not Meeting the Requirements

If a company loses control of its products and product-related activities, it runs several risks:

- Development projects not finishing on time
- New products not providing competitive advantage
- Products not behaving as expected
- Financial losses due to damages resulting from product use
- Damage to the company's image
- Loss of customers concerned about product problems
- Revenues lost to low-cost competitors
- Reduced profit due to costs of recalls and legal liabilities
- Resignation of top executives
- Management appearances in court

Problems with products can result in high costs. In October 2006, Sony announced details of a global voluntary replacement program for certain battery packs using Sony-manufactured lithium ion battery cells. The estimated cost to Sony, based on a potential 9.6 million battery packs, was about 51 billion yen (about $440 million).

When, in July 2000, an Air France Concorde crashed soon after takeoff, 100 passengers and 9 crew members died. Compensation agreements are believed to have cost insurers over $100m. Concorde was taken out of service, and although commercial flights were restarted in 2001, it was withdrawn from service in 2003. Potential ticket sales of tens of millions of dollars were lost.

In 1999, NASA's $125 million Mars Climate Orbiter got to close to Mars and burned up in the atmosphere. The two spy satellites destroyed in November 2003 after lift-off from Tanegashima Island because of an unspecified technical failure cost an estimated 125 billion yen (about $1 billion).

The seven-member crew died when, in 1986, the Challenger Space Shuttle was destroyed 73 seconds after launch. When, in 2003, the Columbia Space Shuttle broke up during re-entry, the seven-member crew died.

All 215 passengers and 14 crew members died when Swissair Flight 111 crashed into the Atlantic Ocean near Halifax, Nova Scotia, on September 2, 1998.

Estimates for the cost of the A380 delivery delay range up to $6 billion. In July 2006, the EADS Board of Directors accepted the resignation of Noel Forgeard as EADS CEO, and the resignation of Gustav Humbert as Airbus CEO. In July 2006, Christian Streiff was confirmed as Airbus President and Chief Executive. In October 2006, Louis Gallois was appointed Airbus President and Chief Executive Officer.

The expected development cost of the A350 XWB is about $10 billion, double that of the initially proposed A350.

Merck voluntarily withdrew VIOXX in September 2004. Worldwide sales in 2003 were $2.5 billion.

The BSE crisis cost the UK more than $4bn in slaughtered cattle, compensation and lost exports.

In 2001, as a result of high tyre failure rates, Ford Motor Company announced it would replace all 13 million Firestone Wilderness AT tyres on its vehicles. It took a charge of $2.1 billion to cover the costs of replacing the tyres.

Global products offer companies the opportunity to have billions of customers and billions of dollars of sales revenues. However, without the right product and the right product deployment capability, the opportunity will be lost. Even worse, billions of dollars may be lost, product users may be killed, and company workers may lose their jobs.

Faced with such opportunity and risk, it may make sense for a company to have a good understanding of its product environment. The following chapter shows what can happen in the absence of such understanding.

3

Problems: Causes and Action

3.1 Addressing Potential Problems

Although the physical effects of a major problem with a product (Figure 3.1) may be the most visible, the principal causes are often organisational and technical. These causes have to be identified and understood so that measures can be taken to prevent their effects recurring.

Ideally, of course, a company proposing global products would want to identify potential problems and take preventive action before a problem occurs. This is not as easy as it may seem. In many organisations there are cultural barriers to admitting the existence of potential problems. Executives prefer to be seen to be running a problem-free, well-oiled organisation, not one riddled with problems waiting to happen. Engineers don't want to draw attention to potential problems, as they don't want to be seen as the source, or the cause, of the problem, or as a troublemaker. If potential problems can be discussed, care needs to be taken in the way they are presented. An investigation into a potential problem may show that people could do a lot better. Although this shows opportunities for the company to improve, it also implies that people were not performing as well as possible in the past. Investigations into problems with products often find many causes.

3.2 Causes for Problems

The Presidential Commission investigating the Challenger Space Shuttle accident found that the physical cause of the accident was the failure of the O-ring pressure seals in the aft field joint of the right Solid Rocket Booster. This was due to a faulty design overly sensitive to several factors, one of which was temperature. O-ring resiliency is directly related to temperature. A warm O-ring that has been compressed will return to its original shape quicker than a cold one when compression is relieved. The seals weren't certified to fly below 53 ºF. The Commission found that on the eve of the launch, NASA and the Booster builder debated whether to operate the Shuttle in the expected cold weather. (Overnight the temperature dropped to 19 ºF and at launch time was 36 ºF.) The engineers recommended a launch postponement. Under pressure from mid-level managers they reversed the recommendation and gave the go-ahead to launch. The Commission found that higher-level NASA managers weren't informed of the late-night debate, then looked at management practices and the command chain for launch commit decisions. It found a culture that had begun to accept escalating risk, and a safety program that was largely ineffective.

The Columbia Accident Investigation Board found that the physical cause for the Columbia Space Shuttle's break-up during re-entry was a breach in the thermal protection system on the left wing's leading edge, caused by insulating foam which separated from the External Tank 81.7 seconds after launch and struck the wing. During re-entry, this breach allowed superheated air to melt the aluminium structure of the wing, resulting in break-up. According to the Board's report, the organisational causes of the accident were rooted in Space Shuttle Program history and culture. Cultural traits and organisational practices detrimental to safety had developed. These included reliance on past success as a substitute for sound engineering practices (such as testing), organisational barriers preventing effective communication of information and stifling differences of opinion, lack of integrated management across program elements, and an informal chain of command and decision-making processes.

The Canadian Transportation Safety Board investigation into the crash of the Swissair Flight 111 MD-11 found that the accident was probably caused by an arcing event on an in-flight entertainment network (IFEN) cable, which set alight nearby flammable material. The Board's report has a long list of "Findings as to Causes and Contributing Factors". The investigation found that aircraft certification standards for material flammability were inadequate. They allowed use of materials that could be ignited and propagate fire. And the type of circuit breakers used in the aircraft was not able to protect against all types of wire arcing events. The original design philosophy had been for "non-essential" passenger cabin equipment to be powered by one of eight cabin buses. These couldn't provide sufficient power for the IFEN system that was originally planned, so another bus was used. The new design didn't include a way to deactivate the IFEN system when the pilot switched off the cabin power or provide the pilots with a procedure to deactivate the IFEN system during an emergency. There were no built-in smoke and fire detection and suppression devices in the area where the fire started and propagated. And, in the deteriorating cockpit environment, the positioning and small size of standby instruments would have made it difficult for the pilots to transition to their use, and to continue to maintain the proper spatial orientation of the aircraft. On the organisational side, the investigation found that, in the past, Swissair had relied on its MD-11 maintenance provider, SR Technics, to manage modifications to its MD-11s. However, after SAir Group was restructured, SR Technics became a separate business entity. For the IFEN project, Swissair chose another contractor for the design, certification, and integration services, and made a separate agreement with SR Technics to provide support to the contractor. The contractor subcontracted parts of the project, and the contractor's prime subcontractor further subcontracted some of the work.

After NASA's Mars Climate Orbiter went off course and was destroyed, an investigation found that a contractor's spacecraft engineering team (in Colorado) supplied information about propulsion manoeuvres in Imperial units (inches and pounds) to the navigation team (in California) which was using metric units.

When the BSE epidemic in the UK was investigated, it was found that carcasses of dead animals were among the ingredients of cattle feed. It had been thought that the protein they contained would make the feed more nourishing, and help development. Later it was realised that carcasses of infected animals could infect other animals to which they were fed.

- Space Shuttles (Challenger and Columbia)
- Space missions (Mars Orbiter)
- Electricity (power cuts in New York, London and Italy)
- Nuclear power plants (Three Mile Island, Chernobyl)
- Aircraft (Concorde, Swissair 111)
- Tyres (Firestone/Ford Explorer)
- Ships (Exxon Valdez, Prestige)
- Medical treatments (hepatitis-infected blood)
- Pharmaceutical products (thalidomide)
- Agricultural chemicals (DDT)
- Consumer chemicals (CFC)
- Asbestos (Combustion Engineering)
- Production plants (Bhopal, Seveso, Toulouse)
- Cattle Feed (leading to Mad Cow Disease)
- Software (vulnerable to bugs, viruses and worms)

Figure 3.1. Some products that didn't behave as expected

3.3 Multiple Causes and Effects

Often an enquiry will be held when there's a serious problem with a product. Usually it is found that there are causes of several types, such as :

- Physical causes
- Technical causes
- Organisational and cultural causes

Typical sources of the problems are :

- Design fault
- Testing not rigorous enough
- People not trained sufficiently

- Standards not adhered to
- Communication problems
- Customer needs misunderstood
- Ineffective safety program
- Culture that accepted risk
- Informal decision-making and decision-taking

Often it seems that everyone was doing their job the way they should have, but somehow, things fell through the cracks:

- Decisions weren't co-ordinated
- Risks weren't fully analysed
- Details were understood, but the overall picture wasn't
- Information got lost
- Customer requirements were misinterpreted
- Time was wasted
- Key relationships were ignored

And then the effects are there for all to see – projects and products failing, customers and users suffering, companies losing money.

3.4 Root Cause and Network of Causes

There are usually multiple causes leading to a problem, but people sometimes have a tendency to look for a single root cause – a single cause that leads directly to the effect, or occurs at the beginning of the series or chain of events that leads up to the problematic effect. Perhaps they hope that when they have identified such a single cause, they will be back in control, and it will then be easy to identify the measures needed to prevent recurrence of the effect.

This approach of looking for a single cause may be valid when applied in an environment that is well-structured and limited in scope, and in which activities are carried out in sequence. However, in more complex environments there are usually multiple causes. In these environments, which include the environment of global product development, production, use and support, there is usually not just a single cause, but a network of interrelated causes. They will all have to be understood and addressed if recurrence of the effect is to be prevented.

3.5 Causes and Measures

When the organisational, cultural, physical and technical causes have been understood, corrective measures can be identified and taken to prevent repetition of the effects.

In September 2006, in connection with the battery problem, Sony Corporation explained that, on rare occasions, microscopic metal particles in battery cells could come into contact with other parts of the battery cell, and this could lead to a short circuit, which could lead to overheating and potentially flames. Sony announced it had introduced additional safeguards in its battery manufacturing process to address this condition and provide more safety and security.

After the attempt in 2006 to steal Coca-Cola's trade secrets, Coca-Cola carried out a thorough review of information protection policies, procedures and practices to ensure that its intellectual capital was safeguarded.

The investigation into the Concorde accident found that, during takeoff, a tyre was damaged when it ran over a strip of metal which had fallen from another aircraft (a Continental Airlines DC-10). Tyre debris was projected against the left wing, and led to rupture of a fuel tank. Leaking fuel ignited. The investigators made numerous recommendations, including strengthened tyres and strengthened fuel tank linings for Concorde.

In October 2006, in connection with the A380 delay, Airbus announced that the amount of work to finalise the installation of electrical harnesses was underestimated. Airbus announced, in a Press Release, "Beyond the complexity of the cable installation, the root cause of the problem is the fact that the 3D Digital Mock up, which facilitates the design of the electrical harnesses installation, was implemented late and that the people working on it were in their learning curve. Under the leadership of the new Airbus President and CEO Christian Streiff, strong measures have been taken, which, in addition to management changes, include the implementation of the same proven tools on all sites, as well as the creation of multi-national teams to better use the best skills available. Simultaneously, training is being organised to swiftly bring the employees using those tools to the optimum level. With the right tools, the right people, the right training and the right oversight and management being put in place, the issue is now addressed at its root, although it will take time until these measures bear fruit."

It will probably be several years before the causes of the delay are fully understood and documented, but in view of the measures announced, possible causes were probably related to:

- Management failures
- A lack of corporate integration between different parts of Airbus
- The organisation of IS applications (tools) across several sites
- The organisation of teams on sites in different countries
- A lack of training
- A lack of effective project management procedures

In February 2007, Louis Gallois, Airbus President and CEO, presented the Power8 restructuring plan. This included a proposed headcount reduction of 10,000 positions. Other measures included reducing the cost of manufactured and purchased parts. A focus on core activities for the A350 XWB would lead to increased outsourcing. Airbus also announced it would introduce a fully-integrated and transnational organisation.

3.6 Effects, Causes and the Details of the Busy Organisation

Part One of the report of the Columbia Accident Investigation Board starts with the sentence “Building rockets is hard.”

This is true, but the reasons for things going wrong with the space shuttles can’t be classified as advanced rocket science beyond the understanding of NASA’s engineers. And, in other situations, things that go wrong with products aren’t due to a failing of people to understand Einstein’s general theory of relativity, but to simple everyday things that employees should know about, and for which managers should have prepared. Building any product is hard.

Over the last 20 years, companies have implemented extremely powerful and precise capabilities to manage their financial resources. As a result, they are now capable of producing their financial results within a few days or weeks of the end of the financial quarter. They may even pre-announce results before the end of the quarter. They can track orders, sales, payments and risks on a daily basis. Having implemented such capability for financial management, they should now implement equally powerful and precise systems for product deployment. Rather than becoming the victims of problems with products, managers should put in place a deployment capability that minimises the risk of problem occurrence.

Simple everyday things can easily get lost in the complex, stressful, competitive environment in which products are developed, produced, used and supported. Many of the causes of the problems that occur are down in the details of the humdrum tasks that the company’s workers carry out every day. Such problems may not be of interest, or appear to be of concern, to managers who are looking at more strategic topics, and are expected to produce results at a higher level. However, it is often a combination of problems and lack of organisation at a low level which leads to the problems with products that eventually become visible at a higher level.

The product environment is complex, and demands precision, yet is continually changing. Many products contain a lot of parts. The movement of a Swiss watch made in the region of La Chaux-de-Fonds may be little larger than a postage stamp, and only be a few millimetres in thickness, yet contains hundreds of parts, some so small they are almost invisible. A machine tool may have thousands of parts, a car tens of thousands of parts, an aircraft hundreds of thousands of parts. A space shuttle contains millions of parts. Application software may contain tens of millions of instructions.

Whatever the product, customers will ask for changes, and different versions and variants of products. That’s manageable for a while. But then, one day, unless great care has been taken when building the product deployment capability, configuration control or project management will break down. The company will no longer know exactly what is in a product that a customer has ordered or is using, or the true status of a development project. Before long, projects overrun. Configuration documentation no longer corresponds to the actual product. Increased scrap, rework and stock result. Incomplete products are assembled and delivered. The wrong product goes to a customer. Unexplained differences appear between as-designed, as-planned and as-built Bills of Materials. Field problems seem impossible to resolve, and inefficiencies occur in spare parts management. When a defective part is found in the field, many more products than necessary have to be recalled. Product costs and part costs become difficult to estimate. Often there is no relevant data available to provide a basis for calculation. And even if some is found, it may be inaccurate or outdated. And when data from different sources is brought together, it may conflict. It may not make sense.

Technical manuals become outdated, yet are not updated. Logistics support data gets out of control. Spares replenishment becomes inaccurate, and customers are obliged to immobilise products while efforts are made to identify correct replacement parts. When the right part arrives, the right handling equipment and maintenance tools are not in place. Information about problems with product use is not fed back to developers, with the result that they design the same problems into the next generation of products.

3.7 An Increasingly Complex Environment

As more and more parts and configurations are developed, and more and more data are generated on computer systems, it becomes more and more difficult to keep track of data, to prevent unauthorised access and to maintain up-to-date product configurations. Organisations have huge volumes of data, thousands, or even millions, of drawings and other documents describing their products. Part models may take up several gigabytes. One company calculated that it needed 250,000 pages of paper to describe a new product, and that, on average, each of these would be reproduced 30 times. Another calculated it handled over 100 million technical documents each year. There's so much data, people often can't find the information they need. And if they think they have found it, it may not correspond to the actual state of the product. For example, a circuit drawing may not correspond to the actual circuit layout.

Developers may be unable to access rapidly a particular design among the mass of existing designs. To find specific information, they may have to search through many paper and electronic files. They lose valuable time. Studies show that engineers may only spend about 10% of their time on creative activities, the rest on administrative tasks and information communication and retrieval. They develop new designs that may be almost identical to existing designs with the result that unnecessary additional costs are generated as the new designs are taken through the various activities necessary for manufacture, and then supported during use. While developing new designs, they may make data entry errors. It's easy to type the wrong character or copy the wrong file. Engineers may lose data, and be unable to retrieve it. When the data is re-created, more errors may be introduced. Several copies of the information describing the same part may be maintained. There may be no agreement as to the master copy. When a change is needed, it may be that some copies aren't changed, some users aren't informed, and some downstream functions aren't alerted. Old, unwanted revisions of parts are produced, while the new, required versions are ignored. Each user of a particular item of information may define the item to suit their particular requirements. All the definitions may be different. Confusion results when users try to share the information.

The Engineering Change, or Product Change, activity is meant to ensure that changes are carried out in a controlled way. However, in many companies, it is bureaucratic, paper-intensive, complex and slow. It takes many months and documents to get a proposed change approved and incorporated into the product. During this time, the product will continue to be produced with an unwanted design. Even when a change has been agreed and announced, many months may go by before the corresponding documentation gets to the field. In some cases, the change to a product may take as long as initial development of the product. As the change process appears as an inefficient and time-consuming overhead, some people will try to avoid it. Informal communications may be developed between departments to cope with changes. Few records will be kept and, in the absence of a particular individual, it may be impossible to know what has happened. For some information, there may even be no formal change control process. Some companies even have a formal ISO 9000-compliant change process, but management doesn't expect anyone to use it. As a result, minor modifications to products and drawings are not always signalled. Components will be substituted in end products without corresponding changes being made to test routines. People will fail to maintain the trace of the exact ingredients in ever-smaller batches of products. Nobody will notice until something goes wrong or another change has to be made. Then, unnecessary effort will be needed to find out where the problem comes from. Additional support staff may be employed to try to prevent further problems.

IS applications are acquired with the objective of improving productivity in the product environment. Large companies may have hundreds of these applications, medium size companies as many as 50. Applications acquired on the basis of local productivity improvement often become Islands of Automation. Then, due to gaps between incompatible applications, data is transferred manually between the applications, and errors occur. They have to be corrected, and their correction has to be managed. Some errors slip through and are not discovered for several weeks or even years. Correcting them leads to months of delay. Part descriptions and Bills of Materials developed with a CAD application may be manually transferred to an ERP application. The Manufacturing Bill of Materials may differ from the Engineering Bill of Materials. The two applications may be the responsibility of different departments or organisations or companies. New versions of the applications may have been introduced independently without sufficient care being taken to ensure that, for example, data created with earlier versions is still usable. The change processes in the two organisations may be different and out-of-step. At a particular time, a given change may have been made in one application, but not in the other. As a result, different users may have different versions of what they believe is the same data. The potential for problems to occur is huge.

Effective project management and resource management help to keep control in this complex environment. However, in many companies, project and resource management tools are not linked to product information. Unintended overlap in data, workflow and resource usage results, wasting time and money. Rules and procedures are difficult to enforce. Design rules may be ignored because there is no way to enforce them. Project planning exercises can't draw on real data from the past, but are based on over-optimistic estimates. Project managers find it difficult to keep up-to-date with the exact progress of work. As a result, they are unable to address slippage and other problems as soon as these occur. With multi-site matrix management, managers in different parts of the company may independently stop and start projects without knowing what the overall effect will be.

The problems that arise with products are rarely due to deliberate attempts by employees to create problems. Usually they do their best. Forward-thinking engineers try to develop great products, but maybe customers don't have corresponding needs. Salespeople may sell products that engineering can't develop. Marketing may propose products that it thinks customers want – but they don't actually buy. Service engineers don't get the information to enable them to track product revisions, so can't control the timing or cost of repairs and upgrades. Management can't assess the business impact of a change to a product because no-one knows what's really going on. Expenditure on development projects may rise beyond original estimates if, after talking to F&A, Marketing has discussions with R&D and changes its customer segments and estimates. Marketing may propose products that R&D cannot develop. Someone in R&D may have said that it would be good to develop them, but not meant to imply that they could be developed. Design engineers may send manufacturing engineers designs that can't be produced. The design has to go back for correction. Sales people offer customised versions without knowing if it will be possible to produce them profitably. Design engineers are unable to get cost information from the finance function, and forget to take account of maintenance requirements during conceptual design. People may not have all the necessary knowledge and experience, so they make assumptions, and get something wrong. Later in the sequence, a correction has to be made. The process loops back and time is lost.

The only way to reduce to a minimum the possibility that such problems occur is to define, build and manage an effective product deployment capability.

3.8 Everyday Product Problems

Most companies don't have products that cause disasters and get to be front-page news. However that doesn't necessarily mean that they don't have the occasional problem. I often work with companies that haven't suffered from disasters to their products. Usually, they are just looking to improve the business, and make more money for shareholders. When we look in detail at the product environment, we often see the same kind of issues that are identified in accident investigations, issues such as :

- Communication silos – people in different functions not talking together
- Data silos – data in one department not being easily available for others
- Technical problems with products in the field
- Rework
- Poor co-ordination with suppliers
- Disconnects between Sales and Engineering leading to the offer for sale of products that can't be built
- Differences between product specifications used by Engineering, Production and Sales
- Slow engineering changes
- Inadequate customer service
- Departmental mentality – each department convinced of its superiority
- Not enough focus on products
- Not enough re-use of existing parts – reinvention of the wheel
- Bureaucratic business processes
- Inconsistencies between data in R&D/Engineering, Production and Support
- Redundant part numbers
- Impossibility to migrate data from a legacy application to a new application
- Many parts, that are either no longer in use or are duplicates, being maintained in databases
- Difficulty of being sure of usage of material across products
- Lack of good product developers
- Wasted development resources
- Poor product quality
- Product release delayed
- Lack of up-front planning
- High service costs
- Multiple names for the same project
- Many Excel spreadsheets containing a lot of different information, often conflicting, about a product
- Changes to product data being made by individuals without any co-ordination
- Conflicting lists of the configuration of a product at a customer site
- Inability to know what maintenance tests have been carried out on a particular product
- Projects coming in late
- Poor scheduling of projects
- Quality problems
- Unwillingness to benefit from external developments – Not Invented Here
- Cycle times lengthening

- Product development costs rising
- Service costs increasing, while service performance deteriorates
- Islands of Automation
- Errors in product definition records
- Equipment under-utilised or over-booked
- Misalignment of expectations
- Using obsolete components in a new design
- Optimising product performance at the expense of fragmenting the supply chain
- Optimising product layout at the expense of longer delivery cycles
- Interruptions and delays as new technologies and features became available
- New products not performing as expected
- Products meeting specifications but failing to meet customer requirements
- Increasing rework and engineering changes

We see these issues in companies of all sizes and in all industries. Many of these companies are highly successful, with some great products and a strong five-year financial track record.

However, the above issues can lead to all sorts of problems. Even with just a few problems, the result can be unnecessarily long lead times, increased product costs and reduced product quality.

It might be thought that, as a result of a company implementing advanced techniques and information systems, product development and support would be easy. But, if the related business processes are fragmented and disjointed, and the applications aren't seamlessly integrated, the result won't be better performance, but higher costs, longer time to market, and poor product quality.

3.9 Action

When there is a serious problem with a product, an enquiry is usually held to understand in detail what happened, to identify the causes, and to take measures to prevent the problem recurring.

The same approach can be helpful even if there hasn't been a serious problem. The product environment can be reviewed to find and eliminate potential problems. The review will also help people to understand what is happening in the product environment, help the company prepare for global products, and uncover other sources of improvement. A product deployment capability can be prepared to support the company's global products.

4

Global Products: At the Coalface

4.1 Introduction

This chapter results from discussions with executives in companies of different sizes and in different industry sectors. It illustrates the different situations of different companies and the complexity of the product environment. It shows the need, in a particular company, for flexibility in identifying an appropriate product deployment capability. Exploring the different situations, relationships and connections in examples from other companies can help to develop the required flexibility.

A lot can be learned from studying and analysing what other companies are doing. Looking at just one company tends to give a biased picture. Its actions may result from particular circumstances that are specific to that company, and are not generally applicable. The bias can be overcome by studying several companies.

Some of the material in this chapter is based on articles and interviews published by Pure Insight. It is used with thanks to Jane Hogan of Pure Insight (http://www.pure-insight.com).

4.2 ABB

This section results from a discussion with Thomas W. Schmidt, Group Vice President, Head of Information Systems, ABB Power Products Division which took place in Summer 2006.

4.2.1 Introduction

The ABB Group was formed in 1988, when the Swedish Asea and Swiss BBC Brown Boveri merged under the name ABB. Asea's history dates back to 1883.

BBC Brown Boveri was founded in 1891. Both were big international companies operating in dozens of countries worldwide. Often they both had a company in the same location.

ABB is now a global leader in power and automation technologies that enable utility and industry customers to improve their performance while lowering environmental impact. The Group operates in around 100 countries and has offices in 87 of these to give its global and local customers the support they need to develop and conduct their business successfully. In 2005, ABB employed about 103,000 people. It had more than 6,000 research scientists and engineers. Revenues for the year ended 31 December 2005 were $22.4 billion. R&D expense was $679 million. ABB has five Divisions: Power Products, Power Systems, Automation Products, Process Automation, and Robotics.

Power Products is ABB's largest Division. It provides products such as transformers, switchgear, circuit breakers, cables and associated equipment to transmit and distribute electricity. It also offers all the services needed to ensure products' performance and extend their lifespan. In 2005, the Division's revenues were US$ 6.4 billions. It is a global leader in power transmission and distribution, with a world market share of over 20%. ABB has built more transmission and distribution substations than any other company – well over 5000. It produces about 1500 power transformers and 400,000 distribution transformers each year. Many of the transformers weigh over 1000 tons, and will be in use for several decades.

4.2.2 Sustainability

Sustainability has become an important issue for ABB. It provides utilities and industry with power and automation technologies that can reduce environmental impact and raise the quality of life – economically, environmentally and socially. ABB aims to deliver products that require less material, have higher efficiencies and consume less energy. For example, its installed base of AC drives is estimated to save 96 million megawatt hours of energy per year. In China, it is building high-voltage direct current power lines that each save enough energy to power 156,000 households. All major ABB products come with recycling instructions to facilitate their efficient disposal at the end of their useful life. As an example, up to 90% by weight of ABB drives can be reused or recycled.

A lifecycle perspective that covers the whole industrial process – from design and material selection to waste management – is required in all product development. This is incorporated into a seven-step GATE model – an internal process governing the development of new products and projects. It requires a lifecycle assessment study of each new product and project, and provides advice on how to reduce the use of unwanted substances. Over the years, ABB has made more than 100 Life Cycle Assessment studies, and many have formed the basis for Environmental Product Declarations (EPD) that inform customers about a product's environmental performance. The EPD is a standardised tool, meeting the requirements of ISO/TR 14025, to communicate the environmental performance of a product across its complete lifecycle.

4.2.3 The Discussion

Q. Mr Schmidt, where do you work in ABB?

A. I am Group VP, Head of IS for the Power Products Division, which is ABB's largest division. It's subdivided into three business units, Transformers, High Voltage Products and Medium Voltage Products. Altogether there are about 27,000 people in the Division. I have been with ABB for 12 years. When I joined, in 1994, ABB already had its "think global, act local" concept of strong local organisations working together across borders to benefit from the Group's total world-wide resources in research, supply, manufacturing, distribution, information systems, processes, as well as access to capital markets and international financing. That concept has helped us develop our business worldwide. By combining the experience and know-how gained in both global and local markets, we provide our customers everywhere the full value of ABB's resources.

There's a balancing act between centralisation and decentralisation, but we aim to be as close to customers as possible. We've been successful in the past; for example we were one of the first companies into Eastern Europe when the Iron Curtain came down, and we've repeated that in key markets like China.

At any specific moment in time, customers in different parts of the world may have very different needs, but we can draw on resources from around the world to meet the specific needs of each. For example, in the power sector, utilities in Asia and the Middle East are currently continuing to support high levels of economic expansion with investments in power transmission and distribution infrastructure. At the same time, in Europe and the Americas, power transmission and distribution investments are aimed mainly at replacing ageing infrastructure and improving the performance and reliability of existing grids.

Q. Is Global Product Development a reality today?

A. Yes and no. We've made a lot of progress, but there's still a way to go. There was a lot of overlap between companies, in capabilities and competence, and in the product portfolio. That makes for a complex, changing environment.

In the early 1990s, we were in a situation in which many companies – which had been more or less independent until then – provided as full a range of products and services as possible. As a result, there was a lot of overlap. Some products were being engineered and manufactured on more than 20 sites. Also, everyone was doing things their own way – their own processes, applications, standards and documents.

In response, we started to focus companies, or sites, onto specific products. We defined modular product architectures so that different sites could work together. We defined the locations at which we wanted to build up particular competencies. We ran corporate programs focusing on quality improvement and time-to-market reduction.

This step, during the 1990s, led to a lot of progress, but there was a long way to go. You have to realise the size and complexity of the business. The Power Products Division is one of five divisions in ABB, yet each of the three business units in the Division is a global billion-dollar business bigger than many companies. One of our aims is to enable products developed on one site to be manufactured on other sites; for example, we may want parts developed in Sweden to be manufactured in a plant in China. It takes a lot of time to harmonise operations across so many sites and locations.

Q. What were the results of that step?

A. After this phase was completed in the 1990s, we took a look at the situation, and saw that there was room for further improvement. We found we'd learnt a lot. For example, we knew we had to identify precisely the extent to which any activity could be standardised. That's really important – if you standardise at too low a level you lose potential synergies, if you standardise at too high a level you lose flexibility. For example, there had been attempts to introduce corporation-wide business processes. We'd found that there were some processes that could be used everywhere, but for other processes, it wasn't feasible to standardise at that time across business units, or even across plants. For each process we had to find the level of standardisation that made sense.

In 2001, we started the next major set of improvement activities. One of the focal points this time was to introduce a Platform strategy that would allow us to use common components across all product lines. We introduced a Stage & Gate approach for projects. We introduced a common approach for IS tools. We focused some plants on particular products, and some plants on particular competencies.

Just as an example of the time it can take for changes to take place, although we selected Pro/Engineer as the standard CAD system for the High Voltage business in 2001, it wasn't until 2005 that all locations were using it. There can be all sorts of reasons for this, such as existing projects for which it didn't make sense to change CAD system in mid-project.

Q. How do you see IS supporting Global Product Development?

A. One of the issues I see is that the IS technology for our type of business and our types of product doesn't evolve as quickly as I'd hope. I find that the applications just aren't built to work in a global product development environment. They may work fine if they are on a local area network, but not on a wide area network, where they create congestion. Because commercially available technology has failed in this, I have seen many projects, also in ABB, run into difficulties.

The result is that we haven't been able to standardise our IS environment (*i.e.* use common technology) as we would like. We use Pro/Engineer, ProjectLink, PDMLink and SAP PLM as well as SolidWorks and SmarTeam. In total we have about 700 CAD users across these 3 business units.

We became better in our IS projects because we aren't just addressing the applications. We are focusing all of the projects to follow a stage gate approach and have a strong business case. We focus on the related processes, documents, and of course training, as much or even more than on the IS technology.

To make progress towards Global Product Development, and implement necessary supporting processes and applications, it's important to have a clear vision and strategy for the next five to ten years. That gives you a clear structure to plan in and to work in. It also allows for learning and adapting the approach if problems are faced, especially with IS technology. Our progress and projects are regularly reviewed and discussed in our management teams.

Q. What do you see as major challenges for the future?

A. Innovation is a key issue, but it's not easy to manage. It's a challenge to get the right balance to enable engineers and scientists to be innovative, yet bring innovation under control and make sure it meets market needs. It's not so much an IS application issue as an organisational and cultural issue, and I'm not aware of many companies that have found the right balance.

4.3 PPM

Product Portfolio Management (PPM) is an activity that is becoming increasingly important. The term 'Product Portfolio Management' is used with several meanings. Sometimes it only addresses existing products, sometimes it only addresses projects for new products, sometimes it addresses both.

The Product Portfolio (the Product Opportunity Portfolio) is the set of product opportunities available to a company for investment. The objective of Portfolio Management is to sequence the opportunities – identify the sequence in which the corresponding projects should be carried out to provide most value.

A review was made of improvement activities carried out by companies in this area in 2006. It was found that there were several similarities among the companies reviewed. The following composite picture resulted.

4.3.1 Actual Situation

The detailed PPM reviews carried out by each company showed that, with corporate objectives demanding more for less, there was a widespread need to improve the overall return on the investment in product development and improvement projects. Many companies found they had too many projects relative to the available resources. As a result, projects were being staffed with fractional resources. Reviews showed a lack of consistency between the evaluation methods used to value different projects. Different managers developed and used different types of business cases, making it difficult to compare different projects and to identify the relative priorities of projects. The result was product development times of many years, and about half of the projects being terminated before commercialisation, even though significant resources had already been invested in them. It was often found that product developers were good at researching and inventing new technology and ideas, but less good at focusing on projects that would create business value for the company. They would keep poorly performing projects alive long after they should have been killed. These projects continued to eat resources that would have been better used on more valuable opportunities.

4.3.2 Improvement Objective

Companies wanted to be sure that their product development resources were focused on the best set of projects. They wanted to be sure that these projects were aligned with business objectives. In many cases, the review showed that companies benchmarked Portfolio Management practices in other companies to identify best practices. They then estimated their improvement potential, for example reducing project cycle times by about 45%, and increasing successful project completion by about 30%. Another objective was to be able to compare the value of each project in the portfolio, so that decision-makers would have clear visibility of the situation and could make informed decisions.

4.3.3 Action

To improve the situation, a company typically defined and implemented a Product Portfolio Management process that would be used for all projects in the Portfolio, and a related Web-based IS application and database. The Portfolio Management process typically tracks the value of the overall portfolio and of individual projects. It includes understanding the upper and lower limits of a project's value. This implies understanding the variables that can lead to different values. The process usually includes a feedback loop to addresss non-conformance and to benefit more in the future from real-life experience.

The IS application usually includes templates that provide a standard basis for understanding, evaluating and comparing projects. It usually includes standard reports that give executives information such as the degree of portfolio alignment with strategic targets, the expected portfolio return, the mix of short-, medium-, and long-term projects, project risk *vs* reward, the mix of risk across all projects in the portfolio, *etc.* (Figure 4.1 and Figure 4.2)

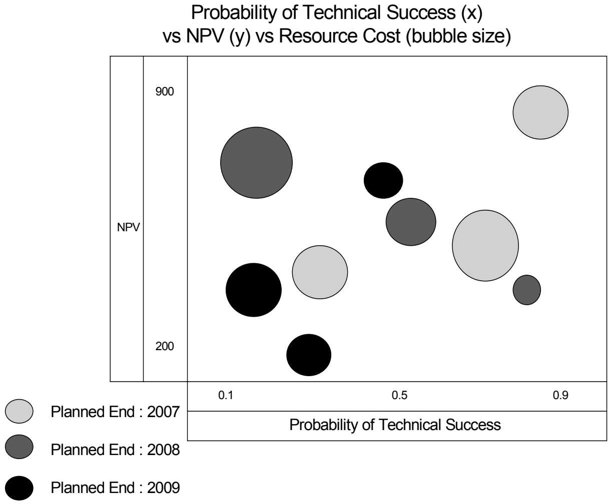


Figure 4.1. A typical PPM graphic

Performance metrics in use included Net Present Value (NPV) of projects launched during a particular time period, cycle time, and the number of projects for which premature termination occurred.

4.3.4 Results

Typical results after implementation of the new process and software included:

- Standardised evaluation of the economic value of projects
- A consistent, comparable basis to assess technical risk and commercial success
- Improved understanding of risk and uncertainty
- Increased transparency and credibility of project information
- Decision-taking based mainly on project value
- Updating of changes to project value as project conditions changed
- Early identification of projects showing signs of failing to achieve the targeted value
- A doubling of the value of the projects worked on
- A doubling of the number of projects terminating successfully
- A doubling of the number of projects terminated early
- A 50% increase in the number of projects started
- A 40% decrease in project cycle time

4.3.5 Lessons Learned

Creating a Product Portfolio requires top management involvement and agreement, cross-functional involvement and enterprise-wide involvement. The main benefit of Portfolio Management is to know that the best set of projects has been selected. The Portfolio Management activity must be driven by a clear business strategy. The Portfolio Management process must fit smoothly with other company processes.

For the portfolio management process to be successful, the most important characterictics of development projects must be identified. They must have the same definition everywhere in the company. Otherwise projects can't be aggregated. All projects should be in the same portfolio, although they may be "grow revenues" or "cut costs", as they may use the same resources and lead to a similar result. Projects need to be categorised; otherwise important projects will get lost in the mass of less important projects.

The Business Manager should own the process. The Portfolio Management process should include activities to provide praise for good performance and to provide ways to learn from problems. The activity of understanding the upper and lower boundaries of a project's value is important because it encourages identification and understanding of project risks. Explicitly managing project risks helps product developers to increase project value. It's important to develop rules about the criteria for decisions to "continue the project" or to "kill the project" before these decisions are taken.

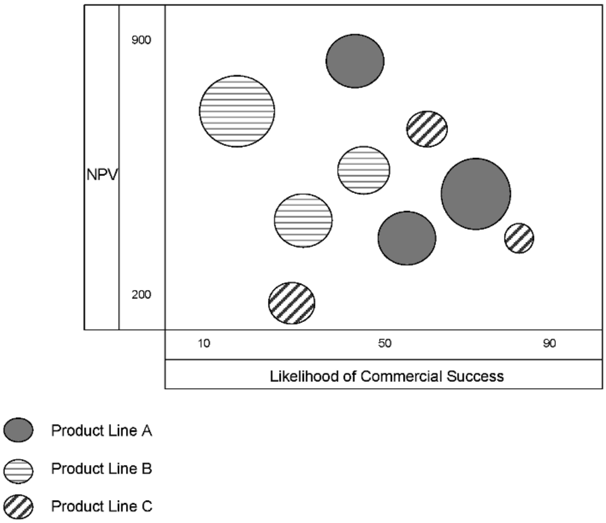


Figure 4.2. Likelihood of commercial success *vs* NPV

Although clear definition of the process itself is all-important, a PPM application is needed to help enforce use of the process. A secure Web-based application allows both data security and wide data visibility.

Implementing the Portfolio Management process usually requires changes to the organisation chart.

When implementing new processes and applications, don't forget to remove the previous processes and systems.

Good portfolio decisions can only be taken on the basis of high-quality data.

Standard templates should be introduced for frequently used project documents.

Metrics are needed to track portfolio progress and project progress.

4.4 Assessing and Managing Portfolio Risk

The importance of Portfolio Management is shown by the following discussion in summer 2006 with Ruedi Klein, then Product Portfolio Manager in the Mobility Access business unit at Lucent Technologies, Inc. On 1 December 2006, Lucent Technologies and Alcatel completed their merger and began operations as the world's leading communication solutions provider.

Lucent Technologies, headquartered in Murray Hill, N.J., designed and delivered systems, services and software for communications networks. In fiscal year 2005, which ended 30 September 2005, Lucent reported revenues of $9.44 billion. Lucent's business segment structure was organized around its products and services. The Mobility Access and Applications Solutions segment included CDMA, UMTS, WiMax and applications. Revenues of this segment in fiscal 2005 were $4.66 billion. The Mobility portfolio consisted of a range of radio access, core, and backhaul products. These included products such as base stations, controllers, and network software. This was a fast-moving portfolio with a need to get new products and new technologies to market fast. Some products had lives as short as 12 months, although others had lives as long as 15 or 20 years. Common platforms helped keep costs down. Typically, there were about 70 development programs, many of which contained several projects, under way at any one time.

4.4.1 The Discussion

Q. Ruedi, as a Portfolio Manager for a large Portfolio of high-tech products, do you feel that Best Practices for Portfolio Management are widely known?

A. The basic practices have been known for many years, but recently people have been taking more interest in them. In the last few years, the focus in most companies has been on getting the development process, the supply chain, and ERP working effectively. Now that has been achieved, companies are looking to ensure they are using the best Portfolio Management practices. However, there is an important area of Portfolio Management that I feel is often neglected – risk assessment and management. Don't forget that a lot of the early work on Portfolio Management was based on Markowitz's theories, originally developed in the 1950s, that addressed Portfolio Management for financial assets. Those theories have been applied to product development investments, but experience has shown that product development projects do not behave like financial assets. For example, if you invest $x in a financial asset you will get one-third the return that you would get if you invested $3x, but if you invest $x in a product development project instead of $3x, the product will probably never get to market, so your return will be zero. There are all sorts of complex relationships between the investment level and the return rate of a project. In addition, often, there'll be dependencies between different projects that add another level of complexity. New product investments are rarely independent. Moreover, if you use a model based purely on NPV, the value of all the options that are open to the project manager will be ignored. Therefore, although many Portfolio Management practices are known, you have to be very careful about the way you use them. Risk Management helps you get better control of your investment.

Q. Are Markowitz's theories such as that for Efficient Portfolios still useful?

A. Yes, there's a lot in the Markowitz' approach to Portfolio Management that is of use for product development projects. Moreover, of course it's widely used in the financial sector. The approach provides a good basis for the Portfolio Manager, helps derive a new product strategy, enhances traditional risk/return maps, helps visualize the return of new product projects, and shows for example why we need to subtract the WACC, the Weighted Average Cost of Capital, from returns when using risk/return ratios for prioritization.

As far as Efficient Portfolios are concerned, in the product development world the theory will probably not lead you to the exact optimum portfolio of projects. However, provided that you are aware of this, then it doesn't matter too much. The Efficient Frontier helps because it sets some boundaries and gives you a good idea of where to focus. In a fast-growing market, with vendor consolidation and start-ups appearing frequently, things are going to change anyway. You need to be aware of, and take account of, the limitations of the theory, and one way to do this is by taking a close look at the risks associated with projects and with the portfolio.

Some of the theories such as Real Options involve many calculations, but it's important to remember that the output data is unlikely to be of real value unless the input data is of high quality. That is one of the risks with Portfolio Management calculations; unless you start with good assumptions and make sure your input data corresponds closely to reality, the results may look very precise and meaningful, but they won't actually mean much.

There are always going to be risks with new product development. You start a project and bring together as much information as you can – market and customer lists, resource information and total R&D spending level, products and R&D project lists, business cases, and so on – but you're never really sure about the results, such as the eventual unit cost, unit price or R&D expense. And of course as time goes by, things change, maybe for the worse, but hopefully for the better when things converge as you get closer and closer to product launch.

Most of the success factors in new product development are not purely technical. For example, you can do great technical development work in the laboratory, but if you're developing a product for which there's no market, you're wasting your time. The four factors that we focus on are price, unit cost, volume, and R&D expense. Delay is a fifth dimension, but we model it through its impact on price or volume, depending on the competitive situation.

We ask about a dozen questions for each factor to find out about the project, questions such as:

- Does the product have any unique attributes that differentiate it from competing products?
- When will the customer/market require this product?
- Have customer commitments already been made?
- How volume-sensitive is the unit cost?
- How stable are the requirements?

We make these questions as unambiguous and as easy to answer as possible. That makes it easier to get clear answers. Having a set of pre-defined questions allows us to be more efficient in checking through the potential sources of risk and not miss anything major. Usually the project champion will have an optimistic view of the project and maybe not see some of the potential risks, so it's important to have questions that will quickly reveal any areas that need to be looked at in more detail.

The questions have different weights depending on the type of project and business case. For example, if it's a project aimed at cost reduction, you're not really looking for revenue increase, so questions about revenue increase would have a low weight.

We assign ratings to the answers, multiply the ratings by the weights, and sum the results to get a score. This rating approach gives us one score, capturing the likely NPV and Profitability for the project. We then try to get a feel for variability. One way we do this is with Tornado diagrams. They help us get a feel for the relative impact that different factors such as R&D expense, volume, and unit cost could have on a project's ROI and profitability. The NPV is often 50 or 100 times more sensitive to unit price than to R&D expense.

Q. Are there Best Practice processes available for Risk Management?

A. Yes, for example, the CMMi Risk Management Process Area provides a good basis. It has sub-areas that help you set up a risk management process, build a risk repository, identify and analyze risks, and mitigate risks. Another approach is with event trees or fishbone diagrams for individual projects. These allow you to link the drivers, probability, and impact of each of several risks, and to get a quantified value.

Q. What are the major technical risk areas?

A. We find that the risk with the biggest impact is schedule slip. This is two or three times more important than the next risks, which are lack of resource, software problems, and feature churn.

Q. Is Portfolio Risk Management mainly about identifying risks?

A. No, there’s a lot more to it than that. It’s partly about identifying the risks and trying to make sure they don’t cause problems but, perhaps more importantly, it’s about reviewing risks as you go through a project, and taking the necessary action. Sometimes in a project, everything will go well, and there may be no need to take risk-related actions. However, in many projects you’ll have to take action to avoid a risk, or to mitigate a risk. You need to prepare for this, taking action to prevent the risk event happening, or putting in place a contingency plan in case the risk event occurs, and estimating required reserves of budget and schedule.

Q. It sounds as if Portfolio Risk Management is an important activity.

A. Yes, and it’s a never-ending activity. Initially it’s a crucial part of project investment evaluation, and then once the project gets started it needs to be considered as an on-going project activity. Often, people in the project get carried away by the excitement of project progress and assume that everything is going well, but it’s important to have a simple regular review to see if there are any potential problems on the horizon. The end results are lower costs and less chaos.

Q. What would you recommend to people who want to get started with Portfolio Risk Management?

A. First of all, start with a review and identify areas of weakness. Then put in place a simple regular Risk Assessment within your Portfolio Review process. You can just use simple prompt lists, but be sure to cover the whole Portfolio and to involve all stakeholders. Don’t forget the follow-through. Make sure that identified risks are addressed and that risks are communicated throughout the company. You want everyone to be aware of the potential risks and take measures to mitigate these risks. In many ways, risk management is common sense, but there are so many potential risks, so many possible impacts, that you need to introduce a formal, clearly-defined, frequently-reviewed process to make sure that you are managing them as well as possible.

Q. What future trends do you see for Portfolio Management?

A. I can see companies putting much more effort into Portfolio Management in coming years. And I expect the frequency of Portfolio reviews to increase. These days, markets and customers call for companies to be agile and responsive. That isn’t achieved by having one or two Portfolio reviews per year. I can see that in a few years, we’ll be doing reviews much more frequently, perhaps every week or so to be sure that we’re responding as well as possible to the market’s changing requirements.

4.5 BSH Bosch und Siemens Hausgeräte GmbH

This section results from a discussion in January 2007 with Uwe Tontsch, Head of ITD, Information Technology – Product Development and Industrial Engineering Solutions, and Head of the Business Process Team for the Product Development Process.

4.5.1 Introduction

BSH Bosch und Siemens Hausgeräte GmbH (BSH) was founded in 1967 as a joint venture between Robert Bosch GmbH, Stuttgart, and Siemens AG, Munich. Initially it had three plants, all in Germany. By 1990, BSH had grown to 13 manufacturing sites. Over the following years, more acquisitions followed. By 2006 it had 42 factories in countries across Europe, Asia, the United States and Latin America.

BSH makes products in every major category of domestic appliance. It makes large appliances such as washing machines, dishwashers, cookers and refrigerators. It makes small appliances such as food processors, irons and coffee makers. BSH sells appliances under global brand names such as Bosch and Siemens, as well as regional and speciality brands such as Gaggenau, Thermador, and Neff, among others.

BSH is organised into six Product Areas:

- Cooking Products
- Washing / Drying
- Refrigeration / Freezing
- Consumer Products
- Dishwashing
- Electronics, Drives and Systems

About half of the R&D staff is located in Germany. BSH has design engineers in about 30 globally dispersed development centres. The largest of the development centres has 80 engineers, and the smallest has 10.

BSH sales rose in 2005 to 7.3 billion euro, consolidating the company's number three position world-wide. Demonstrating the increasingly global nature of the business, less than 22% of sales were in Germany.

4.5.2 Company Aims

BSH has long had a global approach to business and design, with one main goal – to establish a premium position in every market it enters. The intention is to bring premium and quality products to market, while competing in a tough business segment of consumer products.

This premium position strategy requires that all BSH plants – no matter where they are located – provide the same quality products. The first objective is to have the same level of quality, the next to make the product as suitable as possible for the regional market.

Its global development and manufacturing network enables BSH to respond to specific regional customer requirements for product function and features without losing sight of site-dependent factors such as different plant layouts and suppliers, as well as different personnel and logistics costs.

Over the years, as BSH grew through acquisitions, management identified the need to create a product development environment that would allow developers at different locations to benefit from each other's work. Until 1999 BSH didn't have such a common system to handle its global product development needs.

4.5.3 Action

BSH has invested a lot of time and effort in combining its acquisitions into one company. Integrating them into a smoothly-operating, global network has been a major challenge, but necessary to achieve synergy between businesses.

To be sure its quality standards are met in its plants throughout the world, BSH evaluates each plant it acquires, and the products it produces, and then upgrades and integrates as necessary by applying standardised processes.

BSH has five Business Processes, one of which is the Product Development Process.

4.5.4 A Common Product Development Process

As part of the effort to achieve synergy, BSH implemented a common product development process for all product and geographical areas in the world. It begins with the product idea phase, which is followed by the development and production phases. The product idea phase results in a description of:

- The product idea
- What it should achieve
- Who is involved
- What decisions have been taken
- The basis for each decision
- Who made the decision

The product development process specifies the process from the product concept, through release for production. It includes aspects dealing with market introduction and maintenance. It includes development and review of information such as project applications, approvals, production, market introduction and product progress for one year after market introduction. A review is held to see if product development and release targets have been met. Among the information reviewed is time cycles, investment, costs, pricing and quality.

The Business Process Team for the Product Development Process includes R&D leaders of the six Product Areas, Industrial Design, Production, Customer Service and Corporate Technology. The Business Process Team addresses processes and technology. Process User Groups address Best Practices and Methods for implementing PLM tools and solutions to support the development process and the people efficiently.

A Stage and Gate methodology is used for product development projects. It has eight stages.

4.5.5 The PLM Implementation

In 2000, BSH standardised its global product development activity on a PLM solution built on NX and Teamcenter, from UGS Corp. Since then, the company has implemented these applications on over 1000 workstations. About 50 developers use an application from Mentor Graphics for electrical CAD. By the end of 2006, Teamcenter had over 4700 users, including 1500 data authors. Since 2003, the Tecnomatix application has been implemented for Manufacturing Engineering, and now has about 120 users. About 500 people use Teamcenter Community and 25 people use DOORS for Requirements Management. The applications for project management are currently under review.

The future is expected to see ever closer links and concurrency between Product R&D and Manufacturing Engineering. The demand for embedded software is expected to grow. Digital Assistants will become available. With more functionality than Wizards, they will take responsibility for basic activities such as automatically releasing a part.

4.5.5.1 Innovation

To address the needs for effective innovation, BSH implemented an innovation management system based on short-term (one to three years), medium-term and long-term (more than five years) planning tools.

For the near future, roadmaps are used to control the development of new products, technologies and designs. They detail every step in the process from design to manufacturing and launch.

The Innovation Steering Group is one of BSH's medium-term management tools. An interdisciplinary body of leading managers from different business areas and functions, it reviews candidate projects for the future, and makes venture capital available as appropriate.

For long-term innovations, the company uses the "Picture of the Future" tool. Working with experts from various disciplines, executives extrapolate global trends and derive scenarios for the future environment. The objective is to develop a wide-ranging technological vision of the future, showing possibilities for new markets and businesses, and innovative products and services.

4.5.6 Barriers and Success

One issue that arose with the change of applications early in 2000 was that it required a change in the way people worked. It wasn't just a case of migrating from one application to another; people had to abandon the way they had worked in the past, and start to work differently.

Another issue during the PDM implementation in 1996 was the definition and documentation of a common process and a common parts naming and numbering convention. To develop on different sites, people on each site have to name parts in a standard way so that their colleagues on other sites can identify them quickly. If a product is initially designed in Germany, but later needs to be modified in China for the local market, the developers there need to know what they are looking for. The effective communication of design data is a major issue. People working next to each other may name things differently, but it is relatively easy for them to talk together and see what they are doing. For global product development, the communication barriers can be much higher. A standard way of naming and exchanging design data was therefore needed.

Looking towards the future, barriers are expected to be a shortage of competent engineers, a lack of people able to create and implement increasingly complex PLM strategies, and the difficulties of developing the next generation of – ever more advanced – Information Systems. This is because during the last decade people became more specialised. People with a broad general view and knowledge have to be developed.

4.5.7 Results

With its common PLM applications in place, BSH has the foundation for a streamlined process of global collaboration and innovation. Design data, in the form of 3D models, are used throughout the entire development and production process, for example in finite element analysis, multi-body simulation, rapid prototyping, preparation of graphics for catalogues and presentations, NC programme development, sheet metal processing, and the design of injection moulding tools.

4.5.7.1 Metrics

Among the other benefits of the project have been the increased efficiency and reduced time-to-market resulting from use of a common global product development system. The development time for an entire product family can be reduced significantly by involving several global development departments. Overall, in 2004, BSH cut the time from product idea to market launch significantly.

BSH estimates that it achieved a positive ROI from the introduction of its common PLM system about four years after the project started.

4.5.7.2 Global Innovation a Reality

One of the benefits of the new global product development system has been to make global innovation a reality. BSH's global product development platform supports co-operation on projects across national boundaries and in different continents. Developers in, for example, Brazil, China and Spain can work together to create a new appliance. This makes it easier for new products designed specifically for local markets to be based on a common concept.

4.5.7.3 Environment

Environmental considerations are a key factor in product innovation; 95% of the environmental impact of home appliances occurs during the use phase. In the last 15 years, BSH has, with innovative sensor technology, reduced water consumption of washing machines and dishwashers by 40%. During that time, energy requirements of washing machines have been reduced by 34%, and those of refrigerators by 78%.

4.5.8 Lessons Learned

Among the lessons learned were the following:

- The establishment of local production facilities and sales organisations is a prerequisite for meeting the needs and wishes of customers in each country.

- National production sites enable companies to tailor products to specific local requirements.
- Developing high-quality, premium products on a worldwide scale doesn’t necessarily mean providing the same appliances for every region.
- It is not sufficient just to send a design to a new plant and hope that it will succeed – new product design, the quality system and the management system need to be in place.
- To facilitate integration, employees are transferred to and from new plants and corporate headquarters; this know-how transfer has enabled BSH to implement comparable management and technology standards throughout the group, creating a common PLM-supported network for global product development.

4.5.8.1 Investment in the Process

BSH has implemented a common global product development process and common global product development applications. About 10% of the project cost for introducing the common global product development applications was for NX and Teamcenter licences. About one-third of the cost was for training, and the rest was for developing and implementing best practices worldwide. Training was a large part of the project. Each user had three weeks of training followed by another three weeks of on-site support from UGS spread over six months. BSH found that training was an important and useful investment without which the ROI would not have been achieved.

4.5.9 Next Steps

BSH invested 184 million euro in R&D in 2005, an increase from 169 million in 2004. To continue to respond quickly and flexibly to the requirements of the various markets, it will step up investment in new and competitive products and locations.

BSH has started to reorganise its competence centres for R&D from a global perspective. This is the start of a shift of focus to research centres distributed around the world. This is intended to reduce development times further, take greater account of local market requirements and boost competitiveness. Without the common global product development process and IS infrastructure, such an approach would be much more difficult.

4.6 Dow Corning Corporation

This section results from a discussion with Eric Peeters in January 2007. Eric is Executive Director Sealants and Adhesives, Core Products Business, Dow Corning Corporation.

4.6.1 Background

Dow Corning Corporation is a global leader in silicon-based technology. Silicon is processed in many ways leading to a wide range of products as different as building materials, lubricants, water repellents, ingredients that go into skin care lotions, silicon wafers for computers, silicones to protect automotive electronics from heat, silicone sealants, and silicone adhesives. Dow Corning offers more than 7000 products. It has more than 25,000 customers worldwide.

Dow Corning was founded in 1943. For many decades it was seen as an innovation leader. During that period, innovation efforts focused almost solely on R&D and creating new products.

4.6.2 The Situation

However, by 2000, the world had changed. The chemical industry had matured and differentiation was difficult. The pace of product innovation in the chemical industry was declining, and there was strong competition between producers. Energy and raw material costs were increasing. Customer expectations were getting higher, with customers demanding more from suppliers while putting pressure on prices. In this situation, Dow Corning found that its long-time success formula no longer worked as effectively, and that change was needed.

To understand how best to respond to the new situation, Dow Corning carried out a customer needs-based segmentation and analysis. This brought to light a range of findings such as:

- A new customer segment of “price-seekers” was identified. These are customers that don’t need technical support and services. The needs of this segment were not being met, and this was a clear opportunity.
- Another type of customer was identified. Very different from price-seekers, these customers are looking for expertise in areas where Dow Corning has experience such as business expansion into new markets, formulation, analytical testing.
- Customers were being given little choice about the way they interacted with the company.
- Customers were suffering from Information Overload.
- Innovation initiatives weren’t linked to the Voice of the Customer, but were focused narrowly on R&D and developing new products.
- Many “Back Office” employees didn’t have a line of sight to customers.

4.6.3 Action

Dow Corning responded to the findings in several ways. For example, to address the price-seeker opportunity, it launched the Xiameter® business model and brand in 2002 as a choice for customers who wanted to buy silicon-based products but didn't want to pay for services they didn't need. Xiameter has a no-frills web-enabled business model that eliminates the added costs of sales and technical support, but enables 24/7 access for ordering. It offers market-based prices to purchasers of large volumes of some 400 commonly used products who don't need much technical service and can plan two to four weeks in advance. The Xiameter brand offered innovation in six of the ten categories identified in Doblin Inc's ten types of innovation:

- Product system (possibility of modular product purchase)
- Customer experience (provided a new way the customer could order)
- Channel (new route to market)
- Brand (a second brand endorsed by, but differentiated from, the Dow Corning® brand)
- Networking (opens possibilities for new relationships with customers)
- Business model (market-based pricing and self service ordering online)

However the introduction of Xiameter raised some issues. It required Dow Corning to protect equity in the 'traditional' Dow Corning brand and justify its premium offering. This was achieved by transforming the Dow Corning brand from a product-focused supplier into a "solutions" provider. The Dow Corning brand is now positioned as a provider of expertise, advice, fulfilment systems for testing, as well as products and services. The Xiameter brand doesn't offer these solutions itself but if customers request them, they can be referred to the Dow Corning brand. What Xiameter provides is convenience, efficiency, 24/7 online access, and market-based pricing for customers who know what they need and know how to use it.

Achieving the transformation to the new business models required many changes, particularly for customer facing employees. They received extensive training to help them learn new behaviour that matched the brand 'promise'. For many people, the new approach was radically new. No longer, for example, could they have a "Build it, then sell it" culture. This had to change to a "Listen, understand, act, sell, build" culture and a consultative approach to business. It was no longer acceptable for sales people to give services away, or to say: "We don't do that."

People now have to focus on what each customer is trying to do – which starts with a clear understanding of each customer's needs. They are now more involved in customers' businesses, and help customers solve problems and seize opportunities, and find faster, better ways to achieve their business goals. Examples include new solutions to help customers:

- Expand into new geographies
- Create new markets
- Optimise supply chains
- Increase productivity through manufacturing design and trouble-shooting
- Offer new formulations
- Stay competitive through access to market knowledge

To overcome the problem of customers facing information overload, they are now offered several choices of how to interact with Dow Corning such as:

- "Live Help"
- Web events
- Online bulletin boards
- Third party portals
- Extranet site for channel partners
- Web site in multiple languages
- Choice of getting assistance online or from local staff

4.6.4 Results

The new approach has provided new sources of revenue – and a major increase in sales. For example, 2006 was a record year for Dow Corning Corp., with sales of $4.392 billion, 13% higher than in 2005. Growth has been double-digit since 2002. Global research shows high customer satisfaction and clear differentiation from competitive offerings.

Customers value (and are willing to pay more for) expertise. The result is strong long-term customer relationships and interdependencies. With Dow Corning addressing more of its customer needs, it is building customer loyalty and enhancing its competitive advantage.

4.6.5 Lessons Learned

To stay ahead of competitors, Dow Corning has found that, even when it is successful, it must constantly reinvent the customer's experience.

Enhancing the customer's experience requires involvement from all levels, but it starts at the top. The entire company has to be aligned behind the strategy. Employees need to be clear about their roles in the changing environment. Change management support is essential. Recognition and rewards play a key role in reinforcing the change. Company leaders need to be teachers and role models.

The voice of the customer has to be communicated back to the company. Metrics are needed to make sure this happens. They have to be kept visible.

Customer tracking needs to be on the dashboard. A new Customer Satisfaction process has helped monitor customer satisfaction data, assessing, for example, if customers view Dow Corning as innovative, proactive, and an ally that offers choices. It also compares customers' perceptions against their experiences with competitors.

A culture of innovation is needed to reinforce changes in behaviour. This culture must extend beyond R&D and new products, and permeate everything the company is and does. The culture must embrace change, and build on an intimate understanding of market and customer needs to produce solutions that meet customer needs exactly.

4.7 Habasit

This section results from a discussion with Dr Luis Cediel, CEO of Habasit AG.

4.7.1 Introduction

Habasit AG, a manufacturer of power transmission belts, conveyor belts and plastic modular belts, is the global leader in the belting industry. It serves a wide range of industries including textiles, food and beverage, healthcare, leisure, banking and airports. Habasit has 15 production plants and representatives in more than 70 countries. Globally it has over 250 service centres.

Habasit's headquarters are in Reinach, near Basle in Switzerland. In 2004, Habasit had 2224 employees, and revenues were 450 million Swiss Francs (CHF), up 10.6% on 2003. In 2005, sales reached a new record of CHF 625.1 million. Investments increased to CHF 51 million and were mainly financed by the company itself. The total number of employees rose to 3126. The increase in revenues was achieved in a highly competitive and difficult belting market growing mainly in price-sensitive applications and regions.

The belting industry is showing tendencies towards progressive consolidation and restructuring, shifting of activities from industrialised to emerging countries, cost sensitivity, and a strong demand for better service. In 2004, Habasit's competitors reacted to this difficult market situation by launching a price war. In their efforts to cut costs and regain profitability they restructured their activities, reduced headcount and investments and relocated their fabrication or production facilities to Eastern European countries or China.

Habasit, meanwhile, continued its strategy of improving its organisation and concentrating on core strengths. Its targets are to maintain its leading market position in the belting business, to safeguard its identity as a Swiss-based corporation with a world-wide net of affiliated companies and representatives, and to grant a safe future to its employees. It is focusing on fostering and safeguarding customer loyalty by offering them innovative solutions. It is broadening its product-service concept, including new products and services, and offering customers added value.

The results of its strategy can be seen in its record 2004 and 2005 figures. Both revenues and sales volume were at a high. All geographies contributed to this success with the main contributors being Europe (especially Germany and Austria), Asia (especially Japan and South East Asia) and North America.

The record performance was helped by the success of the new ‘HabasitLINK’ plastic modular belt range and the new ‘Cleanline’ and ‘HabaGUARD’ fabric belt ranges, underlining the quality of Habasit’s efforts in product development. With these new product lines, Habasit succeeded in presenting convincing innovations that took full advantage of its closeness to its customers on the international level and enhanced added value for its customers. With more than 15% of the staff working in R&D, and more than 8% of annual sales invested in R&D each year, Habasit has become a leading innovator in the belting business.

This success has resulted from many years work in putting in place business processes and practices that correspond to today’s market place and competitive situation. When Habasit’s CEO, Dr. Luis Cediel, joined Habasit in 1997 as Head of Research and Development, he found a company that was in a period of organic and acquisitional growth and looking to improve its product development capabilities. That year, for example, Habasit made two acquisitions in the US – ABT Inc. (Middletown, CT) and Globe International (Buffalo, NY). It was clear that organisational changes were needed, and Dr. Cediel brought in Peter Foster of i-novastar, a Paris-based consultant, and John Stark Associates, a consultant based in Switzerland, to help him review the product development environment, compare procedures and practices to industry’s best practices, suggest improvements, and develop an action plan.

4.7.2 The Situation

The review showed that, although many projects were running, few new products were getting to market. One key finding was that many projects were failing to achieve acceptance in the Final Prototype activity. Another was that even apparently very small projects were taking a long time to come to fruition.

Another problem was that there was no easy way for management to see the status of development projects. And sometimes it was not clear which criteria were being applied to decide if a project could move forward.

At the more detailed level, there was incompatibility between the IS applications in use, with the result that there was data duplication between applications, and sometimes data were being manually re-entered. Misunderstandings arose in projects due to a lack of clear definition of particular words. There was confusion, for example, between product features and product characteristics, and between customer requirements and application requirements.

There was often a lack of agreement among the product development team members from different functions. People in Marketing felt that their ideas and opportunities were being lost because R&D had no time to work on new projects. People in Production complained that "R&D's projects" interfered with their plant and production runs, costing them excessive set-up time, unnecessary downtime and reduced yield. Meanwhile people in R&D complained about the overload of work they faced, the continual demand for changes from Marketing, the huge volumes of paperwork they had to produce, the numerous meetings they had to attend, and the lack of time to do anything useful for the project in the lab.

Habasit had launched an initiative to clearly define its business processes, but at that time there was no methodology showing developers what they should be doing at each time during a project. The business process initiative has led to Habasit's working practices and processes being certified to the international ISO 9001 standard. The Habasit Affiliated Companies in Austria, Canada, France, Germany, Great Britain, Italy, Japan, the Netherlands, Singapore, Spain, Sweden, and the USA are all ISO 9001-certificated.

Overall, the study showed a need to introduce a well-defined cross-functional Stage and Gate process and methodology supported by a powerful IS application, and a need to visualise the actual status of all projects, and that of the overall Project Portfolio.

It was recommended that a cross-functional project team should be created to design and implement a solution to meet these requirements.

4.7.3 Action

As a market review revealed no 'out-of-the-box' solution that would meet the requirements, Dr. Cediel and the project team decided to work with Step-X, a Smarteam system integrator based in Switzerland, to implement the required process, stages, activities, deliverables, gate criteria, techniques, documents, and IS applications. Experience from previous and ongoing projects, and the consultants' knowledge of similar approaches applied elsewhere, were used in building up an overall project template.

The intention was that all types of project would follow the same overall structure, yet include the necessary specifics at the detailed level. The five Project Types were New Product Development, Product Modification, Product Idea, Technology Development and Technology Improvement. To each of these corresponds a specific process.

Technology Development and Technology Improvement processes are addressed because, in the belting industry, there is a very close relationship between the product and the manufacturing process. Even minor changes in manufacturing conditions, such as a change in ambient temperature, can change the properties of the end product. As a result, Habasit is continuously looking at ways to develop further its process technology and production equipment – and as it does this it must ensure that the characteristics of existing products are not changed. Sound know-how and sophisticated production processes are necessary to meet the demand for top performance in terms of technology and quality in a cost-efficient way.

The Product Modification and New Product Development processes are visually mapped to the same five Stages and Gates. However, the details of the Product Modification and New Product Development processes are very different – with many more tasks and activities specified for New Product Development than for Product Modification. In both cases though, the process clearly establishes criteria for entry into each Stage and provides standards for killing projects.

The Product Idea process differs significantly from those for Product Modification and New Product Development. It provides a fuzzy front end that allows opportunities to be captured, identified and refined before a formal project is launched.

The overall approach taken satisfies the requirements of the different types of user. Managers get a clear overview of project progress and the portfolio of development projects, while product developers are supported as they work with the details of their everyday tasks.

From the user point of view, the new environment implemented by Step-X appears to be focused on the particular project that they are working on. When they open the application, they can immediately go into the Stage of the project that they are working on, and see the current progress, ongoing tasks and data requirements. They also see the contributions of other members of the project team, who may be from other functions or based on another site. Template documents are available to help the users, and the application can guide them to use particular techniques (such as FMEA, QFD and risk management) at relevant times.

From the management point of view, the new environment provides an overview of both the progress of individual projects and the status of the portfolio of products under development. The Stage and Gate capabilities allow Habasit's senior management to take an active and influential role in determining project validity and continuation, using these capabilities as a go/no-go decision-making tool at each gate.

The portfolio functionality, including numerous cockpit charts and bubble charts, helps Habasit managers maintain a balanced portfolio, keeps product development activities in alignment with the overall corporate strategy, and manages development resources across the different types of project.

In addition to defining the new processes and customising the IS application that supports them, another task was to bring the related technical documents into alignment.

To reach its goal of staying at the top, Habasit has always emphasised the importance of the continuous training and education of its employees. A specific training program was developed to enable all those involved in product development to understand the new Stage and Gate process and the related IS application. In this way, the Stage and Gate environment has helped provide a common, business-driven communicative approach to product development.

4.7.4 Results

The main benefits of the implementation of the Stage and Gate environment are seen as:

- Organisation-wide transparency on priorities, projects and status for each project
- Authorised individuals are able to view up-to-date project information at any time
- Improved communication among project team members, and between team members and management
- Significantly faster and better Stage approval process through automated workflows
- Improved reporting
- Ease of generating new reports
- Ease of creation of statistics to track and improve performance
- Creation of a knowledge base, including information from previous projects, to enable on-going learning

Dr. Cediel estimates that, since implementing the Stage and Gate environment, Habasit has reduced product development time by 20–30%. Reasons for this include spending less time on re-development and corrections, and being able to make decisions faster. One of the main benefits, seen across all projects, has been better definition of a project's target and specifications, validated with customers. This helps avoid costly re-design and late changes. Habasit has also eliminated several man-weeks effort per year, per team member, in completing project documentation required as deliverables. Most of this task has been either eliminated or automated. As a result of deploying Stage and Gate, Habasit estimates it has increased its percentage of highly valuable product development projects by 100%.

According to Dr. Cediel, there is now much more discussion regarding the approval of each gate. This does not always lead to a decision to approve progress to the next stage, or to kill the project. Often it shows that the information available is insufficient to take the decision. As a result the project team must get more accurate or complete information. In this way, Habasit's Stage and Gate capability allows it to ensure that what is approved has been well screened by management, and that there is a good shared understanding of status, costs, benefits and risks.

By having more visibility of the project portfolio, the value of the opportunities, and the planning of each project, Habasit can more effectively allocate resources to higher priority projects. It can focus resources on those product ideas with the highest revenue potential. As a result, instead of having to run more and more projects to achieve its goals, Habasit can now reduce the number of projects by focusing on the ones that will provide the best value to the business. Simultaneously Habasit has been able to reduce significantly the time spent preparing for portfolio management meetings.

The Stage and Gate environment has been implemented step by step over the last five years. Changing the way that people across the world work is not something that can be done quickly. As each step has been implemented it has led to new opportunities and suggestions for extending the approach into other areas. Habasit's experience is that implementation of an approach such as Stage and Gate should not be considered as a "one-time only Big Bang", but as an ongoing improvement approach for the product development environment.

The implementation of the Stage and Gate environment is one aspect of Habasit's overall corporate strategy of creating a company with clear business processes and close interaction on all levels, sharing and building up knowledge among its companies throughout the world. The Stage and Gate environment will enable Habasit to release a stream of innovative new products to market without increasing development resources.

In October 2006, Habasit Holding USA, Inc. acquired Summa Industries Inc., making Summa a wholly-owned subsidiary of Habasit, and taking Habasit's consolidated world-wide revenue to a total of about CHF 800 million. This move strengthened Habasit's position as a modular belt supplier, making it the second largest player in this segment world-wide, in a sector that Habasit only entered in 1999.

4.8 Magna Steyr

Global Product Development is sometimes only seen as reducing costs by outsourcing low value development activities to low-cost countries. At the other extreme though, a manufacturer may outsource the entire product development activity to a supplier in a country with similar costs. The reason for this may not be related primarily to cost, but to a lack of sufficient resources, or a desire to develop faster.

4.8.1 Background

In 2005, Magna Steyr, a subsidiary of Magna International Inc., had 11,600 employees, including 2000 engineers. Headquartered in Oberwaltersdorf, Austria, it has operations at 17 locations including Detroit, Györ in Hungary, Munich, Paris and Pune, India. Its vision is to be the leading global, brand-independent engineering and manufacturing partner to automotive OEMs.

In 2005, Magna Steyr produced more than 230,000 cars, including the Mercedes Benz E Class 4MATIC and G-Class, the BMW X3, the Saab 9.3 convertible, and the Jeep Grand Cherokee as well as the Chrysler Voyager and 300 C. Producing cars for four different manufacturers is not simple. Magna Steyr's logistics operations and systems have to be flexible enough to interface smoothly with those of the OEMs. Magna's product team members, in both procurement and R&D, need a good understanding of the OEM's culture.

For the BMW X3 compact sport-utility vehicle, all engineering and production was outsourced to Magna Steyr. More than 500 engineers from Magna worked on the project, while BMW dedicated a team of 30. Many of Magna's engineers followed month-long training sessions at BMW's R&D centres and plants to get to understand BMW's culture and products.

4.8.2 Original Aim

In the automotive sector, there is a trend towards globally networked virtual product development teams in which specialists from different companies work together, each solving their particular task. Management of the innovation and production network is becoming a task of the supplier. However, this is not an easy task. The environment that Magna needs to master is complex, and there are frequent changes. In this environment, the supplier with the best methodology and technology to participate, and add value, in the process and information chains can gain a competitive advantage.

4.8.3 Action

In order to align development and production, and enable secure data exchange with OEMs and suppliers, Magna Steyr implemented a PLM system based on a solution from Agile Software. Magna Steyr worked with the PLM developer to improve BOM (Bill of Materials) management. A modular BOM is used to enable all variants and versions to be mapped.

4.8.4 Barriers and Success

Development of an entire car, or even a major assembly, sees continual changes. The short development cycles in today's automotive sector call for concurrent development and overlapping activities. Each part can be modified until just before the start of series production. Production lines are planned while the parts are still under development. Components are tested for proper interaction even when their specifications are still subject to change. For as long as possible, suppliers provide system modules that only exist as CAD data. The OEMs, Magna Steyr's customers, work with several different CAD systems from suppliers such as Dassault Systemes, PTC and UGS.

By 2005, Magna Steyr was managing more than 650,000 CAD models in different formats, more than a million drawings, and about 600,000 part numbers.

Due to the large number of variants of a car, there may be millions of possible bills of materials (BOM). Assemblies and components are so interrelated that, for example, selection of one variant or option may mean that many other parts need to be adjusted. OEMs frequently change equipment options, and customer preferences may mean that each car will be different.

Innovations and cost reduction programs lead to frequent changes for new and existing components. Every day, Magna Steyr changes 200 CAD models and updates 3000 drawings. Every month, 300 change orders, addressing an average of 40 parts of a model, are processed. The resulting 12,000 detail changes need to be smoothly and correctly planned, accepted and implemented.

4.8.5 Results

External and internal partners can now access relevant information at any time, regardless of the specific data format.

Associated with the modular BOM are rules to ensure that the internal logic of the product is enforced. This allows OEMs to change equipment options without having to check the validity of all bills of materials. Based on the rules, the PLM system automatically assigns the necessary parts.

The PLM system allows simulation of new models before the overall design has been finalised. As a result, planning has been speeded up, and changes can be included automatically.

The system enables Magna Steyr to have up-to-date cost information available, for example, to calculate the series cost, even though individual modules or parts may not be finalised.

4.8.6 Lessons Learned

PLM support is essential for fast, high-quality product development in an environment of many customers and many suppliers.

Working closely with the PLM application supplier can lead to a competitive advantage.

4.8.7 Next Steps

For the future, the PLM solution is seen as the enabler of data management for virtual design. The next step, beyond the management of variants and CAD models, is to create complete prototypes on the computer. This will reduce even further the development cycle time.

4.9 Siemens

At the time of the following discussion in mid-2006, Heinz-Simon Keil was the Director of Siemens AG's Virtual Engineering Centre.

4.9.1 Introduction

Q. Mr Keil, please give us some background on Siemens' activities and results in today's globalised world.

A. Siemens AG is a leader in electrical engineering and electronics for information and communication networks, industrial automation and control, power generation, transportation, medical equipment and other industries. We have nearly 460,000 employees worldwide. More than 60% of our employees work outside Germany. We are active in roughly 190 countries. We have about 47,000 R&D people at over 150 development centres in more than 40 countries around the world. Our Corporate Technology Department, to which I belong, has about 2400 employees at 27 locations. Our sales in 2005 were about €75 Bn. We invested about €5Bn in R&D. Sales in Germany are now only about 20% of the total, compared to about 40% at the beginning of the 1990s. Other European countries account for more than 30%, the Americas for 25%, and Asia-Pacific for more than 10%.

Q. What have been the major actions relative to PLM for Global Product Development?

A. One of the major goals at Siemens is to establish processes, infrastructure, and technology for virtual engineering to facilitate teamwork and collaboration across the globe. We see PLM as the collaborative framework to integrate globally dispersed groups into a unified design chain. Benefits include shortening time-to-market by 10–30% and reducing production planning time by over 30%.

We expect that in the future the trends will be for faster technology change, ongoing globalisation, decreasing resources, and increasing importance of the information/knowledge society. PLM will be a key to innovation, competitiveness and customer focus.

In this context, implementation of the Siemens Reference Process House has been important. The Digital Factory is another main theme, as is Digital Product. The whole area of PDM is important. And innovation is a main objective.

4.9.2 Processes

Q. Shall we start with the Reference Process House. What was the original aim?

A. The development of our Process House started in 2000 when some of our companies needed a common Product Lifecycle Management process. Until then all the business units had their own processes, and that led to difficulties when they needed to work together.

By the way, starting in about 1992, Siemens had moved away from a business model of “one very large ship” to one of “about 150 speedboats”. This was intended to allow each company within Siemens to be able to react as well as possible to its particular market and customers. Although it’s good to have commonality and standardisation within the corporation, we mustn’t go too far in that direction, as that would prevent the businesses succeeding. We have found we need a little “glue” to keep the companies together, but not too much.

The aim of the Reference Process House project was to set a standard for business processes throughout all the Siemens companies. Many of them work together on various products and solutions, and then it’s important for their activities to be aligned. So they needed a common reference for processes.

In 2000, two units approached us in Corporate Technology with the suggestion to develop a common Product Lifecycle Management process. We formed a project team including people from several representative companies in Siemens, defined the needs of our companies, looked at the way other companies were managing their processes, and then started to develop the Process House. This has several levels.

At Level 1 of the Process House, the top level, we have the Management Process, three main processes, and a set of support processes. The three main processes are Supply Chain Management (SCM), Customer Relationship Management (CRM), and Product Lifecycle Management. The Product Lifecycle Management process runs from Portfolio Management (both Product Portfolio Management and Platform Portfolio Management) to Phase Out. Platforming is important for us; we see it as the way to be ahead in customisation, pricing and quality.

We released version 1.0 of the Process House in 2002. In 2003, the Reference Process House was adopted by our CIO organisation, and now all companies throughout Siemens are expected to implement it.

When we developed Level 2 of the Process House we saw that we couldn't have a common solution for all the companies in Siemens as they are in such different businesses. As a result, we introduced three variants. These are for product-oriented, project-oriented, and order-related companies.

At Level 3, a typical company will have about 25 processes. That's the level all companies are expected to comply with. At this level, all the milestones, responsibilities and roles are defined – but not the applications.

Level 4 is the level at which the tools and applications used in the process first appear. That's a very important level for companies that are looking to harmonise applications.

Until 2005 we introduced a new version of the Process House each year. In 2005 we implemented Version 4. From now on we will probably only implement a new version every two years.

4.9.3 Introducing a Process Mentality

We started the activity in 2000 and it's only recently that we can say that everyone has a similar understanding at Level 3. Getting people to change to a process mentality is difficult. It can take several years and, during that time, companies and people have to meet market requirements, so they can't just take time off to think about processes. The mind change that is needed is significant. We have introduced training programs at different levels to help with this. Some of the training programs are corporate, some are made and run by the businesses themselves. The latter are more "on the job". There is a big difference in the process mentality in different companies. Some companies have implemented the Process House down to Level 4, or 5, or even 6. Others have difficulty in getting to Level 3.

The time it takes to implement the Process House is related to the type of product a company makes, and its lifecycle. We've seen that businesses with long lifecycle products take longer to implement the Process House. Part of the reason is that they have a lot of legacy components and issues in the company, and this gives them extra problems.

We've found that the Siemens companies with the best implementations of the Process House are also those that make most money. Another important point is that some of the companies that have the best understanding of their processes are now describing the workflows of their customers. This helps them get a better understanding of customer needs.

It takes many years to introduce a Process mentality. A lot of time and effort is needed to get everyone to the same level. Understanding the business processes helps in all sorts of ways. It even makes it easier to understand IS applications. If a company doesn't understand its business processes it may buy an IS application that doesn't fit the business, and then be forced to customise it. Whereas, with a good understanding of the business processes, it's easier to identify an application that fits closer to the real needs.

We've found that different countries react differently to the Process House. For example, in China we find that our people appreciate the Process House and implement it very well and effectively. In the US we often find that people don't think about the detailed sub-processes, whereas in Germany it's the opposite; we've seen people even going down to Level 7 definition.

You need to be flexible with business process models. The business environment is changing all the time, and the process model needs to change to take account of these changes. There are new requirements coming from the market, and technological changes such as the stronger links between mechanical, electrical and software components. We expect that by 2010 we'll need a new process definition.

The design of business processes will increasingly play a role in the speed of innovation. We will need seamless relationships between the processes of SCM, CRM and PLM.

4.9.4 Digital Factory

Q. Thank you. Shall we look at the Digital Factory initiative now? What was the objective?

A. We have two views of the Digital Factory. One of these views is as a "user" in our own factories. The other comes from our position as a vendor of automation components and products for factories.

The Digital Factory subject arose in 2002, driven by needs of Siemens companies in the automotive industry. They asked us to help them respond to customer requirements and the more we looked at the Digital Factory the more the subject became important. By 2010 we expect all the elements and processes of a factory, including production lines, machine tools and products will be represented by computer models. The Digital Factory will give designers and planners the tools they need to optimise production facilities and carry out virtual production runs.

Although in general there has been a great deal of activity in Digital Product Development for many years, there has been little in the area of Digital Factory.

We have partnered with two leading vendors of Digital Factory applications. We work closely with them to develop new functionality. We have used Digital Factory applications in the design of new factories in both Germany and China.

One of the main barriers is that the factory engineers don't have a "development mentality", but a "production mentality". But in the Digital Factory they also need to think "development" and work with "product developers". As always, changing people's mentalities takes a long time. Another issue is that there is a communication barrier between production engineers and product developers. They don't speak the same language, yet in the Digital Factory they have to work together. Another barrier is that data needs to flow between the "Digital Factory" applications and ERP applications, but the interfaces so far are not very good.

Another problem we face is that components and products are increasingly mechatronic, but Digital Factory applications are still mainly focused on either the mechanical world, or the electrical world.

We have had very good results from use of the Digital Factory. We have saved time on the initial design of plants, but also very important, we can reuse a design developed for a factory in one country in another country with very little additional effort. There are many issues to be addressed, both with mentalities and applications, but we are convinced that this is a key technology for the future.

4.9.5 Product Data Management

Q. Thank you. That leads us to PDM?

A. The original aim of PDM was to manage product data such as CAD files and technical drawings. Our companies implemented PDM independently with the result that we have many different applications in use. Traditional PDM systems are often too heavy and complex for us. There are many things that we would like them to do that they do not do well. Sometimes two of our companies with different PDM systems work together on a particular product and it is necessary for them to share product data. This is not always easy. We need to use PDM systems, and we have done for many years. Obviously they bring many benefits for data security but the effort to achieve those benefits is too high.

To overcome the problem of having so many different PDM systems we are tending towards a two-vendor strategy. We have so many different companies that it would be difficult to meet all their needs with just one vendor's application. Also, as we harmonise processes across companies, we would like to harmonise applications.

For the future we are looking at other approaches to PDM such as Websphere and Sharepoint. There are two related subjects:

- The first is that we need a 3D archive format, such as JT, which will play a role similar to PDF as a universal long-term format.
- The second is collaboration. We have joined the JT Board. Again this is because we need an open standard to allow our people to work together across the product lifecycle.

4.9.6 Digital Product

Q. And Digital Product?

A. The objective of our Digital Product activities is the virtual representation of a product with all its capabilities and attributes so that, ultimately, series production can be launched without the need for a physical prototype. The "Digital Product" will not just be a geometric model of a mechanical part, but a "Digital Master" representing the overall functionality and behaviour of a product or system.

We want to be able to carry out early validation, not just on geometry but also with a full range of simulations of physical behaviour. We want to be able to simulate, for example, airflow and heat flow. To do that we need to have the "Digital Master".

4.9.7 Innovation

Q. And finally, innovation

A. The objective in this area was to retain our market leadership in Innovation. We started the Innovation Program in about 2000. It runs throughout the company as there are opportunities for innovation everywhere – not just with products but also for processes. To start with, it's not clear what is needed in an Innovation Program, so just starting such a Program is important. People then begin to see what is needed and how innovation can be measured and achieved.

We've found that innovation isn't something we can do alone. There are competence networks of various sorts around the world, and our people need to be in these networks. This can be a problem for companies that are not global. We've seen that the competence networks for electronics are in the US and in Asia. That makes it difficult for people and companies based in Europe to innovate in this area.

One of our important metrics for innovation is our number of patents. By this measure, the result of our Innovation Program is that we are No. 1 in Germany, No. 2 in Europe and No. 10 in the US. By the end of 2005, Siemens had more than

53,000 patents. The number of patent applications by Siemens jumped by 15% in 2005, to 5700. Inventions registered rose from 8200 in 2004 to 8800 in 2005.

It's important to start an Innovation Program. Once it's started it will give good results, but getting started is difficult.

4.10 GAC

4.10.1 Introduction

Global Auto Components (GAC) is a leading Tier 2 manufacturer of assemblies and components for the automotive sector. Its customers include OEMs and independent specialists, and it also supplies the replacement market. In 2005, world-wide sales were about $3 billion, the company operated in about 50 countries, the workforce numbered about 10,000, there were nearly 1000 people in R&D, and R&D spend was about 5% of sales.

4.10.2 Background

In 2003 GAC found product development timelines were too long. GAC was faced with project overrun penalties and failed to respond to important proposals. It missed the window of opportunity on new products because it could not get into the market before the competition.

Forward planning was difficult with uncertainties in sales estimates, competitors in low-cost countries producing copies, and cost pressures and changes coming from OEMs. It was expected that, in the future, there would be a need for a greater proportion of software and electronics, but these were areas in which GAC had little experience. Increasingly there was overlap between projects, and customers were mixing components together more and more, and a need was seen for a more systems engineering approach to projects in future. This was also an area in which GAC had little experience.

Top executives were highly stressed, launched many improvement initiatives in their own parts of the organisation, and blamed each other's functional areas for the problems. Marketing called for more Customer Focus, R&D managers introduced new technologies, and business planners examined opportunities for further global expansion. Acquisition, restructuring and cost-reduction projects were running in different countries and for different product families.

4.10.3 Original Aim

In spite of the many improvement initiatives, problems with products continued and showed no sign of abating. As a result, the CEO decided to call in consultants to conduct a company-wide product development audit, to identify problem areas, strengths and weaknesses, and to develop resulting action plans.

4.10.4 Findings

To understand fully what was happening, the consultants conducted interviews with a range of people from each function, and the following selection of comments was included (anonymously) in the audit report to give the CEO and other readers a feeling for the actual situation.

4.10.4.1 Feedback from Top Management

"We don't have a clear overview of where we are with our product development projects."

"R&D doesn't understand that we have to do business, not just play at making new toys."

"We agree a budget to develop a product, R&D develops it, then they ask for another budget so they can redevelop it and remove their mistakes."

"Culturally, this company was historically focused on individual products, not on the overall portfolio of products."

"We need to get Sales, R&D and the plants to plan together for new products."

"We have sales figures for our 65,000 components. I want to see how those sales figures will be affected by new products we're bringing to market. We've spent millions on new products that bring less revenue than the products they replace. We destroy our own value."

"The Board needs a clear overview of project status at every monthly meeting."

4.10.4.2 Feedback from Marketing

"With a huge global market, we have countless opportunities, and many ideas for innovative new products and services, but R&D is unable to deliver."

"R&D reinvents everything. We need a VP of R&D who enforces standardisation and reuse of existing components."

"Customers are asking us to work with their processes, applications and documents. That's great. It gives us insight into their plans. That gives us a head start. The problem is that our processes and systems are not set up to take advantage of this information."

"The Production VP tries to block new product projects because bringing in a new product reduces plant productivity."

4.10.4.3 Feedback from Product Development Project Managers

"They keep changing the priorities of our projects, so as soon as we start making progress with one project, we have to switch to another one they say is more important. A few weeks later they say another project is even more important, so then we have to switch to that one. It's inefficient use of resources and frustrating."

"I used to work for one of our competitors. A friend there told me they now have all their product development project information on the Web so everyone knows what's going on. They have a standard cockpit chart for each project."

"I don't have a tool to manage my projects effectively."

"There are no guidelines for Risk Management."

4.10.4.4 Feedback from Corporate Planning

"We haven't grown our resources to meet the growth in company size. Since I've been here, the company has grown 500% but the product portfolio group is still the same size. If we had more people we could get more data about our products in the field and use it to help plan projects for replacement parts."

"Data checking takes about 70% of my time."

"In our planning process we don't have a way to value the potential reuse of a new component in future products."

"Different project managers provide different data about their projects. That makes it difficult to compare projects and to roll up data."

"Our current ERP system doesn't take account of the manufacturing location. When it was built we only had one location, now we have five, and the costs for each are different."

"Often a project for a new product implies removal of an old product from the market, but there isn't a process to do this, so the old product stays on the market.

Some customers continue to buy the old product, which reduces sales of the new product."

"We don't do audits of projects after they finish. It would be good to look back at a project five years after it finishes to see what we can learn from how it ran, and how the product has performed in the market."

"With all the cost pressures these days we don't have people looking to see what we will need in 10 or 15 years."

"Ten percent of our products bring 90% of our revenues. I'd like to find a way to avoid projects that lead to products that don't make money."

"The data we have about products for OEMs is about 10 times better than products for the after market. That makes it difficult to apply the same value analysis techniques."

"There are too many projects in the company, many are never completely finished."

4.10.4.5 Feedback from R&D

"Marketing people don't realise how much effort is required even for a minor upgrade for their favourite customer. And they don't understand all the work they make when they keep on asking for changes after we've started the projects. Why don't they do their homework before starting the project? And besides, we have almost no time to do real work. Anyone above a trainee engineer spends most of their time in meetings and producing paper. I waste hours each week on tasks that are duplicate work and rework."

"We have trouble working with the guys in Europe on global projects. They have a different project management system and work with different milestones. And they think differently."

"I don't think anyone here has been trained on MS Project. I use it my way. It's a real headache to work with people who use it differently."

"The change projects aren't prioritised, so we just do them in the order they come in."

"Purchasing looks for cost savings with new suppliers, but doesn't realise that the cost of qualifying a new supplier is more than the cost savings they offer."

"The Sales organisation needs to get its act together. Recently we developed a great new product but the Sales people forgot to put it in the catalogue so it was never sold."

“A good product development process, built into software with cockpit charts, guidelines and template documents, would be very helpful.”

“Marketing does portfolio management in the ERP system. I don’t know how it works. We don’t have access. We manage our products in Excel.”

“Each year, a new corporate plan is announced and the actions in it usually impact our R&D projects in several ways – both intended and unintended. I guess someone up there is doing their best for the company, but they don’t seem to realise what the real situation is down here.”

4.10.4.6 Feedback from Operations

“R&D’s tests for new products keep interfering with our plant, costing us downtime for revenue-generating production.”

“We have capacity problems when R&D dumps a big batch of changes to existing products on us.”

“I get so many emails about changes to components and products that I don’t what to do with them. There are so many that I don’t know which ones are important.”

4.10.4.7 Feedback from Communications and Documentation

“No-one tells us anything. We don’t know what’s going on. We just do whatever someone asks us to do, and let the other work wait.”

4.10.4.8 Feedback from Special Projects

“We’re outside the main company organisation and get involved say if a customer in Indonesia or Argentina wants a small batch of products based on an old design from one of our plants somewhere in the world. We have about 200 people worldwide. We don’t do new products. We just make changes to existing products. Our sales figures are rolled up in the corporate ERP system, but on the technical side the situation is different in different countries. We all manage our own data and documentation. Our customers usually want a lot of documentation. The people in corporate documentation don’t have time for us, so we do it ourselves. There’s no overall management of our projects.”

The above “Voice of the Employee” comments gave top executives a qualitative feeling for the issues the company was facing. This was reinforced by data presented on two slides:

- Seven different project management systems in use across the company
- Three different definitions of the product development process
- Five different applications for Portfolio Management
- Ten different formats for project management data
- Five different ways of measuring the length of a project
- Four different ways of quantifying manpower resources
- Many different layouts for documents such as the Project Start template
- No formal documented Portfolio Management process in the company
- No formal documented Pipeline Management process in the company
- No global capacity planning management
- No overall inventory of development projects
- No overall inventory of development skills
- At least 50 different report formats for product development projects
- Five major ongoing corporate improvement projects
- About 20 ongoing departmental improvement projects
- No differentiation between small and large projects, or between projects for large and small customers
- No guidelines for Portfolio Management
- R&D handling over 4000 projects world-wide, an average of more than four per person

4.10.5 Action

The CEO decided that a corporate, cross-functional improvement project was needed to address the problems.

A five-year plan for an initiative called CHAIFA (Commonise, Harmonise, Align, Integrate, Fill, Add) was prepared. The objective was to have a common approach wherever possible across the company. Achieving commonality had the highest priority. Among the aims of CHAIFA:

- A common project management approach across the company.
- All development projects would be included in a common portfolio, which would be managed with a common enterprise-wide process supported by a common enterprise-wide information system with a single database.
- In the first 12 months of CHAIFA, the number of projects was to be reduced to 3000. It was to be further reduced to 2000 in the following 12 months.

Targets for the first year of CHAIFA included:

- Make an inventory of all product development projects
- Reduce the number of projects by 25%
- Make an inventory of the skills of all product developers

- Define the common processes
- Identify IS applications to support a common global approach
- Create a training plan for R&D

4.10.6 Results

The CEO was pleased with the results of the company-wide product development audit. The audit had identified and described problem areas, strengths and weaknesses, and provided a basis for these to be discussed in a positive environment in which the focus was on improvement. It had led to company-wide agreement on a subject that had been a source of headaches for years. The audit results had led to an action plan that was widely supported.

In the first 12 months, an inventory of R&D projects was created, and the number of projects reduced to less than 3000.

5

Lessons Learned and Best Practices

5.1 Similarity of Situation

The examples in the previous chapters show that many companies in different industry sectors are faced by a similar set of product-related challenges in a fast-changing, complex, highly-competitive global environment.

5.2 Managing for Action

Companies have recognised the threats and opportunities of the environment, and are taking action to manage their products, to be in control of the products and to reduce the related risks. They are responding proactively. Doing nothing would not solve their problems.

Typically, the companies want to be able to develop, sell and support products on a worldwide basis. Targets include a reduction in costs, and an increase in the number of customers, sales and profits. Quality remains an imperative.

Companies do not expect that it will be easy to make the changes necessary to enable global products. They expect it will take a long time. They recognise the need for clear vision, strategy and plans for the next five to ten years.

5.3 Ground Rules

Ground rules for global products emerge from analysis of company progress.

5.3.1 Think Global

It may appear obvious, but the first ground rule for global products is to think global. Aiming for a global product will lead to a different order of magnitude for sales and customers. It's a different ball game, and requires a different mind set.

5.3.2 Understand the Global Market

The next ground rule is that it's necessary to understand the global market and the customers. Again, this might seem obvious, but it's easily forgotten. The company must offer products that customers in different parts of the world will want and will buy.

5.3.3 Select the Markets

The next rule is to decide in which main geographical markets the global product will be available. Until specific markets and products are defined, the discussion of what should be global, and what should be local, tends to be academic.

North America, Europe, China, Japan and Australia could be a good start for a high-tech product. For luxury goods, the markets could be North America, Europe, Russia, the Emirates and Asia. For low-cost food products, key markets could be Mexico, Brazil and South Africa.

Low-cost food products will probably be high-volume and call for local production facilities. Luxury food products are often low-volume and produced in the country of origin, then air-freighted. Hi-tech products often contain a lot of low-tech parts that can be produced locally or in a low-cost country, and then assembled with high-tech components produced elsewhere.

5.3.4 Select the Competitive Battleground

No company is better than all other companies in the world at doing everything. Each company has to select the area in which it will compete. These are the areas of commercial and technological differentiation in which it believes it has world-leading competencies and the best product functions and features in the world.

5.3.5 Global Product Strategy

Once the competitive battleground has been selected, a corresponding Global Product Strategy is needed. This has three interrelated parts:

- Product Architecture

- Product Deployment Capability
- Global Product Initiative

The Product Architecture addresses the structure of the product itself (platform, modules, interfaces, *etc*.).

The Product Deployment Capability is the capability to deploy *(i.e.* get requirements, develop, produce, deliver, support, recycle) the product worldwide. Some of the capabilities will be in-house, others with suppliers and partners.

The Product Architecture and the Product Deployment Capability are closely related. The capability depends to a certain extent on the product.

The Global Product Initiative is the "Corporate Project" that a company runs to define and enable the required Product Architecture, and to define and implement the Product Deployment Capability.

5.3.6 Upfront Planning

A lot of upfront planning is needed to define the way that a company will work in the future with global products. This may appear to some executives as a waste of time and effort. However, in the long run, it's better to work out first exactly how products will be managed in the future. The alternative of starting projects for individual products without a clear plan is unlikely to succeed.

5.3.7 Prescriptive Approach

A prescriptive approach is required. In other words, the company has to define what must be done and then everyone has to follow these rules. The opposite approach, "anarchy", is that everyone would decide locally what they want to do. The result would be problems when people in different areas try to work together.

5.3.8 Clear and Common Terminology

A clear and common terminology is needed company-wide. For example, people need to agree on the meaning of words such as product definition, product requirement, product specification. Another set of words about which people may have different understanding is version, variant, release, option, model, revision. Use of the term "Portfolio Management" needs to be clarified and standardised. It is often used with different meanings.

5.3.9 Architectures and Models

Architectures and models describing the product and the product deployment capability have to be defined. An "architecture and model" provides, for a complex object, a blueprint, a structure, a design, a functional description. In the everyday world it's normal practice for architectures and models to be prepared before building objects such as skyscrapers, cars and computers. In the world of global products they are needed to describe and communicate how a company's resources (processes, people, data, products, applications, *etc.*) are organised.

5.3.10 Digital Product and Digital Manufacturing

Digital models enable faster and lower-cost development, analysis, modification and simulation of products, processes and equipment.

5.4 Product Strategy

To enable global products, companies need a Product Strategy. In the past, many companies have not had such a strategy, and their product-related activities have resulted from other strategies such as a Marketing Strategy, an R&D Strategy and a Manufacturing Strategy.

There are three main Product Strategies for global products:

- Managed Complexity and Change
- Global Complex Assembly Provider
- Low-cost Commodity Supplier

5.4.1 Managed Complexity and Change OEM

The product environment for global products is one of complexity and frequent change. The strategy of Managed Complexity and Change (MCC) takes an OEM where less competent potential competitors can't follow, leaving them bemused and trailing. This is the typical strategy for an OEM with its roots in high-cost countries (such as the US, Western Europe and Japan) and a desire to provide products worldwide.

Offering complex, frequently updated products through a global capability, the strategy puts the company on a playing field on which few can compete. In this strategy, the OEM will often define major assemblies, then outsource their development and production to Global Complex Assembly Providers.

An OEM with an MCC strategy has to make money for its shareholders, but it doesn't have to make its product. It can outsource to the best development, manufacturing, sourcing and delivery networks. The OEM focuses on managing its portfolio of products, its product deployment capability, customer requirements, product architecture, product specifications, supplier management, system integration, final assembly and customer feedback. The OEM doesn't make commodity parts and assemblies. However, the OEM may develop and produce particularly strategic or complex components, as well as those using new technologies.

5.4.2 Global Complex Assembly Provider

The strategy of Global Complex Assembly Provider (GCAP) is to provide high-value, complex major assemblies worldwide to OEMs. A Tier 1 automotive supplier could have a GCAP strategy. Airbus is looking to assign large work packages for the A350 XWB to Tier 1 aerospace suppliers.

To attract OEMs, the GCAP will want to be a world-leader for particular components, sub-assemblies and assemblies. It will aim to master particular technologies and competencies.

A company with a GCAP strategy will often develop and manufacture some complex components and sub-assemblies, assemble these with parts and sub-assemblies from a Low-cost Commodity Supplier, and supply the resulting assemblies to OEMs.

A company with this strategy will need to be global to respond to the needs of its customers – the OEMs. It will also need to be financially strong, as OEMs often expect GCAPs to share investment and risk.

5.4.3 Low-cost Commodity Supplier

The strategy of Low-cost Commodity Supplier is typical for companies – usually operating in low-cost regions – that supply commodity parts and services to Complex Assembly Providers and OEMs.

5.5 Product Portfolio and Product Architecture

The strategy of Managed Complexity and Change implies careful definition of the Product Portfolio and the architecture of products. The objective is to be able to launch worldwide, in quick succession, many new products based on a small set of common platforms, modules and interface components.

The basic platforms should change infrequently and be globally as similar as possible. The platform may represent 80% of the product, the modules 20%. As much as 90% of a new product may be the same as for a previous product, and only 10 different. New modules and low-cost facelifts to existing modules will enable the customer to be presented frequently with a succession of ‘new’ products.

Platforms, modules and interface components need to be designed so that they can be assembled in different ways to give customer-specific products.

The decision criteria for what is in the platform, and what is in the modules and interfaces, depend on the product and market. For example, the platform may be heavy or very large, suggesting local production, whereas modules may be light-weight and easy to air-freight.

Often, product localisation will be achieved with modules. In some cases, the modules may include what the customer sees, while the platform includes what the customer doesn’t see. In other cases, the user interface may be in a module that remains unchanged while the platform is upgraded.

Sometimes, installation, maintenance and remanufacturing requirements can affect the product architecture. Specific modules may enable easy installation and easy maintenance.

Special modules can also be included to protect Intellectual Property and to prevent counterfeiting. Trade secrets may be split between several modules, each of which is produced by a different partner or supplier.

In some industries, the modules may include parts that are fashion-related, seasonal, or changing frequently for another reason.

5.6 Beyond the Product

Apart from the product itself, the product deployment capability must also be defined. There are many issues about what should be done locally (implying it may be different in different locations) and what should be done globally (implying ‘common’ to all locations). Key to success is getting the right balance between centralisation and decentralisation, and between global commonality and local specifics. The balance point is different for different products and different processes.

Pricing should be in local currencies. Costs need to be compared in a common currency. Product costs should be calculated globally. There may be global recommendations for product pricing, but local product prices need to be based on local market conditions.

Product and process-related regulations need to be gathered and understood locally, but managed globally to achieve synergies.

IS applications should be common worldwide, and updated at the same time everywhere.

Business processes for a particular product should be as common as possible. Implementation should start from the top, and work down to the level at which it no longer makes sense to enforce commonality.

As mentioned above, the platform should be as global as possible. To achieve this, the product definition of the platform is usually carried out by a global team. However, the product definition of the localising modules is better done by local teams with an everyday understanding of local markets. This implies local development activities round the world that are close to customers – even though this adds complexity to the environment. Local teams for marketing and development can be brought together with technology. As different parts of the world are usually at different parts of the economic cycle, development resources not needed at one location at a particular time can be used to support other locations that do need resources at that time.

Heavy and/or voluminous products and platforms are often manufactured locally to benefit from low-cost manufacturing facilities, and/or to minimise transport problems and/or costs. Some percentage of an assembly or product may need to be produced locally to meet government requirements for product origin.

Light-weight products with high added value, such as software, whisky and wristwatches, may be assembled in one central location, then shipped worldwide for local distribution.

Sales and support are usually best done locally. Local salespeople should have a better understanding of a customer's needs and desires than faraway top executives. Local support teams can provide fast onsite assistance to customers. In specific cases, a more experienced global SWAT (Special Weapons And Tactics) Team can be flown in.

Customer requirements need to be gathered locally, but managed globally to achieve synergy. Although managed globally, they need to be available to local teams for new developments and modifications, and to maintain customer relationships.

For a new product, the global aim is often to lower the price compared to the previous product, or to keep it constant while increasing functionality.

For a new product, the global aim is to be able to launch at the same time worldwide. However, the local launch dates will be based on the local market conditions.

Whereas a single engineering BOM may be the target for a product worldwide, manufacturing BOMs often need to be plant-specific. Manufacturing equipment, accessories and consumables tend to be different in different countries.

5.7 Getting the Deployment Capability Foundations Right

One of the most difficult issues with the deployment capability is just getting started. The concept of a global product deployment capability requires a change in behaviour and thinking at the VP/top executive level. Most likely, someone else will have to estimate the value of the potential opportunities and inform executives about this. Executives have many other things to think about.

A small Executive Team should have responsibility for the product deployment capability. This will help avoid duplication and prevent brushfire activities starting up independently round the world.

A starting place for getting the foundations right is to understand the current situation. This involves several elements – people, processes, applications, data, standards, regulations, information and communication systems, *etc.* In most companies, a lot has already been done. A lot of elements are in place. Sometimes, elements are in place, but there may be some duplication, or some elements may be defined or organised differently in different locations. Activities may be carried out differently in different locations. Sometimes, some elements are missing in some locations, or even globally. Sometimes, missing elements are already being addressed.

People may be doing the same thing in different ways, using multiple versions of the same processes, and multiple IS applications with similar functionality. There may be different definitions and classifications of the same objects and activities, and no standard terminology.

Perhaps some documents are not under control, there is missing information, and some information is difficult to access. Some processes are missing. There is no general agreement about how work should be done. Perhaps there is a lack of training. Sometimes, projects are not under control. Sometimes, product development and change are not under control.

Gaps, duplication and differences can make it difficult to offer global products, difficult to compare across locations, difficult to make worldwide reports, and difficult to switch people from one location to another. Training and support may be ineffective because people at different locations have different requirements.

Many large global corporations have a lot of overlap, and a lot of differences, between companies, sites, products, applications, processes, documents, competencies and skills. It may take them five or ten years to achieve the right global product deployment capability. Achieving it can involve activities such as:

- Focus on Value. For example, partnering with risk-sharing assembly providers, outsourcing or offshoring low-value activities.
- Unification, joining up. For example, integrating independent national organisations, integrating unconnected applications.
- Harmonisation. For example, implementing the same version of a CAD application on all sites, harmonising the engineering change process across multiple sites and harmonising part numbering systems.
- Alignment. For example, adjusting workflows in an application so that they are in line with the steps defined in the corresponding business process.

5.8 Extending the Deployment Capability

The first step when extending the deployment capability is usually to include elements that are missing in the company, but exist and are in use in similar companies. "Missing elements" evolve with time but, in many companies, in 2007, they include:

- Global Product Roll-out
- Compliance Management
- Intellectual Property Management
- Global Requirements Management
- Product Portfolio Management
- Innovation Management

The second step when extending the deployment capability is to include new elements as they become available. Such elements usually appear on the market at least five years before they achieve industrial strength. Technology Watch and roadmapping help to identify them and track their emergence.

6

To a Structured Framework

6.1 From Dog's Dinner to Structured Framework

Most dogs won't object to you preparing their dinner with whatever food is to hand – some freshly purchased meat, some vegetables from yesterday's supper, and some breakfast cereal. They may even appreciate you adding some chocolate and peanuts. However, after some water has been added and everything has been stirred up, it's difficult for anyone else to know exactly what was put in or how the final result was achieved. The resulting mixture is similar in some ways to the product environment in some companies. Over the years, all sorts of things have been added, and now nobody knows exactly what's there. As a result, it's not surprising that the occasional problem appears and sustainable performance improvement is difficult to achieve.

Being in control, and avoiding product problems, are key priorities for managers of global products. Of course, it's important for them to respond to evolving needs such as more innovation, faster product development and effective end-of-life. However, launching improvement activities in an uncontrolled environment, plagued by problems, is unlikely to lead to the required result. For this reason, it's useful to look in more detail, with the objective of eliminating them, at some of the problems that can be expected to occur. Typical issues include:

- Data out of control, data in silos, different definitions of data
- No processes defined, unclear processes, conflicting processes
- Application islands, lack of support applications
- Project status vague, needs not clear, too many projects
- Machines and licences under-utilised or not used
- Lack of certain specific skills
- Differences between the organisational structures of different sites and countries

Although there may appear to be a large number of potential problems, they are all linked to just a few product-related resources. The examples in the previous chapters include one or more of the following resources:

- Product
- Data and documents
- Processes
- Applications
- Methods
- Facilities and equipment
- People

In addition, there are issues about

- Organisational structure

Two other important resources are time and money. They are usually used to measure performance, *e.g.* time to market and revenues, and can be considered under the heading of

- Metrics

The following sections look at each of these issues in more detail. Some readers may feel that there is a lot of detail and complexity in these sections, but the product environment is complex and the devil is in the details.

6.2 The Product

All the examples in the previous chapters involve a product. Although this may seem obvious, it's worth highlighting. The product is important. Whether it is a car, a DVD player, an aircraft or a medicine, it is the product (and related services) that the customers purchase. The product resource is the source of company revenues. Without a product, the company doesn't need to exist and won't have any customers. The company generates revenues from an on-going stream of innovative new and upgraded products. Great products make it the leader in its industry sector. Great products lead to great profitability.

Most companies have more than one product. They have a portfolio of products. The portfolio enables them to balance revenues across different products. Even if one product has a bad year, its poor performance can be compensated by a good year for another product. The declining revenues of a mature product can be compensated by the growing revenues of a new product. The value of the Product Portfolio is of strategic importance. The objective of continuously increasing the value of the Product Portfolio, and increasing product value and revenues, drives product innovation.

It's important to understand the product and its various states and representations during the lifecycle. The product usually exists in a tangible form when it is in the hands of a customer (although sometimes the product is less tangible, software being a good example). However, "products" may actually be services. The services associated with a product can be considered as products. Product packaging may be seen as part of the product, or separate from the product. Product labelling may be seen as part of the product, or separate from the product. A product can also be a package of services, or a bundle of products and services, or a solution containing several products, or a solution containing products and services.

The product may be made of many assemblies and thousands of parts or components or constituents or ingredients depending on the type of product. An assembly may also be made of a large number of parts. These assemblies and parts could be the products of other companies – suppliers. Many products contain industrial components (products) of various types – hardware, software, firmware, electrical, electronic, chemical, *etc.* Many products also contain other types of components, such as agricultural, forestry or fish.

Producing and maintaining a company's products and services requires many activities. There's much more happening than just innovating a great new product and distributing the resulting profits. The product portfolio has to be maintained. Platform products are defined and built. Derivative products follow. Product lines, product groups, and product families are created and maintained. Plans are prepared for future products and services. Projects for new products are defined and carried out. Projects are defined and carried out to modify existing products and services. Products that are no longer needed are retired.

6.3 Processes

The list of activities related to the product expands as the level of detail increases. Product ideas are captured and screened. Proposals for new products are evaluated. Projects for new and modified products are prioritised. Customer requirements are identified. Products are specified. Product BOMs are defined. Design Rules are defined. Products are designed. Products are costed. Parts are purchased. Parts are simulated and tested. Orders for products are managed. Products are configured. Manufacturing is planned. Products are manufactured, assembled, and installed. Product information is communicated. Products are used. Usage information is fed back. Problems in manufacturing are resolved. Problems in the field are analysed and solved. Engineering Changes are defined. Parts are replaced. Products are maintained and refurbished. Actual costs are compared to planned costs. Products are disassembled. Parts are recycled. Products are retired. Organisational structure is defined. Processes are defined and managed. Resources are allocated based on priorities, project demands, and capacity. People are hired and trained. Progress is measured and reported.

And then there are other product-related activities such as alliance management, contract preparation, contract review, control of non-conforming product, delivery, design control, disposal, document control, handling, inspection, labelling, packaging, project management, prototyping, quality assurance, quality control, traceability and training.

Companies group the activities into processes. Often they have a hierarchy of business process, process, sub-process, sub-sub-process and activity. A process is an ordered set of activities with clear inputs and outputs that creates business value. The activities and processes need to be clearly-defined, well-documented, coherent, well-organised, waste-free and low-cost. Within each of the activities there are usually tasks, roles, checklists, milestones, deliverables and metrics that specify the scope, nature, type, information needs and measurement of work.

There is even a process of establishing, documenting, maintaining and improving processes. It includes sub-processes for planning, review, measurement, audit, monitoring, verification, validation, corrective and preventive action.

The many product-related activities and processes across the product lifecycle are given different names in different industries and different companies. They include New Product Development, Product Idea Management, Product Concept Management, Portfolio Management, Product Retirement, Product Modification, Product Obsolescence Management, Product Upgrade, Product Change Management, Engineering Change Management, In-house Product Failure, Product Maintenance, Product Liability, Customer Product Failure, In-house Product Support, Customer Product Support, Product Selection, Product Feedback, Product Renewal, Program Management, Project Management, Intellectual Property Management, Resource and Capacity Management.

Companies position the processes in a process architecture. A correctly-organised process architecture will enable coherent working across the product lifecycle in product-related activities and processes.

6.4 Data and Documents

In addition to the physical "product" made by a company that is in the hands of a customer, there are "product data" describing the product. They are usually on paper and/or in a computer system. An enormous volume and variety of data is needed to develop and support a product. This data may just be 'data', sometimes 'information', sometimes 'knowledge', sometimes even in the more valuable state of 'wisdom'. Product data doesn't look after itself, and like anything that is not properly organised and maintained will, over time, slide into chaos and decay. However this has to be avoided as the slightest slip can have serious consequences for the product and those associated with it.

The term "product data" includes all data related both to a product and to the processes that are used to imagine it, to design it, to produce it, to use it, to support it, and to dispose of it. Product data exists in hundreds of forms such as: analytic models; as-designed, as-built, as-ordered, as-delivered, as-installed and as-maintained configurations; assembly drawings; Bills of Materials; CAD geometry; change control data; costing data; customer requirements; design specifications; engineering drawings; equipment designs; existing product designs; factory layouts; field failure reports; flowcharts; functional specifications; machine libraries; maintenance information; mounting instructions; NC programs; parts classifications; parts lists; patent information; process models; process plans; purchasing information; quality assurance data; recipes; regulatory information; scanned-in drawings; service descriptions; service manuals; shop floor instructions; simulation results; spare part information; standard costs and times; status reports; technical publications; test data files; test results; tool and fixture designs; user guides; user manuals and version management data.

Product data are created and used throughout the life of a product. Some product data (*e.g.* part geometry, NC programs, technical publications) may be created within the engineering function, some (*e.g.* customer requirements, service descriptions, regulatory information, feedback results from customers in field tests) elsewhere. Some of the data (*e.g.* stress or circuit analysis results) is used within design engineering, some (*e.g.* welding instructions) in production, some (*e.g.* installation instructions) on a customer site, some (*e.g.* disassembly instructions) at the end of the product life. Product data can be found on many media, such as paper, CD-ROM and computer memory. There is a lot of it. Some companies have millions of paper documents and electronic files. Product data come in many forms (*e.g.* numeric, graphic, alphanumeric, voice, video). Some of the users of product data will be inside a company, others in other organisations (*e.g.* suppliers, partners, customers and regulatory bodies). Throughout the life of a product, product information is all-important. It is all that people can work with when the product doesn't physically exist in their environment. It needs to be available, whenever it is needed, wherever it is needed, for whoever needs it.

There will probably be millions of objects, descriptions, numbers and words of product data to manage. The sheer volume of product data makes it difficult to manage. In companies with several hundred engineers, thousands of GB of product data may be created and accessed each week, and the volumes keep growing. Estimates for medium-to-large companies foresee data volumes exceeding 1 petabyte. Product data can be found in many locations. The users of product data may be in the same building, or in the same plant, but they could also be in locations in different countries, or even on different continents. Product data will be distributed over several locations. Copies of each individual data item will be held in several stores.

Different views of a product are needed at different times. In early stages of development, the product is defined in specifications describing its functionality and required performance. Later in development, a top-level design assigns specific functions to specific parts of the product. Towards the end of the design process, the physical arrangement of these parts is fully described, through detailed engineering drawings and parts lists. Information is generated to support the processes of production and test of the product. Information is also prepared to support the product in operational use, and, once it has been built, information on its actual performance in the field will be measured and recorded.

Different users will want to see different views of product data, but many users will only want to see and work with one view of the data. For example, a manager may want to see current progress on all parts of a product development project, but not details of the product design itself. A project engineer may want to check an assembly of parts, but have no interest in stress or thermodynamic analysis results. A drafter may only be interested in an individual part. A company may only want to give a supplier a very restricted view of its overall database. In all these cases, while different users may want to see different views of the data, and the applications they use may be different, the underlying data must be the same.

Product data can be in various states (such as in-process, in-review, released, as-designed, as-planned, as-built, as-installed, as-maintained, and as-operated). Different rules apply to access and modification of data in different states. In early stages of development, data is frequently modified, whereas once it has been released it is much more stable. Users may need to work with product data that are in different states.

The same object may be represented in different ways. For example, a circle may be represented by three points on its circumference in one CAD application, but by its centre and radius in another CAD application. The same object may exist in one representation electronically in a spreadsheet, and in another on a piece of paper. Exact conversions are needed when product data is transferred from one representation to another, or from one medium to another, but an exact conversion may be impossible, with the result that a loss of quality will occur.

Different versions of the same information will exist. One person may need the latest version, but others may need earlier versions. People who need the latest version want to be sure that the version they receive really is the latest, and not an out-of-date or superseded version.

There is so much product data that special identification and classification systems have to be used to keep track of it. Unique numbers are needed to identify every specification, drawing, list, test procedure and operating manual which defines the functionality, physical construction, and/or performance of a solution, product, component, assembly, sub-assembly, or part.

Sometimes, though, the same item of product data may be defined differently in different parts of the organisation. The definitions may conflict, leading to confusion and errors. People in different parts of the company may use different words to describe the same thing. Sometimes they use the same word to describe different things. Each department develops its own jargon that may be misunderstood by other departments, partners and customers. This results in confusion and waste when product data is transferred from one part of the organisation to another.

Most product data undergo change at various times in their lifetime. The management of these changes introduces added complexity to the product data management process. Changes to data have to be formally requested, evaluated and properly approved by all interested parties. They must be publicised and recorded.

Making data management more complicated, some product data must be kept for a long time. This is essential particularly when the product is complex and/or has a long life, *e.g.* aircraft, offshore platforms, weapon systems, ships and process plants. Companies have to keep product data that are on both traditional and electronic media for similar periods and similar purposes. Just as some traditional media deteriorate, some electronic media are also unsuitable for long-term storage. However, product data must be capable of outliving the systems that generate and process them. Access to original electronic data is complicated by the rapid obsolescence of computers and the introduction of radically different application systems. For example, new generation CAD applications often pose a problem as they have difficulty in using data produced for old products by old applications. Just as yesteryear's CAD applications have been superseded, today's applications will, in turn, be superseded. Companies need to be equipped to manage old data (for old products), enriched data on old products, and data in new formats.

6.5 Applications

There are many applications supporting the many product- and process-related activities mentioned above. They include idea management, requirements management, CAD (Computer Aided Design), CAM (Computer Aided Manufacturing), CASE (Computer-Aided Software Engineering), NC (Numerical Control) Programming, Design for Manufacturing, CAE (Computer Aided Engineering), BOM (Bill of Materials), routing definition applications, plastic behaviour analysis, rapid prototyping, factory simulation, process mapping, project management, PDM (Product Data Management), CM (Configuration Management), electronic parts catalogues, customer complaint management systems, document management, content management, knowledge management, visualisation and collaboration systems, data exchange and translation applications, Engineering Change Management (ECM) systems, technical publishing systems, applications for capturing product definition data, and applications for presenting product data to customers and suppliers.

These applications create and work with product data in different ways. Each one will probably have its own specific approach to data management. Each will primarily address the function it is supposed to perform, such as geometry definition, or technical publication, with data management being a secondary (and ineffectively implemented) function. These applications typically focus on activity-specific functions. They create product data, but neglect product data management functions such as data definition, structuring, organisation, storage, retrieval, archival, communication, exchange, protection, distribution and tracking.

Some of these applications share and exchange product data (such as part numbers, version numbers, product costs) with other applications such as:

- ERP applications which manage all sorts of company assets, inventories, capacity, schedules, forecasts, orders, costs and revenues
- SCM applications which manage all sorts of materials, information and finances across the supply chain
- CRM applications which manage all sorts of customer information including customer requests, requirements, experience and problems

The majority of the application programs used in product development and support are file-based. They store data directly in files under the control of the computer's operating system. Another program on a different computer cannot easily access the data in these files. This is partly due to the operating system and the communications network, and results from the difficulty of transferring data from a file created in an application running under one operating system on one computer, to another application on another computer running under another operating system or another version of the operating system. It is also because information about an object such as a part or product is not independent of the application that created it. The knowledge about the structure and meaning of the data in the file is often only available in the application that wrote the file, and not available to the other application. As a result, even if the latter application were able to access the data physically, it would not be able to understand it.

Many application developers are unwilling to inform application users about the structure and meaning of the data that their applications produce. As a result, data in a file often remains understandable only to the application that wrote it. Sets of files tend to "belong" to the application that wrote them. Each application then becomes an Island of Automation. For each Island of Automation, a corresponding Island of Data is built up. In medium-sized manufacturing companies it is not uncommon to find 20 or more Islands of Data.

6.6 Methods

There are many work methods and techniques that can be used to improve the product-related activities. For example, companies often use an overall product development and support methodology, such as a phase/gate methodology to let everybody know exactly what is happening at all times, to tell them what they should be doing, and to track project progress. This type of methodology defines the major phases and explains what has to be done in each phase. It shows how the phases fit with the company's organisation and structure.

Techniques such as TRIZ (Theory of Inventive Problem Solving) may be used for specific purposes such as to help innovation. Quality Function Deployment (QFD) may be used to help deploy the product. Design for Manufacture (DFM), Design for Assembly (DFA), Design for Environment (DFE), Design for Recycling (DFR), Design for Six Sigma (DFSS) and Design for Sustainability (DFS) may be applied to improve a design.

Other methods and techniques include Activity Based Costing, Alliance Management, Benchmarking, Compliance Management, Concurrent Engineering, Cost of Quality Management, Early Manufacturing Involvement, Early Supplier Involvement, Failure Modes Effects and Criticality Analysis, Fault Tree Analysis, Life Cycle Assessment, Poka-yoke, Reliability Engineering, Robust Engineering, Value Analysis and Value Engineering.

6.7 Facilities and Equipment

In addition to equipment used during the production phase of the lifecycle, such as a stamping machine to make car body parts, or a milling machine to machine turbine blades, or an oven to heat plastics, equipment is also used at other times in a product's life. Rapid prototyping equipment is used in product development to produce accurate physical prototypes directly from a CAD model. Measuring equipment is used to measure the wear of products in test and in use. Robots can disassemble products when they get to end-of-life.

6.8 People

It takes many people to make and support a product throughout its life. Inside the company, in addition to engineers who define the product, and 'workers' on the shop floor, there may also be account managers, accountants, associates, business analysts, cost accountants, course developers, craters, customer service representatives, database administrators, designers, documentation specialists, drafters, field engineers, financial analysts, HR administrators, HR managers, IT managers, lease representatives, marketers, network specialists, PC technicians, product managers, programmers, project managers, quality managers, regional finance managers, resident engineers, sales representatives, service engineers, software developers, system consultants, system developers, technical support analysts, technicians, and test engineers.

In some cases, most of these roles will be played within the company; in other cases, in companies that have outsourced many tasks, many will be played outside. Outside the company, many other organisations may be involved with the product. They can include suppliers, partners, customers, contractors, distributors, regulators, third-parties, clients, auditors, lawyers, industry bodies, users, acquirers, leasers, owners and quality assurance organisations.

These people may work in different functions and may be at many different locations. They may be working on the company's premises. They may be working for a supplier, or a partner, or they may even be the final customer of the company's product. Their activities need to be part of a controlled process. Product data have to be made available to all these people. At the same time, product data must be protected against unauthorised access.

Many of the users will have an engineering background, and those who do not may come from other backgrounds such as accountancy, human resource management, marketing and sales. These people will work on a variety of tasks. Depending on what they are doing, and their level of computer literacy, they will have different product data usage and product data management needs. Some will create data, some will modify it, some will delete it. Others will only want to reference data, perhaps for management purposes. Some of the users of the product will be customers with completely different backgrounds to those of people in the company.

6.9 Organisational Structure

Many people, and groups of people, carry out or manage all sorts of activities, ranging from product design to compensation management, related to the product. They can be organised in different ways, such as in departments or teams, or by project, product or geography. The organisation of the product is described in the product structure and the Bill of Materials. Many structures are possible. Activities can be organised in different ways into processes. Activities and processes can be organised in different ways on different sites. Data have to be organised, and relations between data elements maintained. The machines that produce products can be organised in different layouts. There are relationships between the organisational structures created for each resource such as products, data and applications. For example, if the product structure is changed, the data structure may change, and the layout of machines may change.

6.10 Metrics

Product-related metrics such as the product's revenues, and the costs associated with a product, are needed to manage various aspects of the product and the product environment. It's important that they don't conflict.

6.11 A Framework for Action

Companies developing and supporting products worldwide need a Framework for their product deployment capability to help organise and communicate about all the resources and issues mentioned above. Such a Framework helps them visualise, quantify and communicate the status of their product-related resources, describe the current situation, and identify next steps.

One of the axes of the Framework is the lifecycle of the product. Splitting the lifecycle into bite-size phases makes it easier to see what's going on. There are five phases in a product's lifecycle:

- Imagination
- Definition
- Realisation
- Use/support/maintenance
- Retirement/disposal/recycling

In each of these phases, the product can be considered to be in a different state:

- During the imagination phase, the product is just an idea in people's heads.
- During the definition phase, the ideas are being converted into a detailed description.
- By the end of the realisation phase, the product exists in its final form (*e.g.* as a car) in which it can be used by a customer.
- During the support/maintenance phase, the product is with the customer who is using it.
- Eventually the product gets to a phase in which it is no longer useful. It is retired by the company, and disposed of by the customer.

6.12 Pains and Gains Throughout the Lifecycle

One of the benefits of defining the phases of the product lifecycle is that it will help people in the company to visualise and classify the many things related to the product during its life. It helps people understand, for example, the problems that occur during the lifecycle. Without the phases, there would just be a long list of problems such as the following:

- Ignoring design alternatives
- Releasing designs with dangerous flaws to manufacturing
- Developing products that don't match the customer's specification
- Missing market windows because of slow product development
- Not doing enough prototyping and testing
- Not adhering to standards
- Ignoring communication problems between departments
- Taking decisions informally, and making changes informally
- Losing, misunderstanding, and ignoring information
- Entering data for Bills of Materials (BOMs) manually

- Having huge amounts of information available somewhere in numerous forms, as a result of which users waste huge amounts of effort, time and money finding what they need
- Wasting time searching databases to generate reports
- Having conflicting data in different data sources
- Having low product data availability during the product lifecycle
- Wasting time accessing data in stand-alone legacy systems
- Having difficulties managing outsourced and offshored functions
- Letting design and engineering departments work in isolation
- Lacking access to, and visibility of, product data at each lifecycle phase
- Not providing salespeople with product availability data
- Not making customer complaint information available to developers
- Having CAD models and BOM files that are not in agreement
- Having difficulties managing market life extensions of mature products
- Having difficulties accessing needed product data in a database in another company in the Extended Enterprise

Such a list is not easy to work with. The message it conveys is that there are a lot of problems, but it's not easy to see if or how they are related, or when they occur. The information that the list contains can be more useful if it is displayed differently. For example, Figure 6.1 shows when the pain is felt in the company – at each stage of the lifecycle.

Figure 6.1 is easy to understand, and people can quickly see the phase of the lifecycle in which they work, and the problems that occur. They can see related problems, group problems and relate problems. They are no longer overwhelmed by an apparently infinitely long list of problems, but can start to understand the causes and think about solutions.

Imagine	Define	Realise	Support/Use	Retire/Recycle
Ideas pirated	Projects late/ failing	Pollution costs	Upgrades ignored	
Lack of ideas	Costs too high	Poor factory layout	Missing applications	
Uncontrollable	Uncontrolled changes	Scrap	Poor communication	Low recycle rate
Ideas Suppressed	Unclear processes	Rework	Data out of control	Materials wasted
Missing applications	Needs not clear	Costly prototypes	Culture of risk	High disposal costs
Culture of sterility	Design faults	Supplier problems	Customers lost	Fines
Failure punished	Application Islands	High material costs	Liability costs	No training
Bureaucracy	Long time to market	Excess inventory	Missing services	Lack of control
Culture of fear	Data silos	Limited part re-use	High service costs	Missing applications
Unknown cost	IP lost/missing	Slow ramp-up	Processes unclear	Processes undefined
No training	Project status vague	Safety problems	Product recalls	Lack of procedures
No process defined	Standards ignored	Wrong data versions	Product failures	Costly disassembly
Imagine	**Define**	**Realise**	**Support/Use**	**Retire/Recycle**

Figure 6.1. Pain throughout the lifecycle

Similarly, the phases help understand where benefits can be achieved throughout the lifecycle. Without the phases, there would just be a long list of potential benefits:

- Improve the interface between product development and product support
- Improve the quality of customer service
- Increase the value of the product portfolio
- Make better use of company knowledge
- Improve control of the product over its lifecycle
- Reduce the time for responding to customer complaints
- Provide better lifetime service
- Enable mass customisation
- Foster innovation
- Create an IS infrastructure for collaboration
- Implement an IS platform spanning all functions and uniting all business partners, suppliers and customers
- Improve the quality of outsourced and offshored development
- Improve the interface between the design chain and the supply chain
- Manage product retirement better

The list is not as good for communication as Figure 6.2:

Imagine	Define	Realise	Support/Use	Retire/Recycle
	Projects on time		Fewer failures	
	Fast time to market	Efficient machine use	Better customer info.	
	Data under control	Trained workers	Add-on modules	
	Clear processes	Less rework	More customers	
Support applications	IP under control	Green logistics	Happy customers	
Supportive culture	Motivated people	Green production	Refurbishment	Re-usable materials
IP under control	Clear requirements	Optimal shop layout	Services revenues up	Re-usable parts
No bureaucracy	Customisation	Less inventory	More services	Environment-correct
Clear process	Clear decisions	More part re-use	Lower service costs	New applications
Imaginative people	Reduced costs	Less scrap	In-service upgrades	Disassembly time cut
Breakthrough ideas	#1 product family	Strategic suppliers	Liability costs cut	Fewer fines
More ideas	Standards adherence	Lower material costs	Warranty costs cut	Better compliance
Imagine	**Define**	**Realise**	**Support/Use**	**Retire/Recycle**

Figure 6.2. Potential gains throughout the lifecycle

6.13 A Grid

Together, the five phases of the product lifecycle and the nine components described in this chapter make a two-dimensional grid or matrix.

On the horizontal axis of the grid are the five phases of the product lifecycle.

On the vertical axis are the nine components that have to be addressed when managing a product (*i.e.* processes, applications, information, *etc.*).

The resulting 5 * 9 grid has 45 cells.

The grid, referred to as the PLM (Product Lifecycle Management) grid (Figure 6.3), helps show why the environment of the product can be so difficult to manage. The scope of the environment is wide.

Many subjects are addressed, ranging from methods for identifying ideas for new products, through organisational structure, to end-of-life recycling tools. The scope is wide, but that reflects the reality of managing global products.

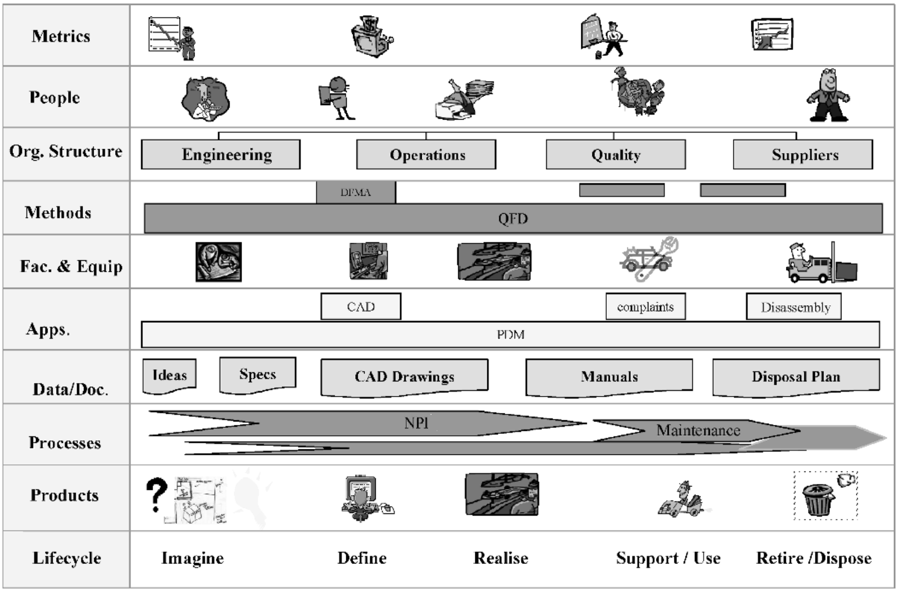


Figure 6.3. The PLM grid

6.14 Benefits of the Grid

The grid can be looked at in different ways. The many items and details may be seen as confirmation that the environment of global products is complex and difficult to manage. Another way of looking at the PLM grid is to see that the apparent complexity of the management of global products can be summarised in a single diagram.

The environment is complex and difficult to manage, but once the complexity and difficulty have been understood, the environment becomes easier to manage.

Now that the scope and the main components of the product environment are clear, the next step is to define what the activity of managing a product across its lifecycle in this environment – Product Lifecycle Management – entails.

7

PLM Enabling Global Products

7.1 Product Lifecycle Management (PLM)

PLM is the business activity of managing a company's products all the way across their lifecycles, from the very first idea for a product all the way through until it is retired and disposed of, in the most effective way. PLM aims to maximise the value of current and future products for both customers and shareholders.

Use of the term PLM implies that the activity of managing products across the lifecycle is clearly-defined, well-documented, proactive, and carried out according to a particular design to meet specific objectives of increasing product revenues, reducing product-related costs, and maximising the value of the product portfolio. The focus on the product is important as a company's products are what the customer buys. They are the source of a company's revenues.

The product is managed throughout its lifecycle – 'from cradle to grave' – making sure that everything works well and that the product makes good money for the company. This means managing the product in every phase of the product lifecycle:

- When it is an idea (*e.g.* making sure the product idea isn't lost or misunderstood)
- When it is being defined (*e.g.* making sure that the development project meets its objectives)
- When it is being realised (*e.g.* making sure the correct version of the definition is used during production)
- When it is in use (*e.g.* making sure the product is correctly maintained, taking account of its serial number, production date, previous upgrades, changes in the market, technical evolution, *etc.*)
- When it is being disposed of (*e.g.* making sure poisonous components and toxic waste don't get anywhere near sources of drinking water)

The concept of a proactive 'cradle to grave' PLM emerged in the early years of the twenty-first century. It first appeared in book form in 'Product Lifecycle Management: Paradigm for 21st century Product Realisation', which was published in 2004.

7.2 The Emergence of PLM

The increasing globality of products makes it more and more important for companies to have an effective way of keeping them under control. This implies managing products across the lifecycle wherever they are. Of course, companies have always, in some way and to some extent, managed their products throughout the lifecycle, but this was not seen as a strategic objective. The way it was done didn't result from a clear, deliberate, documented plan but from the way the company organised other activities. Often, nobody in the company could describe in detail how the products were managed throughout the lifecycle. The subject of how products were managed across the lifecycle had not been explicitly addressed by company management. It was not planned, not documented. Although products were managed to some extent across the lifecycle, "PLM" did not exist in the company.

Figure 7.1. PLM is holistic

7.3 Key Characteristics of PLM

One of the most important characteristics of PLM is that it is holistic (Figure 7.1). Another is that it is "joined-up".

PLM has a holistic approach to the management of a product. It addresses the nine components described in the previous chapters – applications, processes, people, data, work methods, *etc*. This holistic approach distinguishes it from atomistic activities such as Product Data Management (PDM), focused on one particular component.

With PLM, the product is managed in a coherent, joined-up way all across the lifecycle wherever it is needed in the world. PLM joins up many previously separate and independent processes, disciplines, functions and applications, each of which, though addressing the same product, had its own vocabulary, rules, culture and language. PLM manages the product from cradle to grave across the Extended Enterprise. Control of the product across its lifecycle is a necessary foundation for product-based strategies.

7.4 Focus of PLM

PLM is focused on "the product", and is applicable across a wide range of industries – such as discrete manufacturing, pharmaceuticals, food and beverage, fast moving consumer goods, software, apparel and financial – that make and support products.

The list of products for which PLM is applicable is long. It includes agricultural machinery, aircraft, beverages, bridges, buildings, cars, chemicals, computers, consumer electronics, electrical equipment, electricity, elevators, escalators, food, furniture, gas, machine tools, machines, medical equipment, medicines, mobile phones, mortgages, office equipment, offshore structures, pharmaceutical products, power plants, processed food, refrigerators, rockets, ships, shoes, software, telecommunications equipment, telecommunications products, telephones, toys, trains, turbines, washing machines, watches, water and windows.

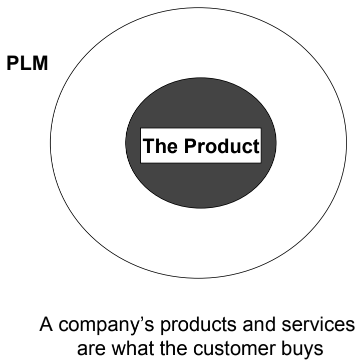


Figure 7.2. At the heart of PLM is the product

The focus on the company's products (Figure 7.2) distinguishes PLM from other activities such as Supply Chain Management (SCM), Customer Relationship

Management (CRM) and Enterprise Resource Planning (ERP). SCM is focused on the Supply Chain, CRM is focused on the customer, and ERP is focused on achieving best use of enterprise resources. PLM is focused on maximising the value of current and future products.

The focus of PLM is the product, not the customer, or the supply chain, or the company's finances, or the human resources, or the company's Information Systems. One of the strengths of PLM is that everyone in a company knows what the company's product is, whereas many would have difficulty in explaining, for example, the company's supply chain or the company's human resource strategy.

7.5 Applicablility of PLM

PLM is used in all sizes of companies. The particular PLM requirements of companies of different sizes may differ, but the fundamental requirements do not. In companies of all sizes, products have to be managed, product data has to be managed, product development and support processes have to be managed, and product data has to be exchanged with other organisations.

PLM is often easier to implement in smaller companies than in larger companies. In a big company, it can be difficult for some people to "get their arms around the PLM Monster". In a company of only a few hundred people, it should be easier to see what's happening and what is needed. There are fewer people, probably fewer documents, fewer applications, less in the way of bureaucracy, *etc.* Yet Small and Medium Enterprises (SME) often face equally intense competitive pressures, equally complex customer requirements, and similar compliance requirements. They may even give higher priority than large companies to being well-integrated with customers and suppliers so that they can participate with them in collaborative efforts.

PLM applies for all products from companies of all types and sizes in all industries. PLM is about "managing products across their lifecycles", and it applies to any company with a product. Many of the companies that are in the public eye are making many (batches of) identical products such as cars, machines and electronic equipment, and perhaps this is what people usually think about when talking about PLM. However, PLM is just as valid for companies making one-of-a-kind products and for companies such as "job shops" in which every product is customised to the customer's requirements. PLM is vital to a job shop because it provides control and visibility over each individual product. The "configuration management" features of PLM make sure all the information about the product is under control. And PLM keeps the "memory" of what was ordered and what was delivered, and eventually what was done to the product after delivery to the customer.

7.6 Functions of PLM

The functions of PLM include:

- Managing a well-structured and valuable Product Portfolio
- Maximising the financial return from the Product Portfolio
- Providing control and visibility over products throughout the lifecycle
- Managing products across the lifecycle
- Managing product development, support and recycling projects effectively
- Managing feedback about products from customers, products, field engineers and the market
- Enabling collaborative work with design and supply chain partners, and with customers
- Managing product-related processes so that they are coherent, joined-up, effective and lean
- Capturing, securely managing, and maintaining the integrity of product definition information, and making it available where it is needed, when it is needed

7.7 Importance of PLM

PLM is important for many reasons. Most important, PLM enables a company to maximise product value over the lifecycle, and to maximise the value of the product portfolio. PLM is also important because it enables a company to be in control of its products across their lifecycle. Not being in control can have serious consequences. If a company loses control of a product during product development, the product may be late to market and exceed the targeted cost. If it loses control during use of the product, the results for the customer may be frustration and a lack of satisfaction, or much worse, injury and death. For the company, the results may be damage to the company's image, loss of customers concerned about product problems, revenues lost to low-cost competitors, and reduced profit due to costs of recalls and legal liabilities.

PLM gives transparency about what is happening over the product lifecycle. It offers managers visibility about what is really happening with products. Without PLM, they are often faced by a huge mass of conflicting information about a product. PLM gives them the opportunity to manage better. With access to the right information, they can make better decisions. With accurate, consolidated information about products available, revenues from new products can be increased and low-cost ways found to extend the revenue-generating lifetimes of mature products.

PLM enables a company to reduce product-related costs. Product-related material and energy costs are fixed early in the product development process. PLM provides the tools and knowledge to minimise them. PLM helps optimise resource utilisation during product development. And PLM can help cut those pesky recall, warranty and recycling costs that come later in the product's life and eat into profits.

PLM is also important because it enables a company to improve its product development performance. Product development, the creation of new products and related services, is the source of future revenues. PLM helps improve product development, enabling a company to grow revenues by improving innovation, reducing time-to-market for new products, and providing superb support and new services for existing products. PLM helps bring new products to market faster. It helps companies to develop and produce products at different sites. It enables collaboration across the design chain and supply chain. PLM helps manage Intellectual Property. It helps maximise reuse of product knowledge. It helps bring together the management of products and processes, and to get processes such as engineering change under control. It helps ensure compliance with regulations.

7.8 Benefits of PLM

PLM provides benefits throughout the product lifecycle, for example by getting products to market faster in the beginning-of-life, providing better support for their use during the middle-of-life, and managing their end-of-life better.

With its focus on the product, companies are looking for PLM to provide benefits in four main areas (Figure 7.3):

- Financial Performance – for example PLM should lead to increased revenue from earlier market introduction, and reduced product development costs.
- Time Reduction – PLM should, for example, reduce project overrun time, and reduce engineering change time.
- Quality Improvement – PLM should help, for example, to reduce manufacturing process defects, reduce the number of returns, and reduce the number of customer complaints.
- Business Improvement – for example, PLM can lead to an increase in the innovation rate, increase the part reuse factor, increase product traceability, and ensure 100% configuration conformity.

In the area of Financial Performance, companies are looking to PLM to increase value, revenues and profits. They want PLM to reduce costs such as direct material costs, warranty costs, prototyping and validation costs, personnel costs, inventory costs, production costs, service costs, and IS costs.

In the area of Time Reduction, companies are looking to PLM to reduce time for many activities. They look to PLM to reduce time to market, time to volume, time to value, time to profit, issue resolution time, project times, and cycle times.

In the area of Quality Improvement, companies are looking to PLM for more and better products, and more meaningful product options and product variants. They are looking to PLM to improve conformance with customer requirements, reduce product faults in the field, prevent recurring product problems, and reduce errors, rework and wasted efforts.

In the area of Business Improvement, companies are looking for all sorts of benefits from PLM. For example, they expect PLM to help improve business decisions, increase reuse of data and parts, provide better visibility of data, improve visibility over the supply chain, increase visibility into manufacturing operations, increase innovation, improve customer responsiveness, improve supplier communications, improve procurement performance, improve resource utilisation, improve risk management, reduce engineering changes late in the lifecycle, ensure compliance with standards, provide traceability, provide the ability to share information, manage product portfolios, analyse product information across the product lifecycle, enable collaborative working, protect Intellectual Property, provide feedback from each phase of the lifecycle, enable better management of outsourced tasks, respond faster to new market opportunities, *etc*.

Figure 7.3. Four main areas of PLM benefit

PLM impacts everyone whose job in some way relates to the company's products and their performance. PLM maximises control, reduces risk, and provides an integrated view of what's happening with the company's products at all times. It is important to all. However, the benefits of PLM are seen differently by different executives. At the highest level, the Chief Executive Officer (CEO) expects PLM to help increase revenues and earnings by bringing better products to market faster, and extending the lives of mature products. CEOs look to PLM to provide visibility and control over products, ensuring there are no unwanted surprises. CEOs look to PLM to maximise product value over the lifecycle, to maximise the value of the product portfolio, and to reduce risk. With PLM, the CEO knows the value of the Product Portfolio and can see how it will evolve. The CEO can make decisions based on reality, rather than guesses. Costs can be reduced as activities that do not add enough value become more visible. With PLM it's easier for the CEO to take account of potential risks.

With PLM, the Chief Financial Officer (CFO) can see the real financial figures for a product across its lifecycle, so knows precisely how much it has cost and earned. Better estimates can be made for the financial figures related to developing, supporting and retiring each product in the future. With uncertainties reduced, more reliable financial projections can be made for shareholders. The value of the Product Portfolio can be monitored, and scenarios built to understand the effect of a variety of possible circumstances such as reduced lifetimes, increased competition and acquisitions throughout the world.

PLM applications need to be addressed in the enterprise application architecture. With PLM, the Chief Information Officer (CIO), or the equivalent person in the company, can put in place collaborative Web platforms and integrated enterprise applications to help bring competitive products to market faster. PLM provides the CIO the opportunity to carry out a wide range of necessary activities to clean up the company's product-related applications, processes and data. This will solve many everyday problems that currently occupy the time of IS professionals, enabling a reduction in IS costs and a redirection of IS effort to activities that add more value.

PLM gives the Chief Product Officer (CPO), or the equivalent person with responsibility for all products, the capability to know the exact status of every ingredient or part, and the exact status and structure of every product. The CPO can take control, both during product development and at later stages in the product lifecycle. The risks associated with products are better understood and managed. PLM helps the CPO get an integrated view over all product development projects. PLM enables secure collaboration with partners wherever they are located. The CPO can develop and implement strategies for faster development and introduction of new products, and for better support of products across their lifecycles.

PLM puts the product once again at the heart of business strategy. It gives Product Managers an integrated view over their product development projects and their products. The exact financial and technical status of every part, product and project is known. With better information available, it's easier for them to take account of potential product and project risks. Product Managers can make decisions based on reality. Unwanted product-related costs, resulting from rework and scrap, warranty and liability claims, and returns and recalls will be reduced, and then eliminated.

7.9 Metrics and Targets of PLM

Companies look for benefits from PLM in four areas – Financial Performance, Time Reduction, Quality Improvement and Business Improvement. Corresponding metrics and targets are needed in these four areas.

In the area of Financial Performance, possible metrics and targets include:

- Increase the value of the product portfolio by 20%
- Increase profit by 100%
- Increase annual revenues by 10%
- Increase revenues, through faster product introduction, by 15%
- Increase revenues, through wider product range, by 20%
- Increase revenues, through extended product life, by 25%
- Increase revenues, through new services on existing products, by 40%
- Reduce costs due to recalls, failures, liabilities by 75%
- Reduce cost of materials and energy by 25%
- Reduce project cost overrun by 80%
- Reduce product development costs by 5%
- Reduce product development administration costs by 50%

In the area of Time Reduction, possible metrics and targets include:

- Reduce time to market by 50%
- Reduce project time overrun by 80%
- Reduce engineering change time by 80%
- Reduce time to value by 30%
- Reduce time to profitability by 25%

In the area of Quality Improvement, possible metrics and targets include:

- Reduce defects in the manufacturing process by 25%
- Reduce customer complaints by 50%
- Reduce product liability costs by 40%

In the area of Business Improvement, possible metrics and targets include:

- Increase the rate of introduction of new products by 100%
- Increase the part reuse factor to 7
- Increase recycled part usage to 90%
- Increase product traceability to 100%
- Increase lifecycle control to 100%
- Increase lifecycle visibility to 100%
- Increase the number of concepts tested by 50%
- Ensure 100% resource optimisation
- Ensure 100% configuration conformity

7.10 Comparison of the Old and New Paradigms

In the environment before the emergence of PLM (the PrePLM environment), the paradigm for managing a product across the lifecycle was an Alphabet Soup of many small activities, each of which managed a product at a different moment in its life. The PLM paradigm sees PLM as one major business activity.

In the PrePLM paradigm, each of the many small activities had technical objectives, not business objectives. PLM has business objectives.

The PLM paradigm has a focus on the product. In the PrePLM paradigm, the nearest equivalent in most companies was a focus on the customer.

The PrePLM paradigm assumed a departmental company organisation. The PLM paradigm assumes an organisation focused on the product.

The PrePLM paradigm was atomistic, the PLM paradigm is holistic.

The PLM paradigm differs in many ways from the previous paradigm. For example, with PLM, the initial focus is on the lifecycle, whereas with the previous paradigm it was on the departments, functions, projects or business processes of the company. From the lifecycle, the focus of PLM then moves to the phases of the lifecycle: imagination; definition; realisation; support; retirement. This has many implications. For example, it could be assumed that to each phase should correspond processes, applications, information, and people. In most companies this was not the case in the early years of the twenty-first century. The resources were aligned with the functions and/or departments, not the phases.

In the PrePLM paradigm, organisations didn't manage products in a joined-up way across the product lifecycle. For example, product development and product support were often carried out in different parts of the organisation even though they addressed the same products. Because they were addressed in different parts of the organisation, the activities were carried out by different groups of people with different managers. Each group created its own processes, defined its own data and document structures, and selected its own computer applications.

With PLM, the organisation manages the product in a coherent joined-up way across the lifecycle. PLM brings together what was previously separate, for example, product development and product support. Other examples of previously separate things joined up in the PLM paradigm include:

- Product infancy and product end-of-life
- Applications such as CAD, PDM and ERP
- Activities such as those for product development and product disposal
- Processes such as those for product assembly and product disassembly
- Product development and product liability
- Product developers and product customers

- Product definition and environmental issues
- Product development and sustainable development
- Innovation and mature products
- Project portfolio management and product portfolio management

7.11 Key Points for the CEO

Assuming that a CEO doesn't have time to go into all the details of PLM, and only needs to know its most important characteristics, then the following points about PLM are important to communicate:

1. PLM manages the product all the way across its lifecycle. (There's been nothing available to do this before in a coherent way, and that has caused many problems.)

2. PLM provides visibility about what is happening to the product across the lifecycle. (So the CEO will know what is happening with products and with product development, modification and retirement projects.)

3. PLM gets products under control across the lifecycle. (Which means the CEO is in control, faces less risk and can influence what's happening.)

4. In the past, products were to a certain extent managed across the lifecycle, so a lot of the components needed for PLM already exist. However, there are gaps, contradictory versions of the same data, information sinks, silos, non-functioning networks, duplicate processes, ineffective fixes, *etc.*, that result in reduced revenues and higher costs. (Which means that PLM doesn't involve starting from new, but building on what already exists.)

5. The benefits of PLM are measurable and visible on the bottom line. (Typical current targets for PLM are to increase product revenues by 30% and decrease product maintenance costs by 50%.)

6. PLM is holistic. (PLM is not another unbalanced Corporate Initiative. It doesn't just addresses one resource, and improve use of that resource while reducing the effectiveness of other resources.)

7. There's currently no "off-the-shelf" solution for PLM. (Which means that each company must define its own solution for PLM.)

8. With PLM, the CEO will be able to give responsibility for all the products – which will be visible and under control – to one person. (Instead of having unclear multiple responsibilities for products.)

9. The CEO should launch a PLM Initiative. (PLM enables the opportunities of global products to be achieved.)

7.12 PLM Applications

There are two main groups of PLM applications. The first group contains "generic" applications that are applicable to all kinds of companies, all types of products, all types of user within those companies. This group includes:

- Data Management / Document Management
- Part Management / Product Management / Configuration Management
- Process Management / Workflow Management
- Program Management / Project Management
- Collaboration Management
- Visualisation
- Integration
- Infrastructure Management
- Product Idea Management
- Product Feedback Management

It will be seen that, as an example, the first application in the list, "data management", is a generic application which is needed by a design engineer in the automotive industry, but also by a project manager in the pharmaceutical industry. They both have enormous amounts of data to manage. Similarly, the fifth item in the list, "collaboration management", is applicable in any situation where people in different locations are working together.

It is probably a slight exaggeration, but in theory, all the above applications are needed for most people working in product-related activities. That is not the case for the applications in the second group. These are much more specific to a particular context. This second group contains more specialised applications that are needed by particular people, departments, functions or industries. This group includes:

- Product Portfolio Management
- Idea Generation Management
- Requirements and Specifications Management
- Collaborative Product Definition Management
- Supplier and Sourcing Management
- Manufacturing Management
- Maintenance Management
- Environment, Health and Safety Management
- Intellectual Property Management

The first item in the list, "Product Portfolio Management", has very specific functionality that is only needed by a few people in a company. Similarly "Collaborative Product Definition Management" will have functionality specific to the needs of people who define the product. The PLM applications are detailed in the following sections.

7.13 Generic PLM Applications

7.13.1 Data Management / Document Management

Enables a company to store and make available data (documents/drawings/files) throughout the entire product lifecycle in a controlled-access secure distributed environment. Enables version management, revision control, classification, search, analysis, reporting, *etc.*

7.13.2 Part Management / Product Management / Configuration Management

Enables a company to manage products, product structures and product attributes throughout the entire product lifecycle in a controlled-access secure distributed environment. Enables version management, revision control, classification, search, analysis, reporting, *etc.* Enables improved design, part and module reuse.

7.13.3 Process Management / Workflow Management

Enables a company to map business processes, to define and automate simple processes (such as change approval and release processes, and the engineering change management process) and ensure compliance with regulatory requirements from organisations such as the FDA and the International Standards Organisation (ISO). Templates enable common, repeatable processes. Workflow management includes routing templates, paths, lists, logic and rules. It can include notification management.

7.13.4 Program Management / Project Management

Enables a company to plan, manage and control projects and programs. Enables stage, gate, milestone, and deliverable control. Enables resource management. Provides visibility into a project's status in terms of progress and costs. Shows interdependencies among project resources, intermediate deliverables, *etc.* Provides a range of display options, dashboards, cockpit charts, pie charts, graphs, *etc.*, with options for rolling up, filtering, and grouping projects to focus on specific issues.

7.13.5 Collaboration Management

Enables geographically-dispersed teams and individuals to work together in a secure, structured, virtual working environment using up-to-date product information.

Includes tools and activities such as calendars, schedules, e-mail, messaging, electronic whiteboards, discussion groups, virtual meeting sites, web conferencing, videoconferencing, audio conferencing, collaborative blogging, collaborative content co-authoring, chat rooms, intranets, shared project spaces, portals, vortals and project directories.

7.13.6 Visualisation

Provides viewing, visualisation and virtual mockup capabilities.

7.13.7 Integration

Enables exchange of product information between PLM applications (*e.g.* between CAD systems). Enables exchange of product information between PLM and enterprise applications such as ERP and CRM.

7.13.8 Infrastructure Management

Manages services of infrastructure such as networks, databases, and servers.

7.13.9 Idea Management

Enables product ideas to be captured and analysed, appropriate actions to be initiated, and progress to be tracked.

7.13.10 Product Feedback Management

Enables feedback about the product to be captured, analysed and made available where needed.

7.14 Task-focused PLM Applications

7.14.1 Product Portfolio Management

Enables review, analysis, simulation, and valuation of a company's Product Portfolio of existing products integrated with the pipeline of development projects, showing estimates of sales and reuse, and showing the effects of decisions such as introducing new technologies, making acquisitions and launching joint ventures. Enables the analysis of risks/rewards for different scenarios. Enables tracking and analysis of product costs against target costs and profit. Provides a range of display options, dashboards, cockpit charts, pie charts and graphs, with possibilities for rolling up, filtering, and grouping projects to meet various objectives.

7.14.2 Idea Generation Management

Enables systematic management of the generation of ideas for new and improved products.

7.14.3 Requirements and Specifications Management

Enables a company systematically to gather, analyse, communicate and manage product requirements describing market and customer needs. Enables a company systematically to manage and standardise product specifications.

7.14.4 Collaborative Product Definition Management

Enables the definition of products by people and teams from different companies working at different locations.

7.14.5 Supplier and Sourcing Management

Enables purchasing teams to collaborate with other team members and external suppliers for various activities such as reviewing, selecting, and purchasing custom and/or standard parts. Enables qualification of new suppliers and tracking of supplier performance. Enables early involvement of suppliers, gives them real-time access to relevant product information. Enables product quality planning and use of Quality Templates. Enables the purchasing process to be streamlined and prevents over-limit purchases.

7.14.6 Manufacturing Management

Enables realisation teams to simulate, optimise and define the realisation process and understand the relationships between product, plant, and manufacturing process.

7.14.7 Maintenance Management

Enables customer support and maintenance teams to optimise processes, get better customer feedback, carry out activities more effectively, and better manage part and equipment inventories.

7.14.8 Environment, Health and Safety Management

Enables deployment and management of business processes complying with regulations of organisations such as the ISO and the FDA for the development and use of a product.

7.14.9 Intellectual Property Management

Enables the valuation and management of the intellectual property represented by a company’s products and related services.

8

Local Performance Improvements

8.1 Improving the Business

There are many techniques and applications to improve the effectiveness of product development and support. They have all met with success in one or more companies, and should be understood by companies embarking on PLM initiatives. However, all companies are in slightly different situations. A particular company may only need a few of these techniques and applications. Another company may need many. Selecting and prioritising such techniques and applications is part of the activity of defining a strategy for PLM. One of the challenges of PLM for a particular company is to identify the techniques and applications that are most relevant to the activities on which the company wants to focus its efforts.

Many books and articles have been written about these improvement technologies, techniques, approaches and Best Practices, and it would not be possible to do justice to them all in one chapter. Instead each is described in a few lines, and it is assumed that readers will be able to find more details elsewhere.

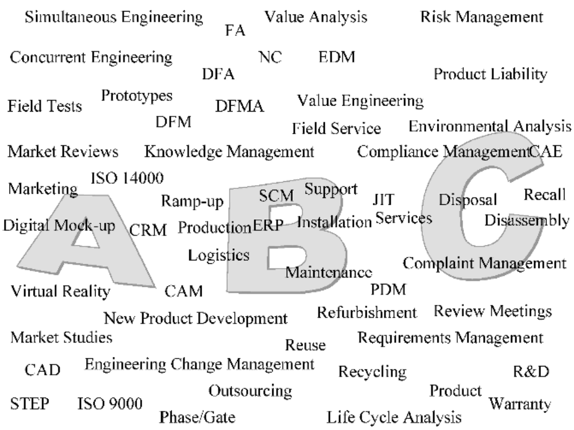


Figure 8.1. Many improvement approaches

8.2 Improvement Approaches

Activity Based Costing is a costing technique used to overcome deficiencies of traditional product costing systems that, under some conditions, such as high volume and product diversity, give inaccurate product costs. Inaccurate product costs create problems when taking pricing decisions for new product introductions, retiring obsolete products, and responding to competitive products.

Alliance Management is needed in the extended enterprise environment to ensure that everything works well among the many participants. This usually means more than just contract compliance, and can include governance activities, building and maintaining alignment, and ensuring that relationships move forward.

Benchmarking is a technique used to compare a company's performance with that of other organisations believed to have more effective operations. If the other organisations are found to have more effective operations, then the company can try to understand how they work and why they are better. The company can then set itself realistic performance targets, and start to improve its own operations.

Business Process Reengineering is a technique used to reorganise significantly a company's business processes with the objective of making very large improvements in performance. Reengineering is an example of transformational change. It involves radically rethinking and redesigning a major business process with the objective of achieving large-scale improvements in overall business performance.

Collaboration software allows people to work together, over the Web, with product and process definition data. Technologies include e-mail, electronic whiteboards, discussion groups, chat rooms, intranets, extranets, shared project spaces, portals, vortals and project directories.

Company-Wide Quality Control is a technique in which all parts of the company co-operate to improve all aspects of company operations.

Computer Aided Design is the generic name for all computer-based tools using interactive graphics techniques that are used in translating a requirement or concept into an engineering design, the geometry of which is stored in a computerised data base.

Computer Aided Engineering is the overall umbrella acronym for all computer-based tools used in the design engineering and manufacturing engineering functions. Sometimes, however, it is only used to mean all computer-based tools used in design engineering. On other occasions, it is used to mean only those computer-based tools used at the front end of the design engineering process, prior to detailed design.

Computer Aided Industrial Design allows an industrial designer to model a design in three dimensions on a workstation. Through the use of shading, colour, movement and rotation, CAID lets designers create photorealistic images and animations from a core design. The model can then be used to communicate designs to other groups involved in product development (*e.g.* marketing and manufacturing).

Computer Aided Manufacturing is a generic name for all computer-based tools used in manufacturing engineering activities. These include Computer Aided Production Engineering, Computer Aided Process Planning, Computer Aided tool and fixture design, NC programming and PLC (Programmable Logic Controller) programming. CAM is used in preparing for a wide range of manufacturing processes, including the cutting of metals, fabrics, leather and composites, and the forming of metals, plastics, rubber, leather, composites and glass. It is used in preparing for paint spraying, composite laying, deburring and parts assembly.

Computer Aided Production Engineering systems digitally model a manufacturing plant, production line or work cell to enable simulation of production processes for particular products in a 'Virtual Factory'.

Computer Aided Process Planning applications are used in the generation of process plans. Process plans describe the operations that a part must undergo. They define the sequence of production operations and specify tooling. They detail speeds, feeds and coolants, and define set-up and run times.

Computer Aided Software Engineering tools are used to support some or all of the phases of the software lifecycle. There are basically three types of CASE tools: those that are used in planning, those that are used in analysis and design, and those that are used in code-related activities.

Component and Supplier Management applications provide access to a common parts database and an Approved Supplier List.

Concurrent Engineering and Simultaneous Engineering are techniques to bring together multidisciplinary teams that work from the start of a development project with the aim of getting things right as quickly as possible, and as early as possible. Input is obtained from as many functional areas as possible before the specifications are finalised. Getting the development correct at the start reduces downstream difficulties in the product lifecycle.

Configuration Management is the activity of documenting initial product specifications, and controlling and documenting changes to these specifications. CM is a formal discipline to help assure the quality and long-term support of complex products through consistent identification, and effective monitoring and control, of all of this information. ISO 10007:2003 provides guidance on the use of configuration management within an organisation. Applicable across the product lifecycle, it describes the configuration management responsibilities and authorities, the process and the planning, as well as the four activities of configuration identification, change control, configuration status accounting and configuration audit. Configuration identification includes determining the product structure, selecting configuration items, documenting items, interfaces and changes, and allocating identification characters or numbers. Configuration control addresses the control of changes to a configuration item after formal establishment of its configuration documents. Configuration status accounting is for formal recording and reporting of the established configuration documents, the status of proposed changes and the status of the implementation of approved changes. Configuration audits are carried out to determine whether a configuration item conforms to its configuration documents.

Continuous Improvement is an approach of incremental change aimed at making many small-scale improvements to current business processes.

Cost of Quality Management is an approach to reducing the Cost of Quality, the sum of all the costs incurred throughout the product lifecycle due to poor quality, *i.e.* by the product not having perfect quality first time and every subsequent time. The Cost of Quality is made up of four types of quality costs:

- Internal failure costs – due to failures such as rework, scrap and poor design that the customer does not see.
- External failure costs – due to failures that occur after the product has been delivered to the customer. They include warranty claims, product liability claims and field returns.
- Appraisal costs – the costs of measuring quality and maintaining conformance by such activities as inspection, testing, process monitoring and equipment calibration.
- Prevention costs – the costs of activities to reduce failure and appraisal costs, and to achieve first-time quality, such as education, training and supplier certification.

Data exchange applications allow product and process definition data to be transferred (and/or exchanged and/or translated) from a format that is usable in one application to a format that is usable in another application.

Design for Assembly techniques aim to reduce the cost and time of assembly by simplifying the product and process through such means as reducing the number of parts, combining two or more parts into one, reducing or eliminating adjustments, simplifying assembly operations, designing for parts handling and presentation, selecting fasteners for ease of assembly, minimising parts tangling, and ensuring that products are easy to test. For example, tabs and notches in mating parts make assembly easier, and also reduce the need for assembly and testing documentation. Simple z-axis assembly can minimise handling and insertion time.

Design for Environment is an approach that integrates all environmental considerations into product and process design.

Design for Manufacture techniques are closely linked to Design for Assembly techniques, but are oriented primarily to individual parts and components rather than to DFA's sub-assemblies, assemblies, and products. DFM aims to eliminate the often expensive and unnecessary features of a part that make it difficult to manufacture. It helps prevent the unnecessarily smooth surface, the radius that is unnecessarily small, and the tolerances that are unnecessarily high.

Design for Recycling aims to increase the level of recyclability and to ensure that recycled material keeps as much of its value as possible.

Design for Six Sigma includes various methodologies to achieve six sigma performance. DMAIC (define, measure, analyse, improve and control) is generally used for an existing product or process. Other methodologies are used to design a new product for Six Sigma quality.

Design for Sustainability is an approach that recognises that products and processes must take account of environmental, economic, and social requirements, and integrates these into product and process design, for example: using energy as efficiently as possible; minimising use of toxic chemicals; taking care of air and water quality; and efficiently using and recycling materials.

Design Rules, Design Guidelines and Design Axioms bring together principles of successful design.

Design to Cost techniques address cost-effectiveness from the viewpoints of system effectiveness and economic cost. The economic costs may be limited to design engineering costs and/or production costs. In other cases, operations and support costs may be included. Cost is addressed by establishing an initial design, comparing estimated costs with an allocated budget at the system or subsystem level, and addressing any cost inconsistencies through subsequent redesign or re-evaluation of requirements.

A Digital Mock-Up is a computer-based product definition of a real product. It provides a digital data set that can be used in many types of analysis.

Digital Manufacturing applications help with activities such as manufacturing cost estimating, factory layout and simulation, process planning, robotics, machining and inspection.

Early Manufacturing Involvement brings manufacturing engineers into design activities that take place early in the product workflow, rather than only bringing them in once the designers have finalised a product that will be difficult or impossible to manufacture.

Early Supplier Involvement brings suppliers into development activities early in the product workflow, rather than only bringing them in to manufacture some of the parts. Companies that focus on upstream customer, specification and product design activities, where they can best use their particular resources, want to outsource downstream activities where they are not cost-effective (*e.g.* in detailed drafting) or are less competent than specialised organisations (*e.g.* in parts manufacture). As a result, suppliers have an important role to play. Companies want to make the best possible use of suppliers with the aim of getting a customer-satisfying product to market as early as possible. This means involving the supplier right at the beginning of the process, when the major modules of the product are being defined. The supplier can then be given the job of designing and manufacturing a complete sub-assembly or assembly. Suppliers are expected to provide fast response, to be responsible, to be reliable and to have excellent skills, knowledge and experience concerning particular parts or activities. The company will want to have long-term relationships with a small group of excellent, knowledgeable and trusted suppliers.

Failure Modes Effects and Criticality Analysis is a technique for identifying the possible ways in which a product or part can fail, the corresponding causes of failure, and the corresponding effects.

Fault Tree Analysis is a technique that uses a hierarchical decomposition technique for analysing faults. A fault tree is a diagram showing the interrelationships between failures and combinations of failures.

Group Technology is a technique to exploit similarities in products and processes so as to improve the overall efficiency of operations.

Hoshin Kanri (Policy Deployment) is a technique of step-by-step planning, implementation, and review for managed change. It is a systems approach to management of change in business processes. A system, in this sense, is a set of co-ordinated processes that accomplish the core objectives of the business. Policy Deployment cascades, or deploys, top management policies and targets down the management hierarchy. At each level, the policy is translated into policies, targets and actions for the next level down.

From about 2000 onwards, the scope of Innovation Management changed. Previously it had mainly addressed product innovation in R&D. Since then, the scope has been extended to include innovation in processes, delivery and business models. ‘Open innovation’ has emerged. It’s a way for a company to search for and acquire innovation outside its borders. Innovation methods include Edward DeBono’s ‘Lateral Thinking’ and ‘Six Hats’, Eric von Hippel’s ‘Lead User Analysis’ and Genrich Altshuller’s ‘TRIZ’.

Just-In-Time started to be used on a widespread basis in the 1980s as a technique for reducing material inventory. The idea was that if parts were manufactured (or delivered) just-in-time for assembly, then inventory and its associated costs could be eliminated. The supporters of JIT have extended it to become a waste-reduction management technique for improving business processes, and even an enterprise-wide operating philosophy with the basic objective of eliminating all non-value-added activities and other waste.

Knowledge Based applications aim to allow the experience and knowledge of humans to be represented and used on a computer so as to increase people's decision-making ability.

Knowledge Management includes major activities such as: creating knowledge; capturing knowledge; analysing knowledge; storing knowledge; indexing/classifying/validating knowledge; synthesising useful/usable knowledge; searching for/finding relevant knowledge; making knowledge available; making value-adding use of knowledge. The Knowledge part of Knowledge Management includes anything about a company, its customers, its products, its competitors, its partners, *etc.* It could be knowledge from the past, current knowledge or, perhaps most valuable, future knowledge (foresight). Examples could include: current internal knowledge – the BOM of a company's product; current competitive knowledge – user profiles of a competitor's best market segment; future internal knowledge – a company's next product design; future competitive knowledge – user profiles of a competitor's target market segments; breakthrough knowledge – how to make a product for half the cost, user profiles of the 10,000 early adopters of a new product. Among the many application areas of Knowledge Management are: customer knowledge management (using knowledge about customers to provide customised product information or customised service information); knowledge data bases (containing experience of best practices across a wide range of industries); knowledge retention systems (conserving knowledge of how people work in different activities); virtual educational organisations – enabling rapid education and training at the knowledge consumer's workplace.

Lean Production appeared in the West in the early 1990s. Key concepts include "only add value in production", "eliminate waste", and "flow value from the customer". Some interpretations of Lean Production also include a focus on people and their knowledge. Six Sigma and JIT are seen as tools to support a Lean Production approach.

Life Cycle Assessment is a methodology used to understand the main impacts arising in each phase of a product's life. Lifecycle assessment involves the calculation and evaluation of the environmentally relevant inputs (such as minerals and energy) and outputs (such as energy savings) and the potential environmental impacts (such as emissions and solid waste) from the lifecycle of a product, material or service. It aims to increase the efficiency of the use of resources, and reduce waste and liabilities.

Lifecycle design incorporates disposal and recycling issues at the early stages of product development. All the issues related to a product's useful life are considered at the outset, and so are those involving the product once its useful life is over. Lifecycle design includes evaluation of environmental protection, working conditions, resource optimisation, company policies, lifecycle costs, product properties and ease of manufacture. The goals of lifecycle design include ease of disassembly, ease of assembly, fast and safe decomposition, lowest cost to find/recover, and lowest cost to recycle.

The Plan-Do-Check-Act cycle is a technique for continuous improvement of any activity or process. In the "plan" step, a plan of action is generated to address a problem. Corresponding control points and control parameters are generated. The plan is reviewed and agreed. In the "do" step, the plan is implemented. In the "check" step, information is collected on the control parameters. The actual results are compared to the expected results. In the "act" step, the results are analysed. Causes of any discrepancies are identified, discussed and agreed. Corrective action is identified.

Poka-yoke existed as a concept for a long time before the Japanese manufacturing engineer Shigeo Shingo developed the idea into a technique for achieving zero defects and eventually eliminating quality control inspections. The methods are sometimes called "fool-proofing", but recognising that this term could offend some managers and workers, he came up with the term poka-yoke, generally translated as "mistake-proofing" or "fail-safing" (to avoid (yokeru) inadvertent errors (poka)). The use of an additional locator pin to prevent misalignment of the workpiece is an example of poka-yoke.

Portfolio Management provides an overview of a company's pipeline of development projects. It allows managers to take trade-off decisions based on the risks/rewards of the product portfolio against a company's strategic objectives. Portfolio Management enables assessment of resource allocation against top-level strategic goals and risk/reward expectations, and shows the interdependencies of resources, intermediate deliverables, and other information. To facilitate analysis, Portfolio Management provides a range of display options such as pie charts and graphs with many possibilities for rolling up, filtering, and grouping projects to focus on specific types of question. Many parameters can be plotted, such as revenue *vs* cost, impact *vs* probability, and market share *vs* Net Present Value.

Process Mapping is carried out to understand, analyse and design business processes.

Product Data Management applications focus on managing product, service and process definition data throughout the product lifecycle. They enable the right information to be available at exactly the right time. Functionality of this type may be found in applications such as Engineering Document Management, Engineering Data Management, Product Data Management, Knowledge Management, Configuration Management, Enterprise Content Management, Regulatory Management and Quality Management applications.

Project Management approaches help manage a company's individual product-related projects in an effective way.

QFD is a step-by-step technique for ensuring that the “voice of the customer” is heard throughout the product development process so that the final product fully meets customer requirements. The first step of QFD is to identify and capture customer requirements, wishes, expectations and demands. In the following steps, these are translated by cross-functional product teams into the corresponding technical specifications. QFD uses a series of related simple matrices and tables as the tool for translating the voice of the customer first to design specifications, then to more detailed part characteristics, then to show the necessary process and technology characteristics, and finally to show the specific operational conditions for the production phase. The interrelated tables and matrices develop to form what is often called a “Quality House”, due to the roof-like shape of some of the tables.

Rapid prototyping is the production of a physical prototype directly from a computer-based model of a part or product. The prototype can be in a variety of materials including investment casting wax, PVC, and polycarbonates. The prototype can be produced in a few hours compared to the days or weeks of conventional prototyping techniques. Rapid prototyping technologies include selective laser sintering, ballistic particle manufacturing, stereolithography, instant slice curing, and direct shell production casting.

Reliability Engineering is a technique to improve the reliability of a product or process. Reliability Engineering includes the activities of planning, measuring, analysing, and recommending changes with the aim of improving the reliability of a product or process. Reliability is the ability of the product or process to perform its functions in a defined environment over a given period of time. The failure rate over the product lifecycle, or during operation of the process, measures the probability of not meeting these requirements. In order to increase capability while saving resources, reliability and maintainability must be formalised concurrently during the design process, and must be valued and measured as much as performance and other design criteria.

Requirements Management gathers and manages user, business, technical, functional and process requirements for a product.

Roadmapping helps portfolio and product managers to identify new opportunities, and the product and technology activities required to get a product to market.

Robust Engineering is the engineering of products and processes such that they will work satisfactorily throughout their lifetime in spite of disturbances that are bound to occur. Robust Engineering takes as a starting point the fact that it is impossible to prevent or control all variations throughout the lifetime of a product or process. As a result, these should be designed to be as immune as possible to the variations that will occur due to a variety of sources in the product or process environment. Typical sources of variation for a product are the manufacturing process and in-use deterioration.

Simulation is carried out to study the performance of a system before it has been physically built or implemented. Simulation can be used to study the likely performance of a strategy without actually implementing it. It can be used to study the performance of a product or a process without actually building or implementing it. Simulation can be used at many stages of the product lifecycle. Simulation eliminates the costly and time-consuming activities of building physical models of the part and the environment. Instead it uses the models designed in the computer which would normally be the basis for building the physical models.

Six Sigma, which appeared in the late 1980s / early 1990s, is an approach and collection of statistical methods for systematically analysing processes to reduce process variation. At Six Sigma quality, a process must produce no more than 3.4 defects per million.

Software Configuration Management is the controlled way to manage the development and modification of software.

Software development methodologies were introduced to manage software development. These methodologies divide projects into phases, and use deliverables and approvals to maintain control. In 1970, W.W. Royce published an article called "Managing the development of large software systems: concepts and techniques." This referred to the Waterfall system development methodology (requirements, analysis, design, coding, testing and maintenance).

Standards of many types influence the product environment. Examples include: ISO 9000, ISO 14000, ISO 10303, the SEI capability maturity model, the AQAP (Allied Quality Assurance Publication) 2000 series, the NATO requirements for an Integrated Systems Approach to Quality through the Life Cycle, *etc.*

Stage/Gate and phase/gate methodologies split the product development activity into separate phases (usually between four and six phases). When product development projects are carried out, people from different functions work together in each phase, carrying out the tasks defined for that phase and producing the required deliverables. At the end of the phase is a "gate", at which a cross-functional team, including managers, reviews results for that phase and only allows the project to proceed through the gate, to the next phase, if it meets pre-defined targets. Project managers can use special reports to monitor day-to-day activities and to assist with appropriate decisions and actions, such as adjusting resources and dates. These reports may vary by type of process; for instance different reports for new product development projects and product improvement projects.

Statistical Process Control is used during the production phase of the product lifecycle to reduce the variation and help correct whatever is wrong. All production processes fluctuate over time, but provided they are stable, will stay within certain well-defined limits known as control limits. If a process gets out of control, the fluctuations go beyond the control limits. At the heart of SPC is the statistical analysis of engineering and manufacturing information. Facts, data and analysis support the planning, review and tracking of products throughout the lifecycle. SPC is based on the use of objective data, and provides a rational rather than an emotional basis for decision making. This approach recognises that most problems are system-related, and are not caused by particular people. It ensures that data are collected and placed in the hands of the people who are in the best position to analyse them, and then take the appropriate action to reduce costs and prevent non-conformance. If the right information is not available, then the analysis, whether it be of shop floor data or engineering test results, cannot take place, errors cannot be identified, and consequently, errors cannot be corrected.

Systems Engineering is an interdisciplinary approach and means for enabling the realisation and deployment of successful systems. The Systems Engineering effort spans the whole system lifecycle. SE focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem. System integration issues are dealt with early on, rather than later in the development cycle.

Taguchi's experimental design techniques allow designers to experiment with a large number of variables with relatively few experiments. Genuchi Taguchi started developing them in the 1950s. The Taguchi approach is particularly relevant to the parameter design phase in which the designer sets the value of design parameters (*i.e.* assigns specific values for product and process parameters) to get a stable reliable product.

Teamwork is a technique enabling a group of individuals, often from several functions who work together ("simultaneously" in time, often "co-located" in space), to share information and knowledge, and produce better and faster results than they would have done if operating independently and in serial mode.

Technical Document Management systems are similar to PDM systems, and provide a vault for all drawings and documents, as well as mechanisms to index and access them.

Total Cost of Ownership (TCO) approaches help companies understand how much it will cost, not just to purchase a product, but also to use, maintain and retire it.

Total Quality is a description of the culture, attitude and organisation of a company that aims to provide, and continue to provide, its customers with products and services that satisfy their needs. The culture requires quality in all aspects of the company's operations, with things being done right first time, and defects and waste eradicated from operations.

Total Quality Management is an approach to the art of management that has become steadily more popular in the West since the early 1980s. The key points of TQM include: customer-driven quality; TQM leadership from top management;

continuous improvement; fast response to customer requirements; actions based on data and analysis; participation by all employees; a TQM culture. Continuous improvement of all operations and activities is at the heart of TQM. Because customer satisfaction can only be achieved by providing a high-quality product, continuous improvement of the quality of the product is seen as the only way to maintain a high level of customer satisfaction. As well as recognising the link between product quality and customer satisfaction, TQM also recognises that product quality is the result of process quality. As a result, there is a focus on continuous improvement of the company's processes. This will lead to an improvement in process quality. In turn this will lead to an improvement in product quality, and to an increase in customer satisfaction. TQM and Six Sigma differ in that TQM offers a complete management approach for an organisation, whereas Six Sigma is mainly a statistical approach to process improvement.

TRIZ is a way of systematically solving problems and creating suitable solutions. It was invented by a Russian engineer and scientist, Genrich Altshuller. TRIZ is known in English as the Theory of Inventive Problem Solving. The TRIZ acronym comes from the Russian original.

Value Analysis and Value Engineering are techniques in which a multifunctional team measures the current value of a product or its components in terms of functions that fulfil user needs. "Value Analysis" is applied to existing products whereas "Value Engineering" is carried out during initial product development. However, the principles are very similar, and the term value analysis is sometimes used where value engineering would be more appropriate. Value analysis should be carried out by a crossfunctional and/or multidisciplinary team (including design, marketing, production, finance, service) with the aim of finding the most cost-effective solution for a particular product that is consistent with customer satisfaction. The team develops and evaluates alternatives that might eliminate or improve component areas of low value, and matches these new alternatives with the best means to accomplish them.

Virtual Reality is the application of computer simulations, based on 3D graphics and special devices, of an environment to allow a user to interact with that environment as if it were real.

Virtual Engineering brings together Virtual Reality, engineering computation, modelling, simulation and CAD technologies.

Virtual Prototyping is the construction and testing of a virtual prototype, or digital mock-up, which is a computer simulation of a physical product that can be viewed, analysed, and tested as if it were a real physical model. Virtual prototyping uses 3D models created in CAD systems for activities such as assembly/disassembly verification, design reviews and visibility verification.

Visualisation and Viewing applications are used for visualising, viewing and printing product and process definition data.

3D scanning systems are used to create a cloud of points corresponding to the surface of a part. They can be used to check that a manufactured part corresponds to its design specifications. For example, an OEM outsources a part, and sends the CAD file to the supplier. The supplier makes the part, scans it, and e-mails the point cloud to the OEM who checks it against the CAD model.

9

The Way Forward to PLM

9.1 Vision Statements to Work with

This chapter describes a PLM Vision, and why it's needed. It mentions some of the difficulties that may arise when developing a PLM Vision. It identifies the various components of the PLM Vision and provides examples of the types of statement that could be used to describe them. For a particular company, some of these statements may be completely wrong, or irrelevant, or not applicable. Many of them, though, can be used, perhaps with some alteration, to help build a description of what PLM will look like in a particular company in the future, for example five years from now. For initial presentations about PLM, it may be sufficient to present some of the statements in this chapter as "Examples of PLM Vision Statements". They will help people to understand what the PLM environment in the company may look like in the future.

Although a few people will immediately understand the meaning of PLM, and the importance of PLM for the company, many will not understand what PLM is, many will misunderstand, some people will disagree, and some will ask for more information. It would not be useful to reply to them: "I'm sorry, PLM doesn't exist in the company today, so I can't tell you about it, but in a few years it should be fully deployed. If you ask me then, I'll be able to tell you more". It would be much more useful to reply: "I can tell you what PLM will look like in the future, for example five years from now". "What it will look like five years from now" is a five-year Vision of PLM. Once this Vision has been created it can be communicated throughout the company so that people will know what PLM is going to look like. It will be easier to make progress if everyone knows where they are going.

It's not unusual or wrong for people to want to know more about PLM if it doesn't already exist. They could have several reasons for wanting to know more. They could want to know more about the PLM environment in which they will be working. They could want to know more about what they will have to do to achieve that environment. They could have questions such as:

- What will PLM look like for us?
- How will it differ from today's situation?
- How can we prepare for PLM?
- What training will be needed?
- What resources will be needed?
- What products will be managed?
- What's the lifecycle for our products?
- Who's managing our products?
- What actions will be needed to achieve PLM?
- What's in PLM, what's not in PLM?
- Is PLM the same as ERP?
- Are we talking about an Enterprise Application?

People will ask all sorts of questions, for all sorts of reasons, to find out more about PLM. Some will want more high-level information, such as information about the way it will affect business results. Some will want more low-level information, such as the details of the business processes and workflows that are part of PLM. Some, perhaps worried about losing power if PLM is introduced, may ask for more details in the hope that the PLM Vision will disintegrate if questioned.

Although a Vision may sound as if it is ghostly and immaterial, the PLM Vision needs to be concrete, clear, complete, consistent and coherent. It needs to be understandable and meaningful to different types of people in the company. It needs to provide people at different positions in the company with different levels of detail. A Vision that is incomplete is not going to result in much progress.

9.2 Vision, Need, Purpose, Benefit

The five-year PLM Vision should provide a high-level conceptual description of the way that the company will manage its products across their lifecycles in five years, enabling it to perform successfully and continue to perform successfully. The Vision should provide a self-contained description of the motivation for PLM, the components of PLM and their organisation. It should offer a picture of an effective product lifecycle environment that will be rewarding for shareholders and exciting for employees.

From one viewpoint, five years is not a long way forward in the future. Most of the technological changes likely to occur over those five years are known today, even if they are not yet implemented. From another viewpoint, five years is a long way forward, and five years is long enough to deploy a PLM solution to achieve the Vision.

Companies need a clear PLM Vision so that they don't drift along, going wherever external forces are pushing them. People in the company need a clear agreed PLM destination that everyone can work towards. A PLM Vision for the company will enable all PLM participants and decision-makers to have a clear, shared understanding of the objectives, scope and components of PLM. It's a good basis for future progress. A PLM Vision is a focal point for everybody in the company that says: "this is where we're going". The Vision is a useful basis for communication about PLM between all those involved with PLM, such as executives, IS managers, Product Managers, product developers, service staff, recycling managers and other stakeholders. It allows everybody to "work from the same book" and "sing from the same page". Without an agreed Vision, individual employees may have their own, conflicting views of PLM, but these are unlikely to lead to the company's required performance levels. Without an agreed Vision, decisions in the PLM area will be taken on an individual, uncoordinated, day-to-day basis. For example, one day, one of the managers may authorise purchase of CAD licenses for the design engineers in the US, a month later another manager may decide to outsource all design engineering activities to China, with the result that there's no-one left to use the licenses in the US. And with the design engineering budget spent, there's no money to invest in managing the activities of the design partners in China.

The purpose of the Vision is to communicate the focus, requirements, scope and components of PLM. It communicates the fundamental "whats, whys and wheres" of PLM, and provides a framework against which decisions can be taken. The Vision will make it easier to carry out all the activities that are needed across the product lifecycle to successfully develop and support products. It will guide people through PLM strategy setting and planning, and help with deployment of PLM.

The creation of a PLM Vision is a good starting point for a PLM Initiative. It will help get agreement about the scope and definition of PLM, and will move the Initiative forward towards strategy development, detailed planning and deployment. People usually react positively to the chance to create a Vision, shape the future of their working environment and improve their working lives. They will start working together, working to enable effective PLM implementation and use.

9.3 Expected Difficulties with a PLM Vision

Creating a Vision that meets the business objectives and the requirements of the people carrying out activities in the product lifecycle is not as simple as it looks. Nobody knows, in advance, what the Vision for a company will look like, so it's impossible to provide a detailed description of what to aim for.

Webster's New World Dictionary defines a Vision as "A mental image, especially an imaginative contemplation". Many people will have difficulties understanding what should be in a Vision. It's important before developing a PLM Vision to make sure that people understand what the result will look like. Otherwise they may create their own unrealistic expectations. That can lead to problems when the PLM Vision is presented. It's important to avoid such problems as they slow down progress.

Different people will have a different understanding about the Deliverable that results from an activity to create a "PLM Vision". Some will think that the Deliverable will be a Vision addressing the future global manufacturing industry environment. Others will think it is a Vision of what will happen within a particular company. Some will think the Deliverable is a "mental image", some will think it is a document describing that mental image. Some will think it is a PowerPoint presentation, some will think it is a voluminous document. It's important to avoid potential confusion by defining the form of the Deliverable before the activity starts.

Several different types of people with very different needs and very different know-how should read a Vision document. One of the aims of the Vision is to get a common understanding of the future role of PLM in the company, so the Vision document has to be readable and understandable for all of those people. It should not go into details that some of the readers will not be able to understand. It is likely that some readers of the Vision document will find that it contains too many details, while others will find that it contains too few. High-level business executives will want a concise, complete Vision document that they can read quickly, and from which they can reach a decision regarding the next stage of the PLM Initiative. They should be able to do this with 5 pages of text and 20 PowerPoint slides. However, when product developers and IS managers read such a concise document, they may see generalisations of little value and a few incorrect details which they would like to correct. They may see little use in them. However, what is important is that they understand, and agree with, the overall picture and the main points. The details can be reviewed and dissected later.

A lot of work is needed to create a PLM Vision. It may take several weeks or months to prepare, discuss, analyse and agree upon the content of a PLM Vision. However, despite all the time and effort that goes into preparing the Vision, there is a danger that, after the Vision document has been discussed and a decision taken about the future of the PLM Initiative, it may not be read again. High-level business executives will not have the time to go back and read the PLM Vision document. They will be looking for the results of PLM deployment. Product developers and IS managers may not want to reread the document as they feel it contains little, if anything, of value. However, if the Vision document is not reread, it is likely that there will be little similarity between the agreed Vision and the eventual deployment and use of PLM. If it is not reread, the high-level specifications it contains will probably be replaced by lower-level shorter-timeframe needs. To overcome this problem, it's important to include expected targets for performance in the PLM Vision, and to regularly review and update the Vision. This will allow management to track progress towards the agreed Vision.

Different readers require different levels of detail about the Vision. All should be interested in a high-level overview. However, none will be interested in all the low-level details. The Vision should be structured so that it provides a single top-level overview or summary that everyone can read and understand, and multiple more-detailed sections addressing specific subjects of interest to particular people or functions. There is no standard style or convention for a Vision document. As a result, the “look and feel” of different Vision documents may be very different. Sometimes, a Vision document will be written primarily in the future tense. Written now, it will describe what will be done, and what the situation will be. Sometimes, a Vision document will be written primarily in the present tense. Although written now, it will project the reader into the future, and describe what the situation is in the future. Sometimes, a Vision document will be written primarily in the past tense. Although written now, it will project the reader into the future, and look back at the intervening period, describing what was done. All of these styles are acceptable. However, it’s important not to mix them together as that could confuse the reader.

Different readers may be looking for different information in the Vision. Some executives may be looking for information about the activities that are needed in the next five years to deploy PLM. Other executives may be looking for information about the way that PLM should be organised in the future, or the way that the company could work after PLM has been deployed. It is to be expected that a PLM Vision will contain a mixture of descriptions of targets (such as “this is where we will be” and “this is what we have achieved”) and activities (“this is what we did” and “this is what we are going to do”).

A PLM Vision addresses the way in which a company manages products across their lifecycles. The PLM Vision does not address the way in which a particular product will perform over its lifecycle. It is also important to make the distinction between the “Vision of PLM” and the “Vision of the Surroundings in which the company will operate in the future”. The Vision of the Surroundings will probably be similar for many companies. Many companies expect that there will be more competition, more outsourcing to China, more offshoring to India, more application software to choose from, more electronics in products, more software in products, more effects of globalisation to take into account, more global competition, more product liability problems, more sales of products in China and India, and more advances in technology. Most companies have very little control over many of these “surrounding issues”. For example, they do not claim to control the level of trade between China and the rest of the world. Fortunately though, it is not the objective of the Vision of PLM to describe a “Vision of the Surrounding Business Environment”. The Vision of PLM should just address issues over which the company does have control. The Vision of PLM may make reference, in a paragraph or two, to the expected business environment in the future, but the focus of the Vision of PLM is not issues over which the company has little control, but product-related issues over which the company does have control.

As it takes a significant amount of time and effort to develop a PLM Vision, some people may be tempted to try to avoid that effort by copying another company’s PLM Vision. However, the Vision of PLM in a company is specific to that company. It is related to the company's products and market position, and describes how the company will be using its various resources to develop and support those products. Because there are so many differences between companies, it's not useful or appropriate for one company to copy another company's PLM Vision. Parts of one company's PLM Vision may be similar to another company's. However, other parts will be different. Differences in the Vision can lead to competitive differentiation.

The Vision is a best estimate for the future. It is the most likely Vision out of an infinite number of possible Visions. It's unlikely that the Vision will be the reality in five years. Most likely, new opportunities will arise over the five years and lead to a different reality. And, during the five-year period, the company will be in intermediate states on the way to the Vision, rather than in the Vision state itself.

9.4 The Deliverable from the Vision Development Activity

The Vision should be communicated in two ways. There should be a written report, and there should be a set of PowerPoint slides.

The PowerPoint presentation will become more detailed and wide-ranging as the PLM Initiative progresses. Before a PLM Initiative is formally launched, the Vision may be limited to two or three PowerPoint slides.

The PLM Vision should be documented in a report so that it can be distributed for review and correction, and to increase awareness. The typical structure of the PLM Vision report is:

- Executive Overview
- Section 1 – The company: objectives, strategy, success factors, key issues
- Section 2 – The PLM Initiative
- Section 3 – Description of the PLM Vision
- Section 4 – Next steps: PLM Strategy, PLM Roadmap, PLM Plan, schedule, resources, value, costs, ROI

The Executive Overview should only be a few pages in length.

9.5 Basic Beliefs about PLM

Unless the company's basic beliefs about PLM are clear, and generally agreed, it will be difficult to build a PLM Vision. These beliefs, some of which may not exist at the start of the PLM Initiative, are the foundations of the Vision. They do not depend on "details" such as the type of product the company makes, or the application programs it uses. The following paragraph describes such basic beliefs.

The focus of PLM is the company's products. There is nothing more important in the company's future than its products, and the way they will be developed and used. Without those products, and their customers, there will be no revenues. The objective of PLM is to maximise the value of the company's products across their lifecycles. PLM aims to increase continually the value of the company's Product Portfolio, and its revenues and profits, bring profitable products to market quickly; increase product quality and reduce product-related time cycles and costs. PLM success is measured in four areas: financial performance; time reduction; quality improvement; business improvement. PLM brings together everything to do with the product, including product development, product recall and product liability. It manages, in an integrated way, the parts, the products and the product portfolio. It manages the whole product range, from individual part through individual product to the entire product portfolio. With PLM, all the product-related issues are united under the PLM umbrella and are addressed together in a joined-up way. The approach is holistic. PLM is seen as the way to address all the product-related issues.

PLM may have implications that go far beyond the management of products across the lifecycle. These can not be considered as basic beliefs, but they help to show how important PLM could become. For example, if PLM enables a company to maximise product value over the lifecycle, and to maximise the value of the company's Product Portfolio, then PLM may be able to provide a figure for the "value" of a company that is of interest to investors. As more and more companies from different countries around the world participate in the extended enterprise environment, there may be a need for a common performance standard against which a company can measure and communicate its competence level. This standard could be closely related to the PLM performance of the company. These are possible implications of PLM. Although it may be useful to mention them briefly in the Vision, they may not be sufficiently concrete to use as building blocks for the Vision.

9.6 Components of the PLM Vision

The purpose of the PLM Vision is to communicate to many different people an overview of what PLM is and will be, why it is important, and how it will be achieved. As they may not understand instinctively what "PLM" is, it may be useful to communicate PLM in terms of concepts that they do understand, such as products, applications and processes. These can be thought of as components of PLM. It is easier to ask questions, and provide answers, about the components than about PLM. For example, what structure should our products have? How many products should we have? Which applications will we need for PLM? Which business processes correspond to PLM?

The three components mentioned above (products, applications and processes) are not sufficient to describe PLM completely, as they do not address, for example, the people in the organisation, or the organisation itself. The following list of 12

PLM components is more complete (Figure 9.1). Any question about PLM in the future should be related to one of these components:

- Vision, Strategy, Plan and Metrics
- Products
- Customers
- Organisation
- Management, Control and Visibility
- Lifecycle and Processes
- Collaboration
- People and Culture
- Data, Information & Knowledge
- Facilities, Equipment, Applications and Interfaces
- Mandatory Compliance and Voluntary Conformity
- Security and Intelligence

Ignoring part, or all, of any of these components in the Vision would weaken the Vision, and would lead to questions about its validity. Ignoring part, or all, of any of these components in the deployment of PLM would weaken the overall ability to manage products across their lifecycles.

9.7 Top-down Vision

The following three paragraphs describe a concise PLM Vision for a particular company. For some people, such as the CEO, the level of detail they provide might be sufficient. Other people, such as programmers of application program interfaces, might find that they do not have enough detail.

The global surroundings exert all sorts of pressure on the company. Examples include: the environmental movement; globalisation; global competition; lean manufacturing techniques; fluctuating value of the dollar; effects of the Chinese manufacturing industry; product liability problems; changes in the age-distribution of populations; the information society and rapidly advancing technology. According to company plans, the company has three strategic objectives. They are innovation, growth and profitability. The company will be a product developer and manufacturer. It will sell products worldwide in more than 100 countries. Last year it sold 3 million units; in 5 years the target is to sell 3.7 million units. In the last 5 years, the company introduced 10 new products; in the next 5 years it plans to introduce 30 new products. These will be market-leading products for the consumer market. Company R&D expenditure is planned to rise six points to 4.0% of revenues. Over the next five years, the number of repeat customers should increase by 15%. The company aims to cut costs by 3% per year.

Our products are expected to become more complex. More technologies will be integrated. There will be an increase in the percentage of electronic and software components. More options will be available. The products are likely to be specific to each customer. The products are expected to be more intelligent, capable of providing feedback about status, use and location. Product leasing is expected to expand at the expense of outright purchase. As a result of the global pressures and the company plans, the company won't be able to work in the future as it did in the past. Products will have to be developed, supported and managed in a different way. The best way will be a cradle-to-grave, PLM, approach to products, with a single set of integrated optimised lifecycle activities from the first idea for a product through to its retirement. As a result, customers will be proud and pleased users of the company's products. The company will have a complete understanding of customers and their use of products. It will understand the nature of the future market, what customers really want, and what their usage of products is saying. The company will be fully responsible for its products. Products and processes will respect the environment. The company's products are at the heart of the PLM Vision. There will be a modular range of products, based on platform products. As much as 85% of manufacturing will be outsourced. Outsourcing and offshoring will be balanced between dollar, euro and yuan regions. Major assemblies will be defined, but detailed design will be outsourced. Twenty main partners will provide more than 60% of parts. These partners will be closely integrated, and will be expected to carry out a large part of the development work. They will be involved as early as possible in development work. Product support activities will be distributed across the world wherever customers are, but there will be a small but very important core organisation providing leadership and direction.

Our Vision for PLM addresses the following 12 components:

- Vision, Strategy, Plan and Metrics
- Products
- Customers
- Organization
- Management, Control and Visibility
- Lifecycle and Processes
- Collaboration
- People and Culture
- Data, Information, Knowledge
- Equipment, Applications and Interfaces
- Mandatory Compliance and Voluntary Conformity
- Security and Intelligence

For each component, our Vision will be described.

Figure 9.1. Example of the PLM Vision

Many of the companies that participate in the extended enterprise will be on other continents, many of them at multiple locations. Nevertheless, the PLM structure and working methods of the extended enterprise will enable products to be successfully managed throughout their lifecycle. Knowing the structure of the extended enterprise will enable the objective, content and location of each activity along the product lifecycle to be defined. The processes that make up the overall lifecycle will be defined and documented. Processes will integrate international and industry standards, and ensure required compliance. On the basis of their skills, knowledge and competence, people will work in product family organisations. Unless people have the right skills, are properly trained, communicate well, and understand where they fit in the process, they won't contribute effectively to the lifecycle. A significant investment in training will be needed. The percentage of female and minority employees will be increased. The best way of working will be identified. People will use the most appropriate methodologies, working methods and techniques. After the processes and tasks are clear, information requirements will be defined. With the work definition and information requirements clear, information systems will be identified to help people carry out their everyday work.

9.8 Detail for Each Component

Management may only want a high-level overview of the Vision for PLM as described in the previous section. Alternatively, more details may be needed. As shown in Figure 9.2, they can be provided by detailing the Vision for each of the twelve components.

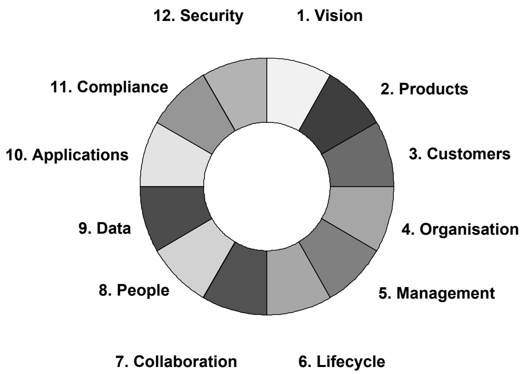


Figure 9.2. Twelve components of PLM

The Vision, Strategy, Plan and Metrics are integrated. Clear metrics will enable fast implementation of PLM and easy identification of the results of deployment. They will enable comparison between the Vision and the deployment. There is an objective to increase continually sales and quality, and reduce time cycles and costs.

Focused on its products, the company will increase revenues with an on-going stream of innovative new products. The value of current and future products will increase each year for the benefit of customers, employees and shareholders. Products will be platform-based and there will be a high level of part reuse. The exact configuration of each product will be known at each stage in its lifecycle.

There will be more customers. The products will increasingly satisfy our customers, who will acquire and use more products.

The company's organisation will be both customer-focused and product-focused. A simple slim-line organisation will be built around Product Family Teams focused on product families. A Chief Product Officer will be appointed with responsibility for all products.

PLM is the management system for all products. It will provide full control and visibility over products throughout the lifecycle.

Products are managed across their lifecycle through five phases: imagination; definition; realisation; support; retirement. A single set of coherent industry-standard business processes will be used across all sites.

Products are managed across the lifecycle in a collaborative, extended enterprise environment.

People will work in a team environment. On average, people working in the PLM environment will receive 10 days of training per year. Enterprise Change Management will be an important activity supporting the deployment of PLM.

A single set of coherent industry-standard documents will be used throughout the extended enterprise. The right data will be available to the right people, wherever they are, at the right time. A full and up-to-date electronic definition of each product (the "Digital Product") will be available at each stage of the lifecycle.

Appropriate facilities and equipment will be used throughout the product lifecycle. Wherever possible, industry-standard applications and interfaces will be used. Applications such as Automated Product Idea Generation, Virtual Engineering, Digital Manufacturing, Collaborative Product Support and Computer-Aided Recycling will support each stage of the lifecycle.

All relevant mandatory regulations will be identified and integrated into processes and automated workflows. All relevant voluntary guidelines will be identified, reviewed, and where appropriate, integrated into processes and automated workflows.

Access control in PLM will ensure that availability of data corresponds to the company's security policies. All security-related activities will be identified and integrated into processes and automated workflows. All intelligence-related activities will be identified and integrated into processes and automated workflows.

For readers who feel that there is still not enough detail in the previous section, the following sections show another type and level of detail.

9.9 Vision, Strategy, Plan and Metrics

For the "Vision, Strategy, Plan and Metrics" component, the following additional details could be provided.

There is a document describing the PLM Vision, a document describing the PLM Strategy, a document describing the PLM Plan, and a document describing the PLM Metrics.

The PLM Vision, PLM Strategy, PLM Plan and PLM Metrics are closely integrated.

The Vision is a major input for strategy development. The Strategy is the major input for development of the plan. The Plan drives the deployment. The success or failure of the deployment is measured with the metrics.

The PLM Vision provides a Big Picture of the expected PLM environment five years from now. It describes the performance and behaviour that is expected at that time. It helps people take decisions when setting strategy. It helps plan resources, capabilities, budgets and the scope of activities. The Vision will include target values for key metrics.

The PLM Strategy reflects the organisation's overall business strategy, and defines how resources will be organised to achieve the PLM Vision.

The PLM Plan shows the detailed activities and resources corresponding to the PLM Strategy. The PLM Plan initially addresses a five-year timeframe. It is updated annually. The Plan addresses all the components of PLM such as human resources, applications, and processes. Individual projects are defined and planned in terms of objectives, action steps, timing and financial requirements. The relative priorities of projects are described.

The planned PLM deployment will take five years. However, it is expected that, once it is complete, there will be numerous opportunities to extend and optimise PLM. During and after deployment, progress is measured against the PLM Metrics. PLM success is measured in four areas: financial performance; time reduction; quality improvement; business improvement.

9.10 Products

This component of the Vision is addressed in five parts.

9.10.1 Product Focus

The product is the focus of PLM (Figure 9.3). This is a basic belief of PLM. Without its products, and the related services, the company doesn't need to exist and wouldn't have customers. Focused on its products, the company generates revenues from an on-going stream of innovative new products. Great products make it the leader in its industry sector. Great products lead to great profitability.

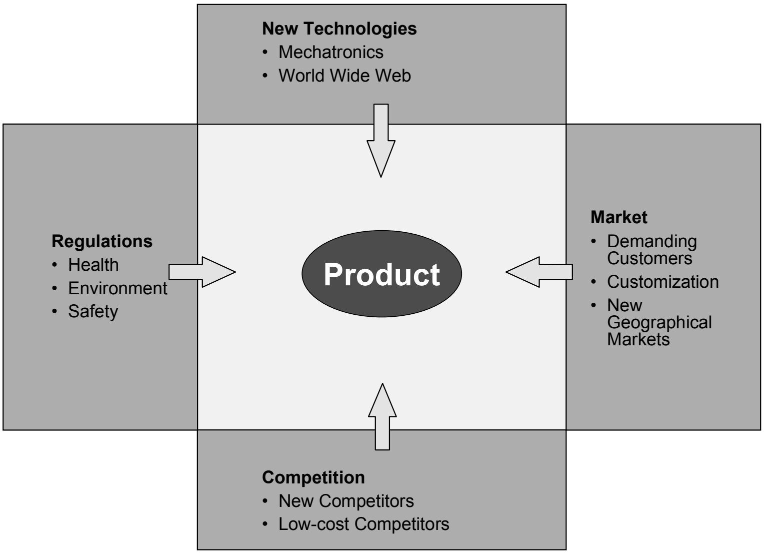


Figure 9.3. The product is important

9.10.2 Product Portfolio

There is a document defining the Product Portfolio, which contains both the existing products and those under development.

The Product Portfolio plays a key role in PLM. It is structured into product families, product lines, products, platforms and modules. It contains actual and forecast sales figures, costs and Intellectual Property values across the lifecycle for current products and for products in the pipeline.

There is a document showing the current status of the Product Portfolio.

The products within a product family are similar. They are created with modules built on a basic platform. There are similarities between their specifications, features, parts, modules, drawings, manufacturing processes, assembly techniques and distribution channels. As a result, there is no need to re-invent the wheel for each new product.

Products are structured so that the individual requirements of specific customers can be met with little additional effort. Products are structured so that modules adding little value can easily be outsourced or offshored. Modules are structured so that it is easier to offer customised products. Functionality has been developed, so that, on option, each product can have a unique identifier making it traceable throughout its life.

At any given time, several generations of a product family are under development. Once the first generation of the family has been developed, the cost and time to develop succeeding products decreases. The second generation re-uses 75% of the parts used in the first generation, greatly reducing product and process design and verification effort.

9.10.3 Five-year Strategy and Plan for Product Families and Products

There is a five-year strategy for the Product Portfolio. It shows how resources in the product lifecycle will be organised to achieve the company's product objectives. It defines policies for the management and use of resources in the product lifecycle. For example, it defines policies for platform products, modular products and part re-use.

There is a five-year plan for the Product Portfolio. It shows how existing products are expected to be upgraded and how new products will be introduced. It shows how and when platforms evolve, how modules are introduced, and how parts and modules are re-used. The five-year plan helps one take decisions in related areas such as outsourcing, offshoring and Supply Chain Management.

The objective of continuously increasing the value of the Product Portfolio, and increasing product value and revenues, drives product innovation. Necessity is the mother of invention. When existing markets offer little further opportunity, new markets are entered with innovative products that make extensive re-use of existing parts and information.

9.10.4 New Technologies

The Product Portfolio shows the introduction of new technologies into products.

Technology and product roadmapping helps identify and prioritise new opportunities.

Among the new technologies of particular importance are those, such as RFID, mobile telephony and the Web, which can be used to provide automatically detailed direct feedback, “in-use information”, from the product. The “Voice of the Product” is considered to be as useful as the “Voice of the Customer”. It provides important data about the way that products are actually used, and gives the opportunity to understand how products behave.

9.10.5 Progress with Products

Targets are needed to measure the success of PLM deployment.

The following ‘report’ might be written five years after the PLM Initiative is started.

A detailed review was carried out to identify duplicate and similar parts. These were then eliminated. The number of modules has increased, but the number of individual parts has been greatly decreased. The reuse frequency of both modules and the remaining parts has increased.

A detailed review was carried out to identify recurring design problems. Action to eliminate these was taken at the source of the problem. Costs due to product recalls, failures and liabilities have been reduced by 50%.

Existing products were reviewed. Products with low and declining sales for which no feasible upgrade path was possible were retired, licensed or sold. An upgrade plan was developed for the other existing products. As a result, they have all been upgraded within the last five years. As a result, revenues from these products have increased by 25%. Revenues from new services on these products have risen by 50%. All product versions currently on the market are less than five years old.

New products are now introduced at twice the rate of five years ago; 90% of a new product is recyclable.

Sales of the company’s products, and related services, have increased at an average 10% per year.

Products from acquired companies were integrated into the Product Portfolio within three months of the acquisition date.

More than 99% of products did not require major maintenance in their first three years of use.

An increasing proportion of revenues is coming from developing new environment-friendly products, providing customised products, providing services to support product use, refurbishing existing products, and taking financial and environmental responsibility for products produced in low-cost countries.

9.11 Customers

This component is addressed in four parts.

9.11.1 Customer Focus

PLM puts the focus on the product, but it doesn't forget the customer. The company's revenues come from customers purchasing products. Customers buy great products. Customer satisfaction can only be achieved by providing a high-quality product. A company wouldn't get a sale without a competitive product, even if it had all the knowledge in the world about its customers, and what the customers had dreamed, imagined, thought, scribbled and said.

To achieve great products it's important to listen to the customer, and to understand how they use products. It's important to take account of what customers say about products and what potential customers say about a competitor's products. It's important that many customers choose the company's products rather than those of competitors. It's only if enough customers buy the company's products that, at the end of the financial year, revenues will exceed costs. If this isn't the case, then before long, the company will no longer exist.

9.11.2 Voice of the Customer

It's important to listen to the customer, and make sure that the customer's demands, expectations, requirements and wishes are reflected in the product. Listening to the customer is a key part of the product development and support process. It's also important to watch how customers use products and see how they adapt them to improve performance. The customer can often provide a lot, if not most, of the product specification.

It's good to listen to the Voice of the Customer, but it's even better to involve the customer in product development and support activities. That enables customer knowledge, experience, behaviour and requirements to be taken into account during the entire product lifecycle, and not just during product development. The best way to take account of them is by directly involving the customers all the way through, from the beginning of the product lifecycle to the end.

9.11.3 Customer Involvement

Involving customers early in the product lifecycle reduces development time and costs, and brings new ideas and potential problems to light quickly, avoiding expensive rework. Involving customers throughout the lifecycle helps avoid the discovery of problems when it's too late to avoid their effect.

Customer Surveys are carried out to discover what customers are thinking about existing products and future products. And, using technologies such as RFID and the Web, information is exchanged directly with customers using the product. Getting feedback from a customer at the actual time of use provides even more valuable information than a survey form.

Customer representatives are involved in product development and support teams. Office space is made available for them so they can work on-site to develop components to their specifications. Joint reviews of field reports are held with customers to get their reactions to existing products, and to understand the performance of re-usable components of existing products. This provides a mass of information about customer requirements, views, experience and wishes.

Working closely with customers helps ensure that products really meet customer requirements. Usually these close relationships with customers prevent errors occurring, so reducing costs. They are also a source of innovative new ideas. And they also save time because people only work on what is really required, rather than on activities that are of no interest to customers or even to potential customers, so don't add value.

9.11.4 Progress with Customers

Targets are needed to measure the success of PLM deployment.

The following 'report' might be written five years after the PLM Initiative is started.

Five years ago, we had customers in 10 countries; we now have customers in 55 countries. Of these customers, 50% are now in the US, 30% in Europe and 20% in Asia Pacific. Our objective is to have 40% of the customers in the US, 35% in Europe and 25% in Asia Pacific. The number of customers has increased by 25%. The number of repeat customers has increased by 40%. The number of customer complaints has decreased by 50%.

9.12 Organisation

This component is addressed in three parts.

9.12.1 Product Family Teams

To meet customers' requirements for better products, the company will deploy PLM. The organisation will be product-focused and built around Product Family Teams (PFT) focused on product families. Each PFT will focus on a single product family, so it will focus on a single product lifecycle. This will result in a better understanding of the activities related to that product family, how they can be improved and where most value can be added. The process will be continuously improved. Information flow will be organised to meet the needs of the process. The PFT will become more and more competitive, and its products will be closer and closer to customer requirements.

Because they will focus on one product family, the people in the PFT will know their products in depth. Through training and experience, they will know how to make a valuable contribution to the product. Everyone will learn about the process. It is important that they know who does what, what has to be done, where everything is, and how things are organised.

A PFT will focus on one product family. It, and the partners in its extended enterprise, will install and optimise the best equipment for that family, and cost-justify it over several generations of the product, not just on one product. Because the PFT will focus on one product, planning and scheduling will be easier. There will be no need to switch resources between projects on completely different products. It will be easier to plan to have the right resources available when they are needed. It will be easier to plan ahead, since so much will already be known about the next generation of the product.

9.12.2 PLM Responsibilities

In the PLM organisation, responsibility for the company's products will be with the Chief Product Officer (CPO). Companies have one manager responsible for other key parts of the business. For example, finance is the responsibility of the Chief Financial Officer (CFO), information the responsibility of the Chief Information Officer (CIO). The CPO will have the responsibility to develop the five-year strategy and plan for products and product-related policies (for example, for platform products, modular products and part re-use), and to achieve the targets. The CPO will report to the CEO, so will the CFO and the CIO. Product Family managers will report to the CPO.

The Chief Information Officer will be responsible for the IS architecture and infrastructure that enables effective product lifecycle management. Aligning information technology decisions with the PLM needs of the business will help drive the company forward.

The Product Data Management (PDM) Manager will be responsible for product data, and will report to the CIO.

The PLM Initiative Manager will lead the PLM Initiative with the aim of introducing highly effective and successful PLM. The PLM Initiative Manager will work closely with the CPO and the CIO.

Just as Process Owners are responsible for individual processes in a company, the Product Lifecycle Owner will be responsible for the maintenance and improvement of the overall product lifecycle.

9.12.3 Product Development and Support Methodology

The product development and support methodology will be defined in detail. Everyone will be trained in its use. They will work in harmony across the lifecycle. People will understand the tools the company has chosen to work with, not only so that they can make best use of them, but also to understand what their team colleagues are doing.

9.13 Management, Control and Visibility

This component is addressed in three parts.

9.13.1 Management

PLM will be the management system focused on the product.

Product Portfolio Management will enable the company to manage its products for the medium-term and the long-term. The process of Product Portfolio Management will be defined.

Project Management and Program Management will enable the company to manage its product-related projects for the short-term and the medium-term. The processes of Project Management and Program Management will be defined.

The PLM Plan will show management the detailed PLM deployment projects. Individual projects will be defined in terms of objectives, action steps, timing and financial requirements.

With PLM, top managers understand and can formulate the need for effective product lifecycle management. They define the key metrics and strategies.

9.13.2 Visibility

PLM will give visibility about what is happening over the product lifecycle. It will give managers visibility about what is really happening with products. Before, managers were often faced by an opaque mountain of unclear and conflicting information. PLM will offer managers an integrated view over all product development projects. It will provide them with the opportunity to manage better. Based on valid information, they will be able to take better decisions.

9.13.3 Control

PLM will enable the company to be in control of its products across their lifecycle. It will get the extended enterprise under control. It will reduce the cost of new products and the time it takes to bring them to market. PLM will enable the company to be in control of its product development projects. Modifications to products will be implemented faster. Part reuse will be increased. Mastering the activities in the lifecycle will make it easier to provide reliable products and to sell related services. Better control over the lifecycle will provide better assurance about environmental impacts. It will be easier to take account of potential risks. Being in control will open up new opportunities. With population levels rising fast in many countries around the world, there will be many customers in distant locations, but PLM will keep control over the products they use, however far away they may be.

9.14 Lifecycle and Processes

This component is addressed in eight parts.

9.14.1 Phases of the Product Lifecycle

The product lifecycle is defined as having five phases: imagination; definition; realisation; support; retirement. It's recognised that, for users of the product, there are also five phases in the product's lifecycle: imagination; definition; realisation; use (or operation); disposal (or recycling). The first three phases are the same for the company and the user, the last two are different.

9.14.2 Management of the Product Lifecycle

The Product Lifecycle Owner has responsibility for defining and maintaining an effective product lifecycle, including the definition of the details of the lifecycle structure.

There is a document describing the lifecycle structure.

9.14.3 Lifecycle Design and Analysis of Products

Lifecycle design and analysis will play an increasing role. All issues related to a product's life will be considered at the outset, including those involving the product once its useful life is over. Lifecycle analysis will be carried out over the complete cradle-to-grave lifecycle including analysis of use of raw materials, production methods and usage/disposal patterns.

9.14.4 Modeling and Analysis of the Lifecycle

The product lifecycle will be modeled and analysed to identify where most value can be added, and where waste can be reduced. Opportunities will be found in the early phases of the lifecycle to increase the speed of generating ideas, translating them into products, launching new products, and generating revenues and profits. Opportunities will be found in the mid-life phases of the lifecycle to ensure sales of a product are as high as possible, for example by extending the life of patents, and protecting the customer base against competitors. Opportunities will be found at the end-of-life phases of the lifecycle to increase sales with upgrades, or to exit the product graciously with product retirement, licensing or sale.

9.14.5 Process Definition and Automation

Clearly-defined, coherent, well-organised processes across the product lifecycle lie at the heart of effective PLM. These processes will be waste-free and low-cost. They will enable concurrent involvement by people in different functions and locations. They will be well-documented; otherwise it will be difficult to improve them further. The key roles in the processes will be identified and described, along with the corresponding information needs. People in many different companies working in different places round the world may take these roles. Hundreds of people may be directly involved in these tasks. The process needs to be explained to them, with regular refreshment. To avoid confusion, the message needs to be very clear.

A clear, standard process architecture will enable coherent working across the product lifecyle. There is a document describing the process architecture across the lifecycle. A common harmonised version of each process in the product lifecycle will be used on all sites.

Relationships between processes in each phase of the product lifecycle will be defined. Relationships between processes in different phases of the product lifecycle will be defined. Relationships between processes in the area of Product Lifecycle Management, and those in other areas such as Supply Chain Management and Customer Relationship Management, will be defined. When possible, process steps will be automated in workflows. The workflows will be consistent with the process definitions. When possible, appropriate methodologies and working techniques will be defined for each process step.

9.14.6 Standard Processes Across the Lifecycle

The company will define standard processes, standard data and standard applications that it, and its many suppliers, customers, and partners in the extended enterprise, can use to save time and money. Without such standards, each interface between different processes and applications would be a source of chaos, would add costs, and would slow down the lifecycle activities.

9.14.7 Standard Methodologies Across the Lifecycle

Without a standard product development and support methodology, it's unlikely that people are going to be able to work in harmony across the lifecycle. A well-defined methodology lets everybody know exactly what is happening at all times, and tells them what they should be doing. It defines the major phases and explains what has to be done in each phase. It shows how the phases fit with the company organisation and structure. It shows the objectives and deliverables at the end of each phase, and the way that phases connect together. It shows which processes, applications, methods, techniques, practices and methodologies should be used at which time in each phase. It shows the human resources that are needed – the people, skills and knowledge – and their organisation. It shows the role and responsibilities of each individual and the role of teams. It shows the role of management, project managers, functional reviewers and approvers. It describes the major management milestones and commitments. It describes the metrics used in the process.

9.14.8 Progress with Lifecycle and Processes

Targets are needed to measure the success of PLM deployment.

The following 'report' might be written five years after the PLM Initiative is started.

The lifecycle architecture was defined and applied. A lifecycle-wide process architecture has been defined and applied. The number of different, site-specific, variants of what should be the same process has been reduced by 50%. The target is to implement a common harmonised version of each process in the product lifecycle across all sites. There is a common harmonised Product Change Management process.

The number of process steps that have been automated in workflows has been increased by a factor of three. There is still a long way to go. Initially, different sites had very different processes and applications, and a lot of harmonisation was needed before it made sense to introduce automated workflows. After reviewing quality problems, feedback processes were defined and introduced to ensure effective feedback of information from product users to product developers. Processes have been reviewed and upgraded with activity steps that ensure and demonstrate compliance with regulations.

9.15 Collaboration

Collaborative technologies support PLM activities across the lifecycle, enabling work to be carried out in the Extended Enterprise in a well-managed way in multiple locations. Activities take place on different sites, and information is available on different sites. Team members may be based anywhere yet work together in spite of space, time and organisational differences.

Collaboration requires changes to behaviour and methods of working. It is characterised by trust, communication and commitment.

The following ‘report’ might be written five years after the PLM Initiative is started.

There is a document describing the Collaboration Strategy. The Collaboration Strategy defines how, and under which conditions, collaboration takes place in the different stages of the lifecycle.

Collaboration policies were defined, a collaboration guideline was produced, and training was carried out. Processes were modified. Technical infrastructure (such as a collaboration portal and project work areas) was defined and implemented to enable a range of technologies such as webcasting, podcasting, videoconferencing, audio conferencing, web conferencing, collaborative blogging, electronic whiteboards, discussion groups and collaborative content co-authoring.

Standard processes, standard data and standard systems are used in the collaborative extended enterprise environment.

To enable effective working in the Extended Enterprise, a small brochure “Collaboration Capability and Competence”, was produced and made available to potential partners and customers. It describes the resources and skills available for product-related activities, as well as those supporting potential collaboration.

9.16 People and Culture

This component is addressed in four parts.

9.16.1 Team Culture

The Product Family Teams will have a team culture, with people from different functions working together and in parallel. Team members will come from many functions such as marketing, design, service, manufacturing engineering, test, quality, purchasing and disposal. They will work together, sharing information and knowledge, and producing better results faster than they would have done if operating as individuals with limited specialist knowledge in traditional departmental or functional organisations. Their composite knowledge of design, processes, materials, manufacturing, recycling, quality, regulations and customer requirements will be applied to develop the best definition of the product and its manufacturing, support and disposal processes.

Team members will think about the product across its lifecycle. They will have a clear view of the status of a product. Engineers designing a product will take account of how it will be manufactured, and how it will be disassembled and recycled. The recycling specialists will keep up-to-date with environmental laws and will keep development engineers informed. Together they will work out how to design products that can be disassembled quickly, and how to re-use parts in new products. With each new product, they will further extend their knowledge for application on future products. Together they will take better decisions, reducing rework, bottlenecks and waiting time. As a result, products will get to market sooner, products will fit better to customer needs, costs will be reduced and quality will be improved.

Working together, team members will use a common, shared vocabulary and standardised data definitions. Information will be well-organised and shared, so information access will be fast. Understanding of information will be improved as fellow team members will be available to provide guidance and more details.

The improved communication among team members will help reduce unnecessary product changes. It will help increase downstream awareness early in the development process. Team members from upstream functions will have a better understanding of downstream reality, resulting in a reduction in problems for downstream functions. The reduction in changes will result in less rework, and in a reduction in the overall product development and support cycles. The reduction in changes will reduce the burden on the product change system.

9.16.2 Skilled, Competent People

Although the company will have a focus on the product, this does mean that human resources will be ignored. The development and support of high quality products will only be possible with highly skilled, well-trained, highly motivated, people. The workforce will be one of the key components of successful activities across the product lifecycle.

There will be a need for a variety of people with different types of skills for the activities across the lifecycle. Even though teamwork will be common, there will still be a need for people with very specialised individual skills, for example, to carry out analysis work requiring in-depth knowledge and long experience in interpreting results.

Alongside the need for specialists will be a need for multi-skilled generalists – people with skills in several areas. Generalists will have a different role from specialists. They will lead teams, act as an interface between specialists, and provide the link to customers and suppliers. Everyone, specialists as well as generalists, will need the hard skills required to work with the company's applications, processes, and methodologies. People will also need soft skills, such as the ability to work in a team, the ability to communicate well with their colleagues, and the ability to work with people who come from other functional, cultural and national backgrounds. They will need to be adaptable, and open to new ways of working, new ideas and new challenges.

There will be a document describing the skills required of the Product Family Team, a document describing the skills of the Product Family Team, and a document describing the training plan for the Product Family Team.

9.16.3 Quality Culture

There will be a culture of quality both at the level of the whole company and at the level of the product lifecycle. The company has, and will maintain, a culture, attitude and organisation that allows it to provide, and continue to provide, its customers with products and services that satisfy their needs. This requires quality in all aspects of operations, with things being done right the first time, and defects and waste eradicated.

Although PLM has a focus on the product, people working in the product lifecycle will have a customer orientation. They will know that, unless customers buy their products, the company will go out of business.

With PLM, people think of both profit and the planet. In addition to financial issues, they take account of non-financial issues, such as the environment, social issues, health, education and sustainable development.

9.16.4 Progress with People and Culture

Targets are needed to measure the success of PLM deployment.

The following 'report' might be written 5 years after the PLM Initiative is started.

The number of people using the PLM infrastructure of processes and applications has increased by 100%. In core competence areas, headcount has increased by 10%. In areas outside core competence, headcount has been reduced by 30%, mainly through outsourcing of certain activities. Training of people in core competence areas has increased by 50%.

9.17 Data, Information and Knowledge

This component is addressed in six parts.

9.17.1 Clean, Standard, Process-driven Data

Throughout the product lifecycle, product information is all-important. It is all that people can work with when the product doesn't physically exist in their environment. Product data is a strategic resource, and its management a key issue. It needs to be available, whenever it is needed, wherever it is needed, by whoever needs it, throughout the product lifecycle. Working closely together, Product Family Team members will use a common, shared vocabulary and standardised data definitions for the PLM environment. To save time and money, team members will want to work together using standard processes, standard data and standard applications. They will also want to work with standard processes, standard data and standard applications with their suppliers, customers, and partners in the extended enterprise environment. Without standards, each data interface between different processes, applications and documents is a potential source of errors, adding costs, and slowing down activities. Once industry-standard processes are clear, their data and document requirements can be defined, and document definition, use and exchange agreed. A single common standard template for each document can be introduced across the extended enterprise.

Feedback about the use of one generation of a product helps improve future generations. Information from product use should be used in product development.

There will be a document describing the common, shared vocabulary and standardised data definitions for the Product Family Team, and a document describing the documents used by the Product Family Team.

9.17.2 Digital Data

All information will be converted to digital form so that it can be used, managed and communicated effectively. Correct and up-to-date digital data about the Product Portfolio, existing products, and products under development, are needed for short, medium and long-term decision-making. Digital product data will flow smoothly through the lifecycle, and will be available when and where needed.

There will be a document describing the data model and flow.

9.17.3 Data Management

A Product Data Management (PDM) application will provide people in the product lifecycle with exactly the right information at exactly the right time. Having digital product data under PDM control will help achieve the objectives of improved product development and support. With PDM, it will be much quicker and easier to access, retrieve and reuse product data. The PDM application will manage all data defining and related to the product across the product lifecycle from initial idea to retirement. It will provide controlled access to correct versions and configurations. It will enable tracking of product configurations.

9.17.4 Legacy Data

The different types of legacy data will be identified. Policies will be defined for managing them and, where possible, for eliminating them.

9.17.5 Data Exchange

A review will be made of the need for different data formats. Where these are found to be necessary, standard approaches will be implemented for data exchange.

9.17.6 Progress with Data, Information and Knowledge

Targets are needed to measure the success of PLM deployment.

The following ‘report’ might be written five years after the PLM Initiative is started.

More than 99.9% of data in use are in digital form. The number of different versions of document templates across sites has been reduced to one for each template. All sites use the same document template for Product Change Management. In 85% of cases, duplicate data *(e.g.* part descriptions) have been eliminated to leave a single clean data element. The target is still 100%.

9.18 Facilities, Equipment, Applications and Interfaces

This component is addressed in four parts.

9.18.1 Facilities

The most appropriate facilities will be used across the lifecycle. Sometimes they will have been purchased by the company, sometimes leased. Often they will be the facilities of other organisations in the extended enterprise environment.

9.18.2 Equipment

The best equipment will be used across the lifecycle. Advantage will be taken of modern computer-controlled technology, such as rapid prototyping equipment that produces accurate physical prototypes directly from a CAD model.

Because the PFT focuses on one product family, the best equipment can be purchased, installed and optimised. It can be cost-justified over several generations of the product family.

Manufacturing and maintenance equipment will be simulated and optimised before use. Simulation helps study the performance of a plant before it has been physically built or implemented. Computer-based simulation is low cost and effective. It uses the models designed in the computer that would normally be the basis for building the plant. It makes it easier to evaluate before implementing. It allows errors to be identified and corrected before they are implemented. Models can be built, tested and compared for different concepts. "What-if" analysis can be carried out. Recommendations for improvement can be made.

9.18.3 Application Standardisation Across Sites Across the Lifecycle

Application programs – such as Automated Product Idea Generation, Virtual Engineering, Digital Manufacturing, Collaborative Product Support, Computer-Aided Recycling – are used in the corresponding phases of the product lifecycle. Application programs also manage the Product Portfolio.

A great deal of time and money is saved in PLM by the use of standard processes, standard data and standard applications. Without such standards, each process or application interface would be a source of problems. Without such standards, duplicate applications are a source of waste. Applications will be harmonised over all sites, and across the lifecycle. There will need to be very good reasons to have, for example, different CAD applications or different versions of the same CAD application on different sites as these can be a barrier to communication and progress.

There will be a document describing the application architecture.

9.18.4 Interfaces

PLM applications contain important product information that must be made available to other enterprise applications such as ERP, CRM and SCM. PLM applications need to have access to information that is managed in other enterprise applications.

Interface programs are costly to develop and maintain, error-prone, and potential breakpoints impeding smooth process and information flow. As a result, all interfaces will be reviewed frequently and their existence questioned.

The target is to eliminate 20% of interface programs per year.

9.19 Mandatory Compliance and Voluntary Conformity

This component is addressed in two parts.

9.19.1 Mandatory Compliance

PLM applications allow the company to meet mandatory compliance requirements of international and industry regulations in areas such as health, safety and environment. They help maintain documentation in required formats, and provide an audit trail showing actions taken.

There is a document describing the compliance requirements.

9.19.2 Voluntary Conformity

PLM allows the company to do more than just comply with regulations and laws. It allows us to go further, and demonstrate our beliefs in the importance of the environment, social justice, health, education and sustainable development. PLM enables voluntary compliance with recommended practices and guidelines in these areas. PLM enables us to act responsibly and address the effect of policies for sustainable production and consumption of existing and new products. Voluntary conformity can improve financial performance. Sustainable development and environmental needs represent major business opportunities for faster growth and profitability. PLM lets us take advantage of voluntary self-regulation initiatives and use them to build new markets.

9.20 Security and Intelligence

This component is addressed in two parts.

9.20.1 Security

PLM provides security in the face of increasing global competition and the potential risks from terrorism and economic espionage. Product information is an increasingly valuable resource for corporate development and must be kept secure.

PLM helps provide security in Information Systems, protecting against viruses, worms, hackers, pirates, hijackers, phishers, denial of service attacks and spying programs. It enables frequent upgrades to keep up with evolving systems, networks and changes in staff behaviour.

Security must also be maintained in areas where people may be less vigilant, such as in telephone conversations, chat-rooms, collaborative workspaces, e-mails, and use of portable computers and similar lap-top and hand-held devices.

It's important to implement rules and take measures to keep information secure in corporate buildings, where competitors may be eavesdropping from outside to steal trade secrets. In bars and restaurants, competitors at the next table may be listening for high-value details of new products among the high volume of low-value corporate gossip. Similar rules should be in force for travel, as luggage may be searched for any potentially valuable financial or technical information, such as designs, patterns, plans and procedures.

There is a document describing the Security policy.

9.20.2 Intelligence

PLM will help the company to carry out three important intelligence activities. PLM will support managers in the development of strategies and plans. It will provide valuable information about customers and competitors, reducing the risks associated with decision-taking. PLM will help monitor trends in new technology that could affect the company's future. It will enable rapid extraction and analysis of information from electronic files, synthesis of knowledge by data mining and text understanding techniques, collation of facts and inferences, and removal of repetitive and irrelevant information. It will allow candidate decisions to be presented on the basis of risk and reward, and will identify and prioritise decisions and strategies. PLM will enable the implementation of counter-intelligence measures to protect against economic espionage.

There is a document describing the Intelligence policy.

10

Current Status

10.1 Global Products are here. And where is PLM?

Currently, nearly all companies have some components of PLM in place. If they didn't, they would have gone out of business. Typically, in the past, though, companies have managed the product in different ways at different times with different approaches, processes and applications such as Product Portfolio Management (PPM), Product Data Management (PDM), Configuration Management, Product Recall, Customer Complaint Management, Product Warranty Management and Engineering Change Management. However, companies have not had a "PLM" that manages a product continuously and coherently throughout the lifecycle. Products have been managed in one way in early stages of the life, then in a different way during their development. Often the company didn't manage the product during its use, and partially or totally lost control of the product. Sometimes the company managed the product again when the product was due for disposal, sometimes it didn't.

Because there wasn't a single, or a coherent, approach or technique or solution or application in a company to manage products across the lifecycle, problems have occurred. With the applications, information and processes spread out between different functional organisations, nobody had a full overview of the product. Product developers could see product details in their CAD system, but had no idea if customers really needed these details or even if these products were being sold. Meanwhile Product Managers looked at Sales figures, but didn't have access to the fine details of products and features, so couldn't see how these were related to sales results. Executives received good-looking Word and PowerPoint reports, but had no access to the underlying data. Quality problems communicated by product users were dutifully logged in Quality databases, but often the developers of new products couldn't access these databases, and the same problems were designed into new products. Many things were done separately, in separate departments or functions across the lifecycle.

Perhaps companies did not manage the product very well, but to some extent they managed it. Some managers made sure that products were sold, making money for shareholders, and enabling employees and suppliers to be paid. And in other parts of the organisation, other managers made sure that new products were developed and brought to market. Various elements of PLM were being done departmentally. To improve productivity, many companies automated some of their product-related activities long ago, creating Islands of Applications and Data, but they were rarely able to leverage these to achieve the expected improvements in business results.

Thousands of companies of all sizes are now either considering investing in PLM or in expanding their existing PLM implementation. There are hundreds of companies offering application software that they describe as PLM software, and many of these companies have annual revenues of over $1 billion. There are thousands of companies offering consultant and system integration services in the area of PLM. There are many conferences on the subject. International research projects have been launched into PLM subjects. The subject of PLM is mentioned in the mainstream press as well in industry journals and technical publications. Numerous articles are written about PLM and its role in managing the entire product lifecycle and the extended virtual enterprise.

CIOs read in IS publications that PLM is the final strategic building block for their enterprise application architecture. They see that CIOs in other companies are looking to combine collaborative Web platforms and integrated enterprise applications to support better the thrust to bring competitive products to market faster. Product Managers read that the product is once again at the heart of business strategy, and PLM will enable a quantum leap in product innovation. They attend conferences and hear Corporate Innovation VPs explaining the benefits of PLM and the need to act before it is too late. Business Process Managers read in Quality journals that PLM is the final plank of the Business Process Framework and that, to earn Quality awards, they should define and deploy lean PLM processes. CEOs read in the business press that PLM will help increase revenues and earnings by bringing better products to market faster, and extending the lives of mature products. Many people in all types and sizes of company are now aware that PLM is on the way (or has arrived), and ask what they should do about it. The answer seems to be, in theory at least, that the benefits of PLM will be reaped after the development of a PLM Strategy and Roadmap, and the deployment of PLM.

10.2 PLM in Industry

Currently, PLM is being used in a wide range of industries. It is used in discrete manufacturing, process manufacturing, distribution and service industries, as well as in research, education, military and other governmental organisations. PLM is used in industries such as aerospace, apparel, automotive, civil engineering, chemical, consumer goods, construction equipment, defence, electrical engineering, electronics, financial services, food and beverage, furniture, industrial products, life sciences, machine tool, machinery, mechanical engineering, medical equipment, petrochemical, pharmaceutical, plant engineering, plastics, rubber, shipbuilding, shoe, software, transportation, turbine, utilities and watches. There are many differences between these industries, and they have different needs and priorities. As a result, although PLM is used in many industries, it is implemented and used differently in different industries.

For example, in the automotive sector, companies must frequently bring innovative new products to market. They must also cut costs and improve productivity. Product Development is seen as a key activity to achieve these targets. As in the aerospace industry, the definition of product geometry data has high priority in automotive companies. Collaborative Product Development (CPD) plays an important role because of the high level of outsourcing and offshoring. Other components of PLM help maximise the reuse of components, parts, and assemblies. Automated workflows speed up processes such as Production Part Approval Process (PPAP) and Advanced Product Quality Planning (APQP), and ensure compliance. European Directives are leading car companies to manage the end of life of the product better. Companies across all tiers of the automotive industry implement PLM to speed time to market, reduce costs and increase new business achievement rates. Typical benefits include 50% faster product development; greatly reduced data transfer time; greatly reduced time to communicate changes from development to manufacturing; standardisation of product development processes across multiple sites; 50% decrease in quotation time; reduced document control costs; increased outsourcing to low-cost suppliers.

Companies with long lifecycle products such as aircraft, power plants and machine tools, focus on configuration management to support future access to data about the products. These products are often highly complex, with electronic, software and electromechanical components, and have regulatory requirements for data retention and auditing. In aerospace companies, Configuration Management plays an important role. Workflows speed up design reviews and change management. Collaborative Product Development is important in this industry as development work is often shared between several companies in different countries. Conformance with European Aviation Safety Agency (EASA) and Federal Aviation Administration (FAA) requirements is needed.

In many high tech industries, companies aim to be market leaders by bringing innovative new products to market before competitors. They need short development cycles and maximum reuse of existing parts. Typical results with PLM include: greatly reduced product change cycles, improved document management; reduced change management headcount; increased outsourcing; enhanced history tracking; global accessibility to product data.

In the consumer electronics industry, the focus is on managing the BOM across the Extended Enterprise. There is an increasing need to meet environmental regulations and compliance issues such as those resulting from the Restriction of Hazardous Substances (RoHS) and Waste Electrical and Electronic Equipment

(WEEE) Directives introduced by the European Union. The RoHS regulations, for example, require electronics companies to provide proof that they have complied with regulations limiting the amount of six hazardous materials, including lead, in their products.

In industries such as industrial equipment, factory automation and heavy vehicle, reliability is important for customers. Products are often complex and engineered-to-order. Configuration Management is a key issue. Typical results with PLM include: change cycle reductions; reduced scrap and rework costs; reduced time to volume production; reduced time savings for generation of Bill of Materials.

In the pharmaceutical industry, the focus is on discovering new compounds, and managing clinical trials. Idea Management is important, as is conformance with regulations. Typical results with PLM include: more new products; reduced product development cycle time; reduced document control costs; improved product data visibility.

In the chemical industry, conformance with REACH, the EU regulatory framework for the Registration, Evaluation and Authorisation of Chemicals is needed.

The medical equipment industry needs to bring innovative products to market rapidly and demonstrate compliance with Food and Drug Administration (FDA) regulations requiring correctly controlled documents, drawings, and data management procedures.

Companies in the utility sector have to meet stringent environmental regulations. With many small subcontractors involved in developments, exchange of product data between different applications is a key issue.

Thus, although companies in different industries have similar objectives for PLM, the exact requirements may differ. PLM is not ‘off-the-peg’, ‘one size fits all’. The functionality and implementation priorities depend on the market needs and objectives of the company. The general definition of PLM is “PLM enables a company to manage a product across its lifecycle, from cradle to grave, from the very first idea for the product all the way through until it is retired and disposed of.” This applies for all products from companies of all types and sizes in all industries. In the pharmaceutical industry, for example, the definition becomes “PLM enables a pharmaceutical company to manage a drug across its lifecycle, from cradle to grave, from the very first idea for the drug all the way through until it is retired and disposed of.” For tyres, the definition becomes “PLM enables a tyre manufacturer to manage a tyre across its lifecycle, from cradle to grave, from the very first idea for the tyre all the way through until it is retired and disposed of.”

10.3 PLM Managers

For most PLM Managers in industry, the current focus is to manage everyday operations successfully. Often this is not as easy as it looks. In many cases, there will have been implementation problems in the past, and these are frequently carried forward rather than solved. However, the budget for them has usually been spent in the past. These problems can be particularly difficult to solve without a budget, and complicate both the management of everyday PLM operations and the planning of future PLM operations.

Most PLM Managers would like to have more financial and human resources so that they can make faster progress with their PLM implementations. However, they are often faced with pressures to reduce costs and headcount. Business executives in their companies often assume that, if the current implementation is running, it could run just as well with slightly reduced resources.

Many PLM Managers have implemented the foundations of their PLM solutions, and would now like to extend the reach of PLM in their companies. Step-wise implementation is often the easiest way for a PLM Manager to extend the coverage of PLM in the company. Often a PLM implementation will start with "Data Management and Document Management". From this basis the PLM Manager can extend PLM to many areas such as Maintenance, Repair and Overhaul; Portfolio Management; or implementation of a phase/gate development methodology. Many PLM Managers map out their progress with a six-level PLM Maturity Model.

10.3.1 Level 1: Archipelago of PLM Islands

At the first level of PLM, companies have unconnected PLM islands such as Product Portfolio Management (PPM) and Computer Aided Design (CAD). There are usually many such islands in the company – islands of automation and islands of data. Most companies have Islands of Automation scattered across the PLM Grid, creating an archipelago of islands. At this level, the company's organisational structure from the PLM viewpoint consists mainly of functional departments and project teams. Each department manages its own view and definition of the product as it likes. Each department has its own application systems focused on its particular requirements. Each department has its own data model. There may be several different application systems managing product data in different parts of the company. There is not an IS architecture for the entire product lifecycle. Product data is reentered several times during the lifecycle. Business processes are defined for some of the phases, but there is not an overall process architecture. People are not trained to think of the lifecycle. There is little awareness that products can, or should, be managed across their lifecycle, or that a business activity of PLM exists. There's no overall plan for managing products across the lifecycle, no overall plan for the people, applications and processes of the product lifecycle.

10.3.2 Level 2: Frontier-crossing PLM

At this level, there is a wider awareness of PLM in the company, but there is not yet a PLM strategy covering the whole lifecycle. At this level, several business processes may have been described, but there is not a complete enterprise-wide business process architecture. The company may have standardised on two or three major applications, but there is still not an IS architecture for the entire product lifecycle. At this level, an attempt has been made to standardise use of documents. An attempt has been made to manage the product range better. The company has successful experience with collaboration. This level usually includes many different types of frontier-crossing. Some processes will have crossed functional borders. There will be cross-departmental activities and structures. For discrete manufacturing companies, an application example at the frontier-crossing level of PLM is CAD/CAM (Computer Aided Design/Computer Aided Manufacture). Process examples that can be found across a range of different industry sectors include the New Product Development (NPD) process and the Customer Complaint Management process. Although these may not necessarily be enterprise-wide, they do run across more than one department or function.

10.3.3 Level 3: Enterprise-wide PLM

Enterprise-wide PLM often addresses just one of the many resources that make up the holistic paradigm of PLM. An example is a Product Data Management (PDM) application that manages product information across the lifecycle, or a technique such as Quality Function Deployment (QFD) that can be applied across the lifecycle. At this level, the company is aware of PLM and its lifecycle implications, and is looking for ways to respond, but has not yet defined a PLM Vision or Strategy. There is a desire to address the management of products across the entire lifecycle, and not just phase by phase. However, although there is awareness of PLM, there is not yet general agreement throughout the company about the concept of PLM.

A company at this stage could be discussing the need to start a PLM Initiative or to develop a PLM Vision or Strategy. It could also have launched such an Initiative, but not completed it. At this level, PLM needs may be unclear, and the required resources may not be known. The scope, costs and benefits of a PLM Initiative are probably not known, and there is a lack of PLM understanding and knowledge.

10.3.4 Level 4: Patchwork PLM

The Patchwork appearance on the PLM Grid at this level comes from the existence of one or more enterprise-wide components of PLM superimposed on the Archipelago of Islands. However, it is only a patchwork. There are many gaps in the Grid. Many companies are at, or near to, this level. In some areas they have achieved enterprise-wide implementation, but in others they still only have Islands of PLM. There is a lack of agreement about the meaning of PLM.

10.3.5 Level 5: Enterprise-deep, Enterprise-wide PLM

When all resources are addressed with enterprise-wide PLM, then PLM has reached the fifth level. At this level it is enterprise-wide and enterprise-deep. At this level, the concept of PLM is clearly understood. At this level, PLM is seen as a way of achieving competitive advantage. The company probably has a PLM Initiative with an integrated PLM Vision, Strategy, Plan and Metrics. However, the Plan may not yet have been deployed to the level and extent at which the corresponding metrics show measurable performance improvement. The PLM strategy is aligned with the corporate strategy. There are documents describing the PLM Vision, the PLM Strategy, the PLM Plan, and the PLM Metrics. There is an effective project management approach for managing a product through its lifecycle. There is an enterprise-wide business process architecture. There are documents describing the lifecycle structure and the process architecture for the lifecycle. PLM procedures are formally described. There is a document describing the common, shared vocabulary and standardised data definitions. There are documents describing the documents, the data model and the data flow. There is a document describing the application architecture. A roadmap for the implementation of PLM applications has been defined. Responsibilities for products across the lifecycle have been defined. Job descriptions contain references to PLM. There is a document describing the skills that people require. There are documents describing their training plans.

10.3.6 Level 6: Global PLM

Whereas the first five levels of PLM address a particular company (either within the ‘four walls’ of that particular enterprise, or within the ‘Extended Enterprise’ of that company and its suppliers, partners and customers), the sixth level is PLM for Humanity. At this level, the issues addressed are common to many companies and to billions of people. Examples include:

- The provision of service to any user of the product anywhere in the world
- The implementation of restrictions on use of hazardous substances – which may differ from one continent to another
- Waste management (for example electronic and electrical waste) at the end of a product’s life – which may occur anywhere in the world
- Management of a product (such as oil) for which exhaustion of the planet’s resources is foreseeable

10.4 Middle Managers: Unsure of Reasons and Effects

Many Middle Managers are currently unsure how to proceed with PLM. They can see the potential for major benefits, but find it difficult to know where and how to achieve them. The reasons to implement PLM differ from one company to another, and depend on the particular position and objectives of the company. Middle Managers may see opportunities in many of the following areas, but it may not be easy to find the best path forward.

10.4.1 Cost, Quality, Time, Business Process Improvement

Cost reduction is an important reason for introducing PLM. Companies are looking to PLM to reduce costs such as product development costs, direct material costs, warranty costs, prototyping and validation costs, personnel costs, inventory costs, production costs, service costs, and IS costs.

Quality Improvement is an important reason for introducing PLM. Companies are looking to PLM to improve conformance with customer requirements, reduce product faults in the field, prevent recurring product problems, reduce manufacturing process defects, reduce the number of returns, reduce the number of customer complaints, and reduce errors, rework and wasted efforts.

Time Reduction is another important reason for introducing PLM. Companies are looking to PLM to reduce time to market, time to volume, time to value, time to profit, issue resolution time, project times, project overrun time, engineering change time and cycle times.

Business Process Improvement is an important reason for introducing PLM. Since the end of the 1980s, companies have focused more and more on mastering their business processes. However, in many companies it is only now that they are looking at streamlining and harmonising processes such as New Product Development and Product Modification. When companies reengineer processes they have the opportunity to identify the most effective way to work and remove waste activities. The introduction of PLM provides an opportunity for them to define and implement the best product-related processes across the product lifecycle.

Companies are also looking to PLM to help improve business decisions, improve visibility over the supply chain, increase visibility into manufacturing operations, improve risk management, reduce engineering changes late in the lifecycle, ensure compliance with standards, provide traceability, manage product portfolios, analyse product information across the product lifecycle, provide feedback from each phase of the lifecycle, and enable better management of outsourced tasks.

10.4.2 Innovation

Thanks to globalisation, companies now have the possibility to sell their products and services world-wide. But they also now have competitors from all over the world. This increased competition means they have to develop better products, develop them faster and develop them at lower cost. Product innovation is becoming a prime concern for many companies. Company leaders are often frustrated by the low level of product and service innovation in their companies. They want to turn on new revenue streams, ramp faster – and count increased revenues sooner. They are looking for PLM to increase the innovation rate without compromising creativity or quality.

10.4.3 Compliance

Companies are faced with an increasing number of regulatory requirements. These are often voluminous and liable to frequent changes. Just managing the regulations and linking them to different products and services in different countries is a time-consuming task. PLM provides product developers and compliance specialists with rapid access to the right information. Regulators need proof that their requirements have been met. The proof comes in the form of documents. These documents are managed in PLM. They include documentation of product characteristics, documentation of analysis of the product, and documents concerning tests of the product. Other documents, for example, process descriptions, describe the way that work is carried out. The templates, results, process descriptions and workflows necessary to demonstrate compliance are all managed within the overall PLM environment.

10.4.4 Mechatronic Products

Many companies develop ‘mechatronic’ products – products that contain a mixture of mechanical, electrical, electronic and software modules. They develop mechanical, electrical and electronic components in a similar way, with similar processes and applications. However, in the past, the processes and applications used for software development have generally been very different. Using two separate sets of processes and applications creates all sorts of problems, and can lead, for example, to customers receiving control software that doesn’t correspond to their product hardware. PLM provides a way of managing mechatronic products.

10.4.5 Collaboration

For various reasons, such as globalisation, a need to shift work offshore to low-cost countries, and a desire to work with the best people, many companies have moved away from the model of a single product development department and a single manufacturing location. However, relocating R&D activities changes the organisation of work. New approaches are needed to manage and work effectively in the new environment of networked and fragmented research, development and support. PLM enables integration of the design chain (internally, and externally with suppliers), to achieve Global Product Development. It enables integration of the supply chain (internally, and externally with partners) to achieve Global Manufacturing.

Web and collaborative technologies that support the PLM activity enable research and development to be carried out in a well-managed way in multiple locations. They enable product developers, sales people and service workers to interact with customers and partners on a global basis. They allow product development and support to occur on a 24/7 basis. Team members can be based anywhere yet work together in spite of space, time and organisational differences. They do not need to be co-located, as PLM enables them to achieve use and re-use of common parts, worldwide engineering change management, and global information exchange, synchronisation and interoperability.

10.4.6 Intellectual Property Management

Product data/information (product know-how) is one of the most valuable resources in a company. It's an increasingly valuable resource for corporate growth and must be kept secure. PLM provides the "Intellectual Property Vault" for protection in the face of increasing global competition and the potential risks from terrorism and economic espionage. Rules for any sharing of product data need to be defined in contracts with the customer/supplier.

10.4.7 Headway

Due to the enterprise-wide scope of PLM, it can be difficult for middle managers to start activities on PLM as they do not have the required authority or responsibility. In addition, they are usually already overloaded with other activities and projects that have higher priority and are already running. The result is that they are able to make little or no headway with PLM, and:

- Decisions about next steps are delayed
- Progress is slow
- Users and managers are frustrated
- Problems arise with partners wanting to move ahead faster
- The company falls behind competitors

10.5 Executives

Due to the enterprise-wide scope of PLM, it is at the level of the VP (or business executive of similar rank and power) that action has to be taken if the expectations of PLM are to become reality. However, in today's highly competitive global environment, many business executives feel that they are already overloaded with responsibility and work. Perhaps they have been given additional responsibilities extending beyond their usual areas, for example, to integrate newly acquired companies or to oversee operations in India, Russia, South Africa or China. With little time available, they may not want to get involved with a subject such as PLM that can seem unclear in both scope and potential benefit.

Another reason that executives may not be convinced that they should invest in PLM is that it is an enterprise-wide approach. As a result, executives may look at PLM and consider that it does not lie in their particular domain of responsibility. A CIO may get the impression that PLM is mainly an issue for Product Managers and Product Development Managers, but they may see PLM as being mainly a question of application systems, so lying in the IS area.

Many business executives are sceptical of claims for new breakthrough approaches and technologies. They see PLM as just one more breakthrough among the many that are touted, and are not easily convinced that it will bring them success.

Many executives are looking for short-term improvements with impact on the financial figures in the next quarter, and are likely to consider that PLM does not fall in that category. In many organisations there is as yet no corporate plan or funding for PLM. As a result, none of the executives may feel any responsibility for PLM, no executive has been assigned to PLM, there is no PLM budget, and executives have not yet been set an annual target for PLM.

10.6 Company Dilemma

A dilemma arises in many companies as people see the need for, and opportunities of, PLM yet don't see the expected resulting action (Figure 10.1). On one hand, there's a feeling in the company that PLM should be implemented as:

- The product is at the heart of business strategy, and PLM will enable a quantum leap in product innovation
- PLM can combine collaborative Web spaces and enterprise applications to support the drive for market-leading products
- PLM is the final strategic building block for the CIO's enterprise application architecture
- PLM enables information automation, distribution and 'biz system-to-biz system' integration with accurate and timely product data
- PLM enables benefits for the 80% of the product-information consumer-base outside the Engineering Department
- PLM is the final plank of the Business Process Framework
- PLM is a keystone activity of the Lean Enterprise
- PLM is part of the foundations of the Extended Enterprise

- PLM increases revenues and earnings by bringing better products to market faster, and extending the lives of mature products

On the other hand, there is little progress with PLM as:

- Business executives are already stretched with other tasks
- There isn't a clear vision of PLM for people to aim at
- Cost pressures may induce the company to wait for the market to improve before investing in new initiatives
- The company is busy with other projects (such as headcount reduction; process definition; application implementation; system harmonisation; introduction of new techniques; improvement of project management performance; integration of acquisitions)
- Headcount reduction has resulted in a lack of resources
- PLM responsibility isn't defined
- PLM doesn't fall nicely into an individual department's scope
- PLM may look too strategic and long-term

10.7 Personal Dilemma

In this situation, with PLM looking strategic, but not being acted on by high-level executives, middle managers face a dilemma. Should they try to do something about PLM, or should they forget about PLM and carry on with 'business as usual'?

If they do try to do something about PLM, they may well be seen later as having been instrumental in helping the company achieve major benefits through use of PLM. They may enable the company to seize new opportunities and solve long-running problems. Of course, on the other hand, if they try to do something about PLM without support from above, they could expose themselves to criticism for not doing what they have been told to do. They could be blamed for not following the plan prepared by their boss. Even worse, they can be accused of lowering morale and productivity by making unnecessary suggestions for change.

Sometimes they start to make a list of reasons to justify why they don't need to do anything about PLM:

- There are already many projects running in the company – PLM isn't the only issue in today's global industrial environment.
- The company has slimmed down so much that there aren't enough people available for a PLM project.
- Few people in a company have a broad enough overview of product-related processes, applications and information to lead a PLM project.
- It's not clear who should be responsible for PLM.
- Business executives are already stretched with other tasks.
- A top executive has put new initiatives on hold.

- Middle managers are already stretched with other tasks.
- Middle managers don't have the authority or the responsibility to launch company-wide PLM activities.
- A lot of people actually enjoy managing, or fire-fighting, the present environment. Why rock the boat and make enemies?
- Many people only focus on the present. They may not want to see, or be able to see, that improvements could be made in the future with PLM.
- Middle managers of projects that overlap with PLM will probably fight PLM as they prefer to manage their existing projects.
- It looks as if PLM will be massive, but it's not clear exactly what it is, or what its scope will be.
- People talk of PLM in different contexts, sometimes of processes, sometimes of application systems, sometimes of product structures, sometimes of configuration management. This is confusing.
- People who are not educated about PLM may find it difficult to understand how it can help them.
- Executives may not have a deep enough understanding of product-related issues to be convinced of the need for change.
- The company is focused on managing for short-term survival and short-term payback. As a result, PLM can look too long-term for the CFO.
- PLM looks confusing and difficult to succeed with.
- Without a dominant vendor driving the PLM market, it may be unwise to venture too far with PLM.
- PLM is not yet in the company's annual plan or budget.
- There is a lack of clearly defined PLM methodologies for the implementation and everyday operation of PLM.
- There is a lack of PLM Best Practice. This is a handicap for a company wanting to benefit from PLM. Companies focusing on cutting costs to the minimum can't engage in extensive and expensive customisation of processes and application systems as a part of a PLM implementation. With clearly described PLM Best Practice, they would know what they are taking on. They would be able to implement fast and use PLM effectively. They could see how Best Practice works in other companies, the likely implementation effort and time scale, and the types of resulting benefits and costs.
- The issue of PLM integration with other applications is high on the agenda of the CIO. Product-related data must be exchanged with applications such as: ERP; SCM; CRM; Maintenance, Repair and Operations (MRO); Marketing and Sales applications; NC controllers; Human Resource Management systems; Financial systems. The CIO may be concerned that integration would be costly to develop and maintain, error-prone, and a source of potential problems that can impede smooth process and information flow.

Having made such a list, the manager realises that it might be better to try to do something about PLM, to avoid being accused of being negligent and not offering the company the opportunity to make major gains through the use of PLM. Of course, if they don't try to do something about PLM, they can always tell themselves that PLM will come one day anyway, and for the moment it's probably not required, as top management has not asked for it. And of course they can comfort themselves with the thought that there's no way they can do it on their own, so they might just as well wait until their boss tells them to do something about it. And of course, if they did try to do something about PLM, they would expose themselves to criticism for doing something that wasn't in their job description. So they may think that the best thing is to get on with that small improvement project which was planned the previous year, even though it will probably not lead to significant results.

10.8 Going Nowhere

These dilemmas have arisen for many managers in many organisations. They lead to a repetitive situation of the following type:

- In previous years, the company has run numerous performance improvement projects, for example, to implement application software (such as CAD, PDM and ERP), define business processes, create a Quality Manual, and take on board approaches such as Concurrent Engineering and Quality Function Deployment (QFD).
- In spite of all those projects carried out in the past, there is a very visible problem related in some way to one or more of the company's products, and there is a discussion about how to solve this problem. The usual way to solve it would be to launch yet another improvement project, such as an Engineering Change Management (ECM) project.
- When middle level managers start looking at the details of the proposed ECM project, they see that there are multiple causes to the problems that the company is facing with management of changes to its products, and these involve several processes, several applications, and several departments.
- They realise that what is really needed is some kind of overall joined-up PLM approach that addresses the problem in a wider context of many applications (CAD, PDM, *etc.*), processes (ECM, NPD, *etc.*), techniques (collaboration, *etc.*), interfaces to applications such as ERP, SCM, Enterprise Content Management, *etc.*
- They are not sure if PLM would really be right for the company, or if starting a PLM activity would make sense. They are not sure how to start a PLM activity, as PLM does not fit into a single department. They think about starting a project to develop an overall integrated PLM Strategy, and look round their organisation for someone to lead such a project, but find that, after all the downsizing, offshoring and outsourcing, nobody has the time to do it.
- They look outside the company, and are quoted more than $50k by consultants for a PLM Strategy

- They only have $60k left in this year's budget, and discuss if they really should spend $50k on a voluminous report, or if they should invest in licenses for a new application that will make everyday work easier.
- They decide to buy the new licenses and start a small project to solve the ECM issue, even though they think it would be better to address Engineering Changes in a project with a wider scope.
- They continue to think about how to find the resources to develop a PLM Strategy.
- While thinking about this, some more product-related problems (such as lack of product innovation, product configuration errors, field failure reports being lost) occur, and get their attention.
- When they look at these problems, they see that these problems don't have a clearly-defined stand-alone scope, but involve several processes, several applications and several departments.
- This confirms the feeling that what is really needed is some kind of overall joined-up PLM approach.
- However, another review of availability shows there is nobody of the right stature available to lead an initiative in this area, and none of the business executives have been given the responsibility for PLM. They decide to start some more small projects to address the latest product-related problems.

10.9 Examples of the PLM Dilemma

The situation described in the previous section may seem absurd, but it arises in many companies, and it can exist for a long time before a true PLM activity is started. Here are some examples.

Company A, in process manufacturing, has been working for several years to deploy a cross-functional product development process. Asked about PLM, they replied that the CFO had said that they would have to complete that deployment before starting an initiative in the area of PLM.

Company B, in consumer electronics, recently launched a corporate effort to redefine all process maps to take account of globalisation, the new Enterprise Resource Planning (ERP) application and the Web. It's a major effort, and executives are wary of starting a parallel PLM initiative. They don't believe the company can handle two major initiatives at the same time.

Company C, in the telecomms sector, is in a phase of merger and restructuring in response to global changes in that industry. The main priority is to get the existing Technical Information Systems, which are based on different architectures, databases and applications, and are on several different continents, to work together. This is a massive task and currently uses all available resources. Nobody in the IS organisation has the time to work on PLM.

Company D, in the automotive sector, is proud of its application of Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Computer Aided Engineering (CAE), Product Data Management (PDM) and Digital Manufacturing, but is faced by many problems in the area of Software Configuration Management (SCM). They want to solve that specific problem before starting a project with a scope as wide as PLM.

Company E, in the aerospace industry, has several overlapping improvement projects, all on subjects that fall into the area of PLM. Some people have proposed consolidating these projects into one PLM project, but the managers of the overlapping projects claim that would slow down progress. Although the Engineering VP is supportive of a PLM project, the CIO and the Quality VP are opposed.

Company F, in the mechanical engineering sector, is in a phase of rationalising existing Information Systems. PLM is seen as something fuzzy that can't be pinned down. They will look at it when they have a clearer understanding of their new system architecture.

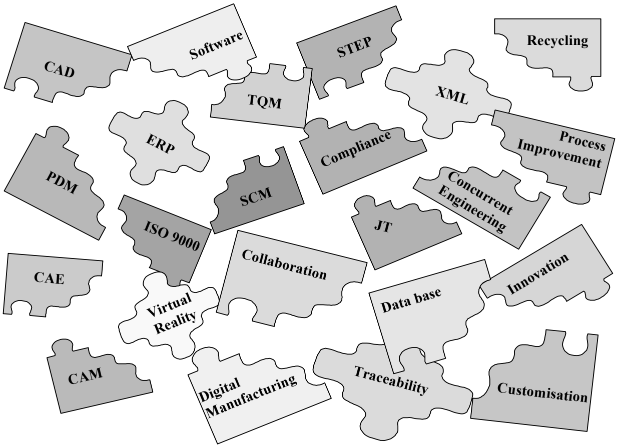


Figure 10.1. The PLM dilemma

Company G, in the machine tool sector, is looking to reengineer its approach to product development to ensure it takes better account of customer requirements, and does not want to address Information System issues. Due to the cost of the ERP project, the CEO has forbidden any customisation of enterprise applications.

Company H, in the pharmaceutical sector, has hundreds of R&D projects running, and is running a high-profile project to find a way to give management an overview of the current status of all R&D projects. That project has top priority, and no resources will be put into new projects until it has succeeded. PLM is on the back burner.

Company I, in the electronics sector, is reviewing its Engineering Change process – again. Some of the people in the project think the problem isn't the change process this time, but the product structure. They would like to take a more global approach to the problem, but the project charter doesn't allow for that.

Company J, in the financial services sector, feels that it has taken a piecemeal approach to its product-related applications and processes in the past, and thinks it is missing something. For the moment it is looking to solve that issue by bringing together all available resources for an ERP project.

Company K, in the plastics processing industry, has decided to stop all improvement projects until its markets start growing again. PLM is on hold.

Company L, in the power equipment industry, having recently terminated major projects to harmonise application systems and improve business processes, is running a product structure optimisation project to enable more modularity and easier configuration for sales over the Web. Until that's completed it will be difficult to start another project addressing the product.

Company M, in the medical equipment industry, recently acquired a company making software for its products, and is looking to see how best to integrate operations so that it can offer integrated solutions to its customers. As PLM is not in the annual plan, it is not addressed.

Some People Underestimate PLM

Figure 10.2. PLM can be difficult to understand

Company N, in the heavy vehicles industry, is struggling to find a way to deliver highly customised products with a Configuration Management application nearly 30 years old. There are several reasons why it's not easy to move forward. One problem is that the IS VP, the Engineering VP and the Marketing VP all claim that PLM is not their responsibility.

Company O, in the electronics industry, finding that software is becoming a major part of its product, is looking at ways to integrate the development, purchasing and management of mechanical, electronic and software components. That project is called 2020 Vision, and PLM may be included among its objectives.

In Company P, in the electronics industry, the PDM Manager tried to start a PLM project, but was told that the ERP project team already had that task.

In Company Q, in the engineering industry, the provider of the Computer Aided Design (CAD) system is restructuring its portfolio, and there's a discussion as to whether this would be a good time to change to a single vendor for CAD and PDM. The subject of PLM has been sidelined until the vendor announces its plans.

Company R, in the medical appliance industry, successfully implemented a PDM application. However, when it tried to expand the scope of PDM, it found the application did not have all necessary functionality, and is now investigating other PDM applications. It is not sure how PLM relates to PDM.

In Company S, part of a global electronics corporation, the PDM Manager tried to start a PLM project but was told that PLM was a corporate activity, not a company activity.

10.10 Overcoming the PLM Dilemma in Three Months

Managers in many companies face a dilemma over PLM. On one hand it's clear that PLM makes sense and is gaining in acceptance. On the other hand, it's not clear what to do about it, or who should take action.

However, it is clear that, at some stage, the person who will have to take action is a top-level business executive with the authority and responsibility to address a subject that is enterprise-wide and addresses products, processes and applications. Someone who is responsible for ensuring the company improves business performance and makes money for shareholders.

And it is clear that the action will include the launch of a PLM Initiative, the development of a PLM Strategy and the deployment of PLM.

And presumably it is clear that before the top-level business executive can launch the Initiative, someone else will have to explain the case for PLM to them, very clearly and concisely, and in language they understand.

And, presumably, that explanation will be in the form of a PowerPoint presentation which will be prepared and presented by one or more people who report to that executive. And the objective of the presentation will be to help senior executives take action.

The presentation could take about one hour, with 20 slides, for example:

Title	1 slide
Contents of the presentation	1 slide
Objective of the presentation	1 slide
This is PLM	8 slides
PLM: our benefits and opportunities	4 slides
Three ways to move forward with PLM	3 slides
Ten step approach to PLM	2 slides

After initial discussions between middle managers, the possibility of making such a presentation can be discussed with a key executive. A draft presentation can be built. The subject can be discussed again with the executive, this time with the help of the slides. More feedback will help improve the presentation. Other people will be invited to join the discussion. Before long, the executive will be making the presentation to other executives, and the company will be on the way to PLM.

The timeline for the above activities could be as follows:

Meet with the executive	Month 0
Create draft presentation	Month 0
Show presentation to executive	Month 1
Improve the presentation	Month 1
Present the presentation again to the executive	Month 1
Discussions with other executives	Month 2
Define and launch PLM Initiative	Month 3

10.11 PLM Initiative

PLM Initiatives in different companies will be different because different companies are in such different situations:

- They can be in different industries with very different products, such as aircraft and chocolates
- They can be in different places in the supply chain, such as an OEM or a supplier of a commodity part
- They can be at different maturity levels of PLM implementation
- The PLM awareness of their engineers, managers, IS people and executives can be very different
- They can have very different business objectives

As a result, there is not a single, off-the-shelf, PLM Initiative that will fit everybody. Without knowing the exact situation within a company it's not possible to know what it should do. This can be demonstrated by considering two companies (Company A, Company B) of similar size and supply chain position supplying similar products to similar OEMs in their industry. Company A reports that it has reduced its Engineering Change time by 80% by implementing a PLM solution. What reduction do you think Company B can achieve by implementing that PLM solution?

The answer, of course, is that it's impossible to give a meaningful answer. What really happened in Company A? Is the reduction due to implementing an application or improving the processes? Was the process previously manual or already automated? Does the reduction apply to all products or just one? Does it apply to all sites or just one? And how does the environment in Company B relate to that in Company A? Has Company B already implemented that PLM solution? In which case it may already have achieved a 90% reduction.

Although there are thousands of different PLM Initiatives in thousands of companies, there are often common features to the Initiatives. As a result, although each company has to build its own PLM Initiative, it can draw on experience from other companies.

Without knowing the details of a particular company's PLM initiative, it's clear that a PLM Initiative will last several years and that it is not realistic to expect that everything will be done at once. As a result, it's useful to develop a PLM Strategy and a PLM Plan to identify what should be done, and to prioritise the order in which these things should be done.

For some activities, it is clear that they cannot be done together. For example, after PLM has been successfully deployed, it must be maintained. It cannot be maintained before it has been deployed. However, for other activities it may be less clear in which order they should be done. For example, it may not be clear if a process should be improved before it is automated, or if it should first be automated, and then improved once the automated process has been used and understood.

Because a PLM Initiative addresses so many components such as products, processes, people, data, and information systems, it may not be clear initially how a company can handle such a huge project. It's even possible that someone will suggest that it's not possible to manage an activity with such a wide scope. They may suggest cutting off a piece of PLM and focusing on that one piece. For example, some people might want to focus on the Product Definition phase of the product lifecycle, and ignore the other phases. Others may want to focus on IS. By focusing their resources in one area, they may hope to get a better understanding that will lead to faster progress and better results.

However, the danger of initially restricting the scope in this way is that it may result in the loss of many of the potential benefits of PLM. It is by bringing together, and joining up, previously disparate and fragmented activities, applications and processes, that PLM overcomes the many problems that result from the old unconnected approach. Cutting off a piece of PLM runs the risk of leading to a new fragment with similar problems to those of older fragments.

Instead of trying to reduce the potential size of PLM by cutting off a piece of PLM and addressing it separately, the first step should be to look for a structure and organisation within PLM that will help simplify its understanding. When this has been achieved, the many opportunities within the scope of PLM can be prioritised, and an implementation roadmap built up from manageable pieces.

Full achievement of PLM can be expected to take a lot of effort and a long time. That is normal. PLM is a major business activity running across the complete product lifecycle and the Extended Enterprise. PLM has a wide scope, and the PLM environment is complex. To achieve PLM will require a lot of effort over many years. In theory it might be possible to do everything in one project, but a single huge multi-year project is likely to end in disaster. In reality, it's better to run a formal PLM Initiative containing many smaller, shorter, more focused projects. Without a formal PLM Initiative, there is the danger that some important activities will not occur, some activities will overlap, the results of some activities will conflict, and some important decisions will not be taken. The end result is likely to be project failure, or downgrading of objectives. Many of the potential benefits of the PLM Initiative will be lost.

A PLM Initiative, made up of many individual projects of various sizes, can be compared to a Development Program, with multiple development projects, that is set up to develop a series of related products. There is a need for leadership of the overall Program, but equally importantly, each of these projects will have its own project leader, objectives and tasks. In the case of the PLM Initiative, the leaders of the individual projects report to the PLM Initiative Manager.

In theory, a PLM Initiative can be led by anyone who can run a complex, cross-functional project. In practice, it's good to have a leader who has experience with the company's products at different phases of the lifecycle, who can handle the cross-functional aspects of PLM, and who has experience of managing the various components of PLM – such as applications, processes, data and work methods.

10.12 PLM Initiatives Range from Strategic to Tactical

The scope of PLM is very wide, and the range of possible PLM Initiatives is also very wide. The PLM Initiative of a particular company may depend on a range of factors such as its existing PLM status, its financial health, its competitive environment, its available management skills, *etc.* The result is that the PLM Initiative it launches may fall anywhere in the range between 'extremely strategic' and 'purely tactical'.

It's important to make it clear to everybody concerned just what the PLM Initiative is expected to achieve. There is a danger that people may expect strategic results from a tactical approach and a tactical investment. This issue can be illustrated by reference to Table 10.1 that shows the results of different types of approach.

Table 10.1. Different approaches to improving performance

Company approach to improving performance	*Time period*	*Productivity change*	*Development cycle change*	*Product cost change*
Uncoordinated cherry-picking and lemon-squeezing	6 months	+ 4%	– 3%	– 3%
A short-term plan	1 year	+12%	–10%	– 9%
A three-year Strategy and Plan	3 years	+40%	–39%	–28%
Integrated Vision, Strategy and Plan	5 years	+100%	–80%	–41%

The results make sense. They show that major gains come from long-term strategic approaches, not from short-term tactical projects. However, they go against the philiosophy of "getting something for nothing".

For a truly enterprise-wide PLM Initiative, the first step may be to develop and communicate a Vision of the proposed new environment so that everyone knows where they are going. The step after that will be to define a Strategy to achieve the Vision. Then a plan has to be developed to implement the strategy. Once the plan has been implemented, the benefits can be harvested.

However, if the focus is departmental cherry-picking, then the Vision, and even the strategy, will not be needed. In all cases though, a plan will be needed to show what has to happen, when it should happen, and who does what to make it happen.

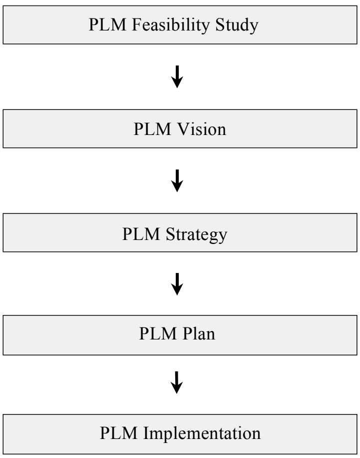


Figure 10.3. Steps in a PLM Initiative

The exact details of a PLM Initiative will be different in every company because all companies are different. Different companies have different products, different positions in the supply chain, different management styles, different business processes, different information systems, different objectives, *etc.* As a result, their PLM Initiatives will be different. Some companies will have already taken initial steps on the road to PLM, and the first steps they need to take now will differ from those of a company that is only just starting out towards PLM.

Usually the first steps in a PLM Initiative are to understand what it means for the company, and how PLM can be achieved. Different companies focus on different parts of the product lifecycle, and many different strategies are possible.

In some companies, a feasibility study will be carried out to find out which type of approach, and which level of response, is appropriate (Figure 10.4):

- Maybe a strategic enterprise-wide initiative targeting new market-leading products and full control across the product lifecycle
- Maybe a cross-functional project to achieve tactical benefits; for example, implementing new lifecycle processes across several functions
- Maybe a project targeting some very precisely defined improvements to achieve benefits in specific operational areas

In other companies, there may already be a good understanding of PLM. As a result, the first step in the PLM Initiative could be to carry out a pilot implementation of PLM software. Some companies will start with a pilot implementation including software because they think it's best to get hands-on experience as soon as possible, and then, on the basis of that experience, they will start the planning and communication activities.

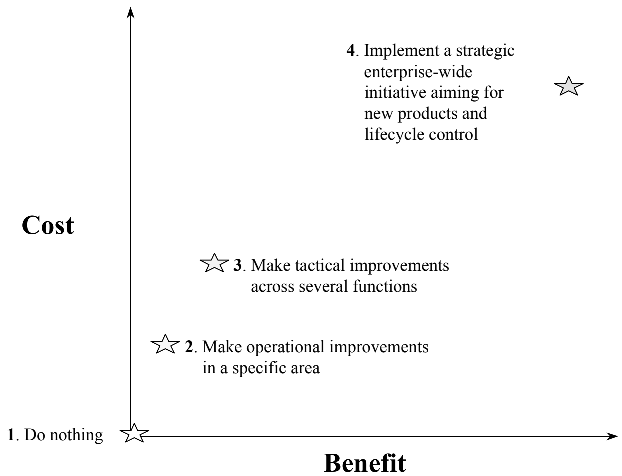


Figure 10.4. Targets of a PLM project can range from tactical to strategic

In other cases, companies will prefer to start by planning what they are going to do, make everyone aware, and then start looking at different possibilities for PLM. One of these could be software-related, but alternatively they might decide that the first step is to train the product teams.

A PLM Initiative is a major improvement activity that is likely to result in activities and changes that affect many people throughout the company. In most companies it takes a long time and a lot of effort to bring about change, and this is likely to be the case for the changes related to PLM.

Recognition of the need for a clearly defined and professionally managed change activity is a key feature of successful change. It’s helpful to understand that change is a major activity in its own right, and is a project in its own right, with its own objectives, activities, tools, techniques and metrics.

Change is not easy. Just exhorting people to do their best is unlikely to have much effect. People will nod their heads in agreement, then go away and do whatever they were doing before. That way, change won’t happen.

A key feature of successful change is that communication, learning and reward systems are given a high priority. Communication is a necessary element of a change project, but alone it’s not enough. Communication and learning are good and necessary, but they’re not enough. Communication, learning and new reward systems are all-important factors in successful change.

10.13 The 10 Step Approach to PLM

Experience shows that it can take longer to make progress with PLM than expected. The reasons for this often include:

- A need to broaden the understanding of PLM issues among business executives
- The difficulty of identifying the best approach to PLM and justifying the business case (Figure 10.5)

Another issue is that companies will be starting from various different positions. As a result they will have different questions about PLM. A company may for example be:

Looking at PLM for the first time:

- How and where do we start?
- How can we improve the chances for success?
- What should be in our PLM concept?
- Where does PLM fit with other enterprise initiatives?

- The vendor of our CAD system suggests one PLM concept, the vendor of our ERP system proposes a completely different concept – which is right?

Phase	Type of Savings	Value of Cost Savings	Type of Gains	Value of Revenue Gains
Imagine	Cost reductions (manpower, fees)	Comparatively low	New products and services	Very High
Define	Cost reductions (project, manpower)	Comparatively low	Better products and services	High
Realize	Cost reductions (material, manpower)	Medium	Fast availability of customised products	High
Support/Use	Cost reductions (manpower, warranties)	Medium	Upgraded/ extended products & services	Very High
Retire/Recycle	Cost reductions (manpower, fines)	Medium	Material reuse	Medium

Phase | Type of Savings | Value of Cost Savings | Type of Gains | Value of Revenue Gains

Figure 10.5. Justification of a PLM Initiative

Creating a PLM Business Case:

- What should we include?
- How can we quantify the value?
- What figures are realistic?

Expanding PLM from workgroup to enterprise:

- What do we do next?
- Where can we gain the biggest benefit?
- How can we stop struggling with multiple CAD and PDM applications?
- How do we handle multiple systems resulting from globalisation and acquisitions?
- How can we get our support costs under control?

Facing business drivers demanding much greater effectiveness and efficiency:

- How do we outsmart the competition this time?
- How can we compete against low-cost producers?
- How can we produce more products faster?
- How can we produce more great products?

The Ten Step Approach to PLM was developed to answer these questions, to overcome these issues and enable faster PLM progress. It offers companies a structured way to determine opportunity and problem areas that can be addressed by PLM.

The Ten Step Approach was built with the experience of many companies in many industry sectors, and aims to help:

- Build a business case for PLM and get management buy-in to proceed
- Uncover hidden needs and opportunities for PLM beyond the obvious
- Identify the best PLM approach in close alignment to business objectives
- Gain clearer understanding of the ROI potential of PLM
- Define and prioritise a clear PLM roadmap (Figure 10.6)
- Implement PLM most readily and cost effectively, preventing false starts and setbacks
- Improve overall PLM success

The Approach includes the following ten activities:

- PLM Status Review, Data Gathering
- Executive PLM Education and Awareness
- Best Practice Positioning
- PLM Concept Generation and Analysis
- PLM Roadmap and Plan Generation
- Business Benefits and Business Case Development
- ROI Calculation
- Management Report Preparation
- Executive Presentation
- Executive Decision Support

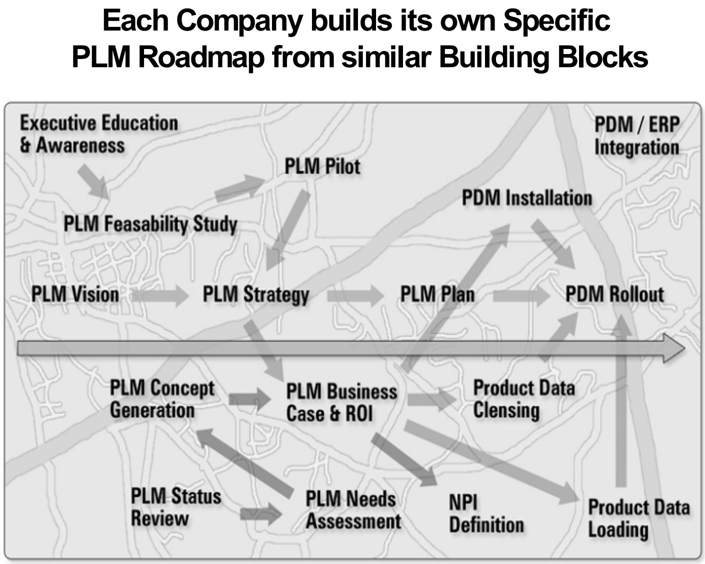


Figure 10.6. Many activities on the PLM roadmap

Experience shows that these ten steps help in understanding where PLM can be applied to a business most effectively and in getting executive approval for the PLM initiative to proceed.

The Ten Step Approach is a tried-and-tested methodology that has been used in many companies, at different stages of PLM progress, in many industries. It has been found that the ten steps make it clear to everyone involved what has to be done. At each step, there are clear deliverables so that people can see what is to be done and what has been achieved.

In a medium-sized company, the typical Ten Step Approach program will run six weeks (Table 10.2), a very cost-effective six weeks compared to the months or more of time and expenses that can be saved down the road.

Table 10.2. The Ten-Step Approach

Step	*Wk 1*	*Wk 2*	*Wk 3*	*Wk 4*	*Wk 5*	*Wk 6*
PLM Status Review, Data Gathering						
Executive PLM Education and Awareness						
Best Practice Positioning						
PLM Concept Generation and Analysis						
PLM Roadmap and Plan Generation						
Business Benefits & Bus. Case Development						
ROI Calculation						
Management Report Preparation						
Executive Presentation						
Executive Decision Support						

Clearly-defined deliverables for each step help show how the project will proceed, and make sure that key findings and proposals are captured and retained. For example, the deliverable from the "PLM Status Review, Data Gathering" step includes a description of the current situation. Much of this will be in the form of text, but it also includes numerous tables, lists and graphics such as histograms, pie charts and radar charts to help visualise why certain recommendations are warranted.

The deliverables from the "PLM Concept Generation and Analysis" step include, for each concept or option: a description; the benefits; the strengths and weaknesses; other issues; main activities; elapsed time; manpower requirements; costs; risks (Table 10.3).

The deliverables from the "Management Report Preparation" step are a comprehensive report and an accompanying PowerPoint presentation that can be presented to executives.

Table 10.3. Deliverables of the Ten Steps

Step	*Main Deliverable*
PLM Status Review, Data Gathering	Report on the 'as-is' situation, and expectations for the 'to-be' situation
Executive PLM Education and Awareness	PowerPoint presentation addressing potential benefits and opportunities of PLM
Best Practice Positioning	Improvement opportunities, strengths and weaknesses
PLM Concept Generation and Analysis	Report on potential PLM concepts, and reasons for the choice of a particular concept
PLM Roadmap and Plan Generation	PLM Roadmap and deployment plan
Business Benefits & Business Case Development	Report on expected costs, benefits, value and ROI
ROI Calculation	Realistic calculation of Return on Investment
Management Report Preparation	Management Report (Word) and presentation (PowerPoint)
Executive Presentation	Full understanding of PLM proposal
Executive Decision Support	Go/No Go decision

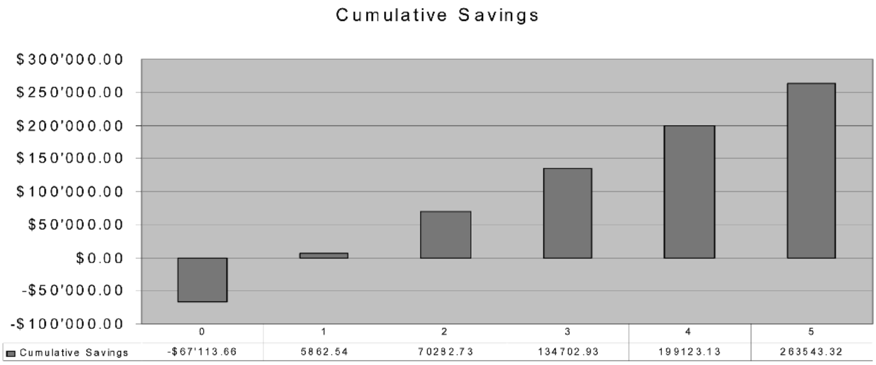
10.14 Results of Use of the Ten Step Approach

Example 1: This company wanted to understand and quantify the different options that had been suggested with 2D and 3D CAD, PDM, workflow management, BOM Management, product development process improvement, and a new development methodology. The 10 Step Approach showed that there were three main options, and highlighted their different costs and benefits. In particular it showed that the benefits of the low-cost option would be negligible, yet the other options would require significant management involvement. This led the company to appoint a PLM VP to drive the PLM initiative forward and achieve maximum benefit.

Example 2: As a result of several acquisitions, this corporation had different CAD and PDM applications, and different product-related processes and methods, at different sites. It wanted to identify the best applications and understand the associated implementation tasks and costs. It wanted to harmonise processes and documents across multiple companies and sites. The 10 Step Approach showed many additional issues and opportunities that had not been addressed, and led to a common PLM strategy for all sites.

Example 3: This company had identified the need for a PDM system, and wanted help with specification of PDM system requirements, short-listing, benchmarking, project planning, cost evaluation and ROI. The 10 Step Approach showed the need for PLM. This simplified the PDM project and led to faster implementation.

Example 4: This company had identified the need for a PLM solution, and initially wanted help with identification and detailing of different PLM concepts. The 10 Step Approach led into support for selection and implementation of the corresponding PLM applications.



Costs						
	0	1	2	3	4	5
Current Ann	$0.00	$147'301.60	$147'301.60	$147'301.60	$147'301.60	$147'301.60
Cost with c	$0.00	$147'301.60	$294'603.19	$441'904.79	$589'206.38	$736'507.98
Potential Annual		$74'325.40	$74'325.40	$74'325.40	$74'325.40	$74'325.40
Investment	$58'557.66					
Annual	$8'556.00		$8'556.00	$8'556.00	$8'556.00	$8'556.00
Cost with n	$67'113.66	$141'439.06	$224'320.46	$307'201.86	$390'083.26	$472'964.65

IRR	NPV
5%	$219'940.65
15%	$156'272.83
50%	$50'464.10
100%	-$428.59
105%	-$3'282.02

Costs	0	1	2	3	4	5
Investment	$58'557.66					
Annual	$8'556.00	$0.00	$8'556.00	$8'556.00	$8'556.00	$8'556.00
Benefits						
		$72'976.20	$72'976.20	$72'976.20	$72'976.20	$72'976.20
Annual Savi	-$67'113.66	72976.20	64420.20	64420.20	64420.20	64420.20
Cumulative	-$67'113.66	5862.54	70282.73	134702.93	199123.13	263543.32

Investment	Annual benefit
$67'113.66	$72'976.20
Payback (years)	Payback (months)
0.92	11

Figure 10.7. Showing the value and ROI of the project

Example 5: This company wanted help with the definition and automation of its Engineering Change process. The 10 Step Approach showed that the source of the problems it hoped to overcome with the EC project was outside the process. The proposed EC project was doomed to failure. The project was redefined to enable an increase in business value.

Example 6: This particular company had started a project to select and implement a PLM solution. As the size of the potential benefits became clear, management asked for external support to validate the findings and identify potential risks. The 10 Step Approach quantified a realistic ROI. A risk management approach was implemented.

Example 7: This company had received a proposal from its CAD application vendor for a PLM solution, and a very different proposal for PLM from its ERP vendor. The 10 Step Approach highlighted the differences between the two proposals and showed how they related to business objectives. This allowed the CFO to launch an opportunity study to show which approach would be best for the company.

These examples show how the 10 Step Approach tends to broaden and deepen a company's understanding of PLM and raise the level of awareness among executives, eventually leading to a PLM Initiative of greater benefit to the company.

11

Changes for Global Products and PLM

11.1 Changing Roles of Product Organisations

In early 2007, the G7 countries of Canada, France, Germany, Italy, Japan, the UK and the US accounted for about two-thirds of the world economy, and 10% of the world population. Since 1976, their leaders had met annually to discuss issues of concern. Thirty years later, the world still had many problems in need of solutions. They included:

- Global Warming, threatening the flooding of many cities and states
- More than a billion people living on $1 per day
- More than a billion people living without safe drinking water and electricity
- Billions of people living in slums
- Thousands of people dying each day of curable diseases and illness. For example, every day, 6000 children die from diarrhoea, usually caused by lack of clean water
- In 2007, according to the World Health Organisation, about 1 billion people are affected by Neglected Tropical Diseases such as schistosomiasis and trypanosomiasis
- In 2007, according to the World Health Organisation, road traffic crashes kill more than 1 million people each year. The annual global cost of road traffic crashes is estimated to be over $500 billion.

Since 1976 and the first G7 meeting, although many problems have not been solved, new and enhanced approaches to product development and distribution have appeared. They include Shareware, Open Source, microcredit and microsavings, generic products, Fair Trade for exports from developing countries to developed countries, and the (Product) Red brand. The role of non-governmental organisations (NGO), foundations and associations has greatly increased. It even extends into product-related areas. For example, One Laptop per Child, a non-profit association, has developed a $100 computer that connects to the Internet.

The Bill & Melinda Gates Foundation has committed $6 billion in global health grants to organisations worldwide.

Many problems remain to be solved, creating many opportunities for product developers. It is to be expected that, in coming years, many other opportunities for product developers will result from technological advances and from customer demands. Of course, it is possible that the future won't be so rosy. World trade patterns could change radically, for example because of wars, epidemics, global warming, and/or increased radiation disrupting communication systems.

Assuming though, that progress continues along a similar path as in recent years, by 2040 the seven countries with the largest economies will include China, India, Brazil, Mexico and Russia. They will have a combined population of nearly 4 billion, over 40% of the world population. Meeting the needs of large populations of poor people may seem more important to their governments than sending profits to foreign companies. They may have the economic power to change the rules of world trade to better meet their needs. For example, they may change the rules protecting property rights that render many products unavailable at prices that people throughout the world can afford. They may consider that true innovation should be justly rewarded, but people should not die because of laws overly protective of past activities in other parts of the world. They may find that state-owned manufacturing companies can be just as effective at producing mature "human rights products" and commodity products as privately owned companies looking for profit.

In such a scenario, with NGOs and state-owned companies developing and manufacturing basic low-cost products for a large part of the world's population, foreign privately-owned companies could be led to focus on developing new, advanced, highly complex, high-value-adding products. They would still be offering products globally, and the need for PLM would be similar. There would still be the need to collaborate, for the development and manufacturing of products, with different types of organisation worldwide. And they would need to be in total control of their Intellectual Property.

11.2 Increased Regulation of Product Companies

As products are so important to customers, governments and investors, it is likely that regulation, certification and audits will increase. Company performance in areas as diverse as community contribution, environmental performance, pollution, sustainability and R&D performance could be a target for new or enhanced regulation or certification.

Currently, many characteristics of a company, such as the financial figures, and the compliance with quality standards, are audited by external organisations. However the value of a company's products is not audited in a standard way. As PLM becomes increasingly important, and more and more standard processes are used, the company's products will be seen as central to its value. They will be audited for the good of users and investors. Auditors could report on the expected future value of a company's product portfolio, a useful figure for investors. PLM will play a key role in this valuation.

The different requirements and regulations in different countries and trade zones will complicate the activity of compliance. PLM will continue to play a role in keeping all the activities and documents under control.

11.3 Better Managed Product Companies

In the global product environment, the potential for problems with products is magnified. Risk management activities will be increased to help avoid major losses and to assure major benefits are achieved. Product development projects will be managed better to be sure that products get to market on time. The Product Portfolio will be managed better to maximise product value.

In the 1990s and the early years of the twenty-first century, many companies made good progress with Lean Manufacturing in production. Increasingly they will look to make similar improvements in white-collar areas. Targets of 50% reduction seem likely. Standard processes, applications and documents will be used wherever possible to cut down on waste. In the absence of standards for PLM components such as processes, applications and data, a lot of effort will be wasted each time that organisations try to work together in an Extended Enterprise. The IS Enterprise Applications of ERP and PLM will probably consolidate under one umbrella application.

Increasingly, society is expecting producers to take responsibility for their products. In coming years, companies can expect to have to take more responsibility, which will mean getting more and more control over the product lifecycle. The penalties for problems resulting from products, and their related processes and services, will probably increase.

In the early twenty-first century, there is little automated feedback from products. In coming years, products will send back much more information to their manufacturers, who will use it to support product use and disposal, and to develop new generations of products.

Increased counterfeiting seems to be one of the effects of globalisation. For example, according to the Center for Medicine in the Public Interest, counterfeit pharmaceuticals are expected to generate $75 billion in revenues in 2010.

Companies will manage their product IP better to reduce the risks of IP theft and counterfeit products. Unique identifiers for products will help improve traceability, IP protection and customer support.

11.4 A Multitude of New Products

Tens of thousands of new products will be developed each year. With about a million engineers graduating each year from India and China, more and more products will be developed in Asia.

Companies in the West will have to improve their product innovation capabilities, and their potential for collaboration with companies in Asia.

11.5 More Product-related Services on the Web

A first phase of product-related services on the Web has led to on-line sales and auctions of products and services. A new phase could start with the need for products in virtual worlds, for example, in Second Life.

As the Web becomes more and more ubiquitous, all the functions associated with a product will need to be available over the Web, leading to Web-based Product Lifecycle Management. Ideas for new products will be generated over the Web. They will be developed over the Web. Production information will be available on the Web. The product will be serviced over the web. And the Web will play a part when the product reaches the end of its life.

11.6 Breakthrough Computer Aided Product Development

With a need for faster innovation of products, applications to suggest new products will appear. Although products that will appear in five years may be unknown today, it is sure that they will exist. Companies need to find ways to identify them sooner. With products becoming increasing complex, there will be an increased need for simulation of a product's physical and financial performance before large sums are invested in its development.

In the absence of a global catastrophe, it looks as if global products are here to stay, and PLM will be key to their successful development and use.

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