Chapter 3
Product Pain

The complex changing environment in which products are developed, realised and supported was described in Chap. 2. This Chapter describes the pain that can result from such an environment. But this chapter only tells half the story. The other side of the coin, the opportunities resulting from such an environment, are addressed in Chap. 5.

3.1 Product Environment

Products, in particular global products, offer companies the opportunity of billions of dollars of sales revenues. However, without the right product and the right product deployment capability, the opportunity will be lost. Even worse, customers and other product users may be killed. Billions of dollars may be lost. Executive reputations will be tarnished. Company workers may lose their jobs.

The complex, risky, continually changing, uncertain, highly competitive 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. They need 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 (Fig. 3.1).

And, since it's never been easy to develop and support good products, and there are many reasons why it could get even more difficult, companies need to be sure they are operating as effectively as possible. They shouldn't be applying principles outlined in the early twentieth century. Back then, the world was a very different place. Many products came from a local farm. Electronics and biotechnology didn't exist. Telecommunications, cars and air travel were in their infancy. Customer choice was limited. People were willing to wait years to buy a product. Since then, the global economy has changed enormously. In industrialised nations,

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agriculture only represents a few percent of the economy. Today's customers have a huge choice. They can buy products almost anywhere in the world. They expect products and services to be available and to work first time. If they don't, it's easy for customers to switch to a more competitive product.

3.2 Private Life Experience

3.2.1 Washing Machine

You can't get much closer to private life than your laundry. Early in the twenty-first century, I bought a washing machine. It had a label showing it came from a "world-class manufacturer". After it was installed, my daughter gave it a test run with a small load. Surprisingly, the washing machine ran across the floor and pinned her against a wall. She switched it off before it crushed her. It turned out that it was shipped with a fixture to stop the tub being damaged during transport. The installation engineer didn't remove the fixture. When the machine got to the spin dry stage, the fixture caused such vibration that the machine moved several feet.

The first electric washing machines appeared in the first decade of the twentieth century. There's about a hundred years of experience and knowledge about their development and use. That makes you wonder what kind of organisation manufactured the machine I bought. Do you think they implemented Total Quality Management? What about their Customer Satisfaction activities? What kind of installation service process did they define? How are the installation engineers trained? Are the installation engineers getting the right information? Why was there no Feedback Form for me to provide valuable customer input? And shouldn't they have designed the machine so that it couldn't start if the fixture was still inside? Don't they know about Poka Yoke (mistake proofing)? What training do their design engineers get? Are the service engineers involved in the design? Do you think this world-renowned manufacturer has control of its products across their lifecycle?

Imagine	*Define*	*Realise*	*Support/Use*	*Retire/Recycle*
Ideas pirated	Projects late/ failing	Pollution costs	Upgrades ignored	Incorrect identification
Lack of ideas	Costs too high	Poor factory layout	Missing applications	Poor documentation
Uncontrollable	Uncontrolled changes	Scrap	Poor communication	Low recycle rate
Suppression of ideas	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
Priority, #1 CYA	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

Fig. 3.1 Product pain throughout the lifecycle

3.2.2 Telephone

As you know, telephones have been with us for some time. Alexander Graham Bell is credited with inventing the telephone in the 1870s. Some time after I bought the washing machine, I wanted to upgrade my GSM mobile (cellular) phone. It had the name of a world-class manufacturer on it. I went to the shop and showed the Customer Services Agent the phone and told him its number. He took a quick look at a database and told me which upgrades were possible. I chose one. He gave it to me, told me to put the SIM (Subscriber Identity Module) card from the old handset in the new one, told me I would need to charge the battery for about an hour. Isn't that great? Modern technology is so wonderful! It's so easy to live in today's service economy!

Well, actually it's not. After I had taken the phone home and charged the battery for an hour, the phone didn't work. I took it back to the Customer Services Agent. I told him it didn't work. "Oh, that's because your old phone worked with a 5 V SIM, but the new one only works with a 3 V SIM card. You'll need to get your service provider to change your card." The whole process took me about 5 h. It could have taken less than 5 minutes. There was no apology from the service provider or the Customer Services Agent. There was no Feedback Form to return to the manufacturer. Seems the Customer Services Agent hadn't been properly trained. Seems the database used by the Customer Services Agent didn't have the right data in it. Do you think this world-class manufacturer has control of its products across their lifecycle? And, by the way, who's is in charge in this Extended Enterprise? The manufacturer, the shop, or the service provider?

3.2.3 Escalator

A bit later, I made two return journeys to Oxford, England over a 2-week period. The first time I went through London Gatwick Airport, I noticed an "up" escalator wasn't 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. I walked up the stairs again. Four days later, going through the airport again, it was in the same state. I walked up the stairs again. And 4 days later it was in the same state. 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. By the way, like many other products we use today (Fig. 3.2), the escalator was invented more than 100 years ago. Escalators were invented in 1891. How many more hundred years before they work properly?

3.2.4 Train

I travelled by train from Gatwick to Oxford. Going through Reading Station, which is on the main railway line going West from London, I noticed the long black plumes of smoke rising from the diesel engines pulling the carriages in their resplendent corporate liveries. (Weren't those plumes of smoke meant to disappear along with steam locomotives?) The passengers in the carriage I travelled in had the doubtful pleasure of being accompanied by diesel fumes. One of them told me travelling conditions that day were good. Apparently, a few weeks earlier, it had got so hot in a carriage that the passengers had broken the windows to get fresh air. Another passenger added that a few weeks earlier, he'd been in a train when it had stopped, all the air conditioning and lighting had failed, and the doors were locked for passenger safety. After a couple of hours, people started screaming and breaking the windows.

On the final journey back I was amazed to see the driver of a superbly coloured engine, pulling an even more superbly coloured set of carriages, get down from the locomotive after he'd stopped the train. He walked over to a bucket of water. He picked up a broom, and proceeded to wash the windscreen. He then got back in, and continued the journey to London.

The first successful rail journey by a steam locomotive was made by Trevithick's Penydarren in 1804. In September 1825, for the first time, a locomotive pulled a passenger train. How come, nearly 200 years later, diesel fumes get in the carriages, passengers have to break windows to get fresh air, and locomotives don't have effective windscreen wipers? Are manufacturers in total control of their products?

3.2.5 Private/Professional Experience

Advising companies world-wide, I travel a lot, and get the opportunity to see a lot of products at work. Quite a lot haven't work well (Fig. 3.3).

Fig. 3.2 More than 100 years of experience with some products

Product	*Decade of Invention*
Aeroplane	1900's
Automobile	1880's
Elevator	1870's
Jeans	1870's
Telephone	1870's
Washing machine	1900's
Zipper	1890's

hotel coffee machines that don't work	hotel elevators that don't elevate
electronic keys that don't open hotel room doors	sensor-operated doors that don't operate
train toilet-door locks that don't work	vending machines that don't vend
rental cars that unexpectedly stop working	aircraft that can't fly
aircraft that hit another object before take-off	jetways that don't extend
credit cards that don't give credit	taxis that break down en route
reclining aircraft seats that don't recline	cash dispensers that don't dispense

Fig. 3.3 Some products that didn't work as expected

3.3 Professional Experience

In case you think these incidents aren't typical, but just happened to one particularly unlucky individual, here are a couple of examples from companies I've worked with. One company 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 2 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." Is that manufacturer really in control of the product lifecycle? It seems the CEO wasn't too happy when he found out they'd lost an order for a few million dollars. He didn't know who to fire. The Sales Manager, the Customer Relationship Manager, the Manufacturing VP, or the VP R&D?

Another company I work with did receive the brand-new high-tech machine it wanted. But the machine 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 the company didn't have 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. Logistics delivered them to customers, and he had to go and fix them and pretend he didn't know what was wrong. Is that manufacturer in control of the product lifecycle?

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 produced, sometimes while it's being used. Sometimes the problem occurs while the product is just an idea. Sometimes it happens at the end of the product's life. Making sure that such problems don't occur is a major challenge.

3.4 Public Experience

Maybe you think it's not relevant if a few individuals and a few companies have a few problems. And, since these stories are so different from the usual hype about today's wonderful products, you may not even believe them. After all, in the last few years, you've probably read many glossy articles and case studies about the development and production of great new products that customers simply can't wait to get their hands on. Did any of them mention this kind of problem? Or did they lavish praise on particular products, companies and executives? Have you read any Failure Stories to match the Success Stories? In case you can't remember anything going wrong, then maybe, digging deep into the distant past, we can find one for you. Here are some you may have heard about.

3.4.1 Electricity

On August 14, 2003, there was a power cut in the north-east of North America. More than 50 million people in dozens of cities including New York, Detroit and Toronto went without electricity all night. Some were trapped in trains and lifts, others were forced to sleep on the streets. The reason for the problem with this product seems to have been "a combination of circumstances".

Two weeks later, in a good demonstration of globalisation, London was blacked out for 30 min. This time, a clearer reason was given. Of the four main power lines serving part of London, two were down for maintenance and one was down due to an alarm. Unfortunately a couple of years earlier, the wrong protection relay had been installed on the remaining, fourth line. Five times smaller then "as intended" it triggered when power surged onto this line, causing the loss of about 20% of London's power supply. This example shows one of the features of today's product lifecycles. There are many organisations involved in getting the product to the customer. In this case, they included the protection relay manufacturer, the organisation installing the relay, the designer of the network, and the operators of the network. Unless the bits are put together very carefully, something will fall through the cracks.

Then, at 11 pm on September 28, 2003, more than 50 million people in Italy were blacked out until the following morning. Apparently an overhead power line had got too close to a tree in Switzerland. One theory behind this problem is that the line sagged too far down as the high power load it was carrying caused its length to increase. Why would there be an abnormally high load of this product at 11 pm when most of the population is asleep? From the point of view of most of the world's population, electricity is an important product for society, saving lives in hospitals, helping children learn in schools, making the streets safer for all of us. Many people yearn to have it. According to the International Energy Agency, about 25% of the world's population doesn't have electricity. Yet, for others, it's just another commodity to speculate in. Don't tie up capital, buy low and sell high, and if possible, reduce the risk by trading in options and futures. At 11 pm, there's a low demand for electricity, so that is the time to buy it.

Even so, electricity has been understood for more than 200 years. Haven't electrical engineers had time yet to learn about the effect of electricity on a power line? Isn't it possible for them to design and operate equipment in such a way that one fault doesn't affect 50 million people?

You may think that electricity isn't a product, so the above examples aren't relevant. In which case, consider some examples involving cars, ships, aircraft, bridges and rockets.

3.4.2 Cars

In 1997, the Mercedes A-Class car and the two-seater Smart car failed the "elk test". The test involves driving fast around a sharp curve as if avoiding a moose on the road. Correcting the flaw lengthened the development time. For the Smart car, the delay was about 5 months. The cost was about $150 million.

3.4.3 Bridges

In November 2003, 15 visitors died when visiting the Queen Mary 2 in its construction dry-dock in Saint Nazaire, France. At the time, the QM2 was the largest passenger ship ever built, at an estimated cost of $800 million. The visitors died when a 30-ft gangway from the quay to the ship broke. It had been installed the day before by a subcontractor.

When the Millennium Bridge opened in June 2000, it was London's first new Thames crossing since Tower Bridge in 1894. The first day that people walked across, it wobbled and swayed, and had to be closed. In some parts, the bridge moved nearly 3 inches. The engineers fixed the problems by adding 91 dampers. The bridge was reopened in February 2002. The modifications cost £5 million, compared to the original cost of £18 million.

The Pont du Gard aqueduct was built by the Romans in 193 BC to supply water to Nimes, France. Two thousand years later, it's still standing. It has three tiers, with the top tier, which is about 150 ft above the river, holding the water-course. The Romans didn't have computers and CAD systems. Building a bridge that doesn't wobble and sway isn't exactly rocket science, is it?

3.4.4 Aerospace Products

Oops. Rocket science. In November 2003, officials at the Japanese space programme said a rocket carrying two spy satellites had to be destroyed after take-off from Tanegashima island because of an unspecified technical failure. The two satellites cost an estimated 125 billion yen (about $1 billion).

In 1999, NASA's $125 million Mars Climate Orbiter got too close to Mars and burned up in its atmosphere. 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. An investigation found the confusion started with a subcontractor of the contractor. Was NASA in control of its product across its lifecycle? To what extent does it learn from experience? The need to take care with metric/Imperial conversion is well known. In 1983, a Canadian Boeing

767 ran out of fuel, and had to glide down to an emergency landing after someone used the wrong metric/Imperial conversion factor to calculate how much fuel it needed to get from Montreal to Edmonton.

The Hubble Space Telescope was a collaborative development of NASA and the European Space Agency. It was deployed in April 1990. Initial images were found to be unexpectedly hazy. Two months later, the telescope was found to suffer from spherical aberration of the primary mirror. In places, the mirror was 2 microns too flat. The problem was corrected with COSTAR (Corrective Optics Space Telescope Axial Replacement) during a service mission in 1993. An inquiry was held into the problem and a technical explanation found. There was a fault in the null corrector, an instrument used in the mirror's manufacturing and testing process. Management failures were also identified. There had been insufficient testing, and under cost and time pressure, contradictory tests results from other equipment weren't sufficiently investigated. No formal certification had been required for the null corrector even though it played a crucial role. Project managers lacked the expertise required to correctly monitor activities and there was poor communication. COSTAR and the corrective mission are estimated to have cost more than $500 million. Hubble's cost at launch was estimated at about $1.5 billion.

Maybe you still think these are exceptional cases? Or you think they weren't investigated seriously to find the real causes? Among the events of this kind that have been most fully investigated are the Challenger and Columbia Space Shuttle accidents. On the morning of January 28, 1986, the Challenger Space Shuttle was destroyed 73 s after launch. The seven-member crew died. It included Christa McAuliffe, who was to have been the first teacher in space. On February 1, 2003 the Columbia Space Shuttle broke up during re-entry. The seven-member crew died. In both cases, there was, of course, a physical reason for the accident, but in both cases the investigators also found organisational problems.

3.4.5 Power Plants

Sometimes the result of losing control of a single product can have world-wide consequences. In April 1986, operators at the Chernobyl nuclear power plant started a simple test run that went wrong. It led to a chain reaction and explosions that blew the roof off the reactor, releasing radioactive products which then travelled round much of the world. Fire-fighters died, hundreds of thousands of people were evacuated, and the incidence of thyroid cancer in local children increased.

That wasn't the first time things had gone wrong with a nuclear power station. In 1979, at the Three Mile Island nuclear power station near Harrisburg, PA, a minor malfunction in a cooling circuit led to a temperature increase causing the reactor to shut down automatically. Unknown to the operators, a relief valve failed to close, much of the coolant drained away and the reactor core was damaged.

The resulting investigation found the causes were deficient instrumentation and inadequate emergency response training.

3.4.6 Financial Products

A home mortgage is a simple financial product. It's a loan from a financial institution to help purchase a property. In return for the loan, the customer agrees to make payments to pay it off, and to use the property as security. The product has a few basic product characteristics, such as loan size, length of loan period, interest rate, and repayment schedule. What could go wrong with such a simple product and such security? Well, financial organisations could offer variable interest rate mortgages to people with no capital, low earnings, and a history of unemployment and loan repayment delinquency. The result was the 2007–2008 global financial and economic crisis. Financial organisations round the world lost trillions of dollars. Some went bankrupt. Many were saved by taxpayer bailouts. Stock markets slumped. People lost their houses, companies closed, global economic growth declined, countries' economies went into recession.

3.4.7 Other Products

Occasionally problems are reported on television about high-profile products such as aircraft, power plants, ships, and cars. But as well as these very visible problems there are also, on an almost daily basis, publicly announced recalls of all sorts of products (Fig. 3.4).

And, apart from the well-publicised problems, you may also have noticed that some of the products and services that you acquired didn't quite come up to the level you expected. Your plane took off late because the pilot found a mechanical fault? Your computer crashed for some unknown reason? Your car didn't start, even though it worked perfectly the day before? Your pen leaked ink over your best dress? Your washing machine leaked water all over your favourite carpet? You couldn't open the hotel door with the electronic key? You broke your fingernail trying to switch your phone on? You tried a new lipstick and your lips broke out in a rash? You ate some cheese and were laid low for days?

airbags	processed food	cars	infant car seats	baby food
water heaters	bicycles	bunk beds	slippers	jackets
toys	television stands	refuse bins	shave gel	door knobs
security phones	cheese spread	chicken salad	cider	cookies
chairs	candleholders	flashlights	refrigerators	rifles

Fig. 3.4 A wide range of recalled products

3.5 Product Development is Important

The above examples focus on the use and operation of products outside the companies that develop and manufacture them. There are also all sorts of problems in the purely company-internal activity of developing new products.

Product development is an important activity in a product's life. It's where everything is defined, from components to costs.

For example, it's in product development that a manufacturer of laundry powders defines which ingredients to use. Will it include phosphates, or a more environmentally-friendly alternative? If it includes phosphates, they may eventually get into lakes and seas, and result in eutrophication and proliferation of seaweed.

It's in product development that a manufacturer of plastic bottles decides which plastic to use, and how much plastic is needed for a particular product. The choice will have environmental and cost impacts.

On average, 80% of a product's cost is defined during its development, even though more than 80% of its life is beyond the factory gate. The cost of product development varies widely from one product to another. Product development can be expensive, figures of about $10 billion are quoted for the A380. Advanced combat systems often cost billions to develop. New cars cost less to develop, usually just a billion or two. And, in the pharmaceutical industry, a blockbuster drug may cost more than $500 million to develop.

Product development is time-consuming. Like product development cost, product development time also varies widely from one product to another (Fig. 3.5). About one-third of products are developed in less than 6 months, and about two-thirds in less than 18 months.

Surveys of product development in industry often show that about 50% of the spend on product development is wasted. Wasted because a product development project is terminated before the product gets to market, or because the product fails in the market.

The frequency of introducing new products has increased in recent years. In the early 1990s, one company I work with renewed less than 10% of its products annually. It renewed about 75% of its products in 2009. Of the 300 or so products it had in 2005, only about 70 were taken forward into 2006.

3.6 Product Development is Hard

Part I 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

Fig. 3.5 Typical development times for products (2003)

Product development time	*Fraction of products with development time in this range*
less than 6 months	1/3
less than 18 months	2/3

beyond the understanding of NASA's engineers. And, in other situations, things that go wrong with products aren't usually 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. Product development is a complex process involving many poorly understood variables, relationships and abstractions. It addresses a wide range of issues, and is carried out by a wide variety of people using a wide range of practices, methods and applications, working in a wide variety of environments. Converting a concept into a complex multi-technology product under these conditions isn't easy. It requires a lot of effort, definition, analysis, investigation of physical processes, verification, trade-offs and other decisions.

3.7 Pain in Use

Building any product is hard. Foreseeing what can go wrong with its use is also hard.

In the late 1950s, a newly discovered drug, thalidomide, was found to be a good sedative. It was prescribed to pregnant women. Unfortunately it had unforeseen effects. They resulted in the birth of more than 10,000 children with major malformations.

Other drugs may seem safe, yet be very dangerous for a particular type of patient. A particular drug might normally be safe but become dangerous when taken with another drug. Thousands of people die each year from adverse drug reactions.

In the 1970s, tens of thousands of people were infected with hepatitis C after being given contaminated blood-clotting concentrates.

In December 1984, water caused a reaction in a tank of methyl isocyanate at a plant in Bhopal, India. The state government reported that the resulting gas leak led to about 3,800 deaths.

In the 1990s, millions of animals were slaughtered as a result of a BSE (bovine spongiform encephalopathy) epidemic. The culprit product was animal feed. It's thought that the epidemic originated when an animal developed BSE in the 1970s. The carcase of the animal was mixed into cattle feed. (The protein that animal carcases contained was intended to make the feed more nourishing, and help development.) Animals that ate the feed were infected. In turn, their carcases were mixed into cattle feed and infected others.

Many countries have problems with old military equipment. In particular, old ships may be polluted with hundreds of tons of carcinogenic polychlorinated biphenyls (PCBs) and asbestos, as well as flammable and poisonous fuels and oils. An accident can lead to environmental damage, toxic spills and fires. Dismantling is dangerous for people and the environment.

In November 2002, the Prestige single-hulled oil tanker sank off Spain, spilling over 60,000 tonnes of oil. The clean-up and environmental cost is estimated at several billion dollars.

In April 2010, the Deepwater Horizon rig explosion led to the death of 11 workers. For months, tens of thousands of barrels of oil spilled daily into the Gulf of Mexico, totalling perhaps a hundred million gallons. BP stopped paying dividends to its shareholders, and agreed to finance a $20 billion clean-up and compensation fund. On one occasion, US President Obama was reported as saying he had visited the Louisiana coast, “so I know whose ass to kick”.

A 2005 report by the Centers for Disease Control and Prevention estimated an annual US total of 76 million cases of food-borne disease, caused by consuming contaminated foods or beverages. It estimated an annual 325,000 hospitalisations and 5,000 deaths related to food-borne diseases.

Melamine is a useful chemical, but harmful to humans. It has a high level of nitrogen, and if added to food, leads some quality tests to overestimate the level of protein. For example, if it’s added to low-quality milk, the tests will show a higher level of protein. As a result, the milk can be sold at a higher price. In 2008, more than 250,000 people in China fell ill after drinking milk to which melamine had been added.

Other examples of difficulties with product use can be seen by taking a walk in any large town. You may see elderly people struggling to climb three or four steps to get into buses, and wonder who wrote the product specifications. Or you may see a young person with a pram struggling to climb those steps, and wonder about the home lives of design engineers. You may see the automatic doors of a bus closing on people, yet see another bus that has sensors to prevent injury. Or buses with engines under the floor, providing unwanted vibration for passengers. Or try and get a bus ticket from a machine and find the machine doesn’t give change. If these are customer-oriented products, can you imagine products that aren’t customer-oriented?

3.8 Effects

When a company loses control of its products and product-related activities, there can be effects in several areas (Fig. 3.6).

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 $100 million. 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.

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. 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 $4 billion in slaughtered cattle, compensation and lost exports. More than 100 people died from the related Creutzfield-Jacob disease, possibly infected by eating contaminated beef.

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.

Toyota estimated that the recall of millions of cars in late 2009 and early 2010 could cost as much as $2 billion.

3.9 Causes

Often an enquiry will be held when there's a serious problem with a product. Usually it's found that there are causes of several types (Fig. 3.7). Typical sources of the problems are shown in Fig. 3.8.

Often it seems that everyone was doing their job the way they should have, but somehow, things fell through the cracks because something wasn't done (Fig. 3.9).

Although the physical effects of a major problem with a product may be the most visible, the principal causes are often organisational and technical. These

Area	*Effect*
Customers	Deaths and injuries
	Loss of customers concerned about product problems
Financial	Financial losses due to damages resulting from product use
	Reduced profit due to costs of recalls and legal liabilities
	High cost of problem clean-up
	Revenues lost to low-cost competitors
Image	Negative publicity in the media
	Damage to the company's image
Environment	Pollution of the environment
Products	Products not behaving as expected
	Development projects finishing late
	New products not providing competitive advantage
	Resignation of top executives
	Management appearances in court

Fig. 3.6 Some effects of losing control of a product

Fig. 3.7 Different types of cause

physical causes
technical causes
organisational and cultural causes

causes have to be identified and understood so that measures can be taken to prevent their effects recurring.

3.9.1 Challenger

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 these 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 O-ring seals weren't certified to fly below 53°F. 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°F and at launch time was 36°F.) 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. The Commission 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.

3.9.2 Columbia

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. This was caused by insulating foam which separated from the External Tank 81.7 s 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

Customer needs misunderstood	Design faults
Design alternatives ignored	Lack of prototypes and testing
Lack of training	Standards not suitable / not adhered to
Communication problems between departments	Culture of risk-taking. Ineffective safety program
Informal decision-taking and change-making	Bureaucracy
Management pressure overriding technical rules	Information lost, misunderstood, ignored

Fig. 3.8 Typical sources of problems with products

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

Fig. 3.9 Issues affecting products

organisational causes of the accident were rooted in Space Shuttle Program history and culture. Cultural traits and organisational practices detrimental to safety had developed (Fig. 3.10).

3.9.3 SR-111

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 wasn't 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. It didn't 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. It 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.

This example shows again the complexity of the product lifecycle, and why it needs to be properly managed. In this case, it's apparent that even an industry certification standards organisation plays an important role in the product lifecycle. And the complexity of the extended enterprise is seen again. There's a contractor

Fig. 3.10 Practices detrimental to safety

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
an informal chain of command and decision-making processes

supporting another contractor which has contracted to a subcontractor which has contracted to a sub-subcontractor.

3.9.4 Multiple Causes

There are usually multiple causes leading to a problem. However, people often 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 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.

The approach of looking for a single root cause may be valid when applied in an environment that is well-structured and limited in scope. However, in an environment in which activities are carried out in parallel, and in other 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'll all have to be understood and addressed if recurrence of the effect is to be prevented.

3.10 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 multinational 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, several causes may have contributed (Fig. 3.11).

In February 2007, Airbus introduced 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.

3.11 Pre-Emptive Measures and PLM

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.

Ideally, of course, a company would want to identify potential problems with a product and take preventive action before a problem occurs. Often, though, this isn't 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, high-performing 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.

Fig. 3.11 Potential causes

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

If potential problems can be discussed, care needs to be taken in the way they are presented. Investigations into problems with products often find many causes. 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 weren't performing as well as possible in the past.

3.12 Current and Future Nightmare

3.12.1 It's a Nightmare

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. Most of the companies I work with 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. There are organisational issues (Fig. 3.12), issues with data (Fig. 3.13), issues with products (Fig. 3.14), issues with processes (Fig. 3.15), and other issues such as IS issues (Fig. 3.16).

In one company, the CEO summarised the situation as "a nightmare". In another company, they called it "a horror story".

Communication silos, people in different functions not talking together
Poor co-ordination with suppliers
Sales/Engineering disconnects leading to offer for sale of products that can't be built
Departmental mentality, each department convinced of its superiority
Not enough focus on products
Wasted development resources
High service costs
Lack of up-front planning
Projects coming in late
Poor scheduling of projects
Cycle times lengthening
Product development costs rising
Service costs increasing, while service performance deteriorates
Misalignment of expectations

Fig. 3.12 Typical organisational issues in the product environment

Data silos, data in one department not being easily available for others
Differences between product specifications used by Engineering, Production and Sales
Inconsistencies between data in R&D/Engineering, Production and Support
Redundant part numbers
Multiple names for the same project
Many Excel spreadsheets containing a lot of different information, often conflicting, about a product
Difficulty of being sure of usage of material across products
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
Product labelling not corresponding to the product

Fig. 3.13 Typical data issues in the product environment

Over the years, I've worked with more than 200 companies. I've seen issues like these in companies of all sizes and in all industries. Many of these companies are highly successful, with some great products and a strong 5-year financial track record.

Usually, taken singly, the issues listed don't lead to major problems. However, cumulatively they can result in, at best, unnecessarily long lead times, increased product costs and reduced product quality, and, at worst, in disaster.

3.13 Global Growing Pains

The type of issues mentioned above can occur when a company only has operations on one site, and only sells to customers in a local market. When the company goes global, it's faced by additional issues. 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's 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?

Technical problems with products in the field
Rework
Poor product quality
Quality problems
Errors in product definition records
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

Fig. 3.14 Typical product issues in the product environment

Slow engineering changes
Inadequate customer service
Not enough re-use of existing parts, reinvention of the wheel
Bureaucratic business processes
Product release delayed
Changes to product data being made by individuals without any co-ordination
Products meeting specifications but failing to meet customer requirements
Increasing rework and engineering changes
Product labelling not corresponding to labelling regulations

Fig. 3.15 Typical process issues in the product environment

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
Lack of good product developers
Unwillingness to benefit from external developments, Not Invented Here syndrome
Islands of Automation
Equipment under-utilised or over-booked

Fig. 3.16 Other issues in the product environment

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, or yuan? 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? And different products for people of different religions and cultures?

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 don't 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?

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. And, apart from all those questions, can we take the risk of something going wrong?

If something does go wrong, people could die, large numbers of people could lose their jobs, billions of potential customers could hear about it, and billions of dollars could be lost.

3.14 No Silver Bullet

Sometimes it feels as if the number of difficulties appearing in product development and support is continuously increasing. And that unless a revolutionary new approach to solving them is invented, companies will grind to a halt. But such a magical solution is unlikely. Progress very rarely happens like that. Even when what may appear as a sudden breakthrough occurs, it's usually based on a succession of improvements made by different people over a long period of time. Watt's invention of the steam engine built on the work of Newcomen, Savery and others. The Wright brothers built on the research of Samuel Langley, Otto Lilienthal and others. As Isaac Newton wrote in 1676, "If I have seen farther than others, it's because I was standing on the shoulders of giants".

As it's highly unlikely that a revolutionary new approach to developing and supporting products is going to appear in the next few years, managers need to make the most of what is currently available. PLM is available, and has a lot to offer.