Chapter 19
Strategies

19.1 PLM Strategy and Implementation Strategy

The preceding chapter showed that two strategies need to be developed, the future PLM Strategy and the Implementation Strategy. The future PLM Strategy will show how PLM resources will be organised in the future, envisioned environment. The Implementation Strategy will show how resources will be organised to achieve the change from today's environment to the future environment.

Perhaps half of a company's resources will be in the scope of PLM. There are many ways to organise them. But what's the best way to organise them to achieve the objectives? What's the best strategy? How would you proceed? If it's not something you have done before, if you have no experience of developing a PLM Strategy or an Implementation Strategy, perhaps you would start by looking to see if someone has written down their experience of developing one. Or look if someone has written about how other people have developed PLM Strategy and Implementation Strategy. You might look elsewhere to see how strategies are developed in general, what's important, and what lessons have been learned.

One source of lessons learned might be case studies from industry, but these are often in the shape of success stories. They don't tend to dwell much on the failures and mistakes that are part of most activities.

An area that could be worth looking at is the development of military strategies. One reason for this is that the events were so large in scale that their description isn't deformed by one or two individuals trying to present their behaviour favourably. Another is that they took place sufficiently long ago for there to be general agreement on objectives and strategies. And most people will be familiar with the events described. And they'll have a general understanding of the overall issues. By looking at historical events, it's possible to see how strategies are developed and implemented, to see their results, and to see how and why they change. The lessons learned can then be applied to PLM strategies.

19.2 Military Strategy

Histories of modern military strategy often start with Napoleon. Between 1796 and 1815 he dominated most of Europe. For hundreds of years before, no-one had achieved such domination. Napoleon had several strengths. After 1804 he was both Emperor of France and commander of the French army, so he controlled both the national and the military strategies. No other general at the time had such freedom. Napoleon also became very experienced. He fought more battles than other generals. Napoleon fought in the name of Liberty. Many of the generals he defeated were fighting in the name of despots. Until Napoleon's time, battles were often formal events requiring mutual agreement to fight and a long set-up time. Napoleon, however didn't just bring his army to a place opposite the opposing army and wait until his enemy was prepared for battle. He carefully selected battlegrounds advantageous to his forces, rapidly concentrated all his forces for battle at a position where his enemy was weak, and forced his enemy to fight by threatening lines of communication and supply.

Carl von Clausewitz saw many of the Napeolonic battles and wrote about military strategy in "*On War*". One of his theses was that "war is nothing but a continuation of political intercourse with the admixture of different means", in other words, an extension of diplomacy. This leads to the concept of total war involving not only a country's army, but also civilians and economic resources. It also implies political direction in military matters.

For Von Clausewitz, as for Napoleon, victory in war resulted from the destruction of the enemy's forces on the battlefield rather than the mere occupation of territory. To achieve this he identified three targets. These were the enemy forces, their resources and their will to fight. According to Von Clausewitz, defensive warfare offered a stronger position than offensive warfare.

Antoine-Henri Jomini, a contemporary of von Clausewitz, and a staff officer of Napoleon, put forward his ideas of strategy in "Summary of the art of war". Unlike von Clausewitz, he favoured a strategy of occupation of territory rather than destruction of the enemy. By the time of the American Civil War (1861–1865) the effects of the Industrial Revolution were becoming apparent. Steam power was widely used. Accurate long-range infantry rifles had been invented. The use of steam power for rail and water transport changed the military equations of space and time. As long-range rifles could wipe out a concentrated attacking force before it could get to grips with a well entrenched enemy, the tactic of frontal attack with concentrated forces was abandoned. It was however used by Lee at Gettysburg, and the disastrous result ended any hopes of victory for the South.

At the time of the American Civil War, Prussia was growing in strength in Europe. The Prussian commander Von Moltke agreed with von Clausewitz that battles are the primary means of breaking the will of the enemy. But he didn't agree that defensive warfare offered the best position. He favoured the offensive. Speedy decisive action with superior forces. This strategy was used successfully against the Danes, Austrians and French. His successor, von Schlieffen, took this

approach one stage further with his strategy of annihilation, a decisive battle from which the enemy couldn't escape. While the Prussian generals were focusing on military strategies that focused on victory by offensive action and decisive battle, other strategists such as Delbrück and Mahan were looking at strategy in wider contexts. Delbrück proposed a strategy of exhaustion in which the enemy was worn down by territorial occupation, blockade, destruction of crops, and destruction of commerce. Mahan proposed a change in US naval strategy away from coastal protection and commerce-raiding to command of the seas.

Some of the results of these strategies were seen in the First World War. Apparently the effect of advances in technology, which had already been clear in the Civil War, hadn't been fully understood by the strategists. The introduction of the machine gun and field artillery had tilted the balance in favour of the defender, yet both the French and German commands favoured offensive strategies. Von Schlieffen's plans for an annihilating attack against France were watered down by his successors. The initial German attack in August 1914 failed to achieve its objectives. By November 1914, the opposing armies were faced with trench warfare in which a well-entrenched defender held the upper hand. A long series of indecisive but costly battles followed. None of the commanders appeared to grasp the futility of their offensive strategies. One of the worst examples occurred at the Battle of the Somme on July 1, 1916. After a week's preparatory bombardment (alerting the Germans to a major offensive) the British infantry attacked on a 15-mile front. They moved in formation, and at walking pace, towards the German positions. By the end of the day, the British had 60,000 casualties, 20,000 of them dead.

The trench warfare lasted for 4 years, becoming a war of attrition in which the naval blockade of Germany eventually played a large part in the Allied victory. By the Second World War, new technologies were available, providing the possibility for a very mobile attack capable of overcoming strong defences. As von Clausewitz had foreseen, war then became as much a test of civilian morale and economic strength as of military prowess.

The following sections help to illustrate military strategies in specific contexts (Fig. 19.1), and related success and failure factors, and provide the basis for some "Lessons Learned". These are a useful input when developing strategies in the context of PLM.

19.3   American Civil War

The American Civil War started at Fort Sumter on April 12, 1861. The North wouldn't accept that the Union could be divided. The Southern states believed the Union no longer protected their rights and interests. The objective of the North was

Fig. 19.1 Different contexts of military strategy

| American Civil War |
| France |
| English Channel |
| Russia |
| Pacific Ocean |

to prevent the Confederate States from seceding from the Union. The objective of the South was to attain independence.

The population of the North was 21 million. The population of the South was 9 million, of which 3.5 million were slaves. Over 80% of factories were in the North. So was 95% of arms production. About 75% of railroads were in the North. The South couldn't hope to achieve its objective by conquering the North, but in view of its objective didn't have to. Its strategy aimed to convince the North that forcing the South to remain in the Union wasn't worth the cost, and to bring about foreign intervention in its favour.

Whereas the Confederate president Jefferson Davis suggested a purely defensive strategy to meet the South's objectives, others such as Robert E. Lee initially believed the South had to carry the war to the North and defeat the Federal armies on their own ground. After the defeat at Gettysburg in July 1863, the South didn't have the resources for an offensive strategy, and with no sign of foreign intervention, it went on the defensive.

To achieve its political objective, the North had to conquer the South. It had to invade, capture and control vital areas and cities. It had three major military aims. The first was to isolate the South. The second was to cut the South into two parts, East and West of the Mississippi. The third was to capture Richmond, the South's capital. In spite of the South's long coastline, the first aim was largely achieved by 1863. The second aim was achieved in July 1863 when Ulysses S. Grant captured Vicksburg after a long siege, cutting the Eastern part of the South off from supplies in the West.

After the failure of the attack on Petersburg and Richmond in June 1864, the North changed its aim to striking at the Confederate Army and the remaining sources of supply. Sherman's army of over 100,000 marched south into Georgia. In spite of occasional defeats, such as at Kennesaw Mountain, it was far too strong for its Confederate opponents. Atlanta was captured on September 1, 1864. The resulting March to the Sea in November and December 1864, followed by the March up through the Carolinas, cut Lee's army in Virginia off from supplies in the South. Lee surrendered at Appomattox Court House in Virginia on April 9, 1865.

In many ways the American Civil War was the first modern war. About 2.5 million men served in the two armies. The casualties were horrific. About a quarter of the participants died. And a quarter were wounded. There were over 25,000 casualties at Antietam on September 17, 1862. At Gettysburg there were nearly 50,000 casualties on July 1–3, 1863.

19.4 France

The battle of Crécy in 1346 is remembered as the end of the medieval age of chivalry and the introduction of the English longbow. At Crécy, the English under Edward III took up position with some 4,000 men-at-arms in the centre and 5,000

longbowmen on the wings. Between them was a sloping valley. The French force under Philip VI was twice the size of the English army. As it advanced up the valley, heavily armed French knights mounted on their war-horses were cut down by concentrated long-distance arrowfire from both sides.

Six centuries later, the experience of the First World War with its static trench warfare in Northern France and its huge losses seemed to show the superiority of the defensive over the offensive. By the end of the war, a superiority of at least three to one was believed necessary for a successful offensive. After the war, a strategy based on defence underlay France's construction of the Maginot line of fortifications between France and Germany. This system of massive self-contained forts ran from near the Franco-Swiss border in the south to Montmédy, south of the Ardennes and the Franco-Belgian border in the north. The French considered the Ardennes impassable to tanks, so not a potential invasion route.

While the French drew the conclusion of the superiority of the defensive from their experience in the First World War, the Germans developed the blitzkrieg, a dynamic war based on the speed of aircraft and tanks. The strategy developed by Guderian was for tanks, concentrated in armoured divisions, to create gaps in the enemy front lines, sweep past, loop round, and create an isolated pocket in which enemy troops would be surrounded and captured by motorised infantry. The ground attack would be supported by dive bombers attacking supply and communication lines.

In 1939, the German tanks were concentrated in 6 armoured divisions, whereas the French tanks were distributed throughout various infantry and cavalry units. In 1939, France's 800,000 standing army was thought to be the most powerful in Europe. The Allied forces were superior to the German forces in terms of numbers and industrial backing. However, their generals had once again prepared to fight the previous war. Germany attacked Holland, Belgium, Luxembourg and France on May 10, 1940. Most of the French army was assigned to defending the Maginot line. The main German attacks into France were elsewhere, either through Belgium or through the Ardennes. By June 14, 1940 the Germans were in Paris, and on June 22, 1940 an armistice was signed. The Germans lost 50,000 men in achieving the surrender of about 2 million French soldiers.

19.5 The English Channel

From the early 1500's to the end of the Second World War, the military strategy of England was built on control of the seas. Providing the English navy controlled the seas, no foreign army could land in England, England didn't have to support a large army, and it was free to participate as it pleased in European politics and in developing a global empire. Its navy ensured necessary imports of food and other supplies, and could sever an enemy's access to the markets of the world.

Examples of the success of this strategy include the Spanish Armada of 1588, and the Battle of Britain in 1940.

In 1534, Henry VIII broke with the Pope and set up the (Protestant) Church of England. His Catholic daughter Mary, who reigned from 1553 to 1558, was married to King Philip of Spain. After her death, Henry's Protestant daughter Elizabeth reigned from 1558 to 1603. Due to the weakness of France at this time and the wealth taken from the New World, Spain was the strongest power in Europe. For various reasons (such as Elizabeth's support of Protestants in the Netherlands, England's refusal to recognise the monopoly of Spanish trade, and the desire to wipe out heresy), in 1588 King Philip of Spain sent his army and navy in the Spanish Armada to attack England. The Spanish navy was expected to gain and hold supremacy in the English Channel long enough for the Duke of Parma's army stationed at Dunkirk to cross the Channel to England. However, the technologically and numerically superior English fleet defeated the Spanish Navy in the English Channel, making the invasion impossible.

In June 1940, after the fall of France, and the evacuation of some 300,000 troops from Dunkirk, Britain stood alone against Hitler's Germany. Its army was vastly inferior to the German army. To conquer Britain, the German army had only to cross the 22 miles of English Channel between France and England. However, Britain's navy was much stronger than the German navy. On August 2, 1940, the Luftwaffe chief Göring issued the Eagle Day directive with the plan of attack to destroy British air power and gain air supremacy over the Channel, and open the way for the invasion fleet of Operation Sea Lion. Germany's strategy was to render Britain's airfields and support installations unusable so that British planes couldn't fly and the German invasion fleet would be able to cross the Channel escorted by the German air force. Germany's air force was much stronger than Britain's. Initially, the British had some 600 fighters, Germany about 1300 bombers and 1200 fighters.

During the summer of 1940, German planes attacked Britain's airfields until they were nearly useless and there were few British planes and pilots left. At the beginning of September, the British retaliated by bombing Berlin. As a result, Hitler ordered the Luftwaffe to switch its attacks from airfields to London and other cities. This change of strategy allowed Britain to repair its airfields, produce more planes and train more pilots. Although the British lost 900 planes in the Battle of Britain, Germany lost 1700, and by the end of September 1940, the British were shooting German bombers down faster than they could be replaced, with the result that the invasion plan was abandoned.

19.6 Russia

Germany's overall objectives at the beginning of the Second World War were German domination of Europe, a continental empire embracing all Europe including the European part of the Soviet Union, and equal rank for Germany with Britain, Japan and the USA.

A non-aggression pact was signed between Germany and the Soviet Union in 1939. This was seen as a matter of expediency by Germany which expected to fight a war with the Soviet Union in 1943. However the events of 1939 to 1941 led Germany to attack the Soviet Union much sooner. Operation Barbarossa began on June 22, 1941. By June 27, 1941, Guderian's tanks had advanced the 200 miles to Minsk and 300,000 prisoners had been taken. By July 16, they had advanced another 200 miles and were at Smolensk, taking another 200,000 prisoners. At this point, they were 200 miles from Moscow. They had plenty of time to make decisive gains before the start of the Russian winter.

However, Hitler and the German High Command then disagreed on strategy. The High Command wanted to continue the attack (in a north-east direction) for Moscow on the assumption that the main Soviet armies would be brought to the defence of Moscow, and defeated there. Hitler wanted to attack Leningrad (which was to the north-west) and Stalingrad (which was to the south-east) on the assumption that the destruction of these cities named after such important Communist leaders would be the end of Bolshevism.

The resulting arguments led to time being wasted, a division of forces, and attacks in all three directions. It wasn't until October that the main attack on Moscow was renewed, and not until December that the German Army reached Moscow. By then, the Russian winter had started, the Soviet commanders had prepared their first major counteroffensive, and the German Army was forced to retreat, having failed to achieve any of its objectives.

The following year, 1942, saw a limited German offensive in the South of the Soviet Union. It began on June 28 with Rostov, the first major objective, being captured on July 23. Hitler then divided his forces, with one army under Kleist aimed at the oil fields of Caucasia, and the other under Paulus aimed at Stalingrad. The double objective and the resulting division of resources were to lead to defeat. The available manpower and fuel resources were insufficient to achieve both objectives.

19.7 The Pacific Ocean

In the early part of the twentieth century, Japan's objective was predominance in Asia. It was militarily successful in wars with Russia, Korea and China. However, by the 1930's, it hadn't achieved its objective. Soviet Russia was getting stronger. And half of the Japanese army was tied down by growing Chinese resistance. US influence in Asia was growing. The colonial powers of Britain and the Netherlands still controlled huge areas of Asia.

The war in Europe offered Japan a chance to achieve its objectives. In September 1940, it joined with Germany and Italy in the Tripartite Pact, hoping to neutralise its conflicts with the Soviet Union (which had a non-aggression pact with Germany), paralyse US influence, and exploit the colonies of the European powers. During the next year its opponents (the Allies) increased diplomatic and trade pressure with the result that war became increasingly likely.

Japan's military strategy was based on control of the seas. Provided it could control the Western part of the Pacific Ocean it could achieve its objective of predominance. The Eastern part of the Pacific Ocean is almost devoid of islands (hence air and sea bases) so any attack on Japan from that direction would be difficult.

In 1941, the Allies had about 300,000 troops in Asia. They were widely dispersed, had little combat experience, and were supported by obsolete planes. The Japanese army alone was over 1,000,000 strong. It was well-equipped and had been battle-hardened in China. The Japanese expected it to achieve victory quickly. Then a defensive ring would be built, from Burma in the west to the Gilbert Islands in the east, to keep out the British and Americans.

The Japanese attacked Pearl Harbor on December 7, 1941. The US fleet there was destroyed. By June of 1942, Japan controlled most of the Western Pacific. Its control extended from the Aleutian Islands in the North, down past the Kuril Islands, parts of China, Korea, Indochina, Siam, Burma, Malaya, the Dutch East Indies, Borneo and New Guinea to the Solomon Islands. Its control of the surrounding seas allowed it to move troops and resources from one country to another. This made it difficult for an enemy to bring together the forces that could start to take back the conquered territory. And made it almost impossible to attack Japan by air.

To defeat Japan, the US developed a strategy to first destroy Japanese naval supremacy in the Western Pacific and then make use of US air power. This strategy took the strategy of "control of the seas" one step further to include control of the air over the sea. On June 4, 1942 a Japanese force led by four aircraft carriers attacked Midway, one of the few islands in the Pacific it didn't control. The US Navy, having broken the Japanese Navy's code, was waiting for them and Japan lost all four aircraft carriers. Midway was saved from invasion, and from then on, the Japanese were on the defensive and the initiative passed to the USA. American forces moved across the Pacific to Japan in a series of battles (Gilbert Islands, ..., Saipan, ..., Iwo Jima, ..., Okinawa) following the same outline strategy. The battles took place within range of existing American air bases and were in places suitable for runways and anchorages. The attack would begin with a heavy air attack to destroy the defending Japanese air forces. Then a heavy air attack would bombard Japanese troops. US aircraft carriers would prevent Japanese reinforcements. Landing craft would bring US troops ashore. After fierce fighting they would take control. Engineers would land to build runways and port facilities. The next attack would be prepared.

19.8 Lessons Learned

Lessons can be learned from the above examples of the application of different military strategies, and related success and failure factors (Fig. 19.2). They are a useful input when developing strategies for PLM.

19.8.1 History Repeats Itself

In the brief descriptions of military strategy given above, there is a certain amount of repetition. In completely different eras and geographical locations, countries have had similar objectives and strategies. For example, both England and Japan had strategies based on "control of the seas". Both Germany and the USA had strategies based on "control of the air".

19.8.2 Over Time, Strategies Change

As the environment and the resources change, strategies change. A strategy that may succeed at one time, and in one place, may be disastrous under other conditions. It is sometimes said that Generals prepare to fight the last war. This can be seen in France in the First World War where the French generals' desire to attack stemmed from Napoleon's strategies. But the conditions created by the development of machine guns and artillery meant that a defensive strategy was appropriate. By the time of the Second World War, the value of defence had been understood and the Maginot line created. However, the resources available had changed again, and a strategy based on defence led to a French defeat a few weeks after the start of the German offensive.

It can also be seen how the Prussian and German strategists ranged from defensive to offensive strategies through the nineteenth century in response to the changing environment.

19.8.3 Offensive or Defensive Strategy

A strategy can be offensive or defensive. In most cases it seems that an offensive strategy is necessary. There are occasions, though, such as in the First World War, where a defensive strategy based on blockade, and sapping the strength of the enemy, is successful.

19.8.4 Small Range of Simple Strategies

Potential strategies are shown in Fig. 19.3. There are strategies of control, and there are others ranging from offence to defence.

Fig. 19.2 Lessons learned

history repeats itself
over time, strategies change
a strategy can be offensive or defensive
a small range of simple strategies
the choice of strategy depends on the objectives
there's a hierarchy of strategies
it's dangerous to change strategy during implementation

These strategies all appear simplistic and are described in a few words. This is because strategies have to be simple. Otherwise, few people will be able to understand them. And even fewer will be able to implement them.

19.8.5 Strategy Depends on Objectives

The choice of strategy depends on the objectives. There's always a choice of possible strategies. No strategy is going to be right under all conditions. The only way to judge whether a strategy is right or wrong, is whether or not it results in the objectives being met.

19.8.6 Hierarchy of Strategies

Countries have a hierarchy of strategies. A country will have a strategy for a particular battle. There will also be a strategy for a series of battles, such as those of the USA in the Pacific after Midway. At the same time, the USA was also fighting in Europe so had a strategy there. The strategies in Europe and in the Pacific fitted into an overall strategy.

19.8.7 Danger of Change During Implementation

It's dangerous to change strategy during implementation. Once the decision has been taken to select a particular strategy, it's dangerous to organise or use resources differently. Lee's attack at Gettysburg didn't correspond to the South's strategy of defence, and led to the South's defeat. The hesitation of the German Army in front of Moscow led to the eventual attack taking place in much worse conditions in the Russian winter of 1942. It also gave the Soviet Union the time to regroup its forces.

Fig. 19.3 A small range of
simple strategies

control of the seas
control of the air
control of a land region
attack in overwhelming strength
attack with overwhelming speed
destroy the enemy's will to fight
divide the enemy's resources
cut the enemy's communication lines
cut the enemy's supply lines
siege
blockade
impregnable defence

19.9 Principles of Military Strategy

Military strategy has been studied for thousands of years to understand the "rules" for successful war. Commanders and military observers have tried to identify strategic constants. These are principles of strategy that remain valid despite technological and environmental change. One of the earliest attempts was Sun-tzu's 13 principles of strategy written down in "*The Art of War*" about 400 BC. Sun-tzu stressed the importance of taking account of political considerations. Many of his ideas were used more than 2,000 years later by the Chinese communist armies.

By the 1980's, the Soviet, UK, and US military were more or less agreed on the 11 principles of military strategy shown in Fig. 19.4.

19.10 Manufacturing Strategy

The history of war goes back thousands of years, providing many examples of strategy. Another area where examples of strategy are numerous is in manufacturing operations. Like armies, manufacturing organisations need a strategy to meet their objectives, and to manage and use their resources. The latter include people, machines, methods, materials and money.

For thousands of years, progress in increasing manufacturing productivity was slow. However, a few hundred years ago, mechanisation made possible a leap forward. The machines introduced in the Industrial Revolution led to an organisation of work that differed from the previous approach. Adam Smith in *The Wealth of Nations* (1776) described the new system in a pin factory, "One man draws out the wire; another straights it; a third cuts it; a fourth points it; a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on is a peculiar business; to whiten the pin is another;

objective	keep the basic objective uppermost in mind. Don't be distracted by less important matters
offensive	a defensive strategy is sometimes appropriate, but in the long run, victory can only be achieved with an offensive strategy
unity of command/co-operation	modern warfare brings together different types of forces (army, navy, air force). To succeed, they have to work together under a unified command
concentration of force/effort	in battle, concentrate forces and aim them against an enemy weak point
economy of force/effort	use minimum force to achieve an objective. Any additional force is wasted
manoeuvre/flexibility	the strategy shouldn't be rigid. It should allow different options to be followed depending on the evolution of events
surprise	aim to outwit the enemy, striking when and where least expected
security	take action to prevent the enemy achieving surprise
simplicity	complex strategies aren't well-understood, don't get properly implemented, and lead to defeat
maintenance of morale	one's own forces may be defeated if their morale, or the morale of their civilians, is low
administration	a successful result in battle or in war requires enormous administrative and logistic support

Fig. 19.4 The 11 principles of military strategy

it is even a trade by itself to put them into the paper; and the important business of making a pin is in this measure divided into about 18 distinct operations".

Workers were assigned to a particular position at which they carried out a specific task. The owner supervised the workers making sure they worked at the pace of the machines. This led to a division of labour between the owner and the workers. The owner couldn't watch over all the workers all the time, so a hierarchy of supervisors and managers was developed.

In the nineteenth century, machine tools changed the environment again. They enabled strategies of mass production with the characteristics shown in Fig. 19.5. In mass production, tasks can be performed by unskilled workers, often immigrants or agricultural workers leaving the land, since much of the skill is in the machine and the organisation. Manufacturing enterprises grew to such a size that a large hierarchy of supervisors and managers became necessary. The increasing size and complexity of operations called for a large management staff including accountants, engineers and personnel managers.

The next step, introduced to manufacturing by Henry Ford, was the assembly line. Its concepts had been developed in the meat-packing industry in Cincinnati and Chicago, where overhead trolleys moved carcasses from one stationary worker to another. Each worker did one task, at a pace dictated by the line, minimising unnecessary movement and increasing productivity. Ford applied these methods to the manufacture of cars, reducing the price of cars, bringing it within reach of more people. According to Ford, the assembly line was based on the planned and continuous progression of a commodity through the shop, the delivery of work to a worker (instead of leaving it to the worker to find it) and an analysis of operations into their constituent parts.

Frederick Taylor brought a scientific approach to these principles. A new discipline, industrial engineering, appeared. Taylor broke each job down into its constituent parts, analysed them to find out which were essential, and timed the workers with a stopwatch. With superfluous motion eliminated, the worker, following a machine-like routine, became much more productive.

However, in the years after the introduction of scientific management, its disadvantages, due primarily to neglecting the human element, began to appear. Elton Mayo, a social scientist, carried out experiments at the Hawthorne plant of the Western Electric Company in Cicero, IL to see how changes in lighting affected productivity. He found that productivity rose even when lighting conditions didn't

high volumes
mechanisation
organised material flow through various stages of manufacturing
sub-division of labour
low skill level of workers
managerial staff with specialised skills
simplification and standardisation of common parts to allow long production runs of parts that can be fitted to other parts without time-consuming adjustment

Fig. 19.5 Characteristics of mass production

change. Just by involving the workers, a new attitude was created. This result led to strategies of worker involvement.

Mass production increased the trend to an international division of labour. Factories often needed raw materials from other countries. Saturation of national markets led to a search for customers overseas. Some countries became exporters of raw materials and importers of finished goods, while others did the opposite.

The introduction of computers in Manufacturing in the mid-twentieth century led to strategies of Shop Floor Automation (NC machines, CNC machines, robots, and Flexible Manufacturing Systems). It also led to the introduction of MRP and ERP systems for planning and control of manufacturing and logistics.

In the 1960s and 1970s, Total Quality and Just in Time (JIT) strategies were introduced to cut out waste in Manufacturing. Stocks were reduced, and non-value-adding activities eliminated. Assembly lines were simplified by focusing on a particular product line. Later in the twentieth century, these ideas were extended, and Lean Manufacturing strategies were developed.

The skills needed by assembly-line workers are easily acquired. Standards of living in many developing countries exporting raw materials are so low that wages can be kept below those of already industrialised countries. As a result, developing countries can adopt strategies of industrialisation and export of manufacturing goods. In response, manufacturers in developed countries outsource, getting parts made in low-cost countries. In the early 1990's, original equipment manufacturers (OEMs) in the electronics industry faced pressure to get products to market faster than their competitors. They took to outsourcing in a big way, with parts or whole products made or assembled in developing countries. This started with outsourcing of printed circuit board assembly to electronics manufacturing services (EMS) providers, and eventually led to an EMS industry which offers design, manufacturing and related services to the OEMs.

The logical ultimate in the evolution of strategies seems to be the re-configurable Lights-out Factory producing customised products in a batch size of one. This implies elimination of all manual labour and the introduction of flexible manufacturing and assembly machines with automatic controls providing accuracy and quality beyond human skill levels.

From the above, it can be seen that, as in the military environment, when resources and technologies change in the manufacturing environment, strategies also change.

19.11 Company Strategy

Both military and manufacturing strategies change in response to the changing environment of resources and technologies. The strategies that companies adopt are also subject to change. Two main strategies have been used by companies to meet their objectives. One of these is the low-cost, "cost leadership" strategy. The other is a high-value strategy based on differentiation.

A cost-leader aims for the lowest product cost in a particular industry. This usually requires a high market share and a high volume of standard products. It implies substantial capital for large continuous-flow production runs and facilities. By selling a low-cost product in large numbers, the costs of product development and manufacturing equipment are spread over a large number of products and become relatively insignificant. Usually it's the manufacturing cost that's most important, so this type of company focuses on reducing the cost of manufacture. This implies strong abilities in facility engineering, manufacturing engineering and purchasing.

High-value differentiation strategies are based on having a product or service that differs significantly (for example, by virtue of its design, or technology, or customer service) from those of competitors. Higher prices can be charged because of the uniqueness of the product and the few available alternatives. To make the product special usually requires skills in identifying customer needs, and in defining the product correctly.

Other strategies include "niche", "trend-leader" and "follower". A niche strategy serves a particular market segment, or particular type of customer, or particular geography, or particular part of a product range. Within a given niche, a company can hope to succeed with either a cost-leadership or a differentiation strategy.

A company with a trend-leader strategy will constantly innovate in an attempt to lead the market and be the first to produce a particular product or service, and gain the associated benefits. This type of leader is unlikely to be a cost-leader, due to the difficulty of getting products to market first. Instead, revenue is generated from sales to customers who are anxious to be "early adopters", and are willing to pay the additional costs this entails. This strategy requires good product development skills so that a market-leading product can be brought to market quickly.

A "follower" is a company that enters the market when the leader has moved on to the next generation of products, or when the leader can be attacked through cost or quality features. A follower could aim to be a cost-leader. The follower doesn't aim to sell to one of the few early adopters of the product (who often represent less than 10% of the market) but aims to sell to the main market (the other 90%). For a follower, it's less important to have skills to develop new products than to be able to understand and improve what has already been developed. This calls for skills in reverse engineering and in reducing product costs.

The above description of strategy may seem theoretical. In reality, the strategies of many companies don't fall nicely into one of the above categories. Many companies pick and mix, taking elements of different strategies to create their own strategy. Recent years have seen the introduction of new strategies such as "low-cost variety", "fast response time", "partnering", and "process-based" strategies (rather than product-based strategies) such as "capabilities-based competition" and Concurrent Engineering. The driving force behind many of these new strategies was Japanese companies using manufacturing excellence to gain competitive advantage. They put new concepts into production quickly, reduced

manufacturing times to the minimum, and continuously pumped out new and innovative products. Manufacturing and engineering were equals with marketing and finance in the eyes of top management, and considered essential in the process of developing strategy. The performance of Japanese companies showed that activities in the product lifecycle can provide a competitive advantage. For example, a company which is better at developing new products and services can use this advantage to gain market share. While competitors are busy developing the same abilities, the leading company introduces new products and features faster, and also develops new abilities. When a competitor reaches its targeted level of improved competence, the leader is ready with a newly developed advantage and the competitor is again behind. It spends money to build competence which doesn't provide the needed return on implementation, because the environment has changed.

Strategies such as "fast response time" have been introduced because, as a result of technological advances and changing customer behaviour, products have increasingly short lives. To make money on a short-life product it's important to bring it to market quickly and give it the longest life possible. This also means that product offerings will be fresher. And the latest technology can be included because less time passes between definition of the product and its arrival on the market. Less time in development means less labour and less cost. The company responds quicker to customers, gets more sales, and sets the pace of innovation. A company like this is going to need a strategy that allows it to develop new products quickly, and get them into production quickly, to change production volume quickly as demand builds up, and to switch to production of other products when demand drops.

"Partnering" is often driven by the need for innovation and the limited resources available for developing new products. Partnerships between companies allow greater value and features to be offered to customers, while allowing each partner to concentrate efforts on things it does well.

A "capability" is a clearly-identified and well-defined set of business processes. Capability-based companies achieve competitive success by making their key business processes (the ones that make them leaders) as effective as possible.

"Process-based" strategies are based on the belief that "we know how to do things well". It's not the particular product that counts, but the successful way it can be got to customers. This type of company needs to have a good understanding of its processes, and the ability to adjust them to handle different products.

According to the Bible, "What has been will be again, what has been done will be done again; there is nothing new under the sun." This can be applied to strategy development. Company strategies bear similarities to military strategies. New business strategies draw on elements of old business strategies. The Napoleonic strategy of focusing resources and attacking on a weak point in the enemy line can be compared to a "niche" strategy of a company, focusing resources on a particular part of the market. The military strategy of "Attack with overwhelming speed" corresponds to the "fast response time" business strategies. Strategies for PLM can be expected to share characteristics with military, company and manufacturing strategies.

19.12 Principles of Business Strategy

Just as there are "principles of war" that can help in the development of military strategy, there are "business principles" that can help in the development of business strategy. For example, Peters and Waterman identified common attributes of excellent companies in their 1988 book *In Search of Excellence* (Fig. 19.6).

Although the context is completely different, there are similarities between these attributes and the military principles. "A bias for action" can be compared to "offensive". "Stick to the knitting" can be compared to "concentration of force/effort".

Understanding strategies in other environments helps get an understanding of strategies for the activities of the product lifecycle. For example, how could Ford's assembly lines be translated from the production environment to the product development environment? How could Just In Time strategies be applied in the Imagination phase of the product lifecycle? How would the military principle of "unity of command" translate to the organisation of the activities of the product lifecycle? If Elton Mayo found that worker involvement increased productivity, what would be the effect of increasing customer involvement in the product lifecycle?

19.13 Importance of Strategy

Strategy may seem intangible and irrelevant for some people. And they may think that strategy development is unnecessary. If so, they should look at the effects of the strategies chosen by some military and business leaders.

The French strategy in the First World War led to the death of about 1.5 million French soldiers. Another 4 million suffered injury.

In the 1980's, Switzerland's Swissair was considered one of the world's leading airlines with an excellent reputation for quality service. Switzerland doesn't belong to the European Union, and Swissair feared it would be excluded from the European internal market. In the mid 1990's, it developed a strategy to ensure its place in Europe by buying stakes in several European airlines. These weren't such good performers. After the events of September 11, 2001, airline passenger numbers and revenues dropped sharply. Swissair filed for bankruptcy with about $10 billion of debt. It had 70,000 employees.

Fig. 19.6 Common attributes of excellent companies

| a bias for action |
| close to the customer |
| autonomy and entrepreneurship |
| productivity through people |
| hands-on, value-driven |
| stick to the knitting |
| simple form, lean staff |
| simultaneous loose-tight property |

19.14 Principles of Strategy

19.14.1 Principles of Military Strategy

From study of the military environment, a set of military principles was developed (Fig. 19.7). These principles help in the definition of military strategies.

19.14.2 Company Principles

From study of the business environment, a set of attributes of excellent companies was developed (Fig. 19.8). They help in the definition of business strategies.

As Fig. 19.9 shows, although the principles address the different domains of war and business, there are several similarities.

Fig. 19.7 Principles of military strategy

Principles of Military Strategy
objective
offensive
unity of command/co-operation
concentration of force/effort
economy of force/effort
manoeuvre/flexibility
surprise
security
simplicity
maintenance of morale
administration

Fig. 19.8 Common attributes of excellent companies

Company Principles
a bias for action
close to the customer
autonomy and entrepreneurship
productivity through people
hands-on, value-driven
stick to the knitting
simple form, lean staff
simultaneous loose-tight property

Principles of Military Strategy	Company Principles
offensive	a bias for action
simplicity	simple form, lean staff
concentration of force/effort	stick to the knitting
manoeuvre/flexibility	simultaneous loose-tight property

Fig. 19.9 Similarities between the military and company environments

19.14.3 PLM Principles

From study of the product lifecycle environment, we developed a set of PLM principles that can be used to help in the development of PLM Strategies (Fig. 19.10).

Again, although the domain addressed is different, it can be seen that there are similarities between these principles and those applied in the military and company environments. For example, the PLM principle of "watch the surroundings" has a direct military parallel. The above principles of PLM Strategy will be addressed in more detail in the following chapters. Some will be described briefly below.

19.15 Implications of Principles

Some of the implications of "Focus on the product" are shown in Fig. 19.11.

Some of the implications of "Involve the Customer, listen to Product Feedback" are shown in Fig. 19.12.

Some of the implications of "Remember the planet and mankind" are shown in Fig. 19.13.

Fig. 19.10 Principles for PLM Strategy

Principles for PLM Strategy
focus on the Product
involve the Customer, listen to Product Feedback
remember the Planet and Mankind
simple slim-line organisation
highly-skilled people
use of modern technology
coherent PLM Vision, Strategy and Plan
continually increase sales and quality, reduce time cycles and costs
watch the surroundings
maintain security

Fig. 19.11 Implications of "focus on the product"

a Chief Product Officer (CPO) with unity of command over the product
five-year Product Plan and Strategy
platform products and derivative products
part re-use
integrated Product Portfolio

Fig. 19.12 Implications of "involve the customer, listen to product feedback"

get Product Feedback
listen to the Voice of the Product
involve the customer in product development
listen to the Voice of the Customer
use technologies such as RFID

Some of the implications of "simple slim-line organisation" are shown in Fig. 19.14.

Some of the implications of "highly-skilled people" are shown in Fig. 19.15.

Some of the implications of "watch the surroundings" are shown in Fig. 19.16.

Some of the implications of "maintain security" are shown in Fig. 19.17.

investigate opportunities of sustainable development
investigate opportunities resulting from environmental requirements
investigate opportunities resulting from ageing populations in industrially developed countries
investigate opportunities resulting from large populations in developing countries

Fig. 19.13 Implications of "remember the planet and mankind"

Fig. 19.14 Implications of "simple slim-line organisation"

simple organisational structure
simple, clearly defined processes across the product lifecycle
product-focused organisation
Product Lifecycle Owner
simple product lifecycle methodology
cross-functional teamwork

Fig. 19.15 Implications of "highly-skilled people"

hiring good people
training
multi-cultural workforce
need for generalists and specialists
need for soft skills and hard skills
career paths
skills matrix

watch the surroundings, that's where the customers are
watch the surroundings, that's where the competitors are
watch the surroundings, that's where most new trends and new technology are found
watch the surroundings, that's where the danger is lurking

Fig. 19.16 Implications of "watch the surroundings"

Maintain security in bars and trains. Potential customers may be close by, and overhear the details of how you hope to fix the problems with that product they were going to buy
Maintain security in restaurants and planes. Competitors may be close by, and learn of your new products and pricing strategies.
Maintain security in chat-rooms and e-mails. You don't know who may be reading what you write
Maintain security in buildings. Your competitors may be eavesdropping from outside
Maintain security when travelling. Your flight may be delayed and your luggage searched
Maintain security in Information Systems. Competitors and other organisations may attack with viruses, worms, hacking and spying programs

Fig. 19.17 Implications of "maintain security"

19.16 Coherent PLM Vision, Strategy and Plan

The PLM Vision provides a Big Picture of the future environment, and the expected performance and behaviour. It provides a picture to guide people in the choices they have to make during strategy-setting and planning of resources, priorities, capabilities, budgets, and the scope of activities.

The future PLM Strategy defines how resources will be organised to achieve the objectives. It defines policies for the management and use of these resources.

Once the PLM Vision and the PLM Strategy are defined, it will be possible to develop an Implementation Strategy to achieve them. And the planning of detailed implementation activities can start.

PLM plans address all the components of PLM such as product data, equipment, human resources, applications and processes. Individual projects are identified and planned. Their objectives, action steps, timing and financial requirements are defined. The relative priorities of projects are understood. When planning is complete, implementation can take place.

The end result of the chain from business mission and objectives through PLM Vision, strategy, plan and implementation is that the PLM organisation behaves in such a way that the company meets its objectives.

19.17 Continually Improve

Some of the implications of "continually increase sales and quality, reduce time cycles and costs" are shown in Fig. 19.18.

A company should proactively aim to increase sales. The opposite approach is to set out to reduce sales. This is likely to send the wrong signals to employees and customers. Without the pressure to improve, employees will spend more time on internal politics, angling for promotion and more office space. Customers will assume the company is on the way out of the market, and can't be relied upon for long-term service. If a company can't see opportunities in its existing markets, it must enter new markets with innovative products and services. These should make extensive re-use of existing parts and information.

A company should aim to increase product and service quality. The concepts of TQM should apply both at the level of the whole company and at the level of the product lifecycle. The company must have a culture, attitude and organisation that allows it to provide, and continue to provide, its customers with products and services that satisfy their needs. The culture requires quality in all aspects of

Fig. 19.18 Implications of "continually increase sales and quality, reduce time cycles and costs"

increase product sales
increase sales of services
increase product quality
increase service quality
reduce time cycles throughout the product lifecycle
reduce costs throughout the product lifecycle

operations, with things being done right the first time, and defects and waste eradicated.

A company should have a bias for cycle time reduction. Cycle time has become a key competitive parameter. Reduced lead times open up new market opportunities and improve profits. They reduce market risk by reducing the time between product specification and product delivery. The sooner that customers use a product, the sooner their feedback can be incorporated in a new, improved version. Getting a product to market early will mean that more people will buy it during the early stages of its life. This is because there will be less competition. Slower competitors won't have got their products to market.

Short cycles provide an opportunity to gather a bigger share of the market by being first. In addition to a higher market share, early introduction of a product means a company can ask a higher price. This is possible both because it will be seen as a new and better product, and because there will be less competition from lower-cost products. So, by getting to the market before competitors, a company can have its products on the market longer, and increase its market share, revenues and profitability.

Early introduction also means the company will get the best customers, the ones who will pay more to get the product early. Not only will they pay more, but this kind of customer will also be back for more, or other, products.

Another reason for reducing cycle time is that, in fast-changing technological and consumer environments, sales revenues get eroded because products become obsolete sooner. The reduced time between product launch and product retirement erodes sales revenues. Since this phenomenon of earlier product retirement depends on factors beyond a company's control, the only way a company can lengthen a product's life is to get it to market earlier.

Cycle time reduction leads to faster increase of development experience. Because development cycles are shorter, there will be more of them. So a company will go up the experience curve faster. Which means it can make its products even better and faster.

Another advantage of a short development process is that, as well as finishing development earlier, it will also be possible to start development later. And, starting development later than competitors, means the customer's requirements should be understood better and should be less likely to change. So the faster developer will face less risk.

And, by starting later, it's possible to exploit the latest advances, most recent technologies, and newest styles and fashions. Bringing products to market quickly means that less time passes between definition of the product and its entry to the market. So product offerings will be fresher and the latest technology can be included.

Short cycles are ideal for companies wanting to offer customised products. Because the development process is clean and short, it will be easier and cheaper to adjust to special orders, so they can be fulfilled within the required time and budget. The company will be seen as a leader in innovation, and customers will want to buy from it again and again.

Over time, the advantages that result from reducing cycle time will build up. During the time that the competitors of a fast developer are busy trying to develop the same abilities, the fast developer will introduce new products and features, and will also develop new abilities. When a competitor reaches the level of competence it thought it needed to compete effectively, the fast developer will be ready with a newly developed advantage and the competitor will be behind again.

A company should have a bias for cost reduction. With average manufacturing wages in the United States many times greater than those in China, it can be expected that product costs will continue to drop, and that product development, manufacturing and support costs will continue to drop.

As well as being quicker, a shorter development process also costs less. Many companies find that if they reduce development cycle time by 40%, development cost is reduced by 10%. Doing things quicker (provided they are being done right) means less effort is needed.