
Chapter 4 - Aviation Industry

4.1 Development of maintenance programs

It is necessary to develop a maintenance program for each new type of aircraft prior to its introduction into airline service. For this reason documentation exist, the purpose of which is to assist in the development of a proposal on the scheduled maintenance program for each new type of aircraft and/or power plant¹⁶. The intent of the program is to maintain the equipment. This program becomes the barrier to govern its maintenance policy. Some of the aspects addressed in a document of this nature are¹⁶:

- Objective of an efficient maintenance program
- The content of an efficient maintenance program
- The method by which an efficient maintenance program can be developed

The objectives of the maintenance program should be¹⁶:

- To ensure the realisation of the inherent safety and reliability levels of equipment.
- To restore safety and reliability to their inherent levels when deterioration has occurred.
- To obtain the information necessary for design improvements of those items whose inherent reliability proves inadequate.
- To accomplish these goals at a minimum total cost, including maintenance cost and the cost of resulting failures

The content of the maintenance program consists of two main tasks¹⁶:

1. A group of scheduled tasks to be accomplished at specific intervals. The objective is to prevent the deterioration of the inherent safety and reliability of equipment. These tasks include:
 - Lubrication

- Visual Checks
- Functional Checks
- Restoration

2. A group of non-scheduled tasks which result from:

- Scheduled tasks accomplished at specific intervals
- Reports of malfunction
- Data analysis

The objective of these tasks is to restore the equipment to an acceptable condition. An efficient program is one that only schedules those tasks that will contribute to increase the reliability of the equipment.

The maintenance program document further suggests a method for developing a maintenance program. These programs are developed via a guided logic approach and will result in a task-orientated program.

From this, maintenance can be divided into two major departments. The first is often called the 'Engineering department' and the second the 'Maintenance department'.

The 'Engineering department, or the 'thinkers' will traditionally be responsible for the development of, and improvements in the maintenance systems as well as improvements in components which will increase the reliability of the equipment. In the aviation industry the latter is greatly governed by the OEM's. Any major changes to components will therefore have to be approved by OEM's before it can be implemented on aircraft.

The 'maintenance department' or 'doers' is typically responsible for monitoring the condition of equipment and the restoration of components to acceptable levels. This function is often referred to as the 'front line' of the maintenance function.

It is clear that these two department focus on different aspects in the maintenance function. For this reason the individual departments will utilise different technologies in order to become more effective. It is important to note that these two departments have the same goal and that is to ensure the effective implementation and management of the maintenance function. The communication between these two departments should therefore be very effective. A breakdown in communication may lead to a barrier in effective technology transfer. Because an engineering department very often operates on a higher level as the maintenance department, the difference in perception of how the maintenance function should be applied may also be a barrier and cause a breakdown in communication.

The scenario described in chapter 4.1 is faced by every airline. It is clear that maintenance play a major role in the aviation industry and that many diverse technologies can be employed, in order aid the maintenance function in becoming more effective. In the light of this the rest of this section will take a deeper look at maintenance.

4.2 Maintenance - Overview¹⁷

Organisations exist to make a profit and this is accomplished by converting resources into product/services. Many sub-functions play an important role in the conversion, for example functions like marketing, sales and also maintenance.

Only in the last decade has maintenance been regarded as an important mainstream function of an organisation. The cost of maintenance may vary between 0% and 50% of the total operating cost. As a result more and more emphasis is placed on this important function. The maintenance function therefore has a substantial impact on profit margins and in today's competitive environment, this necessitates greater awareness and control over this function. Therefore, the management of the maintenance function in every organisation should have the same priority as the management of any other



mainstream function. The cost of maintenance certainly warrants a representation at the highest level in the company.

The importance of managing maintenance is emphasised by its recent recognition as an accelerating discipline at university level.

The application of general management principles like, planning, organising, staffing, leading and controlling brings the following advantages to the function of maintenance:

- Maintenance provides a structure for the efficient teaching of maintenance management;
- It provides the means for designing maintenance management systems in a more rational manner;
- It allows the auditing of existing maintenance departments/systems in order to identify problem areas;
- It provides for a cost effective, efficient operation of the maintenance function.

The advantages mentioned in the previous paragraph are not that easily obtained because of the complexity of maintenance. Kelly¹⁸ states the following reasons for this complexity:

- Maintenance is one of many sub-systems of the organisation with complex relations with the other sub-systems.
- The focus is often secondary to the production or service functions.
- Maintenance is influenced by external factors like legislation and design specifications.

- The output of maintenance is difficult to define, as it is the relationship between inputs and outputs.

The average maintenance cost for S.A is estimated as approximately R 6800 million. It is ranked seventh after other major economic sectors i.e. manufacturing, finance/business services, general government, trade, mining and transport¹⁹.

4.2.1 Maintenance.

The objectives of maintenance are to maximise equipment availability in an operating condition, which will result in the desired output and quality. In order to fulfil the maintenance objectives, skills are needed to integrate people, policies, equipment and practices. It also needs adequate engineering and technological skills in order to provide the best maintenance, repair and overhaul of equipment. Maintenance can actually be a profit producing activity rather than merely an unpredictable, ungovernable function of business.

Many companies all over the world realise that they have to be 'world class' in order to stay internationally competitive. For an organisation to be world class, individual business units should also strive towards 'world class'. This is also true for maintenance, especially if maintenance is your core business. Campbell²⁰ introduced the concept of continuous improvement to achieve a World Class Maintenance Organisation. This concept is illustrated in Figure 4.1

At the first level a practical vision for maintenance must be created. Management of resources plays an important role on this level, where the critical move towards a culture of continuous improvement enjoys attention. At the second level, improvement is obtained through proper planning, the scheduling of maintenance tasks and the measuring of maintenance performance, as well as the use of information management systems. On the

third level the implementation of a suitable maintenance philosophy can increase the asset productivity dramatically. In many situations however total re-engineering of the entire maintenance function may be necessary, to achieve the required maintenance performance.

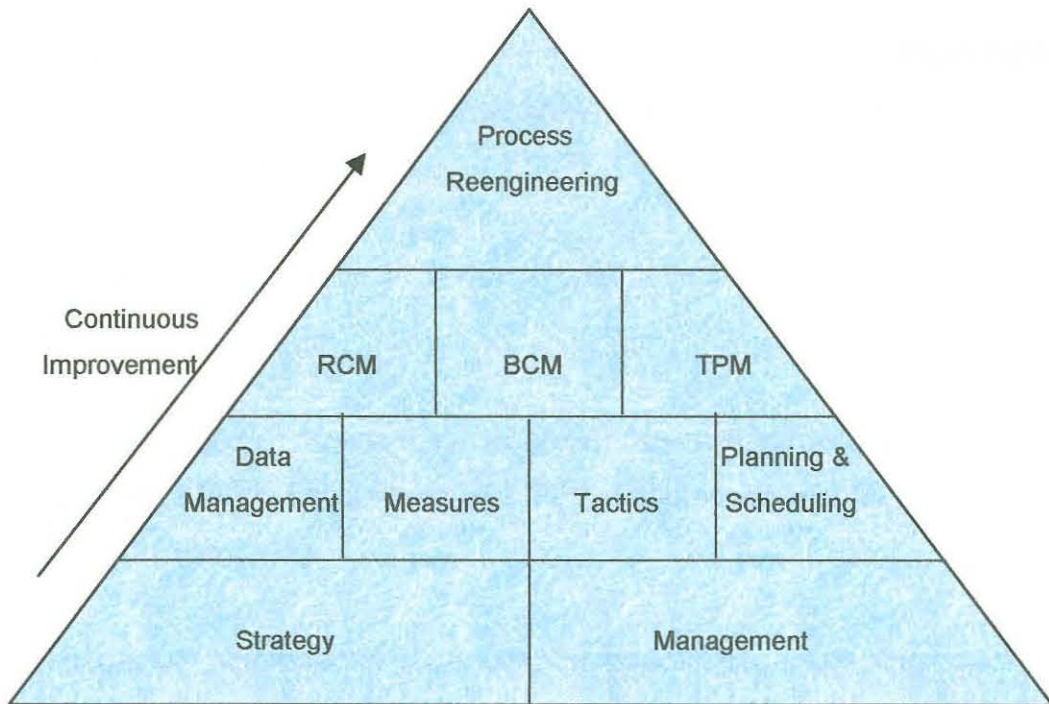


Figure 4.1 Toward World Class Maintenance
(Adapted from: Cambell²⁰)

4.2.2 Definitions¹⁷

- **Maintenance Management** – involves planning, organising and controlling of all resources/activities associated with the maintenance function. These activities include the repair, replacement, modification, adjustment and monitoring of a technical system in order to assure the availability and performance for a specific period.
- **Planned Maintenance** – is maintenance carried out with forethought, with the help of a predetermined schedule.



- **Unplanned Maintenance** – is maintenance carried out to no predetermined schedule.
- **Improvement Maintenance** – is maintenance carried out with the intent of improving equipment.
- **Preventive Maintenance** – is maintenance carried out at predetermined intervals or according to prescribed criteria and is intended to reduce the probability of failure.
- **Corrective Maintenance** – is maintenance that is carried out after equipment failure.
- **Condition based maintenance** – is preventive maintenance initiated as a result of knowledge about the state of the equipment because of routine or continuous monitoring.
- **Time based maintenance** – consists of periodically inspecting, cleaning and servicing equipment.
- **Emergency Maintenance** – is maintenance that must be carried out immediately in order to prevent failure and serious consequences.
- **Running Maintenance** – is maintenance, which can be carried out while the item is in operation (on line).
- **Shut down Maintenance** – is maintenance that can only be performed while the item is out of service (off line).

4.2.3 Five Main Functions of Maintenance Management¹⁷

1. *Maintenance Performance*

A system is created to provide some performance or to pursue a specific objective. A certain trade-off sought, is between making sure the system provides its performance, and the cost involved. One of the main functions involved in assuring that the desired performance is met, is maintenance. The maintenance function assures the availability and performance of the system. In order to do this at minimum cost proper management of the maintenance function is necessary. Therefore a close watch should be kept on the effectiveness of the maintenance function. In order to do this, performance indicators should be defined and the performance should be measured against the initial objectives, set for the maintenance function. These performance indicators include the following:

- Total equipment productivity
- Maintenance cost as percent of total sales
- Maintenance cost per unit of output
- Maintenance man-hours as percent of total man hours
- Downtime as percent of total time

2. *Maintenance Planning*

Maintenance planning involves three main activities namely:

- Defining appropriate objectives for maintenance
- Selecting strategies in order to attain objectives
- Defining detailed maintenance plan

3. *Maintenance Organisation*

The primary task of a Maintenance Organisation is to organise the

maintenance resources, which consists of people, money, facilities, technology, tools and information, around the maintenance tasks that have been identified by maintenance planning. It is important to note that this is not a static process and should be able to react to the dynamic nature of the enterprise. Activities in the organisation of maintenance include the following:

- Preparation of the maintenance workload.
- Resource scheduling, which includes:
 - Human Resources
 - Spare parts
 - Tools
 - Information
 - Facilities
 - Technology
 - Materials
- Work planning, scheduling, and control
- Administration of maintenance function

4. Maintenance Control

This is one of the main functions of maintenance management. The maintenance function's main aim is to properly direct all resources towards achieving the maintenance objectives. One of the aspects that have to be controlled is the cost of maintenance and therefore the budget of maintenance. Other aspects that need to be controlled are availability, reliability and the workforce.

5. Maintenance leadership

The final main function of management is leadership, the objective of which is to harmonise objectives of individuals and those of the organisation. This is one of the most difficult functions, for there are as many objectives as there are individuals. Management is dealing with the human factor and therefore

management need not only be skilled technically, but they also need excellent people skills. One of the main tasks of management in this regard, is motivating the workforce and keeping them motivated.

4.2.4 Maintenance Management Information Systems

Because of the increasingly competitive local and international markets, organisations are striving towards a more effective maintenance strategy and the reduction of the cost in this function. This can be achieved by control of the maintenance function. In order to control the function better, more relevant information is needed to analyse what is going on in the maintenance function. Manually this requires a tremendous effort. For this reason companies are buying, developing and using computerised Maintenance Management Information Systems (MMIS) to assist them in the planning and control of maintenance. The advantages of these systems are:

- Improved maintenance efficiency
- Reduced maintenance cost
- Reduced equipment downtime
- Provision of historical data for planning and budgeting purposes
- Provision of maintenance experts

A comprehensive MMIS will contain the following modules:

- Equipment module
- Inventory module
- Purchasing module
- Work order module
- Reporting module
- Preventative maintenance module
- Personnel module

It is clear that technology plays an important role in the maintenance function. Technological developments should be tracked in the field of maintenance and any relevant technologies that would help an organisation with their maintenance should be considered.

4.3 Aviation industry

The purpose of this section is to highlight trends in the aviation industry. The trends are divided into four main areas. These areas are as follows:

- Training
- Collaboration
- Maintenance
- Outsourcing

4.3.1 Training

Predictions are that the aerospace industry in South Africa will experience shortages in skilled personnel to service the industry over the next few years. According to Me C Larkin²¹, Aviation Training and Development Foundation executive manager, the factors responsible for this are closely linked to developments in the international aviation industry. During the past five years the volume of air traffic has increased dramatically and this trend is expected to continue. Fleet sizes have increased on the local domestic scene and more routes have been introduced, with more frequent flights offered. Larken believes that the demand for trained workers is not likely to diminish in the next twenty years.

Airbus and Boeing, the biggest suppliers of passenger aircraft in the world, forecast a tripling in world airline traffic by 2017 growing at a rate of 5% per year. According to their predictions cargo is expected to grow around 6% per year. The required increase in skills training has not yet materialised. This is due to the fact that training cost is high and employees would have to foot the bill. In an extremely competitive industry, this cost is not easily justified which

can only be described as a very short-sighted view. The demand can clearly be seen in markets in the USA. Regional airlines are experiencing shortages in pilots due to the increased volume of flights. These airlines have dropped their qualifying experience for pilots from 2000 flight hours to 800 and this is expected to drop to 600 hours. The reason for this is the shortages experienced and the fact that traditional sources of trained pilots like the airforce is drying up. Another factor is that airlines are slow to acknowledge the fact that there is an increasing demand for skilled personnel in the aviation industry. It is estimated that by 2006 the USA will need 155000 aerospace technicians, 13% more than the current 137000 employed in the industry.

In the light of this the South African aerospace industry must assure that these demands set by the increased volume of traffic, are met in order to stay internationally competitive. It is also of utmost importance that the levels of quality are maintained.

'Airlines in the USA are likely to face greater scrutiny of their programmes for training and managing mechanics, as the FAA responds to pressures to bolster maintenance operations.²²' These comments were made after several campaigns to convince the FAA officials and airline executives to improve training of mechanics and to ensure that technicians performing repairs for customers are up to standard. These sentiments echo even louder after aircraft malfunction and crashes.

Some carriers find that closer collaboration with mechanics can help in improving the status of training and eliminate errors in the performing of the maintenance function.

Boeing in setting its sights on maintenance training for new growths and revenues as the world fleet grows and increasingly complex aircraft enter service. Boeing's predictions are that the maintenance training business is to "explode" due to changing airline markets and advances in learning technology. World civil aviation authorities also are edging closer to requiring training for maintenance technicians, similar to the initial and recurring training

courses airline pilots now receive. Boeing's research reveals mechanics at third party repair centres average less than forty hours of training each year. They also revealed that airlines have been reluctant to invest in maintenance training due to the high turnover of employees and their more modest pay scales, compared to that of pilots.

One of Boeing's new strategies is the scheduling of a wide range of geographically convenient maintenance training classes world-wide. Boeing has the capacity to provide maintenance training for 70% of the world's active commercial transport fleet. This comes to almost 10 000 aircraft²³.

4.3.2 Collaboration

There are several examples in the South African aviation industry of collaboration between organisations. Commercial Airways (Comair), one of the domestic operators and British Airways (B.A) has recently partnered together in the form of a franchise. In terms of this agreement Comair will operate in B.A livery while retaining its own management and ownership. B.A on the other hand, will be able to market its brand in the South African market through Comair. There will certainly be transfer in functions like marketing, sales and transfer in service-related issues. Technically however, there will not be any transfer of technology.

Another role-player in the South African aviation industry, the South African Airways partnered with several international organisations like Lufthansa and Swiss-Air. Again several opportunities for transfer will exist in several functions such as maintenance. S.A.A. has already performed major maintenance on some of Lufthansa's fleet. This is an ideal opportunity to transfer technology and know-how to S.A.A.

4.3.3 Maintenance

The following are examples of how technology was or can be utilised by different companies in order to help them with their operations.

In 1993 the FAA investigated charges of improper practices in the Maintenance division of one of the US's largest carriers. This followed after senior managers, anxious to control the cost of maintenance, pressured maintenance supervisors and mechanics to cut corners in performing maintenance²⁴.

It is incidents like this that necessitate tight control on the industry. The problem lies in the depth of the control needed. Every aspect of the maintenance function needs to be recorded and controlled. This kind of data can instantly accumulate to 'heaps' of data. Controlling and processing these huge amounts of data into useful information, is the challenge set to all large airline operators. The only way of successfully meeting this challenge, is by employing modern technology.

Individual carriers are experimenting with various ways of boosting productivity for maintenance workers. Many of the suggested strategies give individual employees greater control over the responsibility for how their work is done. "We have to improve our cost if we are going to expect to survive"²⁵ Robert Lutzinger, General Manager for United Airlines said. For this reason they, together with the FAA are looking into the role human factors play, in the maintenance function. FAA and airline officials quickly discovered many areas of improving how mechanics work, particularly through better communication at every level in the industry. Communication formed some part of more recommendations than any other topic addressed. Communication was one of the biggest motivations for including mechanics in the design of Boeing's new 777.

The FAA researchers visited several maintenance facilities to assess the environment in which mechanics work. They found that by increasing light, productivity could also be increased. This is evident in one of the hangers they visited at Boston's Logan airport. They increased the light in the hanger to levels where it is now possible to work under the aircraft without flashlights. The lighting in the hanger was something the mechanics often complained about in this particular case, but the complaints fell on deaf ears. Productivity

rose after the upgrading of lighting, again emphasising the importance of communication.

Subsequent improvements have been made in improving the mechanics ability to do their jobs more efficiently and productively. The biggest assets airlines have, are these highly skilled workers, and sufficient effort should be made in order to protect this important asset.

4.3.4 Outsourcing

A major trend emerging in the civil aviation industry is outsourcing. A growing number of airlines view outsourcing maintenance, repair and overhaul as a way to reduce costs and increase the productivity of their assets. The world air traffic is poised to grow and as airlines expand their fleets, outsourcing will become commonplace. Although competition world-wide between maintenance providers remain stiff, companies specialising in maintenance repair and overhaul (MRO) are already benefiting from the upsurge in air travel. These companies will benefit further as hundreds of new aircraft enter service during the next few years. Start-up companies will lease older aircraft and outsource both engine and airframe work, to concentrate on their core business - transporting passengers²⁶.

Outsourcing is becoming a more and more important strategy in the ongoing restructuring of the global airline industry. In the outsourcing strategy only those activities that add value to an airline's business will be kept in-house and everything else will be shifted to contractors. A growing number of airlines view outsourcing as a way to increase productivity of their assets, reduce cost and reap the benefits from focussing on areas like business, market access and penetration.

Outsourcing can save carriers enormous amounts of money. Airlines, which spend billions of dollars retaining large amounts of spare parts, could slash those costs by transferring ownership to suppliers for inventory management. Airlines like KLM Royal Dutch Airlines has a goal of eventually owning no spare parts at all. Estimations are that the airline industry hold about \$20



billion worth of rotatable parts in stock and has another \$25 billion of non-rotatable inventory. Some airlines that make use of outsourcing - a trend that is believed to grow, is *Southwest Airlines*. They outsource maintenance of all landing gear components. Outsourcing is expected to grow in the next few years, mainly because of the financial advantages such as reduced labour cost and administrative expenses. Labour unions however will strongly oppose attempts to outsource maintenance because they will feel that work is being taken away from them and they will fear job losses.

Outsourcing presents an opportunity for many start-up airlines. These companies do not need the expertise of maintaining aircraft. They also don't need to fork out massive amounts of money in order to train these personnel. If they maintain their fleets themselves, their maintenance departments as a function, will have to compete against third party companies specialising in aspects of maintenance. Between 1990 and 1995 the U.S transport department received more than 180 applications from would-be airlines. Although not all were approved and many failed to actually begin operations, the demand for low fare carriers is evident. It is believed that outsourcing will aid start-up companies and a greater percentage of applications will actually start operation.

Airline executives increasingly view maintenance as a non-core function of their operations and they would rather want to focus their attention on their core business. B.A has split their maintenance function from their organisation²⁷. The business unit functions separately now and they offer clients (other than B.A) a total support programme which include complete maintenance services. One of the areas of maintenance that are experiencing major outsourcing is that of aircraft engines. Continental and B.A outsource all of their engine maintenance work. Continental expects a saving of around \$200 million each year. In addition to MRO companies, original equipment manufactures such as Pratt & Whitney, General Electric, and Rolls Royce, are becoming more aggressive in challenging airlines for

engine overhauls. OEM's have now become major competitors in the market of repairing aircraft engines.

I am of the opinion that we will see a shift in the focus of maintenance in airlines. They want to focus on their core business - transporting passengers and providing them with an excellent service. Therefore major scheduled maintenance will be increasingly outsourced in the future. Even unscheduled maintenance may be farmed out to third party companies. I think the only part of the maintenance function that will remain in-house is that of co-ordinating the 'maintenance' function from the airline's side.

As airlines strive to lower fleet maintenance cost, several strategic moves are considered. One of these moves is considering whether or not a third party should be made responsible for maintaining a fleet. British Airways (B.A) for instance has set its maintenance and engineering unit apart with the expectation that the unit can generate profits for the carrier through third party contracts²⁷. At the same time B.A has put the unit at notice that it will consult with third parties for maintenance work if prices for services were not competitive. This move has paid off for B.A's maintenance unit, as it now maintains aircraft for more than 100 airlines. This is a world-wide trend to separate airline's maintenance divisions from the airline and manage it as a separate business function. The following factors should however be considered before separating business units and considering vendors.

- Will the carrier avoid a major capital investment in tooling and training, or will it waste assets in which it has already invested in.
- Can people and equipment, freed up when work is farmed out, be sensibly re-deployed in order to speed up other maintenance functions.
- Will the use of outside vendors provide enough savings to offset the cost of terminating workers whose jobs are eliminated by the move?



- Can the vendor respond to sudden increases in demand for its services, such as compliance's with service bulletins and airworthiness directives?
- Reliability and certification of the vendor.

If we view the situation from a different perspective, airlines will farm out maintenance services to vendors who will give them the best service at the lowest cost. As airlines move their maintenance units to operate separate from them they will also have the options to look at other vendors for services that are better and cheaper than their 'own'. It is a case of sticking with your core business. If there is some aspect in the maintenance function that you are good at, concentrate on it and strive to develop this aspect to become world class. Therefore vendors will exist that specialise in certain aspects of maintenance and your 'own' vendor will specialise in something else.

The Emirates group has recently joined in the world-wide trend of third party maintenance. They have opened a state-of-the-art facility at the Dubai International airport. They are currently performing line maintenance for 26 airlines operating from the Dubai International Airport. The new facility gives the maintenance base capacity well beyond its own needs and therefore they will have the capacity to perform third party work²⁸.

4.4 Industry developments

Section 4.4 introduces recent developments in products and/or services in the aviation industry. The aim of this section is to identify some of the diverse technologies that can be applied in the aviation industry.

Delta Airlines are tapping into new technology to bolster their finance. They are looking at new information-technology applications to help cut their operating costs. These efforts saw the birth of their new Operations Control Centre. This centre is now the home of Delta's flight control, maintenance

and equipment control, radio crew routing and meteorology units. Representatives of these units work with colloquies from flight operations, in flight services, airport customer services, reservations and marketing. The 'bridge' as it is also known, manage more than 100 000 'irregular' operations - like flights delayed by either, unscheduled maintenance or any other problem. Delta's officials estimate the centre's greater control capabilities will cut the cost of managing operations by \$45 million a year²⁹.

Three separate projects enable the centre to manage the maintenance function electronically. The first project called the Maintenance Information Retrieval System (MIRS) is an effort to integrate reliability, regulatory - compliance and cost data in a single system that tracks, monitors and schedules maintenance. Implementation required every component on each of Delta's more than 540 aircraft to be entered into the control and tracking system.

The second project involves line maintenance. This system is intended to track the condition of each of Delta's Aircraft and monitor its routing. This would alert maintenance managers, for instance, that they should alter the routing of an aircraft with an identified problem so that maintenance can be performed at a station that is equipped to do so.

The third project involves converting all of Delta's technical manuals to digital format. Delta may eventually market the maintenance aids generated by these projects to outside customers.

Japan Airlines, (JAL) is developing an automated computer-linked maintenance system to speed up aircraft turn around times during maintenance. The automation of the inspection and cleaning procedures allows JAL to recover and repair more parts in a shorter time. The labour saving potential of robots are also impressive³⁰.



The airline has introduced an automated fluorescent penetration inspection system in their engine maintenance plant. This system can accommodate 95% of parts for the Pratt & Whitney JT9D engine.

They also developed more sophisticated systems, but they are not yet operational. These include a fan blade recovery process, which uses three very sophisticated robots to automatically perform the following functions. The first robot is responsible for the machining away of worn fan blades' leading edges. The second robot fits titanium bars as replacement and secures them with an electron beam weld. The final robot, machines the repaired blades to within acceptable tolerances. Each fan blade recovered in this process, rather than being scrapped, saves the airline \$1100. If kept in mind that for JAL the cost of new parts represents 65% of the engine maintenance budget, this new process can translate into huge savings for the airline.

Computer-based aids are being introduced to help maintenance personnel perform their functions more efficiently. Boeing has developed such a device called the Portable Maintenance Aid or PMA. These aids are designed to be used in conjunction with onboard computers of aircraft like the Boeing 777 and the 747-400. These aids would allow mechanics on the ramp or hanger floor to quickly access manual data and technical tips for performing an inspection, substitution or repair of a component. Other data like maintenance performed, time spent etc. can be logged and at the end of the day and/or shift this data can be downloaded on the mainframe and introduced to the general information system used. All work performed will therefore be logged for future reference.

Another development by Boeing is a new method of measuring aircraft dependability that more accurately reflects cost. This computerised method, called *Dependability Cost* could change the way carriers perform aircraft maintenance and help improve dispatch reliability. *Dependability Cost* assigns a cost for each repair that includes related schedule interruptions expenses, spares and spare holding costs, repair time, training shop material

and associated expenses. Values are assigned based on statistics and market research. Airline-unique charges can be added to any individual database to measure cost of a specific operation³¹.

One of this programmes advantages is that it can identify small items or procedures that cost the airline a lot of money. In an experiment conducted using this system, 3000 items were included in the *Dependability Cost* database for the Boeing 737, 250 (8.3%) were found to be responsible for 85% of the cost. Many of these are simple items that can be upgraded for longer service life. Boeing is offering this software and documentation free to airlines. This program can run on any PC-based system.

In another development by Boeing they have put together a detailed catalogue of their maintenance training services and world-wide course schedules. This is available as a hard or soft copy and will be mailed to all their clients. It is also available on the Internet. In addition to the world-wide courses offered by Boeing, they also plan to vigorously apply new technology to produce an almost "just in time" instruction medium. For example information and/or technical tips can be downloaded via the Internet, before the aircraft arrives at its destination. The company is also looking at developing desktop simulators that are easy to move from location to location³².

United Airlines has recently switched to an integrated highly-automated operations maintenance monitoring system to increase flight reliability and safety. The payback period for this multimillion-dollar intelligent workstation network is estimated to take about a year, through savings from reduced flight delays and cancellations.

Portions of the system architecture, software and interface philosophies can be adapted for other departments in the airline. United's chairman, Stephan M. Wolf is seeking to increase airline efficiency to better compete with low

cost operators. The implementation of this system is a step towards realising this goal.

The system makes use of advanced telephone technology. This allows a flight crew on route or a line mechanic calling *United's System Aircraft Maintenance Control (SAMC)*, to automatically reach the maintenance expert on duty, for that specific aircraft type. As the maintenance expert answers the phone, individual maintenance data and related information will be displayed on his PC screen. The SAMC monitors the progress of 550 transports in United's fleet on a 24-hour world-wide basis. The system's main function is to co-ordinate unscheduled maintenance activities and help pilots and mechanics diagnose equipment problems on all their aircraft. Early and correct notification of part and tool requirements, aid mechanics in completing repairs during aircraft stopovers or turn-arounds. During peak flight periods each SAMC controller can receive up to 40 calls an hour requesting help to solve aircraft maintenance problems. The SAMC system also allows for fast access to relevant information, with minimum keystrokes. In addition the system also allows for telephone conferencing with other maintenance experts. Safety and consistency is believed to increase by providing more information for the controllers decision-making process. The new system also helps maintenance controllers better manage the workload. Departure critical repairs can be prioritised and colour coded on the controller's screen. Chronic aircraft problems can be more easily identified by the system. Secondary benefits of the system includes the ability of managers to focus on flights with a history of being delayed and the performance of high yield popular flights can be monitored³³.

United Airlines also recently installed a Sony electronic photography system that enables its top engineers to identify maintenance problems and provide expert design solutions for repairs, right from their offices to mechanics in the field. This system was installed in 1992. A logical upgrade of this system will be to go digital and send the images via e-mail. The benefit of a system like this is that experts, who are not near the physical location, can do 'visual

inspections'. This means that an airline can best utilise its knowledge on a specific topic, no matter where in the world the fleet operates. The system can also be used with a borescope camera (instrument able to look inside engine) for fast engine inspections. The benefit of the system is that one receives instant undistorted information, without sending a team to gather it³⁴.

United said that the system paid for itself in the first few weeks when one of their aircraft was damaged. A structural engineer designed and completed a sheet metal patch from the information he received from the photographs. It saved United a trip to Japan and two days out of service costs.

Continental Airlines is using cockpit resource management (CRM) techniques in a training program for its technical and maintenance personnel. CRM encourages teamwork and effective problem solving skills. The aim of the program, which Continental calls Crew Co-ordination Concepts (CCC), is to improve safety and efficiency. The CCC program attempts to increase communication between team members, whether they are mechanics or pilots and teach them how to identify the essential problem of a given situation and stick to solving the problem. Human factors specialists often describe this kind of program as one that brings forth 'work environment related cultural changes'. The executives at Continental rather think of the program as one that sets a different environment. With this program they try to involve more of the people in the decision-making process³⁵.

Boeing has assembled a suite of advanced training courses to match its new high technology 777 transport aircraft. The 777 maintenance training takes advantage of the latest educational media and computer advances. Students now spend about 50% of their time in on-hands training. Boeing now trains the students to identify problems and trouble shoot systems, rather than theoretically teaching them the systems. In the classrooms students can practice their new skills after class on computer-based simulators in the classroom. The set-up is exactly the same as they would find in the 777's maintenance access panel of the on-board computer. There are also 13 real

simulator sessions where the students are provided with a lifelike environment in which to practice troubleshooting. With the introduction of the new technology, the training period has shrunk from 75 days to 45 days³².

Flight technicians may be able to cut aircraft troubleshooting time substantially through the assistance of new personal computer-based maintenance systems, also known as the 'Virtual Maintainer' (VM), featuring a video teleconferencing capability, digitised technical library and comprehensive system database³⁶.

In use, a maintenance technician would carry a VM to the flight line and plug it into the aircraft. Fault codes are read directly from the aircraft and interpreted by the VM. This enables the technician to find the problem and identify it. Once the fault is isolated, the system displays the most likely cause and information about the procedures to rectify the problem. The video-conferencing function allows experts to be contacted and consulted on the problem on hand. The video feed also allows a remote viewer to comment on the condition of the actual parts. The system also allows for a borescope camera to be connected and photos or video clips can be sent to the main shop or to any person in consultation. The system will hold information on procedures and even video clips and images on how to perform certain maintenance operations.

4.5 Conclusion

The first four chapters served as an introduction to the field of technology and the transfer of technology. Some of the most important aspects were highlighted in the technology transfer process and the reader was introduced to the aviation industry, and in particular, the maintenance function. The reader was also introduced to some new developments in the aviation industry in order to show what technologies are employed in the industry, especially in the maintenance function.



Apart from serving as an introduction, the first four chapters also laid the foundation for the research. The preceding chapters set a theoretical standard, with which aspects concerned with the transfer of technology in practice, can be compared with. It must be said that the theory must be seen as the 'perfect world', while industry must be seen as the 'real world'. These two worlds differ due to the fact that in theory, certain assumptions are made which are not possible in the real situation, to mention only one difference.

Chapter 1 shows the important role technology can play in the modern enterprise. Research into the South African aviation industry will establish whether the industry feels that technology can play a significant role in this industry. Chapter 2 highlighted the important aspects involved in the transfer of technology. Research into the South African industry will show whether it is familiar with these aspects, which concepts they use, and if so which are better than other. Research will also show if technology is transferred in industry, what mechanisms are used and what the greatest barriers to the transfer of technology are.