DEFENCE TECHNOLOGY MADE EASY

Minah Sindane Bloem
Llewellyn Hartnick

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DEDICATION

A special dedication goes to my co-writer, Llewellyn Hartnick, who came up with the idea of writing this book. He was also instrumental in lobbying for the funding of the project. I will be eternally grateful to him.

A project of this magnitude is never a success without the necessary funding. Llewellyn and I thank Denel SOC (State Owned Company) for making the necessary funding available for the book. It did not take much convincing on our part to get Denel SOC on board. We shared our vision with them and their vision coincided with ours.

This book is launched at a time when the country has just celebrated twenty years of democracy in our beloved country, South Africa. Denel, as a state entity within the defence industry, saw fit to publish a book aimed at demystifying the defence industry. Denel has historically demonstrated commitment towards funding the education of young people who do well in the sciences, in preparation for studying further in the areas of critical skills that are needed for the economic growth of South Africa. These are the same skills that are required to sustain and grow the defence sector.

While it is difficult to single out individuals, it is however appropriate to thank Denel's representative on this book project, Vuyelwa Qinga, the Executive for Corporate Communication, for co-ordinating this project so well. Her dedication and commitment contributed immensely to the completion of this book.

To the 'Defence Technology Made Easy' project team, this book would not have been a success without their input. All good books tell us that there

is wisdom in the multitude of counsellors. There was a lot of wisdom in this committee. We started off well. When the book was at its final stages we all criticised the work we had put together. We queried the presentation of the content. We wondered if the targeted learners would understand the book and appreciate its content. We wondered if they would actually read it or just get it and put it on the shelf. We were very frank with ourselves. We had to look outside of ourselves for answers. We decided to get the manuscript out there to solicit the opinions of people from different backgrounds, people who would understand the targeted audience.

To all those within Denel and within the wider defence industry, as well as the educational sector, who contributed to the content of this book, we are truly grateful. We may need a separate book to mention each one by name.

We dedicate this book to all the learners of our country who have aspirations of going into careers previously unknown to most South African children. It is a fact that not many black Africans operate in this field internationally. While we expect more learners to join the defence sector in its myriad of careers and enterprise opportunities, it is our hope that the reading of this book will help swell the numbers, and that those who historically were blocked off through legislation from fulfilling meaningful roles in this 'mysterious` industry will take advantage of their opportunities.

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PREFACE

The reason for this book is to demystify defence technology to South African learners and hopefully attract them to that environment to contribute to the economic development of South Africa. It is hoped that the learner's interest in military matters will be stimulated and the learner will choose a career in the defence, aerospace and related sectors.

The concept of the book was brought about by Minah Sindane-Bloem and Llewellyn Hartnick. Both individuals have a combined experience of over twenty years in the defence environment. They have a burden to educate South African learners about issues of defence.

The target group for this book is a Grade 9 learner, but a Grade 7 learner should also be able to read and understand it with ease. By the time learners commence Grade 10 they need to be able to choose subjects that are relevant to their career of choice. It is our intention to persuade them towards choosing mathematics and science so that they have a chance of participating meaningfully not only in the defence industry but in all the areas that need critical skills for South Africa's knowledge economy to grow.

The language that is used is simple with very little jargon. Where jargon is used, it is explained. While the book is meant to educate and demystify the defence environment, it is also meant to instil self confidence in the young South African learner. It is meant to tell the South African learner that he [reference to one gender is inclusive of the other throughout the book] has a place in this world. It is meant to tell the South African learner that he has the ability and the intellect to contribute in an environment

which remains a mystery to him. It is meant to tell the South African learner that he has something to give to the world, and that he does not have to always wait for the world to give him something.

Through an understanding of defence technology South Africa is waiting for our young learner to unleash his potential and leave a lasting legacy.

MESSAGE FROM THE CHAIRMAN OF DENEL

While our country celebrates twenty years of democracy, the learners reading this book should celebrate the opportunities that our democracy brings into their lives. These opportunities are not only to be celebrated but they are to be taken advantage of for the benefit of not only the individual learners but their families, their community and the broader South African society.

While it is true that as a country we come from a painful past of segregation, it is equally true that there are many examples of people who have made it in life despite this segregation. You have to believe that in spite of your circumstances, you have the ability to rise above any circumstances and contribute positively towards the growth of our country.

With this book, Denel is offering you an opportunity to understand what may initially appear to be a 'mysterious' industry. With this book in your hand, Denel has set out to demystify the defence/military space. The advent of democracy has made it possible for all children of South Africa to have an opportunity to express their abilities. Denel has undertaken to support this project with you in mind. We are in constant discussions with Government on how Denel can best maximise its contribution to society. Supporting this book

is one of the ways we are making a sustainable return on our shareholder's investment. Denel's shareholder is the South African Government.

Denel is passionate about skills development, and that is why the company has made investments in artisan training, internships, apprenticeships and mathematics and science learner support.

Denel has many capabilities, more particularly in areas of scarce and critical skills. Many of them are explained in this book. The company also has various programmes that contribute towards skills development, as well as various opportunities for the young South African learner. Space technology is one of the areas that you, as the learner, might be interested in.

I hope that this book will not only be for your simple reading pleasure, but that it will make you, the learner, aware of the endless number of opportunities within the defence space. Making the defence space your career choice would be a wise move for yourself, your community and your country. Take advantage of this information to craft a better life for yourself.

Martie Janse van Rensburg
Interim Chairman, Denel

MESSAGE FROM THE GROUP CEO

Globally, the defence industry is an important incubator for cutting-edge research, innovation and technology. In South Africa, Denel, as the country's premier provider of defence, security and aerospace solutions, is at the forefront of some of these developments.

To adequately and effectively play this role within the South African context, Denel goes out to attract the best and the brightest talents that emerge from our schooling and higher education systems. Denel's involvement starts at an early stage – through our involvement in youth development programmes and in providing extra tuition in mathematics, science and technology to young learners.

When they exit the schooling system, we offer bursaries and scholarships to deserving students and provide on-going mentoring and part-time work opportunities within the company. At the completion of their studies some are employed as qualified engineers, artisans or technicians within the Denel Group.

The Denel Technical Academy takes in learners from South Africa and the rest of the continent in the main to serve the requirements of the aviation industry. Trained in a wide range of technical skills for the maintenance and repair of both helicopters and fixed-wing aircraft, our graduates play a significant role in keeping the African airspace safe.

We are justifiably proud of the contribution that Denel continues to make within the broader South African society. Many of the research and development projects initiated for the defence environment have led to breakthrough solutions in broader society.

It is because of our innovative solutions and high-tech products that we have been able to contribute meaningfully towards efforts to combat rhino poaching and the smuggling of ivory, drugs and contraband. It is through our advanced technological innovation and technology that we make our contributions to the country's initiatives to curb cable theft, protect our country's borders and conserve our precious natural resources.

As a state-owned company, Denel makes a special contribution towards achieving national developmental goals through our role as a research house and a manufacturer of advanced technology products. Denel further invests millions towards youth development and skills development.

We believe that our existing skills and experience must constantly be strengthened by the addition of new talents and energy. If you have the skills, the determination and commitment – Denel should be your employer of choice.

Riaz Saloojee
Group Chief Executive, Denel

MESSAGE FROM THE GOVERNMENT OF SOUTH AFRICA

Your career forms an enormous part of your life, and will ultimately help shape and define you, and your legacy. Getting the foundation right will help you toward a healthy and happy career. Use the information in this book to plan the school subjects you will continue with from Grade 10 and decide on a brighter future for yourself.

In 2010, the South African Government agreed on twelve outcomes relating to education, skills, health, safety and security, human settlements, and the environment. Outcome 5 referred to skills for the country, which required the development of 'a skilled and capable workforce to support an inclusive growth path'. One of the outputs for this outcome was the development and implementation of a standardised framework for cooperation on the provision of career guidance and information services in the country. The vision encompassed by this framework is to ensure that all South Africans have access to quality career information and career services throughout their lives, so that they are able to make better and more informed career choices that deliver high levels of employment and help to increase sustainable economic growth in the country. A book like this one, 'Defence Technology Made Easy' is in direct response to that call, and will go a long way towards helping South Africa in achieving radical socio-economic transformation.

This book will enable each and every young South African to have the tools they need to push back the triple challenges of poverty, inequality and unemployment in their own homes and communities. Once the defence

industry is demystified to you, it means that a door has been opened for you to enter the world of highly specialised skills that were previously only known to a few, and that is just one key to economic growth and development. Education is an apex priority for government and our developmental objectives as a country will be achieved even quicker once young people in general, but black people primarily, and women secondarily, begin to enter areas of scarce and critical skills. By so doing, they will be helping redress the imbalances of the past. Without this book, very few South African learners would have known of careers as Aircraft Mechanics, Aircraft Avionicians and in Aircraft Structural Work. Even fewer of you would have even heard of Electronic or Computer Engineering, Aeronautical Engineering, Mechatronic Engineering and Systems Engineering.

Nowhere else but within the defence sector would you have heard of careers in Control Systems, Radio Frequency, Electro-optical engineering, Optic Engineering, Digital Engineering, Software Engineering, Power Electronics, Logistics Engineering, Megatronics and Systems Engineering. It is after reading this book that you can make a better-informed decision about becoming a Technician in Radar, Optical, Telecommunication and even Telemetry. The book will further enable you to make a decision to be a Data Analysis Scientist. This is the world of defence for you, which you might have thought that it was only about becoming a soldier. No, it is not. You, the learner holding this book in your hand right now, must begin to claim your space in historically hidden and exclusive male dominated areas of expertise so that you can also make a positive contribution to the growth and development of South Africa. Make sure you read this book, take the advice contained in it and make better informed choices about your career – whether you go to a university or a college. South Africa needs you!

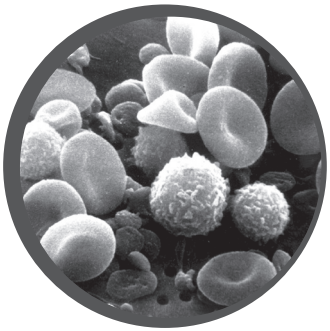
CHAPTER 1

WHAT DEFENCE IS:

The Collins English Dictionary defines the word defence as follows:

- Resistance against danger or attack;
- In sport – the action of protecting oneself or part of the playing area against an opponent's attack;
- Defence mechanism – psychoanalysis (an unconscious mental process designed to reduce anxiety or shame);
- Defence mechanism – physiologically (the protective response of the body against disease).

God the Creator has created the human body 'wonderfully and marvellously`. He knew that the human body would at times be under attack. He therefore created a defence mechanism for the body to fight off disease. This defence mechanism is commonly known as the immune system by the medical fraternity. The immune system refers to the soldiers of the body (medical doctors and nurses call it white blood cells), which fight off any infection that attacks the body.



BLOOD CELLS ATTACKING VIRUS

Some attacks can be felt as headache,

stomach-ache, coughing, infections, etc. Some of them happen without our knowledge. The human body is exposed to over sixty viruses at any given time. When a virus or a germ enters the body, the soldiers of the body increase in number and surround that virus or that germ. They attack it until it dies and the body heals.

At our homes we have burglar bars on the windows and the doors to defend ourselves against possible attack by intruders. Others have palisade fences around their property to prevent intruders, who may want to attack or steal from them, from entering the property. Police officers put on bulletproof vests to protect themselves against attack. People buy insurance for their houses, their cars and themselves as another form of protection against attack. In the case of a car, when one is involved in an accident, having insurance means that at least there will be money to repair the car or buy another one. When someone who is insured dies, it means that there will be enough money for the family to conduct a decent funeral and to continue with life with the financial support from the insurance.

So defence is part and parcel of our daily lives. We eat to attack hunger. We drink fluids to prevent ourselves from becoming dehydrated, i.e. we attack thirst. We learn to drive and get drivers' licences to better equip ourselves to avoid having accidents and being a danger to society.

Doctors go to school for seven years to learn how to treat a human body. There are rules that prevent the doctor from doing certain things in order to protect humanity.

We use sunscreen to prevent our skins from getting burned, which means protection against an attack from the sun. We walk around with umbrellas on a hot summer's day to protect ourselves from the sun. We eat healthily to prevent our bodies from getting unhealthy and catching disease easily. So defence is part and parcel of our lives.

South Africa has a national **defence force**. According to Section 200(2) of the Constitution of the Republic of South Africa, the following is the primary objective of the South African National Defence Force:

> 'To defend and protect the Republic, its territorial integrity and its people in accordance with the Constitution and the principles of international law regulating the use of force.'

Just like the body has its defence force, called the immune system, South Africa has the South African National Defence Force (SANDF) which is there to protect South Africa. Just like people have insurance for their cars, South Africa has its insurance called the SANDF. There are people who never get ill but they have an immune system. When this person dies, do we say that there was no need for an immune system? No. It is very possible that the germs or viruses that attacked that person were dealt with thoroughly by that person's immune's system while he was alive. The immune system was very good.

There are people who pay for their car insurance for years without being involved in an accident. Many end up selling that car without claiming from an insurance company. Should one then say it was not

necessary to pay for that insurance? No. There are many stories of people who had insurance for a long time, decided to cancel it, and then a few weeks after the cancellation they were involved in an accident. They then found themselves in trouble because they did not have the money to repair the car. Others cancel household insurance because they are trying to save some money. Shortly after the cancellation the house could be broken into, resulting in all the electronic equipment getting stolen – radios, computers, flat screen television and microwave.

The SANDF is no different from the body's immune system. It is no different from an insurance policy. The fact that the body does not get ill does not mean it does not need an immune system. The fact that one's car does not get involved in an accident does not mean that it does not need insurance. The fact that there is no war does not mean that we do not need our defence force. Remember also that soldiers are not boxers. They do not fight with fists. They fight with weapons. Those weapons must be ready to be used at all times. That is why there is also a need for a defence industry that is viable, that will be able to support our national defence force with the necessary equipment. In South Africa, we have a company called Denel, which is owned by our government. Denel is one of the big companies within the defence industry. In South Africa there are also other private companies that also supply our national defence force with equipment.

If it ever happened that another nation wanted to attack South Africa, it would never write a letter to the President informing him about its intentions. That country would just attack South Africa without warning. Just like a thief who comes into one's home to steal. The thief does not write an email or send an SMS to the owners of the house informing them of

the date and time when he is going to break into their house. That is why when the owners go to sleep, or leave the house, they lock the gates, the doors, unleash the dog and put the alarm on, because they do not know when a thief may attack their house.

Even a car owner is not warned about the day or the hour when their car will be involved in an accident. It just happens. A country as big and beautiful as South Africa has to be able to defend itself, just as the human body defends itself, and similar to how car owners protect themselves from the risk of not being able to pay for the damage to the car once it is in an accident.

The SANDF therefore exists even during times of peace and not because there is a war. That is why it is called the **defence** force, and not the **attack** force. This means that soldiers do not go around teasing people and looking for a fight. They **defend** when attacked. They even go further. They do not want to be attacked so they have a solid posture. What does this mean? It means they have a position that discourages a potential attacker from even thinking of attacking them. Thieves think twice before attacking a house with a high palisade fence, a high wall, burglar bars on the doors and windows and a board with the name of a security company guarding the house.

A well-equipped defence force acts as a deterrent to a country's potential attackers. No animal in the jungle attacks an elephant. Why? Its mere posture tells the other animals that they will be in trouble if they try to attack it. South Africa's national defence force works very hard at equipping itself properly so that it can be ready to defend the country at any time. Its posture is that it will not attack anybody but when attacked, it will defend South Africa and her citizens.

The SANDF has four different services. It has the army, which in the main operates on the ground, the air force, which is responsible for aircraft operating in the air, the navy responsible for ships operating in water and the Military Health Service, which is responsible for the health and well-being of soldiers.

The SANDF has many career opportunities for highly skilled individuals within the defence force. It is also always looking for people to join to be trained as soldiers. The SANDF builds good relations with communities and often exposes those communities to the military environment. One of these happens through a programme the SANDF runs where volunteers are trained for two years through the Military Skills Development Programme. After the two-year programme, a person may choose to continue as a permanent professional soldier or be part of the Reserve Force while they pursue some other career.

Anyone who wants to join the SANDF must be physically fit. Subjects like mathematics and science are not the only subjects considered for selection, but they will put one at an advantage. The SANDF needs skilled people or those who can be trained in many areas of scarce and critical skills, over and above the ability to handle and use weapons. The defence force has modern equipment that must be operated by people who understand how it works and are trained to operate it. South Africa's defence force has many opportunities in professional and technical careers. It is up to you, the learner, to grasp these opportunities. This book is opening up the world of defence beyond just the military.

FACT BOX

Did you know that soldiers are the only people who take an oath to die for their nation? It is a solemn oath in that even when they die for their nation there is no equal reward given to them. As a nation, we need to give our soldiers a lot of respect for this. Men and women voluntarily join the National Defence Force and take this oath.

Did you know that in October 2000, the United Nations took a special resolution (decision), Resolution 1325, on the participation of women in defence? This resolution clearly indicates that women play an important role in the prevention and resolution of conflicts, peace negotiations, peace building, peacekeeping, humanitarian response and in post-conflict reconstruction. It stresses the importance of the equal participation of women and full involvement in all efforts for the maintenance and promotion of peace and security.

Did you also know that South Africa is a signatory to this resolution? This means that the SANDF abides by this decision. Defence is clearly not only about attacking, it includes peacekeeping. It has been proved that the instinctive maternal attributes that women have, come in handy during peacekeeping missions in the rest of our continent. So the UN Resolution 1325 sees a crucial role for women in defence. This resolution moves away from the generally held belief that defence is only for men. There are women within the defence force who are pilots; there are paratroopers – they can jump out of a moving aeroplane using their parachutes. Others launch rockets that can reach over 20km from the battle. So there is a place for everybody in the defence force, both men and women.

CHAPTER 2

HOW THE HUMAN BODY DEFENDS ITSELF

Illness in the body manifests itself in different ways to show that there is war going on inside. For example when one is sick and goes to a hospital,a clinic or to a private doctor, there is a procedure that medical staff undertake to check for signs that will indicate how serious one's illness is. These are called vital signs. They include the following:

- **Temperature** – a high body temperature indicates that there is some infection whether bacterial or viral that the body is fighting;
- **Pulse** – this determines the heart rate;
- **Respiration** – to check your breathing because struggling to breathe might indicate that there is something wrong within the respiratory system;
- **Blood pressure** – this determines the pressure at which the heart pumps blood through the body and the pressure at which the heart receives blood from all parts of the body.

These signs are called vital because they determine signs of life in the body and the state of one's health. If one goes to a medical facility feeling ill, the nurse takes one's vital signs. If these are found to be normal the doctor does not worry as much as he would if abnormal signs were detected.

It is possible for one to go to the doctor with a headache and then be admitted to hospital. Why? Checking the vital signs might tell the doctor that something else is wrong with the body. One may just be feeling a headache but the blood pressure might also be very high. This means that if that high blood pressure is not attended to one might, for example, have a stroke or something worse.

While South Africans generally feel safe within the country and go about their daily duties in a normal environment, if there are wars or wars threatening in neighbouring countries, the safety of South Africans is also compromised. South Africa might for example have to accommodate refugees from conflicts of the neighbouring countries. The country's resources might be over-extended and possibly even become depleted because all of a sudden our country has to accommodate an increased number in the population. Increased resources would then have to be invested in places of safety, water, sanitation and healthcare provision. One of the very important roles of the SANDF therefore is to participate in peacekeeping missions around our continent. This is for the benefit of all.

If one's neighbour is unemployed, but he has children to feed, cannot afford to take them to school and cannot afford to take them to hospital, it might not be your problem but it would affect you as the neighbour.

The stability of our region in Southern Africa, and the entire African continent, is important for the stability of our country. This means that the stability of our neighbours is also important for our own stability.

When one feels thirsty, that is a defence mechanism from the body. The body should not feel thirsty. By the time it feels thirsty, it is reporting to the owner that something should be done or else it will go into a state of dehydration. So by feeling thirsty, the body is protecting itself from being dehydrated. Hunger is also a defence mechanism. The body reports to its owner that it requires food so that it may function optimally. When the body has had enough food, the nerves around the stomach area report to the brain that the stomach is full. Then one has to stop feeding the body. When that nerve system is not working, or it is not listened to, one can eat much more than the body needs. Of course that will cause obesity.

Crying is a way of offloading emotions from the body. Many a time in the townships our parents used to say *'o fokotsa metsi a ka mo tlhogong'*. That means when one cries, one is reducing the high level of water that is in one's brain. When people do not cry or do something to release emotions the body will defend itself. The person might collapse. The body might go into spasms. The person might have other unexplained ailments in the body. This is the message that the body gives the owner to relieve the bottled-up emotions.

When one puts one's hand on a hot stove, there is almost a knee jerk reaction to quickly remove the hand from the stove. The whole process happens in a split second. When one puts the hand on the stove, the nerves around that hand relay the message to the brain that the hand is in trouble. The message that comes back from the brain to the hand tells

the hand to remove itself from the stove. If the nervous system does not work, as in the case of people with leprosy for instance, the person will not remove the hand because the message path is not working.

It is possible to have a person with normal looking eyes but they cannot see. There are many reasons for this. For the purposes of this book, it could be that the message path (nervous system) from the eye to the brain and from the brain to the eye is not functioning. This means that the sight interpretation centre of the brain is not working. Something could be blocking that path.

Coughing is another way the body defends itself. The person coughs because there is something in the lungs that the body must get rid of. Many of us run to get cough mixtures to suppress the cough. When the body catches 'flu or a common cold, it is defending itself. Many a time we walk around with colds that take a long time to heal because we do not listen to our bodies.

When a body collapses, often it is defending itself from being overworked. Many of us overwork our bodies. We do not rest them. The body then collapses to prevent itself from further overwork or from a complete shutdown. It then forces the owner of the body to rest it. The likelihood is that a doctor will tell the patient that he is stressed. Then that person has to rest.

Some ladies remove their eyebrows and then put a black line where the eyebrows were because they believe that makes them look beautiful. What these ladies forget is that the hair of the eyebrows protects the eyes from sweat. When one sweats these eyebrows trap the sweat so that it does not get into the eyes. Some ladies extend their eyelashes. What one

will observe is that once the eyelashes are extended the eye blink rate increases because the eye is protecting itself from a foreign object that has been put very close to it. The human eyes are like light to the body. Without them, one cannot physically see.

Likewise, any country defends itself using different ways. For the purpose of this book, some of the defence technologies will be explained.

CHAPTER 3

HOW ANIMALS DEFEND THEMSELVES/ MILITARY FORMATIONS

Many animal species have some kind of defence mechanism so that they can survive in harsh environments. As indicated in the previous chapter, human beings have defence mechanisms that we take for granted. The porcupine is one of the most vulnerable animals. When anybody or any animal approaches it, it extends its spikes as a warning that it will hurt you if you come closer. When an ordinary lizard is under attack, it can shed its tail, which will spin wildly. This is a **decoy**. In military terms a decoy is something designed to deceive an enemy. The decoy tail of the lizard makes you forget about chasing the lizard and concentrate on the wriggling tail. While you are busy looking at the wriggling tail, the lizard has a good opportunity to run away.

In the military there are **missiles** that are used in a war situation. These are weapons that are directed at a target. Usually they are shot from an aircraft designed for war, called a fighter jet. Most missiles are heat seeking devices and often attack an enemy aeroplane. This means that they will follow the tail of an aircraft because it emits heat. An aeroplane that is under attack will release what are called decoys so that the missile will

follow the released heat-emitting decoy and not follow the actual aircraft it was intended to attack. In that way the aircraft will be safe from the missile.

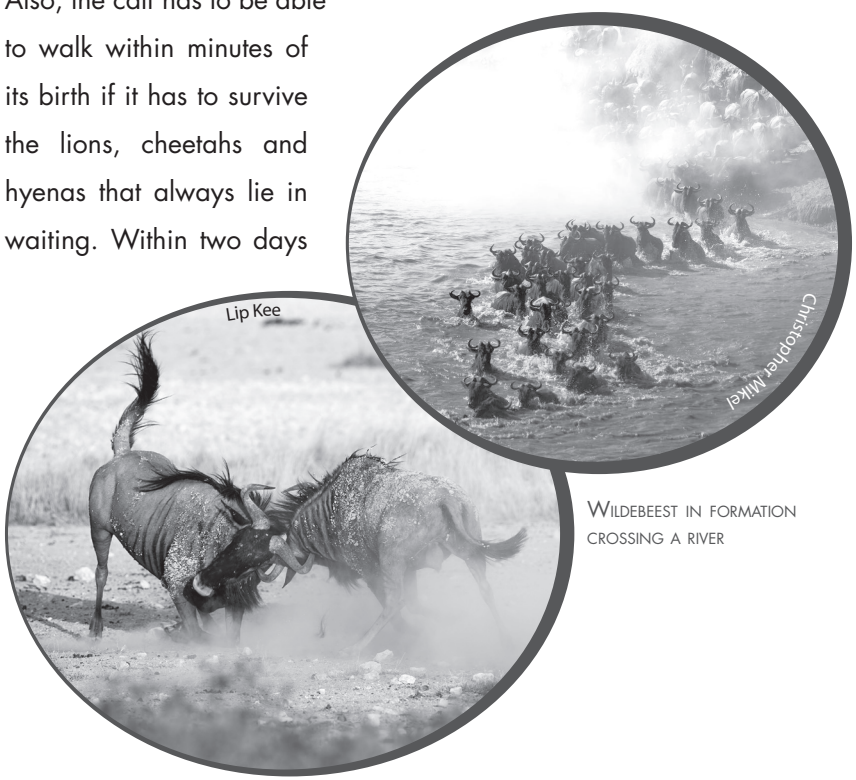
During a war situation there is always a **command and control** unit. It is managed and operated by people who are called commanders. They give orders to the troops. They can give commands to shoot or to cease fire. They can give commands to advance or to retreat. What is important is that there is order and there is control. The troops do not do as they wish because they might put their lives in danger. To an untrained eye, one might think combat situations are just about a lot of gun crazy soldiers shooting at random. However there is always order in that shooting. It is not just any soldier who gives orders. Soldiers also know to whom they must listen, and that is their commander.

Military armies are organised in such a way that there are various formations. There is a particular order that is followed. If one looks at how the wildebeest, (also gnu in English) wild animals of the antelope family migrate, one will see something similar to an army formation. They build up to a high density before they cross a river. When they are about to cross a crocodile-infested river, they will not just cross. They have commanders that must give an order to cross or to wait. These commanders check if the coast is clear before giving the command to cross. They first have to see that the area is safe for the wildebeest to cross.

Of course their crossing of the river means a feast for crocodiles. Like in any war situation, there will always be casualties. The crocodiles will not be able to attack a massive group of wildebeest. It will normally attack that wildebeest that is on its own and not part of the group. Once it is attacked the other wildebeest are unable to help it or come to its rescue.

When wildebeest are in a formation or in a group, even a lion is unable to attack them. What the lion does is to make a noise in the hope that one of the wildebeest will come out of the group and be available for the lion to attack. There have been reports of enraged herds of wildebeest trampling hunting lions to death.

The female wildebeest is normally a tame animal. It is weaker than its male counterpart. However it will fight to the death to protect its young. Normally male wildebeest are not so loyal in protecting the young because they will mate with more than one female. This dilutes their loyalty among a number of offspring. The mother will have one calf that it has to protect. Also, the calf has to be able to walk within minutes of its birth if it has to survive the lions, cheetahs and hyenas that always lie in waiting. Within two days



WILDEBEEST IN FORMATION CROSSING A RIVER

of birth the young calf of the wildebeest can run as fast as its mother.

Nobody knows yet what triggers the migration of the wildebeest but they migrate to get good grass and fresh water. Countries fight using the military to protect their interests. However, countries go to war as the last resort when all other avenues of solving problems have failed. Like the female wildebeest protecting its offspring, soldiers will fight unto death to protect the sovereignty of their country. As you read earlier, soldiers are the only people who take an oath to die for a country that they will never own.

FACT BOX

Here is something very interesting found in the Reader's Digest book entitled *Exploring the Secrets of Nature:*

'In spring each year, the wildebeest of Kenya's Masai Mara Reserve join zebras and gazelles in great mixed herds, some up to half a million strong, to travel more than 200 km southeast to Tanzania's Serengeti Plains, where the females give birth. Along the route, lions, hyenas and crocodiles prey on the herds and, each year, about 42 000 wildebeest die during migration.

The Masai Mara has sufficient food all year for the wildebeest'senergy needs, so why do they make this hazardous yearly journey? The answer is in Serengeti's grass. It grows on soil rich in phosphorous, a mineral vital to the formation of strong bones in the calves. When they are born, in the middle of the wet season, the grass is rich and lush, enriching the mothers' milk and giving the calves a better start than they would have had on the Masai Mara. In the dry season, the grass dies and the herds return to the northern woodlands.'

CHAPTER 4

THE USE OF RADAR SYSTEMS IN DEFENCE

The Collins English Dictionary defines the word 'radar' as follows:

1. A method for detecting the position and velocity of a distant object. A narrow beam of extremely high-frequency radio pulses is transmitted and reflected by the object back to the transmitter. The direction of the reflected beam and the time between transmission and reception of a pulse determine the position of the object.
2. The equipment used in such detection.

The use of **Radar systems** within a country (territorial surveillance which includes landward borders, airspace and coastal systems) starts primarily with territorial protection from unknown threats both natural and unnatural.

Radar observation serves as a forewarning mechanism in terms of weather patterns, external enemy threats as well as a system that enable a country to manage its interest i.e. fauna and flora, energy resources, infrastructure such as Air traffic control towers, railway lines, telecommunications towers etc.

South Africa has the capability of designing, developing and manufacturing radar that searches and tracks objects for the SANDF.

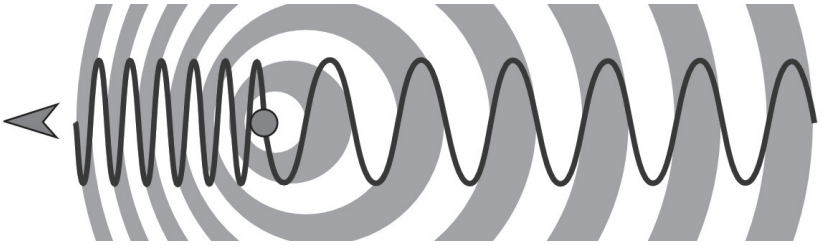
Radar can track in the air, in the water (sea) and on land. Radar is also useful in the mining sector where sensors are used to check movement and surveillance.

While this technology is used by human beings, animals have had it before man discovered it. Radar technology can be likened to how bats operate. According to the Reader's Digest[1] 'bats are the champions of sound navigation. From the echoes of their calls, they can build up a detailed picture of their surroundings'. Bats hunt at night. They spot flying insects by what is called echolocation. They send out high pitched shrieks at regular intervals and listen for echoes that bounce off an insect's body. In this way, the bat can pinpoint the position of the insect and how far away it is. Dolphins use the same system in locating their food.

Some bats have ears as long as their bodies. They use these ears to listen for the sound of an insect's wings beating as it prepares for flight, and they swoop in to kill it. These bats rely on their eyesight to find their way about. They also use very weak echolocation signals once it gets too dark to see. One would have observed how a bat comes in flying at high speed towards a wall and as it is about to hit the wall it immediately changes direction. Echolocation allows them to both navigate and to spot flying insects in total darkness.

1. Exploring the secrets of nature – the amazing world of animals and plants – published by the Reader's Digest Association Limited, London - 1994

The echoes not only reveal the presence of an object, they also tell the bat its position. Sound always travels at the same speed in air, so the bat can judge distance by the length of time an echo takes to return. The relative intensity of the sound in each ear tells the bat the direction. Usually each bat call starts at a high pitch and falls rapidly, sending out a range of wavelengths. This has two advantages for the bat. Firstly, the longer wavelengths penetrate further and scan a wider area and the shorter wavelengths bounce off tiny objects. Different wavelengths strike an object in different ways and so can give a more detailed picture. By turning its head to scan from side to side, a bat can tell not only the position of an insect by echolocation, but also the direction in which it is flying. It can do this because of the Doppler Effect, a phenomenon named after Christian Doppler, the Austrian physicist who discovered it. A Doppler machine is used in hospitals to detect the baby's heartbeat while it is in its mother's womb.



Doppler Effect

To understand this better, think of the effect a police car siren has on a pedestrian's ear. The siren's notes seem to be higher as the car approaches and lower as it speeds away. This is because, although the notes have not changed pitch, as the car gets closer the sound waves have less distance to travel, so their frequency per second increases, and

as the frequency increases so does the pitch. As the car speeds away the sound waves returning have a longer distance to travel, so their frequency decreases as does the pitch.

The bat compares the pitch of the echoes from the flying insect with the pitch of the constant frequency signals it sends out. An echo of a lower pitch than the signal means that the insect is moving away. An echo of higher pitch means that the insect is moving closer. In this way, the bat tracks the insect's flight path.

A frog that cries out at night calling a female frog to mate is in danger from a bat. Its sound is intercepted by the bat. The bat homes in on the source of the sound and eats the frog. Crickets also call loudly to find mates. They are also in danger of being eaten by bats. However crickets seem to have found the solution. They sing in unison at exactly the right sonic frequency to 'jam' the tuning-in signals used by bats. This confuses the bats. This 'jamming' is also used in defending a country in a war situation where radio waves from the enemy are "jammed" to intercept either radio sounds or missiles when attacking.

So while one may look at a radar system and get intimidated, it is something that one sees daily and possibly interacts with.

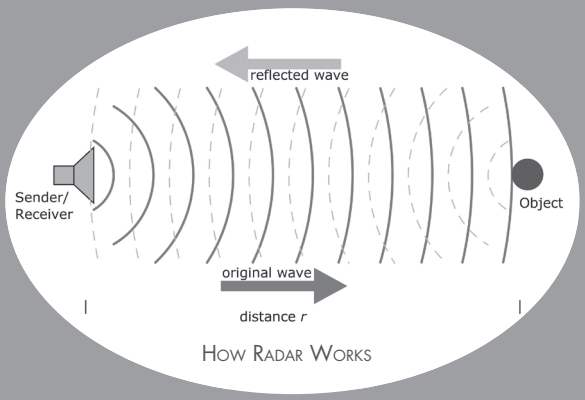
FACT BOX

Radar (Radio Detection and Ranging) detects objects at a distance by bouncing radio waves off them. The delay caused by the echo measures the distance. The direction of the beam determines the direction of the reflection. The polarization and frequency of the return

can sense the type of surface. Navigational radar scans a wide area two to four times per minute. It uses very short waves that reflect from earth and stone. It is common on commercial ships and long-distance commercial aircraft.

General purpose radar generally uses navigational radar frequencies, but modulates and polarizes the pulse so that the receiver can determine the type of surface of the reflector. The best general-purpose radar distinguishes the rain of heavy storms as well as land and vehicles. Some can superimpose sonar data and map data from a GPS position.

Search radar scans a wide area with pulses of short radio waves. It usually scans the area two to four times a minute. Sometimes search radar uses the Doppler Effect to separate moving vehicles from clutter. Targeting radar uses the same principle as search radar but scans a much smaller area far more often, usually several times a second or more. Weather radar resembles search radar, but uses radio waves with circular polarization and a wavelength to reflect from water droplets. Some weather radar uses the Doppler Effect to measure wind speeds.



How Radar Works

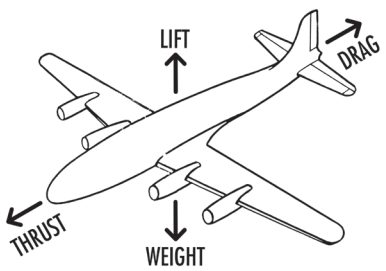
CHAPTER 5

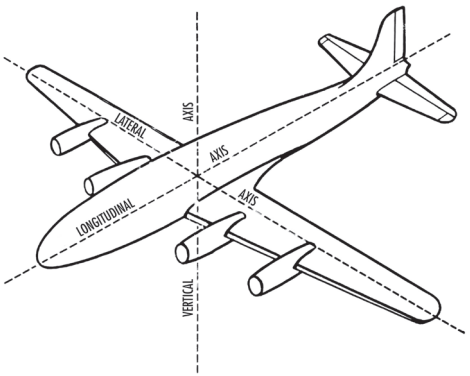
MANNED AIRCRAFT – HOW DOES AN AEROPLANE FLY?

There are two types of aircraft – manned and unmanned. **Manned aircraft** are the ones we know best, as they fly over our skies. For the purposes of this chapter, only the physics of manned aircraft will be explained. Chapter 8 will explain about unmanned aircraft.

There are two types of aircraft: **fixed-wing aircraft (FWA)** and **rotary-wing aircraft (RWA)**. The RWA are the helicopters. They have wings that move, i.e. which rotate, hence the word rotary wings. This chapter explains a fixed-wing aircraft. There are small aircraft and big aircraft. The difference between the two is in the power the aircraft possesses. The bigger the aircraft, the more power it possesses. A small aircraft takes four hours to fly from Johannesburg to Cape Town and a big one only two hours.

There are four basic forces that act on an aircraft. Firstly, thrust is a **forward force**. Secondly, drag is a **backward force** (resistance). Thirdly, **lift is a force going upward**. Fourthly, **weight is a force going down**, i.e. gravitational force. When these forces are in equilibrium





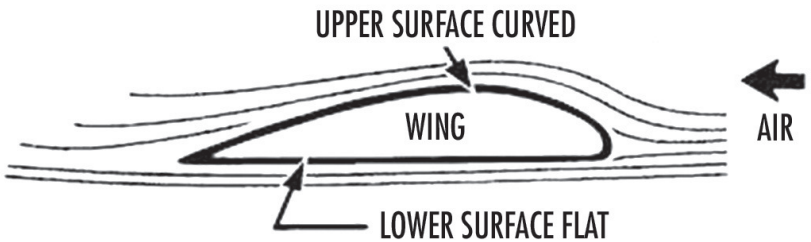
then the aircraft is straight and level. The imbalance of forces is caused by either the plane accelerating (the thrust force is more than the drag force) or decelerating (when the drag force is more than the thrust force). It can also happen when the pilot is ascending (lift force is higher than the weight force) or when the pilot is descending (weight force is higher than the lift force). Lift force acts on the centre of pressure and weight force acts on the centre of gravity.

There are three axes along which the plane acts (axis is singular and axes is plural; and an axis is an imaginary line about which a body, such as an aircraft, can rotate). These have to do with the stability of the aircraft. Firstly, there is the lateral axis (similar to a person standing with outstretched arms, i.e. wing to wing). Along this axis the aircraft pitches (this means its nose position goes either up or down). Secondly, the longitudinal axis (horizontal or from nose to tail or from tail to nose) along which the aeroplane rolls, i.e. wing tip movement up or down and thirdly, the vertical axis (top to bottom. It yaws (turns) along the vertical axis, either left of right. When an aircraft yaws, it does not lose altitude (height).

For the aircraft to fly it needs wings. These wings must be shaped in a way that will generate lift or speed. The wings are called aerofoils. The plane cannot fly without a certain amount of wind. Just like a bird cannot fly without a certain amount of wind. Of course there is always wind in the atmosphere.

The air has a tendency to move from a high pressure area to a low pressure area. When the aircraft is in flight (in the air), the air pressure below the wings is high and moves at a slower speed. The air pressure above the wing is low and moves at a higher speed because of the top shape of the aerofoil (wing tip), which is shaped like a curve. When the aircraft flies the wind is split at the wings from the leading edge (the front part of the wing) to the trailing edge (the back part of the wing). When this split occurs some air flows on top of the wing and some air flows at the bottom of the wing. Remember that the air on the top of the wing moves faster with the resultant reduction in pressure. The pressure below the wing therefore becomes relatively higher than the pressure above. This then results in the lift of the aircraft.

Wind moving in the direction opposite to the flight path of the aircraft is called a head wind. In other words it is the wind hitting the head of the aircraft. Wind moving in the same direction as the flight path of the air craft is called a tail wind. In other words it is the wind hitting the tail of the aircraft. Wind moving in a direction across the flight path of the aircraft is called a cross wind. In other words it is the wind hitting the body of the aircraft. Ideally, the aircraft performs better when flown into the wind (head wind) both at take-off and at landing.



This is because the pilot has better control of the aircraft. If one moves a kite into the wind, the kite flies higher and if one runs with the kite in the same direction as the wind, the kite will not fly. If for example an aircraft has to land at a speed of 70 knots (129.5 km/h: 1 knot = 1.85 km/h), and the head wind is 30 knots (55.5 km/h), then the actual landing speed of the aircraft is 40 (74 km/h) knots. This is a much reduced speed and more comfortable. If on the other hand the aircraft must land at 70 knots and the tail wind is 30 knots then the actual landing speed of the aircraft is 100 (185 km/h) knots. The aircraft might overshoot the runway if there is not enough runway length.

When the aircraft is airborne it is economical to have a tail wind. This means that when the aircraft is flying at 70 knots and the tail wind is 30 knots the actual ground speed of the aircraft is 100 knots. The advantage of this is that the aircraft will reach its destination faster than the scheduled time. The fuel will also be saved. When the aircraft is flying against a head wind of 30 knots and it is flying at 70 knots its actual ground speed is 40 knots. That means the aircraft will take much longer to reach its destination and it will also consume more fuel.

It makes sense for the aircraft to run at a high speed before take-off. This helps the aircraft to gain the flying speed faster. If it does not run at a high speed from the ground, it may not be able to take off. The opposite occurs when the aircraft has to land. It has to come at an approach speed, which is lower than the take-off speed, in order to land safely.

Have you ever wondered why aeroplanes do not collide in mid-air as often as cars do on the ground? Flying remains one of the safest modes of travel. Aircraft are made with backups. A normal Boeing/Airbus will

fly using four engines, two on each wing. The plane can still fly when one of the engines fails.To enable the safe flow of aircraft in the air there are air traffic controllers. They manage the safe flow of air traffic. Air traffic service units(ATSUs) are stationed at all airports and most airfields. Military airports provide their own traffic service units.

Air Traffic Control

The company called Air Traffic and Navigation Services (ATNS) is responsible for the control of air traffic. They are stationed at all airports around the world. Each aircraft is given a certain level at which it must fly, e.g. 30 000 feet above sea level. Radar systems help pilots to know if there are any obstacles ahead. Obstacles may refer to cloud, mountains or other aircraft. Radar systems also help air traffic controllers to know the location of aircraft. Aircraft also have sensors, which will alert the pilot if there are any objects close to the aircraft. This is just like some of the modern cars we have which will give a warning signal upon reversing if the car is close to hitting an obstacle.

CAREER REQUIREMENTS

For anybody who wants to be a pilot there are certain qualities that one should have in order to qualify. One must have the correct height, weight, and be in good health. One's hearing and sight must be good.

One must be well co-ordinated, and able to do multiple tasks at the same time. It helps to be able to use arms and legs, as well as an ability to swim and play football. Mathematics, science, geography and English should be the subjects of choice at school. It is important also for one to have self-discipline. A pilot cannot be a maverick (a person of independent views) as he must be able to work as a member of a team. A pilot must have a good memory and must have respect for others. Serenity and calmness are necessary qualities.

The academic qualifications are mathematics and science at Grade 12 level to be able to get into any flying school. There is a chapter later in the book entitled the A-Z of careers in aviation. This will give more details on all careers associated with aviation.

CHAPTER 6

HOW AEROPLANES ARE MADE TO FLY

ORYX

Denel has a division called Aerostructures. They design the structure (shell/body) of both manned and unmanned aircraft, test the concept and manufacture the structure so that it can interface with all other systems of the aircraft. They do the framework (the bones and skin that form the body) of the aircraft and all the other parts will then be built into the basic structure/frame.

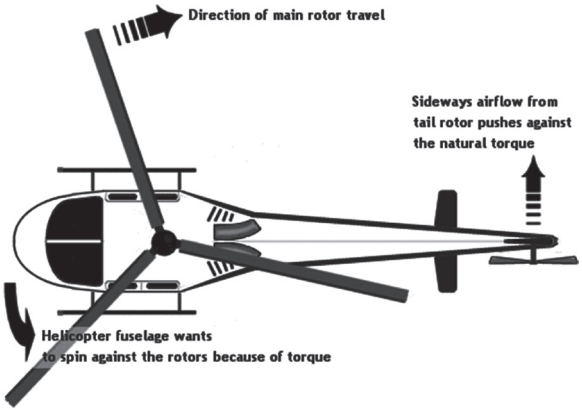
Denel Aerostructures has a history of designing and manufacturing military and civilian aircraft, both RWA (helicopters) and FWA (jets). For military applications, the rotary-winged aircraft vary in their shape, size and application. These include combat support (fighter) helicopters such as the Rooivalk, light utility helicopters such as the Agusta 109 LUH and medium to heavy lift utility helicopters such as the Oryx. The military fixed-wing aircraft also has various shapes, sizes and applications. These include combat support (fighter) jets such as the Gripen, transport aircraft; medium and heavy lift aircraft such as the Airbus A400M. The South

African Air Force uses combat and utility aircraft, both helicopters and jets. Some parts of all of these combat and utility helicopters and jets were built by Denel. Both the Oryx and the Rooivalk helicopters are proudly South African aircraft, which were designed and manufactured by Denel. Big sections of the Gripen fighter jets were also built in Denel Aerostructures for military aircraft; the current project that Aerostructures is engaged in is the design and manufacture of major sections of the A400M.

In the same way that military aircraft have different shapes, sizes and applications, commercial aircraft are the same. Commercial aircraft are mainly used for the transportation of people (called passengers) and goods (called cargo or payload) across different distances (also called range). For the fixed-wing aircraft, the bigger the aircraft, the more passengers and cargo it can carry and the longer the distance it can fly. The smallest passenger aircraft (fixed-wing) are usually private or business jets that carry between 9-15 passengers flying up to 4500 km (equivalent to three trips from Johannesburg to Cape Town). Thereafter, the sizes increase to include regional aircraft that carry 20-70 passengers, flying up to 1500 km (from Johannesburg to Nelspruit 3 times). There are also single-aisle aircraft that carry 70-150 passengers for up to 2000 km. Finally, there are the twin-aisle aircraft that carry 150-500 passengers and are capable of flying from one continent to another.

On the commercial side Denel Aerostructures manufactures very important sections of private jets. The company is planning to manufacture frameworks for both regional and single-aisle aircraft.

Denel Aerostructures manufactures parts of the manned aircraft at their Kempton Park campus under their slogan 'Make them fly'. Situated next to



How a helicopter flies

them is Denel Aviation which is responsible for the maintenance of the aircraft under the slogan 'Keep them flying'. Denel Aviation also has pilots who test and operate all the different aircraft.

In aviation there is a term 'aerodynamics', which the Collins English Dictionary defines as 'the study of the dynamics of gases, especially of the forces acting on a body passing through air'. That is why it is said that an aircraft is aerodynamically shaped. It is shaped and structured in such a way that it is able to deal with the forces acting upon it while in flight. When an aircraft is designed and built the following must be taken into consideration: the maximum speed of the aircraft, the maximum altitude (height), and the maximum weight of the aircraft (including passengers and cargo) and the total number of years that the aircraft needs to keep flying. On average an aircraft flies at a speed of 850 km/h at an altitude of 41 000 feet (12 km) above the ground. It is for this reason that aircraft require complicated concepts, designs and building processes in order to fly the way they do.

For companies like Denel Aerostructures there are two ways that an aircraft can be built. Firstly, it can be by way of a "built-to-print" like the Gripen fighter jets and the Agusta 109 LUH light utility helicopters that the South African Air

Force is currently using. This means that the manufacturer is given the design drawings of the aircraft by a company that owns the design of the aircraft. Such a company is called an original equipment manufacturer (OEM). All that the builder has to do is to study the designs and decide on the machines and methods to be used to build the aircraft to an exact match of the design of the OEM. It is like a builder of a house who gets the plan from the architect to build the house. The builder needs to have the training and skills to be able to interpret the drawings of the architect's design.

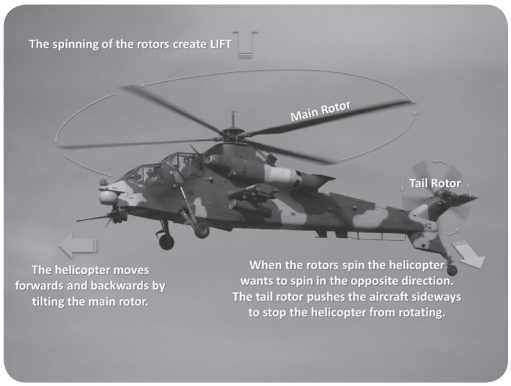
Secondly, an aircraft can be manufactured by way of "designed-to build" meaning that the designers and the manufacturers of the aircraft are the same service provider. With the A400M Denel manufactures critical parts of the body and send them over to the Airbus plant in Europe. Like completing a jigsaw puzzle, Airbus integrates (joins) the parts that were designed and manufactured by Denel into the final body of the aircraft.

The plant where this integration (joining of parts) occurs is called the final assembly line (FAL). Together with seven other companies from seven different countries, Denel is a design and manufacturing partner of this high technology, modern heavy lift aircraft. The learner should be aware of how global our economy is. One aircraft can be built by different countries. Besides the eight different design partners, many other companies across all continents make smaller parts for the A400M. Different to these many other companies, Denel Aerostructures, together with the seven other design partners, manufactures very large, complex and flight-critical parts. If these parts fail to work while the aircraft is flying, then the aircraft will fall from the skies orfail to land safely.

Denel Aerostructures specialises in the design and manufacture of parts

that enable the aircraft to take advantage of the air flowing around the aircraft in order to make sure that it lifts into the sky and can be controlled by the pilot. These parts are referred to as flight control surfaces. In many instances, these parts are the wings and smaller parts around the wings.

A fixed-wing aircraft has a set of two big wings on either side of the body (also known as the fuselage). At the back of the fuselage (round body of the aircraft) the fixed-wing aircraft has another set of two wings. One wing is horizontal (lying flat) and the other is vertical (standing up). Combined, these two wings make up the tail of the aircraft and they are jointly called the empennage; they serve the purpose of keeping the aircraft stable when it is flying. The vertical wing (stabilizer) has a small part called the rudder. This rudder is the one the pilot uses to gently turn the aircraft to either the left or the right just like a fish would use its tail to turn in water. When he turns the rudder to the left the aircraft gently turns to the right and when he turns the rudder to the right then the aircraft gently turns to the left. The big wings on either side of the aircraft fuselage serve the purpose of lifting the aircraft up or allowing it to drop. These wings have smaller movable parts called flaps. These parts can move up or down to allow the pilot to lift the aircraft, to slow it down or to make the aircraft make sharp turns to the left and the right. When the pilot has to make a sharp turn to the right he will open only the flaps on the right wing. The air that is flowing below the wing is then trapped through the flaps and makes the aircraft slower on the right side so that it can turn to the right. This is the same when the pilot turns the aircraft to the left. This is all about managing and manipulating the airflow around the aircraft in order to control it.



If any of the wings fail or the rudder or even the flaps fail, the pilot cannot manipulate the airflow. This means the pilot may not be able to control or land the aircraft safely. It is for this reason that Denel employs highly skilled and bright people in order to make sure that these flight control surfaces (wings, flaps, empennage, rudder, ailerons, winglets, wingtips etc.) are designed and manufactured in the best way to make sure that they never fail while in flight. Another interesting fact about the aircraft's big wings is that, not only do they help to control the aircraft, but they also serve as fuel tanks for the aircraft.

Large aircraft such as the twin–aisle aircraft store about 100 000 litres (same amount as water in two large household swimming pools) of jet fuel that is kept in various pockets and compartments of the wings. That means that these wings must be able to withstand the weight of the fuel plus the splashing of the fuel inside the wing (called sloshing) when the aircraft is in flight. Most critical of the wings is their ability to store the fuel without leaking, otherwise the aircraft would run out of jet fuel while in flight. The issue of weight is one of three critical aspects that define the requirements for the design and the functionality of aircraft. These aspects are: fatigue, environmental elements and the weight of the aircraft alone, not taking into account the weight of the fuel, passengers and cargo (also

called payload). For military aircraft, the payload includes the weapons that are mounted onto combat (attack) aircraft.

Firstly, on the issue of weight it should be noted that the heavier the aircraft (body of the aircraft including its passengers and cargo) the more fuel it burns in flight, meaning that the lighter the aircraft the less fuel it burns. Jet fuel is very expensive, much more expensive than motor vehicle fuel. Designers and manufacturers of aircraft, like Denel, must continuously find ways to build aircraft that weigh less and less in order to make it cheaper and more economical to fly. Even with the aircraft weighing less it must be strong enough to fly for many years. Over the past fifty years, companies like Denel have been increasing the use of two types of materials that are light but strong.

The framework (the bones and skeleton of the aircraft) is built from aluminium, the same material that is used to build motor cars, cool-drink cans and window frames. The aluminium for aircraft is however stronger and more durable than other aluminium materials. The skin of the aero structures is predominantly built from composite materials. These are plastic materials similar to the material used to build car dashboards. They are called composites because they are composed (made up) by bringing together a number of other materials and then baked into the shape and form required by the designer (like mixing flour, milk and sugar to bake a cake). More than 80% of the structure of the aircraft is made from

aluminium and composites. New aircraft designed in the past ten years (and for the future) are made from more composites than aluminium. The reason is that composites are lighter than aluminium and can be formed into various complex shapes and have the ability to be stronger in specific areas compared to aluminium.

Secondly, there are environmental elements that affect the aircraft when in flight. These factors are temperature, high winds (also called turbulence), moisture in the air (including rain), heat of the sun and objects like ice crystals and birds that hit against the aircraft body when in flight. Chemicals like jet fuel and hydraulic oils are strong and attack parts of the aircraft whenever there is a leak. Therefore all these aerostructure parts that are manufactured from aluminium and composites may be strong, tough and light, but they require special treatment to be able to withstand all these environmental elements. If not protected, then these parts will weaken and fail when the aircraft is in flight. Special chemicals like chromic acid and sulphuric acid are used by Denel to make the aluminium withstand rust and other chemical attacks.

Thereafter special paints are used to further protect both the aluminium and composite materials. There are paints that resist fuel and hydraulic oil attack. Other paints resist the heat from the sun and the jet engines. Other paints are specially made to resist the cold temperatures of up to minus 58 degrees Celsius when the aircraft is flying at 12 km above the ground, at 900 km/h. Considering that water freezes at 0 degrees Celsius and that the average home chest freezer runs at minus 18 degrees Celsius, it can be understood how cold the aircraft gets when in flight, meaning the paint needs to be really strong to protect the skin and frame of the aircraft.

The last type of special paints are designed to protect aircraft skin and frames against abrasions and impact by ice, birds and debris that the aircraft collides with while flying at high speeds and high altitudes. When all the special protective paints have been applied to the aircraft, the last type of paint used is decorative paint, which gives the aircraft an aesthetic look. In military aircraft, such paint will be the green and brown camouflage paint that gives the aircraft a recognisable standard look plus allows it to blend into the bush (jungle) environment.

The third aspect that affects the design and functionality of the aircraft is fatigue. The constant, repeated exposure of the aircraft to high speeds, heavy loads (passengers, cargo and the body of the aircraft), cold temperatures, low pressures, vibrations of the body and impact by debris stresses the body of the aircraft, slowly making it weak over time, which may lead to failure. This stressing is called fatigue and the weakening of the structure is referred to as aging.

Considering that an average aircraft flies for thirty years before it is retired, the amount of fatigue that the aircraft endures must be taken into account by companies like Denel, when they design and build aircraft, to ensure that none of the critical parts fail due to fatigue while the aircraft is in flight. The heavier the body of the aircraft and its cargo and passengers, the more fatigue it will endure. The more complicated the flight manoeuvres (moves) that an aircraft makes, especially when heavily loaded and at high speeds, the more fatigue the body of the aircraft will endure.

These three aspects make it clear how complex and strong aerostructures need to be in order to perform as designed for as long as is required.

CAREER REQUIREMENTS

In order to work in an environment such as Denel Aerostructures the following is required.

- Disciplines – mathematics and science;
- Process engineers – industrial engineers, quality engineers, special process engineers and project engineers/managers who define the control of processes to manufacture aircraft;
- Design engineers – mechanical engineers who specialise in aeronautics and then become aeronautical engineers. As an aeronautical engineer one can specialise as a stress engineer (analysing fatigue) or a designer specialising in aerodynamics;
- Production (building) engineers - manufacturing engineers who interpret the design and compile the recipes (machines and steps) to build the aircraft parts;
- Process control engineers – chemical engineers, metallurgical engineers, mechanical engineers and non-destructive testing engineers. They test samples of aircraft parts to verify the strength and durability of the parts (fatigue);
- Industrial engineers – establish the facilities to build the aircraft;
- Artisans and technicians – sheet metal, composites, assembly aircraft machinists, tool designers, spray painters. They are the people who build the actual aircraft parts.

CHAPTER 7

HOW AIRCRAFT ARE KEPT FLYING

"We keep them flying."

Designing and building aircraft is only the beginning of the process required to 'keep them flying'. To keep an aircraft flying it has to be airworthy just like motor vehicles have to be roadworthy for them to drive on the road. So when an aircraft is designed it is designed to have what is called a design life. This means that it is designed to fly for a certain period only; life span measured in hours of utilisation or calendar months. Let's break this down further: what are the actions required to be undertaken to keep an aircraft flying?

The company responsible for flying an aircraft has to perform all the necessary actions to enable an aircraft to take off and land safely without injuring passengers or people on the ground. The company designing the aircraft, i.e. the manufacturer has the responsibility to define for those who will fly the aircraft which parts of the aircraft require maintenance and more importantly how to perform that maintenance and when the maintenance is to be undertaken. The manufacturer also has a responsibility to keep a record of all the work performed according to the design and continually to monitor the usage of that aircraft. This monitoring is to ensure that all the parts are behaving in the expected manner. If at any time any item on

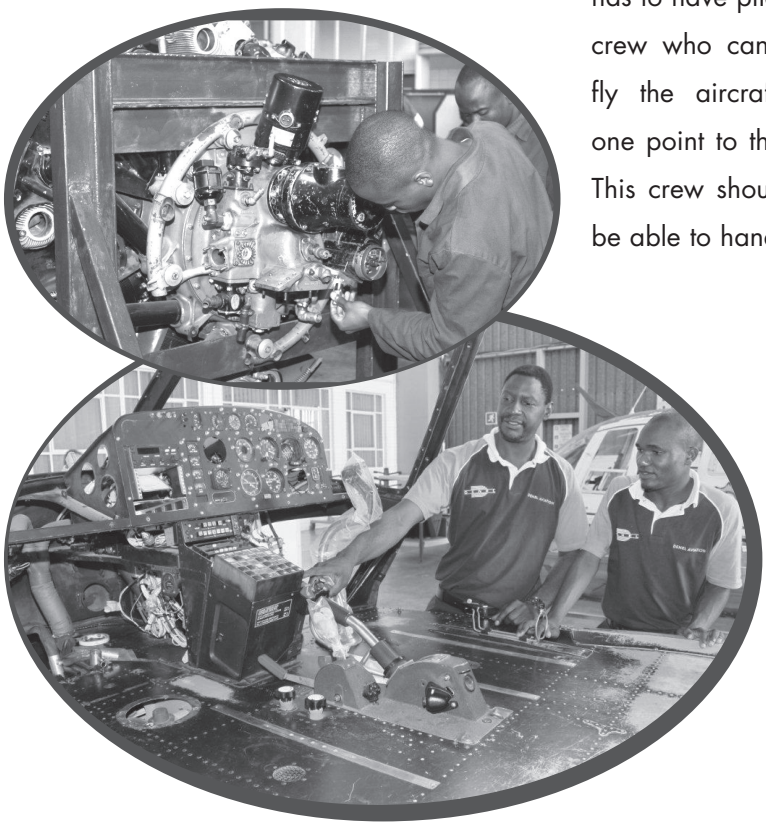
board the aircraft does not perform as designed, the manufacturer can redesign, change the structure and correct the item. If the manufacturer thinks that this could affect the flying safety, the manufacturer, through the Safety Authority (the organisation regulating aircraft safety) can issue an instruction for corrective action.

Normally the manufacturer of a car is not always the one that attends to the maintenance of the car. When one's car needs a service, one does not usually go to the manufacturer for this. It is so in the world of aviation. The manufacturer of the aircraft is not necessarily the person who does its maintenance. However, these two work together. The people who **maintain, repair and overhaul (MRO)** aircraft perform four tasks: maintenance, preventative work, scheduled maintenance, and emergency or unscheduled maintenance. The MRO uses the techniques and processes developed by the manufacturer to ensure that all the maintenance is performed correctly.

The MRO has technically trained, qualified and skilled persons working with the aircraft on a daily basis. The MRO is in a position to tell the manufacturer how to perform tasks, both maintenance and repair, learnt or discovered during in-service maintenance activities, which are outside the scope of the normal documents and books. The MRO has the ability to change the structure of aircraft provided the authority approves, as well as recommend and design, either with the manufacturer or alone, structural

changes or product improvements. Both the MRO and the air operator (normally the company flying the aircraft) are responsible for testing the aircraft after maintenance.

We have defined what the manufacturer's role is and what the MRO's role is. However these people do not fly the aircraft. It is the aircraft operator who does the flying of people or goods from one place to another. The aircraft operator would typically be an organisation like South African Airways. They fly aircraft under the approval of the authority. This means they need to have a licence to be able to fly aircraft. The aircraft operator has to have pilots and crew who can safely fly the aircraft from one point to the next. This crew should also be able to handle any



situation that arises during the flight, most importantly, since the world is not perfect, emergencies may arise. The aircraft operator provides specific information to both the manufacturer and the MRO for the general upkeep of the aircraft and defects reporting. So the aircraft manufacturer, the aircraft operator and the MRO form a triangular link (they are three, hence triangle) to make sure that the aircraft is safe to fly.

In the aviation world, safety is non-negotiable. The triangle of the aircraft manufacturer, the aircraft operator and the MRO is monitored. There is an authority which regulates this triangle. In South Africa the regulator is the Civil Aviation Authority of South Africa (CAA). Aircraft flight is complex and all persons involved have a desire to make it as safe as possible; therefore an additional independent oversight organisation like the CAA is required. This body is part of the State. The only interest this body has is flight safety. This body ensures that all persons working on aircraft are adequately trained. They also investigate and monitor all aircraft incidents and accidents and come up with ways of ensuring that the chance of these incidents or accidents being repeated is minimised.

How are aircraft actually maintained? Cars are serviced to keep them running, to keep them safe and to prevent unexpected breakages.

When parts of aircraft are designed there are time limits for these parts measured in flying hours or calendar months, whichever comes first. Therefore certain parts need to be changed or repaired at a predetermined time. For example the cam belt that drives the engine of a car must be changed when the car clocks a distance of 100 000 km. One can continue driving the car and not change the belt, but that might affect the performance of the engine and cost the owner of the car more money to get a new engine. One can imagine how important it is to maintain an aircraft that flies in the air and has no chance to stop on the side of the road to fix a problem.

One takes a car for a service not because it is damaged. The manufacturer designed it so that when it has done a certain distance, specific maintenance for that distance must be done. It is no different with aircraft. There is a predetermined safety margin. The medical profession encourages people to have a yearly medical check-up, not because they are feeling ill; but just to ensure that all is well with their bodies. With aircraft maintenance the MRO does not only change the parts as per the manufacturer's instruction, but the MRO will look at all other things. The manufacture will spell out after how many flying hours the aircraft has to be maintained. They will also spell out what is called calendar limits. This means that if the designer predetermines

the shelf life of an aircraft as four years, even If the aircraft operator buys the aircraft and does not use it for four years, the aircraft will have reached its calendar limit after four years and the manufacturer cannot guarantee its safety in the air.

With aircraft maintenance there is scheduled maintenance, unscheduled checks and emergency checks. A scheduled maintenance will typically be what is in the maintenance manual directing after how many flying hours maintenance work should be done. Unscheduled checks are similar to when one goes to the garage to fill up with petrol. Tyre pressure, oil and water are also checked. This is done every time an aircraft lands and before it flies. Emergency checks will be done when an aircraft cannot fly because of some unexpected technical fault.

If there is a problem with any system during aircraft maintenance technicians will attend to that problem guided by approved maintenance manuals and standard operating procedures. If they are unable to resolve the problem they call in aircraft engineers who will look at the detail design and improve on the part or maintenance procedure and define how the part should be fixed. They may even change the maintenance manual and maintenance bulletin, which may be an improvement for the aircraft. The manufacturer will report this information to the Civil Aviation Authority (CAA) and distribute it to all MROs that maintain that type of aircraft to ensure that they use up-to-date maintenance information and practices.

Aircraft are designed in such a way that if any part does not work, there must always be an alternative way of making it work. The term that they use is redundancy – if everything else fails there is always a mechanical way of doing it, which is a back-up system.

Maintenance work includes checking things like tyres, landing gear, wings, engine and gear box. To be a maintenance technician one must be able to give attention to detail. There will always be two technicians who will check the same thing to ensure that it is correctly done every time. One technician will check and when he is done another will check the same things to make absolutely sure that all is well. After this there will be another person who does quality control to check what the other two technicians have checked. Recording of everything that is done on the aircraft is extremely important. When anything happens with the aircraft, the MRO or the manufacturer or the aircraft operator has to have a record of what was done on the aircraft and by whom; it is called traceability.

CAREER REQUIREMENTS

Minimum requirements to work in this environment as a maintenance technician are Grade 12 with mathematics and physical science. Post Grade 12 there are two ways to qualify as a maintenance technician. One way is to go through a technical academy like Denel where apprenticeship is done. Once this is complete a trade test is done, and one can apply to the Civil Aviation Authority for a licence. The licence is renewable every twenty-four months to ensure that the licence holder is still current and up to date with maintenance requirements, practices and competency.

The second way is via a technical university where one can do mechanical, electronic or electrical engineering. After going through a technical university, one still has to go through the process of apprenticeship, trade test and licence application like the first one. Either way, one can always study further to do more advanced courses.

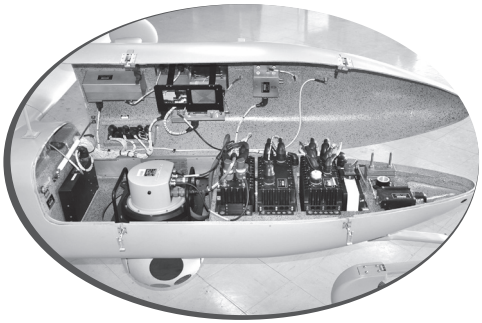
CHAPTER 8

UNMANNED AIRCRAFT

The name of these aircraft is self-explanatory. They are called **unmanned aerial vehicles (UAVs)**. They move (vehicles) in the air (aerial) and they have nobody inside them (unmanned). Unmanned Aerial Vehicles (UAVs) are used when it is too dangerous for human beings to go on mission or do a specific job. They are also used when the mission is a dull one, i.e. boring but necessary. It could be that certain areas must be studied where the UAV has to fly for hours on end. A normal human being can only concentrate on flying for a maximum of six hours.

The size of a UAV can be as small as a bird or as big as a Boeing aircraft. So it can be any size. Boeing UAVs are used for reconnaissance (the process of obtaining information about the position of an enemy). It can also be used with dolls which simulate human beings to test how people can survive when a normal plane with passengers crashes, i.e. used for experimentation.

Some UAVs are unobservable by radar (radar system is addressed in Chapter 4). Most of the ones we have in South Africa are for surveillance of ground based targets. One can



use them to get a picture of one's battle forces. The UAV has a video camera inside it. These cameras can work both day and night. At night the camera on the UAV is heat sensitive. It can detect a human being, a vehicle or an animal. During the day the UAV uses a colour camera. It produces the same picture quality as the ones produced by our television cameras. Video can also be in high definition HD which means the video pictures are of a very high quality.

A little bit of history on the UAVs in South Africa will be helpful. They were started in 1977 at the Council for Scientific and Industrial Research (CSIR) National Institute for Defence Research (NIDR). The department is now called Defence, Police, Safety and Security (DPSS) within CSIR. During that time the then South African Defence Force was engaged in a war within its borders. Soldiers died. Aircraft were shot down. In the National Institute for Defence Research there were a few people who thought that there was a need for UAVs.

Prof Piet Stoker, Mr Charl Veldman, Pet Jonker and Hannes Gouws were the people who believed in the need to have a UAV. They started building a UAV after their normal working hours. They did this because the NIDR was just a research institute and not a manufacturing plant. Also, their idea did not have support because there was no formal request for a UAV from any quarter.

They built the first UAV airframe to prove the concept. That airframe was flown at the Orient Gliding Club near Krugersdorp for the first time in

1977. It weighed 90kg and it flew for about a minute and a half. It flew only about five meters from the ground. Talk about the Wright Brothers of South Africa! It was too heavy to fly. The weight was then reduced to 70kg. They flew it again three months later. Col Jan Pieterse of the anti-aircraft artillery started supporting the project. This time they flew the UAV at Leandra in Mpumalanga at an airstrip. This flight, the second one, was successful. It flew for about ten minutes – doing orbit flying. The UAV flew at about 200m from the ground. It was done like radio controlled model flying. A person on the ground controlled the aircraft with a transmitter sending commands to a radio receiver in the aircraft.

Although successful it crashed accidentally on landing. It was redesigned and built with composite (glass fibre) material to optimise the mass, i.e. it had to be both strong and light. Two prototypes were built out of composite material and these were flown at Gelukspan near Bothaville in the Free State in 1978 because it was a big open area. The flight test was successful. At this stage the team thought they had a UAV system. In 1978 NIDR was transformed into a company called Brimstone Projects, which later became Kentron (a division of Denel). The first CEO was Mr Clyde Ivy. Clyde pointed out to them that if they had a UAV that flew they had only about10% of the work done to get to a UAV system. In about 1979 a UAV system was bought from an overseas company and they used it to learn about everything that was involved in building a UAV system.

In 1983 a new complete UAV system was built consisting of the following:

1. Ground Control Station (GCS) – the pilot (based in the station and not in the UAV) controls the UAV, the observer controls the

payload (camera), and the communication technician looks at the technical aspects of the UAV, checks the communication between the station and the UAV and checks if all is fine during the flight. The pilot controls the UAV through an autopilot. In the GCS the pilot has flight instrumentation that gives him information about the attitude, airspeed and altitude of the aircraft. The autopilot will keep the UAV in a safe flying mode while the pilot only needs to tell the UAV how fast, how high and how far it must fly. Other instruments in the MCU (Mobile Control Unit) give the pilot information on the UAV engine speed and temperatures.

2. Tracking and Control Unit (TCU) – it is separate from the ground control station although the two are connected by a cable. It has transmitters, receivers, directional antenna (dish antenna that always point towards the aircraft) and Omni antenna (in all directions). The main purpose of the Tracking and Control Unit (TCU) is to communicate with the aircraft using radio waves.

   This unit transmits radio waves; incoming radar guided missiles can lock onto the antenna and destroy the TCU. To protect the people operating the system this unit stands separate from the MCU and no-one is in the unit during operations. The TCU is positioned on the ground to very accurate known GPS coordinates. By measuring the angle of the dish antenna and slant range to the aircraft relative to the known GPS coordinates, the position of the aircraft can be determined.

3. The GPS system onboard the aircraft also sends the aircraft position back to the TCU to help with the navigation of the UAV.

4. Field Support Group (FSG) – this is where all spares and consumables like fuel and oil for the UAV are kept and repairs to the UAV can be done. It will allow the UAV to operate independently for a month without any logistical support.
5. Normally four UAVs go with the system. This allows the crew to always have a UAV in the air. While the one is flying the other UAVs are prepared for flight. It is possible to have more than one UAV in the air at the same time controlled by one MCU. At the start of the project only black and white cameras (monochrome cameras)were used as the technology had to be developed to make colour and thermal imaging cameras.

The first complete system was commissioned and delivered to the SA Air Force 15 Squadron in 1986. This squadron was based at Potchefstroom Air Force Base. The Seeker System (UAV) has an 80 litre fuel tank (uses the same fuel as we use in our cars) and it can stay in the air for ten hours. It can fly up to 250 km from the ground station. For example one can launch from Hamanskraal in Pretoria and the UAV will reach Polokwane. The only reason that it does not fly more than 250 km is that beyond that it goes out of sight due to the shape of the earth. The curvature of the earth will cut off the signal. The radio waves travel straight and the earth is curved. So if there are children who believe that the earth is flat they have a challenge to increase the distance of flight for the UAVs.

If communication is lost with the ground station, the UAV will automatically come back to the ground station. It is like a pigeon returning home. The operators of the system know how far the UAV is from the ground station by determining how long it takes for a message to be transmitted to

the UAV and back. Remember the bat that is also able to determine how far its prey is by echolocation as discussed in Chapter 4 about radar. That will tell the operators how long it will take the UAV to come back. The antenna, which always looks at the aircraft, –by measuring the angle of the dish antenna and slant range to the aircraft relative to the known GPS coordinates, the position of the aircraft can be determined.

Today the UAV uses the global positioning system (GPS) to navigate back and forth. So one would just dial the GPS co-ordinates and the UAV will fly there and back because it is programmed to recognise the GPS co-ordinates of the ground station. Various systems onboard the UAV help to navigate it. One of these systems is an inertial navigation system that works with gyros and accelerometers to determine the position of the UAV. So in the case of a war the UAV does not have to rely on GPS to navigate as the GPS can be cut off.

The content or payload of the UAV can consist of – firstly, Synthetic Aperture Radar (SAR) builds an electronic picture for the observer to see what is on the ground. This radar can see through clouds, meaning it

can fly above the clouds and still take pictures on the ground. Secondly, there are electro optical cameras that can take pictures both at night and during the day. Thirdly, it has a system (Electronic Surveillance Payload) that will be able to detect whether there is any radar on the ground. It has a data base of radar, so it can locate the radar and its name.

There is an external pilot who takes off and lands the UAV. However there is already an automatic take-off and landing system. The external pilot then acts as a back-up in case the system fails. The UAV can also be launched into the air with a pneumatic launcher (launcher working with pressurised air) and recovered with a parachute. Two different types of parachute are used. One is a round parachute that is normally used to recover the UAV if there is a failure onboard and the UAV can't fly anymore; the other parachute is a steerable parachute that can be controlled to land the UAV in a specific area.

The UAV is mainly used during wartime to get information about enemy movement or to determine whether one's bombs are falling on or near the enemy. The UAV can measure the fall of shot very accurately and then calculate the correction that must be made by the canon to hit its target. During peace operations UAVs are also used to find rhino poachers, to check who gets in and out of the country over our borders during election time, monitor illegal activities like abalone poaching off the Cape Coast, and to detect forest fires (UAV can see someone lighting a fire). At national parks, using a UAV, one can see the hot area where, for example, an elephant has left its droppings.

It is possible that the inventors of these UAVs studied the migration patterns of birds. For example swallows of northern Europe may fly 11000

km to Africa during winter. Then they return to Europe. There is a proverb 'one swallow doesn't make a summer'. It simply means that seeing one swallow is not a sign that summer is here. One has to see many swallows to conclude that summer is here. They come to Europe in summer and they usually migrate in large flocks. The human race does not yet understand the whole concept of bird migration. The birds use stars and the sun as their navigational aids. They also have some kind of internal magnetic compass. In the book entitled *Exploring the Secrets of Nature, 1994* by Reader's Digest the following is written:

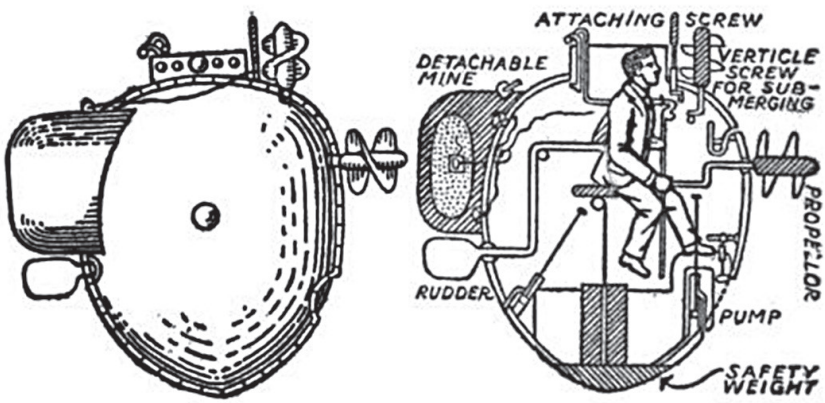
> 'A crowd of Manx shearwaters – these birds are famous navigators. One shearwater was transported across the Atlantic from its nest burrow on neighbouring Skokholm Island to Boston, Massachusetts, and then set free. After 12 days the bird had returned to base, having beaten by 12 hours the letter informing Skokholm of its release.' p378

The homing instinct of pigeons is proverbial and has been researched by man for centuries. Learn to observe nature. Maybe you, as the learner, might come up with some solution to some of the problems of mankind.

CHAPTER 9

THE SUBMARINE

The sea occupies about 71% of the surface of the earth. Mankind has always been fascinated by what is under the sea. The first submarine recorded in history was designed by a man named David Bushnell from the United States of America and was dubbed the Bushnell Turtle because it had to come up to breathe just like a turtle and also because of its look in the water. A submarine is shaped like a bullet in order to make it **hydrodynamic**. An aeroplane is shaped like a bird because it is **aerodynamic**. While we dealt with aircraft flying in chapter 5, here we deal with a submarine, which can be considered to fly underwater.



The Turtle Submarine – 1776

The primary use of the submarines is warfare. In warfare submarines are used to find surface ships and target them. Submarines are able to hide themselves under the sea. They have the element of surprising the enemy because they can hide under the sea. In the early years of submarine warfare a long pole was fitted on the submarine with an explosive attached at the end. The long pole was used to ram the ship with the explosive. This method was not very successful because in some cases, it would sink the submarine itself.

Other modern uses of submarines are for exploration of the ocean. They are also used to research the seabed and for recreational purposes as well. Submarines used for recreation purposes have windows. Naval submarines are built to take a weapon to sea to sink other ships in order to stop trade going to one's enemies. Merchant ships would be targeted as well as oil tankers – the economy of the enemy can be brought to a standstill when this happens. Other uses of naval submarines include surveillance and reconnaissance, mine-laying and clandestine operations.

How does a submarine work? A submarine is fitted with special tanks on the outside of the pressure hull (the inside of the submarine) which must withstand the pressures of the sea. On the outside of the hull there are tank spaces that carry fuel, air or water. The tanks are permanently open at the bottom. They are called ballast tanks. They are used for two things only: diving and surfacing the submarine. They do this by changing the weight of the submarine. There are also openings at the top which can be closed or opened.

When a submarine needs to dive, the top valves (openings at the top of the ballast tanks) are opened so that the air in the tanks is forced out of the top opening and sea water is forced into the bottom opening of the

tank. Once these tanks are full the submarine will be the same weight as the water and will slowly lower itself (submerge) into the water using the motor. One can alter the depth of the submarine either deeper or shallower. Once the submarine has dived the top valve is closed. The same tanks will be used to empty the water if the submarine has to be resurfaced. There are air bottles all over the submarine, called compressed air bottles, to provide a lot of air so that the submarine can resurface if need be. Valves are opened from the compressed air bottles to supply the ballast tanks with high pressure air, which forces the water out of the tank through the bottom holes making the submarine lighter; it then pops out (emerges) from the ocean. A compressor compresses air into the air bottles while the submarine is at the surface. The size of the ballast tanks is sufficient to ensure that the submarine will be properly on the surface and can hold sea water weighing about 10% of the weight of the submarine.

It is also possible to settle the submarine at the bottom of the seabed. This is normally done purposefully to hide from enemy forces especially to prevent being detected by sonar (sound navigation and ranging) from surface vessels. The submarine is able to disguise itself as part of the seabed. After diving it is important to make the weight of the submarine the same as that of the water (the submarine is neutrally buoyant, i.e. it is not going up or down). This is done by stopping the motors and increasing the weight slightly for it to slowly sink to the seabed. There is a tank inside the submarine called the compensating tank. The water in this tank is emptied or filled to change the weight of the submarine. The more water flooded into the compensating tank, the heavier the submarine will be. The heavier it is, the easier it is for it to go down. One makes the submarine

purposefully heavy to be able to slowly sink it to rest on the seabed.

When a submarine is submerged it conforms to two principles; firstly, the Pascal principle and secondly, the **Archimedes principle**. The **Pascal principle** says that the submarine is subjected to the same amount of pressure in all its surface areas. The lower it gets the more pressure it is subjected to. The hull of the submarine is made in such a way that it is able to withstand such pressures. Remember there is equipment and there are people in the hull that need to be protected. The Archimedes principle says that the apparent loss in weight of a body immersed in a fluid is equal to the weight of the displaced fluid. Said differently, **a body that is immersed in water is equal to the amount of water that it displaces**. Pascal was a French mathematician and a scientist. Archimedes was a Greek mathematician and physicist.

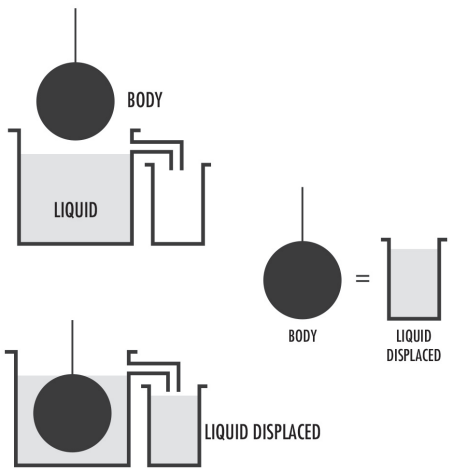


Illustration of the Archimedes principle

When moving in water the submarine should be horizontal, in a straight line. Submarines also have planes that are used to move the submarine up or down and a rudder to move it left or right. Moving the submarine in a straight line may not always be possible in light of the fact that there are people operating in the submarine. Imagine if twenty people moved to the front of the submarine. If the average weight of a person is 70kg that means a weight of 1 400kg will be in the

front of the hull of the submarine. The submarine will tilt, meaning that the trim will alter. The submarine should not move in that tilted position. To correct this there is a different system (called the trim system) of tanks in the submarine that move water to either the front or the back, depending on where the people are, to level itself – weight compensation.

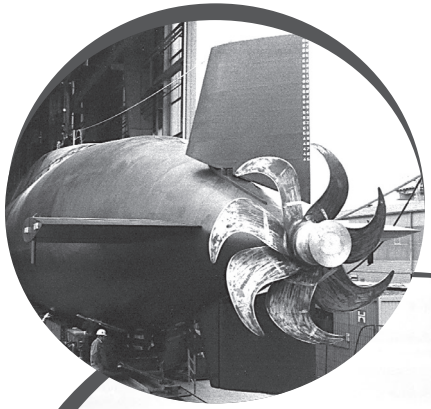
There are, generally speaking, two types of submarines. **Nuclear submarines** are propelled by nuclear energy and conventional submarines are propelled by electrical energy from a battery. A nuclear reactor can operate for as long as twenty years providing energy. It is the ideal submarine because it does not need to surface. There are two reasons why a submarine needs to resurface – to replenish food to feed the crew and to refuel. The nuclear submarine does not need air; it cleans the air in the submarine of carbon dioxide and puts oxygen back to keep the air stable for human consumption and survival.

Conventional submarines need air. Most conventional submarines use batteries to run an electric motor, which turns a shaft that turns a propeller that takes the submarine forwards or backwards. In conventional submarines these batteries must be charged. They are normally charged by a diesel generator inside the submarine. The diesel turns the motor, called the generator, making electrical energy that is sent to the main battery – one battery cell can weigh 500kg and gives off about two volts and there are usually many hundreds of them in a submarine. Although two volts is not a high voltage, because of the high amperage in a battery cell there is a lot of power available and this power is sufficient to melt a spanner if it is inadvertently placed across the terminals. The battery provides a major part of the weight of the submarine. The submarine usually moves only

forwards. Seldom does it move backwards. A nuclear submarine is driven by a nuclear reactor. The nuclear reactor generally produces steam which is used to create propulsion power to the propulsion system.

The fin/sail/conning tower is the part that one sees protruding from the submarine when it is just below surface. It looks like the fin of a fish. It is used when the submarine is on the surface to give the submarine operators height above the water. The submarine is usually controlled by watch keepers at the top of the conning tower when it is on the surface. The conning tower provides access to the bridge of the submarine. There are masts and radar and a periscope to see

THE PROPELLER SYSTEM OF THE SUBMARINE. THIS IS THE REAR VIEW OF THE SUBMARINE.



THE CASING (DECK) OF A NUCLEAR SUBMARINE

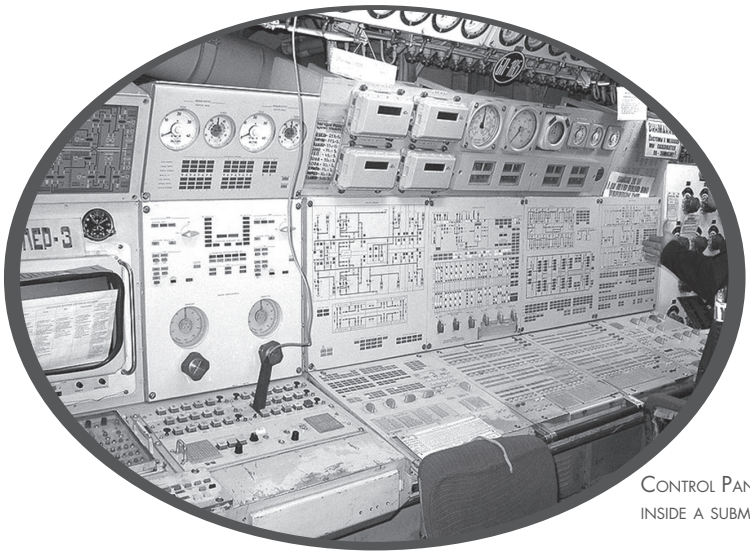
SUBMARINES

what is happening on the surface. During surface operation the boat is controlled from the bridge and monitored by the navigation system. This conning tower is also used to get fresh air into the submarine for the crew when the submarine is on the surface. There is a mast in the conning tower that feeds the diesel with air when charging batteries while the submarine is submerged but near the surface. Communication and other masts are also housed in the conning tower.

Ideally a **submariner** (crew member of a submarine) should be a technically adept and hands-on person because of the vast amount of technology found in a submarine. There are about forty crew members in a conventional submarine. A single crew member does not have to know everything. There are specialists on board. The type of person favoured to be a crew member in a submarine must not be an extremist of any kind. Very normal people are preferred; submariners must not be overly aggressive and must also not be overly pacifistic (believing that violence

of any kind is unjustifiable and that one should not participate in war). Remember that the primary use of the naval submarine is for the conduct of naval warfare.

One normally has to be a good team player in order to function well in a submarine. Submariners must be of psychologically sound mind. Working inside a submarine can cause one to become claustrophobic. However one can get used to working in a submarine even if one is claustrophobic. The submarine casing, (the deck) is almost at the same level as the sea when on the surface. A submariner is expected to work on the deck. So the submariner is somebody who must be comfortable with water. The person must be healthy – remember a submarine is a confinement with many people working in a small space. So the person wishing to be a submariner must be physically healthy to cope with poor air quality and working conditions. The person must be able to flourish in a relatively unhealthy environment. The quality of the stored water in a



CONTROL PANEL
INSIDE A SUBMARINE

submarine tends to deteriorate with time. So being a healthy person is an important part of being a submariner.

It is also important that a submariner is not colour blind. Different colours are used to identify different systems, including oxygen, carbon dioxide, fresh water, diesel and air pressure. So it is important that the submariner knows these colours to prevent unnecessary accidents that can cost the lives of all crew members. A simple thing like lack of oxygen can have disastrous results for a submarine crew and the safety of the submarine. One has to be *au fait* (French for familiar) with symbols and numbering because systems like the cooling system, the oil system, the fuel system and the exhaust gas system are identified with numbers and symbols. One also has to be a person who is always alert. There are many valves that do many things, for instance a fuel valve, a freshwater valve, a seawater valve or a compressed air valve – so one has to know what valve to use when.

As indicated earlier, submarines are mostly designed to take weapons to sea. These weapons can be torpedoes, submarine launched land attack missiles, submarine launched anti-surface missiles and submarine launched anti-air missiles. A torpedo is a bomb that looks like a mini submarine without the conning tower. They are used to sink surface ships and other submarines. They are the most common submarine weapons. They can be used to locate and sink both surface vessels and other submarines. A torpedo has a sonar sensor, a control unit, a warhead, a battery and propulsion. Land attack missiles are used to attack selected targets on land, anti-surface missiles are used to attack surface vessels, and anti-air missiles fired from submarines are generally used to attack anti-submarine helicopters. Being

a recent development, submarine launched anti-air missiles are not very common; they are used more for self-defence than for offensive attack.

Submarine crews normally don't allow less than 17% of oxygen in the air inside the submarine. The carbon dioxide in the submarine must be constantly removed and replaced with oxygen. Oxygen candles are used for this. While they are called oxygen candles they give off heat and not flame because flame would use the oxygen being produced. These oxygen candles are made up of special chemicals that, when started with an electrical current, release oxygen. Carbon dioxide is removed from the air using a machine containing absorption chemicals. A fan sucks in air laden with carbon dioxide; the air is then dragged over the chemical substance, which absorbs the carbon dioxide and then expels the air without carbon dioxide.

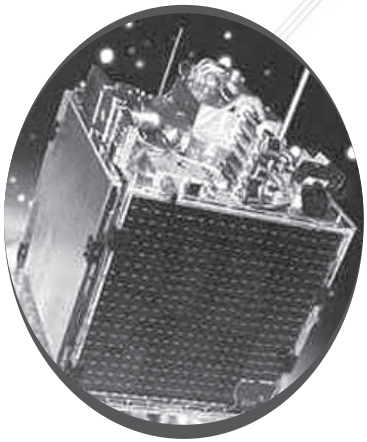
A submarine is a complicated system with a lot of technology in it. This chapter may not do justice to the complication of a submarine. However, the few explanations given here are enough to make you, the learner, appreciate what a submarine is and what it does. For example there is a garbage ejector to remove all the garbage that crew members generate. There is a toilet system that is used by the crew and it functions perfectly well, even in a pressurised environment. There is a shower system that provides every crew member with clean water to shower. There is an air conditioning system. The modern conventional submarine can stay underwater for periods of up to thirty days. It is a whole world on its own. The limitations are food for the crew and diesel for the submarine. Eventually all submarines have to surface. You, as a learner, have the challenge of coming up with technology that will make the submarine

stay submerged for longer without having to come to the surface. Also, improving the means to detect submarines when they are submerged would be a useful endeavour. Currently this is difficult but it is possible. You have the challenge of making that possible. Good luck!

CHAPTER 10

SPACE TECHNOLOGY

What is space technology? Space in this case is **an area outside earth**. The Collins English Dictionary defines technology as 'the application of practical or mechanical sciences to industry or commerce'. In this case we look at how space technology benefits us here on earth. Space technology can be applied to cellphones. It covers a large area in terms of giving services.

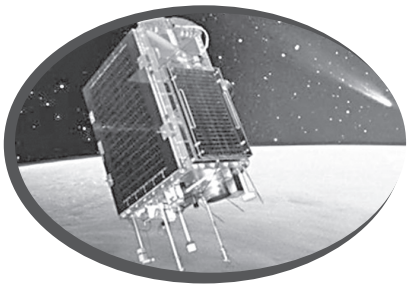


Space is an area outside the earth. Space technology is technology that is placed in outer space (outside the earth) and will provide services to the citizens of the earth. These services range from communication: cell phones, mobile radios, internet; navigation such as GPS (Ground Positioning System) and DSTV. When one makes a telephone call from South Africa to overseas one goes through space via something called a satellite.

When one has DSTV at home, there is a satellite in space that beams television signals, which are received by the DSTV satellite dish at home and then one sees the TV picture in one's room.

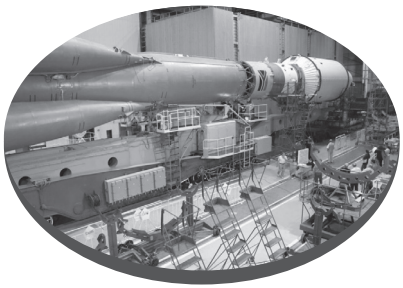
A satellite is a base station that connects the communication lines all

over the world. A satellite is sent to space to regulate this communication. It can stay for anything between three to fifteen years in outer space. When a satellite is sent into space **it must be continuously spinning around the orbit of the earth**. If it stops spinning it will drop down to earth and injure people. It is controlled from the earth through a **Mission Control Station**.



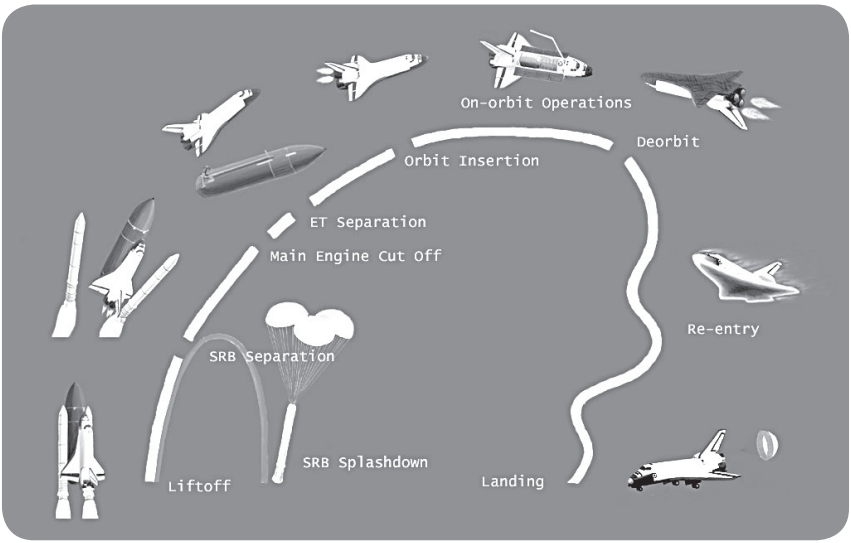
SUMBANDILASAT IN SPACE SATELLITE IN SPACE

South Africa has sent two satellites into space. The one is called SUNSAT 1 (Sun Space Satellite) which took pictures of the earth. This satellite was launched in 1999. The second one is SumbandilaSat which was sent into space in 2009 to take pictures of the earth. Sumbandila is a Tshivenda name for pathfinder. The SUNSAT1 was designed to last for only a year in space. It is not returned to earth, but is burnt in space. It is too costly to bring it back to earth. Some satellites can be repaired while in space.



SUMBANDILASAT INTEGRATED WITH THE SOYUZ-2 LAUNCH VEHICLE AT BAIKONUR COSMODROME, RUSSIA

Denel is currently building a third satellite for South Africa to send into space. It is also used for taking pictures of the earth. Why is it necessary



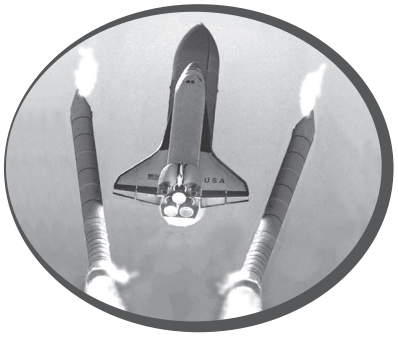
American Space Shuttle Mission profile

to take pictures of the earth from outer space? These pictures are necessary for proper planning in agriculture, mining and water systems (rivers, dams, lakes and seas). These pictures are not taken randomly or for fun. They are taken at specific times and in specific areas. That is why one needs the mission control station to direct the satellite to take the needed pictures.

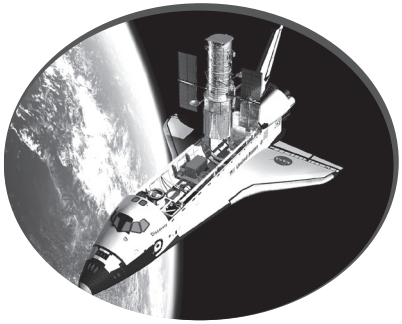
Space Shuttle on a Launch Pad before launch

Some of the uses of space technology are used with ATMs (Automated Teller Machine). When a person needs money from the ATM, he puts in the pin code. This pin code is like making a phone call to the bank. The ATM has a dish similar to the DSTV dish which beams signals to the satellite in space and then the satellite beams the same signals to the bank to approve

Space Shuttle Lift-off



Space Shuttle Booster Rocket Separation



Space Shuttle In-Orbit Operation – Satellite Orbit Insertion

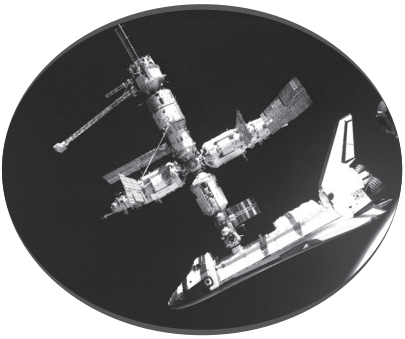
payment of the money requested.

These satellites are like the cell phone base stations that we see around the country. When one makes a call, the signal goes to the cell phone base station, which directs it to the right phone number and the person one is calling receives the call. Of course, depending on the service provider, the user has to pay the service provider for all those calls. It is the same with satellites. Everyone who uses satellite base stations for any form of communication must pay the satellite providers for the services that they render.

The other aspect of space is science missions where research is done. Human beings are curious by nature. So when they go to space it is also to check whether there is life on other planets. There is always the possibility that we might find some kind of solution to some earthly problem.

How do we get a satellite to go into space? Satellites get to space

SPACE SHUTTLE EXTERNAL TANK SEPARATION AND ORBIT INSERTION



SPACE SHUTTLE IN-ORBIT OPERATION – DOCKING WITH THE MIR RUSSIAN SPACE STATION

using space launch vehicles. The common one is the space shuttle used by America.

The satellite is put inside the space shuttle. The space shuttle is launched into space vertically (facing upwards) using rockets (bombs). The place where a shuttle is launched from is called a space port. South Africa has its own space port based in the southern Cape. The reason rockets are used is so that they can propel the satellite at a very high speed to escape the force of gravity. It takes up to about eight minutes for the space shuttle to arrive in space. Once the space shuttle reaches outer space it will open its doors and release the satellite. Then the space shuttle will come back to earth and land at an airport.

For interest's sake, American space shuttles are piloted by people inside the shuttle while the Russian ones are on automatic pilot with no one inside. Defence also uses satellites for communication as well as to take pictures for their own planning.

CAREER REQUIREMENTS

If interested in working within the space technology arena the learner has to do mathematics and physical science. The learner must pass with at least 60% in both subjects. Then the learner can either do mechanical engineering, electrical engineering, aeronautical engineering, chemical engineering or metallurgy. Denel has a space technology department that needs young able people.

Career Disciplines within Space Technology

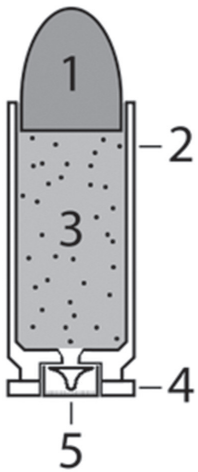
- Materials Engineering – Materials Specialist
- Mechanical Engineering – Structural Engineer, Mechanical Engineer
- Electrical Engineering – Power Systems Engineer
- Electronics Engineering – Digital Systems Engineer
- Software Engineering – Software Engineer
- Chemical Engineering – Propulsion Engineer

CHAPTER 11

AMMUNITION

Ammunition is a term used to describe the complete piece of cartridge case, projectile, primer and propellant. Bombs, missiles and chemicals that are capable of being used as weapons are called munition. This chapter is about ammunition. Some other weapons use more or less the same principle as that of ammunition.

The following picture summarises what is said above.



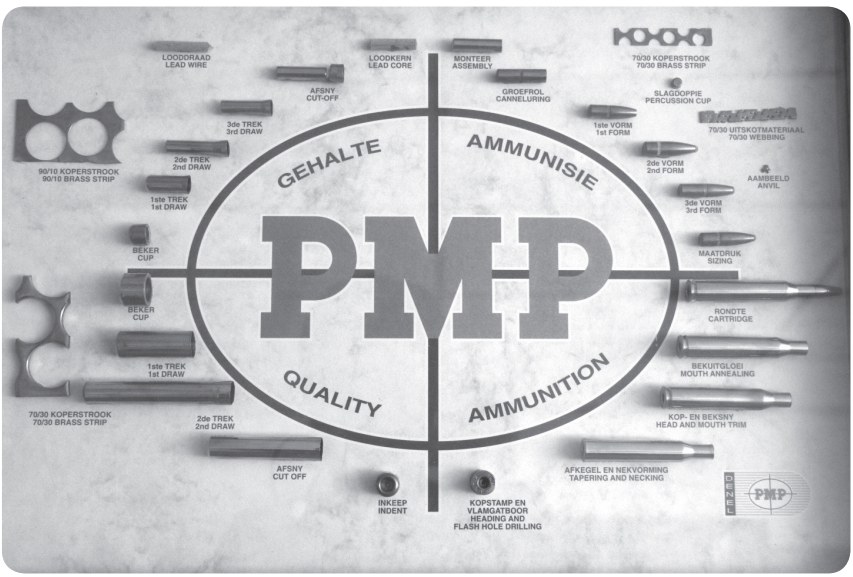
A modern cartridge consists of the following:

1. The bullet, as the projectile;
2. The case, which holds all the parts together;
3. The propellant, for example gunpowder or cordite;
4. The rim, which provides the extractor on the firearm a place to grip the casing to remove it from the chamber once fired;
5. The primer, which ignites the propellant.

Guns use ammunition to shoot. Without ammunition, the gun is pretty much useless. There are many companies around the world that manufacture ammunition. South Africa has its own ammunition manufacturing company called Pretoria Metal Pressings (PMP). It is situated on the western side of Lotus Gardens next to a well-known township called Atteridgeville. In Chapter 15 it is indicated that when a fighter pilot is in danger he might actually leave the aircraft using a parachute. For that to happen, a rocket motor is used to accelerate his seat so that it can be ejected. Denel PMP manufactures the power cartridges that accelerate that ejection seat.

Denel PMP has been in existence for the past seventy years making ammunition for the military, the police and for commercial use, i.e. ammunition for those who hunt animals as a sport. Denel PMP manufactures small and medium calibre ammunition. Small will be anything between

STAGES OF MAKING AMMUNITION



5,56mm and 12,7mm and medium will be anything between 20mm and 35mm. It is interesting that what ordinary people call a bullet is not what the manufacturer calls a bullet. A bullet is the projectile that comes out once the trigger has been pulled. What remains is called a cartridge case, which holds the propellant; primer and a bullet(check the diagram at the beginning of the chapter).

The above diagram is an interesting one. The bottom part of the diagram shows the stages of the cartridge case. The first stage is a metal sheet made of brass. It is literally like a sheet we use on the bed.

Cups for Cartridge Cases

It is in brass. Between steel and aluminium, brass remains the best material because of good forming (extruding) capabilities. The brass is extruded(squeezed or forced out)into cups as the diagram above shows. Once the cup is cut there is what is called the first and the second draw. A machine literally takes the small cup that one sees on the diagram and elongates it twice. Before the cups can be used to draw bullets or cartridge cases they have to be annealed (softened by heat treatment to remove internal stress and normalise the crystal structure), washed and lubricated. Normally sulfuric acid is used for the cleaning process and a soapy solution lubricates the cups.

Then the tube is cut off to a particular size. The next step is to make an indent at the bottom of the tube. A flash hole is then drilled into the head of

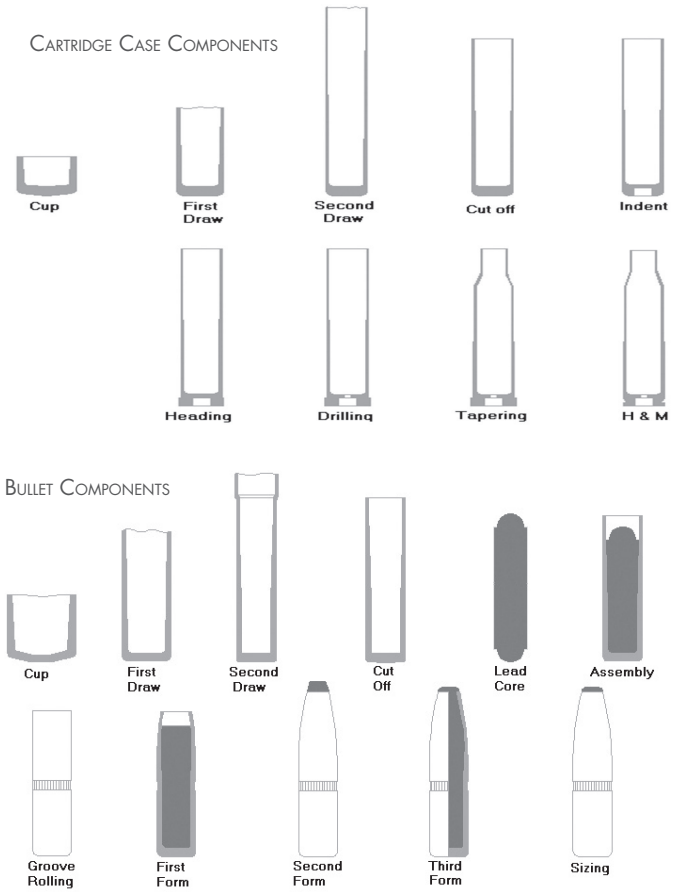
the case. The Afrikaans words are very picturesque. The heading is called *kopstamp* and the flash hole is called *vlamgatboor*. *Kop* is head, *stamp* is to knock; *vlam* is a flame or fire, *gat* is a hole and *boor* in this case is to drill.

The next stage is that the brass is tapered (made narrow) and a neck is formed. This neck is made to accommodate the bullet (the projectile).

The upper part of the diagram also shows the stages of making a bullet, i.e. the sharp part that penetrates the body or any object that is being shot. Like the casing, the bullet is made from a cup that is cut from a copper sheet. Unlike the casing, it has three draws. It is also cut off. The core of the bullet is lead and copper lead assembled. The first, second and third forms of the bullet are made. Then sizing of the bullet is done. That is why one hears about a 9mm gun. That is the size of the diameter of the bullet. Obviously the sizes of ammunition are important so that they can fit into the right size weapon. It is the same as people's shoes. If a person wears a size 7 one cannot go and buy a size 9 or a size 5. This sizing is done by machines to ensure accuracy. Then the bullet is fitted into the tube.

A percussion cup is made by manufacturing a brass cup that is filled with a small quantity of explosives (approximately 20mg); an anvil is also manufactured from brass and is placed inside the primer cup on top of the explosives. The function of the anvil is to pinch the explosives when the firing pin from the gun strikes the primer; the primer detonates, igniting the propellant, which generates gas that propels the projectile (bullet) from the barrel.

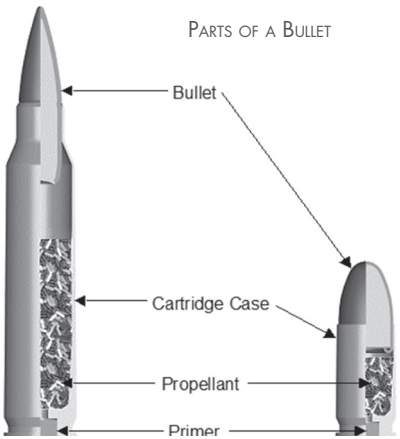
What is not in the diagram is another process where the propellant is loaded in the cartridge case. The complete cartridge has a cartridge case propellant and a bullet. During activation of the primer by the firing pin in the gun, the sensitive explosive composition is pinched between the cup



and anvil with a resultant detonation that ignites the propellant through the flash hole(s). The propellant is lit (on fire) and then propels the bullet from the barrel. What remains is the cartridge case. It is from this cartridge case that investigators can determine what calibre of ammunition was used.

A propellant can be described as a substance or combination of substances, which burns at an extremely rapid, but regular, rate

producing a large volume of gas and evolution of heat. These gases are used to accelerate the bullet in the barrel of the gun. Propellants must be distinguished from high explosives, the reaction occurring on detonation of the latter being altogether too violent for use in a gun. Propellants constitute a particular class of explosive substances, which are designed to burn without detonating.



PARTS OF A BULLET

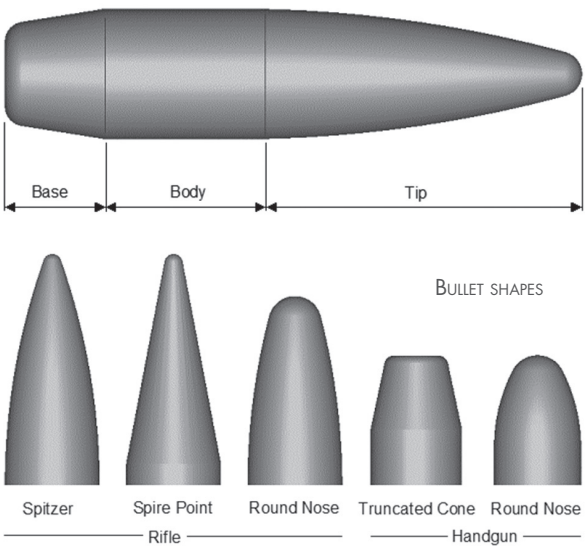
The bullet is the most important component of the cartridge, being the only part that reaches the target; the other components are merely at its service. The term bullet is only used in small arms ammunition. Normally bullets with a diameter of 20mm and larger are referred to as projectiles. The body is the cylindrical part of the bullet and generally goes partially into the case but is in close contact with the case neck. This part determines the bullet's diameter.

Bullet design is determined by ballistic considerations and the type and application of the bullet. Before firing, being firmly seated in the cartridge case, it serves as a seal, which prevents moisture from reaching the propellant charge inside the case, thus ensuring stability and long life to the propellant. During firing, it must travel the expected path to the target, this path being defined by the bullet shape, weight, velocity and also atmospheric parameters, but always after having exited the muzzle of the gun without having suffered abnormal deformations.

Lastly, the main objective is the required effect on the target. This effect

is obtained through the careful design of the bullet's construction, shape, dimensions and weight.It is interesting to note that once the cartridge cases and the bullets are completed, gloves are used to handle these until they are packaged and taken to the buyer.

Denel PMP also manufactures rock drill bits for the mining industry and primary explosives and explosive products. While PMP manufactures ammunition, it also has a test range. This is used to test the ammunition that they manufacture. It is also used by other customers who want to test ammunition of different kinds.



Ballistics is the science of projectiles in motion. This is an area a learner can consider going into.

Internal ballistics is the study of activities within the weapon, from primer ignition until the bullet exits the muzzle.

Intermediate ballistics studies is the motion of the bullet directly after muzzle exit, but while still subjected to the action of the propellant gases. Roughly 75 % of the available energy of the propellant passes through the muzzle of which the majority is retained in the propellant gases in the form of heat, pressure and motion. After muzzle exit the behavior of these gases has considerable influence on the bullet and gun motions. They also give rise to the effects known as blast and flash.

PMP .30 180GR PROAMM SOFT POINT BULLET; RECOVERED SHOWING PERFECT EXPANSION

External ballistics is the motion of the bullet through the atmosphere after it has left the gun (and the influence of the emerging gases) is dealt with – in short, its trajectory. The following are important parameters/characteristics to measure during this phase of the ballistic cycle: bullet velocity, spin rate and drag.

Terminal ballistics may be defined as the study of the effects of a bullet on a target. Wound ballistics form part of this. In addition to accuracy and terminal velocity, various terminal effects need to be studied such as penetration and expansion and mass retention for expanding type bullets. Learners will remember that a ballistic expert was called to describe the effect of the bullet/s that Oscar Pistorius shot at Reeva Steenkamp.

The diagram above shows what can happen to a bullet in an animal after it has been shot.

CAREER REQUIREMENTS

A minimum 60% pass in mathematics and physical science remain standard on most technical careers within the defence environment.

The following career opportunities are available in the ammunition manufacturing environment:

Mechanical Engineering:

- Mechanical Engineer
- Technicians
- Artisans

Chemical Engineering

- Explosives Technology
- Analytical Chemist

Explosive Technologist

- Metallurgist

Inherent Requirements

Mechanical Engineering

- Mechanical Engineer: University degree
- Technicians: University of Technology related qualification
- Artisans: Trade test certificate

Chemical Engineering

- Explosives Technology: University accredited certificate

- Analytical Chemist: University degree or University of Technology related qualification
- Explosive Technologist: University degree or University of Technology related qualification

Metallurgist

- University degree or University of Technology related qualification.

What do ammunition manufacturing personnel do?

Development, maintenance, manufacturing of ammunition, ammunition components, explosives, chemical and metallurgical processes related to ammunition manufacturing procedures, as well as the qualification and testing of small arms and medium-calibre ammunition.

Core Skills

- **Fitter and Turner:** Trade Certificate. Maintains and operates ammunition production machines
- **Gunsmith:** Trade Certificate Testing of Ammunition
- **Toolmaker:** Trade Certificate

As a learner, did you think there was so much to do in the world of ammunition? Also remember that this chapter concentrates only on small and medium calibre and not on explosives. As a learner, career opportunities in this area are countless.

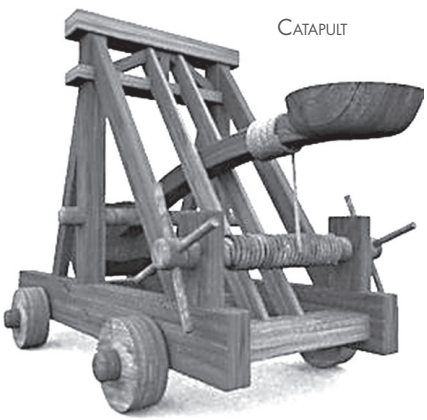
CHAPTER 12

ARTILLERY

Artillery is a term used in the military to describe a weapon that can engage one's enemy or a threat from a safe position at a long distance in an indirect way.

Artillery is a very old concept. The principle of artillery started off in the Middle Ages. The first artillery piece was called a catapult. It was not using explosives at that time. It was there to engage the enemy at longer ranges than a bow and arrow could.

Subsequently artillery developed into a large gun from which round solid steel balls could be fired by means of a propellant. In the modern artillery, steel balls are no longer used. What is used is a projectile shaped weapon, which is launched accurately from a very long barrel and which is filled with explosives, to have a more damaging effect on one's target and on the enemy.



CATAPULT

From the position of the weapon one usually does not see the target. One must have intelligence from the observer's point of view to indicate exactly where one's enemy is. One can then fire in an

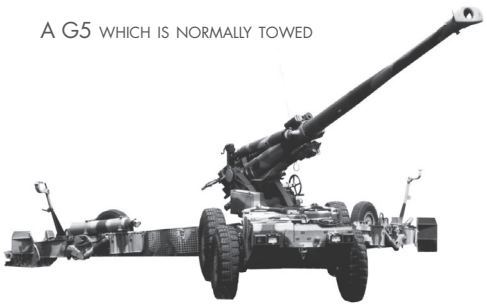
HORSE DRAWN ARTILLERY

indirect mode at ranges of up to 56 km to either harass one's enemy or to inflict as much damage as possible so that the threat to a normal soldier, who has to engage the enemy at short range, is as small as possible. This is fighting from a safe distance and eliminating the threat to infantry (foot soldiers) who normally fight at close range. If one can destroy the enemy with artillery then one can save the lives of infantry soldiers.

Artillery has additional tasks of illuminating the battle field at night and creating smokescreens to hide one's own troops from enemy view. Illumination is done by firing special illumination projectiles over the required area. The illumination candle is deployed by parachute from the illumination projectile and burns for approximately two minutes. This assists one's own forces to identify the enemy and possible threats, as well as making it difficult for the enemy to move during night-time. Smokescreens are normally provided during daytime to screen one's own forces from enemy view. This is done by firing a special smoke projectile that ejects smoke canisters at a predetermined position, which then burn for approximately two and half minutes. By firing illumination and smokescreen in succession they can provide illumination or smokescreen for any required amount of time.

A projectile is filled with explosives. When it reaches the ground it explodes and creates shrapnel that damages one's target. The standard

international colour for an explosive projectile is green, the illumination one is white and the smokescreen one is light green. The projectiles are launched in the same way as a bullet from a rifle, though on a larger scale. So the projectile is launched through the barrel of the gun by the pressure built up by the burning propellant. The propellant will burn out completely. The projectile will leave the barrel and explode when it reaches its target. The speed at which the projectile leaves the barrel is approximately 900m/sec. Put differently, the projectile travels the length of nine football fields in one second. The weight of one such projectile is 45kg, which is almost the weight of a cement bag (a cement bag weighs 50kg).



A G5 WHICH IS NORMALLY TOWED

Artillery guns need to be moved fast from point to point to execute their firing duty as requested by the general in charge of the mission. Artillery guns are heavy and are therefore normally mounted on large vehicles.

South Africa makes a gun called a G6, which weighs 45 tons (45 000kg). The G6 vehicle can achieve speeds of up to 85 km per hour. One of the reasons for artillery guns to be able to move quickly is to avoid being detected by the enemy by means of modern radar systems; if detected enemy artillery could then be directed at one's own artillery guns. In such cases, it is important to move to different positions to continue the firing task. In the olden days artillery guns were drawn by horses, which did not matter, because there was no radar and the guns did not have to move out of position so fast.

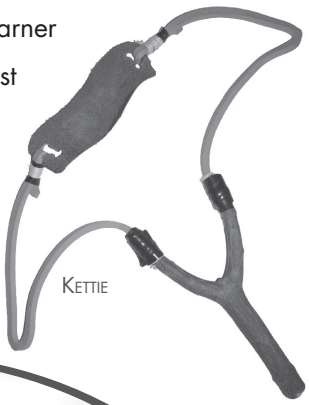
So practically what happens, when firing a projectile, is the following: If one looks at the picture of the G6, one will see a large vehicle with six wheels and a box on top with a long pipe sticking out from the box. The box is called a turret and the long pipe is called a barrel. An artillery gun is also called a howitzer. Inside the vehicle there are normally four people. One is the driver of the vehicle, one is the gunner, one is the commander and one is the loader. The projectile is only fired when the commander gives instructions to do so.

The G6 can move quickly into position and move its turret with the barrel to point in the direction of the enemy. By changing the elevation of the barrel and the size of the charge/propellant, the projectile can be fired at targets that are at different distances from the gun. With artillery there is always somebody who can see the enemy and radio the enemy's position back to the gunner. Computers then do the necessary calculations to determine the position of the turret, the elevation of the barrel and the size of the propellant. The calculations also take into consideration the speed and direction of the winds along the calculated flight path of the projectile. Strong winds can blow the projectile off its intended course and this should be taken into account if one wants to hit the target.

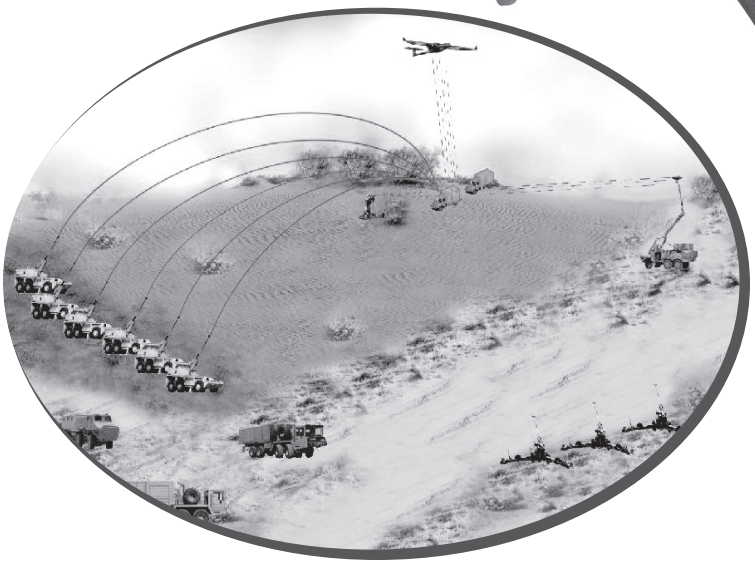
THE G6

The G6 can fire at a target up to 56 km away. South Africa also has a towed howitzer, called the G5. If one looks at the picture of the G5, one can see that it cannot be driven for long distances on its own. It has a small

engine for very short distances. For long distances it needs to be towed by a gun tractor. Otherwise the G5 has the same firing capabilities as the G6. Both the G6 and the G5 fire projectiles with a diameter of 155mm. The projectile is filled with explosive material which explodes when the projectile reaches its target. It is this explosion which causes the damage in and around the target. Apart from the 155mm projectiles, one can also have howitzers which fire smaller diameter projectiles with less explosive material for a different target. If the learner is finding difficult to understand projectiles just think of a kettie (catapult) that is used mainly by children to shoot birds on a tree.



KETTIE



A TYPICAL BATTLEFIELD WHERE ARTILLERY IS USED

CAREER REQUIREMENTS

A learner, who aspires to work in an artillery environment, has to have passed Grade 12 with mathematics and science. There are product designers in this environment. For one to be a product designer, meaning one will be designing artillery products, the learner will need to have an engineering degree. It can be any of the three engineering disciplines – mechanical, electrical or electronic engineering. In this environment there is also an opportunity for project managers. For a learner to be a project manager, the learner will need to have project management qualifications. It is not necessary to be an engineer to do project management in this area. To make the parts and systems, the learner needs to be a qualified artisan in the three fields of mechanical, electrical and electronic engineering. If the learner is interested in the ammunition (projectiles and propellant) side of artillery, the learner needs to be a chemist or chemical engineer.

CHAPTER 13

MISSILES AND HOW THEY WORK

Missiles are very complicated weapons. This chapter simplifies the physics behind missiles to help you, the learner, to understand.

The military uses a missile to hit a target that is miles away from where they are shooting. It is probably the favourite weapon of any military man.

Imagine the shape of the missile, like a tube, with five compartments. Each compartment has a duty that it fulfils. The first compartment is responsible for viewing the target and making sure that the missile is

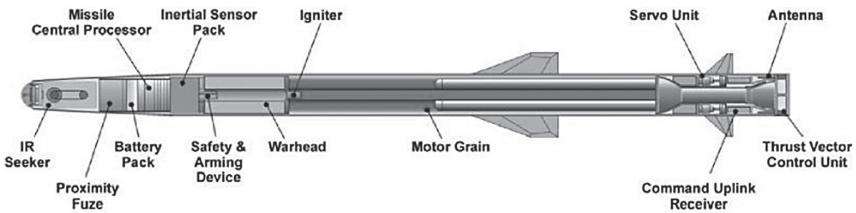


FIGURE 1 - THE CONTENT OF A MISSILE

actually going to hit the target. The second compartment is responsible for driving the missile to the target. There is the third and the fourth compartment. The fifth compartment is responsible for making sure that there is enough fuel for the missile to be able to reach its target.

Once the missile is at full speed the third compartment begins to work.

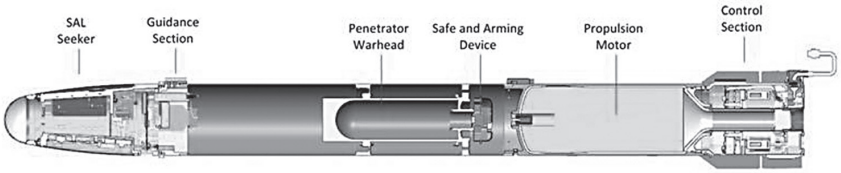


FIGURE 2- A TYPICAL MISSILE

There are two functions. One is to drop balls one by one to see if the target has been reached. The second is to catch the balls that bounce back. Once the target is reached, the balls that are being dropped bounce back into the missile. It is almost as if there is a pitcher and a catcher, if we use baseball language. The balls that bounce back are an indication that the missile has reached the target. The third compartment then informs the fourth compartment that the missile has reached the target. The fourth compartment must now engage the explosives (blast them) to hit the target and the target is taken out with a big bang.

There are different types of missiles and they are described below.

FIGURE 3 - DENEL MANUFACTURES THIS MISSILE

Air-to-ground Missiles

These are carried by an aircraft and used to fire at enemy targets on the ground, targets such as airstrips, vehicle convoys and bridges.

The recent trend in these types of missiles is to take standard dumb aircraft bombs, and attach guidance and control systems to them as well as wings in order to increase the range as well as the accuracy.

They can be equipped with different types of warheads depending on

the type of target. Some warheads are used to make a hole in the target – these are called penetration warheads; others are used to blast the target apart, such as a bunker. These are called fragmentation warheads.

Al-Tariq is a family of medium- to long-range, GPS/ INS precision-guided weapons currently being developed, with the main aim to provide a cost-effective precision weapon by utilizing existing warheads (e.g. Mk 81, 82 and 83).

Range can be extended by adding an optional booster and/or wing kit.

Surface-to-Surface Missiles

These are fired from the ground and are used to attack other targets on the ground.

Surface-to-air (or air defence missiles)

These are fired either from the ground from stationery platforms or launchers mounted on vehicles (trucks) into the air to target enemy aircraft – in order to protect a country's air space from enemy aircraft, such as military jets and helicopters. They can also be launched from ships, from stationary platforms on the ground or from trucks.

Depending on the type of seeker head they have they can have short, medium or long ranges. Those with a radar seeker head normal have long ranges.

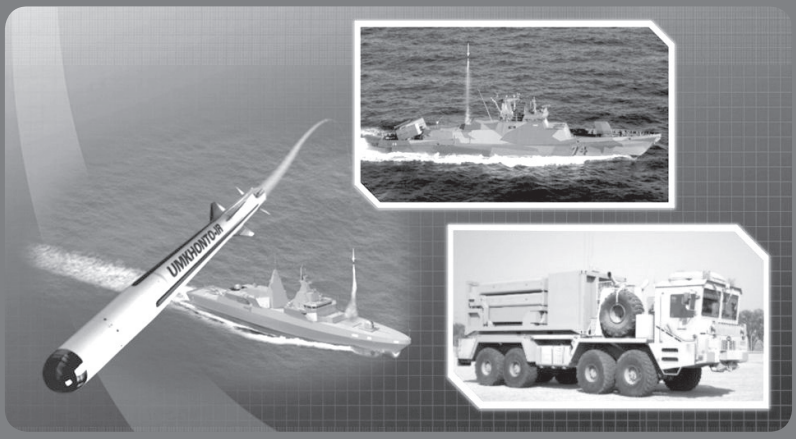


FIGURE 4 SURFACE-TO-AIR MISSILE (FIRED FROM A SHIP OR ARMY TRUCK)

How do they work?

The platform from which the missile is to be fired is fitted with radar. The radar continually scans the skies for any aircraft that might be there. Once an aircraft is spotted – still very far away, the missile goes through an exercise of confirming if it is a friend or an enemy. Once it is confirmed that it is a target, a missile is fired, which then uses its seeker head to locate the target and lock onto it (lock-on after launch), following the heat of the engine(s). Once it reaches the target, it uses a distance measuring system to find out where the target is and if it is near enough it explodes next to the target.

Air defence missiles can also be used to intercept slower ground-to-ground missiles, such as intercontinental ballistic missiles, as these are much slower.

FIGURE 5 A MISSILE FIRED FROM A MILITARY VEHICLE

Air-to-Air Missiles

These are carried by an aircraft under its wings and are used to shoot down enemy aircraft, such as helicopters and other fighter aircraft

Traditionally surface target missiles (STM) were called anti-armour as these missiles were specifically designed to defeat armoured vehicles like tanks. The renaming to STM comes from the newer wider application of the missiles to also defeat other types of surface targets, such as buildings, bunkers, boats or ships. The addition of different target types led to the development of alternative warheads to optimise the effect on the alternative targets. Presently Denel has two missiles available in STM: Ingwe and Mokopa.

FIGURE 6 AN AIR-TO-AIR MISSILE FIRED FROM AN AIRCRAFT

The Ingwe missile has a range of about 5 km. It can be fired from a land vehicle or from a helicopter. It has a mass of approximately 28kg and can destroy army tanks. A laser light on the platform from which the Ingwe missile is to be fired lights up the target. The missile then follows; it actually flies along the path of the laser light until it reaches the target.

The Mokopa is a bigger surface target missile weighing in at 50kg and can hit targets that are up to 10 km away.

It can also be fired from helicopters or vehicles on the ground.

Intercontinental Ballistic Missiles

Intercontinental ballistic missiles (ICBM) are long range missiles, with ranges in excess of 5000 km that are used to deliver nuclear war heads. Their development was started during the cold war, after the Second World War, by the then world powers, the United States of America in the west and the Soviet Union in the east. Intercontinental ballistic missiles can be fired from vertical shafts dug in the ground, from fixed structures on the ground or from vehicles like the Russian Topol missile shown below.

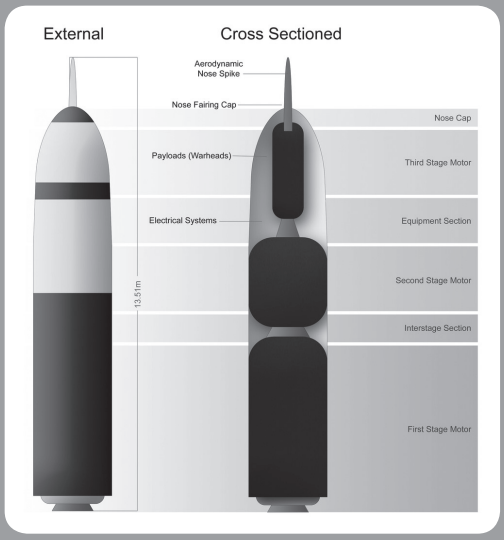


FIGURE 7 SCHEMATIC OF A US TRIDENT II D5 NUCLEAR MISSILE SYSTEM. IT IS A SUBMARINE-LAUNCHED MISSILE CAPABLE OF CARRYING MULTIPLE NUCLEAR WARHEADS UP TO 8,000 KM

They are propelled by rocket motors, which can have several stages, like rocket motors going into space. As the missile flies to space, exiting the earth's atmosphere, the used rocket motors are jettisoned (ejected). The re-entry vehicle loiters in space; as soon as it finds its intended target it re-enters the earth's atmosphere (just like the way space shuttles come back from space) and releases the warhead(s) that then dive for their target(s). The warhead(s) can sometimes be reprogrammed to hit targets that

are different from those that were originally programmed when the missile left the earth. Intercontinental ballistic missiles can have either one or many warheads that can be programmed to hit different targets on the ground. The warhead(s) are generally nuclear, but conventional as well as chemical warheads are also used.

FIGURE 8 RUSSIAN TOPOL ICBM - RANGE 11 000 KM

Missile Seeker Heads

The seeker head is what enables the missile to 'see' what it should fire at.

Missiles can have different types of seekers (those eyes that find the target).

There are **infrared seekers** that look for heat that comes from the

target (e.g. aircraft engine). Such seekers work on the line of sight principle – they cannot see a target that is around the corner. They do not work very well in cloudy conditions. The range of missiles called **radar seekers** work on a radio signal. Missiles with a radar seeker have a longer range than missiles with infrared seekers. They also work in all weather conditions.

CAREERS REQUIREMENTS WITHIN A MISSILE MANUFACTURING ENVIRONMENT

Denel Dynamics consists of three broad disciplines:

1. Unmanned Aerial Vehicles (UAV) Systems
2. Systems Engineering
3. Missiles Technology

Critical skills:

- Electronics/ Computer Engineer
- Mechanical Engineer
- Aeronautical Engineer
- Mechatronic Engineer
- Systems Engineer

Inherent requirements:

A four year degree (B. Eng.)

WHAT DOES AN ELECTRONICS/ COMPUTER ENGINEER DO?

Areas of specialisation at Denel Dynamics include the following:

- Control systems
- Radio frequency
- Electro-optical engineering
- Optic Engineering
- Digital Engineering
- Software Engineering
- Power Electronics
- Logistics Engineering
- Management
- Systems Engineering

WHAT DOES AN AERONAUTICAL ENGINEER DO?

Areas of specialisation at Denel Dynamics include the following:

- Flying gracefully
- Airframe design
- Wind tunnel testing
- Performance stimulation
- Flight testing
- UAVs and micro drones

WHAT DOES A MECHANICAL ENGINEER DO?

Areas of specialisation at Denel Dynamics include the following:

- Mechanical design
- Structural analysis
- Fine mechanics
- FEM analysis
- Servo mechanisms
- Thermal design
- Control systems
- Missile launcher mechanics
- Stable platforms
- Management

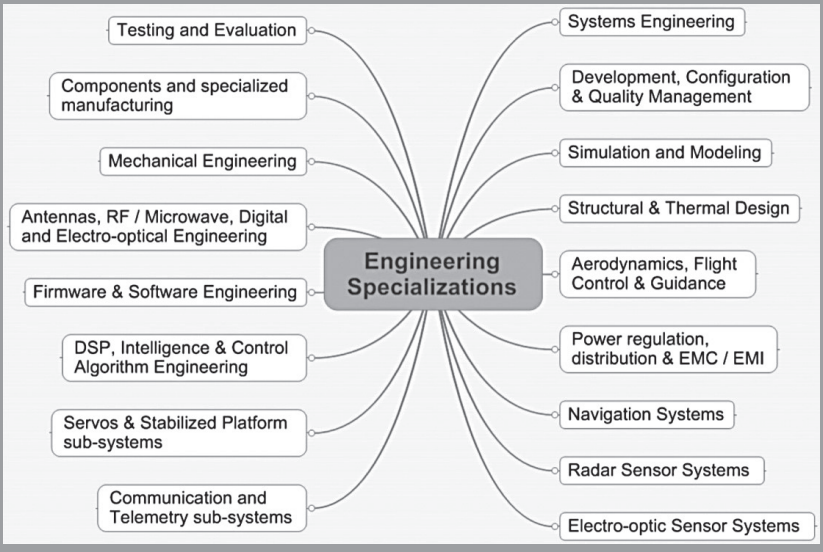
WHAT DOES A MECHATRONIC ENGINEER DO?

Areas of specialisation at Denel Dynamics include the following:

- Making mechanics and electronics work together
- Inertial sensors/ gyros
- Servos
- Gimbal systems
- Microelectronic machines.

DENEL DYNAMICS'S BURSARIES:

Core Skills:



WHAT DO ENGINEERS DO AT DENEL DYNAMICS?

Denel Dynamics offers a range of selected aerospace products and related services to defence communities around the world. The product lines develop the main Denel Dynamics products such as anti-tank missiles and air-to-air missiles.

What do missiles consist of?

- Optical/radar tracking heads (to tell the missile where the target is)
- Autopilot (to tell the missile how to get to the target)
- Servos (to control the wings)
- Power supply (to supply electrical power to the electronics)
- Proximity fuse (to detonate the warhead)
- Warhead (to destroy the target)
- Rocket motor (to move the missile)
- Airframe (to hold the missile together and enable it to fly).

These are called subsystems. They are developed by groups who specialise in different areas of engineering. Some of the groups are:

- Guidance and control engineering
- Structural and test analysis
- Mechanical design
- Electronic design
- Logistics engineering and support
- Software development.

Guidance and control engineering involves mathematical modelling and character-isation to facilitate the design and evaluation of aerodynamic, guidance, fire control and flight control systems.

Includes:

- Concept studies (generating bright ideas)
- Cost effectiveness (keeping it cheap)

- Aerodynamic design and analysis (establishing if it will fly)
- Guidance and control system design and analysis (putting a good autopilot in the missile)
- Navigation subsystem specification and evaluation (telling the autopilot where the missile is)
- Modelling and simulation (building and testing the missile on a PC)
- Field test design and analysis (Testing if the idea works)
- Wind tunnel testing (Testing small missiles)

Structural Testing and Analysis (Mechanical) – offers expertise in all fields related to structural design, analysis and testing. Includes:

- Structural testing (Testing if it is strong enough)
- Fatigue (establishing when it will break)
- Aero-mechanical Design (designing wings so they will not break)
- Stress analysis (letting the PC tell us where it is weak)
- Thermal analysis (keeping it cool)

MECHANICAL DESIGN INCLUDES:

- Pneumatic and electromechanical servos (moving the wings)
- Stabilized platform mechanics (keeping the telescope steady)
- Airframes (flying)
- Launchers (getting the missile to fly)
- CAE and prototyping (build the missile using a PC)
- Structural analysis and evaluation (checking that it is strong enough)
- Advanced mechanical design and development (getting clever)
- Composite material applications (using strong materials)

ELECTRONIC DESIGN INCLUDES:

- Radio Frequency Electronic (the radio mechanics)
- Digital signal process (using BITs (Built in Tests) to do the work)
- Power Electronics (working with power)
- Electro-optics (using the power of light)

Software Development: the development of software including embedded and hard real-time software for a variety of processes such as algorithms for navigation, flight control and fire control. Includes:

- Computer software system analysis (what does the customer want?)
- Software design (how should we do it?)
- Software implementation (doing it)
- Software verification and validation (testing it)
- Hardware and software integration (getting it to work)
- Software quality assurance and control (killing all the bugs)
- Software configuration management (using the correct version)
- Software qualification (ensuring that it does the job)

LOGISTICS ENGINEERING AND SUPPORT INCLUDES:

- Logistics engineering (planning for a long product life)
- Operational environment studies
- Reliability and maintainability analysis
- Fault/ failure test
- Built in test (BIT) analysis and BIT standard
- Logistics support analysis
- Simulation and modelling
- Logistics support planning
- Logistics development support (keeping the product alive)

SYSTEMS ENGINEERING

Extensive experience in generating, controlling and managing requirement and design specifications at various levels is essential and incumbents become exposed to formal system design reviews, participation in and monitoring of system/element design, development, simulation, integration, testing and qualification processes and activities.

PROJECT/PROGRAMME MANAGEMENT:

The effective management of subcontractor deliverables forms the basis of this profile.A technical qualification coupled with extensive experience managing multi-disciplinary projects and contracts are prerequisites for these opportunities.

CHAPTER 14

TESTING MILITARY EQUIPMENT

Learners should know that every piece of equipment, big or small, undergoes tests before it is brought to the market to be used by people. The TV at home, the cellular telephones we use, microwaves, cars, aeroplanes, etc. are all subjected to some form of test before they are taken to the market. Military equipment is no exception. It also undergoes a variety of tests to ensure that it performs to specifications.

In the previous chapter it was explained how a missile works. When a missile is built it has a particular range and intelligence technology to be able to identify and lock on to its target and then shoot it down. First the missile has to be tested to ensure that it can do all that before it is used by the armed forces. The reason for testing is obvious. One does not want to find a situation where a missile is launched and it comes back to destroy the people who fired it or follows a wrong target.

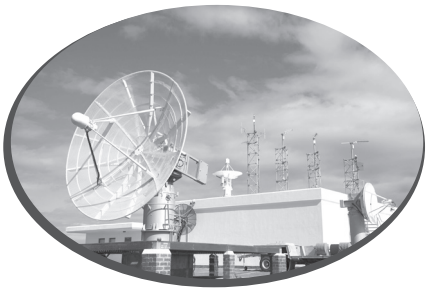
South Africa has an interesting test range where live firing tests can be conducted in order to verify the performance of missiles. It is Denel Overberg Test Range at Arniston near the southernmost tip of Africa.

The Test Range has the capability of providing precise information on the flight path selected by the missiles. This is achieved by tracking sensors that collect and record data used to compute the position in space and display it on map screens (like GPS displays).

These so-called 'external' measurements are done by a comprehensive array of instruments that attain the level of proficiency and reliability required for modern flight testing. The instruments used include high precision radar, high speed optical and infrared cameras installed on tracking systems like the cinetheodolite (picture above) and trackmount, which is able to track the missile in real time and fixed cameras and high speed cameras to ensure the visibility of the missile to the test team at all times. The cinetheodolite is an optical tracking instrument that is aimed at the missile while in flight and that delivers angular information i.e. the elevation and bearing angle by which the position of the missile can be calculated using two or more of these instruments. It also provides a video image of the missile it is tracking.

CINETHEODOLITE

INSIDE THE TELEMETRY STATION



OUTSIDE THE TELEMETRY STATION

Furthermore, internal missile functioning can be monitored by means of 'telemetry', which means making use of radio waves to transmit readings

of events occurring inside a missile to a ground based reception station. Such a telemetry reception station can be deployed almost anywhere in the world and is used for missile behaviour measurements as well as for the gathering of data during the launching of deep space satellites. Telemetry data capturing is also referred to as 'internal measurements'. Typical parameters to be measured include missile (or satellite) position and speed; computer commands issued by the on-board systems, motor performance and navigation data. In most cases a 'test' missile transmits its telemetry data by means of a transmitter; often called a 'telemetry pack' that is installed in the space normally taken up by the warhead (the warhead comprises the explosives used to destroy the target).

It must be noted that there is a difference between a test range, where equipment is tested, and a firing range, where guns are fired. Denel Overberg Test Range evaluates in-flight performance rather than the destructive power of weapons. A missile is an intelligent weapon. A bullet is not an intelligent weapon. A missile is launched to go to a specific target. Once it is launched, it is able to go where it is sent as explained in the previous chapter. On the other hand a bullet, once it is fired, will follow the direction in which it was fired. So if the target moves to a different position from the one it was in when fired at, the bullet will not have the intelligence to know that the target has moved and it will miss the target.

Learners should think of a laboratory at school where different tests are conducted as per their physical science or chemistry books. Imagine Denel Overberg Test Range as a big outside laboratory. One can never test equipment like a missile in an enclosed building because it will blow up the building.

What happens when a missile has to be tested? The manufacturer of a missile asks Denel Overberg Test Range engineers to test whether the

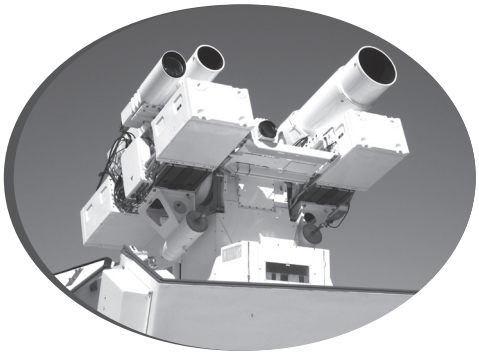
manufactured missile performs according to specifications. Two teams are put together for this type of test, the team of Denel Overberg Test Range and the team of the manufacturer of the missile.

Control room

Before a test is done there is a design process that is clearly defined. A **simulation test** ensures that everything is in place and that it will work before the real test – this is part of the design process. The **weather** on the specific day of the test is also taken into consideration. **Optical instruments** play a major role during a test; therefore cloudy and rainy conditions will obviously cause a visibility problem.

Weibel Radar

When all is set and ready for a test to take place the following is at play: the **telemetry station records the data** transmitted by the telemetry pack in the missile. The Test Range has four telemetry stations, of which two are mobile



Trackmount

and can be deployed anywhere in the world. A **meteorology** (study of the earth's atmosphere especially of weather-forming processes and weather forecasting) service is in place to provide data about what is happening in the atmosphere and on the surface. A **central control centre** has all the equipment required for an advanced test execution. This is where the test range's test manager, the test execution officer and representatives of the different systems as well as the client view the flight trail of the missile as well as other information regarding the test on graphic displays (television screens). All measurements and data recordings are computed and shown in the control room in real time. This is done by a central computer cluster, which receives the data from the instruments and does all the calculations.

There is an extensive network, which consists of **fibre optics** and **microwave links** to provide real time communications between all participating instrumentation and the central computer cluster from where it is sent to the control room. There are also radio communication links that are available from the control room to all the test range's measuring sites, as well as to participating aircraft or ships.

The most important aspect during tests is safety. For each test there is a **safety zone** or footprint in which the test must be conducted, which is supplied by the customer. The test is conducted in such a way that no lives are endangered. The test range has a 70 km coast line. It is well situated to conduct many kinds of tests such as air- to-ground, ground-to-air, air-to-air, air-to-sea as well as sea-to-air, sea-to-sea and sea-to-land tests. When tests are done at or over the sea all ships must be informed when the tests are going to be conducted so that they can avoid the test area. Safety is given such serious consideration that during a test there is a safety officer

whose job it is to see that the tested missile is going where it is meant to go. Should the missile leave the safety footprint, the safety officer must press a button for the missile to **self-destruct** (a command destruct capability).

HELPFUL HINTS

What are the qualities that the learner should have if he wants to work in an environment like Denel Overberg Test Range?

- Firstly, the learner must be somebody who is disciplined. The best definition of discipline I have heard is 'giving yourself a command and following it'. If one is given work to do one must be able to do it according to one's job description.
- Secondly, the learner must be somebody who works well in a team. Testing munitions such as missiles or bombs needs the cooperation of everybody involved. The learner cannot want to work as an independent person and not be part of a team.
- Thirdly, the learner must be willing to follow prescribed protocols or procedures when doing tests.
- Fourthly, the learner must be somebody who is honest. Test results are used by the client to improve their equipment based on the information given.
- Fifthly, attention to detail is absolutely important. In this environment nothing is too small to be recorded or taken note of because even something that happens a millisecond too early or too late can affect the outcome of a test.

CAREER REQUIREMENTS

In most cases, mathematics (not maths literacy) and physical science are important school subjects to consider. One of the employees actually said that at Denel Overberg Test Range one sees the importance of mathematics. One of the scientist's advice to learners who want to be a scientists is as follows: "Curious? Kind of meticulous? At ease with Maths? Go for it!"

The following are career opportunities within Denel Overberg Test Range:

Engineer in the development of flight test instrumentation. This person is responsible for the upgrade and upkeep of instruments so that they are up to date with new technology developments in the industry. The data provided by these instruments to the clients must be of the highest integrity.

School Subjects: Mathematics, Physical Science and Computer Science (Optional)

Qualifications: BEng/BSc (4 years) in electronic engineering is sufficient for a career as an electronic engineer. A Master's Degree and PhD is recommended if one would like to specialise in a particular field.

Scientist (Data Analyst) optimises the tracking data from optical and radio frequency instruments to get relevant results for the development of advance weapon systems and aircraft.

School Subjects: Mathematics, Physical Science and Computer Science.

Qualifications: BSc with subjects such as Applied Mathematics, Physics and Computer Science.

System Analyst is involved in planning, development, installation and maintenance of various software-related computer systems. This person is also responsible for the integration of new maintainable software systems on instrumentation systems.

School Subjects: Mathematics (not Maths Literacy), Physical Science and Information Technology (not Computer Applications Technology)

Qualifications: A three year BSc degree (or equivalent) in Computer Science/Information Systems would be the minimum qualification required for this type of work.

Technician involved in maintaining and operating various radar systems. The work covers a wide spectrum ranging from high voltage components, mechanical parts, communication and RF (Radio Frequency), to video and computers.

School Subjects: Mathematics and Physical Science.

Qualifications: National Diploma in Engineering.

Technician in the Command & Control Section which consists of video, radio, time-base and fire systems. This person maintains the fire alarm; access control and public address systems. This person has to continuously upgrade these systems and install new fire alarm systems. This person also runs a prototype circuit board manufacturing laboratory to support development projects at the Test Range.

School Subjects: Mathematics and Physical Science.

Qualifications: National Diploma Electrical Engineering.

Electronic technician works in the telemetry section.

School Subjects: Mathematics and Physical Science.

Qualifications: National Diploma in Engineering.

WHY DENEL OVERBERG TEST RANGE IS A GREAT PLACE TO WORK AT

There are many advantages to working at Denel Overberg Test Range. It is a tranquil place situated on a 43 000 ha (43 000 football fields) uninhabited site. The overland portion comprises two sectors separated by the De Hoop Nature Reserve and forms part of the Greater De Hoop Conservation. It has a 70 km coastline facing a virtually unrestricted sea area stretching into the south Indian Ocean. The Test Range is 200 km east of Cape Town.

Most engineers and technicians working there cite the following things as the best part of their work: exposed to the many facets of

electrical/electronic engineering through challenging projects and a variety of engineering problems. One works with a very experienced staff of scientists, engineers and technicians. They cite the environment as exciting and challenging in that no one test is the same as the next tests. Their work is never static. They test equipment manufactured by companies from different parts of the world so they are able to meet and get to know clients from all around the world. It is also interesting that they are a diverse group of people who have one goal in mind – to make every test campaign a success.

The best part about the Denel Overberg Test Range is that one can practice a career in a highly technical environment in a rural setting!

CHAPTER 15

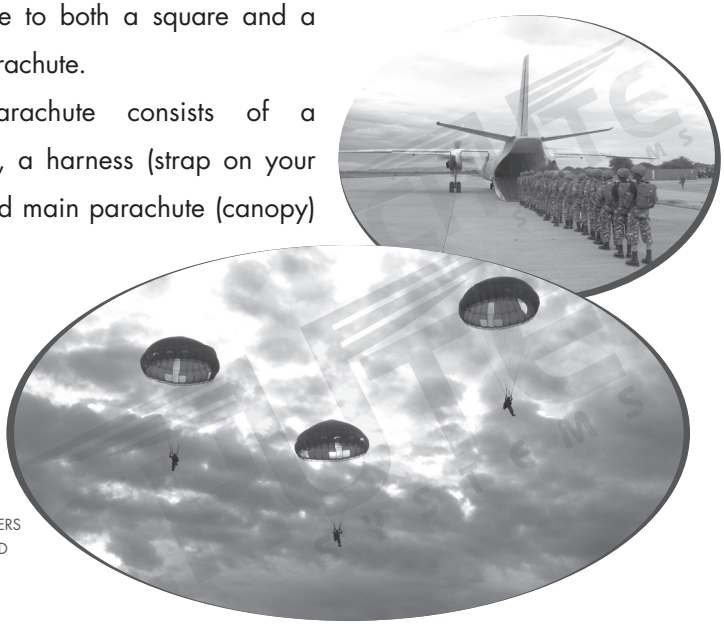
PARACHUTES

Paratroopers are military parachutists –soldiers trained in parachuting into an operation and usually functioning as part of an airborne force. They are used for tactical advantage as they can be inserted into the battlefield from the air. Paratrooper use parachutes of a round design and they can be controlled to a certain degree. There are two types of parachutes, round parachutes and ram-air (square) parachutes. There are also two types of round parachutes, a steerable one and a non-steerable one. In a day scenario the idea is for soldiers to be in a group and land as close to each other as possible. At night the idea is to have all soldiers to drift in the same direction as the wind. The round parachutes are mostly used for soldiers at war.

A round parachute has open slots. When the soldier pulls down to the right on a steering toggle he will turn right and when he pulls the steering toggle to the left the parachute will turn left. It is always advisable to land a parachute against the wind. When pulling down it releases air from the canopy to effect the turn. One must always turn into the wind so that

one can land safely. If a paratrooper drifts with the wind he will be pulled down so fast and uncontrollably that he may injure himself. This is similar to an aircraft landing against the wind. This landing against the wind is applicable to both a square and a round parachute.

A parachute consists of a container, a harness (strap on your body) and main parachute (canopy)



PARATROOPERS WITH ROUND PARACHUTES

that is packed into a container. A parachute is packed in a deployment bag which goes into a container. The deployment bag has a static line that is hooked on a cable inside the aircraft. When the paratrooper leaves the aircraft the deployment bag and the static line remain with the aircraft and the paratrooper will be freed from the aircraft under his own canopy. The main canopy is packed on the back of the paratrooper. There is also a front-mounted reserve parachute. This is a parachute that the paratrooper will use if the main one on his back has a problem and fails to open. Think about the disaster that would occur if there was no reserve parachute should the main parachute fail to open.

The paratroopers are taught a drill that once they have left the aircraft they must look up and examine the condition of their canopy and see that the lines are not tangled and that there is no damage to the canopy. If the canopy is damaged the paratrooper must deploy the reserve parachute. This reserve parachute is hooked onto the harness at the front of the parachutist and it becomes part of the entire system.

Parachutes were originally developed in the early 1900s for pilots who were shot down. This concept was further developed for soldiers and was used by them during World War II. The reason was for rapid deployment of soldiers. The soldier will have all his equipment – rifle, magazines, water, food, medical equipment, etc. with him when descending with the parachute.

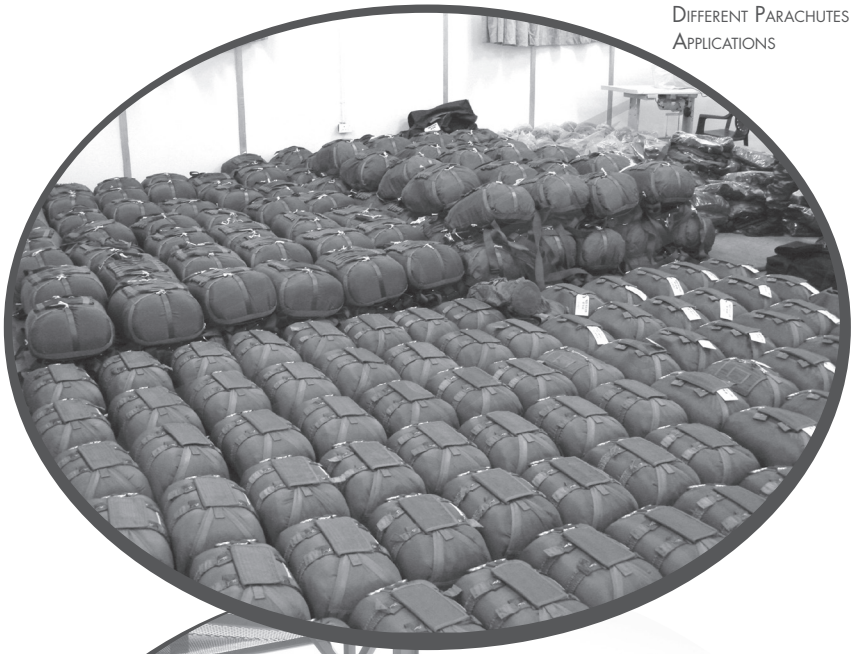
The ram-air parachute (technical name for square canopy) is a parachute that does not drop but descends in a flying motion. This type of parachute is used for special missions. Static line round parachutes are used for mass drop of soldiers into battle.

The use of parachutes in the defence force is specialised – high altitude (oxygen masks are used at this altitude), low altitude and water jumps are conducted for various missions.

There are also guided parachutes that can be used to supply soldiers with ammunition, medical supplies, food and water in a war zone. Vehicles, boats and other equipment required by the soldiers on the ground can also be dropped with cargo parachutes. Our troops have used cargo parachutes to supply medical equipment, water, fuel, etc. in neighbouring countries where relief work was required.

Pilots using fighter aircraft also use parachutes when they have to escape from the aircraft in emergency situations. The seat that they use is called an

Different Parachutes Applications



Reserve parachutes can be seen on the front of the soldiers

ejection seat and is equipped with a parachute. When the pilot escapes by means of the ejector seat a parachute deploys so that the pilot can land safely.

Parachutes are inspected by a qualified master rigger who can train and qualify people to pack both round and square parachutes. Reserved parachutes are repacked every six months. When the main parachute does not open, the reserve parachute has to open as it is the last chance the soldier has to survive. Being a master rigger is a highly specialised qualification.

Tandem parachutes can also be used for transporting people who are not paratroopers, for instance a doctor. The passenger is fitted with a harness, which is attached to a tandem master's harness. A tandem master can also jump with excessive equipment (150kg).

Here is what one training company called Chute Systems says about jumping from an aircraft with a parachute:

'The act of parachuting, which involves throwing oneself into space is not a natural act. The parachute is a means of transport and many use this vehicle every day. With proper training, it becomes a simple and normal performance and not a daring "stunt".

HELPFUL HINTS

- Do you have fear of heights?
- To be a paratrooper, one has to conquer fear of jumping from an aircraft.
- The more one jumps the more the fear is controlled. If one cannot conquer the fear of jumping from an aircraft one cannot be allowed to continue with the course.

- Soldiers who have qualified as paratroopers receive an emblem of wings, which is worn on the soldier's uniform.
- To qualify as a paratrooper one must pass a strict physical training course
- After passing the physical training phase, instruction is given on the ground in a hanger where aircraft drills and other fight drills are taught.
- Once the soldier has completed this phase the jumping from an aircraft commences. Every jump is evaluated to see how the soldier progresses.
- The soldier will qualify as a paratrooper after about ten successful jumps.

CHAPTER 16

PROJECT MANAGEMENT IN DEFENCE

In South Africa we have a company called the Armaments Corporation of South Africa (ARMSCOR). This company has a very important role to play between the SANDF and the South African Defence Industry (SADI). Their work is outlined by law in the ARMSCOR Act of 1963.

ARMSCOR is a South African state-owned company mandated by the Armaments Development and Production Act, 1968 (Act 57 of 1968), and continues its existence through the Armaments Corporation of South Africa, Limited (Ltd) Act, 2003 (Act 51 of 2003). The Minister of Defence and Military Veterans is the executive authority responsible for ARMSCOR.

The following history appears in the ARMSCOR website (5.09.2013):

With the change of government in 1994, government spending priorities changed from defence to social upliftment, and by the end of 1997 the defence budget had been reduced to about 1.6% of the gross domestic product. In anticipation of these changes, ARMSCOR drew up a three-point plan, which included converting the defence industry from a manufacturer of military products only to a manufacturer of civilian products as well. As the Act in terms of which ARMSCOR had

been set up prohibited it or any of its subsidiaries from manufacturing civilian products or competing with the private sector, this plan resulted in the splitting of ARMSCOR into two separate entities. On 1 April 1992 a new company, Denel (Pty) Ltd, was established under the Minister of Public Enterprises.

ARMSCOR has since focussed its energies towards programme management and acquisition, whilst Denel is a major supplier of manufactured products and systems.'

ARMSCOR receives a request from the SANDF to get particular equipment for them. However, the SANDF does not spell out that they want a jet or a fighter aircraft or a ship. The SANDF will typically tell ARMSCOR what their needs are, for instance, "We are doing peacekeeping missions throughout the rest of the continent. We do not have an aircraft that can transport goods from one place to another. The distance this aircraft should fly is at least 800 km without stopping to refuel. We want the aircraft to transport not only goods like food for soldiers but we want it to transport military equipment and soldiers. Where it is going to fly there is no proper infrastructure like a big tarred runway. This is how much we have budgeted for this equipment. Please, ARMSCOR get such a plane for us."

The project managers of ARMSCOR (possible career choice for the learner), who are typically technical people, trained in that particular area, will then write what the SANDF wants in engineering terms. This means that ARMSCOR will write technical specifications for the potential industry that will supply such an aircraft. They will include things like the weight of the aircraft, its speed, the size of its wings, how many engines it should have,

how big its fuel tanks should be and what its maximum weight should be when it is carrying equipment. This is just one example of equipment that is acquired by ARMSCOR on behalf of the SANDF. The equipment can be military vehicles, military ships, bombs, missiles, etc.

The role that ARMSCOR plays is an extremely important one. It reduces the risk of acquiring equipment that may not live up to the expectations of the SANDF. When this process is not followed it is very possible that one can buy an aircraft that does not fly. When the SANDF asks the manufacturer why the aircraft does not fly, the manufacture might answer, "But you did not specify that, and to make it fly will cost another R50 million."

Once the specifications are written by ARMSCOR, they go out to industry with a request for proposal (RFP). The RFP is to let industry know that the SANDF has a requirement with those specifications and enquires from industry if it can deliver on those specifications. In the RFP ARMSCOR will also state the closing date of the RFP. Those companies that manufacture such aircraft will then submit a proposal according to the specified requirements to ARMSCOR. After the closing date ARMSCOR goes through all the RFPs sent and then sends out what they call a request for quotation (RFQ). This means that the manufacturers must indicate what all the specifications will cost.

It is very possible that the manufacturer of the aircraft does not meet all the specifications. What the manufacturer does is agree with certain suppliers that they will be subcontracted to do some of the work. This agreement of subcontracting is between the manufacturer and the subcontractor. ARMSCOR will only be liaising with the manufacturer and not the subcontractor. From the ARMSCOR side a team will be put together to

manage the project. There will be a project manager from ARMSCOR and a project officer from the SANDF, who will typically be someone who is able to use the equipment being acquired. The project officer represents the user, which is the SANDF. There is also an important person from ARMSCOR called the quality manager. This is the person who approves the quality of the equipment and must be satisfied that the equipment does what it is meant to do. There will be no payment to the contractor without the approval of the quality manager. There is also a representative from the manufacturer. There are other members of the team who do the administration work. The team works together until the completion of the project – an aircraft according to the specifications the SANDF had stated.

After the RFQ has been received ARMSCOR will put together an evaluation committee. This committee decides which manufacturer must be given the work. For good corporate governance, the people who write the specifications of the aircraft do not sit on the evaluation committee. The evaluation committee then makes its recommendation. That recommendation is taken to another committee to confirm the recommendation of the evaluation committee. Once this recommendation is approved by this committee, the recommendation is then taken to the ARMSCOR Board of Directors for approval. Once the project is approved, the project can start with the work of acquiring the aircraft.

The reason for undertaking what may seem like a long and cumbersome process to an observer is in actual fact intended to reduce the risk to the user, which is the SANDF. The process is long but carefully crafted also because proper accounting should be undertaken, as the money that is used comes from the South African taxpayers.

FACT BOX

Some of the technical careers available within the Armscor environment are as follows:

- Project Managers
- Engineers
- Quality Controllers
- Quality Managers
- Technicians

CHAPTER 17

THE A–Z OF CAREERS IN AVIATION

The following are the careers that the learner will find in aviation. Just from reading what careers are available the learner should be able to see the opportunities that await him or her in the world of aviation.

Career	Description
Aeronautical Engineer	Develops, designs and tests aircraft, missiles, satellites and other systems.
Aircraft Assembler	Assembles, fits and installs pre-fabricated parts to manufacture fixed-wing or rotary-wing aircraft or aircraft sub-assemblies.
Aircraft Composite Structures Worker	The technician in this trade is responsible for the maintenance, repair and manufacture of plastic, fibreglass and honeycomb structure components.

Aircraft Electroplater	This trade entails the plating of a thin protective layer on aircraft parts by means of electrochemical processes.
Aircraft Instrument Mechanic	This person is trained to repair, test and install navigational and flying instruments, such as the automatic pilot and electronic compasses.
Aircraft Maintenance Engineers (AMEs)	Diagnoses, adjusts, repairs, replaces or overhauls aircraft engines and assemblies, such as hydraulic and pneumatic (concerned with air, gases or wind) systems, wings and fuselage, and functional components including rigging (putting components of an aircraft in their correct position), surface controls, and plumbing to ensure airworthiness.
Aircraft Painter	Technicians in this trade are responsible for the protective and decorative finishing of the aircraft, its engines and components.

Aircraft Radiotrician	This person's responsibility is to carry out maintenance of all communication equipment in the aircraft.
Aircraft Structures Worker	The aircraft structures worker is mainly responsible for the maintenance, repair, overhaul, manufacturing and modification of the aircraft structure and its components.
Aircraft Trimmer	This trade is responsible for the manufacturing, maintenance and repair of interior components such as fabric covered panels, carpets, curtains and seat covers.
Aircraft Welder	This technician is responsible for the repairing of aircraft components by applying various welding processes and advanced technologies.
Airline Station Manager	The station manager is in charge of all ground and flight operations for his airline.

Airport Planner	It is this person's job to plan and design airport facilities. It is also his role to create a master plan for the airport, noting the increasing demands of passengers and the airline services.
Airport Customer Relations Agents	This person is responsible for management and resolution of customer queries. They also ensure availability and serviceability of airport infrastructure.
Air Traffic Controller	An air traffic controller's job includes tower control, which handles all aircraft movements, take-offs and landings, while an approach controller monitors approaching and departing traffic, en route control and information and advisory services.

Aviation Law	This is a highly specialised aspect of the law, and is very much internationally orientated. It is recommended that you contact universities for more information.
Aviation Medicine	General practitioners take the course to be in a better position to deal with patients transported by air, or to carry out the required medical examinations for the issue and renewal of personnel licenses.
Aviation Safety Specialist	Aviation safety specialists report incidents and accidents and ensure that their causes are made widely known to all who could benefit by the knowledge.
Aviation Turner and Machinist	The technician in this trade is responsible for the modifications, repair and manufacture of aircraft parts.

Cabin Crew / Flight Attendant	Checks passengers' names and destinations, enforces safety rules, serves food, oversees passengers' comfort and directs evacuation procedures in the case of an emergency.
Co-pilot	The co-pilot assists the pilot in the operation of the flight controls, watches the instruments and weather, handles radio communications and keeps logs.
Electromechanic	The electromechanic maintains teletype equipment, landing lights, beacons and stand-by generators.
Electronics Maintenance Technician	This person maintains navigational aids and communication equipment, such as radar and radio beacons.
Fitter and Turner	The fitter and turner is trained to manufacture parts and aircraft components.

Flight Dispatcher	The flight dispatcher works with the pilot and plans flight requirements, authorises take-offs or cancels flights, and advises pilots in the air on weather and route changes.
Flight Engineer	The flight engineer monitors the in-flight operation of the engines and the aircraft's mechanical and electrical systems.
Flight Line Mechanic	The aircraft is prepared for test flight after final assembly by the flight line mechanic.
Ground Handling and Emergency Services	When on the ground, aircraft need to be moved around refuelled, cleaned and so on. Also, emergency services such as airport rescue and fire-fighting teams have to be available at all times to react to emergencies. Paramedics and firefighters are employed by these services.
Helicopter Pilot	These pilots can make flights to otherwise inaccessible areas.

Loadmaster	Supervises proper tie-down procedures of cargo and calculates weight distribution of the load.
Meteorologist	Analyses weather data and convey weather reports to the pilot and dispatcher. He may also work with the flight dispatcher preparing flight plans.
Navigator	The navigator plots the course, reports position and estimates arrival time.
Operations Agent	The operations agent oversees the loading and unloading of the aircraft and checks the distribution of the aircraft load and fuel.
Pilot	Flies aircraft of all sizes, transporting passengers and cargo across the country and around the world. They are responsible for the safety of the aircraft, its passengers, the crew, and any cargo on board.

Radartrician	Radar systems are used in aircraft as well as on the ground. The radartrician is responsible for this equipment in the aircraft.
Reservations Clerk	The clerk handles telephone inquiries about flight schedules and fares and makes flight reservations for airline passengers.
Ticket Agent	The ticket agent sells ticket, weighs and tags baggage and answers questions on schedules and fares

AIRCRAFT PAINTER

CAREERS OFFERED BY AIRPORTS COMPANY SOUTH AFRICA (ACSA)

Airport Operations

- Aviation Safety and Security Officer
- Airport Fire Fighter

Requirements

The requirements are Grade 12, Safety and Security Diploma, Fire Fighter 2 and other relevant regulatory qualifications e.g. NKP, PSIRA

Airport Engineers and Technicians

Requirements for this are Grade 12, B-Degree in Engineering (Industrial, Mechanical, Electrical, etc.) or any other relevant three year qualification.

Aviation Services

- Airport Planner
- Airport Statistician
- Environmental Safety

Requirements

The requirements are Grade 12, B-Degree in Environmental Studies, Architecture, etc.

Airport Customer Relations Agent

Requirements

The requirements are Grade 12 and relevant tertiary qualification e.g. Travel and Tourism or similar field.

CAREERS OFFERED BY AIR TRAFFIC & NAVIGATION SERVICES (ATNS)

Air Traffic Controller (ATC)

Requirements

- Must be at least 18 years
- Grade 12
- Pure mathematics: HG – D, SG – C or Level 4
- English: HG – D, SG – C or Level 4

Air Traffic Services Assistant (ATSA)

Requirements are the same as for the ATC above.

Engineering Technicians

Requirements S4 Electrical Engineering (Light Current)

CAREERS OFFERED BY THE SOUTH AFRICAN AIR FORCE (SAAF)

Pilot and Navigator Training

Requirements

- Grade 12
- English: HG – D, SG – C, or Level 4
- Pure mathematics: HG – D, SG – C or Level 4
- Physical science: HG – D, SG – C or Level 4

OR

- N4 with mathematics and physical science: 60% or higher

OR

- N5/6 or first year University of Technology: 50% or higher

Engineering

Aeronautical Engineering; Electronic Engineering; Industrial Engineering; Mechanical Engineering

Requirements

- Grade 12
- English: HG – C, SG – B or Level 5
- Pure mathematics: HG – C, SG – B or Level 5 and
- Physical science: HG – C, SG – B or Level 5

OR

- N4 with mathematics and physical science 60% or higher

OR

- N5/6 or first year University of Technology: 50% or higher

CAREERS OFFERED BY THE SOUTH AFRICAN AIRWAYS (SAA)

SAA Cadet Pilot Training Programme

Requirements

- Matric certificate / Grade 12 / N3 or relevant qualifications (SAQA accredited)
- Pure mathematics or statistics 101: HG – D, SG – C or Level 4
- Physical science or computer science: HG – D, SG – C or Level 4
- English: HG – D, SG – C or Level 4

Cabin Crew / Flight Attendant

Requirements

Applicants should be outgoing South African citizens: medically fit; at least 1,58 metres tall

SAA Technical

- Aircraft Mechanic
- Aircraft Electrician
- Aircraft Instrument Mechanic
- Aircraft Radiotrician
- Aircraft Structures Worker
- Aircraft Welder
- Aviation Turner and Machinist

- Aircraft Painter
- Aircraft Trimmer
- Aircraft Electroplater

Requirements

- Grade 12
- Pure mathematics: HG – D, SG – C or Level 4
- Physical science: HG – D, SG – C, Level 4

OR

- N3 Certificate with mathematics and engineering science

CABIN CREW AND PILOTS

HELICOPTER PILOT

CAREERS OFFERED BY THE SOUTH AFRICAN POLICE SERVICES (SAPS)

Pilot

Fixed-wing helicopter

Requirements

- Grade 12
- Private Pilot License
- Previous flying experience

Technical

- Aircraft Avionician
- Electronics Mechanic and
- Aircraft Maintenance Engineering

Requirements

- Grade 12 (Pure maths and science Level 5)

OR

- N3 with aircraft maintenance theory as a subject (for apprenticeship)

Contact Details

Department of Transport (DOT)
Private Bag X 193, Pretoria 001
www.dot.gov.za

South African Civil Aviation Authority (SACAA)
Private Bag X 73 Halfway House, 1685
www.caa.co.za

South African Air Force (SAAF)
SANDF Recruiting Centre, Private Bag X 281, Pretoria 0001
www.saairforce.co.za

South African Police Service (SAPS Air Wing)
Career Management
Private Bag X 241, Pretoria, 0001
www.saps.org.za

Airports Company South Africa (ACSA)
P O Box 75480, Gardenview 2047
www.airports.co.za

Air Traffic and Navigation Services (ATNS)
Private Bag X 15, Kempton Park 1620
Email: recruitment@atns.co.za
www.atns.co.za

South African Airways (SAA)
Private Bag X13
OR Tambo International Airport, 1627
www.flysaa.com

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www.caa.co.za/careers in aviation

CHAPTER 18

CAREERS SPECIFIC TO THE SOUTH AFRICAN AIR FORCE

MINIMUM ENTRY REQUIREMENTS FOR ENGINEERING

1. The tables below illustrate the minimum entrance requirements for the four (4) year engineering study programme at the various universities utilised by the SAAF for fulltime engineering studies.

   a. **University of Pretoria:** A valid National Senior Certificate (NSC) with admission to degree studies with the minimum subject requirements as set out below

Language English/ Afrikaans	Physical Science	Mathematics	Admission Point Score (APS)
5	6	6	35

b. **University of Stellenbosch:** A valid National Senior Certificate (NSC) with admission to degree studies and an aggregate of at least 70%, with the minimum subject requirements as set out below

English first additional language	Physical Science	Mathematics	Admission Point Score (APS)
5	5	6	A selection formula is applied, using the results of 6 senior certificate subjects (excluding life orientation) and mathematics literacy) with mathematics and physical science counting double.

c. **Witwatersrand University:** A valid National Senior Certificate (NSC) with admission to degree studies with the minimum subject requirements as set out below

English	Physical Science	Mathematics	Admission Point Score (APS)
5	5	5	36

d. **University of Cape Town:** A valid National Senior Certificate (NSC) with admission to degree studies. All applicants normally resident in South Africa must write the NBTs in academic literacy, quantitative literacy and mathematics. The results of these tests will be used in calculation of the Engineering & Built Environment (EBE) Faculty Point Score (FPS).The minimum subject requirements as set out below are also required

EBE FPS Points	Physical Science	Mathematics
70	≥80%	≥70%

PUPIL PILOT/NAVIGATOR

1. Minimum Entry Requirements
   b. Must be single when applying and remain single for the duration of training.
   c. Minimum naked mass must be 50kg and Maximum naked mass must be 100kg.
   d. University exemption (Suggested minimum APS of 35).

2. Phases of training Durations
   a. 6 Months Basic Military Training.
   b. 6 Months Officers Forming Course.
   c. 3 Year University Degree studies.
   d. 2 Year Flying training at CFS Langebaanweg for Pupil Pilots or at 80 ANS for Pupil Navigators.

3. Flying Training
   a. **Ground School:** Ground School is no longer presented at the Military Academy; it is now presented at 80 ANS. After the member completes his selection, BMT, OFC and at least a 3 year university degree the member will commence with Ground School at 80 ANS. The Ground School is presented for both the Pupil Pilot and the Learner Navigator.
   b. **Survival Training:** 80 ANS provides the training. Members will undergo a Basic Parachute Course at 44 Regiment with 80 ANS as the co-ordinating body. The rest of the survival course is presented by 80 ANS

at AFB Ysterplaat and consists of a First Aid Course, Land Survival Training, Sea Survival Training and Parasailing Training.Survival Training is presented for both the Pupil Pilot and the Learner Navigator.

4. Learner Navigator Flying Phase

   a. No side by side training. The Learner Navigators are stationed at AFB Ysterplaat. Flying phase subjects are as follows: Basic Map Reading (C208), TAN(Sim), IF(Sim), Air Plot(Sim), Track Plot(Sim), IF (Flying), Systems, Degradation, Low Level, Tactical Low Level, Helicopter Phase, Advance Navigation, Test Flight (Rover).Aircraft used are the C208 Cessna Caravan, PC-7 MKII and C47 TP. Training lasts for two years which includes the Ground School, Survival and Flying Phase. Members complete 90 flying hours and 60 simulator hours before they qualify.

   b. Members that completed the training are streamed by a Streaming Board to determine in which line function a Navigator will be utilised, namely: Fighter, Helicopter or the Transport line.

5. Pupil Pilot Flying Phase

   a. No side by side training. The Pupil Pilots are stationed at CFS Langebaanweg. Flying Phase subjects are as follows: Solo, Basic General Flying, Advanced Basic General Flying, Instrument Flying, Advanced Instrument Flying, Night Flying, Navigation Flying, Formation Flying and Wings. Aircraft used is the PC7

– MkII. Training lasts for two years which includes the Ground School, Survival and Flying Phase. Members complete 190 flying hours and 40 simulator hours before they qualify.

b. Members that completed the training are streamed by a Streaming Board to determine in which line function the Pupil Pilot will be utilised, namely: Fighter, Helicopter or the Transport line.

6. The PC7 – MKII is a tandem aircraft and not a side-by-side aircraft.

CHAPTER 19

MILITARY RANKS IN SOUTH AFRICA

Rank plays an important role within any military. It is a command structure. Commands must be obeyed. Whoever has a higher rank is the one who must be obeyed. Our military has four sections, and they are called services. They are the **army**, the **navy**, the **air force** and **Medical Health Services**

In South Africa the Kalahari uniform members (uniform colour is like the Kalahari Desert sand) are members of the army, i.e. these are mostly ground troops. The white uniform members are members of the navy, i.e. mostly on water with war ships. The blue uniform members are the members of the air force, i.e. mostly with aircraft. The brown with maroon uniform members are the members of the Medical Health Services. There is also a service called defence intelligence where members from all services participate. These are members who gather all sort of information that is used to determine where the threats to the country are.

The ranks below are for your information so that whenever you see a soldier you will know which rank he or she is in. Suffice to know that a General ranks high in the military and a Colonel is part of middle management. In the navy a general is usually called an Admiral. Generals also have their ranks from junior to senior: a brigadier general is a junior, followed by a senior major general, who is followed by a more senior

Lieutenant General and a General (highest). They usually have stars on their epaulettes (a piece of ornamental material on the shoulder of a garment of a military uniform. Nurses and police also have them). So a Brigadier General will be called a one star, a Major General will be called a two star, a Lieutenant General will be called a three star and a general will be called a four star.

There is some discrepancy: A captain in the army is a junior, but a captain in the navy is the same rank as a colonel in the army. So when one calls a senior person like a colonel in the army a captain, it is considered an insult because a captain in the army is a junior. One general said that in the military one ignores rank at one's own peril. That is true.

See page 181 for the Rank Insignia.

CHAPTER 20

DEFENCE TECHNOLOGY AND ITS BENEFITS TO SOCIETY

There are many defence technologies that have benefited humanity and the commercial world. The following are some of the benefits.

Drive-through

Many of you may have seen a drive-through at McDonalds; KFC and other take away food places. Did you know that the drive-through idea came from the military? Remember that when the soldiers are at war they have enemies. However they still want to eat. They cannot park their car at a parking lot and then go to buy food and come back to the vehicle. The enemy is always looking for the soldier. So the drive-through idea that we see in some fast food outlets is born out of protecting the soldier. One will realise that

KFC DRIVE-THROUGH

many of these services are fast and there is no need to switch one's car engine off. We as civilians benefit from this because we are able to use these drive-throughs. They come in handy when we are in a hurry or when it is raining and one does not want to get out of the car.

Run flat tyres

Did you know that the run-flat tyres that are called revolutionary technology also come from the military? One can imagine that if a military vehicle is in a war zone and its tyre runs flat in the territory of an enemy or an area that is dangerous, the vehicle needs to have some time to drive to a safer place where the tyre can be changed. The tyre has to be able to drive for a while until the vehicle reaches a place of safety. This is how military vehicles are made. This technology is now used by some car manufacturers in their vehicles. Us as civilians are able to be safe with run- flat tyres.

The gastro scope

Did you know that the camera that is used in hospitals to check the inside of our digestive system (from the throat to the stomach) comes from the military? The military uses long thin tubed spy cameras. This camera is now used in hospitals to check our digestive systems. Doctors are able to pick up any ailment along the gut using these cameras. The procedure of putting a tube in one's mouth up to the stomach is called, in medical terms, gastroscopy – 'gastro' is stomach and 'scopy' is a scope or a camera.

The Internet

Did you know that the internet is an old technology that was used by the military? We see it today as something revolutionary that we cannot do without yet it has its origins in the military. The military invented a system of putting information of each soldier in a compact form and then have the soldier hang it on his neck. This would make it easy to get all of the soldier's information at once especially in a war zone. That is how the idea of a memory stick came about.

The Ground Positioning System (GPS)

In a war zone the military vehicles' whereabouts also need to be tracked. The tracker system that we use in our vehicles today has long been used by the military to track their cars. Companies that use these trackers are able to use them even to track individuals. Thanks to the military.

Portable X-ray machine

At some stage ARMSCOR was busy developing a technology of a portable X-ray machine for soldiers to use in the field. Imagine the benefits for the community. X-rays can be taken at a sports field to determine whether or not a player's bone is broken or not. People in the rural areas can benefit from this where they do not have the benefit of big hospitals that have modern equipment. So a lot of young people interested in joining the world of the military can take some of its current technology and develop them to benefit society.

CHAPTER 21

DENEL SUBSIDIARIES AND ASSOCIATE COMPANIES

DENEL MECHEM

Mechem, a subsidiary of Denel, is based in Lyttleton. Over the past nineteen years, Mechem has been a world leader in the field of commercial and humanitarian demining.

Extensive research and development in the field of counter landmine operations, demining and battle area clearance (BAC) over a period of four decades has created a capacity and a capability to effectively and cost-efficiently execute mine action operations all over the world.

Mechem is a company at the leading edge of mine clearance technology in the world and is internationally acknowledged as one of the most technologically advanced companies in this field.

Since 1991 Mechem has been actively involved in several commercial mine clearance operations. During this period Mechem personnel have gained valuable experience in the planning and execution of survey, rapid response BAC, EOD, manual clearance, and MRE operations all over the world. Over the years Mechem has cleared in excess of 120 million square metres of land and removed and destroyed more than 500 000 mines and unexploded ordnance.

Skills Development and Training within Mechem Training Portfolio

Through the past years Mechem has trained its own personnel to be able to deploy competent and experienced staff in all the different disciplines of landmine clearance operations.

In this process it has developed a variety of formalised training courses. Mechem has also presented numerous commercial courses to satisfied international clients.

Trainers/Facilitators

Mechem has access to a pool of well-trained and experienced trainers in their respective fields of expertise.

Mine Action Training Courses

Mechem trainers are well established to present the following training courses:

- Basic Demining & IMAS EOD Level 1
- Battle Area Clearance
- IMAS EOD Levels 2 & 3
- Demining Survey
- Demining Management
- Mine Protected Vehicle Driver Training
- Mine Awareness Training
- IEDD Awareness Training
- Mine Risk Education (MRE)

Dog Handler Training Courses

- Mine Detection Dog Handlers (MDD)
- Explosive Detection Dog Handlers (EDD)
- Narcotic Detection Dog Handlers (NDD)
- Protected Animal Species Dog Handlers

Dog Training Courses

- Mine Detection Dogs
- Explosive Detection Dogs

DENEL INDUSTRIAL PROPERTIES

Denel Industrial Properties (Deniprop) a division of Denel owns and manages eleven sites in the Gauteng, North West and Western Cape provinces. The property value is in excess of R1 billion with income sales of over R280million.

Deniprop provides infrastructural solutions and world-class facility management and support services to defence, aerospace and other external clients, in the Gauteng, North West and Western Cape provinces.

Deniprop recognises that sustainability issues play a central part in the provision of world-class facilities and support services to its clients. The Denel Group views sustainability as a moral and economic imperative and aims to be a responsible manufacturer, implementing robust business processes that take into account sustainability aspects including safety, health, environment, quality and social issues.

Career Opportunities within Denel Industrial Properties

The maintenance of our facilities is a core function, and requires various trade disciplines to ensure that services and infrastructure are provided and maintained to a high standard. The following career opportunities exist within Deniprop;

- Boilermakers/Welders
- Electricians
- Air-conditioning Mechanics
- Machine Tool Fitters
- Plumbers
- Carpenters
- Handymen

AIRBUS DS OPTRONICS

South Africa is one of a select few countries with world-class capabilities in designing, developing and manufacturing advanced military and civilian optical and optronic (optical electronics) products for use on land, sea and air. Airbus DS Optronics, part-owned by Denel in South Africa and Airbus Defence and Space in Europe, pioneered helmet-mounted sighting systems that nowadays allow pilots to aim their missiles and other weapons simply by looking at an airborne target. These innovative systems are already fitted to modern fighter jets like the Eurofighter and Gripen. Airbus DS Optronics also builds

sophisticated observation and targeting systems for ships, helicopters and manned and unmanned aircraft, as well as handheld devices for soldiers on the ground. The company's expertise and extremely high standards of precision and quality enable it to provide the ultra-modern optronics for submarine periscopes in service with numerous navies around the world.

Critical skills

- System Engineering and acquisition for new product development
- Project Management
- Electro-optical-mechanical design and product development for air, sea and land applications
- System integration and assembly

Core Skills: Mechanical & Optical Engineering

- Structural design and structure dynamics
- Environmental design and testing
- Fine mechanics
- Solid modelling
- Simulations
- Control systems
- Design for Flight Safety requirements
- Broad experience in bearings, lubricants, adhesives, electric motors, etc.
- Optical coatings

Electronic Engineering

- Power electronics
- Digital electronics (design, modelling, simulation & tolerance analysis, embedded processors, PCB layout, DSP)
- Analogue design
- FPGA/CPLD design
- Video (analogue, digital (HD), symbology)
- EMI/EMC
- RTCA/DO-254 hardware certification to levels A, B, C, and D
- Control hardware design and development

Software Engineering

- Software development management and quality assurance
- RTCA/DO-178B Certification to levels A, B, C, D
- Applications both Embedded and PC based
- Environments (x86, i960, Shark, PowerPC, VxWorks, Texas Instruments
- TMS320Cx, Motorola DSP 56000, PIC, Family of ATMEL Controllers)
- Control software and navigation algorithms
- Hardware communications protocol design and development

System Engineering

- System Engineering and Design processes (INCOSE)
- System performance modelling and simulation
- System Acquisition and technical management

SAFRAN TURBOMECA AFRICA

Turbomeca Africa is a multi-national company, committed to continuous improvement through high level training. The core business is divided into two main technical disciplines, helicopter engine maintenance and new part manufacturing for mainly the aviation industry.

Turbomeca therefore predominantly trains Aircraft mechanics and Turner Machinist. The job scope of Aircraft mechanics in the Turbomeca context works directly on helicopter engines. Activities include, but are not limited to maintenance, repair and overhaul of the engines. As an artisan you could also move to other activities such as Accessories fitting, working on the fuel & hydraulic control units.

The job scope of a Turner machinist performing high precision machining of parts, mostly gears and shafts for the aerospace industry. As an artisan you could specialize in other related disciplines such as Milling, Grinding & Gear cutting on both conventional and/or NC machines.

Socio Economic Development

Turbomeca is involved in various sponsorships one of which is RGM (Rowley George Marolen) school of excellence. The project focuses on the empowerment through education where career guidance of Grade 10 - 12 learners is done at campuses in Daveyton.

Career Requirements

Minimum requirements:

Grade 12 and/or N3 including relevant technical subjects – Mathematics, Science, Technology, etc.

After completion of a 3 year apprenticeship with 1 year theory and 2 years practical the trainee will be a qualified artisan.

RHEINMETALL DENEL MUNITION (PTY) LTD

Rheinmetall Denel Munition (RDM) is jointly owned by Rheinmetall Waffe Munition GmbH (51%) of Germany and Denel South Africa.

RDM specialises in the development, design and manufacture of large- and medium- calibre ammunition families and is a world leader in the field of artillery, mortar and infantry systems as well as plant engineering.

Rheinmetall Defence's business is mainly focused on NATO countries. RDM's focus is on Asia, the Middle East, South America, South Africa and African countries.

Rheinmetall and its South African unit are able to draw on an expanded product portfolio when serving their respective core markets.

Systems & Products - The RDM product portfolio encompasses:

- Artillery ammunition (105mm and 155mm)
- Mortar ammunition (60, 81 and 120mm)
- Missile subsystems (propulsion units, warheads, etc.)
- Minefield breaching systems
- Aircraft bombs
- Ammunition for naval applications
- 40mm infantry ammunition and pyrotechnics
- Propellants and raw materials
- Ammunition and metal components.

The following Career opportunities exist within RDM in fields of study:

External Bursary opportunities:

- Chemistry (BSC.)
- Chemical Engineering (Btech)
- Mechanical Engineering (Btech)
- Polymer Science (PHD)

The following Internship opportunities are offered:

- Chemistry (BSC.)
- Mechanical Engineering (Btech)
- Industrial Engineering (Btech)
- Chemical Engineering (Btech)

- Marketing (Btech)
- Human Resources (Btech)
- Financial Accounting (B.Com)

The following Workplace Experiential opportunities are also offered:

- Mechanical Engineering / Draftsman / Fitter / Electronics
- Chemical Engineering
- Analytical Chemistry
- Industrial Engineering

The following Apprenticeship & Learnership opportunities are offered:

Artisan development Programme, that includes, but are not limited to:

Turner Machinist / Electrician / Instrumentation / Boilermaker / Toolmaking / Fitter & Turner / Draftsman • Chemical Operations NQF1 Learnership

CHAPTER 22

ADDITIONAL TRAINING AND CAREER OPPORTUNITIES

APPRENTICE DEPARTMENT

Denel Centre for Learning & Development courses are accredited by the Aerospace Chamber to offer training, in accordance with the Competency Based Modular Training system, to ensure that apprentices are adequately trained both practically and theoretically to allow them to continue their experiential training to qualify them to become artisans.

Opportunities

Denel Centre for Learning & Development in conjunction with Denel offers rudimentary training opportunities to prospective apprentices in the following fields:

1. AIRCRAFT MECHANIC

A diverse and appealing occupation carrying a high degree of responsibility, the aircraft mechanic is required to have a broad and thorough understanding of an aircraft and all its integrated systems.

Their function is to perform preventative and corrective maintenance to ensure the safe operation of an aeroplane which includes repair, adjustments, testing and ultimately to certify it for flight.

2. AIRCRAFT STRUCTURAL WORKER

Commonly referred to as sheet metal workers, these people are responsible for the manufacture and repair of the physical airframe of an aircraft. Primarily, their work is devoted to the repair of damage caused by incidents, fatigue or corrosion to restore the integral strength of the airframe.

3. FITTER & TURNER

These are multi-skilled maintenance fitters that keep 'the wheels of industry' running smoothly. They are capable in most machining processes including; turning, milling, grinding and welding which make them virtually self-reliant in their trade and an asset to any company. They too are often involved in the development and fitting of new production processes.

4. TURNER & MACHINIST

These are specialist machine artisans that are highly skilled on either one or a variety of machines such as lathes, milling machines, surface and universal grinders and drilling / boring machines. Their task is to accurately produce or repair parts, which can also include the highly specialised field of gear cutting / grinding, in accordance to the client's drawings and specifications.

5. TOOLMAKER & JIG MAKER

The toolmaker and jig maker is a craftsperson with the ingenuity to produce specialised jigs, fixtures and tooling to assist industries to produce their products consistently and accurately and with minimal waste. These people are skilled in the use of hand tools as well as grinding, turning, milling and drilling machines.

6. AIRCRAFT RADIOTRICIAN

The radiotrician is responsible for all the radio telemetry equipment on board an aircraft which include navigation and communication. It is a very challenging career in view of the many new developments happening in the field and is appealing to anyone who has a keen interest in electronics. Other facets of their trade include the installation, repair and adjustment of their equipment on the aircraft.

7. AIRCRAFT INSTRUMENT MECHANIC

This is a highly specialised field that integrates the rare combination of both, electronic and fine mechanical skills, in one trade. An aircraft Instrument Mechanic is responsible for all the onboard instruments used to maintain flight safety and include the 'auto pilot'. Due to the compact nature of the instruments, candidates are required to have excellent fine motor dexterity.

8. AIRCRAFT ELECTRICIAN

Aircraft Electricians are responsible for the delivery and integration of electrical power between the various units or components of

an aircraft. Included in their responsibilities are the diagnostics, maintenance, repair and installation of electrical components which include generation systems and batteries.

9. AIRCRAFT AVIONICIAN

The aircraft Avionician incorporates all three of the existing aircraft avionic–related trades, namely; aircraft Electrician, aircraft Radiotrician and aircraft Instrument Mechanic. It is restricted to first-line maintenance, which includes installations, minor maintenance, and repairs of the equipment, that the above mentioned trades people work on.

10. ELECTRICIAN

Electricians are responsible for the installation and maintenance of the electrical network that powers all the machinery and outlets in the factory and household. They too need to ensure that such installations are always safe for the user and also comply with all the stringent regulations as prescribed by law. The electrician's work range will include both single and three phase electrical systems and light to heavy duty current.

11. MACHINE TOOL MILLWRIGHT

This trade was specifically introduced to cater for people interested in the maintenance and repair of machinery. It covers a broad spectrum integrating the combination of both mechanical fitting and electrical/ electronic skills which include electrical installations, electronic controllers and microprocessors such as those found in Computer Numeric Controlled (CNC) machines.

12. WELDER

Highly skilled welders are increasingly in demand due to modern advancements in production processes and materials. They need to be proficient in a wide variety of welding techniques and capable of continually producing high quality welds in often difficult conditions. Qualified welders can look forward to a variety of interesting opportunities in a wide range of industries.

QUALIFICATION AND CONDITIONS FOR APPRENTICESHIP

Minimum Entrance Qualification For All Trades

- Grade10 (N1) with Mathematics and Science for the following trades:
  a. Aircraft Mechanic
  b. Aircraft Structures Worker
  c. Fitter & Turner
  d. Turner & Machinist
  e. Toolmaker & Jig Maker
  f. Welder
- Grade11(N2) with Mathematics and Science for the following trades:
  a. Aircraft Radiotrician
  b. Aircraft Instrument Mechanic
  c. Aircraft Electrician

d. Aircraft Avionician
e. Electrician
f. Machine Tool Millwright

Apprenticeship Period

The duration of apprentice for all trades is 95 weeks minimum and 208 weeks maximum. However after the minimum period (subject to tasks completed as laid down) an apprentice may perform a trade test and qualify as an artisan.

Working Hours

All students will work a 5 day week.

If you are interested in a technical career, direct your application to:

APPRENTICE & ARTISAN TRAINING MANAGER
DENEL CENTRE FOR LEARNING & DEVELOPMENT
PO BOX 16610
ATLASVILLE
1465

For further enquiries:

Tel: +27 11 927 4465/5172/3284
Fax: +27 11 927 4449
Email: recruitmentdcld@dcld.co.za

Contact information on other career opportunities

Now that the learner knows what is available within the defence and aerospace environment, the following is a list of contact details within Denel. The learner can use these to get more information about pursuing a career within Denel or the wider defence and aerospace. What Denel does not offer should be offered by other companies within the defence and aerospace environment.

Bursaries to non-employees

The company allocates bursaries for full time studies at tertiary institutions.

These bursaries are allocated on the following conditions:

- The core competencies and core functions of Denel are enhanced;
- The bursaries are allocated with consideration of the requirements of legislation regarding representivity of the demographics of the country.
- Students become permanent employees after completion of their studies.
- Denel may take over bursaries from other institutions.

Maintenance and repair of the Physical Airframe of the aircraft

Contact details: Elelwani Mainganye

Communications & PR Consultant

Tel: +27 11 927 3535

E-mail: elelwanim@denelaviation.co.za

Website: www.denelaviation.co.za

DENEL OVERBERG TEST RANGE

Denel Overberg Test Range information is covered in this book. It is a versatile test facility specialising in the testing of advanced weapon and aircraft systems for the local and international aerospace industries. The Test Range operates on the forefront of modern technology and offers exciting and challenging career opportunities to its employees.

Contact details:

Bridget Salo – Deputy Chief Executive

Tel. +27 28 445 2011

E-mail: otrhr@denelotr.co.za

Web: www.denelotr.co.za

DENEL LAND SYSTEMS

This section deals with military vehicles and artillery on page 83

For more information please contact:

Dikeledi Makhubela – Skills Development Facilitator

E-mail: DikelediM@dlsys.co.za Tel: +27 12 620 3240

MECHEM

For more information on commercial and humanitarian demining, please contact the following:

Tallies Taljaard: Senior Manager Training
Tel: +27 (0)12 640 3000
Fax: +27 (0)12 664 3528

Skills Development Facilitator: Ruth Molapo
Tel: +27 (0)12 640 3000
Fax: +27 (0)12 664 3528
Web: www.mechem.co.za

DENEL DYNAMICS

Missiles, which are addressed extensively in Chapter 13, are manufactured by Denel

For more information please contact

Makhotso Mabote: Bursary & Graduate Recruitment Specialist
Tel: +27 12 671 2488
E-mail: makhotso.mabote@deneldynamics.co.za
Web: www.deneldynamics.co.za

DENEL PMP

Chapter 11 gives ample information about this organisation in as far as ammunition is concerned. It also outlines career opportunities available within this environment

For more information please contact:

PJJ (Peet) Potgieter: Manager Personnel Services PMP
Private Bag X334, Pretoria, 0001
Tel: +27 (12) 318 1484
Fax: +27 (12) 318 1088
E-mail: peet@pmp.co.za
Web: www.pmp.co.za

DENEL INDUSTRIAL PROPERTIES

For more information please contact:

Ntombesizwe Hashe: HR Office
Tel: +27 (12) 671 2815
Fax: +27 (12) 675 2815
E-mail: ntombi.hashe@deneldynamics.co.za

AIRBUS DS OPTRONICS

For more information please contact:

Aggie Mdluli: HR Consultant

Tel: +27 (0) 12 674 0186

Fax: +27 (0) 12 674 0198

Fax to mail: 08 66 386 051

Mail to: aggie.mdluli@cassidian-optronics.com

Website: www.cassidian-optronics.com

SAFRAN - TURBOMECA AFRICA

For more information please contact:

Dheshini Naidoo – HR: Skills Development Facilitator

Email: dheshini.naidoo@turbomeca.co.za

Tel: 010 001 4970 Ext 2927

RHEINMETALL DENEL MUNITION (PTY) LTD

For more information please contact the following:
Sharon Langeveld: Skills Development Facilitator
Tel: +27 (0)21 850 2964
Fax: +27 (0)86 201 8206
E-mail: Sharon.Langeveld@rheinmetall-denelmunition.com
Web: www.rheinmetall-denelmunition.com

DENEL AEROSTRUCTURES

Denel Aerostructures (DAe) is a powerhouse in aircraft development and manufacture in South Africa. With the largest aerostructures manufacturing facilities in Africa, DAe invests extensively to establish modernised, world-class facilities for advanced manufacturing of complex, light weight aerostructures assemblies. This incorporates high-end machining, advanced composites lay-up, special processes, assembly and a full range of engineering capabilities including design, development, testing and certification. Our mastery of technology and depth of skills have been forged through over four decades of experience in the aerospace sector, building fuselage sections, fairing, pylons, landing gears, wings and other control surfaces for fixed and rotary wing aircraft.

For more information please contact

Sam Senekal: HR Consultant

Tel: +27 11 927 3217

Email: sams@denelaerostructures.co.za

Website: www.denelaerostructures.co.za

For all other information that the learner may need that is not available at Denel, please contact the following:

Aerospace, Maritime and Defence Association

Postnet Suite no: 1147

Private Bag X10

Elarduspark

0047

Tel: (012) 752 5880/2

Fax: 086 247 4585

Email: info@amd.org.za

Web: www.amd.org.za

EPILOGUE

MESSAGE TO THE LEARNER

Having read this book places some obligation on you as a learner. Firstly, you might share this information with others by telling them the content of this book or by giving them this book to read. Secondly, you might choose to follow a career path within the defence environment. Thirdly, you might not want to follow a career within the defence environment but you might want to follow a career in another environment. Please look for the relevant information for your career path if it is not addressed in this book.

Denel has attempted to bring you closer to understanding what is available within the defence environment. Get an education so that you can have a level of financial independence. The more independent we become financially the more money government has to spend on things like roads, electricity, water and health. Self- support strengthens self-respect and a noble independence. The ball is in your court as a learner.

Defence technology is nothing other than the means to solving problems of people within the defence/military environment. Technology in general is nothing other than solving problems of society. As a learner, our country needs you more than you need it. There are many problems that we encounter that are waiting for you to solve. You are free to look at any societal problem and decide how you can come up with a solution for that problem.

Looking at how things have evolved over the years, there is no limit to

what people can develop. There is no limit to what you as a learner can develop as a solution to societal problems. You have the ability. You just have to believe in it.

On June 24, 2014 the *Sowetan* newspaper ran a two page spread on the South African aviation industry. A number of people who have made it in the aviation industry were profiled. Their stories are encouraging because they did not have it all. They had to work hard to be pilots in spite of the unavailability of money. Unfortunately, the world does not listen to excuses for not succeeding. They listen to how people become successful against all odds.

The defence mystery is out of the box. The ball is in your court. Play it.

CONTRIBUTORS TO THE BOOK

The bulk of the content contributors are Denel engineers and technicians. A list of other contributors is as follows:

Chapter 5

Major General (Retired) NLJ Ngema
Founder of Siyandiza and the National Aviation Academy

Chapter 9

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Senior Staff Officer (SSO) Submarine Warfare
South African Navy

Chapter 15

Andrew van der Spuy
Programme Manager Technical: Parachute Systems
ARMSCOR

AND

Douw Raimondo
Parachute Training
Mobile 1: +27 79 894 5161
E Mail: douw@chutesyst.co.za
Web: www.chutesyst.co.za

Training opportunities for parachutists

This company offers parachute training in the following areas:

- Parachute Packing Courses
- Parachute Packing Round
- Parachute Check Round
- Parachute Packing (Ram Air)
- Parachute Check (Ram Air)
- Rigging Courses
- Reserve Packing Courses (Round and Ram Air)

Parachute Training

- Basic Static Line Jump Course
- Basic Static Line Jumpmaster Course
- Basic Static Line Instructors Course
- AIRBORNE Battle Handling
- Air Force Orientation Course
- Drop zone Safety Officers Course
- Free Fall Course
- Free Fall Jumpmaster Course
- Free Fall Instructors Course
- High Altitude Parachute Operations (HAHO / HALO)

Specialised Airborne Training

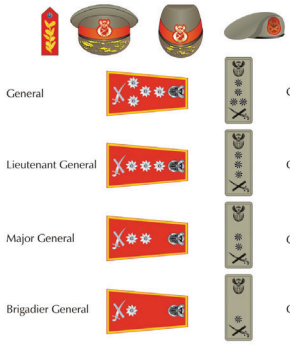
- Airborne Assault Course
- Helicopter Repel ling
- Helicopter Fast Roping
- Mountaineering Course

RANK INSIGNIA
OF THE SOUTH AFRICAN NATIONAL DEFENCE FORCE

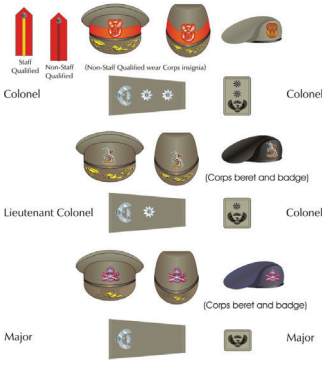
South African Army

Rank | Rank Insignia | Form of Address

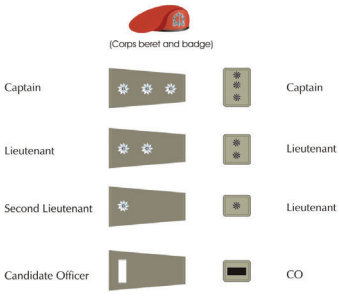
General Officers



Senior Officers



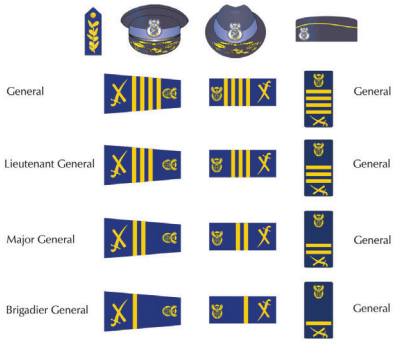
Junior Officers



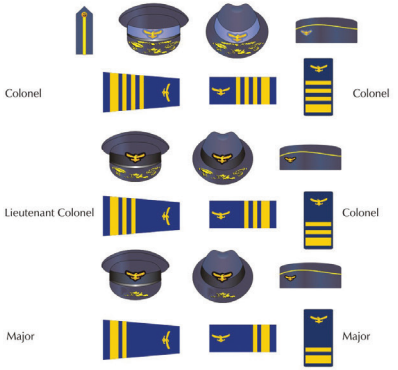
South African Air Force

Rank | Rank Insignia | Form of Address

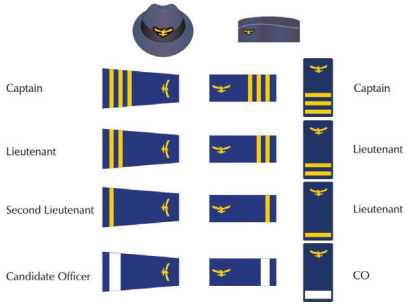
General Officers



Senior Officers



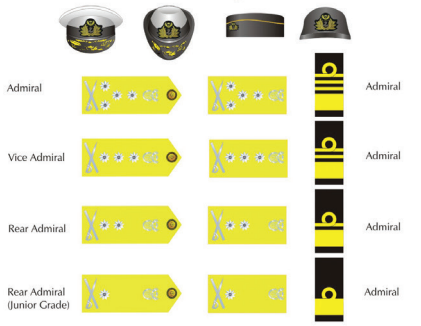
Junior Officers



RANK INSIGNIA
OF THE SOUTH AFRICAN NATIONAL DEFENCE FORCE

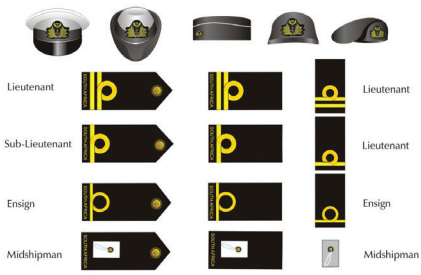
South African Navy

Flag Officers



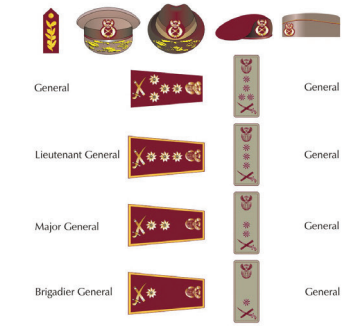
Senior Officers

Junior Officers



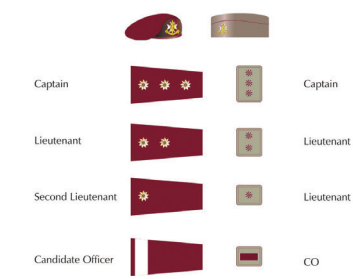
South African Military Health Service

General Officers



Senior Officers

Junior Officers



South African Army

Rank | Rank Insignia | Form of Address

Warrant Officers

Master Chief Warrant Officer (MCWO) — Warrant Officer

Warrant Officer

Senior Chief Warrant Officer (SCWO) — Chief Warrant Officer (CWO)

(Corps beret and badge)

Master Warrant Officer (MWO) — Senior Warrant Office (SWO) — Warrant Officer

Warrant Officer Class 1 — WO1 — Warrant Officer

Warrant Officer Class 2 — WO2 — Warrant Officer

Non Commissioned Officers

(Corps beret and badge)

Staff Sergeant — Staff — Ceremonial

Sergeant — Sergeant — Caterers Corps

Corporal — Corporal

Lance Corporal — Corporal

South African Air Force

Rank | Rank Insignia | Form of Address

Warrant Officers

Master Chief Warrant Officer (MCWO) — Warrant Officer

Warrant Officer

Senior Chief Warrant Officer (SCWO) — Chief Warrant Officer (CWO)

Master Warrant Officer (MWO) — Senior Warrant Office (SWO) — Warrant Officer

Warrant Officer Class 1 — WO1 — Warrant Officer

Warrant Officer Class 2 — WO2 — Warrant Officer

Non Commissioned Officers

Flight Sergeant — Flight

Sergeant — Sergeant

Corporal — Corporal

Lance Corporal — Corporal

Chaplains

Brigadier General — General

Colonel — Colonel

Staff Qualified — Non-Staff Qualified

Chaplain

Christian — Hindu — Jewish — Muslim

Form of address: Chaplain / Religious title, subject to the denomination / religion of the incumbent
(For protocol, Chaplains hold Colonel Status, but not in Command and Control Line)

Chaplains

Brigadier General — General

Colonel — Colonel

Chaplain

Form of address: Chaplain / Religious title, subject to the denomination / religion of the incumbent
(For protocol, Chaplains hold Colonel Status, but not in Command and Control Line)

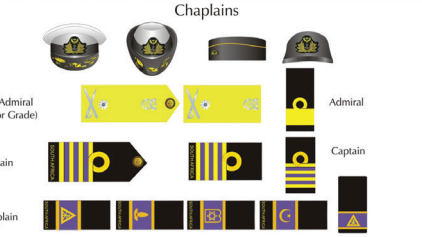
South African Navy

Rank | Rank Insignia | Form of Address

Warrant Officers

Ratings

Chaplains



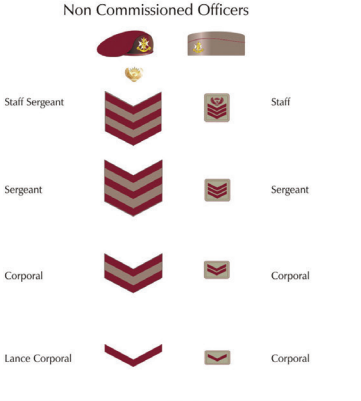
Form of address: Chaplain / Religious title, subject to the denomination / religion of the incumbent
(For protocol, Chaplains hold Captain(SAN) Status, but not in Command and Control Line)

South African Military Health Service

Rank | Rank Insignia | Form of Address

Warrant Officers

Non Commissioned Officers



Chaplains

Form of address: Chaplain / Religious title, subject to the denomination / religion of the incumbent
(For protocol, Chaplains hold Colonel Status, but not in Command and Control Line)

When you're in Grade 9, you need to start thinking about what subjects you need for the career you intend to follow. If you have an interest in military and technology, *Defence Technology Made Easy* gives you a glimpse into the myriad of career opportunities in the South African Defence Force.

You will gain important insight into each of the different services, what jobs are available in each, which school subjects are required, and contact details.

This book also complements Denel's educational programme which aims to improve learners' maths and science.

DENEL

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