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SECTORAL ANALYSIS OF THE AEROSPACE INDUSTRY IN SOUTH AFRICA

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Sectoral Analysis of the Aerospace Industry in South Africa

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Sector Profile

Overview of the sector

The lack of consistent and comparable data for the South African aerospace industry hinders the assessment of a sector that is acquiring growing interest in the policy arena. Various sources suggest that there are currently between 100 and 200 domestic organizations engaged in aerospace activities in South Africa. The sector is highly concentrated in a few, very large organizations, although the segment of small, medium and micro enterprises (SMMEs) is rapidly growing and has been recently estimated to comprise about 75% of the organizations. South African aerospace companies mainly operate in the Gauteng province, while a smaller hub is based in the Western Cape in connection to the University of Stellenbosch.

According to the Labour Force Survey, the sub-sector ‘manufacture of aircraft and spacecraft’ employed approximately 1,500 people in 2005, contributing to about 0.14% of total employment in the manufacturing sector. However this figure underestimates the real size of the sector since aerospace activities are largely spread across other sub-sectors such as ‘weapons and ammunition’ and ‘special purpose machinery’. Unfortunately, current methods of data collection do not allow extracting explicit figures for aerospace activities.

The origins and development of the aerospace industry in South Africa cannot be separated from the defence industry. Designed to serve the state’s military purposes in a period of economic isolation, aerospace and defence activities have largely relied on funding support from the government. Later exposure to international markets uncovered the urgency to reformulate sustainable competitive alternatives to maintain the existing South African aerospace capabilities.

Drivers of change in the aerospace sector

Changes in the sector are driven by multiple factors, but perhaps the most prominent are related to the dramatic changes that are taking place in global production chains. Recent dynamics in the global industry have generated large opportunities and challenges to the few emerging economies that have managed to achieve capabilities in aerospace manufacturing, such as South Africa.

During the years of economic isolation, South Africa developed the capability to manufacture and design complete aircraft. However, new priorities on government spending and major changes in global production chains led to readjusting the sector strategy to become a specialised lower-tier supplier for international leaders. This strategy involves competition with other emerging economies such as Brazil, India and China. However, recent policy perspectives contemplate cooperation between emerging regions to cultivate their complementary niches in aerospace, rather than competing among them as global suppliers.

Manufacturing aircraft and spacecraft is highly technologically intensive. Therefore, technology changes have a significant impact on employment and skill requirements in the aerospace production. Technological advance promotes the constant upgrade of skills in the workforce for this sector. However, advances affecting the sector originate in both aerospace and adjacent sectors (such as composite materials, tools and automotive).

New policies and initiatives are also driving changes in the South African aerospace landscape. Recent initiatives promote the development of skills and integration of the sector into domestic and international value chains.

The rapid growth in domestic civil airlines and the growth of tourism have a positive impact in the sector, increasing potential market opportunities. However, other socio-economic factors have a negative impact on the industry, such as high unemployment rates, and social problems such as HIV/AIDS pandemic and the migration of technical skills.

The demand for skills

According to the LFS, about 25% of the employees in the subsector 'manufacturing aircraft and spacecraft' are employed in managerial positions. Professionals and technical personnel are mainly involved in technical design activities, and account for about 15% of those employed. Plant and machinery, operators and assemblers, constitute the largest single category comprising about 30% of aerospace employment. Compared to the average of the manufacturing sector in South Africa, aerospace manufacturing has three times the proportion of managers and senior officials, and twice the proportion of professionals. Technicians, clerks, service workers and assemblers are also in higher demand. Elementary occupations represented only 3% of total employment in aerospace in 2001-05, considerably lower than the average of 20% of elementary occupations in the manufacturing sector.

The Labour Force Survey ndicates that employment in the subsector 'manufacturing aircraft and spacecraft' has consistently increased since 2003 to present. However, increases have not taken place homogeneously in terms of occupations, level of skill, age, race and gender.

From a gender and racial perspective, most employees in the sector overall are male and white South African employees. Occupations held by women, and non-white employees are predominantly located in the semi and unskilled occupational levels. Yet major changes have taken place in 'senior official and management' occupations. This category has gone through a rapid transformation during the last decade, with the inclusion of more black employees as well as female, younger and intermediate skilled workforce.

Changes in other occupational categories, particularly those related with technical and advanced manufacturing skills, such as 'professionals' and 'technicians' have been very limited. A particular challenge facing the sector is increasing the participation of non-white, females, and young people in the technical occupational categories. Meeting the future demand of technical skills in the sector largely depends on the correction of these imbalances.

In general, the aerospace industry has a larger proportion of highly skilled workers than the average for all industries. However, the demand for skills in the sector has experienced a significant transformation during the last decade. Demand for low skilled labour has clearly increased while the demand for higher skilled workers has declined. At the same time demand for workers with intermediate skill is rapidly growing, accounting for nearly 60% of the employees in 2001-05. These changing patterns could be reflecting the current process of adaptation within South African aerospace companies to their new competitive environment.

The supply of skills

Any manufacturer of complex machinery requires a pool of skilled labour available. Moreover, a country wishing to establish and promote aerospace manufacturing must have access to a sophisticated academic system, capable of producing highly educated engineers. This is especially relevant for South Africa, who is competing as supplier for international global leaders while acquiring capabilities to upgrade its aerospace manufactures. Local producers are now required to build products that meet strict international standards, and this has direct implications for the education and training systems in South Africa.

A detailed analysis of the availability of Further Education and Training (FET) and Higher Education and Training (HET) graduates with qualifications in the aerospace and engineering fields presents interesting results. For FET the analysis indicates the low number of enrolments in aerospace subjects. Moreover, some aerospace-related subjects have been practically deserted during the last decade. In general, results indicate that pass rates have decreased over time, suggesting that the quality of education in technical subjects has deteriorated.

For HET the total number of graduates in technikons and universities with qualifications in engineering was 4,348 in 2004. However, only 16 of these had majored in aeronautical engineering, and just over 600 in mechanical engineering (with direct application to aerospace manufacturing). Overall, graduation rates in engineering are strikingly low, and although they show moderately improvements in technikons (from 8% in 2000 to 11% in 2004), they have declined in universities from 19% overall in 2000 to just 14% in 2004. MERSETA (2006) has suggested that an improved graduation rate is desirable as insufficient numbers are coming through the system to meet demand from Industry.

National Learners' Records Database (NLRD) data showed that for engineering, National Diploma is the major exit qualification, followed by Professional Degrees and B-Techs. However, there has been an increase in the number of people that stay longer in the HET system as the number of people with postgraduate qualifications is increasing (from 576 in 1996 to 1 063 in 2005).

Migration and HIV/AIDS are some of the social factors affecting the supply of skilled professionals in South Africa. Emigration trends collected by Statistics SA, reveal that there is an increasing loss of 'engineers and related technologists', while the immigration of skilled engineers has declined from 1998 to 2003. In relation to HIV/AIDS, given the occupational and skills profile of the aerospace industry, a lower prevalence of HIV/AIDS would be expected in comparison to other sectors. However, up to date figures on the prevalence of HIV/AIDS in the aerospace industry are not available. Nevertheless, this study found the general recognition of the need for intensified education and awareness in health and safety for aerospace workers.

Training and skills development practices in the aerospace sector

The competitiveness and sustainability of aerospace firms depends on their ability to maintain technological capabilities in the areas of product development and human resources. Continuous education and training of the workforce becomes thus essential. However, the absence of a specific training authority for aerospace limits available formal training options for South African aerospace companies.

Two Sector Education and Training Authorities (SETAs) partially service the aerospace sector: the Manufacturing, Engineering and Related Services SETA (MERSETA) and the Transport Education and Training Authority (TETA). MERSETA covers a number of manufacturing activities such as automotive, new tyre, plastics, metal and motor manufacturing, but not aerospace manufacturing; while TETA is responsible of aerospace but only as a mode of transport service.

Grants, learnerships, apprenticeships and tax incentives can be accessed from MERSETA and TETA to encourage companies to increase their training activities. Nevertheless, personal interviews revealed the limited use that South African aerospace manufacturers make of the SETAs.

Denel Centre for Learning and Development (DCLD) is the largest skills development and training programme in South Africa for the aerospace and defence industries. DCLD operates as a private entity and its courses are accredited by the TETA and the Aerospace Chamber. Their figures on intakes and learnerships provide an indication of the characteristics of available formal training in aerospace. DCLD statistics show that the number of intakes has grown exponentially since 2000. Black males and black females accounted for about 60% of the intakes in 2007.

Personal interviews indicated that the development of skills in the workforce beyond entry-level appears to be mostly provided by the employers. A large part of the technical and management training takes place in-house or in occasional collaboration with private training institutions, customers, other domestic companies, universities and technikons. The relevance of training is reflected in companies' reported focus on training as a central aspect of their strategy. The intensity of training is also high; on average employers devote between 5-10% of their sales to training expenses.

Technical training appears to be a priority in aerospace companies, which is achieved from a variety of sources. Major international clients play an important role in training South African aerospace workers. Offset agreements imply that foreign contractors have to reinvest a certain amount of the value of their purchases in South African development. In some cases this is achieved by establishing skills development programmes with the foreign contractor that involve sending local technicians overseas. Technicians and associated professionals seem to benefit most from training, as in management training is less frequent.

Identification of scarce and critical skills

The number of orders in the South African aerospace industry is rapidly growing, and all companies interviewed expressed their lack of skilled personnel to attend to current and future customer demands. The shortage of technical personnel, in particular engineers, stands out. Scarce skills in the sector are mainly for technicians and associated professionals, as well as airframe artisans, plant operators and assemblers. Although these occupational categories are experiencing growth over time, their rate of formation does not seem to be keeping up with the rapid pace of change in the industry.

Scarce and critical skills are related to the processes and procedures that global contractors require from South African aerospace manufacturers. However, the capacity of local companies to compete is largely limited by the scarcity and quality of available engineering skills, as well as the intermediate level of artisans and composite specialists.

Personal interviews revealed that critical skills are generally the result of various factors, such as insufficient training prior to entry in the work place, technological changes and recent regulatory changes in the identification of engineering work. There is widespread concern about the need to expose skilled personnel to the industry environment during their period of education. Specialised technical skills were identified as critical for production workers; however, soft skills, computer skills and project management were the most important critical skills in the sector as they cut across all occupational groups.

METHODOLOGY AND DATA COLLECTION

There is an on-going policy concern to ensure that South Africa has the appropriate skills base both now and in the future to sustain economic growth and to compete internationally in a number of identified ‘priority sectors’, including aerospace. This task requires following up the constant changes in these industrial sectors, considering their implications for future skills demand and skills provision. The purpose of the present report is to examine the current level, characteristics and requirements of skills in the South African aerospace sector. This will conclude with the identification of scarce and critical skills and a number of policy recommendations.

This study has largely relied on existing documents and background information on the sector from both local and international sources. A few published reports are available. Although most of them are either general in their approach or not focused on the need of skills in the aerospace sector, they have allowed the identification of different strategies, trends and views. Information on global dynamics was obtained from international reviews and strategic reports from the UK, EU and US.

Data on employment was obtained from the Labour Force Survey (LFS) and the supply of skills for Further Education and Training (FET) and Higher Educations and Training (HET) from the National Learners’ Records Database (NLRD). Statistics SA provides data on migration of technical skills and the Department of Trade and Industry (DTI) compiles detailed figures on exports and imports.

Secondary sources of data have been complemented with first-hand information collected through interviews. Interviews were conducted for a small sample of seven aerospace manufacturers using a semi-structured survey instrument developed to capture comparable information on key issues of skills development and training practices. Interviews were performed personally (except for one case) at the premises of each company and in most cases engaged key management personnel involved in human resources development and engineering activities. In some cases, interviews were complemented with visits to the training workshops in the plant. The companies interviewed included three first-tiers (Denel, Aerosud and Sunspace), two lower-tiers (ATT Composites, and CCII), and two aerospace services companies (one small, TMI Consulting and one large, ARMSCOR). Despite the small size of the sample, the variety of companies represents the different types of organizations operating in the industry.

Additional meetings were conducted with relevant personnel at the Department of Trade and Industry (the DTI), the Aerospace Industry Support Initiative (AISI), the National Aerospace Centre of Excellence (NACoE) at WITS University, and the Aerospace, Maritime and Defence Industries Association of South Africa

(AMD). These meetings contributed to draw the profile of the aerospace sector and establish contact with some of the firms interviewed in the sample.

CHAPTER ONE: PROFILE OF THE AEROSPACE INDUSTRY

Information and studies on the aerospace sector in South Africa are not conducted regularly and in many cases they provide only a partial view of the sector. Reliable and consistent sources of data are a major constraint for adequate policy formulation. This chapter attempts to modestly contribute to this limitation through a compilation of existing material on the South African aerospace industry from various sources, placing domestic facts and figures in an international context.

Definition of the aerospace industry

Typically the term ***aerospace*** is used to refer to the industry that researches, designs, manufactures, operates, and maintains vehicles moving through air and space. Aerospace is a very diverse sector, with a multitude of commercial, industrial and military applications. In the South African context the sector involves activities surrounding: Defence, Civilian, Aeronautics and Space.

To be consistent with other aerospace-related research in South Africa, this study adopts the definition of aerospace industry as “the research and development, design, manufacture, support, maintenance, conversion and upgrade of: rotary and fixed wing aircraft; satellites, satellite launch and tracking systems; air traffic control systems; unmanned aircraft; and weapons systems as well as their relevant subsystems and components” (Paul Hatty, 2000). This definition focuses on manufacturing activities and excludes the operation of domestic and international aircraft or ground/flight crew, attendants, and catering.

The global aerospace industry can be broken down into five tiers that are summarised in Table 1.1:

Table 1.1: Classification of aerospace production

	Description	**Level of skills**
Top-Tiers or First-Tiers		
Tier One (Complete system)	Entire aircraft with all the required sub systems already fully integrated. *Example: Rooivalk helicopter*	- High value added - High level human resources
Tier Two (Major sub-systems)	Sub-systems that are made up out of a significant number of minor subsystems. *Examples: main airframe sections (e.g. wing), undercarriage, complete avionics system*.	- Medium value added products - Medium level human resources and production skills
Lower Tiers or Sub-Tiers		
Tier Three (Minor sub-systems)	Defined assembly of components indivisible into other systems. *Examples: Aerodynamic control surfaces (flaps), gearboxes, navigation systems, weapons and ordinances, computer system*	- Medium value added products, - Medium level human resources, Production skills.
Tier Four (Components)	Devices with a clear function that is of no use unless integrated into a tier-3 system. *Examples: Electrical circuit boards, Machined engine parts, Valves and pumps.*	- Medium value added products - Medium level human resources, Production skills.
Tier Five (Parts)	Units that can be defined as a single monolithic part. *Examples: Un-machined castings, Shafts, Rivets, Electrical components*.	- Low value added products - Medium level human resources.

Source: Extracted from Assegai (2004)

South Africa has developed considerable capabilities and local companies in most of these categories, and has achieved the ability to design and manufacture tier-one complete systems, as well as lower-tier products such as parts and components. Based on these categories, the present chapter examines the opportunities of the South African aerospace industry and the potential to improve the industry's integration in global and local supply chains.

According to Statistics South Africa (StatsSA), the Industry code 386 ('manufacture of aircraft and spacecraft") represents the core of aerospace manufacturing activities for both civil and military purposes. Most of the analysis along this study is based on information available for this sub-sector.

Table 1.2: Industrial classification codes

Code	Activity
3	**Manufacturing**
386	**Manufacture of aircraft and spacecraft**
357	**Manufacture of special purpose machinery**
	Manufacture of agricultural and forestry machinery
	Manufacture of machine tools
	Manufacture of machinery for metallurgy
	Manufacture of machinery for mining, quarrying and construction
	Manufacture of machinery for food, beverage and tobacco processing
	Manufacture of machinery for textile, apparel and leather production
	Manufacture of weapons and ammunition
	Manufacture of other special purpose machinery

Source: Statistics SA

However, it is important to note that figures for this sub-sector largely underestimate the real size of the aerospace sector. Aerospace activities are spread across various other sectors such as communications equipment, instruments, special purpose machinery and other industries. Unfortunately, available statistical sources in South Africa do not allow extracting figures for aerospace activities across other sub-sectors.

Understanding this great limitation, this study compares 'manufacture of aircraft and spacecraft' (Code 386) with existing figures on 'manufacturing of special purpose machinery' (Code 357), which includes a proportion of defence-related aerospace activities ('manufacture of weapons and ammunition'). This comparison provides an indication of trends in other sub-sectors connected to aerospace. Also figures on total manufacturing have been included as terms of reference.

Aerospace: a global oligopoly in transformation

The aerospace industry is peculiar in several ways. Its technology and capital-intensive nature, the complexity of production and the high risks involved in new product development, have traditionally linked the industry to strong government support. The sector has been generally associated to national security and defence objectives, although aerospace technologies have also been used for commercial purposes. The aerospace industry is divided into two main sectors: the military (or defence sector) and the civil (or commercial sector).

Aerospace is also considered home to key skills and technologies as well as an important driver of innovation. Due to its role in transportation, communication, observation, security and defence, it has been regarded as a strategic industrial sector. Nevertheless, not many nations have managed to develop substantial aerospace industries[1].

Global aerospace is concentrated in a few countries; however, it is perhaps one of the fastest globalizing industries in terms of both market structure and production system (Kimura, 2006). The following sections describe some international dynamics of the sector.

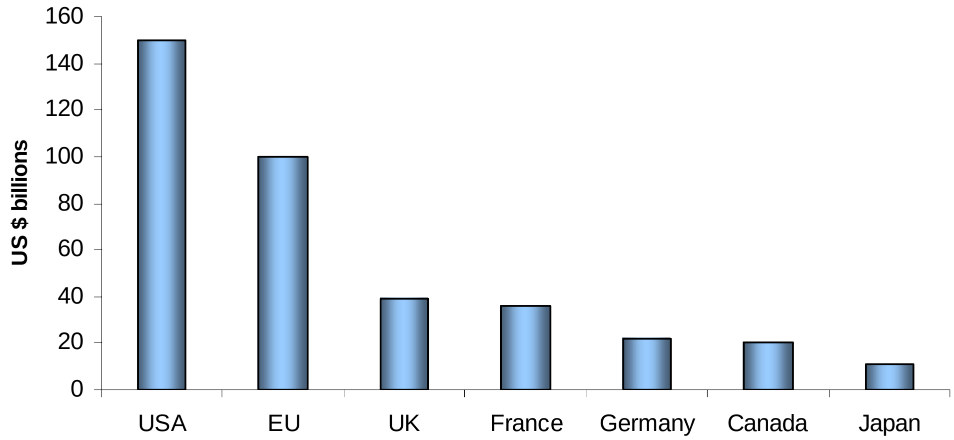
The state of global aerospace

In 2005 the global aerospace industry achieved the size of US$ 330 billion at an annual growth rate of 4.5% (RNCOS, 2005). In 2005, 86% of the sales corresponded to the defence segment of aerospace and the remaining 14% was civil aviation. The aerospace industry is growing at a very rapid pace. By 2009, the global aerospace market is predicted to have attained a value of US$ 380 billion (RNCOS, 2005).

The aerospace industry is concentrated geographically in the United States followed by the EU (see figure 1.1). USA and EU concentrate over 80% of the global turnover in aerospace: the US represents one half while the EU accounts for about a third. The UK, France, Germany and Italy are the main European producers, while in Asia Japan is the dominant player.

[1] A recent AMD study (2006) states that only nineteen countries in the world have achieved substantial domestic defence industries.

Figure 1.1: Global leaders in aerospace 2004*



Note: * consolidated turnover figures
Source: RNCOS, 2005

The US and EU dominance in global markets is mainly at the level of first-tier or primary contractor, while the rest of the countries have acquired relative competitive advantages as lower-tiers. For instance, the Japanese aerospace industry has managed to design and produce its own aircraft; however, Japan has globally developed a role as high tech subcontractor to foreign (essentially US) aerospace companies (Kimura, 2006).

Analysts expect that opportunities in global aerospace markets will increase considerably for newly emerging economies in the coming years. These opportunities are mainly driven by the civil aviation segment. Civil aviation relates to the exponential growth in infrastructure and transportation in certain Asian, African and Latin American regions.

Only a handful of emerging economies, such as Taiwan, Indonesia, Brazil, China and South Africa, have managed to establish their own ‘indigenous’ aerospace industries, which are starting to have an impact on international markets. Aerospace activities in these countries are growing at unprecedented rates although their share of global turnover is still very small. Despite their great potential, they still suffer from severe limitations, such as lack of specific skills, design capabilities and maturity of supplier base to keep up with the rapid advances in aerospace products. Therefore, their tendency is moving towards forming strategic alliances and performing as low cost platforms to major players in the global industry.

Brazil produces regional aircraft (with 10% of the world regional aircraft market) and is involved in a number of minor military aerospace co-operations. Indonesia also competes in the regional aircraft market. India is rapidly developing its capabilities in aerospace, and has been identified as low cost sourcing destination for low-batch precision machined parts & assemblies (UK Trade and Investment, 2006)

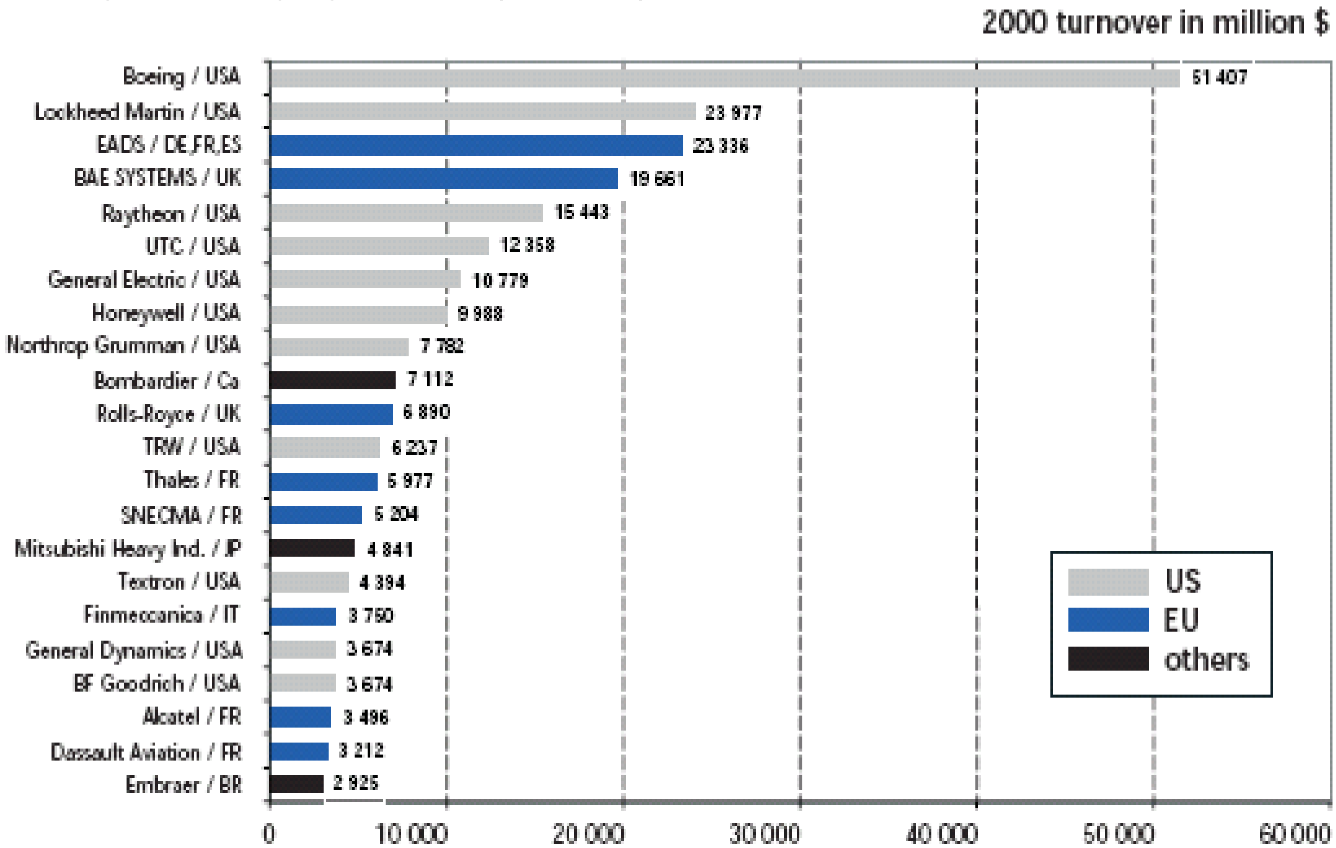
China's aircraft industry is still in its early stages. Chinese airline companies have most of their aircrafts imported from foreign countries. However, in 2006 China has produced its first domestically manufactured passenger aircraft, and negotiations with domestic airline companies may bring the local aircraft to their domestic market.

The South African case will be explored with more detail in further sections this report.

A global industry in transformation

Concentration is the central feature of the aerospace industry not only geographically but also at the level of corporations. As shown in Figure 1.2, most civil and military aerospace production is in the hands of only a few big players: Boeing and Lockheed Martin in the US and EADS and BAE Systems in Europe.

Figure 1.2: Major global aerospace companies



Source: STAR21, EC

Aerospace is a global oligopolistic sector, where almost all the countries offering world class planes were established after WW1. Goldstein (2002) argues that catching-up aerospace firms have tended to follow a three-phase learning process, beginning with license manufacturing, continuing with sub-contracting arrangements with established assemblers, and culminating with attempts at developing and manufacturing complete products.

The landscape and dynamics of aerospace companies have been and continue to be characterised by rapid transformation. Some of the major drivers of change in the global industry are:

- Consolidation

The aerospace and defence industries have experienced a decade of intense consolidation, particularly at the level of top-tier producers in US and EU. Rapid consolidation in the US since the mid 1990s led to the creation of the three giants: Boeing, Lockheed Martin and Raytheon. In EU, British Aerospace and Marconi Electronic Systems merged to form BAE Systems and a further stream of mergers resulted in the European Aerospace, Defence and Space Company (EADS), Europe's first major cross-country merger.

This trend is expected to continue in the sector but instead of first-tiers, at the still highly fragmented sub-tier supplier level (Avionics Magazine, 2006). The current focus of consolidation is around growth segments such as electronics or capturing leadership in relatively fragmented markets at low-tier levels, such as aerostructures.

- Liberalization and privatization of civil aviation

The civil aviation market is increasingly becoming more competitive and deregulated. Liberalization and privatization are altering the relationships between the airlines (main users) and airframers (first-tiers). Air traffic in emerging economies is growing exponentially and the low-fare segment of civil aviation has enjoyed the largest growth. Growth of low-cost airlines is expected to continue with subsequent increases in their purchases of aircraft. These forces put pressure on first-tiers to reduce their manufacturing costs by placing more design, manufacturing, risk-sharing, and supply chain management responsibilities on lower-tier suppliers (A.T. Kearney, 2003; Avionics Magazine, 2006).

- Aircraft production: vertical integration towards system integrators

The supply chain in the global aerospace industry has gone through a fundamental shift during the last decade. As a response to competitive pressures tier-one producers have changed their business model and opted for a systems integration mode of production, whereby key components and sub-assemblies are designed and manufactured across an international network of risk-sharing partners. By this new model, top-tier producers concentrate on core competencies (overall aircraft design, systems integration and sales) leaving large responsibilities and technological requirements to their lower-tier suppliers.

This change is having a profound effect on the capabilities at low-tier level, which provides piece parts and components. Low-tier suppliers now must develop their own systems integration skills and take on greater financial risk as well as survive stricter quality control standards and raise the competitiveness of their product support (Avionics Magazine, 2006).

In summary, it is becoming increasingly difficult to survive at the lower-tier level therefore these companies must multiply their efforts in order to adapt to the new terms of competition with new skills and technological capabilities.

- <u>Decline in government expenditure on defence</u>

The end of the Cold War, led to a global decline in defence expenditure and the implementation of disarmament measures. Shrinking defence budgets affected the relationships between the public sector and the private industry. Globally, relationships are getting more profit-minded and there is increasing pressure for consolidation. Similar trends affected South Africa, where defence budgets declined dramatically after 1989 with the end of apartheid and the change of government priorities.

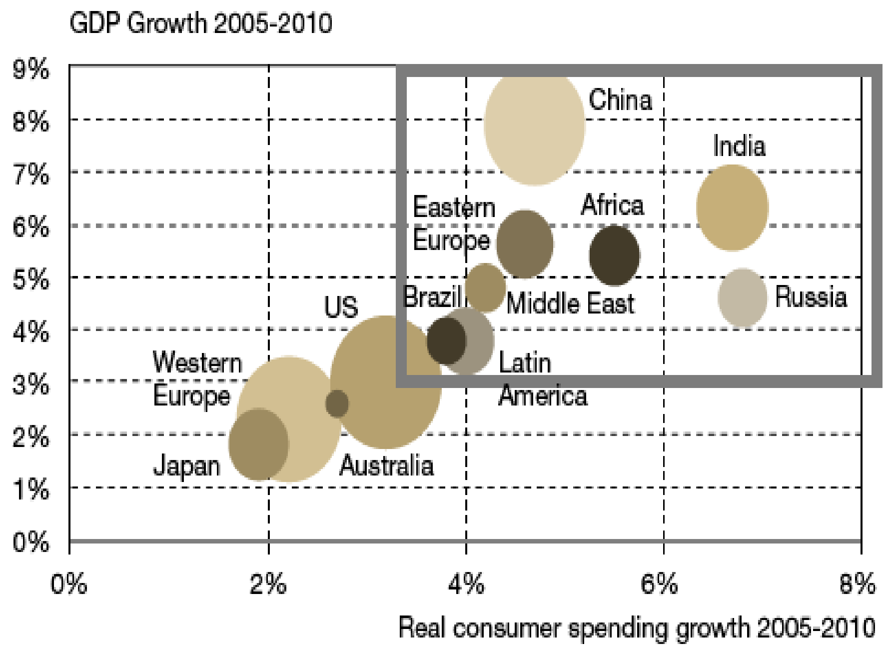
Arising opportunities for emerging economies

These dynamics in global production chains obviously have large implications for emerging economies, like South Africa. While consolidation has raised entry barriers at top-tier levels, the emergence of global outsourcing has provided increasing opportunities for lower cost sites in developing countries at the lower-tier level. Companies in emerging economies are now competing with suppliers at higher cost locations in more mature economies.

Some authors have pointed out the challenges for developing countries to sustain a competitive position in this technology-intensive and global industry (Steenhuis and Bruijn, 2004). Major limitations are generally related to the questioned ability of these countries to maintain the rapid sophistication of skills and capabilities necessary to attend international demands.

However, opportunities and threats in developing regions do not only come from the industrialised regions, but also from the developing countries themselves. Figure 1.3 shows that the estimated purchasing power of China, India, Russia and Africa (especially South Africa) is moving rapidly.

Figure 1.3: Emerging countries as drivers of change in global markets

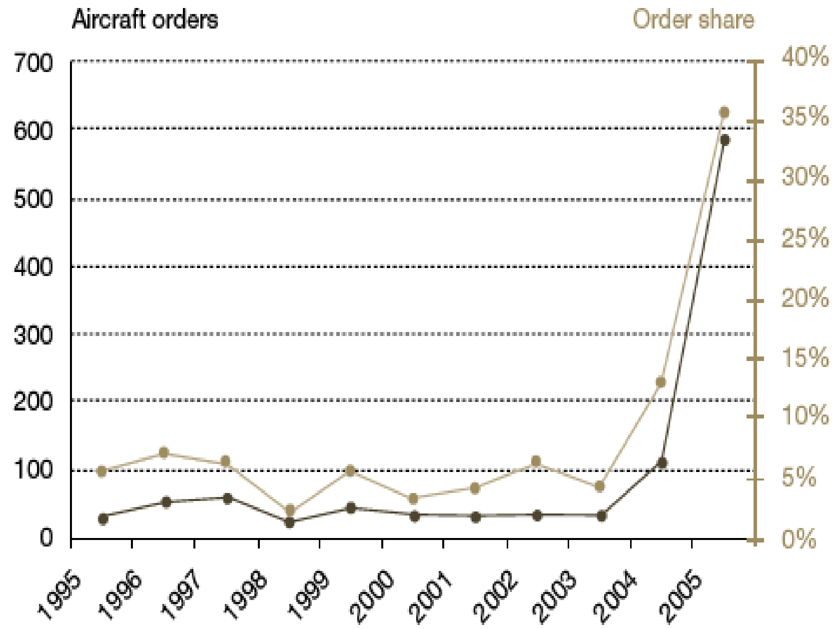


Source: Extracted from Global insight, Airbus (2006)
Note: Bubble size proportional to real GDP at PPP in US$ billion estimates in 2010

In the view of these dynamics, emerging economies are already placing huge demands of aircraft to satisfy their fast growth requirements[2]. Markusen (2001) suggests that internationalized production has taken place primarily in an effort from major companies to acquire new foreign customers. For example in 2001 Airbus subcontracted some parts of the wing fabrication to China to secure certain volume commitment in sales[3], and a similar example can be found with the ongoing A400M Programme in which South Africa is involved (explained below).

[2] For example, Chinese authorities were looking to build around 150 regional airports within the next decade.
[3] An Airbus company official states that "we are not going to get the Chinese to order Airbus aircraft unless we are in there, like Boeing." (Kingsley-Jones, "U.K. takes to the wing")

Figure 1.4: Emerging markets on the rise: aircraft orders from Brazil, Russia, India and China



Source: Extracted from Global insight, Airbus (2006)

Rapid growth in civil airlines, increase in private airlines and predicted future growth in the manufacturing capacity especially in the private sector are working in favour of aerospace developments in emerging economies[4].

Table 1.3: Highest traffic growth in emerging and large population regions in 2006-10

	Yearly traffic growth		
Expanding regions	China	+10.8%	**5.4 billion people**
	India	+9.8%	
	Eastern Europe	+9.7%	
	Middle East	+8.0%	
	CIS	+7.4%	
	Asia*	+7.1%	
	Africa	***+7.0%***	
	Latin America	+6.2%	
Developed regions	Australasia	+6.6%	**1 billion people**
	Western Europe	+5.6%	
	Japan	+4.7%	
	North America	+4.1%	

[4] For example, the Indian aerospace technology outsourcing market, which is currently at US $155 million is predicted to reach US $1 billion in 2009 (RNCO, 2006)

Source: Global insight, Airbus (2006)

The rise of demand in emerging economies is placing new opportunities for first-tier producers, but new threats too. For first-tiers, the prospects of accumulating sales in emerging markets come along with serious concerns on whether these markets would eventually become major aircraft manufacturers and thus, competitors. The great potential of indigenous demand in emerging economies has been already demonstrated which adds up the incentives for domestic lower-tier suppliers to upgrade their capabilities towards higher-tier manufacturing. At the same time, subcontracting to emerging economies becomes more attractive with their rise in technological capabilities supported by public R&D, and technology transfers through offset agreements.

Aerospace capabilities can be found in only a handful of developing countries. Therefore, competition is expected to grow among them as offshore locations. The highly cyclical and capital-intensive nature of the industry makes the entry barriers very high in global aerospace. This means also that if developing countries fail to carefully promote and upgrade their aerospace production, once the technology, skills and infrastructure are eroded or disappear, they are extremely difficult to re-create (EU, 2002). Emerging economies must develop clear and realistic aerospace strategies in order to keep up with the new avenues and opportunities of growth.

New policy perspectives are contemplating the promotion of co-operation between South Africa, India and Brazil to cultivate their complementary niches in aerospace rather than competing in their low-tier supplies to developed economies. A recent study from the South African Institute of International Affairs (SAIIA, 2006) exploring the IBSA initiative[5], revealed that although cooperation between these countries is currently very small, the potential benefits of cooperation have been widely recognised among members of the SA industry. Three areas of co-operation have been identified as part of the agenda of the IBSA Working Group on Trade: (1) the expansion of aerospace supply chains, (2) collaboration in support of strategic defence needs and (3) small and micro satellites (SAIIA, 2006).

[5] The IBSA Dialogue Forum (India, Brazil, South Africa) provides the three countries with a platform to engage in discussions for coordination on global issues and cooperation in several sectoral areas.

Development of an aerospace industry in South Africa[6]

The origin of the aerospace industry in South Africa cannot be separated from the history of its defence industry and related to what has been named by some authors as the military-industrial complex (MIC)[7] or the South African Defence Related Industries (SADRI)[8].

South Africa's aerospace and defence sectors have been nurtured since the 1950's. Relying heavily on imports from abroad (mainly Britain), by the mid-1960's nearly 1,000 private sector firms were involved in various aspects of domestic defence production (Dunne, 2006).

The Armaments Development and Production Corporation (Armscor) was established in 1968, with initially limited tasks (i.e. managing and expanding state-owned arms manufacturing facilities and the administering of all arms exports and imports); however, Armscor expanded its production activities through the acquisition of private companies and the establishment of new subsidiary companies.

Following the imposition of a UN mandatory arms embargo in 1976, condemning the apartheid regime, the South African government embarked in a large reform of Armscor expanding its responsibilities. Armscor became the central player in South Africa's domestic defence industry, by acting as both player and referee in the domestic defence market (Goldstein 2002, Dunne 2006). The UN embargo drove the South African defence industry towards self-sufficiency, which was facilitated by the availability of many inputs, including skilled personnel (Goldstein, 2002). By the end of the 1980s the defence industry had expanded into one of the largest manufacturing sectors. South Africa, which bought 70% of its armaments from abroad in the 1960s, relied on imports for 5% of its needs only (Aicardi de Saint Paul, 1997[9]). During this period South Africa became a first-tier producer, producing complete systems such as the Cheetah fighter, a combat aircraft.

Armscor benefited from massive state investment and received privileged access to state resources such as foreign exchange, R&D subsidies, government loans

[6] This section is largely extracted from the work of Goldstein (2002), Dunne (2006) and Batchelor and Dunne(1998)

[7] Goldstein (2002) indicates that the term MIC indicates that the defence industry plays a proactive role in the policy-making process, reflecting its multiple interactive links with the rest of the society and the vested interests that originate as a consequence (Dunee, 1995). Aerospace differs from other components of the MIC in that the scope for diversification into civilian uses is greater.

[8] AMD (2006) SADRI Study.

[9] Quoted in Goldstein (2002), p.532.

and exports subsidies. By the late 1980's it was one of the country's largest industrial companies with total employment of over 30,000 people.

In the early 1990s, global trends together with political transition in South Africa and economic recession resulted in dramatic cuts in the national defence budget. As a result, many firms exited the defence industry, which became increasingly concentrated. The sustainability of the industry became a major concern and Armscor was split into two entities: Denel was established in 1992 as a private company with the state as its sole shareholder, while Armscor remained part of the Ministry of Defence.

From its inception Denel has actively pursued conversion and diversification towards more civilian business, particularly through the acquisition of non-defense products or firms, mergers and joint ventures with civilian firms, and the development of civilian products derived from existing defense technologies and products (Batchelor and Dunne, 1998[10]). Nevertheless, in 1996 military sales still represented 64% of total sales[11], although more recent company reports declare that local military sales accounted in 2005 for only 30% of total. However, the company's financial performance reveals the struggle of its conversion into a profitable, commercially viable company while adjusting to a dramatic decline in demand for its most important products, armaments (Dunne, 2006). Denel's dismal financial performance has resulted in massive losses, particularly due to the commercial failure of the Rooivalk helicopter[12].

Further cuts in defence budget, continuing declining demand and further competitive pressures in international markets at the top-tier levels confirmed the impossibility to maintain an autonomous local defence industry and led to the decision to procure externally in the late 1990s. This decision came along with the intention to maintain the competitive parts of the industry by obtaining concessions from foreign suppliers in the form of defence-related industrial participation programs or "offsets".

[10] Quoted in Dunne (2006)
[11] Batchelor and Dunne, 1998- Table 12
[12] From the start to the present, the Rooivalk programme is believed to have cost over $1-billion (roughly R7-billion). However, its technological success has been also recognized, as well as its essential role in the creation of highly successful South African private- sector aviation companies such as Advanced Technologies & Engineering (ATE) and Aerosud (Engineering News, 2007).

Current state of the South African Aerospace Industry

The South African defence related industry (SADRI) was developed during a long period of economic isolation. Designed to serve the state's military purposes, the industry relied on large funding support from the government while protection from external competition allowed it to acquire positions in the domestic market. Successful aerospace manufacturing companies today are thus largely a result of government investment (Assegai, 2004).

Main players[13]

The South African aerospace and defence landscape is currently dominated by a few large companies. The public sector defence industry entities consist of Armscor, Denel and CSIR Defencetek. Private sector companies include Aerosud (South Africa's largest private sector aviation-industrial company), African Defence Systems (ADS), Advanced Technologies and Engineering (ATE), Grintek, and Sunspace (as the only local satellite manufacturer).

- <u>Armscor</u>: since the reform that led to a split into Denel, the new role of Armscor is explicitly to acquire defence materiel, primarily for the Department of Defence (DoD) but also for other security services such as the South African Police Service (SAPS) and Correctional Services. In 2003, Armscor was organized into seven main groupings, each headed by a general manager. In 2006 Armscor employed about 1,000 people (which has remained relatively stable during the last years) and reported a revenue of about 1 billion Rand.

- <u>Denel</u>: is the largest single entity in defence and aerospace in South Africa. Denel was incorporated as a private company in 1992 and it is government owned. Denel is based in Gauteng and currently employs about 8000 people. Employment and revenues have been in consistent decline since 2003, and in 2005 the group reported total revenue of about 2 billion Rand, operating at a loss. Denel has focused on restructuring in recent years, shifting from a loose network of companies and divisions to more autonomous business groups. In 2002 its training division, *Denel Centre for Learning and Development (DCLD)*, became a separate entity.

- <u>Defenceteck</u>: is a division of the Council for Scientific and Industrial Research (CSIR), and therefore fully sponsored by the SA Government. Defencetek is a simulation, design, testing and evaluation facility of aircraft and air weapons. It also provides advice on and technology support for radar,

[13] Information for this section has been largely extracted from companies' websites and annual reports as well as various articles of Engineering news (see references section)

artificial intelligence products, electronic systems engineering, and navigation systems technology.

- Aerosud: Aerosud Holdings is an aeronautical engineering group with a very strong engineering design capability. Aerosud was formed as a private company in 1990 and since then it has grown rapidly. It currently employs over 400 people in structural fabrication, composite forming and engineering, custom design and development and aircraft and interior refurbishment. The company has secured contracts for aircraft parts manufacture from global main players, such as Airbus, Boeing and AgustaWestland (for Westland helicopters) is plans to increase its staff to 700 employees by next year to fulfil its current contract obligations.

- ATE (Advanced Technologies and Engineering): ATE is a privately owned military systems company based in Midrand, Gauteng. Established in 1984, ATE has grown from a consulting group to a development company with a workforce of 320 personnel, mainly engineers and technicians. The company offers turnkey solutions and takes responsibility at platform level for both new and upgraded fixed wing aircraft, helicopters unmanned air vehicles and armoured vehicles. ATE is supplies to Thales (France), BAE Systems (UK) and Armscor (South Africa). The company has been very successful in the international as well as the local markets and has maintained a steady growth of 10% per year for the last 10 years.

- Saab-Grintek Group: is a partnership between Kunne Bros Holdings and Saab AB (Sweden). The group has deep roots in defence production in South Africa and most of its enterprises are heavily engaged in production of military material. Grintek's contemporary interests range across a spectrum of private sector telecommunications and electrical power applications, and it is an acknowledged world leader in the miniaturization of aircraft communications.

- Sunspace: represents South Africa's "space" component in the aerospace industry. Based in Stellenbosch, this small company is centred on the microsatellite design and satellite sub-systems. SunSpace currently employs about 90 employees, and is an unlisted proprietary limited company of which the University of Stellenbosch is a shareholder. Sunspace skills mainly come from the expertise developed by the University's Department of Electrical and Electronic Engineering through its SunSat programme. The first and so far only, South African satellite was manufactured by Sunspace and launched in 1999.

Most aerospace companies are located in Gauteng, especially in Pretoria and Johannesburg. A smaller hub of aerospace firms has developed in the Western Cape, in a science park (Technopark) developed in connection to the University of Stellenbosch.

Size and shape of the SA aerospace industry in figures

Lack of consistent studies on the aerospace industry in South Africa turns the attempt to evaluate the contribution of the aerospace industry to the economy into a complicated task.

- Number of companies, employment and turnover in the aerospace sector

An AMD study in 2006, estimated that 74 companies were operating in the South African Defence related Industry (SADRI), ranging from large and SMMEs (about 60) and B-BBEEs (about 17). More recently, in August 2007, the Minister of Trade and Industry, Mandisi Mpahlwa, estimated that currently there are more than 200 local companies involved in aerospace-related work, of which 75% are small, medium and micro enterprises (SMMEs), suggesting the existence of a thriving medium-sized industry base (Business Report, 2007). However, informal conversations with members of the industry suggested an approximate number of about 100 companies dedicating a substantial proportion of their total output to aerospace-related activities.

Figures on total revenue for the industry also vary depending on the source. An AMD study (2006) estimated that the South African Defence Related Industry (SADRI) had total revenues of about R9.6 billion in 2005, which represented a contribution of 0.56% to total GDP and 3.42% of manufacturing GDP. Based on interviews with 17 companies, the same study estimated the civil and military turnover of the SADRI by means of extrapolation[14]. Their results indicated that in the domestic market, about 90% of the total sales are still of military nature in contrast to less than 10% of civilian sales. Moreover, these percentages have remained relatively stable from 1994 to 2004. However, the study reports a significant increase in the share of civilian sales in exports, which has moved up from about 1% to nearly 20% of the total exports. Despite the marginal shift towards civil sales in exports, overall sales are still clearly dominated by the military sector, accounting for about 95% of total turnover[15].

A US report on the South African aerospace industry from 2006, estimated that the market size for aerospace (excluding defence) in 2003 was R8,5 billion (equivalent to about 1 billion US$). These figures were based on unofficial estimates obtained from industry sources. According to the same sources, the estimated annual projected growth rate until 2007 was of approximately 5%.

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[14] According to the ADM study the interviewed companies represented approximately 60% of the total sector's human resources and 64% of the total turnover.

[15] Note that in more developed aerospace markets, such as the UK, turnover is equally shared by defence and civil sides, each representing 50% of turnover (UK Aerospace Industry, House of Commons, 2005).

According to the Labour Force Survey, South Africa's 'manufacturing of aircraft and spacecraft' directly employed about 1,500 people in 2005, accounting for 0.15% of total employment in the manufacturing sector. However, as further explained below, this figure does not account for aerospace employment in other subsectors, including defence-related employment. Overall, the defence sector is an important national employer, providing direct and indirect employment for roughly 76,000 people[16].

Evident difficulties in measuring the most basic features of the South African aerospace sector indicate the urgency to conduct systematic studies on its actual size and economic potential, to allow the formulation and evaluation of informed policy initiatives. As it is commonly said: "If it cannot be measured it cannot be managed".

- Trade dynamics in aerospace products

For aspects related to trade, more systematic data can be obtained from the Department of Trade and Industry (DTI) trade database.

Following the lift of the UN embargo in 1994, trade figures in aerospace and defence related products experienced a significant increase. Opening up to international markets placed the industry in the international arena pressuring domestic companies to revise their business strategies.

The South African aerospace industry has been traditionally reliant on imports. However, the latest available data from the DTI trade database indicates that significant changes are taking place (see table 1.4). In the last 4 years exports have grown exponentially, at an average annual rate of nearly 50% while imports have decreased at about 13% annually. The decline of imports and acceleration of exports gained momentum in 2005.

Table 1.4: Trade of aircraft, spacecraft and parts (R millions)

	2003	**2004**	**2005**	**2006**	***Average annual growth rate (2003/06)***
Exports	796	1,210	4,254	4,018	***49.9%***
Imports	9,336	11,806	9,510	5,379	***-12.8%***

Source: DTI Trade database

Aerospace sales are highly complex transactions. Due to the complexity of the product, relationships between the buyer and the supplier tend to be formalised in individual contracts that can last many years- some products can have a

[16] SAIIA Trade Policy Report, No.13 (2006), pg.11.

production life of over 25 years. The bulk of the payment is not necessarily equally spread over time, generating large variations in the value of sales from year to year. It is not surprising to find considerable fluctuations in the value of total exports and imports of aerospace products, as value in one particular year can be largely influenced by the finalisation or commencement of new projects. In the following tables the significant effect of the Airbus A400M program joined by South Africa in 2005 becomes visible - (details of this program will be provided in below in this chapter).

According to the country of origin, imports have experienced a growing concentration in US aerospace supplies to South Africa. Dependence on US imports is not necessarily related to a significant increase in the value of imports (in fact, there has been a decrease in absolute values from R 3,573.6 millions in 2003 to R 2,740.9 millions in 2006) but in the considerable reduction in the role of France as a major supplier (imports from France have dropped from 48% of total imports in 2003 to 6.4% in 2006). Instead, France has become a net importer of South African aerospace products, as indicated by the considerable increase of exports to France between 2003 and 2006 (from 2.5% to 18.4% of total exports). The share of exports to the US has dropped for this period (from 45,5% to 9.3%), again not so much as a change in absolute values (which has increased) but as a consequence of the larger diversity of foreign markets that South African aerospace companies now supply to.

Table 1.5: Top 10 countries in aerospace trade

Imports					Exports				
	2006		2003			2006		2003	
Country	**% of total imports**	**Value**	**% of total imports**	**Value**	**Country**	**% of total exports**	**Value**	**% of total exports**	**Value**
USA	51.0	2,741	38.3	3,574	France	18.4	740	2.5	20
Netherlands	13.2	713	0.2	21	Angola	13.4	537	0.5	4
Italy	8.2	439	0.9	88	USA	9.3	374	45.4	362
France	6.4	345	48.2	4,497	Zambia	4.0	160	0.4	3
Sweden	4.5	242	0.7	62	Sweden	2.5	100	0.7	6
UK	3.9	212	5.6	522	Canada	2.4	97	0.4	4
Canada	2.1	115	1.2	115	Israel	2.3	91	0.5	4
Germany	1.9	104	0.5	49	Kenya	2.1	85	3.5	28
Switzerland	1.7	90	0.7	66	UK	1.8	72	4.6	36
Denmark	1.5	79	0.1	9	Germany	1.6	66	0.6	5

Source: Calculated from DTI Trade database
Note: values in million Rands.

Tables 1.6 and 1.7 show the value of exports and imports of aerospace-related products “aircraft, spacecraft and parts”, according to the Harmonized Tariff System (HS) at a 6-digit level. This code level allows us to identify changes in the composition of trade at the product level. The tables also indicate the rank of these products in relation to their contribution to total exports/imports in 2006 and 2003.

Table 1.6 indicates that despite the major decline in the volume of aerospace products, the composition of imports by product does not seem to have changed significantly since 2003. For the major 10 products the ranks in terms of value of imports have remained relatively stable. However, significant changes can be identified in the composition of exports, where some degree of increase in complexity can be detected according to the changes in the major 10 exported products.

Table1.6: Composition of Imports by product and changes from 2003-2006

Product	**Value 2006**	**Rank 2006**	**Rank 2003**
Aeroplanes and other aircraft of an unladen mass exceeding 2000 KG but NOT exceeding 15000 KG	1498.6	1	2
Aeroplanes and other aircraft of an unladen mass exceeding 15000KG	1456.1	2	1
Other parts of aeroplanes and helicopters	1331.0	3	3
Aeroplanes and other aircraft of an unladen mass NOT exceeding 2000 KG	342.7	4	7
Other aircraft of an unladen mass exceeding 2000 KG	302.5	5	4
Other aircraft NOT exceeding 2000 KG	270.7	6	6
Under-carriages and parts thereof	168.6	7	5
Propellers and rotors and parts thereof	59.1	8	8
Part of goods of heading NO. 88.01 OR88.02. Other	41.9	9	10
Parachutes and Rotochutes, parts and accessories	11.6	10	11
Air combat simulators and parts thereof	9.7	11	15
Aircraft launching gear; deck-arrestor or similar gear; ground flying trainers; parts and articles. Other	7.8	12	9
Aircraft launching gear; deck-arrestor or similar gear; ground flying trainers; parts and articles.	7.5	13	12
Gliders and hang gliders	4.3	14	14
Balloons and dirigibles; gliders, hang gliders and other non-powered aircraft. Other	2.1	15	13

Source: Elaborated from DTI Trade database
Note: values in million Rands.

‘Parts of aeroplanes and helicopters’ constituted the first exported category of product in 2003, but moved to the third position in 2006. In 2006 entire aircrafts (or complete systems) constituted the first two categories of exported products. Tier-three (minor-sub-systems, such as ‘parachutes, rotochutes parts and accessories’, propellers and rotors’) have moved down in the rank of top exported products during this period giving place to more complex first-tier and second-tier products (i.e. ‘other aircraft’ categories).

Table 1.7: Composition of Exports by product and changes from 2003-2006

Product	**Value 2006**	**rank 2006**	**rank 2003**
Aeroplanes and other aircraft of an unladen mass exceeding 15000KG	2346.4	1	3
Aeroplanes and other aircraft of an unladen mass exceeding 2 000 KG but NOT exceeding 15 000 KG	678.7	2	2
Parts of aeroplanes and helicopters	594.2	3	1
Other aircraft of an unladen mass exceeding 2 000 KG	162.3	4	15
Other aircraft NOT exceeding 2 000 KG	70.8	5	8
Part of goods of heading NO. 88.01 OR88.02. Other	46.6	6	6
Under-carriages and parts thereof	33.6	7	9
Aeroplanes and other aircraft of an unladen mass NOT exceeding 2 000 KG	30.3	8	4
Parachutes and Rotochutes; parts and accessories	22.9	9	5
Propellers and rotors and parts thereof	20.6	10	7
Aircraft launching gear; deck-arrestor or similar gear; ground flying trainers; parts and articles. Other	6.8	11	13
Aircraft launching gear; deck-arrestor or similar gear; ground flying trainers; parts and articles.	3.1	12	10
Balloons and dirigibles; gliders, hang gliders and other non-powered aircraft. Other	1.3	13	14
Gliders and hang gliders	0.6	14	12
Air combat simulators and parts thereof	0.1	15	16
Spacecraft (incl. satellites) and suborbital and spacecraft launch vehicles	0.1	16	11

Source: Elaborated from DTI Trade database
Note: values in million Rands.

However, the location of aerospace products is more complicated than the HS classification suggests, as many of the major suppliers are located outside the "aircraft, spacecraft and parts" category. For example, some manufacturers of engines and turbines could be categorised under 'Automotive', whilst other military aerospace can be classified as 'manufacture of weapons and ammunition'. All of these categories have an aerospace content and hence reflect the diverse and often complex nature of the aerospace industry globally, and especially in the South Africa. The following section will try to clarify some of these complexities, representing the connection of aerospace with other economic sectors.

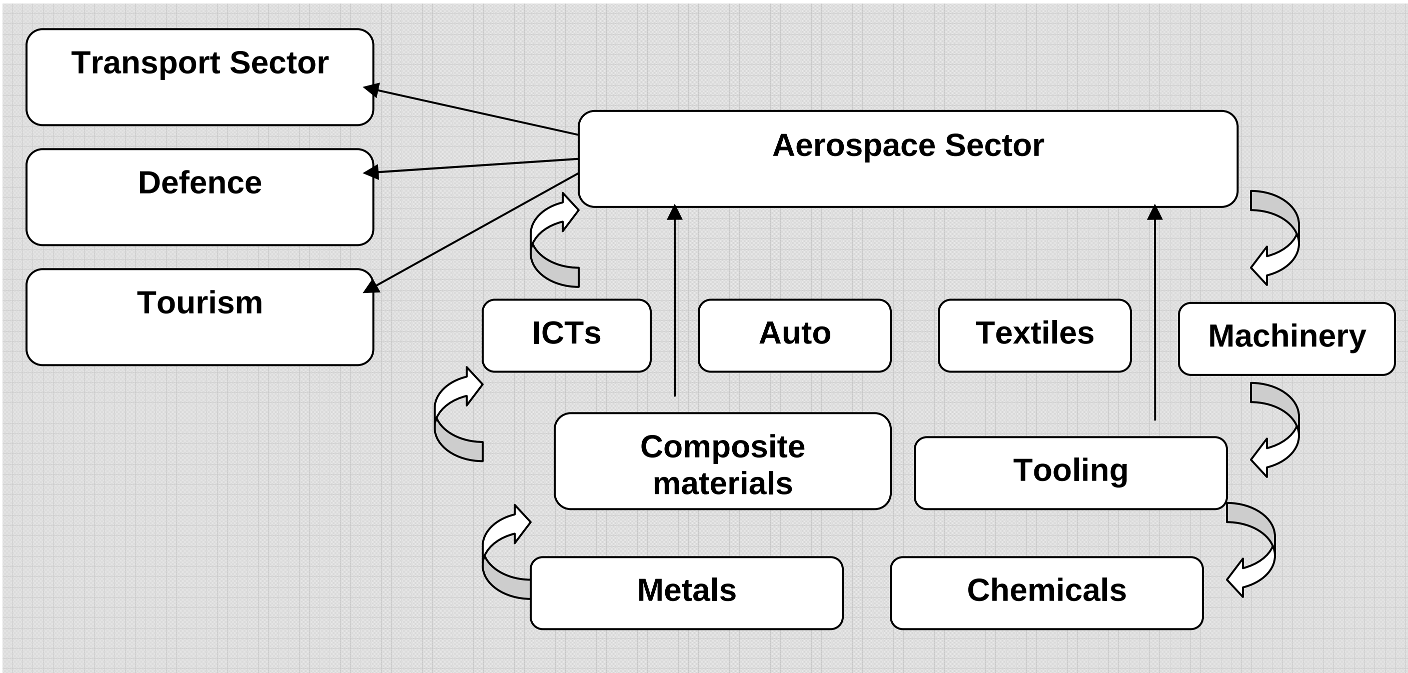
Upstream and downstream linkages

The overall impact of the aerospace industry must be considered in connection to other productive activities. Efficient aerospace production requires not only obvious elements of adequate infrastructure and skilled labour force, but also access to basic aircraft production inputs such as aluminium, steel, wire, cable, fasteners, and also more sophisticated inputs such as electronic components, software, computerised parts, testers, etc. These inputs are obtained from other industries: mining sector, composite materials, tooling, machinery, automotive, ICTs and textiles.

The connection between the aerospace industry and other economic sectors is represented in figure 1.5. This figure shows that the aerospace industry is both indirectly and directly connected to more “representative” industries in terms of employment in South African context such as metals and chemicals, which are as well key suppliers to the composite material and tooling industries. These latter industries supply not only to more advanced manufacturing sectors such as the automotive, electronics and machinery sectors, but also directly to aerospace.

The previous section highlighted the growing export orientation of South African aerospace manufactures. Nevertheless, a proportion of aerospace products are still consumed domestically. South African aerospace major domestic clients include the transport sector (national carrier, South African Airways), the defence sector (South African National Defence Force -SANDF). Smaller low-cost airlines such as Kulula.com, Nationwide, Comair, 1Time and Mango, are well placed to exploit the discount retail business and may expand fleets with used regional and single aisle aircraft (Canada Report, 2004). These recent developments are starting to show their impact in the fast growing tourism sector.

Figure 1.5: Aerospace industry's domestic linkages to other economic sectors in South Africa



Source: Elaborated by author

South Africa's wealth in raw materials, combined with considerable capabilities in advanced industries like automotive and ICTs, indicate that aerospace is well position to maintaining a domestic supplier base of high-quality and competitive prices. Increasing global pressures to keep costs down are vital in the aerospace industry.

South Africa has a large potential to exploit existing advantages in composites, advanced materials and the tooling industry, which complements its strength in more traditional sector such as the mining sector and the metal industry. However, currently many local suppliers in the composites and the tooling industries are losing out on supply contracts because original-equipment manufacturers (OEMs) award their projects to overseas suppliers who use superior technology and can produce and deliver parts more quickly and more cost-effectively than South African suppliers. For instance, many tooling projects have been lost to Asia as a result of inefficiencies in South African industry; while about two-thirds, on average, of parts used in local assembly are still exported instead of being incorporated into locally manufactured products (extracted from Engineering News, 2006).

In general, locally manufactured products in less technologically advanced industries that could supply the domestic aerospace production have become export commodities[17].

Innovation dynamics and technological achievements in South African aerospace

The aerospace industry is widely regarded an incubator of critical technologies. Many of the technologies, methods and processes researched and developed by the aerospace industry have the potential to be employed in other economic sectors. The previous section indicated that the aerospace industry is a major absorber of technologies from other adjacent sectors (ICTs, automotive, tools, machinery, etc). Following this argument, the benefits from technological innovation and research and development (R&D) in aerospace are not confined solely to the industry itself.

However, the relevance of technology transfer across sectors is more applicable in countries where the aerospace industry has matured over time through close interaction with other industrial sectors. In South Africa the aerospace sector has developed in isolation not only from global markets but also from the rest of the domestic economy as a result of strategic funding used for military purposes. Interdependence between the military and civil sides of the aerospace industry is still remarkable nowadays. Not only do the major companies produce for military and civil markets, but much of the technology is common to both[18] (DTI, 2004).

Nevertheless, recent changes must be acknowledged and some researchers have already pointed the increasing 'technological openness' of South African aerospace. In this line, a recent AMD study asserts that "the South African Defence and Related Industry (SADRI) has matured from a "technology colony" through backward industrial integration" (AMD, 2006).

A study by DTI (2004) examined the strengths and advantages of South Africa in various aerospace-related technologies that were highlighted as being critically important for the continuous development and growth of the aerospace sector. The study revealed that that South Africa's competitive strengths in Composite Materials and in Health & Usage Monitoring systems (HUMS) technologies, place it in a strong position to develop further these technologies and become a leading global player in the aerospace industry.

[17] Engineering News (2006) gives the example of a specific reproduction material used for construction, tooling, coating and modelling which is mainly exported; while approximately 60% of the raw materials are sourced in South Africa (Engineering News, 2006)
[18] Denel is a clear example.

High performance composites are used extensively in commercial liners in Airbus and Boeing (first-tier leaders) and their demand is increasing at a global scale. Research on composite materials allows offering attractive advantages of weight, aesthetics, recycle ability, smartness and flexibility of design (Engineering news, 2007). In 2005, the composite industry in South Africa employed around 12,000 people and used around 30,000 tons of resin with 15,000 tons of reinforcement. The total value of finished composites goods was R4 billion (Hanekom, 2007)

Research in critical areas such as composites is done in industry together with local universities and science councils, strongly in the domain of aerospace technology development. Research and Development (R&D) of composite metal hybrids and nanocomposites is being conducted by CSIR and has direct applications in the automotive and aeronautical fields (Engineering news, 2007).

Efforts are also being put into 'green' composites affecting various supply-chain aspects of the materials and products supplied to aerospace. Green composites include the use of natural organic material, which can be disposed of in a controlled environment, requires less handling and is chemically less hazardous. The development into green composites would be agriculturally advantageous. It would create rural employment for growing and sustaining plantations of natural organic composites, such as hemp and flax. These advances have a direct significant impact in the lives of disadvantaged group and displaced areas and should be promoted as a strategic sector (Engineering News, 2007). A key analyst for CSIR recently stated that "the primary objective [of 'green' composites research] is to establish supply-chain linkages between rural-based enterprises and local and international companies where natural and renewable resources are value-added through novel processing and manufacturing, requiring science, technology and innovation" (Engineering News, 2007).

- <u>Investment in R&D and support for innovation</u>

It is generally agreed that success in aerospace stems directly from its R&D investment, which: "stimulates innovation and knowledge creation, supports research in universities, and has considerable spin-off benefits into non-aerospace activities (UK House of Commons, 2004).

Aerospace activities require enormous amounts of research and development (R&D) spending (ASSEGAI, 2004), and interviews from the industry players reflect that government incentives would be most valuable in this area. The CEO of Aerosud recently stressed the "need of incentivisation, such as tax breaks for technology development and creating jobs; some already exist but they need strengthening" (Engineering News, 2003).

The latest Innovation Survey conducted in South Africa by HSRC in 2005, found that nearly 52% of the companies in South Africa were engaged in technological innovation activities (including both innovation in products and innovation in production processes). The latest Innovation Survey and R&D Survey found that about R6 billion were spent y companies in South Africa in 2004/05, corresponding to 2.4% of the total turnover of all surveyed enterprises in both the industrial and service sectors. Unfortunately, there is not comparable for the aerospace industry for the same period.

An AMD study (2006), presents some evidence of the high innovation and R&D intensity of defence-related activities. According to this study, 100% of the companies in the SADRI sector presented technological innovations in 1998-2001 in comparison to the 44% for the national average in all economic activities. Similarly, the SADRI sector spent an average of 5.47% of sales in R&D related to innovation in 2000, while the national average for that year was 1.55%.

Interestingly, this study also presented the R&D intensity for other economic sectors, showing that the high R&D intensity of defence-related activities was only surpassed by chemicals (5.77%) and transport equipment (9.37%), being both sectors closely linked to the aerospace value chain, either as direct suppliers or as customers.

South African Vision in Aerospace for development

The potential from a reorganisation of the aerospace industry was detected in the early 2000s. This interest has continued and grown over time, and nowadays "there is awareness that the unlocking of opportunities of domestic capabilities can only be achieved if the South African aerospace industry becomes organised" (Francois Denner, 2005- Engineering News). However, an overall strategy for the sector is still under construction.

The SA government's vision is to develop the aerospace sector as a sustainable, growing, and internationally recognised industry by 2014 (Assegai, 2004). The industry has been identified as a national high-priority sector and its growth trajectory has been clearly modelled on that of the successful automotive sector (SAIIA, 2006). Strategic international partnerships and integration in global, regional and local value chains are at the centre of this vision. Part of this vision involves participating with highly innovative new products, such as eco-friendly civil aircraft.

Research conducted by the state-owned Industrial Development Corporation (IDC) in 2006, recognized the wealth-generating and job-creation potential of the aerospace industry, and the growth of this sector is viewed as vital to future national economic welfare. Aerospace industry is regarded as technology driven and at the same time labour intensive, providing opportunities for South Africa to stay in the global race for technological advancements and to provide technically oriented jobs and subsequently contribute to tackle the brain drain of skilled people.

Government efforts are aimed at growing networks in aerospace not only internationally but also domestically, comprising industry, government and academic stakeholders. Synchronised efforts from local actors are seen as crucial to identify and develop the technology and human resource needed to enhance the competitiveness of the sector[19].

Regulatory environment and policy framework

A number of organizations and policies determine the operating environment for South Africa's aerospace industry. Major organizations include the industry association and government departments. Areas of major concern for the industry are related to upgrading manufacturing capabilities, development of strategic international partnerships, technological advance and skills development.

Major organizations[20]

- The Aerospace, Maritime and Defence Industries Association of South Africa (AMD): is the representative industry association for the South African defence-related industry (SADRI). AMD represents the collective interests of SADRI and is recognised by the DTI as Joint Export Action Group. At present AMD has 45 member companies both public and private, that supply products and services to the DOD, Government organizations and other contractors, either locally or internationally, within the defence and security marketplace.

  AMD started its business life as and association representing the aerospace sector in the early 1990s, but it later transformed to include "Defence and Maritime". According to an AMD report (2006), AMD membership represents more than 90% of defence-related business in South Africa and more than 97% of the country's defence exports.

  The AMD strategy and structure are being currently reviewed and expanded. Supply chain coordination, technical assistance, export support and assisting the government with policy advice, are some of the main items in AMD's expanding agenda.

- The Department of Trade and Industry (DTI): is the key responsible government department in the promotion and support of the initiatives related to the development of the aerospace industry in South Africa. The DTI's Micro

[19] Perceptions extracted from personal interviews with NACoE and DTI.
[20] Information for this section has been largely extracted from the organizations' websites.

Economic Reform Strategy and in the Integrated Manufacturing Strategy formed the basis to identify key sectors that need to be supported, such as aerospace.

Particularly since 1994, the DTI has been deeply involved in the design of funding support for aerospace-related initiatives in collaboration with international agencies and is currently focused on developing an overall strategy for aerospace in South Africa, including skills development, supply chains and foreign strategic partnerships.

The DTI also funds ongoing research through IDC[21] to attract local and international investment into the aerospace industry. However, the DTI is not the only government department concerned when it comes to aerospace.

- The Department of Defence (DoD): has been traditionally responsible of the South African defence and (subsequently) aerospace industries. The DoD is also concerned about the future development of the industry, which provides essential support for the South African Air Force. The DoD, through its agency Armscor, oversees the Dip programmes.

- The Department of Science and Technology (DST): The direct involvement of DST in aerospace-related policies is more recent, and in particular focused on the “space” segment of aerospace. DST is responsible of the recent development of the South African Space Agency (Sasa), although the agency does not yet have a firm target date for its activation (Engineering News, 2007)

The advanced manufacturing, defence and technological aspects of the aerospace industry have involved the implication of various government departments in the promotion of aerospace. Furthermore, state-owned enterprises like the Denel group fall under yet another ministry; Public Enterprises. This indicates that for the aerospace sector, interdepartmental coordination becomes essential.

[21] The Industrial Development Corporation (IDC) is a member of the DTI group involved in the implementation of policies/strategies formulated by the DTI in order to support and enhance growth and development of the South African economy

Industrial policy and promotion of advanced manufacturing

The Industrial Manufacturing Strategy (IMS) in 2002 constituted the first government strategy to clearly specify priority economic sectors with particular focus on knowledge intensive sectors. Aerospace was not identified as a priority sector by IMS. However, technological advance and the emergence of integrated supply or value was seen by the IMS as the hallmark of modern production processes (Lowitt and Altman, 2006: 17[22]). Following strategies gradually shaped the identification of higher valued activities, although only very recently aerospace achieved recognition as a priority sector to achieve South Africa's development goals.

- The Advanced Manufacturing Technology Strategy (AMS): was launched in 2005. The AMTS is premised on recognising the centrality of the manufacturing sector within the wider South African economy (DoL, 2007). The AMS identified priority sectors with the greatest potential for supporting relevant goals contained in the IMS and the *National Research Development Strategy* (DST, 2004). These goals include national and social goals such as job creation and employment equity, stimulating technological upgrading in industry and innovation.

  The AMTS introduced for the first time aerospace as a priority sector in relation to a number of cross cutting key technology areas such as advanced material, product technologies, production technologies, and ICT in manufacturing among others. AMTS illustrates the impact of potential aerospace in four areas: beneficiation, downstream value addition, competitive advantage and local design and development capacity

  The strategy envisaged its implementation through a combination of Industry Support Centres, Innovation Networks and specific initiatives or projects, such as the Aerospace Network (described below).

- The ASGISA initiative: was launched in 2005. This initiative brought together a set of 'horizontal' interventions (such as infrastructure programmes, skills and education and macro-economic issues) with sector-specific strategies. Also, ASGI-SA defined three types of sector specific strategies, defined by the extent of their readiness for implementation: top priority, intermediate and low priority sectors. The two top priority sectors (business process outsourcing and tourism) were characterised by being labour-intensive, rapidly growing sectors worldwide, and open to opportunities for BBBEE and small business development (PCAS, 2006). Aerospace was not in the list of priority sectors from ASGISA.

[22] Quoted in the (DoL, 2007) "The State of Skills in South Africa"

- The DTI's new *National Industrial Policy Framework* (NIPF): was released in 2006. Similar to the previous initiatives, the NIPF also places manufacturing at the centre of the country's economic development (DoL, 2007). NIPF recognises the commonalities between certain sectors in terms of challenges and required support, and combines the sectors into related clusters. In addition, NIPF considers that clusters could be formed around supply chains to strengthen downstream beneficiation and economise the administrative resources needed to deal with these sectors. Classified as 'advanced manufacturing sectors', automotive and components, aerospace, energy, rail and marine are placed in the same cluster (DTI, 2006).

These groupings have clear implications for the promotion of skills development, and their related Sector Education and Training Authorities (SETAs). The new forms of industrial clustering currently being considered by the DTI, organising stronger value chains, may suggest a new way forward for SETAs so that they align more effectively with the new industrial requirements (DTI, 2006).

- Offset Agreements: South Africa established counter-trade offsets in trading relationships with foreign sellers in 1996. The basic idea of offsets is to provide an incentive to the buyer by agreeing to mechanisms in which the buyer can attenuate the costs of outright purchase (Henk, 2004). There are two types of offset programmes: the National Industrial Participation (NIP) managed by the Department of Trade and Industry; and the Defence Industrial Participation (DIP) managed by Armscor on behalf of the Department of Defence.

The NIP obliges a foreign supplier in any South African government contract exceeding $10 million, to invest at least 30% of the contract value in South Africa's economy. This obligation rises to 50% in the case of defence contracts. The NIP investment generally must be placed in enterprises other than the defence-related industries. The DIP applies to foreign suppliers of defence-related materiel in any contract exceeding $2 million. The DIP programme requires investment in the South African defence industry.

The impact of offset agreements has been questioned, and critics have raised concerns about the capability of the local industry to benefit from the deals. The aerospace industry however has been generally considered as better placed than other components of the MIC, thanks to its significant capabilities in electronics (including radar), avionics, systems integration, weapons systems and ammunition (Goldstein, 2002). Nevertheless, the overall economic and welfare benefits of the offsets are still undetermined (Batchelor and Dunne, 1999).

By the end of 2005 all the NIP programmes combined were estimated to have generated investments and export sales with a value of $3,5 billion, of which about $1 billion has been in the form of investments; a total of around 8,000 direct new jobs have been created (Engineering News, 2005).

Another visible impact has been the opportunity for domestic companies to develop niche markets through their links with foreign companies. For instance, Denel and private companies have been included into the international circuits of defence production, both in terms of indirect and direct offsets (Dunne, 2006)

Skills development policies

- National Skills Development Strategy (NSDS): The National Skills Development Strategy was first launched in 2001. The first phase of the NSDS saw the establishment of 25 Sector Education and Training Authority (SETAs) and the provision for learnerships leading to recognised occupational qualifications[23]. NSDS is now on its second five year phase: NSDS (2005-2010), where issues of “scarce skills” and SMME development are emphasised. This phase also saw a reduction of the SETAs from 25 to 23.

- JIPSA (the Joint Initiative on Priority Skills Acquisition): was launched in 2006 as a response to the ASGISA recognition of skills shortage as a key factor that constraining growth in South Africa. With JIPSA, skills development became a number one priority in government’s effort to stimulate economic growth and reduce poverty and inequality (DoL, 2007). JIPSA together with the ‘National Scarce Skills List’[24] prioritised the problem of scarce and critical skills, stressing the shortage of engineers in South Africa. JIPSA is involved in a number of short-term interventions to support skills-centered initiatives such as ASGISA. Two affecting the supply of skilled workforce to aerospace are (a) improving the supply-side provision of engineers, technologists and technicians by an additional output of 1,000 per annum by 2011, and (b) increasing the number of artisans graduating to and average of 12,500 per annum, or 50 000 between 2007-2011 (JIPSA, 2006).

[23] According to the Ministry of Education, from 2001 until the end of September 2006 a total of 325,247 learners have been registered on accredited occupational based learning programmes (Polity, 2007).

[24] The National Scarce Skills List represents the combined efforts to achieve a consensus in the definition of scarce and critical skills. It was a collaboration of the Departments of Labour, Education, Trade and Industry, Home Affairs, Public Enterprises, Public Service and Administration and Science and Technology.

Tariffs and taxations

For current WTO signatories, such as South Africa, most impediments to trade in civil aircraft and parts were eliminated in the General Agreement on Tariffs and Trade (GATT) Agreement on Trade in Civil Aircraft. This prompted a dramatic increase in cross-border subcontracting and component sourcing (US Commercial Service, 2004).

Recent policy developments and key programmes underway[25]

- The European South Africa Science and Technology Advancement Programme (ESASTAP): This initiative is a Specific Support Action, implemented by the South African DST and funded by the European Commission (EC) under the Sixth Framework Programme (FP6)[26]. This programme promotes and supports networking and partnering between scientists and institutions from the EU and South Africa in new and emerging scientific and technological areas, including aeronautics and space sciences.

- The National Aerospace Centre of Excellence (NACoE)[27]: The NACoE was established in 2005 by the DTI as the first Industrial Centre of Excellence to address the scarcity of skills and capacity in the local aerospace industry. The NACoE is based on national collaboration between government, industry, academia and research institutions around partnership principles for the provision and co-ordination of specialised skills, programmes and services for the improved competitiveness of the South African aerospace industry. To achieve its goals NACoE has entered into R&D partnerships with major global players such as Airbus and local Universities (WITS, Stellenbosch University and the Cape Peninsula University of Technology) and domestic companies. Under the partnership with Airbus 30 South African postgraduate positions have been funded to work on aerospace-related topics. The NACoE is also in the process of finalising an undergraduate bursary partnership scheme with DENEL Dynamics. The NACoE operates in close partnership with several other Government programmes such as the Aerospace Industry Support Initiative (AISI) of the DTI and the Advanced Manufacturing Technology Strategy (AMTS) Aerospace Network of the DST.

[25] Information for this section has been largely extracted from the initiatives' websites.
[26] The first intergovernmental agreement ever concluded between South Africa and the European Union, the Agreement on Science and Technology Cooperation signed in 1996, afforded South African researchers the opportunity to participate fully in the EU's Framework Programmes for Research and Technology Development.
[27] For more information see http://www.wits.ac.za/centres/nacoe/

- The A400M Programme: The Airbus A400M is a four-engine turboprop military transport & tanker, designed by Airbus Military. The contract to manufacture the A400M was signed in 2003, between Airbus Military and OCCAR[28]- representing Belgium, France, Germany, Luxembourg, Spain, Turkey, and United Kingdom- to partner in the production and purchase of 212 aircraft. South Africa is one of only two extra-European partner countries in the A400M programme, the other being Malaysia. In 2005, Armscor concluded a contract with Airbus Military to participate in the development of the A400M and the delivery of eight aircraft by 2012.

The multi-national A400M program is considered is considered as the most significant single contract for the South African aerospace industry (particularly, for aero structures[29] manufacturers) and one of the most important aviation programmes currently under way in the world. For South Africa, the relevance of the A400M lays in the fact that South African companies became risk-sharing partners in the project not mere customers gaining industrial participation (IP) benefits.

Although the program is administered by Armscor, much of South Africa's aero structures expertise resides in two companies: State-owned Denel, and private-sector Aerosud, and these companies are both partners in the A400M programme[30]. However, the benefits of A400M also affect other local companies, through sub-contracting. In total, it has been estimated that South Africa's work share on the A400M is expected to be worth more than R6-billion (EUR750-million) over the next 20 years (Engineering News, 2006).

Denel and Aerosud supply the A400M programme with a range of components including wing tips, wing-to-fuselage fairings, centre top shells, composite cargo holds, nose fuselage linings, and other composite and metallic airframe components. Furthermore, both companies will repair equipment during the programme's life span, and are expected to compete for the provision of aircraft maintenance and training services. The aircraft will be finally assembled in Seville, Spain.

[28] OCCAR: Organisation Conjointe de Coopération en Matière d'Armement

[29] An aero structure is a part of a complete airframe: for example, a vertical tail fin, or sections of the fuselage or wing.

[30] Denel is producing two top shells for each aircraft and is also making very large wing/fuselage fairings, manufactured mainly from composite materials but including aluminium parts. Denel is also set to shortly start contributing with primary structures, such as centre wing box structural components. Aerosud is mainly responsible for secondary structures, such as nose fuselage linings, cargo-hold linings, and cockpit linings, but the company is also making the cockpit rigid bulkhead, the wing tips, and the nose fuselage galleys.

The impact of the A400M program seems to have mixed results. Some companies are largely benefiting in terms of engineering capabilities, although other companies have suggested that the engineering work involved in production for A400M is insignificant.

- South African Space Agency: The establishment of the first South African Space Agency was approved in 2006 by the Department of Science and Technology (DST) to co-ordinate and implement the country's space science and technology programmes. The agency is not yet operative but it is envisaged to be active by 2008, working closely with the South African Council for Space Affairs and reporting to the Minister of Science and Technology.

- Aerospace Industry Support Initiative (AISI): AISI was established in 2006 by the DTI. This initiative is housed at the Innovation Hub in Pretoria and managed by the CSIR on behalf of the DTI. AISI's main goals are to promote the interests, capabilities and competitiveness in the South African aerospace industry as well as the facilitation of partnerships and innovation between Government, industry and academia, are pursued though a number of programmes. These programmes comprise: (a) industrial and Governmental coordination, (b) technology advancement, (c) supply-chain development, (d) human resource development and (e) optimisation and utilisation of national facilities.

The Centurion Aerospace Village (CAV) constitutes AISI's first direct intervention. CAV is an aerospace supplier park modelled on the insights and successes gained by the automotive industry. The concept of an Aerospace Village involves the development of an Aero-Mechanical Manufacturing Cluster around a Primary Supplier (Tier-One) such as Aerosud, and simultaneously the upliftment of lower-tier suppliers, especially SMME and BBBEE companies in the aerospace industry[31]. Funded by the DTI and the European Union, the CAV is not yet fully operational. It is estimated to cost about R130 million and be developed by 2010.

- Aerospace Network: the aerospace network is a forum developed under the Advanced Manufacturing Technology Strategy of DST in 2005. The mandate of the Aerospace Network is to facilitate the interaction between the actors related to the development of the aerospace sector in South Africa to support technology advance and the provision of adequate skills. To date the aerospace network has held two meetings where a number of specific projects are presented and discussed among members and attendants.

[31] A Pilot face in 2007 saw the roll-out of the solution at local OEM Aerosud and 16 of its suppliers – including five local BEE companies, eight other local suppliers and three international suppliers (ITWeb Informatica, 2007).

CHAPTER TWO: DEMAND FOR SKILLS

This chapter begins with a brief description of the general skills requirements in the aerospace to identify the types of skills that are commonly used in the sector. Following sections present figures on the employment dynamics in aerospace in South Africa, in relation to various aspects (occupation, gender and racial equity, age) to identify recent changes and the extent to which further transformation is required.

Key skill requirements in the aerospace industry

The design and manufacture of technologically sophisticated products for the aerospace industry require inputs and skills from various types of workers. Skilled production, professional and related, and managerial jobs generally make up the bulk of employment. Those employed in managerial and administrative support occupations manage the design process and factory operations, coordinate production, and ensure compliance with regulations and international customers' specifications. In general, the aerospace industry has a larger proportion of workers with education beyond high school than the average for all industries.

General occupations in the industry[32]

- Professionals, technicians and associate professionals: generally develop new designs and make improvements to existing designs. This category includes a number of specialists such as:

  - Aerospace *engineers:* they are integral members of the teams that research, design, test, and produce aerospace vehicles.
  - *Electrical and electronics, industrial, production and mechanical engineers* also have a central role in the research and development, as well production of aerospace products.
  - *Engineering technicians* assist engineers, both in the research and development laboratory and on the manufacturing floor.
  - *Inspectors and testers,* perform numerous quality-control and safety checks on aerospace parts throughout the production cycle. Their work is vital to ensure the safety of the aircraft.

[32] Information for this section has been largely extracted from the description of aerospace careers from the U.S. Department of Labor, Bureau of Labor Statistics.

- Senior officials and management: include also business and financial occupations. In some cases workers advance to these jobs from professional occupations. Many managers in the aerospace industry have a technical or engineering background and supervise teams of engineers in activities such as testing and research and development. In addition to technical and production managers, financial managers, accountants and auditors are needed to negotiate with customers and subcontractors and to track costs.

- Plant and machinery operator and assemblers: *Machinists* make parts that are needed in numbers too small to mass-produce; they generally follow blueprints and specifications and are highly skilled with machine tools and metalworking. *Tool and die makers* are responsible for constructing precision tools and metal forms, called dies, which are used to shape metal. Increasingly, as individual components are designed electronically, these highly skilled workers must be able to read electronic blueprints and set up and operate computer-controlled machines. *Assemblers* usually specialize in one assembly task; assemblers may put together parts of airplanes. Those involved in assembling aircraft or systems must be skilled in reading and interpreting engineering specifications and instructions.

- Crafts and other trade related occupations and some elementary occupations: In aerospace this generally involves personnel employed in production; installation, maintenance, and repair as well as transportation and material-moving occupations. Many of these jobs are not specific to aerospace and can be found in other manufacturing industries. Many production jobs are open to persons with only a high school education; however, special vocational training after high school is preferred for some of the more highly skilled jobs.

- Clerks, service workers and other elementary occupations: the remaining jobs in the industry are in office and administrative support, service, and sales occupations. Most of these jobs can be entered without education beyond high school.

Aerospace employment in South Africa

According to the Labour Force Survey (LFS), the subsector 'manufacturing of aircraft and spacecraft' directly employed only 1,500 people in 2005. However, this figure clearly underestimates actual employment in aerospace, since solely Denel (the largest defence and aerospace manufacturer in South Africa) employed over 9,000 people in 2005.

As mentioned above, the contributions of defence and civil aerospace are very difficult to separate -especially in South Africa- since the same companies often produce for both markets. Identifying the size of aerospace employment is thus largely constrained by the fact that some aerospace manufactures are classified as 'weapons and ammunition' which fall into other categories, such as 'manufacturing of special purpose machinery' (Code 357 in Stastistics SA). The LFS accounts nearly 40,000 people employed in 'manufacturing of special purpose machinery' in 2005; however, current methods of data collection do not allow extracting the proportion of aerospace related employment within this subsector. In this report, we suggest that the real figure on aerospace employment is very likely to be higher than 1,500 employees. Understanding this limitation, the analysis presented below is based on available data.

Aerospace is not a major contributor to employment in South Africa. According to figures from the LFS, from 1996 to 1999 the sub-sector 'manufacturing of aircraft and spacecraft', represented about 0.15% of total employment in total manufacturing.

Despite low representation of aerospace manufacturing in terms of employment, previous chapters have already highlighted that the relevance of the aerospace industry cannot be yet measured in quantitative aspects, such as size of the sector or contribution to job creation. Instead, the importance of the sector relates to qualitative aspects linked to the technological upgrade of manufactures, as well as preservation and development of key advanced skills.

Dynamics in aerospace employment in South Africa

This section will draw on available figures from the LFS data for the subsector 'manufacturing of aircraft and spacecraft'. Although it has been already stressed that this figure does not represent the whole aerospace sector, this exercise allows understanding major changes in the composition of this segment of aerospace. Multiple comparisons with the subsector 'manufacturing of special purpose machinery' and 'total manufacturing' contribute to the analysis and interpretation of the data.

The composition of employment in aerospace has undergone considerable changes during the last decade. These changes might be the result of various factors: the dynamic nature of the aerospace industry, the adaptation of South Africa's industry to changes in international markets and finally, newly employment dynamics at the national level following South Africa's political transition.

Changes can be examined from many perspectives. The following sections examine these dynamics through various lenses, analysing the changes in labour demand according to type of occupation, level of skills, race, age and gender.

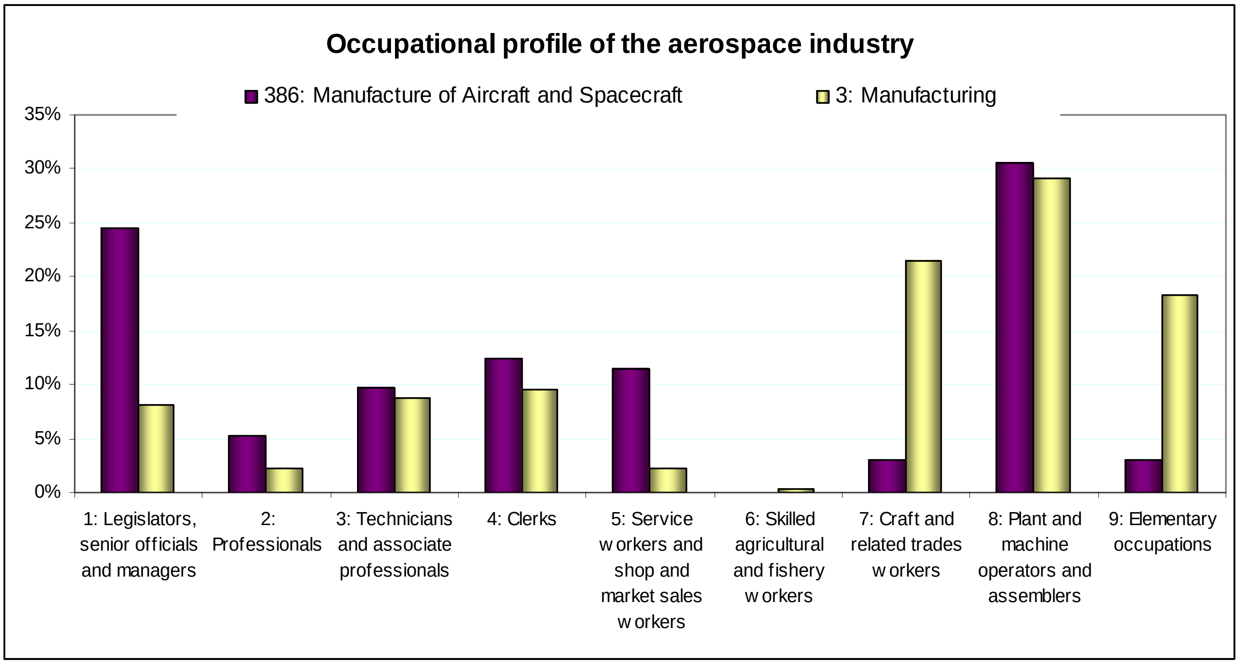
To avoid some of the problems related to high fluctuations in employment data in aerospace, the figures and tables below present average percentages for two time periods: 1996-1999 and 2001-2005[33]. For the particular case of aerospace, given its large fluctuations over time, average figures might present a more accurate profile of the aerospace industry than figures for a single year.

Changes by occupation categories

Figure 2.2 shows that, opposite to national dynamics, people employed in elementary occupations in aerospace accounted for the smallest single share of total employment (3%) in 2001-2005[34]. 'Senior officials and managers' accounted for about one quarter of total employment in aerospace, while professionals and technicians together represented all together 15% of the total number of people that were employed in aerospace manufacturing in 2001-05. However, the largest single category corresponds to 'plant and machine operators and assemblers', accounting for 30% of total average employment in the sector. Finally, clerks and service workers together represented 23% of employment.

[33] Data is not available for the year 2000.
[34] In 2005, persons employed in elementary occupations accounted for the largest single share of employment (22.9%).- (MERSETA, 2006)

Figure 2.2: Occupational profile of the aerospace industry (2001-2005)



Source: Elaborated from Labour Force Survey (LFS)

Compared to the total manufacturing sector, aerospace has three times the proportion of managers and senior officials, and twice the proportion of professionals. Technicians, clerks, service workers and assemblers are also higher in proportion in the aerospace industry. Elementary occupations and craft and related trade workers are about six times lower in aerospace than the average in the manufacturing sector.

Table 2.1 shows the changes in the composition of employment by category between two periods of time: 1996-99 and 2001-05. Percentages for categories in relation to total employment have been calculated as the average for each period of time. These figures are compared across sub-sectors ('manufacturing aircraft and spacecraft' and 'manufacturing of special purpose machinery') as well as with total manufacturing.

Table 2.1: Occupational profile of the aerospace industry

	386: Manufacture of Aircraft and Spacecraft		**357: Manufacture Of Special Purpose Machinery**		**3: Manufacturing**	
	1996-99	2001-05	1996-99	2001-05	1996-99	2001-05
1: Legislators, senior officials and managers	16%	24%	15%	12%	7%	8%
2: Professionals	12%	5%	5%	5%	3%	2%
3: Technicians and associate professionals	n/a	10%	8%	10%	8%	9%
4: Clerks	n/a	12%	11%	18%	9%	10%
5: Service workers and shop and market sales workers	n/a	11%	3%	1%	3%	2%
6: Skilled agricultural and fishery workers	0%	0%	0%	0%	1%	0%
7: Craft and related trades workers	17%	3%	26%	26%	23%	21%
8: Plant and machine operators and assemblers	15%	30%	17%	19%	25%	29%
9: Elementary occupations	25%	3%	15%	8%	20%	18%
0: Other not applicable and Unspecified	16%	0%	2%	0%	3%	0%
Total	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***

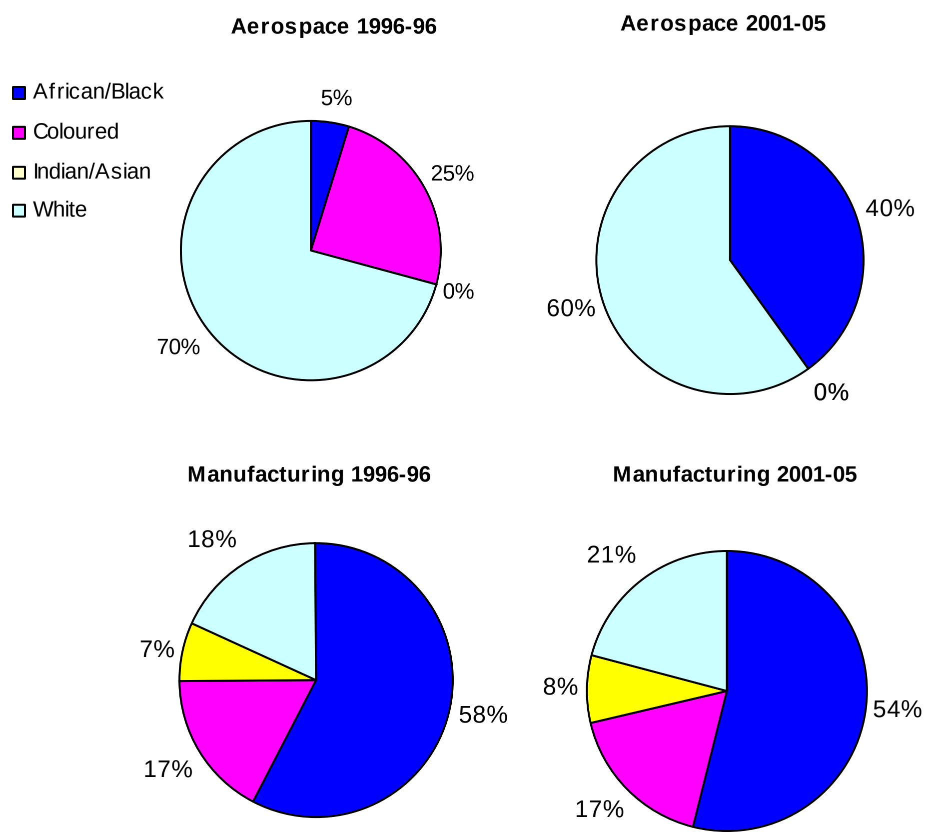
Source: Elaborated from Labour Force Survey (LFS)
Note: n/a indicates data is not available

Results in table 2.1 reveal that the proportion of ‘senior officials and managers’ has increased at a much faster rate in ‘aircraft and spacecraft manufacturing’ than in the two comparative sectors (‘manufacture of special purpose machinery’ and ‘total manufacturing’). Increases are even more pronounced for the cases of ‘technicians and associated professionals’, clerks’, ‘service workers’ and ‘plant and machine operators and assemblers’. Three categories present considerable decreases over time: ‘elementary occupations’, which dropped from 25% of total employment in 1996-99 to 3% in 2001-05; ‘crafts and related trades workers’ declined from 17% to 3% and ‘professionals” from 12% to 5%. It must be noted that the decline in the category representing “other and unspecified”, could possibly be reflect changes in the data collection and might be affecting the count of employees in various categories.

Changes by racial distribution

According the provided classification of employees according to their ethnic origin or 'race'[35], figure 2.3 reveals the uneven racial distribution in aerospace employment in 1996-99. During this period, 70% of aerospace jobs were held by 'white' workers, 25% by 'coloured' and only 5% were 'black' employees. According to LFS data, proportions have experienced dramatic changes over time, and in 2001-05 about 40% of the jobs in aerospace were held by 'black' workers. Surprisingly, the category of 'coloured' seems to disappear over time, suggesting changes in the classification of workers rather than their exit from the sector. A possible reallocation of 'coloured' workers into the 'black' category would explain the remarkable increase of 'black' workers in 2001-05.

Figure 2.3: Formal employment in aerospace and total manufacturing by race



Source: Elaborated from Labour Force Survey (LFS)

[35] The author recognizes the scientifically incorrect use of "race" to refer to persons with different ethnic origin. However, this report makes use of this term to facilitate the comparison to other existing studies and reports.

The changing patterns in the racial distribution of aerospace employment are not shared by the rest of the manufacturing sector. For total manufacturing, proportions of employment by race have remained stable with majority of ‘black’ employment (54% in 2001-05), followed by 21% of ‘white’ workers, 17% of coloured and 8% of ‘Indian/Asian'.

Table 2.2 shows that variations in the racial composition of overall aerospace employment are the result of major changes in a few specific occupation categories. The segment of ‘senior officials and management’ has experienced the most dramatic transformation, moving from a 100% of positions held by ‘white’ workers in 1996-99 to a nearly equal distribution between ‘white’ and ‘black’ in 2001-05. Nevertheless, the lack of participation of the ‘Indian/Asian’ segment at all levels is striking.

‘Plant and machine operators and assemblers’- the largest single category in total employment in the sector- has experienced a significant change in terms of racial composition of employment. The predominance of ‘white’ workers which held 69% of these positions in 1996-99, has shifted towards the ‘black’ workers (65% in 2001-05).

The two categories that present no variations over time are ‘professionals’ and ‘elementary occupations’. In ‘elementary occupations’, the reallocation of ‘coloured’ workers into the ‘black’ category seems apparent, which retains 100% of the employment in both periods. On the contrary, the category ‘professionals’ remains entirely held by ‘white’ employees.

Table 2.2: Changes in employment by occupation category and race

	1996-99				2001-05			
	B	**C**	**I/A**	**W**	**B**	**C**	**I/A**	**W**
Total	***5%***	***25%***	***0%***	***70%***	***40%***	***0%***	***0%***	***60%***
1: Legislators, senior officials and managers	-	-	-	100%	46%	-	-	54%
2: Professionals	-	-	-	100%	-	-	-	100%
3: Technicians and associate professionals	-	-	-	-	27%	-	-	73%
4: Clerks	-	-	-	-	-	-	-	100%
5: Service workers and shop and market sales workers	-	-	-	-	-	-	-	100%
6: Skilled agricultural and fishery workers	-	-	-	-	-	-	-	-
7: Craft and related trades workers	-	-	-	100%	100%	-	-	-
8: Plant and machine operators and assemblers	31%	-	-	69%	65%	-	-	35%
9: Elementary occupations	-	100%	-	-	100%	-	-	-
10: Other not applicable and Unspecified	-	-	-	100%	-	-	-	-

Source: Elaborated from Labour Force Survey (LFS)

Changes by level of skills

There exists both skilled and relatively unskilled employment in high technology sectors such as aerospace and the demand for these categories may move in different directions.

Table 2.3 shows the demand of employment by level of skills in ‘aircraft and spacecraft’ in comparison to the dynamics in ‘special purpose machinery’ and ‘total manufacturing’. This table discloses some interesting results:

Firstly, the highly skilled profile of the aerospace industry seems to be rapidly transforming. In 1996-99 highly-skilled employment represented 28% of the total employment in ‘aircraft and spacecraft’ and by 2001-05 highly skilled employment dropped to only 7%. On the contrary, ‘total manufacturing’ has experienced a moderate increase in the demand of highly-skills, moving from 3% to 5% of total employment. Coming from a high-skills intensive profile, the aerospace sector seems to be converging towards the general profile the total manufacturing in their demand of high-skills.

Secondly, the segment of intermediate skills has generated the largest employment opportunities in the aerospace industry during the last decade. In 1996-99, 43% of the employed in ‘aircraft and spacecraft’ had intermediate skills, and in 2001-05 this percentage had increased to 58%.

Thirdly, the trends in low-skilled employment seem to be opposite to the observed in ‘special purpose machinery’ and ‘total manufacturing’, where the percentage of low-skilled labour force has largely decreased during the last decade. In the aerospace industry, low-skilled employment has increased from a 29% in 1996-99 to 35% in 2001-05.

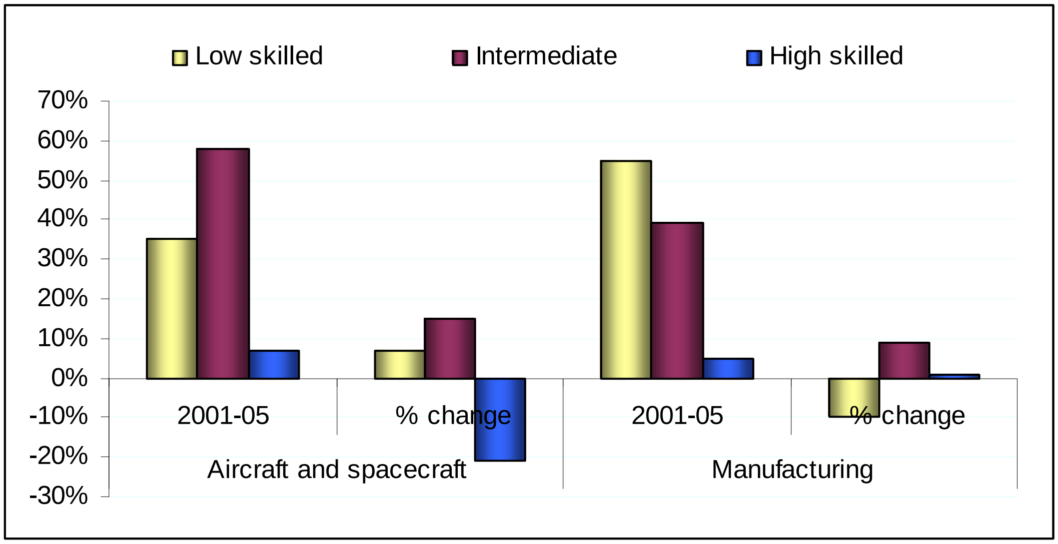
Table 2.3: Demand of skills in the aerospace sector and changes over time

	Manufacture of Aircraft and Spacecraft			**Special Purpose Machinery**			**Total Manufacturing**		
	1996-99	***2001-05***	***change***	***1996-99***	***2001-05***	***change***	***1996-99***	***2001-05***	***change***
Low skilled	29%	35%	*7%*	59%	37%	*-22%*	65%	55%	*-10%*
Intermediate	43%	58%	*15%*	26%	48%	*22%*	30%	39%	*9%*
High skilled	28%	7%	*-21%*	13%	12%	*-1%*	3%	5%	*1%*
Unknown	0%	0%	*0%*	2%	3%	*1%*	1%	1%	*0%*
Total	100%	100%		100%	100%		100%	100%	

Source: Elaborated from Labour Force Survey (LFS)

The dynamics and changes observed for the period 1996 to 2005 highlight two major facts: (1) the demand for skills in the aerospace industry in South Africa is converging towards the profile of the overall manufacturing sector; in aerospace the demand of lower skills is raising while the demand for high skills is declining. Meanwhile, the overall manufacturing sector is moving towards a higher skilled profile; (2) similarly to the trends in total manufacturing and related sub-sectors, such as ‘special purpose machinery’, the demand for intermediate skills in aerospace is rapidly growing, accounting for nearly 60% of the employees in 2001-05.

Figure 2.4: Changes in the demand of skills in aerospace



Source: Elaborated from Labour Force Survey (LFS)

Table 2.4 presents the demand of skills by occupation category. Results in this table reveal that major changes have taken place at the 'senior officials and management level'. This segment was comprised by 100% of high-skilled personnel in 1996-99; however, in 2001-05 only 6% remained high-skilled while 94% shifted to an intermediate level of skills. The category of 'Professionals' is comprised by highly-skilled personnel in both periods, although 'craft and related trade workers' as well as a large proportion of 'plant and machine operators and assemblers' have shifted from intermediate to low-skilled over time. These changes might be partially a result of inconsistencies in data collection, but might also indicate that the aerospace industry in South Africa is adapting its production to the reality of the available workforce and current market opportunities, in a search for lower but specialized skills rather than simply high-skills.

Table 2.4: Demand of skills by occupational category and changes over time

	1996-99			2001-05		
	Low	***Int.***	***High***	***Low***	***Int.***	***High***
Total	***29%***	***43%***	***28%***	***35%***	***58%***	***7%***
1: Legislators, senior officials and managers	-	-	100%	-	94%	6%
2: Professionals	-	-	100%	-	-	100%
3: Technicians and associate professionals	-	-	-	-	100%	-
4: Clerks	-	-	-	100%	-	-
5: Service workers and shop and market sales workers	-	-	-	-	100%	-
6: Skilled agricultural and fishery workers	-	-	-	-	-	-
7: Craft and related trades workers	-	100%	-	100%	-	-
8: Plant and machine operators and assemblers	28%	72%	-	65%	35%	-
9: Elementary occupations	100%	-	-	-	100%	-
10: Other not applicable and Unspecified	-	100%	-	-	-	-

Source: Elaborated from Labour Force Survey (LFS)

Changes by age

The aerospace industry in South Africa developed during years of isolation, to satisfy government purposes. Under apartheid regime, access to training on specialised aerospace subjects was restricted to a very small segment of the population. After political transition the formation and dynamics of new entrants to the aerospace employment certainly changed. Additionally, reductions in the defence budget affected the perception of the prospects of building up a career in aerospace.

All these dynamics have affected the age profile of the aerospace workforce. Currently, there is a growing concern about an ageing aerospace workforce, which could translate into a significant limitation to the sustainable growth and expansion of the sector.

However, table 2.5 indicates that the percentage of young employees to the aerospace industry has increased since 1996 by 13% compensating the overall decrease in employees over 50 years old (decline of 14%).

Table 2.5: Formal occupation in aerospace and total manufacturing sector by age

	Manufacture of Aircraft and Spacecraft			**Manufacturing sector**		
	1996-99	***2001-05***	***change***	***1996-99***	***2001-05***	***change***
Less than 30	5%	17%	***13%***	27%	25%	***-2%***
Between 30 and 50	65%	63%	***-2%***	60%	60%	***-1%***
Over 50	30%	17%	***-14%***	13%	15%	***3%***

Source: Elaborated from Labour Force Survey (LFS)

Nevertheless, the 'renewal' of employees has not taken place equally in all occupation categories. Table 2.6 reveals that 'Senior officials and managers' are clearly ageing; in 1996-99 100% of the employees in this occupation were between 30 and 50 years old, whereas in 2001-05 nearly 50% of them are over 50 years old, with no participation of youth.

'Professionals' has remained totally in the hands of older employees over 50 years old during both periods. The only categories that have received young personnel of less than 30 years old have been 'Technicians and associate professionals' and 'Plant and machine operators and assemblers', although the majority of the employees in these categories still remains held by older employees.

Table 2.6: Employment in aerospace by age group

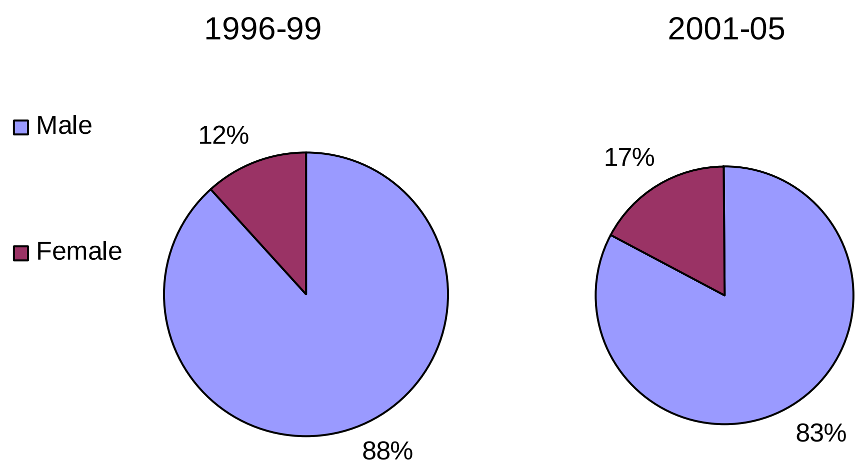
	1996-99			**2001-05**		
	Less 30	***30-50***	***Over 50***	***Less 30***	***30-50***	***Over 50***
Total	***5%***	***65%***	***30%***	***17%***	***63%***	***17%***
1: Legislators, senior officials and managers	-	100%	-	-	54%	46%
2: Professionals	-	-	100%	-	-	100%
3: Technicians and associate professionals	-	-	-	27%	73%	-
4: Clerks	-	-	-	-	100%	-
5: Service workers and shop and market sales workers	-	-	-	-	100%	-
6: Skilled agricultural and fishery workers	-	-	-	-	-	-
7: Craft and related trades workers	-	53%	47%	-	-	-
8: Plant and machine operators and assemblers	31%	-	69%	48%	52%	-
9: Elementary occupations	-	100%	-	-	100%	-
10: Other not applicable and Unspecified	-	100%	-	-	-	-

Source: Elaborated from Labour Force Survey (LFS)

Changes by gender equity

The gender dimension presents severe predominance of the male segment. In 2001-05 male employees constituted 83% of the total in ‘aircraft and spacecraft manufacturing’. Figure 2.5 shows that although there has been some progress in gender equity over time, it is occurring at a very low pace. From 1996-99 to 2001-05, there has been a total increase of only 5% in female participation in the aerospace industry.

Figure 2.5: Changes in the composition of aerospace employment by gender



Source: Elaborated from Labour Force Survey (LFS)

Gender disparities are even more acute at the level of occupation categories. In 1996-99 female participation in employment was restricted to ‘elementary occupations’, in which they constituted 48% of employees. In 2001-05 female employees could only be found as ‘service workers’ and a small percentage of ‘senior officials and managers’. In this latter, women have achieved 23% of the positions in 2001-05. The rest of the categories were entirely held by male employees.

Table 2.7: Formal employment in aerospace and manufacturing by gender and occupation

	1996-99		2001-05	
	Male	**_Female_**	**_Male_**	**_Female_**
Total	**_88%_**	**_12%_**	**_83%_**	**_17%_**
1: Legislators, senior officials and managers	100%	0%	77%	23%
2: Professionals	100%	-	100%	-
3: Technicians and associate professionals	0%	-	100%	-
4: Clerks	0%	-	100%	-
5: Service workers and shop and market sales workers	-	0%	-	100%
6: Skilled agricultural and fishery workers	-	-	-	-
7: Craft and related trades workers	100%	-	100%	-
8: Plant and machine operators and assemblers	100%	-	100%	-
9: Elementary occupations	52%	48%	100%	0%
0: Other not applicable and Unspecified	-	-	-	-

Source: Elaborated from Labour Force Survey (LFS)

Conclusions

Changes in the demand of aerospace have not taken place homogeneously in terms of occupations, level of skills, age, race and gender.

From a gender and racial perspective, most employees in the sector overall are male and white South African employees, and occupations held by women, and black employees are predominantly located in the semi and unskilled occupational levels. Major changes are taking place at the senior and management level. This segment has gone though a rapid transformation during the last decade, with the inclusion of more black employees as well as female, younger and intermediate skilled workforce. However, changes in the composition of other occupational categories, particularly those related with technical and advanced manufacturing skills, such as ‘professionals’ and ‘technicians’ have been very limited. Particularly women and non-white employees are largely unrepresented in technical and professional occupations.

CHAPTER THREE: SUPPLY OF SKILLS

Any manufacturer of complex machinery must have a pool of skilled labour available. Moreover, a country wishing to establish and promote aerospace manufacturing must have access to a sophisticated academic system capable of producing highly educated engineers. This is especially relevant for South Africa, who competes as global supplier for international tier-one customers while acquires capabilities in more advanced products. Local producers are required to build products that meet the strict international standards, and this has clearly implications for the education and training systems in South Africa.

The main groups of providers of education are: the formal school system, Further Education & Training (FET) and Higher Education & Training (HET) institutions- including technikons and universities- training authorities and employers. The role of these institutions in the supply of skills for the SA aerospace industry is discussed below.

Supply of aerospace-related skills

In South Africa, the National Qualifications Framework places all learning on eight levels (1 to 8), across three bands. Level 1 is ‘General Education and Training’, predominately the schooling band. Level 2 to 4 comprises ‘Further Education and Training’, the arena of FET Colleges, Schools, Trade and Industry training. Level 5 to 8 is ‘Higher Education and Training’, the domain of Universities, Higher Level Colleges and Professional Qualifications.

The following sections examine the supply of skills for the aerospace industry, following this classification. However, given the high-qualification base of the sector, figures are presented for the second and third level of learning, this is ‘Further Education and Training’, and ‘Higher Education’; which can be respectively considered as “intermediate” and “high” skills supply.

Further Education and Training

The Further Education and Training (FET) sector is a vocationally-oriented level of education that resides in the “junction” of primary and secondary education, and university level studies. The FET has been considered to have the potential to play a significant role in the ‘skills revolution’ in South Africa (NSDS, 2005; USAID, 2007).

Figures on enrolments and pass rates are presented below for a number of subjects related to aerospace manufacturing at the FET level. Some subjects have direct application in aerospace manufacturing (such as Aircraft Maintenance and Aircraft Technology) with little application outside the aerospace production; while other such as Engineering Science and Computer Science, are core for aerospace manufacturing but can also be applied in other industries outside aerospace.

Table 3.1 shows the low number of enrolments in aerospace subjects. Only three subjects had a relatively significant number of entrants in 2005: Aircraft Maintenance Theory, Aircraft Technology and Aircraft Metalwork Theory. Enrolments in these subjects show positive growth rates since 1996, and figures accelerated since 2001 reaching growth rates of 20% per year[36]. The rest of the subjects (Aerodynamics, Aircraft Electrical Theory, Aircraft Electronics Theory, Aircraft Instrument Trades Theory) have been practically deserted during the last decade.

For other subjects related to aerospace, Engineering Science and Engineering Technology are the most populated in 2005, followed by Industrial Electronics. These also present positive growth rates since 1996, although there is a clear deceleration in 2001-05, where annual growth rates fell to 3-4%. For the rest of the subjects, there has been an overall decline in enrolments from 2001 to 2005.

[36] However, this growth has to be interpreted cautiously given its low initial base.

Table 3.1: Number of entrants in aerospace subjects in FET

	Number of Enrolments				
	1996	**2001**	**2005**	**1996-01 average growth p.a**	**2001-05 average growth p.a**
Aerospace subjects					
Aircraft maintenance theory	188	336	677	12%	15%
Aircraft technology	69	71	115	1%	10%
Aircraft Metalwork Theory	23	26	58	2%	17%
Aviation Electronics	11	23	8	16%	-19%
Aerodynamics	2	0	0	-100%	0%
Aircraft Electrical Theory	3	0	0	-100%	0%
Aircraft Electronics Theory	2	0	0	-100%	0%
Aircraft Instrument Trades Theory	1	0	0	-100%	0%
Other aerospace-related subjects					
Engineering science	93,712	121,699	140,723	5%	3%
Engineering Technology	18,610	51,650	61,426	23%	4%
Industrial Electronics	26,678	43,030	49,562	10%	3%
Communication Electronics	2,519	4,989	3,029	15%	-9%
Motor Electrical Theory	1,115	1,319	1,214	3%	-2%
Computer Principles	1,357	1,606	769	3%	-14%
Control Systems	860	715	714	-4%	0%
Motor Machining Theory	308	159	93	-12%	-10%
Armature Winding Theory	58	43	81	-6%	14%
Internal Combustion Engines	53	133	63	20%	-14%
Electro-Mechanics Theory	69	13	3	-28%	-25%
Aluminium Technology	207	0	0	-100%	0%
Electronics	1	0	0	-100%	0%
Missiles	14	2	0	-32%	-100%
Radar Systems	38	2	0	-45%	-100%
Radar Technology	16	0	0	-100%	0%
Radar Trades Theory	12	0	0	-100%	0%

Source: Elaborated from National Learners' Records Database (NLRD)

Pass rates in relation to the number of entrants can be used as an indication of the quality of education. Table 3.2 shows that the highest pass rates in 2005 can be found in those subjects directly linked to aerospace. In particular, 'Aviation Electronics' and 'Aircraft Maintenance Theory', present 75% and 58% respectively of passes in relation to enrolments. Again these figures must be taken cautiously given the low base. With the exception of Computer Sciences, pass rates for aerospace related subjects are low - below 50% - in 2005.

In general results indicate that pass rates have tended to decrease over time, suggesting that the quality of education in technical subjects has deteriorated. One relevant exception is the positive, although moderate, improvement of ‘Engineering Science’, where pass rates have gone up from 39% in 1996 to 43% in 2005.

Table 3.2: Pass rates in aerospace-related subjects

	% Passed				
	1996	**2001**	**2005**	**Change (total %) 1996-01**	**Change (total %) 2001-05**
Aerospace					
Aviation Electronics	27	43	75	16	32
Aircraft Maintenance Theory	55	63	58	7	-4
Aircraft Metalwork Theory	43	81	52	37	-29
Aircraft Technology	45	44	50	-1	7
Aerodynamics	0	-	-	-	-
Aircraft Electrical Theory	0	-	-	-	-
Aircraft Electronics Theory	100	-	-	-	-
Aircraft Instruments Trades Theory	0	-	-	-	-
Aerospace-related					
Computer Principles	58	51	52	-7	1
Communication Electronics	51	55	49	4	-6
Control Systems	34	46	47	12	2
Engineering Technology	55	52	46	-3	-6
Motor Electrical Theory	36	37	45	1	8
Engineering Science	39	42	43	3	2
Industrial Electronics	53	53	39	0	-14
Internal Combustion Engines	42	63	38	22	-25
Armature Winding Theory	72	74	34	2	-40
Motor Machining Theory	54	30	16	-23	-14
Electro-Mechanics Theory	51	38	0	-12	-38
Aluminium Technology	4	-	-	-	-
Electronics	100	-	-	-	-
Missiles	29	50	-	21	-
Radar Systems	39	50	-	11	-
Radar Technology	56	-	-	-	-
Radar Trades Theory	25	-	-	-	-

Source: Elaborated from National Learners’ Records Database (NLRD)

Higher education supply

The number of engineers is consider as a good proxy for the core skills sets required by manufacturing activities (MERSETA, 2006), including aerospace manufacturing. According to the Engineering Council of South Africa (ECSA) the number of enrolments in engineering disciplines in higher education institutions (both technikons and universities) increased from 23,299 in 2000 to 37,303 in 2004. However, the number of graduates was considerably lower, from 2,529 in 2000 to 4,338 in 2005.

The tables below show enrolments and number of graduates in engineering disciplines in technikons and universities by type of engineering discipline.

Table 3.3: Engineering Enrolments and Graduates in Technikons

Discipline	2000			2004		
	Enrol	**Grad**	**grad/enrol (%)**	**Enrol**	**Grad**	**grad/enrol (%)**
Aeronautical	13	0	0%	0	0	0%
Agricultural	36	0	0%	7	4	57%
Chemical	1,686	133	8%	4,527	471	10%
Civil	3,008	364	12%	6,010	728	12%
Electrical	7,720	470	6%	12,357	1,234	10%
Industrial	754	68	9%	1,497	239	16%
Mechanical	2,808	190	7%	3,180	361	11%
Metallurgical	617	66	11%	778	102	13%
Mining	133	2	2%	335	22	7%
TOTAL	**16,775**	**1,293**	8%	**28,691**	**3,161**	11%

Source ECSA 2004-2005

In both technikons and universities, the number of enrolments has increased - although in universities the increase has been lower than in technikons. Electrical, mechanical and chemical engineering represent the major disciplines in terms of enrolments and number of graduates, and also in technikons civil engineering has gained a large number of enrolments in 2004.

Table 3.4: Engineering Enrolments and Graduates in Universities

Discipline	2000			2004		
	Enrol	Grad	grad/enrol (%)	Enrol	Grad	grad/enrol (%)
Aeronautical	54	4	7%	165	16	10%
Agricultural	76	15	20%	57	13	23%
Chemical	1,237	239	19%	1,529	192	13%
Civil	930	150	16%	952	147	15%
Electrical	2,347	446	19%	3,055	431	14%
Industrial	355	77	22%	513	70	14%
Mechanical	1,234	246	20%	1,783	256	14%
Metallurgical	80	19	24%	132	9	7%
Mining	211	40	19%	426	43	10%
TOTAL	**6,524**	**1,236**	19%	**8,612**	**1,177**	14%

Source ECSA 2004-2005

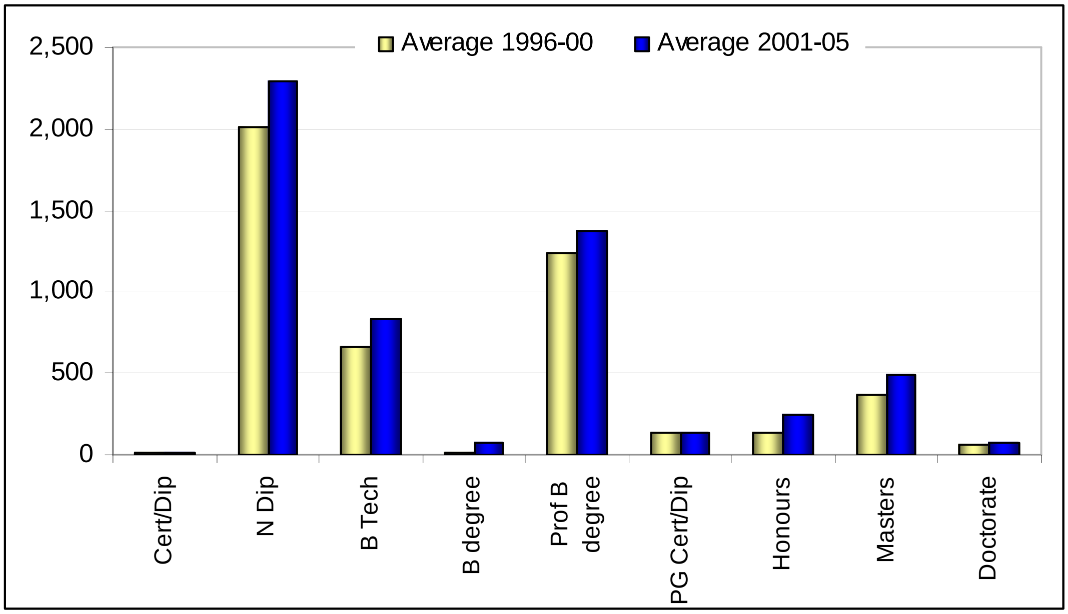
Despite the overall increase in enrolments, MERSETA (2006) suggests that an improved graduation rate is desirable as insufficient numbers are coming through the system to meet demand from Industry. Tables 3.3. and 3.4, indicate that graduation rates are strikingly low. Although they have moderately improved in technikons (from 8% in 2000 to 11% in 2004), graduation rates have declined in universities from 19% overall in 2000 to 14% in 2004.

In relation to the type of qualification, figure 3.1 shows that the National diploma (three years of studying period) still remains a major exit point in the engineering qualification, followed by Professional Degrees and B-Tech[37]. In general, undergraduate studies are more popular than postgraduate studies, comprising about 85% of total graduates in engineering in HE[38].

[37] B-Tech degree is aimed was to bridge the gap between the Technikon diploma and the University degree. B-Tech contains an industry-focussed research component.

[38] Undergraduate programs comprise Certificate/Diploma, National Diploma, B-Tech, and Professional Degrees; while post-graduate studies include Postgraduate Diploma, Honours, Masters and Doctorate Programs.

Figure 3.1: Supply of Engineers in HE by level of qualification

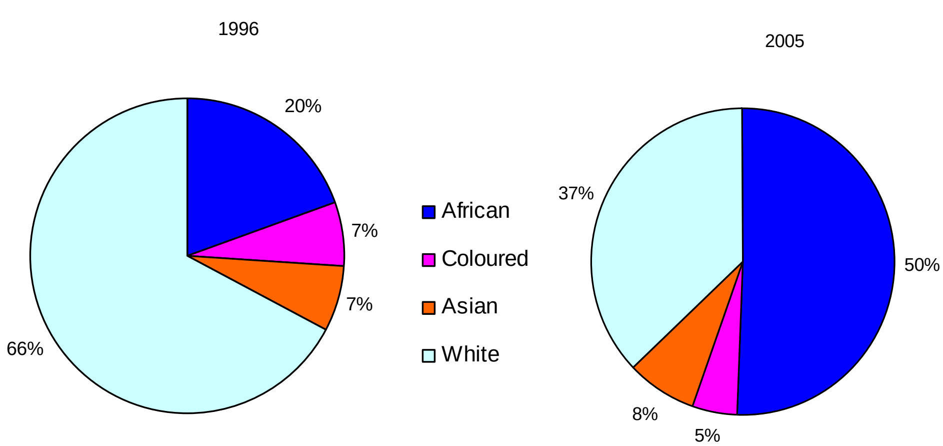


Source: Elaborated from National Learners' Records Database (NLRD)

- <u>Changes by racial composition of supply</u>

Figures 3.2 and 3.3 show the pace at which composition of engineering graduates have changed. In 1996, 66% of all engineering graduates were 'white', 20% 'black', 7% 'coloured' and 7% were 'Indian/Asian'. By 2005, 'black' engineering graduates increased their share to 50%, although the representation of coloured and 'Indian/Asian' graduates remained practically unchanged.

Figure 3.2: Racial composition of the supply of engineers in HE (1996 and 2005)



Source: Elaborated from National Learners' Records Database (NLRD)

Table 3.5 shows that racial equity achievements are visible at the undergraduate level (from 30% of ‘black’ graduates in 1996-00, to 46% in 2001-05), as well as the post-graduate level (from 13% post-graduates in 1996-00 to 25% in 2001-05). However, ‘white’ post-graduates still represented about two thirds of the total in 2001-05. The ‘coloured’ and ‘Indian/Asian’ representation has remained relatively low and presents little changes over time.

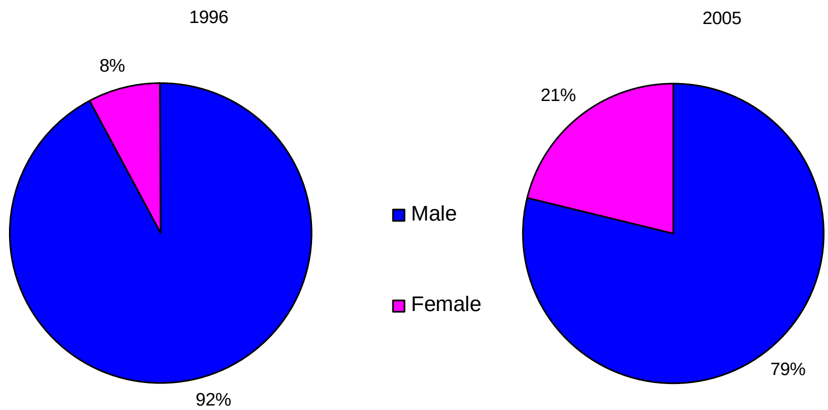
Table 3.5: Supply of Engineers in HE by level of qualification and equity

	1996-00				**2001-05**			
	A	**C**	**I/A**	**W**	**A**	**C**	**I/A**	**W**
Undergraduates	***30%***	***6%***	***7%***	***57%***	***46%***	***6%***	***8%***	***40%***
Cert/Dip	50%	9%	0%	41%	73%	0%	0%	27%
N Dip	42%	8%	6%	45%	65%	8%	4%	23%
B Tech	20%	6%	8%	65%	47%	7%	9%	36%
B degree	29%	2%	5%	64%	25%	2%	4%	69%
Prof B degree	15%	3%	10%	71%	23%	3%	13%	62%
Post-graduates	***13%***	***2%***	***5%***	***80%***	***25%***	***3%***	***8%***	***64%***
PG Cert/Dip	30%	2%	10%	59%	42%	3%	10%	46%
Honours	7%	0%	3%	90%	25%	2%	9%	65%
Masters	10%	2%	6%	81%	22%	3%	10%	65%
Doctorate	4%	0%	2%	93%	12%	2%	6%	80%

- Changes by gender composition of supply

Figures 3.3 illustrate the pace at which the gender distribution of graduates had been changing. In 1996, only 8% of all engineering graduates were female. By 2005, female graduates had increased their share to 21%.

Figure 3.3: Gender distribution of supply of Engineers in South Africa (1996-2005)



Source: Elaborated from National Learners' Records Database (NLRD)

Table 3.6 shows that although female representation at undergraduate level has doubled during the last decade, 80% of the undergraduates in engineering were male in 2001-05. In post-graduate studies, advances in gender equity have been minimal from 1996 to 2005 (increase from 11% to 15%)

Table 3.6: Supply of Engineers in HE by level of qualification and gender equity

	1996-00		**2001-05**	
	Male	Female	Male	Female
Undergraduate	***90%***	***10%***	***80%***	***20%***
Cert/Diploma	52%	48%	70%	30%
National Diploma	90%	10%	78%	22%
B Tech	92%	8%	82%	18%
B degree	71%	29%	69%	31%
Professional B degree	89%	11%	82%	18%
Post-graduate	***89%***	***11%***	***85%***	***15%***
PG Certificate/Diploma	88%	12%	79%	21%
Honours	90%	10%	82%	18%
Masters	89%	11%	87%	13%
Doctorate	86%	14%	86%	14%

Provision of training for the aerospace industry

Previous chapters have stressed that the competitiveness and sustainability of South African aerospace firms depend on their ability to maintain technological capabilities in the areas of product development and human resources. Given the rapid pace of innovation and technological changes companies need to adapt to new markets and products. Continuous education and training of the workforce in the aerospace sector becomes thus essential.

Personal interviews emphasized the severe skills constraints faced by South African aerospace manufacturers. Skill shortages are evident in terms of both overall skills to maintain current production and also of specific skills to be able to confront future changes in demand and markets.

The absence of a specific training authority for aerospace manufacturing, limits the amount of formal training useful for companies. A number of firms have developed their own in-house training programmes but smaller firms lack the resources to provide on-going training. Skills development and training continue to pose a major challenge to this industry.

Sector Education and Training Authorities (SETAs)

There are 23 Sector Education and Training Authorities (SETAs) and each represents a sector or an industry cluster. However, none of these industries or clusters includes aerospace manufacturing.

Two SETAs partially service aerospace companies: the Manufacturing, Engineering and Related Services SETA (MERSETA) and the Transport Education and Training Authority (TETA). MERSETA covers a number of manufacturing activities such as automotive, new tyre, plastics, metal and motor manufacturing, but not aerospace manufacturing; while TETA is responsible of aerospace but only as one of the modes of transporting people and goods in South Africa, this is, as a transport service.

All interviewed companies reported to belong to either the MERSETA, TETA or both. Registration with a SETA generally implies the payment of skills development levies, from which they claim a percentage of their expenses on training through a financial year[39].

[39] In terms of the Skills Development Levies Act, all employers are required to register with the SETA that represents their industry sector and pay a levy that amounts to 1% of their total payroll to the SA Revenue Service (SARS), which acts as collection agent for the SETAs. The levy is accessible to employers as three separate grants but is also used to fund a quality assurance system reviewing, measuring and analysing the quality of training and education in each industry. Where there is no provision for education and

Grants, learnerships, apprenticeships and tax incentives can be accessed from the MERSETA and TETA to encourage companies to increase their training activities. Nevertheless, personal interviews revealed the limited use that South African aerospace manufacturers make of the SETAs. The policy implemented by the SETAs is that reimbursement of the training costs will only be made so long as the trainers are accredited training providers; this is a qualification registered with the South African Qualifications Authority (SAQA).

Given the complex and technology-intensive nature of aerospace manufacturing, in most occasions specific training cannot be found nationally and in order to fulfil the customers' requirement they need to send their employees abroad or to un-accredited training programmes. This results in a large pool of unclaimed contributions that remains unused at the SETAs, and an increase in the costs of training costs for domestic aerospace manufacturers. For contract specific skills training, some of the large aerospace companies have managed to negotiate a percentage of the training costs in overseas institutions, although they need to be accredited in their respective countries[40]. However, not every company is in a position to claim back these expenses.

Finance Minister, Trevor Manuel, recently stated that at the end of 2006 "SETAs held over R3.7bn in cash reserves, effectively levy income that employers had not yet utilised to reimburse training expenses or skills development projects that had not yet been implemented" (Medium Term Budget Policy Statement, 2007).

Several SETAs have been under criticism for their weak performance. At the beginning of the second phase of National Skills Development Strategy (NSDS) in 2005, the numbers of SETAs was reduced from 25 to 23. Further consolidation and changes in the strategy are envisaged to take place in following years (USAID, 2007).

The effectiveness of the SETAs, in particular for the aerospace industry, has been largely questioned and there have been several calls for a re-assessment of their structure from industry.

Private training providers

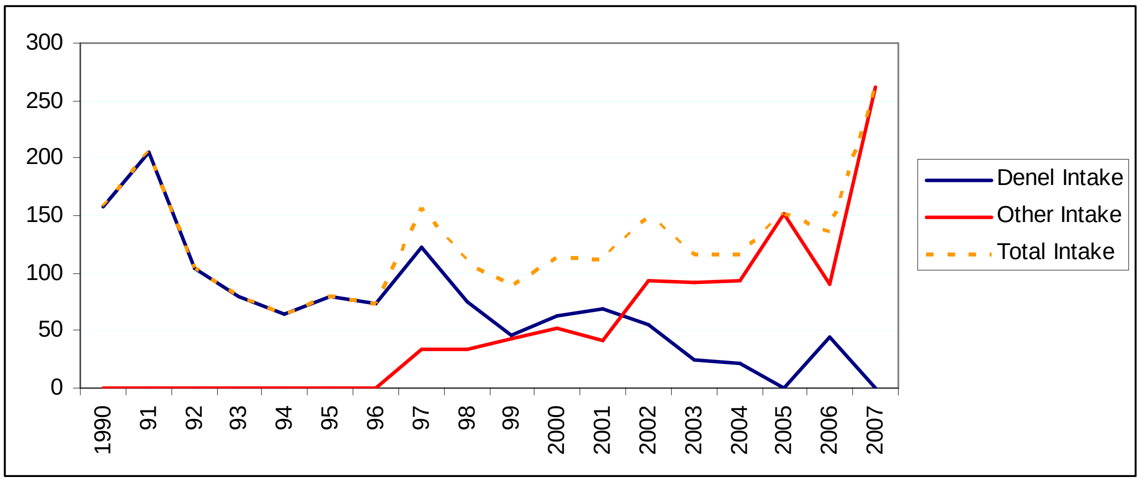
training (but employers and employees have expressed a need for it), it is the SETAs' responsibility to ensure the creation of learning programmes and organisations.

[40] In some cases they can claim up to 70% of the costs.

The *Denel Centre for Learning and Development (DCLD)* was part of Denel Corporation until financial pressures in Denel reduced the considerably the number of intakes and forced the learning centre to attract students from outside the company. In 2002 DCLD was established as a separate entity. Its courses are accredited by the Transport Education Training Authority (TETA) and the Aerospace Chamber, offering training according to the Competency Based Modular Training system. According to the organisation, the DCLD is the largest public skills-development and training programme in Africa for the aerospace and defence industry.

DCLD services Denel and also national and foreign private companies. In 2006 only 4% of the total apprentices corresponded to foreign companies, although our personal interview with DCLD revealed that they expect a significant increase of African apprentices (mainly SADC) as a result of their international accreditation from IASA (International Aviation Safety Association). Figure 3.4 shows that the intake of apprenticeships from outside Denel has largely overcome the intake from Denel since 2002.

Figure 3.4: Intake of apprentices in DCLD (1990-2007)



Source: DCLD

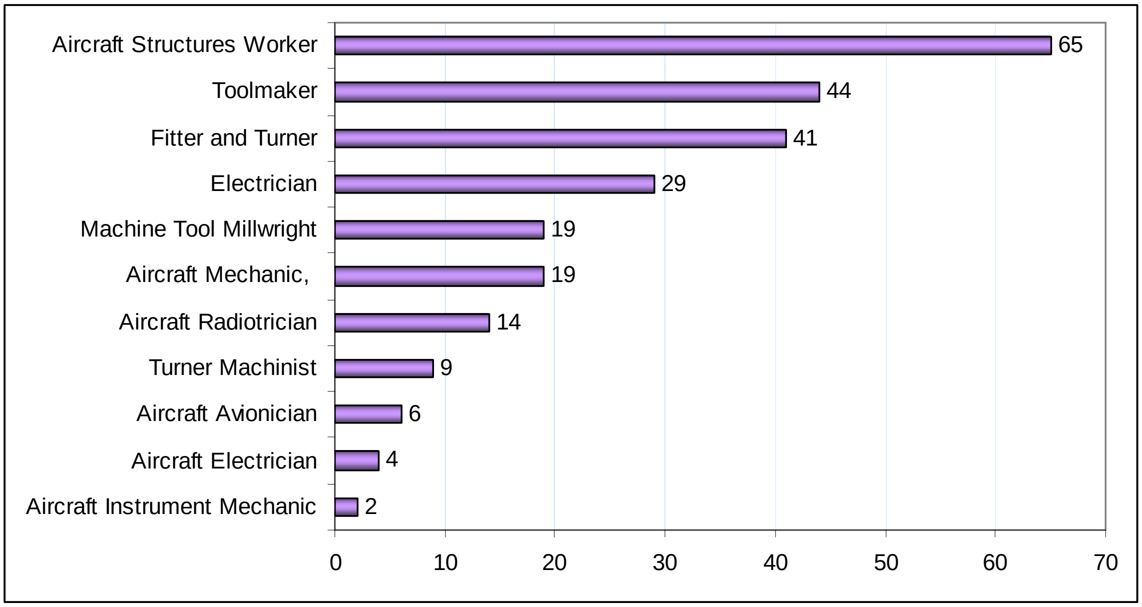
DCLD runs three programmes:

- <u>Denel School of aerospace</u>: provides advance and type training Department. This program offers specific aircraft related courses and specific contract training. It is the most popular and tends to be ad-hoc, short-term training; it comprises about 90% of the training provided to Denel.
- <u>The Apprentice School</u>: DCLD holds over 250 apprenticeships for domestic and international organizations. Some of these apprentices are subsidized but others are self-funded.

- The Youth Foundation Training Programme; works in conjunction with the DoD. This program places emphasis on the development of aerospace-related skills for women and previously disadvantaged groups. In 2007 DCLD reported an intake of 70 percent women, mostly from rural areas.

The Denel School of Aerospace offers courses on: Aircraft Mechanic, Aircraft Structural Worker, Fitter and turner, Turner Machinist, Toolmaker, Aircraft Radiotrician, Aircraft Electrician, Aircraft Avionician, and Machine Tool Millwright. Figure 3.5 illustrates the number of apprentices by course in 2007.

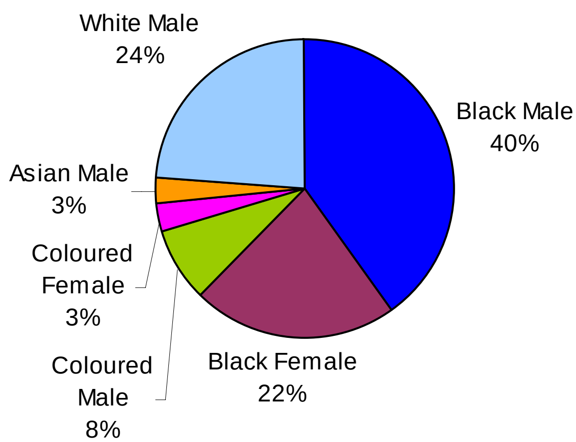
Figure 3.5: Number of apprentices in DCLD by course (2007)



Source: DCLD

Figure 3.6 shows that the majority of intakes in 2007 corresponded to black males (40% of total intakes in 2007) followed by white male (24%), and black women (22%). Asian and coloured intakes account together for only 14% of the total.

Figure 3.6: Composition of apprenticeships at DCLD by race and gender (2007)



Source: DCLD

Identified training practices in companies

Previous chapters have described the challenges that South African aerospace manufacturers face in global context. They highlighted that although the national tertiary skills base is growing, the adaptation of the education systems does not seem to be keeping the rapid pace of change in industry. The development of the skills of the workforce beyond entry-level skills, at the work place, is consequently critical to maintain current competitiveness in the sector.

Not surprisingly, training was recognised as central to production activities in all companies interviewed. Although training patterns and practices differed for individual firms, common issues were raised across the sample.

The most practiced training was technical training, including In-house, overseas and local technical training. On the contrary, management training was not a priority in training practices -neither local nor overseas.

In general, the ***funding sources*** for training activities appeared to be a combination of company's internal funds, specific training provided by the client, and available SETA's training refunded through the Skills Development Levy.

To ensure their future skills needs, larger companies generally offer funding bursaries to students studying engineering and other related courses at tertiary institutions. Some of the larger companies have associated training schools, allowing more continuous and longer-term training strategies. Only high-tier producers, with more than 500 employees, reported to have an associated training school. However, half of the companies reported to have personnel with training responsibilities, regardless of the size of the firm.

However, interviews revealed the uncertainty that smaller companies face in relation to the sustainability of their training programmes, such as internships, apprenticeships and learnerships. In some cases, the funds obtained for these programmes from government departments are not ensured for their entire duration, forcing the company to search for alternative sources of funding and facing the risk of having to fund it internally - compromising the financial stability of the firm.

Companies were asked to identify the two most important ***areas for training*** for each of the broad occupational categories. For *managers and supervisors*, training on soft skills was the most common identified area, and also production planning and financial skills. For *engineers and technicians*, computer skills appeared to be crucial. Aerospace production is becoming increasingly computerised and these skills have become a prerequisite for South African manufacturers to gain international contracts[41]. Project management was also widely regarded as an important area to train engineers and technical staff. Other specific technical skills related to particular customer requirements, were usually obtained ad-hoc. For *production workers and artisans*, training appears to be more regular and focused on specific job tasks such as moulding, composites training, design, and also OHS.

Table 3.7: Identified key areas for training

Occupation	**Most important areas for training**
Managers/supervisors	- Soft skills: communication, leadership - Team building

[41] For example, CATIA is a suite of software products of PLM (Product Lifecycle Management) solutions. It covers the process of design, simulation and manufacture allowing companies to improve efficiency with minimal errors. CATIA is continually evolving and has been established as a prerequisite for awarding contracts to suppliers.

	- Line management - Occupational Health and Safety - Human resources management - Financial skills - Production planning
Engineers and technicians	- Computer skills: programming, application software, - Project and Contract management - Quality assurance - Production planning - Logistics and maintenance
Production workers/artisans	- Design training - Moulding - Composites training - Occupational Health and Safety

Source: personal interviews

Interviews also provided insights on the ***intensity*** and *relevance* that aerospace companies devote to skills development activities. Six out the seven interviewed companies reported to have a central focus on training during the next five years. However, there were differences in the intensity of training as a percentage of total sales. Three companies reported relatively low expenses (1-5% of sales in training), while four companies reported training expenses greater than 10% of sales.

In all cases, companies reported to have sent employees outside the company for formal training during the last financial year, and with only one exception, all companies also used ***external training*** institutions to train personnel in their plant. External training institutions include external local agencies as well as foreign specialised trainers.

Given the limited availability of aerospace training in South Africa, relationships with customers constitute a crucial factor to achieve technical training and skills development. The exchange of technical engineers, sending technical personnel to customers' abroad location and sharing intellectual property were emphasised as the major tangible benefits from the companies' relationship with customers, other than sales income. Table 3.8 shows that customers were identified by the companies interviewed as the most frequent training provider followed by local universities and vocational institutes.

Table 3.8: Major training providers in interviewed companies

Most frequent training provider	**No. of companies**

Customers	5
Universities	4
Vocational Institutes	3
Industry Associations	3
JV Partners	3
Suppliers	2

Source: personal interviews

The South African aerospace landscape has been described as "highly fragmented with very little domestic co-operation between companies" (Assegai, 2004). For this reason, ***collaboration on training*** aspects was examined in our interviews. Companies were asked whether they have joint training programmes with other firms. Results revealed that five out of seven companies do collaborate with other companies to provide training to their employees.

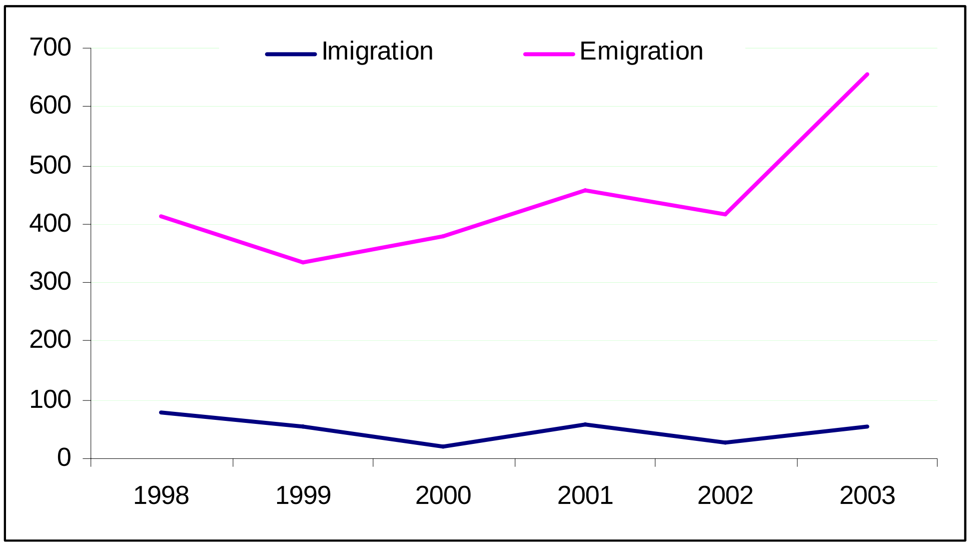
These collaborations occur in different forms, but the most frequently reported was by ad-hoc arrangements with other firms (domestic and international) generally designed to attain specific customer requirements. The two exceptions that were not engaged in collaborative training programmes asserted that they would find it useful if such collaborative programmes were available. Scarce specialised personnel and other aerospace-related resources (such as adequate installations and equipment/software) make of joint training programmes a very attractive option, particularly for the growing base of smaller low-tiers.

Social factors affecting the supply of skills

Migration of skilled professionals

In South Africa, the problem of shortage of high skills has generally been associated to the extensive emigration, or "brain drain". Official figures published by Statistics South Africa are summarised in figure 3.7. These figures confirm the growing pace in the emigration of 'engineers and related technologists', while the immigration of skilled engineers has clearly declined from 1998 to 2003. In 2003, over 600 engineers reported to have left the country although studies suggest that unofficial figures could be much higher.

Figure 3.7: Immigration and emigration of engineers and related technologists: 1998-2003[42]



Source: Statistics South Africa, Tourism and Migration, Data Series PO351.

HIV AIDS

The HIV/AIDS pandemic is a cross cutting issue affecting all sectors. Estimates have suggested that some companies in the South African manufacturing sector already have an HIV positive rate of between 20% and 40% of the skilled workforce (MERSETA, 2005).

At the same time, studies have suggested lower incidence and prevalence of HIV/AIDS in managerial occupations, higher-skilled workers, and people with tertiary education (HSRC, 2002, Evian et al, 2001). Given the occupational and skills profile of the aerospace industry, one would expect a lower prevalence of

[42] In 2004 Statistics South Africa stopped collecting and publishing emigration figures. Emigration trends can therefore not be traced beyond 2003.

HIV/AIDS in comparison to other sectors. However, up to date figures on the prevalence of HIV/AIDS in the aerospace industry are not available.

Personal interviews revealed that Occupational Health and Safety (OHS) Training is considered by most aerospace companies as central for the next 5 years. MERSETA (2005) also recognizes that there will be a need for intensified education and awareness and in addition focused skills development interventions to replace lost skills.

CHAPTER FOUR: SCARCE AND CRITICAL SKILLS

Scarce and critical skills are defined as an absolute or relative demand, current or in future, for skilled and experienced people to fill particular occupations or in the labour market (Skills Portal, SA). Scarce skills refer to those occupations in which there is a scarcity of qualified and experienced people – current or anticipated. Critical skills refer to particular capabilities needed within an occupation (DoL, 2007).

Despite the emergence of scarce and critical skills as a major issue in the most recent policy agenda, their identification is much needed in the context of the South African aerospace industry. An attempt to conduct a critical skills survey took place in 2006 by DTI, with the purpose of identifying skills areas and occupations that are in short supply. This attempt resulted in only one respondent from the aerospace sector.

The data available for determining skills shortages and critical skills is very poor in the aerospace sector. Industrial associations, relevant government departments and related SETAs need to address information gathering amongst the organizations in this industry.

Scarce skills identification

Personal interviews revealed that companies in the South African aerospace industry share similar constraints in terms of skills. In general most companies reported an expected increasing number of employees in upcoming years[43]. The number of orders in the industry is clearly growing, and interviewed companies generally expressed their lack of personnel to attend current and future customer demands – given the length of aerospace contracts, orders are extended over time, therefore unavailable skilled personnel affects their ability to deliver in the future and limits their capacity to take new orders.

Companies were asked to describe their major constraints to reduce costs and improve quality. Four out of seven companies rated the lack of manpower and the quality of skills as their major constraint for competitiveness.

Table 4.1 presents the identified groups and sub-groups of skilled labour force mentioned by the companies, as well as the qualification required to perform these jobs.

[43] For example Aerosud forecasted an increase of about 50% of total number of employees during the next financial year.

In general the shortage of engineers was highlighted in all cases. Technical skills are in high demand in the South African aerospace industry. The urgency of companies' requirement of engineers is commonly translated in a limitation to take orders and fulfil their customers' demands. Mechanical, aerospace, electronic, design and logistic engineers were the most mentioned specialities.

Additionally, the lack of logistic engineers seems to affect most aircraft manufacturers. Logistics in aerospace manufacturing is a key area since the lifespan of a product can be of 30-40 years. Logistics includes the maintenance of the product through that long period of time, and requires very specific technical skills. Given the increasing responsibility being assigned to lower-tier manufacturers in the global industry (as mentioned in previous chapters), together with the low number of logistic engineers in South Africa, this field seem to be a key scarce occupation in the industry. In addition, five out of seven companies reported that their expected future demand of skilled workforce will be also for airframe artisans, plant operators and assemblers.

Table 4.1: Identified scarce skills in South African aerospace manufacturing

Group	**Sub-group**
Engineers	▪ Mechanical Engineers ▪ Aerospace Engineers ▪ Electronic Engineers ▪ Design Engineers ▪ Logistic engineers
Artisans	▪ Machine ▪ Sheet metal ▪ Assembly ▪ Composite
Computer skilled/Software developers	▪ Computer aided design packages

Source: personal interviews

These scarce skills are related to the processes and procedures that the first-tiers (such as Airbus, Boeing, etc) require from South African lower-tier aerospace manufacturers. Aerospace domestic firms seem to be adjusting to its new role in the global value chains as low-tier manufacturers and managing to attract a considerable share of orders of aerospace sub-systems. However, their capacity to compete and expand is largely limited by the quantity and quality of the available engineering base as well as at the intermediate level of artisans and composite specialists.

Trade and Industry Minister Mandisi Mpahlwa recently announced that the National Skills Fund (NSF) has allocated R300 million to support the development of the 22 scarce skill, priority artisan trades (Skills Portal SA, August 2007)

Critical skills identification

Personal interviews revealed that critical skills are generally the result of insufficient training prior to entry into the work place, technological changes, and recent regulatory changes relating to the identification of engineering work.

In our interviews, companies were asked to rate the provision of skilled personnel by local universities and technikons. On average, companies considered the quality of the supplied skilled personnel as moderately good (rated as 3 in a scale from 1 to 5). However, many weaknesses were also identified. The most common were:

- Lack of understanding of job specifications
- Lack of innovation capabilities
- Lack of adaptation to markets changes
- Lack of practical skills
- Lack of business skills
- Lack of soft skills

There was widespread concern in the need to expose skilled personnel to the market place during their period of tertiary education and the initiation of their work life. Internships, vacation work for engineering students, mentorship programmes and bursaries inclusive of training in the company, were identified as the most successful ways to ensure the readiness of the personnel and their loyalty to the company.

Critical skills listed by employers included:

(a) For management staff: financial skills, leadership skills, communication skills, human resources management, performance management, project management.

(b) For production workers: computer skills, engineering design, quality assurance, project management, soft skills.

Specialized technical skills and engineering design were identified as critical for production workers in aerospace manufacturing. However, soft skills and project management were the most important critical skills in the sector as these skills are required across all occupational groups.

CHAPTER FIVE: CHALLENGES, OPPORTUNITIES AND POLICY RECOMMENDATIONS

This report highlights a number of challenges and opportunities of the South African aerospace industry. This chapter summarises them to conclude with some policy recommendations.

Challenges

Some of the challenges for the South African aerospace sector pointed in throughout this report include:

1. The changing nature of aerospace manufacturing. Major changes in global production chains are increasingly demanding higher technological capabilities from lower-tier suppliers, such as South Africa.

2. The second challenge is the related to the ability of domestic aerospace companies to adapt to the new terms of global competition. During the years of isolation, South Africa developed capabilities as a first-tier supplier. However, the current survival of the industry depends on its ability to respond to competitive challenges as a supplier of parts and components along with the survival of exiting capabilities at the first-tier level. An associated challenge is related to the industry's aptitude to upgrade the manufacturing capabilities of lower-tier suppliers.

3. The integration of aerospace manufacturing into domestic supply value chains remains a big challenge. Recent initiatives have recognized the potential benefits of exploiting South Africa's existing advantages in green composites, advanced materials and the tooling industry, which are key suppliers to aerospace. However, technological capabilities in these sectors still remain insufficient while most of the production is exported instead of incorporated into domestic advanced manufactures.

4. The next challenge is related to the complex nature of aerospace and its traditional connection to the state. Creating an adequate regulatory environment for aerospace requires coordination efforts among several departments, such as the Department of Trade and Industry, the Department of Defence and the Department of Science and Technology. Close collaboration between government, industry, academia and research institutions has been recently recognized as a key element to improve the industry's competitiveness.

5. Challenges in the competitive environment also relate to the changing nature of work. South Africa's current aerospace strategy is largely based on the development of strategic partnerships with foreign organizations. Developing these niche markets requires conforming strict quality standards and a workforce with very specialized skills. Technicians and artisans are in increasing demand. One of the main challenges for aerospace companies is their ability to compete and expand their production and increase global competitiveness under the severe shortage of technical personnel.

6. Another challenge relates to the quality of the supply of skilled personnel. Confirming the general view of the companies interviewed, low pass rates in FET and HET suggest that the quality of education in technical subjects has deteriorated during the last decade. This aggravates the ability of aerospace manufacturers to maintain competitiveness.

7. In addition, formal training in aerospace is very limited in South Africa. Aerospace companies obtain a large part of their training from their international customers. One common practice involves sending technicians and engineering staff abroad. Given the scarcity of trained aerospace personnel, high training expenses threaten the financial sustainability of firms, for the growing base of aerospace-related SMMEs.

8. Another challenge relates to the persistence of social factors affecting the supply of technicians and engineers, such as migration and HIV/AIDS.

9. Structural problems are reflected in persistent inequalities in terms of the demand and supply of technical personnel and engineers, which remain dominated by white males. Non-white people, women and youth remain marginalised. The correction of these imbalances seems crucial for the industry's long term sustainability.

10. The tenth challenge is to ensure that objectives in aerospace are achieved in line with key economic policies of government such as in reducing unemployment and eradicating poverty. Alignment with these core development goals remains an indispensable condition to realize a sustainable aerospace industry in South Africa.

11. Last but not least, a major challenge lack of consistent and comparable data for the aerospace industry in South Africa. The preparation of this report revealed that despite the great interest that aerospace has achieved in the policy arena, there is an urgency to quantify and measure the actual size as well as the social and economic impact of aerospace activities.

Strengths and opportunities

Based on the evidence provided in previous chapters, major identified strengths and opportunities for the South African aerospace sector are:

1. South Africa is one of the few developing countries that have managed to develop capabilities in aerospace manufacturing. Changes in global production chains offers significant opportunities to South Africa as a global supplier. The promotion and upgrade of aerospace capabilities can contribute to tackle the brain drain of skilled people and the preserve the country's technological base.

2. Rapid growth in air traffic and civil airlines, are raising the favourable prospects of an increasing aerospace demand in emerging economies. This provides incentives for domestic aerospace manufacturers to upgrade their production and eventually become first-tier producers. The demand for regional aircraft in Africa is expected to grow in the near future and South Africa is well positioned for easy market access not only to Southern Africa but also the rest of the continent.

3. South Africa can also benefit from collaboration with other developing countries, such as India and Brazil, to cultivate their complementary niches in aerospace as global low-tier suppliers to developed economies (such as the IBSA initiative).

4. South Africa's wealth in raw materials, combined with considerable capabilities in advanced industries like automotive and ICTs, indicate that aerospace is well position to maintaining a domestic supplier base of high-quality and competitive prices. Sectors such as composite materials and the tooling industry have the potential to unlock the developmental opportunities of the aerospace manufacturing. In particular, advances in green composites could create supply-chain linkages between rural enterprises and aerospace domestic and international firms through innovation and technology development.

5. New initiatives have recognized the benefits from reorganizing the aerospace industry in South Africa and the need for synchronised efforts from various local actors. Integration of supply chains, strengthening strategic partnerships and skills development are at the centre of recent initiatives. However, it is still early to see the results.

Policy recommendations

Based on the analysis presented throughout this report, this section formulates some recommendations to consider. It is important to note that these recommendations are based on the relatively limited evidence available for the aerospace industry and the general views expressed during our interviews with aerospace companies.

1. There is a clear need to improve the education and training systems affecting aerospace manufacturing. Interventions leading to an increase in matriculations on Science and Maths at the school level could to increase the number of students that qualify for Engineering in tertiary education.

2. Careers in Science, Engineering and Technology need to be promoted and made attractive for young generations. Education departments need to motivate and raise interest in engineering, especially in previously disadvantaged communities and females. For the aerospace sector, the renewal of engineers and technologists in professional occupations appears critical.

3. Aerospace companies seem to struggle to compete and expand due to the lack of available skilled workforce. Declining levels of immigration of technical and engineering personnel can be tackled by facilitating the employment of international labour when skills are not available locally.

4. The mobility of skilled employees should be promoted and facilitated. Offering bursaries, learnerships and training programmes without obligations towards the place of employment could contribute to make careers opportunities in aerospace more attractive.

5. This report highlights the intensive training efforts in aerospace companies. The shortage of available accredited training providers in South Africa needs to be addressed. Interventions should promote the development of training networks to ensure the survival and growth of aerospace firms, particularly SMMEs.

6. There is a clear need to promote downstream linkages of aerospace with domestic sectors. Networking and collaboration among industries needs to be encouraged. This includes the promotion of collaborative R&D between aerospace and key suppliers such as composites materials.

7. Encouragement of new emerging initiatives that facilitate the development of strategic partnerships with global leading companies, such as NACoE and the A400M programme. It is important that these initiatives ensure that national engineering capabilities benefit from these partnerships.

8. There is a need to engage a variety of actors and organizations related to aerospace in South Africa in the development of a detail database of the domestic aerospace sector. Detailed, updated and comparable information on the sector is crucial to: (1) analyze the impact of aerospace in relation to key economic indictors, (2) benchmark the performance of the sector in a global context, (3) evaluate recently implemented initiatives and (4) formulate future interventions in relation to specific targets.

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