CHAPTER 3

# Aerospace

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## The nature of the aerospace industry

Aerospace is a very diverse industry, with a multitude of commercial, industrial and military applications. In South Africa, aerospace activities include those surrounding defence, civilian aviation, aeronautics and space. To be consistent with other existent 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' (Hatty 2000, cited in AMTS 2004: 4). This definition focuses on manufacturing activities and excludes the operation of domestic and international aircraft or ground/flight crew, attendants and catering.

Aerospace manufacturers can be broken down into several categories according to the level of complexity of the final product. These categories are commonly referred to as 'tiers': the top tiers include tiers one and two, while the lower tiers or suppliers include tiers three to five.[1]

1 Tier one refers to organisations producing an entire aircraft with all the sub-systems already fully integrated (for example, the Rooivalk helicopter). First-tiers are also known as airframers.
2 Tier two produces major sub-systems that are made up of a significant number of sub-systems. Examples include main airframe sections such as the wing, undercarriage and complete avionics systems.
3 Tier three produces minor sub-systems. These are components that are indivisible into other systems. Examples are gearboxes, navigation systems and computer systems.
4 Tier four produces components. These are devices with a clear function that have no use unless integrated into a tier-three system. Examples are electrical circuit boards, machined engine parts, valves and pumps.
5 Tier five produces parts. These are units that can be defined as a single monolithic part. Examples include unmachined castings, shafts, rivets and electrical components.

Each of these categories can be associated with different value added and different skills requirements. These are summarised in Table 3.1.

South Africa has developed considerable capabilities and set up local companies in most of these categories, and has achieved the ability to design and manufacture tier-one complete systems, as well as

1 Details on this classification can be found in AMTS 2004.

**TABLE 3.1:** *Aerospace manufactures, associated value added and level of skills*

| | Value added products | Level of skills |
|---|---|---|
| Top tiers or first tiers | | |
| Tier one (complete system) | high | high level of human resources |
| Tier two (major sub-systems) | medium | medium level of human resources + production skills |
| Lower tiers or sub-tiers | | |
| Tier three (minor sub-systems) | medium | medium level of human resources + production skills |
| Tier four (components) | medium | medium level of human resources + production skills |
| Tier five (parts) | low | medium level of human resources |

Source: Adapted from AMTS 2004



lower-tier products such as parts and components. Based on these categories, this chapter examines the opportunities that exist within the South African aerospace industry and the potential to improve the industry's integration into global and local supply chains.

The aerospace industry is peculiar in several respects. The complexity of production, its intensity in regard to technology and capital, and the high risks involved in new product development have traditionally linked the industry to strong government support. The sector has been generally associated with national security and defence objectives, although aerospace technologies have also been used for commercial purposes. The aerospace industry can be 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 commonly regarded as a strategic sector. Nevertheless, not many nations have managed to develop substantial aerospace industries.[2]

According to Statistics South Africa (Stats SA), the Industry Code 386 ('manufacture of aircraft and spacecraft') represents the core of aerospace manufacturing activities for both civil and military purposes, and most of the analysis in this chapter is based on information available for this sub-sector.[3] However, it is important to note that 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 permit extraction of figures for aerospace activities across other sub-sectors.

2 A recent AMD study (AMD & Vuxaka 2006) states that only 19 countries in the world have achieved substantial domestic defence industries. Note that the aerospace and defence industries are closely entangled.

3 Full details of the Standard Industrial Classification (SIC) system are available at http://www.statssa.gov.za/additional_services/siccoder/siccoder.htm.

## Profile of the aerospace sector in South Africa

The origin of the aerospace industry in South Africa cannot be separated from the history of its defence industry, and is related to what has been named by some authors as the 'military-industrial complex' (MIC)[4] or the 'South African Defence-Related Industries' (SADRI).[5] 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. During this period South Africa's aerospace industry expanded and became a first-tier manufacturer, producing complete systems such as the Cheetah fighter, a combat aircraft.

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 (Dunne 2006). Later exposure to international markets revealed the urgent need to formulate sustainable competitive alternatives to maintain the existing South African aerospace capabilities.

### Key facts and figures of South African aerospace

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. Lack of available and consistent data collection is a major constraint on an adequate assessment of the sector and ultimately, on policy formulation. This section provides a compilation of existing material on the South African aerospace industry from available sources,[6] placing domestic facts and figures in an international context.

#### Size and shape of the aerospace sector

Various sources suggest that there are currently between 100 and 200 domestic organisations engaged in aerospace activities in South Africa. Aerospace companies mainly operate in Gauteng province, while a smaller hub is based in the Western Cape, connected to the University of Stellenbosch.

The sector is highly concentrated in a few very large organisations, although the segment consisting of small, medium and micro enterprises (SMMEs) is rapidly growing and has been recently estimated to comprise about 75 per cent of the organisations.[7] 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).

Figures on total revenue for the industry also vary depending on the source. An AMD study (AMD & Vuxaka 2006) estimated that the SADRI had total revenues of about R9.6 billion in 2005, which represented a contribution of 0.56 per cent to total GDP and 3.42 per cent of manufacturing GDP. However, a USA report on the South African aerospace industry[8] suggests that the market size for aerospace

4 Goldstein (2002: 522) states that aerospace differs from other components of the MIC in that the scope for diversification into civilian uses is greater.
5 As referred to in the AMD *SADRI Study* (AMD & Vuxaka 2006).
6 Data on employment were obtained from the Labour Force Survey (LFS) (Quantec 2007), and the Department of Trade and Industry (DTI) compiles detailed figures on exports and imports (DTI 2003–2006). Other information on various aspects of the sector has been extracted from international and national papers and reports. Additionally, personal communication with relevant institutions in the sector (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)) contributed to drawing the present profile of the sector.
7 *Business Report*, Aerospace industry gets threefold boost, 28 August 2007.
8 See US Commercial Service 2004.

alone (excluding defence) in 2003 was R8.5 billion,[9] with an estimated annual projected growth rate of approximately 5 per cent until 2007.

The AMD study also revealed that about 90 per cent of total sales in the domestic market are still of a military nature, in contrast to less than 10 per cent in civilian sales. However, the study detected a significant increase in the share of civilian sales in exports, which moved up from about 1 per cent to nearly 20 per cent of the total exports in the past decade. Despite the marginal shift towards civilian sales in exports, overall sales are still clearly dominated by the military sector, which accounts for about 95 per cent of total turnover.[10]

According to the Labour Force Survey (LFS) , the sub-sector 'manufacture of aircraft and spacecraft' employed approximately 1 500 people in 2005, contributing about 0.14 per cent of total employment in the manufacturing sector (Quantec 2007). However, this figure does not account for aerospace employment classified within other sub-sectors such as 'weapons and ammunition' and 'special-purpose machinery'.

## Trade dynamics

The South African aerospace industry has traditionally been reliant on imports. However, following the lifting of the UN embargo in 1994, exports of aerospace and defence-related products accelerated. Opening up to international markets put pressure on domestic companies to revise their business strategies.

The latest available data from the Department of Trade and Industry (DTI) trade database, summarised in Table 3.2, reflect the recent shift in trade dynamics (DTI 2003–2006). From 2003 to 2006 exports grew exponentially, at an average annual rate of nearly 50 per cent, while imports decreased at about 13 per cent annually. The decline of imports and acceleration of exports gained momentum in 2005.

Not only has the direction of trade changed but also the origin and destination of aerospace manufactures. DTI data also show that imports have experienced a growing concentration in the USA, accounting for 51 per cent of total South African imports of aerospace products in 2006 (DTI 2006). This has been accompanied by a considerable reduction in the role of France as a major supplier (imports from France dropped from 48 per cent of total imports in 2003 to 6.4 per cent in 2006). Meanwhile, export markets have followed the opposite trend, becoming more diversified. From exporting mostly to the USA in 2003, South Africa broadened its exports in 2006 to include the EU (France, Germany and Sweden) and other sub-Saharan countries (Angola, Zambia and Kenya).

**TABLE 3.2:** *Trade in aircraft, spacecraft and parts (R millions), 2003–2006*

| | R Millions | | | | Average annual growth rate (%) |
|---|---|---|---|---|---|
| Trade | 2003 | 2004 | 2005 | 2006 | |
| Exports | 796 | 1 210 | 4 254 | 4 018 | 49.9 |
| Imports | 9 336 | 11 806 | 9 510 | 5 379 | −12.8 |

Source: Based on DTI 2003–2006

9 These latter figures were based on unofficial estimates obtained from industry sources.
10 Note that in more developed aerospace markets, such as the UK, turnover is equally shared by defence and civil sides, each representing 50 per cent of turnover (UK House of Commons Trade & Industry Committee 2005).

## Upstream and downstream linkages

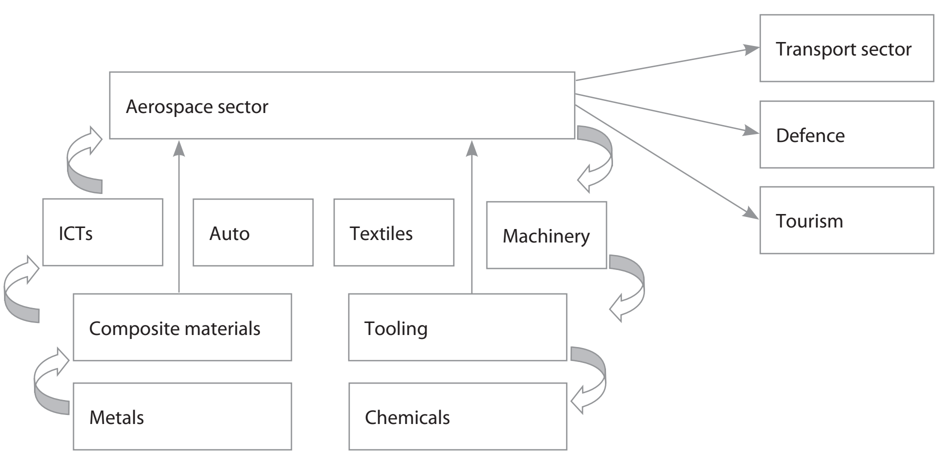
The overall impact of the aerospace industry must be considered in connection to other productive activities. Efficient aerospace production requires not only the obvious elements of adequate infrastructure and skilled labour force, but also access to basic aircraft production inputs such as aluminium, 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: the mining sector, composite materials, tooling, machinery, automotive, ICTs and textiles.

Upstream and downstream linkages of aerospace are represented in Figure 3.1. The figure shows that the aerospace industry is linked to more 'representative' industries – in terms of socio-economic impact in South Africa – such as metals and chemicals, which are also key suppliers to the composite materials and tooling industries. These latter sectors are suppliers not only to more advanced manufacturing sectors such as the automotive, electronics and machinery sectors, but also directly to aerospace.

Although the previous section highlighted the growing export orientation of South African aerospace manufactures, some products are still consumed domestically. Major domestic clients include the transport sector (the national carrier, South African Airways) and the defence sector (the South African National Defence Force (SANDF)). Smaller, low-cost airlines are also exploiting the fast-growing tourism sector, and are expanding their routes and fleets.

South Africa's wealth in raw materials, combined with considerable capabilities in advanced industries like automotive and ICTs, suggests that the aerospace industry is well positioned to maintain a domestic supplier base of high quality and competitive prices. There is a large potential to exploit existing advantages in composites, advanced materials and the tooling industry, which complements the country's strength in more traditional sectors such as the mining sector and the metal industry. However, locally manufactured products in less technologically advanced industries that could supply the domestic aerospace production industry have become export commodities.[11]

**FIGURE 3.1:** *Aerospace industry's domestic linkages to other economic sectors in South Africa*




11 *Engineering News* gives the example of a specific reproduction material used for construction, tooling, coating and modelling which is mainly exported; while approximately 60 per cent of the raw materials are sourced in South Africa; see Heydenreych A, Opportunities emerge in aerospace, marine sectors, *Engineering News* 9 June 2006.

In summary, the strength of upstream linkages of aerospace activities with the defence, transport and tourism sectors is not matched by its downstream linkages. Integration of the aerospace industry within domestic value chains seems central to its long-term competitiveness.

### Innovation and technology dynamics

Aerospace activities require enormous efforts to be expended on R&D (AMTS 2004). Therefore the sector is widely regarded as 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, it is clear that the benefits from technological innovation and R&D in aerospace are not confined solely to the industry itself.

However, in South Africa, the aerospace sector has developed in isolation not only from global markets but also from the domestic economy as a result of strategic funding used for military purposes. Nevertheless, some researchers have already pointed to the increasing 'technological openness' of South African aerospace. For example, an AMD study asserts that 'the South African Defence and Related Industry (SADRI) has matured from a "technology colony" through backward industrial integration' (AMD & Vuxaka 2006).



A study by the 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 South Africa's competitive strengths in composite materials and in health and usage monitoring systems (HUMS) technologies place it in a strong position to further develop these technologies and become a leading global player in the aerospace industry.

In particular, high-performance composites are used extensively in commercial liners by Airbus and Boeing (two first-tier global leaders) and their demand is increasing on a global scale. In 2005, the composite industry in South Africa employed about 12 000 people (Hanekom 2007). Efforts are currently being devoted to research in composite metal hybrids, nanocomposites and 'green composites'. Regarding the latter, advances in the development of green composites could have a significant impact in the agricultural sector. They have been recognised as a potential way of adding value to natural resources and creating rural employment, by growing and sustaining plantations of natural organic composites, such as hemp and flax, thereby benefiting disadvantaged groups and displaced communities.[12] Again, the widespread benefits of intense innovation and technology development in the aerospace sector seem largely dependent on the success of its integration into international markets, but equally important is its creative integration within domestic value chains. It is, however, essential that integration of the industry is entirely committed and subordinated to the country's primary goals of poverty alleviation and sustainable development.

## Drivers of change in the aerospace sector

Changes in the sector are driven by multiple factors. Dramatic changes in global production chains are creating new opportunities for, and threats to, domestic aerospace companies. At the national level, new policy initiatives and emerging market opportunities also influence the direction the industry is taking. At the manufacturing level, technology intensity and innovation dynamics in the sector open new avenues of competition and production.

12 Naidoo B, SA composites industry needs R&D, says research council, *Engineering News* 8 June 2007.

## Global changes in production

The landscape and dynamics of aerospace companies are characterised by rapid transformation. Aerospace and defence industries have experienced a decade of intense consolidation, particularly at the level of top-tier manufacturers in the USA and the EU. At the same time, liberalisation and privatisation are altering the relationships between the top-tier aerospace giants and their lower-tier suppliers.

Global decline in defence budgets and increasing privatisation of aerospace companies have provided greater room for the expansion of civil aviation. The exponential growth of low-cost airlines all over the world continues to increase purchases of aircraft. These forces are pressurising first-tiers to reduce their manufacturing costs.

These dynamics affect South African domestic aerospace companies in two ways. Firstly, first-tiers are increasingly outsourcing globally to lower-cost sites, which has clear implications for the handful of emerging economies that have managed to develop significant aerospace capabilities, such as India, Brazil, China and South Africa. Secondly, to reduce costs, first-tiers are concentrating on core capabilities and placing more design, manufacturing, risk-sharing and supply-chain management responsibilities on lower-tier suppliers (*Avionics* 2006).

In summary, global changes in production are generating large opportunities for the few developing countries that can supply aerospace products, as low-cost offshore locations. However, it is becoming increasingly difficult to survive at the lower-tier level. The ability of these countries to maintain the rapidly increasing sophistication of international demands in this technology-intensive industry has been questioned (De Bruijn & Steenhuis 2004). South African aerospace companies must multiply their efforts in order to adapt to the new terms of competition, with updated skills and technological capabilities.

## New policy initiatives and key programmes under way

South Africa's government has identified aerospace as a national high-priority sector. Its vision is to develop the sector as a sustainable, growing, and internationally recognised industry by 2014 (AMTS 2004). To achieve this goal, the growth trajectory of the sector has been modelled on the successful experience of the automotive sector (SAIIA 2006). Aerospace has been recognised as both technology-driven and a labour-intensive sector, able to provide technically oriented jobs that can contribute to tackling the brain drain of skilled people. However, an overall strategy for the sector is still in progress.

Recent policy programmes reflect this vision and are oriented to different areas, although the majority of policy interventions appear to be driven by the need to fill an obvious skills gap. Most initiatives have only been operative for a few years; therefore, it is still too early to perceive their impact.

Skills-related initiatives include: (i) the European South Africa Science and Technology Advancement Programme (ESASTAP) that promotes and supports networking and partnering between scientists and institutions from the EU and South Africa; and (ii) the National Aerospace Centre of Excellence (NACoE) established in 2005. The NACoE offers skills programmes and bursary schemes with major domestic companies. It has also entered into R&D partnerships involving major global players, local universities and domestic companies.

Manufacturing-related initiatives include: (i) the Airbus A400M programme agreement, signed in 2005, whereby major domestic aerospace players became risk-sharing partners in the international manufacture of an Airbus military aircraft. So far, the A400M programme seems to have had mixed results; some companies seem to have benefited in terms of engineering capabilities, while other companies have suggested that the engineering work involved is not significant; (ii) the Aerospace Industry Support Initiative (AISI), which was established in 2006. Its most significant planned intervention will be the Centurion Aerospace Village (CAV) scheduled to open in 2010, an aerospace supplier park modelled on the automotive industry.

Key programmes under way include the South African Space Agency, which was approved in 2006. The agency is envisaged to be active by 2008 and to co-ordinate and implement the country's space science and technology programmes. In addition, 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.[13]

### Changes in domestic conditions

The rapid growth in domestic civil airlines and the growth of tourism have had a positive impact on the sector and are raising favourable prospects of future aerospace products demand. This provides incentives for domestic aerospace manufacturers to upgrade their manufactures and eventually become first-tier producers. In addition, South Africa is well positioned to easily access new regional markets, not only in southern Africa but also on the rest of the continent. Airbus has estimated that air traffic in Africa will increase by 7 per cent annually from 2006 to 2010 (Airbus 2006).

### Technology and innovation

Manufacturing aircraft and spacecraft is highly technology-intensive. Therefore technology changes have a significant impact on employment and skill requirements in aerospace production. Technological advance promotes the constant upgrading of skills in the workforce for this sector. As mentioned in previous sections, technologies affecting the sector originate both in aerospace and in adjacent sectors such as composite materials, tools and automotive.

# Measuring the skills gap in aerospace manufacturing

This section examines the 'size' of the skills gap in aerospace manufacturing, comparing the demand and supply of skills as well as their changes in composition over time.

## Demand for skills

The design and manufacture of technologically sophisticated products for the aerospace industry require inputs and skills from various types of workers, including managers, technicians, plant operators and assemblers, as well as administrative and support staff. However, overall the aerospace industry has a larger proportion of workers with education beyond high school than the average for all industries.

13 The agenda of the India-Brazil-South Africa (IBSA) working group in this respect can be found in SAIIA 2006.

## Aerospace employment in South Africa

According to the LFS, South Africa's 'manufacture of aircraft and spacecraft' directly employed about 1 500 people in 2005 (Quantec 2007).[14]

This figure reflects the fact that aerospace is not a major contributor to employment in South Africa. On average, the sub-sector 'manufacture of aircraft and spacecraft' represented about 0.15 per cent of total employment in manufacturing for the period 1996–2005.

Available data show that employment in 'manufacture of aircraft and spacecraft' has consistently increased from 2003 to the present. However, growth in labour demand has not taken place homogeneously in terms of occupations, level of skills, age, race and gender. Changes in the composition of demand 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, new employment dynamics at the national level following South Africa's political transition.

Figure 3.2 shows that, contrary to national dynamics,[15] in the aerospace sector employees in elementary occupations accounted for the smallest single share of total employment (3 per cent) in 2001–2005. Compared to the total manufacturing sector, aerospace has three times the proportion of managers and senior officials, and twice the proportion of professionals. The numbers of technicians, clerks, service workers and assemblers are also proportionally higher in the aerospace industry. The proportions of elementary occupations and craft-and-related-trades workers are about six times lower in aerospace than the average in the manufacturing sector.

From a gender and racial perspective, most employees in the sector are male and white. Occupations held by women, and by black (i.e. African, coloured and Indian) employees, are predominantly located at the semi-skilled and unskilled occupational levels. Yet major changes have taken place in 'senior officials and managers' occupations. This category has gone through a rapid transformation during the past decade, with the inclusion of more black, female and intermediate-skilled employees; however, the data also show that this category is rapidly aging (see Table 3.3).

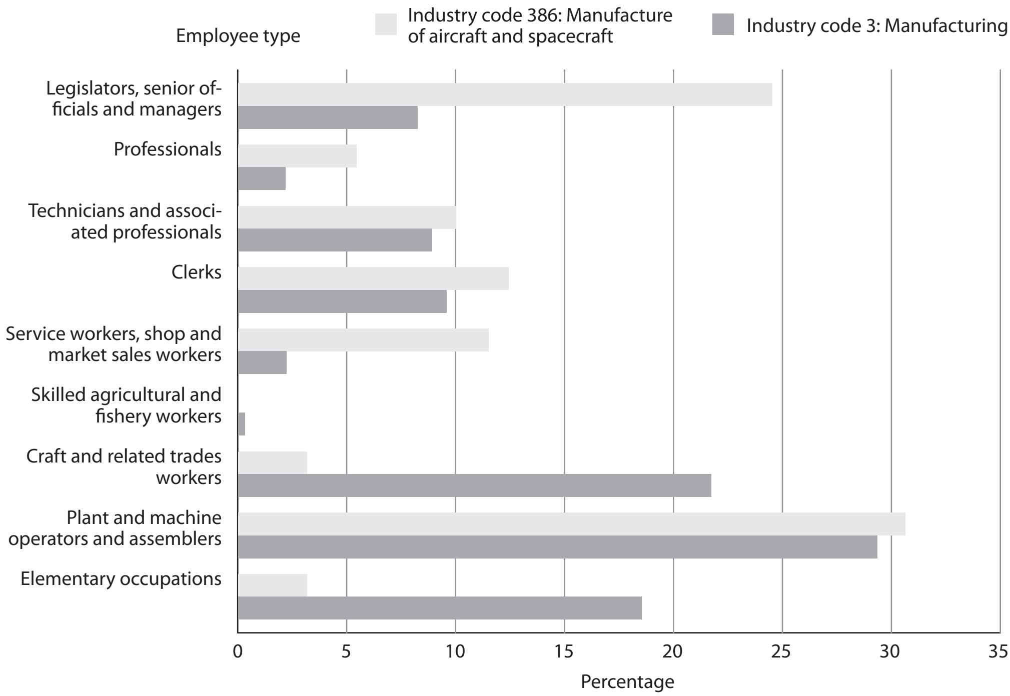
Changes in other occupational categories, particularly those related to technical and advanced manufacturing skills, such as 'professionals' and 'technicians and associated professionals' have been very limited. A critical challenge facing the sector is increasing the participation of non-white, female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

Another interesting feature is presented in Table 3.4. This table shows the rapid growth of the demand for intermediate skills in the aerospace industry. From representing 43 per cent of total aerospace employment in 1996–1999, the intermediate-skilled workforce accounted for nearly 60 per cent in 2001–2005.

14 It must be noted that 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 can be classified as 'weapons and ammunition', which fall into other categories such as 'manufacturing of special purpose machinery'. Current methods of data collection do not allow for extracting the proportion of aerospace-related employment within other sub-sectors. In this report, we suggest that the real figure on aerospace employment is very likely to be higher than 1 500 employees.

15 In 2005, elementary occupations accounted for the largest single share of employment (22.9 per cent) (MERSETA 2006).

**FIGURE 3.2:** *Occupational profile of the aerospace industry relative to the total manufacturing sector, average 2001–2005*




Source: Quantec 2007 (Stats SA OHS data for 1996–1999; Stats SA LFS data for 2000–2005)

**TABLE 3.3:** *Changes in composition of aerospace employment in key occupations, 1996–2005*

| Staff composition | Senior officials & managers (%) | | Professionals (%) | | Technicians & associated professionals (%) | |
|---|---|---|---|---|---|---|
| | 1996–1999 | 2001–2005 | 1996–1999 | 2001–2005 | 1996–1999 | 2001–2005 |
| Black | 0 | 46 | 0 | 0 | 0 | 27 |
| Female | 0 | 23 | 0 | 0 | 0 | 0 |
| Intermediate skills | 0 | 94 | 0 | 0 | 0 | 100 |
| Younger than 50 | 100 | 54 | 0 | 0 | 100 | 100 |

Source: Quantec 2007 (Stats SA LFS data for 2000–2005)

Results also indicate that the demand for skills in the aerospace industry is converging towards the profile of the overall manufacturing sector. In aerospace manufacturing the demand for lower skills is rising, while the demand for high skills is declining. Meanwhile, the overall manufacturing sector is moving up from a low-skill base towards a higher-skilled profile.

**TABLE 3.4:** *Percentage change in skills demand in the aerospace sector and the total manufacturing sector, 1996–2005*

| Skills level | Manufacture of aircraft and spacecraft | | | Total manufacturing | | |
|---|---|---|---|---|---|---|
| | 1996–1999 | 2001–2005 | % change | 1996–1999 | 2001–2005 | % change |
| Low | 29 | 35 | 7 | 65 | 55 | −10 |
| Intermediate | 43 | 58 | 15 | 30 | 39 | 9 |
| High | 28 | 7 | −21 | 3 | 5 | 1 |
| Unknown | 0 | 0 | 0 | 1 | 1 | 0 |
| Total | 100 | 100 | | 100 | 100 | |

Source: Based on Quantec 2007 (Stats SA LFS data for 2000–2005)

## The supply of skills

Any manufacturer of complex machinery requires a pool of available skilled labour. 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, which is competing as a supplier to global leaders through upgrading its aerospace manufactures. Local producers are now required to build products that meet the strictest international standards, and this has direct implications for the education and training systems in South Africa.

### Further and higher education and training

An examination of the availability of further education and training (FET) and higher education and training (HET) graduates with qualifications in the aerospace and engineering fields reveals the poor state of skills supply for aerospace activities. Statistics from the National Learners' Records Database (NLRD) reveal the low number of enrolments in FET courses on aerospace subjects. Moreover, some aerospace-related subjects have been practically deserted during the last decade (DoE 2007b). The NLRD also shows that pass rates have decreased over time, suggesting that the quality of education in technical subjects has deteriorated.

In relation to HET, the total number of graduates in technikons (now called universities of technology) 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 moderate improvements in technikons (from 8 per cent in 2000 to 11 per cent in 2004), they declined in universities from 19 per cent overall in 2000 to just 14 per cent in 2004 (DoE 2007a). The Manufacturing, Engineering and Related Services Sector Education and Training Authority (MERSETA) has suggested that an improved graduation rate is desirable, as insufficient numbers are coming through the system to meet demand from the industry (MERSETA 2006).

Table 3.5 illustrates the pace at which the racial and gender distribution of engineering graduates in HET has evolved. Racial equity achievements are visible at the undergraduate level (from 43 per cent black graduates in 1996–2000 to 60 per cent in 2001–2005), as well as at the postgraduate level (from 20 per cent postgraduates in 1996–2000 to 36 per cent in 2001–2005). However, white postgraduates still represented about two-thirds of the total for 2001–2005. Although female representation at undergraduate level has doubled during the last decade, in 2001–2005, 80 per cent of the undergraduates in

**TABLE 3.5:** *Supply of engineers in HET: percentage of black and female graduates, 1996–2005*

| | Undergraduate | | Postgraduate | |
|---|---|---|---|---|
| | 1996–2000 | 2001–2005 | 1996–2000 | 2001–2005 |
| Black (%) | 43 | 60 | 20 | 36 |
| Female (%) | 10 | 20 | 11 | 15 |

Source: Based on DoE 2007a

engineering were male. In postgraduate studies, advances in gender equity were minimal from 1996 to 2005 (with female postgraduates increasing from 11 per cent to 15 per cent of the total).

## Drivers of change in aerospace skills

This section examines the existing routes for new skills formation in the aerospace sector. It provides a brief description of available training providers, complemented with first-hand information on skills development practices in individual aerospace firms. This information has been collected through personal interviews with a sample of seven aerospace manufacturers[16] and also with the Denel Centre for Learning and Development (DCLD).

### Supply of training

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

### SETAs and domestic training providers

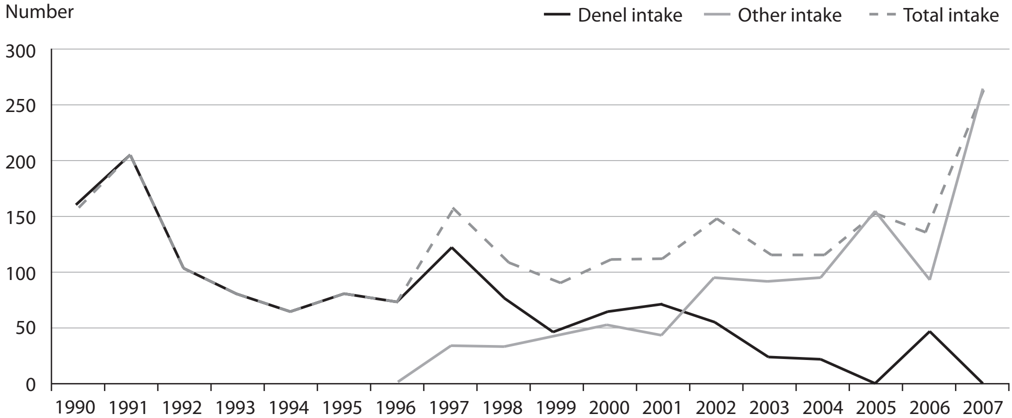
Two SETAs partially service South African aerospace companies: the MERSETA and the Transport Education and Training Authority (TETA). The MERSETA covers a number of manufacturing activities such as automotive, new tyre, plastics, metal and motor manufacturing, but not aerospace manufacturing; while the TETA is responsible for aerospace, but only as a transport service.

All interviewed companies reported that they belonged to either the MERSETA, the TETA or both. Nevertheless, the interviews with these companies revealed the limited use that aerospace manufacturers make of the SETAs. Grants, learnerships, apprenticeships and tax incentives can be accessed from the MERSETA and the TETA to encourage companies to increase their training activities. The SETAs' policy is to reimburse training costs, but only if the trainers are accredited training providers, that is, in possession of a qualification registered with the South African Qualifications Authority (SAQA).

Due to the complexity of aerospace manufacturing, training often cannot be found nationally. In order to fulfil the customers' requirements, aerospace companies tend to send their employees abroad or

16 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 organisations operating in the industry. All interviews were conducted between 10 July and 30 September 2007.

**FIGURE 3.3:** *Intake of apprentices to the DCLD, 1990–2007*




Source: Denel Centre for Learning and Development, personal communication with the author

to un-accredited training programmes. This results in a large pool of unclaimed contributions to the SETAs that remains unused, and an increase in the costs of training for domestic aerospace manufacturers.[17] The effectiveness of the SETAs, in particular for the aerospace industry, has been generally questioned and there have been several calls from industry for a reassessment of their structure.

The DCLD was established in 2002 as a separate entity to Denel. The courses provided by this training centre are accredited by the TETA and the Aerospace Chamber. According to the organisation, the DCLD is the largest public skills development and training programme in Africa for the aerospace and defence industry.

The DCLD services Denel and other national and foreign private companies. Figure 3.3 shows that the intake of apprentices from outside Denel has largely overtaken the intake from Denel since 2002.

The DCLD apprentice school holds over 250 apprenticeships, and runs a Youth Foundation Training Programme in conjunction with the Department of Defence. The majority of intakes in 2007 were African men (40 per cent of total intakes), followed by white men (24 per cent) and African women (22 per cent). Indian and coloured intakes account together for only 14 per cent of the total.

## Training practices in aerospace firms

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

The interviews indicated that the development of skills in the workforce beyond entry level tends to be mostly undertaken by the employers. A large part of the technical and management training takes place in-house, or occasionally in collaboration with private training institutions, customers, other

17 For contract-specific skills training, some of the large aerospace companies have managed to negotiate a refund of a percentage of the training costs at overseas institutions, although they need to be accredited in their respective countries (some companies reported claims of up to 70 per cent of the costs of training). However, not every company is in a position to claim back these expenses.

domestic companies, universities and technikons/universities of technology. 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 and 10 per cent of their sales income to training expenses.

Technical training appears to be the most common form of training, including in-house, overseas and local technical training. Management training, on the other hand, is not a priority in training practices, whether local or overseas. Major international clients play a key 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, which involves sending local technicians overseas. Overall, technicians and associated professionals seem to benefit most from training, as management training is less frequent.

Interviewed companies were asked to identify the two most important *areas of training* for each of the broad occupational categories (see Table 3.6). For managers and supervisors, training in 'soft skills' was the most commonly 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.[18] Project management was also widely regarded as an important area in which to train engineers and technical staff. Other specific technical skills related to particular customer requirements, and were usually obtained on an ad hoc basis. 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 on occupational health and safety.

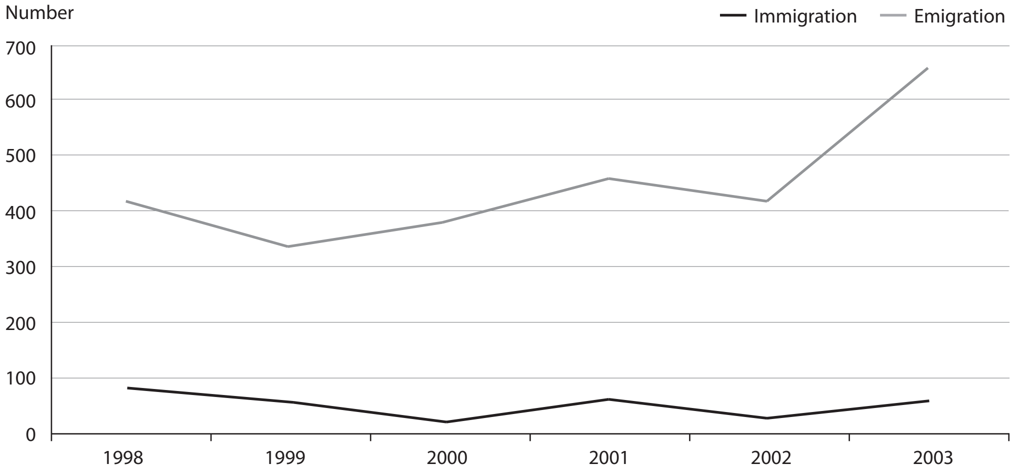
**TABLE 3.6:** *Identified key areas for training*

| Occupation | Most important areas for training |
|---|---|
| Managers/supervisors | soft skills: communication, leadership<br>team-building<br>line management<br>occupational health and safety<br>human resources management<br>financial skills<br>production planning |
| Engineers and technicians | computer skills: programming, application software<br>project and contract management<br>quality assurance<br>production planning<br>logistics and maintenance |
| Production workers/artisans | design training<br>moulding<br>composites training<br>occupational health and safety |

Source: Author interviews with industry participants

18 For example, CATIA is a suite of software products for 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 competence in this technology has been established as a prerequisite for awarding contracts to suppliers. See Tyrer L, Investment in technology key to competitiveness, *Engineering News* 2 June 2006.

**FIGURE 3.4:** *Immigration and emigration of engineers and related technologists, 1998–2003*




Source: Stats SA 2000; 2003

Note: In 2004, Stats SA stopped collecting and publishing emigration figures. Emigration trends can therefore not be traced beyond 2003.

## Socio-economic drivers

Migration and HIV/AIDS are some of the social factors affecting the supply of skilled professionals in South Africa. Emigration trends collected by Stats SA highlight that there is an increasing loss of 'engineers and related technologists', while the immigration of skilled engineers declined during the period 1998–2003 (Stats SA 2000, 2003). These trends are shown in Figure 3.4.

In relation to HIV/AIDS, a lower prevalence would be expected in comparison to other sectors, given the occupational and skills profile of the aerospace industry. However, to date figures on the prevalence of HIV/AIDS in the aerospace industry are not available. Nevertheless, this study found a general recognition amongst employers of the need for intensified education and awareness in relation to health and safety for aerospace workers.

## The skills gap: scarce and critical skills

The number of orders received by the South African aerospace industry is rapidly growing, and companies have indicated that they lack the skilled personnel to attend to current and future customer demands. In general, the shortage of technical personnel, in particular engineers, stands out. Scarce skills in the sector are mainly related to technicians and associated professionals, as well as airframe artisans, plant operators and assemblers. These occupational categories are experiencing growing demand over time, but the rate of formation of these types of workers 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 skills at the intermediate level of artisans and composite specialists.

## Scarce skills

In general, the shortage of engineers was highlighted in all interviews. Technical skills appear to be in high demand in the South African aerospace sector (see Table 3.7). The urgency of companies' need for engineers is commonly translated into a limitation on their ability to accept orders and fulfil their customers' demands. Mechanical, aerospace, electronic, design and logistic engineers were the most frequently mentioned specialities. In addition, five out of seven companies reported that their expected future demand for skilled workforce would also be for airframe artisans, plant operators and assemblers.

These scarce skills are generally related to the processes and procedures that the first-tiers require from South African suppliers. Domestic aerospace firms seem to be adjusting to their new role in global value chains 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 by limitations at the intermediate level of artisans and composite specialists.

## Critical skills

Interviews conducted for this study revealed that critical skills are generally the result of insufficient training prior to entry into the workplace, technological changes, and recent regulatory changes in the identification of engineering work.

In the 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 on a scale of 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.

**TABLE 3.7:** *Identified scarce skills in South African aerospace manufacturing*

| Group | Sub-group |
|---|---|
| Engineers | mechanical engineers<br>aerospace engineers<br>electronic engineers<br>design engineers<br>logistic engineers |
| Artisans | machine<br>sheet metal<br>assembly<br>composite |
| Computer-skilled/software developers | computer-aided design packages |

Source: Author interviews with industry participants

There was widespread concern about the need to expose skilled personnel to the marketplace during their period of tertiary education and the initiation of their working 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:

- for management staff: financial skills, leadership skills, communication skills, human resources management, performance management, project management;
- for production workers: computer skills, engineering design, quality assurance, project management, soft skills.

Specialised 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 they cut across all occupational groups.

## Conclusions and policy recommendations

South Africa is one of the few developing countries that have managed to develop capabilities in aerospace manufacturing. Changes in global production chains are bringing new opportunities and challenges to South Africa as a global aerospace supplier. Likewise, rapid growth in air traffic and civil airlines raises the favourable prospect of increasing aerospace industry demand. The number of orders in the industry is clearly growing, mostly in connection to major global players such as Boeing or Airbus.

However, these changes are also demanding higher capabilities from South African aerospace manufacturers. The growth of global outsourcing causes growing competition among low-cost sites in other emerging economies such as China, India and Brazil. Domestic companies need to respond to new challenges through upgrading their manufacturing capabilities as international suppliers. In achieving this goal, the integration of aerospace manufacturing into international and domestic supply value chains still remains a major challenge. South Africa's existing advantages in green composites, advanced materials and the tooling industry (which are key major suppliers to aerospace) remain unexploited. Most of the production in these sectors is exported instead of being incorporated into domestic advanced manufactures.

Technicians and artisans are in increasing demand, and shortages of these skills are constraining the capacity of domestic firms to expand their production and survive. Simultaneously, the quality of the supply of skilled personnel seems to have deteriorated during the last decade, reducing the ability of local aerospace manufacturers to maintain competitiveness.

The formation of new skills also appears to be limited, with domestic companies bearing a large fraction of the costs of training. Interviews with industry participants emphasised the severe skills constraints faced by South African aerospace manufacturers. Skills shortages are evident in terms of both overall skills to maintain current production, and also specific skills to be able to confront future changes in demand and markets. Accredited training providers seem to be scarce, while high training expenses threaten the sustainability of firms, particularly the growing base of aerospace-related SMMEs.

Structural problems in the composition of the skills base are reflected in persistent inequalities in terms of the demand and supply of technical personnel and engineers, which remain dominated by white men. Black, female and young employees remain marginalised. The correction of these imbalances seems crucial for the industry's long-term sustainability. The persistence of social factors affecting the supply of technicians and engineers, such as migration and HIV/AIDS, also threatens existing skills shortages. In conclusion, it is essential to ensure that objectives in aerospace are achieved, in line with key economic policies of government, such as reducing unemployment and eradicating poverty.

### Policy recommendations

Effectively addressing the existing skills gap in aerospace manufacturing requires the design of a sustainable and broad strategy for the sector, in connection to adjacent domestic industries. The formulation of interventions needs to be grounded in detailed, updated and comparable information on aerospace activities. Such information is still lacking in South Africa.

Shortages of technical skills emerge in this chapter as a central concern. Careers in science, engineering and technology need to be promoted and made attractive for the young generation, especially in previously disadvantaged communities and among women. In the shorter term, firms' capacity to compete and expand can be tackled by facilitating the employment of international labour when skills are not available locally.

The development of skills beyond entry-level training at the workplace is considered critical to maintaining current competitiveness in the sector. Training was recognised as central to production activities in all the companies interviewed. The shortage of available accredited training providers in South Africa requires urgent attention. Interventions should also promote the development of training networks as well as improve mobility of skilled employees across aerospace firms.

Creating an adequate regulatory environment for aerospace activities requires co-ordination efforts among several departments, such as the DTI, the Department of Defence and the Department of Science and Technology. New initiatives have recognised the benefits that will result from reorganisation of the aerospace industry in South Africa, and the need for synchronised efforts on the part of various local actors, including industry, government and educational organisations. Integration of supply chains, strengthening of strategic partnerships and skills development are at the centre of recent initiatives. However, it is still too early to feel their impact.

Last but not least, objectives in aerospace need to be formulated in line with key economic policies of government, such as reducing unemployment and eradicating poverty. Alignment with these core development goals remains an indispensable condition for realising a sustainable aerospace industry in South Africa.



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