NSI interactions between government and industry: The case of the South African aerospace industry.

NSI Interactions between government and industry: The Case of the South African Aerospace Industry.

By

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Declaration

I declare that this mini-dissertation for the qualification Magister Technologiae: Comparative Local Development at the Tshwane University of Technology is my own original work, that it has never been submitted before for any degree or examination in any other institution of higher learning, and that all the sources I have utilised or quoted have been indicated and acknowledged as references.

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PD Mokumo

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Abstract

The aerospace industry refers to the research and development, design, production, support, maintenance, conversion and advancement of rotary and fixed wing aircraft, satellites, satellite launch and tracking systems, air traffic control and management systems, unmanned aerial vehicles, and weapon structures as well as their relevant subsystems and components. The industry has the potential of developing high-tech products that spill over to other related industries such as the automotive industry. The industry contributes towards NSI in different ways including absorbing innovations in technological advancements.

This project questions interactions among players within the NSI specifically focusing on the Aerospace industry in the Tshwane Metropolitan Municipality in order to find out how the players interact with each other and whether such interactions lead to the improvement and competitiveness of the Aerospace industry. Although there are several studies in the aerospace industry, this study emanated from a limited research in the areas of interactions between the government and the aerospace industry in South Africa.

This research project found that although Government has financial incentives and other support mechanisms for technology development and enhancement in place, there is no coordination in the liaison between Government and the aerospace industry. The industry contributes positively to the National Systems of Innovation through human capability improvement and the development of scientific and technical skills

Institutions of higher learning have a vital role to play in developing the aerospace industry by producing engineers and scientists; however, there is a mismatch between the graduates and the level of skills required by the industry. Most of the engineers and scientists in the aerospace industry are fairly old, previously designated as white people who are nearing their retirement age, and this poses a risk to the overall skills level of the industry.

The recommendations highlight the need for a coordinated interaction among the industry players, this can be achieved through the involvement of industry

associations and professional bodies within the industry. Although government has incentives to support different industries, there is a need to have an aerospace industry specific incentive scheme to support global competitiveness of local industry players and development of firms within the aerospace industry. There should be areas of mutual interest such as employment creation and skills development serving as a basis for improvement in interactions among the players.

Table of Contents

List of Abbreviations

AISI	Aerospace Industry Support Initiative
AMD	Aerospace Maritime and Defence Industries Association
AMTS	Advanced Manufacturing Technology Strategy
ARMSCOR	Armaments Cooperation of South Africa
ASSEGAI	A Strategy for a Sustainable, Economical and Growing Aerospace Industry
CAV	Centurion Aerospace Village
CSIR	Council for Industrial and Scientific Research
DIP	Defence Industrial Procurement
DoD	Department of Defence
DPE	Department of Public Enterprises
DST	Department of Science and Technology
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
IATA	International Air Transport Association
IBSA	India, Brazil and South Africa
ICT	Information and Communication Technology
IPAP	Industrial Policy Action Plan
MRO	Maintenance, Repair and Overhaul
NIPF	National Industrial Policy Framework
NIPP	National Industrial Participation Programme

NRF	National Research Foundation
NSI	National Systems of Innovation
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
PWC	PriceWaterhouseCoopers
R&D	Research and Development
S&T	Science and Technology
SMME	Small, Medium and Micro-sized Enterprises
SPII	Support Programme for Industrial Innovation
DTI	Department of Trade and Industry
THRIP	Technology and Human Resources for Industry Programme
UNIDO	United Nations Industrial Development Organisation

List of Figures

CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

1.1 INTRODUCTION

Science and technology have played a significant role in encouraging and improving the country's competitiveness economically in South Africa. It was due to similar reasons that the White Paper on Science and Technology (1996) introduced the concept of National Systems of Innovation. The aim was to maximise technological performance across various sectors through the creation, acquisition and diffusion of newly acquired knowledge to assist the country to achieve its national goals.

It has become evident that, like other industries, the aerospace sector requires investment in new technology and collaboration between various actors, including Government, to endure and sustain global competitiveness in the market. In order for this to happen, the aerospace industry requires not only effective implementation of NSI, but greater Government intervention in order to function effectively as the basis of increased economic activity and national competitiveness. This includes effectively managed relationships between research institutions, enterprises, institutions of higher learning and training, and other role-players participating in the industry.

The aim of this study is to evaluate the relationship between Government and the civil aerospace industry. The role of Government in the support of, among others, Research and Development, innovation and Science and Technology policy development will also be investigated. Also considered are lessons learnt from other countries in order to evaluate similarities with the South African aerospace industry.

1.2 PROBLEM STATEMENT

A problem statement assists in guidance during the early stages of research for research planning and development of the proposal (Brynard *et al.*, 2014). The problem statement also assists in determining the exact area to be researched and

helps to determine the main idea for the proposed research (Lues & Lategan, 2006). The South African aerospace industry contributes to the total gross domestic product through taxes paid by enterprises in the industry (AMD, 2006). Although these enterprises supply locally manufactured components to international OEMs, it is often difficult for smaller enterprises to supply directly to OEMs such as Airbus and Boeing. Smaller enterprises depend on sub-contracting work from Aerosud and Denel Aerostructures for smaller components. This allows smaller enterprises to form part of the international value chain; however, it limits them because they cannot compete for larger work packages from the OEMs.

South Africa possessed a robust centrally organised mission focused method to R&D investment (Gerryts *et al.,* 2008). The apartheid government terminated this strategy and as a result, spending on R&D by Government decreased from approximately 1.1% of the total Gross Domestic Product to 0.7%. In the present dispensation, investment in science and technology was regarded as a tool to assist in addressing the socio-economic challenges in the country and subsequent policies were aimed at growing S&T investment and capacity (Gerryts *et al.,* 2008). Although the current government focuses on the aerospace industry, support has declined since Government tends to focus more on addressing the inequalities of the past and other social challenges.

Government has support mechanisms in place including but not limited to, the Technology and Human Resource for Industry Programme (THRIP), the Aerospace Industry Support Initiative (AISI) and the Support Programme for Industrial Innovation (SPII), among others. It is, however, unclear whether such assistance is sufficient for technology and innovation development to enable local enterprises to be internationally competitive. On the other hand, it is not known whether smaller enterprises invest enough in innovation activities as it is costly. It is also not clear whether there are proper facilitation and interaction in the relationship between smaller enterprises, large enterprises, institutions of higher learning and training, and research and development institutions in the aerospace industry. Also what is not clear is the impact of Government incentives on industrial competitiveness

Investigating relationships among actors in the aerospace industry will help to identify gaps that exist in interactions among institutions of higher learning and

training, research institutions, enterprises, Government and other innovation agents involved in the industry and or system. Hobday (1998) noted that the aerospace industry encompasses several of the most reputable and refined supply chain arrangements, in which enterprises continuously outline limits of activities and information relevant to each other. Similarly, aerospace products are essentially multifaceted components and structures containing high value, capital goods which are based on engineering. Nonetheless, there is insufficient comparable data for the aerospace industry, which makes it difficult for the state to assess the influence of the industry on the overall economy as one of the high-tech sectors that generates knowledge.

Since companies cannot depend only on Government support to innovate, there are services offered by organisations including the Council for Scientific and Industrial Research (CSIR) and Technology stations hosted by institutions of higher learning and training for basic R&D. It is not clear whether companies are aware of such services, and whether they are aware that utilising such services may be less costly compared to researching foreign organisations. In addition, is not known whether local research institutions contribute to the reduction of time to market for aerospace innovations.

1.3 AIM OF THE RESEARCH

Throughout the research, the researcher's main aim is to investigate the application of the National Systems of Innovation (NSI) in the South African aerospace industry. The aim of the study will be addressed by means of NSI in general, interactions between the Government and the aerospace industry, and the identification of various support mechanisms offered by Government to aerospace enterprises in the NSI. The interactions between other relevant actors within the NSI will also be analysed to determine the type of interaction and contributions they make to the aerospace industry.

1.4 BACKGROUND

Since World War One, the aerospace industry has served both civilian and military sectors and that has shaped the industry's development (Prencipe, 1997). Enterprises involved in the aerospace industry manufacture products that are of dual use, and they can be used in both military and civil applications. In addition to the aerospace industry's importance to the global economy, this is a relevant field of study to reach a better understanding of how knowledge foundations advance and demarcate across enterprises. The South African aerospace industry encompasses some of the most reputable and refined supply chain systems, with enterprises actively defining limitations of activity and of knowledge in relation to each another.

During the apartheid regime, South Africa manufactured and assembled one of the most cutting-edge arms industries than most developing or newly industrialised economies globally. The strategy was part of the overall Government strategy of self-sufficiency attainment, regardless of the cost to the country. The spending on arms by the Government was attributed to the defence of white minority rule against threats that were regarded as internal and external at the time. Essential to this policy was the establishment of a significant public-sector defence industry centred on one Government-owned armaments procuring and manufacturing entity, Armscor, and corresponding with the regime's determination to offer infrastructure and other fiscal support to large-scale private capital and to secure careers for working-class Afrikaners. The approach left South Africa with a well-developed and widespread industry, but at a huge financial and economic cost (Dunne, 2006).

Investments by Government in R&D are a strategic involvement in enhancing the performance of the aerospace industry's NSI. Knowledge is widely regarded as a public good that can be used by one enterprise without limiting others from accessing it. The present study will also investigate how enterprises in the industry use interactions to share knowledge for the emergence of new technological innovations in the country.

The NSI perspective is helpful to understand those factors involved in the innovation processes, the impact on the economy from such innovations and, ultimately, the introduction of newly developed products and new manufacturing processes in the

industry. This means that a well-functioning interaction, among actors, in the aerospace industry will lead to more growth and development by the industry. The present research will investigate interactions among actors in the aerospace industry and identify gaps that exist in interactions between institutions of higher learning and training, research institutions, enterprises, Government and other innovation agents involved in the NSI.

1.5 HISTORY OF THE AEROSPACE INDUSTRY

The history of the aerospace industry in South African has its origins in the South African Airforce (SAAF) which was established in early 1920s. The air force operated in World War Two and the Korean War, among others. According to Mlhanga (2016), after the War, a huge amount of military equipment that was not used was re-sold to users in the civilian market, and given the increase in the number of aircrafts, this gave rise to the need for capacity in developing and manufacturing spare components for the maintenance and refurbishment of the aeroplanes. Additionally, enterprises were established to service the industry in R&D activities.

According to Collison (2007), Great Britain donated hundred surplus warplanes to the Union of South Africa together with spare parts and support equipment, which resulted in the formation of the SAAF. In the military aviation segment, the first air force base was established in 1922 in Tshwane (the Pretoria) and it was called the Air Force Base Swartkop.

The apartheid government allocated large amounts of public financial resources towards the industry through the defence budget, which meant that the aerospace industry experienced continuous growth and development. This growth made it easier for the industry to integrate and customise existing technologies to local operational conditions. In the eighties, Government paid more attention to projects aimed at research and the development of new aircraft. It was during this era that with, the assistance from Government, the local aerospace industry developed the ‘Cheetah’ Fighter Aircraft and ‘Rooivalk’ combat support helicopters with local capabilities.

Rooivalk attack helicopter was developed and manufactured by Atlas Corporation based on designs of the Puma helicopter which originates from France (Collision, 2007)

Cheetah fighter aircraft was developed by Denel Aviation as the main contractors of the SAAF. Denel has the design authority for the Cheetah C and D fighter jets. It is currently in operation by the Ecuadorian Air Force (FAE). The aircraft is an upgrade Dassault Mirage III.[1]

Given the increased activity in the South African aerospace industry, Rand Airport as the initial commercial airport became too small for the larger aeroplanes that were used for intercontinental travel, and therefore a new airport at Palmietfontein[2] was built. Soon this airport also became too small for larger aeroplanes like the de Havilland Comet 4 and OR Tambo International Airport (then Jan Smuts Airport) was constructed in the Ekurhuleni municipality area. This airport started operating during April of the year 1952. There is a number of MRO aerospace companies located in the airport that provide services to aircrafts owned by local and international airlines.

The aerospace industry has, moreover, incorporated a significant skilled workforce and some of these people have gained most of their experience in the civilian sector of the industry. During the apartheid regime, Government restricted skilled workers from working in the civilian market, but only preferred the skilled to work in the defence market. Between 1989 and 1990, about 10% of the total number of engineers and scientists in the R&D field were employed by Armscor (Batchelor, 1996). This is still the case as most of senior personnel in enterprises operating in the aerospace industry are from the previously designated white population. Kaermer-Mbula (2008) highlights that the domination by the previously designated white people in the aerospace workforce meant the structural exclusion of black people, and the composition of the workforce is demonstrated by persistent inequalities in terms of personnel in the aerospace industry.

Despite cuts in the budget for the industry by the democratic Government of the Republic, the Denel group and a state-owned enterprise are still largely responsible

[1] http://www.denel.co.za/album/Cheetah/24, accessed 12 April 2018

[2] Palmietfonein is situated in the City of Johannesburg Metropolitan Municipality. It was a wartime base for the air force which was converted into a temporary aerodrome while the OR Tambo international airport was being built.

for most of the work undertaken in the local aerospace industry. The reduction in funding from Government compelled Denel to diversify its activities to not only focus on defence products, but to also manufacture products for civilian use.

The aerospace industry is highly regulated and emphasises safety. Trading in the defence segment of the industry is managed by the Conventional Arms Controls Committee which issues trade permits for importation and exportation of products. This allows the NCACC to manage trade and the usage of such products and traceability due to safety concerns. The stringent regulations of the industry ensure not only that companies conform to international standards; however, some companies have experienced difficulties in trading their products because they are of dual use. Such products often cause confusion regarding which Government entity should be responsible for their regulation. Although the NCACC is responsible for the regulation of trade of defence-related products, it is important to note that the organisation is a committee and not an entity. The committee issues their reports on a quarterly basis, which make it difficult for enterprises to make informed decisions due to a lack of information regarding trade patterns.

1.6 RESEARCH QUESTIONS

The research seeks to address the following questions.

Main question

Are there interactions between the Government and industry players in the Aerospace Industry?

Sub questions

a). What is the role and effect of interactions between Government and industry on the aerospace NSI?

b). What is the relationship and contribution of the aerospace industry to the NSI?

c) What role does Government play in supporting R&D and innovation activities in the aerospace industry?

d). What are interactions among actors in the aerospace industry, and what gaps exist in interactions among institutions of higher learning and training, research institutions, enterprises, the government and other innovation agents involved in the NSI?

1.7 CHAPTER OUTLINE

The researcher formulated the following framework ensure that the study achieves its objectives:

- The first chapter outlines the introduction, problem statement and introduces the research questions.
- In the second chapter, related literature is reviewed.
- The third chapter outlines the methodology to be followed in the research and the design thereof.
- Chapter four analyses and interprets the findings and the results.
- Chapter five presents the conclusion and recommendations of the study.

1.8 SUMMARY

As a technology-driven industry, enterprises in the aerospace industry must constantly interact with each other and with Government to ensure that each one of them contributes towards the country's innovation of new product offerings and processes continuously. Government must support the industry through incentives, especially for basic research, as it may be risky for private enterprises to invest early in the innovation process.

Government, through policies such as those aimed at long-term investments, training and education, or by issuing rebates and tax breaks, can guide and direct the competitiveness of the nation. This can, in turn, impact on the R&D levels in the

aerospace industry. Interest by the South African Government in developing a strategy for the aerospace industry, and financial incentives, could have a major effect on the capability enhancement and competitiveness of local enterprises. It is therefore the responsibility of the National Novernment to impose standards and regulations, thus making interactions among enterprises effective, and to make the environment conducive to enable interactions (Calliano & Carpano, 2000).

This chapter explored the background of the aerospace industry and NSI. The introductory discussions contained the problem statement and the research questions.

CHAPTER TWO: THEORETICAL AND LITERATURE REVIEW

2.1 INTRODUCTION

The chapter presents a review of extant literature on the aerospace industry and policies that are used by Government to support interactions in the aerospace industry's National Systems of Innovation (NSI). This will be achieved by reviewing and contextualization of the theoretical perspective of aerospace industry's role in the NSI, exploring the international aerospace industry, identifying the drivers of the South African aerospace industry, and analyses of the industry's policy perspective.

2.2 DEFINITION OF TERMS

This section presents keywords that are frequently used in the study. The relevant keywords that are defined are of significant importance to the research and are referred to often. Defining these concepts and key words assists in the provision of insights into the entire study.

2.2.1 The aerospace Industry

The term 'aerospace industry' refers to the research and development, design, production, support, maintenance, conversion and advancement of rotary and fixed wing aircraft; satellites, satellite launch and tracking systems; air traffic control and management systems; unmanned aerial vehicles; and weapon structures as well as their relevant subsystems and components (Hatty, 2000).

2.2.2 Nation (in NSI)

According to Pick (2011), a nation can be defined as a boundless political communal setting that is not dependent on the organised aspects of Government. Innovation requires a firm-level innovation with the establishment of new product lines,

manufacturing processes as well as the improvement of product design. As a result, the nation can remain a legal unit used to analyse and describe the performance of the nation's innovation efforts in the global context. The notion of a nation affords the opportunity to understand the nature of how a country or nation generates new knowledge. Resulting from this, it can be suggested that, from a strategy perception, the advancement of innovation inside a nation cannot prosper if it is not determined by dominant actors and states with the authority to influence national improvements. Subsequently, a Government's role particularly in developing economies is essential in supporting and promoting the advancement of innovation (Manzini, 2012).

2.2.3 System (in NSI)

A system, in NSI, could be defined as a set of organised elements (Ackoff, 1971). According to Maull and Yip (2009), a system can further be defined as a body that is coherent containing complex inter-related elements. This definition implies that enterprises cannot uphold an innovative phenomenon without the involvement of other actors. Actors need to incorporate and utilise knowledge that may be produced by others within the system. Improved speciality and the assimilation of information and technical knowledge in separate goods or services necessitate access to information that is in possession of others within the system. The systems approach identifies the need for enterprises to be in close proximity with their customers to enable quicker adaptation to changes and evolving demands based on market requirements. Enterprises need to constantly remain in contact with their significant suppliers of production inputs within the system, and in some instances with competitors to keep up with developments in the market. Significant contact among actors with the aim of information sharing can be useful when making decisions for upcoming innovations (Manzini, 2012).

2.2.4 Definition of innovation (in NSI)

Thompson (2004) defines innovation as the capability to constantly convert information and concepts into completely new systems, ideas and procedures. Howard and Sheth (1969) further mention that innovation refers to the improvement of an existing product or an introduction of new products into the market. This is a

result of renewed innovation processes by an individual actor within the industry, of identifying of a new demand for the products, and the establishment of new suppliers of raw material or improvements in an organisation. The ability to advance newly generated ideas and novelty is prioritised by many actors within the NSI in response to changing market needs. The rate of strong international rivalry and technical advancement has ensured competitive advantage through rapid innovation by different actors (Schumpeter, 1934).

2.2.5 National System of Innovation (NSI)

The definitions of the National Systems of Innovation take into account the three previously defined concepts that form part of NSI.

According to Freeman (1987), an NSI refers to a coordinated web of institutions in both the public and private economic sectors, as well as the active interaction used to initiate, introduce, improve and share new technological developments. Nelson (1993) alludes that the concept of an NSI is a set of related institutions from which innovative performance of national enterprises is determined through interactions. Lundvall (1992) further mentions that the relationships for production of new knowledge and the diffusion thereof are developed from within the borders of the nation state. The state rules, incentives and capabilities always direct the level of learning and technological development in a state (Patel & Pavitt, 1994).

There is a distinction between the two definitions of an NSI, namely the narrow definition and the broad definition. The former definition focuses on institutions that intentionally encourage the attainment and distribution of knowledge and regard them as the main enablers of innovation within a state. The latter acknowledges that institutions in the narrow definition are entrenched within in a socio-economic structure influenced by political and cultural policies to have a bearing on the direction of innovation activities within the state (Freeman, 2002).

The narrow definition essentially focuses on research activities conducted by institutions of higher learning and training, and research undertaken at privately owned institutions, providing a foundation for introduction of new products and

processes. The acquired knowledge in this regard is defined as an invention when implemented by enterprises or individuals within the system. Invention refers to the introduction of a completely new process in an enterprise or a product in the market (OECD, 1997). New knowledge or processes are the results of extensive R&D.

2.3 THE DRIVERS OF THE SOUTH AFRICAN AEROSPACE INDUSTRY

In the South African context, it is difficult to separate the aerospace and defence industry. South Africa's aerospace and defence industry was originally established prior to the Second World War with British aid. During the War, the industry manufactured a significant amount of basic weaponry for the Union Defence Force and the Allied forces, including, bombs, armoured cars, ammunition and aeroplanes. After the War, the majority of the wartime arms manufacturing plants reverted to their pre-war civilian activities (Cawthra, 1986) and during the 1950s and early 1960s, South Africa relied heavily on imported arms, predominantly from Britain.

Although enterprises in developing countries historically lacked technological experience or the organisational capabilities needed to enter global markets, they need not remain in traditionally low-technology industries. They are gradually becoming more involved in dynamic and high technology industries. The effective use of existing capacity to develop other capabilities such as skills, knowledge, or innovation capabilities, could eventually lead to improved technological capabilities. Accumulating a wide range of technological capabilities such as the absorptive, integrative, coordinative and generative capabilities mentioned above, would require the proper support structures that this study identifies as constituting a framework for technology development (Mayindi, 2009).

2.3.1 Human capabilities and knowledge management

According to Rosdi and Chew (2010), human capital can be described as "knowledge, skills and abilities" of employees and manager within an enterprise. They also indicate that individuals within an organisation play a significant role in the process of creating new knowledge and improve existing knowledge. The level of

education and training, especially related to the job that the individuals perform, is important in the enterprises' capabilities. Since different enterprises within the NSI possess different types of knowledge (both technological and business-related), enterprises that proactively seek knowledge and share this with the NSI benefit more regarding their own development. Knowledge is a critical resource for enterprises within NSI, but due to their limited size and resources, enterprises often lack sufficient technical and business knowledge to acquire relevant knowledge.

2.3.2 Institutions of higher learning

The role of Institutions of higher education and training in terms of innovation has increased over the years, because the development of new technologies depends heavily on the outcomes of university research (Nelson, 1994). This is linked to the growing significance of multi- and interdisciplinary R&D and the reinforced interrelation of basic research and industrial application. Important innovation impulses in key technologies such as advanced manufacturing technologies and telecommunication technology are drawn from university research (Gibbons *et al.,* 1994).

Klevorick *et al*. (1995) found that the findings of university research are mainly applicable to enterprises in R&D intensive industries such as the aerospace industry. Enterprises in these sectors predominantly make use of findings from applied sciences (chemical engineering, mechanical engineering and electrical engineering), while new findings from basic research in mathematics and physics are not of significant relevance to industrial innovation.

The innovation activities of enterprises depend on the interactions of internal R&D and the degree to which external resources are implemented (Martin, 1994). By following this route, enterprises have the option to supplement their technological competencies, either through internal efforts or external sourcing to enterprises that specialise in the area in question. Organisations such as the CSIR should work with Government to ensure that their infrastructure is made available to smaller enterprises to fulfil their potential for innovation. This will also ensure that the network of companies in certain regions within the country will become more efficient, as companies may tend to complement each other within the national

systems of innovation. There is a crucial role that institutions of higher learning can play in supporting human capabilities in the aerospace industry; however, due to a lack of coordinated relations, opportunities are missed.

2.3.3 Infrastructure

According to Henry (2012), technology and communications have long been an infrastructure limitation on innovation. However, the introduction of the Internet and the growth of new social technological competencies seem to have improved their collective and cumulative effect. They have become critical assets in their own right and constitute a facilitator in infrastructure that can improve the efficiency and productivity of other assets. Technology has become another vital factor of production amongst the traditional factors of capital, land and labour.

Roads, bridges, airports, and large public transport systems are still important assets. However, governments everywhere are experiencing an uncomfortable squeeze as rising demands for spending meet rapidly dwindling public investment funds. Therefore, the discussion moves to the merits or otherwise of direct funding by the public sector or the more likely approach these days of various forms of public-private partnerships and other similarly ‘mixed economy’ models of funding and investment in the aerospace industry (Henry, 2012).

2.3.4 Networking

Several strategies have been introduced, such as opportunities to improve knowledge, lower costs of production, access to new markets, and R&D. Simon (1997) categorises the benefits of collaborative business relationships into tangible and intangible benefits. Tangible benefits include improved market share, sustained competitive and additional profits advantage, and intangible benefits comprise of the creation of specialist skills and competencies. This can be achieved when enterprises work together in the NSI to ensure that they focus on their areas of speciality to produce quality products for the markets.

The benefits of such relationships is that emphasis is placed on areas where an aerospace company within the NSI has a competitive advantage over others and

instead of competing, work is divided according to capability and capacity of each firm within the NSI. This does not only benefit those who are directly involved in the manufacture of final aerospace products; it also benefits many smaller enterprises within the supply chain's value chain and, as a result, more jobs are created.

Harvey (2004) emphasises the acknowledgement of connections between firm-level activities and the broader processes linked to such networks as these are important, since the innovation process is now dispersed across various actors (Harvey, 2004). As new technologies become increasingly complex and information and communication technology more accessible, enterprises of all sizes in the aerospace industry should be encouraged to innovate independently or in collaboration within the industry. Enterprises should also be encouraged to work with institutions of learning and other enterprises through innovation networks in and between sectors and nation-states. Those that are far from institutions of higher learning and training must be assisted with incentives to access them and other facilities that are available within the NSI.

2.3.5 Competency improvement

Within the National Systems of Innovations, enterprises do not only produce goods and services, as Edquist (2001) indicates that additional to 'production', enterprises must show ability to have a good general innovation performance by consistently being able to innovate over long periods. Innovation enterprises must have certain competencies such as the capacity to carry out research for new scientific knowledge. It can be also indicated that to be more innovative and remain competitive, enterprises must interact with other actors within the NSI, especially institutions of higher learning and training in order to constantly acquire new knowledge that may emerge of these institutions of higher learning. Training and enterprises must also be flexible in order to absorb scientific knowledge that may be developed by others.

Although innovation may be expensive in the initial stages, it is important for enterprises to improve and invest in their scientific developments in the process of innovation. This yields a positive result to enterprises because it enhances their science base. Another way in which enterprises could improve their competence is

to take their innovation to organisations with capacity to further add value to the product or process to ensure that commercialisation takes place. Enterprises across the world are moving from labour-intensive methods of production and are opting for more automated processes due to cost-cutting measures and labour-related challenges. This ensures accuracy and general competence, and has also benefits such as quicker turnaround times and efficiency.

2.3.6 Economic policy

Nilsson and Sia-Ljungström (2014) emphasise that many countries' economic policy focuses mainly on innovation as a mechanism to achieve sustainable economic growth. The latter is also evident within the academic policy debate (Nilsson & Sia-Ljungström, 2014). This can be seen through the development of the Innovation Systems (IS) perspective, which has grown into one of the leading policy perspectives in many countries. It signifies a systemic approach to innovation and innovation policy, thereby emphasising interaction among different system actors (research and educational institutes, enterprises, and supporting actors) in promoting innovation. Therefore, a crucial matter in the NSI approach to policy is how supporting actors can facilitate innovation by taking on intermediary roles within the system (Nilsson & Sia-Ljungström, 2014).

The NSI concept, on the other hand, has brought a new way of thinking with regard to science and technology in South Africa and the way in which agents interact with each other within the system. Manzini (2012) indicates that the NSI concept has made explicit the causal relationship between scientific activity and economic performance. It has further emphasised the need for consistency and integration in the functions and activities of the country's institutions of science and technology. Innovation has become the focus of all scientific and technological efforts. The NSI notion has presented a justification for science, engineering and technology to be shifted from the sidelines towards the centre of the country's macroeconomic policies, thereby cutting across nearly all sectors of government.

The above literature review is relevant for the aerospace industry in South Africa. It is through interactions between Government and other agents within the NSI that ensured that capabilities that were initially developed for the defence market are

converted into civilian use. Since there is minimal demand in the defence applications, interactions between Government and agents in the NSI should foster more research, development and innovation activities to focus more on the civilian applications.

2.4 IMPORTANCE OF INTERACTIONS

According to Tidd, Bessant and Pravitt (2001), the theory of interactions among economic actors has become popular as they offer many benefits for technology development in enterprises. Interactions are appropriate where the benefits of co-specialisation, the use of joint infrastructure and standards outweigh the costs associated with network governance and maintenance. Interactions are most beneficial where the costs of purchasing a technology are too high, and where uncertainties exist since enterprises can share costs to minimise the risk of incurring higher costs of uncertain technologies.

Strategic alliances take place through voluntary arrangements between enterprises involving exchange, or co-development of technological products or services (Gulati 1998). The importance of interactions of contact between actors is that they can become sources of information for all participants within the industry. Those enterprises that have direct connections with each other, are more likely to possess common knowledge or information, on innovations and their organisations. Interactions among industry players can also promote behavioural conformity by serving as conduits for both technological and social information about organisational activities, which in turn have the ability to influence the extent to which new innovations are adopted (Mayindi, 2009).

The ability of aerospace engineers and scientists to identify, obtain and effectively make use of scientific and technical information relevant to the industry is one of the main factors of efficiency within R&D process (Blados *et al.*, 2001). It is therefore important to promote responsiveness and exchange of scientific and technical aerospace information in order to encourage the success of the innovation process. It is on this basis that the Advisory Group for Aerospace Research and Development

(AGARD) proposed the establishment of the International Aerospace Information Network (IAIN) to serve as a self-sustaining worldwide network of partner organisations dedicated to sharing their information resources. The network of international partners would allow them to share information and, since they are members of the organisation, they are believed to trust each other and would not be reluctant to share information. With recent developments in information technology and information management, increased participation in the aerospace sector, and the realities of scarce resources, the strategies and benefits of international collaboration and resource sharing have become apparent (Blados *et al.,* 2001).

2.5 THE TRIPLE HELIX SYSTEM (GOVERNMENT- INDUSTRY- ACADEMIA)

According to Etzkowitz (1993), the concept of the triple helix generally interprets shifting from systems that are dominated by relationships between Government and industry to the one that is inclusive of institutions of higher learning and training to create knowledge. Schumpeter (1942) observes that the creative destruction alone cannot lead to natural innovation, but the contribution and effective interactions between the three spheres could lead to an economically developed and knowledge-based society.

Etxkowitz (1993) indicates that the main purpose of the triple helix systems is to produce, diffuse and encourage the use of knowledge and innovation and it encompasses societal, entrepreneurial and cultural policy. Furthermore, the triple helix theory represents relationships among components that interact continuously though collaborations, technology transfer, leadership and networking. This system is relevant to the aerospace industry because Government must act as a contact point between industry and institutions of higher learning and training. From the networks among the actors, initiatives can be created and can inform national innovation policies.

The triple helix system also ensures that policy formulation is informed by results from interactions among Government, industry and academic institutions. This helps Government when developing policies as they will be informed when developing

policies such as the IPAP. According to Leydesdorff and Etzkowitz (1996), in the triple helix system academic institutions and Government are involved in the formation of new firms within the NSI. Academic institutions offer training and development for prospective employees in the form of graduates while Government promotes innovations rather that acting as a traditional regulator.

2.6 CONTEXTUALISATION OF THE AEROSPACE INDUSTRY

The South African aerospace industry originated from expertise developed from identifying capabilities that were used in the defence sector. These include capabilities in aerostructures from the then Atlas Corporation (now Denel Aeronautics) used in the development of the Rooivalk and Cheetah fighter aircraft, among others. The same capabilities are currently utilised to manufacture products for civilian markets. The aerospace industry is partly intended to help Government in emergencies that may arise during a need for military interventions and is largely dependent on Government funding.

The National Systems of Innovation approach emphasises that movements of knowledge and information, and how they flow among the actors within the system, are important in ensuring that the innovation process runs smoothly. Interactions and relationships by actors within the NSI result in the advancement and development of innovation and technology. Decision-makers in Government must be informed the nature of the NSI in order to implement the necessary interventions (OECD, 1997).

The lack of research and development activities in the industry may be the result of high cost required and smaller enterprises that cannot afford to conduct such activities. This further prevents SMMEs from participating in the industry, because small enterprises, especially those owned by black entrepreneurs who do not have the capital required and cannot access credit from financial institutions.

Enterprises in the aerospace industry are compelled by conditions in the market to innovate rapidly – both in terms of their processes and products. The recent

international trend for additive manufacturing requires the industry to develop new and advanced manufacturing processes and to use new components and materials such as titanium to produce low-weight products. According to Kraemer-Mbula (2008), a dynamic and prosperous aerospace industry is important because it produces state-of-the-art technologies that spill over to other related sectors of the economy and may actually grow manufacturing in the entire country.

The South African aerospace industry has insufficient comparable information, which has made it difficult for authorities to assess the realities of this industry as a knowledge-generating high-tech sector in the economy. The origins and development of the South African aerospace industry cannot be studied in isolation to the defence industry. Additionally, the industry was exposed to the international market at a fairly late stage due to economic sanctions, but enterprises within the industry had to implement sustainable measures to maintain their competitiveness (Kraemer-Mbula, 2008). Retaining existing technologies is coupled with the development of new products through industry collaborations; however, small enterprises often miss such opportunities because they can seldom co-invest with large enterprises and would need Government to intervene in the form of incentives.

The industry has also faced a process of demilitarisation, and enterprises in the industry have made a dramatic shift towards manufacturing civilian products. This shift can be attributed to the declining defence budget implemented by Government. There are policy interventions aimed at restructuring the industry by Government, including the formation of Denel and ensuring that Armscor becomes less militarised. Government also leverages on Government procurement as a tool to develop the industry. Generally, the industry was left to compete with international counterparts without assistance from Government.

The restructuring of the industry to diverse to the civilian market is the reason why the study of the industry is salient. The industry was developed at a huge cost to taxpayers and was regarded as a strategic national industry by the then government; however, the industry has currently somewhat lost its relevance because the demand for defence products has decreased drastically. The transition to democracy meant that Government spent more on social challenges, and defence was regarded

as not so urgent and therefore companies are diversifying to civilian production (Batchelor & Dunne, 1998).

The reduction in demand for defence products and equipment meant that the industry had to, in response, reduce its manufacturing activities and to restructure. As a result, some enterprises in the industry increased their exports, while others opted for diversification to civilian products in order to survive.

Throughout history, countries such as Brazil and India have been attempting to improve their economic, social development and growth, and had been aiming to also introduce high-tech value-adding activities. High-tech activities are capital-intensive and require a country to be well-equipped with a skilled labour force and technology. Only a few countries can afford to engage in such activities. The initial disruption of the Industrial Revolution in the 1800s from agriculture to the manufacturing sector left many countries behind, because they could not afford the transition. The country as a whole also needs to focus on high-tech manufacturing sectors such as aerospace (AMTS, 2004).

Most of the employment opportunities created by the aerospace industry are extremely capital-based and the skills required are quite technical. In South Africa, employment opportunities in the aerospace industry were reserved for the previously advantaged white minority during the apartheid regime. The industry therefore perpetuated racial divisions within the labour market and contributed to the lack of skilled labour among the black majority.

Since the sector is dominated by a few large manufacturers, it is critical for large enterprises to serve as technology absorbers to allow technologies developed by SMMEs to find a place in the market. According to Kraemer-Mbula (2008), the sector is regarded widely as an off-taker of crucial technological developments. Numerous technological developments developed in other related industries have been absorbed by the aerospace industry and further spilled over to others such as automotives and the ICT sector.

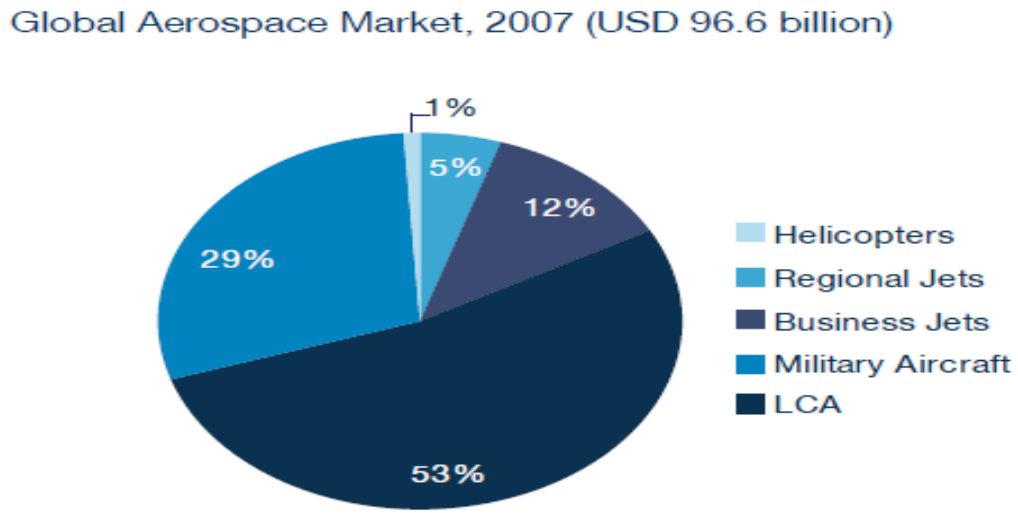
The decline in local demand has compelled enterprises, both that are privately owned and those owned by the state, in the industry to diversify and expand, or in some instances, some have scaled down their activities. Government adopted a

hands-off approach and this left the industry with no option but to lay off a number of workers. (Batchelor & Willet, 1998).

2.7 THE INTERNATIONAL AEROSPACE INDUSTRY

A report by PricewaterhouseCoopers (2015) indicates that an increased demand in the civilian and defence aviation sub-sectors is considered a as a significant contributing factor to the growth of the international aerospace industry. It is projected that the demand from both the civilian and defence sub-sectors will improve significantly and will contribute positively to the local aerospace industry. The civilian aerospace industry is expected to grow due to an expected increase in travelling in developing economies, while the defence side of the industry is also expected to grow in terms of international initiatives to ward off terrorist activities. However, the current economic climate makes it difficult to make long-term projections. Nonetheless, PWC (2015) highlights that it is extensively recognised that the aerospace industry is cyclical in nature.

Figure 1: International aerospace market



Source: PWC, 2015

Figure 1 above presents an overview of the international aerospace market for number of aircraft manufactured in 2014. From the figure it can be seen that

business manufactured over 53% of aircrafts in the world – these were business jets. It can be argued that although business jets dominate the international market in terms of the percentage of manufactured products, airline aeroplanes manufactured by Boeing and Airbus lead the market in terms of value. Approximately 29% of aeroplanes manufactured were regional jets during the same period. Light combat aircraft and helicopters amounted to 12% and 5% respectively.

For comparative analysis purposes, the study analyses the Aerospace National Systems of Innovation in Brazil and India, because like South Africa, they are affiliates of the IBSA (India, Brazil and South Africa) grouping. IBSA was introduced in 2004 initially as a forum for dialogue and has since hosted trilateral engagements among foreign ministers of these countries on an annual basis. The countries analysed were selected for the study as they are considered to be developing countries, and their economies are significant enough to influence their prospective regions. Their aerospace industries are expected to compete and tap into systems of innovation resulting from the increased demand of innovative products in international markets. It should be noted that the comparison is limited to the aerospace industry in the selected countries and its contribution to GDP, skills and the overall Government support will be analysed to determine how the industry is performing.

It is important of highlight that, out of the three countries analysed in this study, the South African aerospace industry is the oldest. It originates from the early 1990s since the formation of the South African Air Force. The industry was formed initially to service the SAAF aircrafts and has since diversified to the civilian market, which is the focus of this study. It is also essential to indicate that the components that will be compared for the three countries will focus mostly on industry's contribution to GDP and employment levels. According the World Bank (2017), South Africa, Brazil and India have a total population of 55.91 million, 207.7 million and 1.324 billion respectively.

Sotero (2009) indicates that India, Brazil, and South Africa (IBSA) are exceling geographically with their history, and differences in their regional involvement economically and are promoting their interest individually and collectively regardless of the persistent economic challenges. The gradual decline of the hegemony of the

Unites States of America presents economic and business opportunities for developing economies in the so-called global south.

There are a number of initiatives within the IBSA Forum and interactions among academics from the three countries that also facilitated participation in forums by civil society organisations (Sotero, 2009). Furthermore, these countries have similar historical backgrounds. An inter-regional relationship among these countries was not regarded as necessary 10 years before it was IBSA was established. When Brazil faced challenges in trying to address high inflation rates, South Africa was moving into the new dispensation of democracy, and India was facing regional challenges from nuclear possessing neighbours. Currently, the grouping is arguably effective, but more work still needs to be done to achieve the individual agendas of the different member states.

Bilateral agreements between South Africa and Brazil date back to the 1918, while at the same time there were no agreements with India related to trade. The government of Brazil had agreements with South Africa even while there were sanctions against South Africa. By 1966, Brazil topped the list of countries exporting to South Africa from Latin America (Selcher, 1974). Notwithstanding common economic interests, IBSA countries were initially not partnering economically and the formation of the grouping was not expected

During the apartheid regime, the Indian government broke relations with South Africa but later re-entered in both economic and political bilateral agreements with the new Government of South Africa that was elected in 1994. Some of the industries considered during the initial bilateral agreements in 1994 were aerospace and ICT (Soule-Kohndou, 2013). Braveboy-Wagner (2009) indicates that initial intentions aimed at the promotion of cooperation by the global south countries after the Cold War were to counter inequality against larger developed countries and to depend less on these countries.

2.7.1 The Brazilian experience

The Brazilian industry employed approximately 23 000 people in 2006, most of whom are skilled. The industry generates BLR 1.7 billion in annual revenue from the

construction and maintenance of aircraft systems, airframes and engines. The total contribution of the industry to the country's GDP annually is estimated to be around 0.1% (IATA, 2011). The industry originates from the early 1940s and was the result of significant Government investment. The industry is regarded as one of the greatest dynamic sectors of the county's economy. Data from the Aerospace Industries Association of Brazil (AIAB) highlights that the industry has approximately 35 firms, but is dominated by Embraer.

The Brazilian government's initial intension to discourage imports through increased tariffs was used to compel international manufacturers in the aerospace industry to establish collaboration agreements with the local government. Foreign enterprises were also compelled to implement technological transfer and to share experiences in terms of manufacture of the finished goods to the Brazilian-based enterprises. According to Goldstein (2010), these kinds of arrangements assisted the Brazilian industry to become a single supplier of some aeroplane structures to international Original Equipment Manufacturers.

The Brazilian experience was regarded as the driving force for the development of manufacturing capabilities and technological capacity as a form of competing with the likes of the USA in the aerospace assembling sector. The Brazilian government pushed for the acquisition of knowledge initially and opted for specialisation in deigning of components and assembly thereafter. In trying to avoid technological dependence on foreign countries, Brazil adopted a policy of issuing technology licences, but opted for the acquisition of those technologies that were sought by their local industry for aerospace assembly. Government support was therefore important for the facilitation acquisition of technological capabilities (UNIDO, 2016).

According to Prichard *et al.* (2000), facilitating close collaboration and information exchange between institutions of higher learning and training and enterprises from different industries is essential during the initial stages of industrial development. To address capital needs of the industry, financial assistance from Government is critical, although it will never be enough and should be complemented by contributions by the private sector to eliminate obstacles that prevent industrial development. The Brazilian government took both the responsibility of being a financial sponsor and an off-take customer. The government and its agencies

ensured that a wide range of financial support mechanisms were made available for access by the aerospace Industry. A development bank was also created for the purpose of addressing financial requirements and financed activities related to R&D, and later a tax system (preferential) was introduced in support of the aerospace industry.

Most enterprises in the Brazilian aerospace industry are concentrated in sound clusters where knowledge-producing institutions have a prominent presence, thus accelerating knowledge spill-overs and technological change (Martínez, 2011). Accordingly, their government competed to attract enterprises in the supply chain, by establishing an aerospace business parks, providing tax breaks and supporting R&D (Santiago, 2008).

According to UNIDO (2016), the following were some of the important characteristics of the establishment of the aerospace industry's systems of innovation in Brazil with support from their government:

- Establishing a niche market such as passenger aeroplanes for aerodromes with poor infrastructure.
- Financing newly designed products.
- The establishment of a state-owned entity to commercialise innovations.
- Provision of capital by Government through the acquisition of locally built aeroplanes and tax incentives to encourage private investment.
- Interactions in technology access among local companies, sharing of products through co- production, and support for research and development for aerospace-related activities.

2.7.2 The Indian experience

In a presentation made at the Vibrant Gujarat 2017 Global Summit, the Gujarat Government indicated that the Indian aerospace industry is worth approximately USD6.2 billion and has been growing steadily since 2010. As is the case in South Africa, the industry is dominated by a few Government enterprises and there has

been a decline in the number of private players. The presentation further highlighted the recent entry of private enterprises such as Mahindra, Tata and Reliance to the aerospace manufacturing industry. According to Thirunavukkarasu & Petchi (2015), the Indian aerospace industry is estimated to have a growth rate of 9% per annum until 2020, and will also arguably be the third largest market internationally by then.

A report by the International Air Transport Association (IATA, 2011) highlights that the aerospace sector's contribution is approximately 0.5% to the total Indian GDP and has employed around 276 000 people by in 2009. The contribution to GDP in monetary terms amounted to approximately INR 147 billion. The projected growth of the Indian aerospace sector can be related to the increased number of international travellers, which led to more aircrafts in need of service and spare parts in India.

Shane and Venkataraman (2000) indicate that, unlike the South African and Brazilian aerospace industries, the Indian aerospace industry was not built from large investments by Government, but it was stimulated by offsets agreements that obliged international OEMs to utilise locally based suppliers of components when servicing government contracts. Off-sets will be discussed further in this chapter to analyse it as a tool for industry development.

According to Varma (2013), India's aerospace industry can be regarded to be on top of the list for the fastest market globally in terms of growth. The industry has been active for over sixty years and has since developed to meet international standards. Given its international recognition, India's aerospace industry has opportunities and capabilities to manufacture, maintain and overhaul small and large aeroplanes and components. According to PWC (2015), the industry's expansion is due to a diversified consumer base comprising airlines, businesses and high net-worth individuals. The rapid growth of this industry has attracted major global aerospace companies to India. All segments of the aerospace industry, including civil and military aerospace and space, are showing a significant level of growth.

India is rapidly investing in the skills and technology necessary to make a successful shift to being the preferred aerospace components manufacturing destination. The manufacturing sector's rapid growth is making its presence felt globally by adopting international quality standards and investment in efficiency and quality manufacturing facilities.

India's excellent engineering and production skills have been recognised and harnessed by foreign companies outsourcing manufacturing work to India. This presents an opportunity for India to utilise its expertise in manufacturing processes, from the design to the final manufacturing stages. The success of such projects would lie in India's large pool of engineering resources which are required for managing frequently changing designs to suit performance needs (PWC, 2015).

2.7.3 South African experience

Information on the South African aerospace industry is limited, because studies and information on the sector are not produced on a regular basis. This poses a major constraint when analysing the sector and is a challenge for policy-makers. According to AMD (2006), the industry (including defence sub-sector) had an estimated annual income of R9.6 billion in 2005.

A 2011 report by IATA indicates that the aerospace manufacturing sector employed approximately 7 000 people directly. In addition, the industry supported close to 25 000 indirect employment opportunities in the supply chain. Most of the industry's labour force is highly skilled in the engineering and technical fields.

The industry plays an integral role in offering engineering and technical graduates from institutions of higher learning internships and experiential learning opportunities, especially in manufacturing enterprises. However, it is less competitive compared to India and Brazil due to a lack of sufficient training and development of the labour force. Kraemer-Mbula (2008) indicates the need to continuously train and educate the labour force for competitiveness with peer countries; however, there is no training authority for aerospace, which make it difficult for our labour force to compete globally.

The South African aerospace industry currently has a vast range of skills as a result of strategic funding used for military commitments over the past forty years. The industry has the ability to design and manufacture tier 1[3] complete systems like unmanned aerial vehicles. Therefore, there is no doubt that the aerospace industry

[3] According to Kraemer-Mbula (2008), tier one refers to organisations producing an entire aircraft with all sub-systems already fully integrated. First tiers are also known as airframes.

presents an opportunity for South Africa to achieve global leadership in innovation and emerging technologies (BMC, 2004). However, the lack of continuous development and government support in areas such as skills poses a risk to the industry's competitiveness. An investment in continuous skills development and government support can further improve the industry's competitiveness.

Summary

From the comparisons above, it can be concluded, based on sources consulted, that the South African and Brazilian aerospace industries presented similar scenarios during their establishment phases. They were both initiated by interventions from their respective governments subsequent to being identified as strategic sectors. On the contrary, the Indian aerospace industry originates from investment by the private sector. This indicates that Government could have missed the opportunity to identify potential arising from aerospace industry development. The Indian aerospace industry is the second developed after Brazil, and this was stimulated by the off-set agreement entered into between Government and the international OEMs. The Brazilian industry has been stimulated by OEMs such as Embraer, which is a tier 1 manufacturer of aeroplanes for both the civil and military market.

2.8 HISTORICAL CONTEXT OF INTERACTIONS BETWEEN GOVERNMENT AND THE AEROSPACE INDUSTRY

South Africa is one of the countries that continuously improve aerospace innovation, research, development and manufacturing. For instance, South Africa was already manufacturing full aircraft by the late 1920s and has since shifted towards engaging in long-standing partnerships with many of the world's leading aerospace original equipment manufacturers such as Airbus and Boeing.

Furthermore, the South African Government has been actively supporting the industry through a wide range of complementary mechanisms and has allocated certain duties to various government departments in order to ensure growth (AeroAfrica-EU, 2013).

The South African aerospace industry was advanced during the long period of economic isolation. Government R&D funding was used to design and develop core technologies from scratch. As a result, development was mainly focused on the military sector, which saw the design and manufacturing of completely new military systems, such as the Rooivalk attack helicopter. This meant protection from competition and a captured market, and has since resulted in a lack of international customer knowledge and difficulty in integrating systems and production to meet the demands of international customers because there is too little understanding of the requirements and needs of its of international OEMs (DTI, 2003).

The South African aerospace industry currently has vast capabilities as a result of the strategic funding used for military purposes over the past forty years. The South African manufacturing industry has the ability to design and produce tier 1 complete systems such as unmanned aerial systems. There are also existing pockets of niche expertise in various aerospace disciplines and sub-sector activities. There is no doubt that the aerospace industry has a vital role to play in making South Africa a leader in innovation and emerging technologies. (BMC, 2004)

The aerospace industry is considered one of the significant strategic sectors of economy because it is seen as a form of national pride and competence, a generator of highly specialised jobs, an incubator of innovative technologies and an engine of evolution and wealth (Lefebvre & Lefebvre, 1998).

Figure 2: Aerospace industry support by the Government

Period	Activity
2000	• The first study into the South African aerospace industry is undertaken by the Department of Trade and Industry (DTI).
Late 2002	• The Advanced Manufacturing Technology Strategy (AMTS) is developed by the Department of Science and technology (DST) as a response
2003	• The all-encompassing ASSEGAI national strategy is developed. • The DTI's "Big 6" industry forum is launched to provide strategic guidance
2004	• Negotiations for the A400M programme are initiated between Government and Airbus. • The DTI establishes the National Aerospace Industry Support Initiative (AISI) decides to host it at the CSIR.
2005	• The AISI becomes operational, with particular objectives for technological development, improvement of the aerospace supply chain and collaboration between the DTI and DST. • The DTI establishes the National Aerospace Centre of Excellence (NACoE) to address human capital challenges and the inclusion of previously disadvantaged individuals. The University of the Witwatersrand is selected as the host of the programme. • Local industry receives work packages for the A400M.
2006	• The DTI establishes the Centurion Aerospace Village (CAV) in Tshwane as South Africa's base to become the country's first aerospace supplier park
2007	• The NACoE and Airbus signs a strategic partnership agreement.
2008	• The AeroAfrica-EU project becomes operational. • A sub-programme on SMME enterprise support is launched within AISI • The NACoE funds bursaries for Masters students.

2009	• A workshop for analysis of the FP7 call is hosted in Pretoria and Cape Town by the the AeroAfrica-EU project • The AeroAfrica-EU project maps all local players to determine their applicability to the call • The AeroAfrica-EU project formally promotes South Africa at the ETNA brokerage event in Brussels (Sept)
2010	• The NACoE and Airbus enter into a second strategic partnership agreement. • The NACoE successfully starts its titanium thematic area in partnership with Airbus • The AeroAfrica-EU project starts developing the shortlist for its international advisory panel.

Source: AeroAfrica-EU, 2013

Figure 2 summarises some of the South African government's major interventions to support the aerospace industry since the early 2000s. Government, through the Department of Trade and Industry, undertook a study to identify opportunities and gaps in the development of the industry and later through the Department of Science and Technology, developed the AMTS. It is important to highlight that the interventions where aimed at integrating the country's technology resources for better development and a focus on the competitiveness of the manufacturing sector.

2.9 SUMMARY

Chapter Two focused on a theoretical perspective of NSI in the aerospace industry, the international aerospace industry context and the historical context of interactions between Government and the aerospace industry. The chapter further explored the drivers of the South African aerospace industry, and the triple helix, as well as the policy environment that guides NSI in the aerospace industry. The following chapter peruses the design and methodology used by the researcher conducting the investigation.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter outlines the design and methodology followed by the researcher in conducting the investigation. Since the study uses first-hand information from questionnaires and existing secondary sources of data, a combination of qualitative and quantitative research approach has been followed.

3.1.1 Qualitative research

Qualitative research investigates the structure of social experiences and gives meaning to the experiences. According to Denzin and Lincoln (2000), in qualitative research, emphasis is placed on the qualities of entities and processes, and meanings cannot be investigated in terms of amounts and quantities. Additionally, Flick (2007) indicates that for qualitative research, texts are utilised as research material as opposed to numerical components. Qualitative research includes methods that assist the researcher to develop an understanding of human or social problems.

According to Creswell (2007), in qualitative research, the researcher investigates the subject based on a natural setting, and analyses words and reports to develop a holistic picture to validate facts that are already in existence. Qualitative methods are contrary to the quantitative method in that they present explanations of things that numbers are not utilised straight away, and data can be gathered by means of observation of a certain phenomenon.

3.1.2 Quantitative methods

According to Flick (2007), qualitative research is an illustrative approach while quantitative research focuses on outcomes in the actual sense of the word. Lunenburg and Irby (2008) highlight that quantitative research encompasses research on elements such as numbers and records that are mathematically

significant, and the result of which is quantifiable. Hair *et al.* (2007) distinguish the two methods firstly by indicating that quantitative research methods relate to the use of a list of respondents and a set of questions that are structured with predetermined options of responses.

For the reasons stated above, this study uses both qualitative and quantitative methods in order to arrive at an understanding of problems experienced by both Government and the industry in their interactions, and to further determine how these interactions could be enhanced. This approach allows for gathering comprehensive information for the study and is more useful than it would be if one method would was used.

Figure 3. Qualitative and quantitative research approaches

Characteristics	Quantitative approach	Qualitative approach
Purpose	Used to track trends and is also useful for data with many characteristics	Determines concealed inspirations and values
Research goals	Discovers and identifies new ideas and thoughts for understanding objectives	Validates factual estimations
Type of investigation	Designs explores a phenomenon	The designs are expressive and often fundamental
Type of questions	Questions are not structured and are open-ended	Straightforward and well-structured
Type of execution	Limited duration between the beginning and the end (short time)	Duration can be longer
Representativeness	Respondents are limited to the sample	Respondents are unlimited and may include the entire population
Type of analysis	Interviews, independent,	Numerical, expressive,

	informative	predictive
Researcher skills	Interpersonal communications, observations, interpretive skills	Scientific, statistical procedure, translation skills; and some subjective
Generalisation of results	Very limited only preliminary insights and understanding	Factual estimations

Source: Hair *et al.* (2007)

Generally, qualitative research methods are used to establish and develop concepts in instances where limited or no theory exists on a particular phenomenon or current theories do not sufficiently grasp the complexity of the challenge under investigation. The methods are used to describe the instruments or connections in fundamental concepts or models (Denzin & Lincon, 2011). According to Cameron and Price (2009), qualitative studies set out to analyse complex pictures of the subject under study. According to Babbie and Mouton (2001), qualitative studies seek to describe and understand the qualities or characteristics of a social phenomenon; additionally, qualitative research evolves from theoretical assumptions to interpret procedures involved when studying social or human problems.

This research followed entails analysing the interactions between Government and industry. The research seeks to determine how Government interacts with industry and how Government support to assist the industry to become competitive. Qualitative data was collected through an analysis of publicly available reports from the enterprises' websites and relevant Government departments' websites. It is important to note that the Department of Trade and Industry, Department of Science and Technology and the Department of Transport are mainly involved in the civil aerospace, while the Department of Defence as well as the Department of Public Enterprises are more active in the defence side of the aerospace industry.

Hair *et al.* (2007) indicate that it is advisable to use quantitative data measurements where numbers are directly utilised to represent something's characteristics. The most common form undertaken in such studies entails statistical analyses. For quantitative data for this study, a questionnaire was sent to representatives of

enterprises in the aerospace industry and analyses were performed based on the responses from the questionnaire.

3.1.3 Research design

The presentation of the research problem in Chapter One guided the type of approach that was followed by the researcher. The problem statement further guided the researcher regarding the challenges or issues that needed further investigation. The research design and methods presented in this chapter guided the researcher to attain the desired outcomes of the study.

Yin (1994) refers to a research design as a process of developing a plan of action for moving from one point to the next, where the starting point could be the questions that the study attempts to answer and the end point being conclusions derived from responses. Babbie and Mouton (2001) describe research design as a "plan or blueprint showing how a researcher intends conducting his/her research" Hair *et al.* (2007) define a research design as the direction that must be followed when conducting a research project, in addition Nachmias and Nachmias (1992) further define a research design as a guiding strategy for the researcher in the course of "collecting, analysing and interpreting observations".

The main objectives of the present research are to assess and evaluate interactions between Government and the aerospace industry, including institutions of higher learning and training, research institutions and within the National Systems of Innovation. As indicated in Chapter One, the aim of the research is to investigate the application of the National Systems of Innovation (NSI) in the South African aerospace industry. The objective will be realised through the analysis of NSI in general, interactions between Government and the aerospace industry, and identifying various support mechanisms offered by Government to enterprises in the aerospace industry. From the literature review in Chapter Two, it was found that, most of the sources regard the aerospace industry as dependent on Government support and collaborations to succeed; however, Mayindi (2009) indicates that most studies prescribe models that developing economies should follow to be part of the global supply chain and further argues that for the aerospace industry to be sustainable, technology is one of the most important requirements.

Chilisa and Kawulich (2012) assert that once the researcher has a topic to study in mind, he or she must consider which method would be suitable to go about in investigating it. Furthermore, Schwandt (2000) highlights that researchers have their own views of what is truth and knowledge and based on their views, researchers have beliefs, different ways of thinking and assumptions about society and the world at large. According to Brown and Dowling (2001), the main objective of research is to describe a field under investigation and to understand practices and activities. They further highlight that the research process helps researchers to gain an understanding of the complexities of human experiences.

3.2 DATA COLLECTION INSTRUMENTS

The research is aimed at assessing and evaluating interactions among actors in the aerospace industry and to further investigate how such interactions and Government support can be improved to ensure that the industry becomes more competitive. To achieve the objectives of the study, the researcher made use of both primary and secondary data.

3.2.1 Primary data

A questionnaire was used to collect first-hand information from companies in the aerospace industry and further analysed to answer the questions of the research. According to Babbie (2004), questionnaires can be used mainly in survey research, but can be of assistance in field research and other observation methods; additionally, a questionnaire is a useful instrument for gathering data to define and address a problem.

According to Marshal and Rossman (2005), a questionnaire, if carefully planned, can produce usable data of high quality and should the response rate be good, a questionnaire can assist the researcher to achieve the desired outcome. A questionnaire assists the researcher to effectively collect information to meet the following conditions:

- Respondents are clearly identified and defined.
- Respondents are clear about what is being asked.
- There is a focus of numerical analysis.

In this study, the researcher has already identified the respondents as representatives from enterprises that are in manufacturing within the aerospace industry based in the Tshwane Metropolitan Municipality and who are experienced in the field, and who possess extensive knowledge of engagements/interactions with Government.

3.2.2 Secondary data

The following sources of secondary data were used:

3.2.2.1 Reports

The researcher utilised a number of publicly available reports with different scopes and purposes. Reports such as annual reports from the Aerospace Maritime and Defence Industries Association (AMD), the Council for Industrial and Scientific Research (CSIR) and reports from other Government departments such as the Department of Trade and Industry and the Department of Science and Technology were used to obtain high-level information. In addition, the researcher also scrutinised reports from companies such as Denel and Aerosud. Regarding institutions of higher learning, reports from institutions of higher learning and training that are active in the aerospace industry such as the University of Pretoria (UP) and University of the Witwatersrand (WITS) were scrutinised for their contributions towards the development of the aerospace industry.

3.2.2.2 Official documents

According to Van der Waag-Crowling (2013), the term official documentation refers to a distinct collection of official documents. Most of the official documents that the researcher scrutinises include policies published by departments that have interest in the aerospace industry. Sources such as these are very useful for the present study

because they highlight the national objectives on how Government envisages the direction of the aerospace industry.

3.2.2.3 Material from company websites and publications

Websites have been very useful in this study, because many organisations in the aerospace industry use websites to communicate with their stakeholders for information-sharing and the publication of important reports. Websites were also used because they are accessible and are accessible and cheap sources of information. Van der Waag (2013) highlights that it is cheaper to publish documents on websites than to print paper reports and newsletters. Websites are also environmentally friendly.

3.2.2.4 Books and theses from other researchers

In Chapter Two (the literature review), extant literature by researchers were consulted, specifically those that discussed the National Systems of Innovation of Innovation and interaction thereof with links to the aerospace industry in South Africa. The researcher also consulted sources relating to the aerospace industry in Brazil and India for an international perspective.

3.3 SAMPLING

The study is focused solely on interactions within the aerospace industry. The population of the study therefore included all enterprises involved in manufacturing aerospace products and contributing to aerospace innovation and technology development. From the population, the researcher drew a sample from only those enterprises with manufacturing activities. The nature of the research therefore necessitates a purposively selected sample in order to acquire reliable and relevant expert information. According to (Nastasi, n.d.), purposeful sampling focuses on specific characteristics of particular group of individuals. The sample included senior

managers of enterprises operating within the aerospace sector in the City of Tshwane.

According to Mouton (2001), a researcher can classify his or her data sources into different categories such as self-reporting where surveys and electronic resources could be used as tools for data collection. Consulted enterprises were sent the questionnaire using an email. Enterprises that responded to the questionnaire employ approximately 4 500 employees in total and, although the enterprise's facilities are based in Tshwane, it does not necessarily mean all their employees reside within the boundaries of the city. The sample was chosen because they are members of the Aerospace Maritime and Defence Industries Association and their contact details were obtained from their respective websites, which made them easier to reach.

It is important to note that the questionnaire was sent to 18 enterprises, but only 11 responded. Of the 11 respondents, three are classified as large enterprises in terms of their number of employees since they employ more than 300 employees each. The remainder of the respondents are from small and medium sized enterprises because these enterprises employ up to 200 employees.

3.4 DATA ANALYSIS

The research was aimed at investigating interactions between Government and the aerospace industry in South Africa. The researcher used a mixed methods approach, meaning that both qualitative and quantitative methods were used for the analysis of the interactions between Government and the aerospace industry. Existing literature was reviewed to address the qualitative approach. A detailed questionnaire was developed for the collection of primary data from enterprises within the aerospace industry and was used for quantitative analysis.

The researcher used existing industry reports and official reports as part of the secondary data, and primary data collected from the questionnaire was used to analyse the level of, and results from interactions between Government and the

aerospace industry. The researcher focused on companies that have manufacturing activities of products used in the aerospace industry based in the Tshwane region.

3.4.1 Limitations in analysis

According to Stangor (2011), there are limitations regarding the level of analysis, especially in questionnaires. This may be influenced by the fact that respondents may only provide positive information and not negative aspects of their organisation, which represents bias. To address this challenge, the researcher set out to ensure that the questionnaire did not include distracter items.

3.5 VALIDITY AND RELIABILITY

According to Bulmar and Warwick (1983), the validity of a study is based mainly on the accuracy of the technique used, its degree of legitimacy, and the effectiveness of that technique. According to Babbie and Mouton (2009:122) validity and be described as “the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration”. Validity must be proven or achieved through another researcher conducting the same study. Validity is therefore achievable through data triangulation (Guion, Diehl & McDonald, 2011). This process involves the use of different sources of information.

This study used triangulation by making use of available literature on the South African aerospace industry and the importance and role of interactions between industry enterprises, Government and academic institutions, official documents, reports, and other publications. The use of all these different sources of information will improve the validity of the study.

According to Bulmar and Warwick (1983:149), reliability is more about whether or not the research would yield the same results if it was conducted by another researcher at a different point in time. Reliability also depends on the capacity and personality of the researcher as well as environmental circumstances.

Reliability and validity provide the basis for evaluating the trustworthiness the research data, findings and conclusions (Lincoln & Guba, 1985).

3.6 LIMITATIONS OF THE STUDY

During the course of the study, the researcher experienced a number of challenges. These may be attributed to the fact that the Aarospace industry is dependent on, and is often closely linked to the defence industry, therefore some of the information required may be regarded as classified. Additionally, since the researcher is a human resource in the research, mistakes may be made and may have personal bias inferences. According to McMillan and Schumacher (2010), researchers are continuously influenced by the external environment during the research process. The research should analyse different sources of information to avoid being bias and to ensure inclusivity of as many as possible sources of information. Time was also identified as one of the restrictions because the researcher had a limited time in which the study had to be completed to comply with the institution of higher learning and training's prescribed duration of conducting research.

The research focuses on enterprises with manufacturing activities in the aerospace industry, and since the sample was fairly small, assumptions made may not be inclusive of the industry at large. The location of the sample was limited to companies in the Tshwane region; this means that the research is not comprehensive and exhaustive.

3.7 SUMMARY

This study uses a combination of qualitative and quantitative approaches to analyse interactions among actors in the South African aerospace industry. The analysis was conducted using open-source information obtained from secondary sources such as annual reports and questionnaires used for the quantitative analysis. For quantitative research, it is essential to select a sample that represents the features of the

population. It is essential to note that qualitative research focuses on processes rather than on outcomes. It is important to analyse such interactions to further widen existing knowledge on how the participants benefit the industry as a whole, especially with support from Government. Generally, the research thus follows an interpretative research process.

CHAPTER 4: DATA COLLECTION AND ANALYSIS - THE INTERACTIONS BETWEEN THE GOVERNMENT AND THE AEROSPACE INDUSTRY

4.1 INTRODUCTION

This chapter addresses the main questions of this study. The initial phases focus on the theoretical question on the interactions between Government and the aerospace industry to address the question pertaining to literature from existing sources. The latter section of the chapter uses primary research from results of the questionnaire from industry role-players. The primary data was analysed based on the responses to the questionnaire.

4.1.1 Interactions between the aerospace industry and Government

According to Edquist and Hommen (1999), the concentration on relationships among actors within the National Systems of innovation echoes the significance of institutions and the involved organisations beyond the boundaries of the market. Crucial to the whole innovation process is thus marked by interactions and partnerships between enterprises and various other actors (such as government, Institutions of higher learning and R&D institutions) who are integral and central to innovation. For the purpose of this study, the term relationship is used as an overarching word meaning interactions, collaborations and co-operations (Inzelt, 2004). Interactions in the innovation process include knowledge diffusion within the NSI and the contribution to innovation including minor contributions. The interactions and relationships between Government and industry are the foundations for collaborations in the aerospace industry.

Collaborations can take place in different forms; that is, between individuals, between groups, between institutions, sectoral and at a national level, whilst it may also be intra or inter-depending when economic actors are part of the collaboration. Government and industry collaborate with the aim of addressing national challenges such as unemployment and economic development. A number of actors in the NSI, including Government and private organisations, are not always driven by profits, but

their innovative activities are guided by a set of norms, rules and legal conditions to which they must conform.

Interactions between Government and the aerospace industry are not only important; they also ensure that the industry is competitive and gains a sustainable competitive advantage. According to Potgieter (2014), the interactions between industry and Government improve the industry's willingness to continuously maintain the skills base and product development capabilities, thereby contributing positively to the NSI. In South Africa, enterprises have sustained a high quality of technical skill levels in aerospace manufacturing using collaborative methodologies within the NSI. Opportunities created as a result of such interactions within the NSI, depending on how the local industry responds to international supply chains, will enable South African actors to position themselves better then international suppliers.

Due to the high-risk nature involved in the development of aerospace products and the high capital required by the industry, the industry has to some extent been characterised by political influence. According to OECD (2010), the aerospace industry in South Africa was generally driven and supported by Government to maintain regional dominance by the military and to maintain food security and sufficient energy supply. Government interaction with the industry has since ensured continuous support for innovation and technology, and the process was channelled towards state organisations in areas such as aerospace.

Interactions between Government and industry improve both parties' awareness of challenges that prevent the industry from improving their capabilities. This, in turn, allows Government to develop policies and interventions that can assist the industry in becoming more competitive. Interventions such as incentives and policies are discussed in greater detail in subsequent sections.

Interactions in the NSI can be formal or informal. According to Freeman (1991), both formalised and no-formalised collaborative networks play a significant role in NSI. Since the aerospace industry is regarded as a knowledge-based industry, Lundvall and Johnson (2003) highlight that, for knowledge-based industries or high-tech industries, such interactions are important for the creation, accrual and diffusion of knowledge aimed at enhancing technological advancement and innovations.

Although formal and informal interactions exist between the industry and Government, Edquist (1992) indicates that the mode of collaboration is inclusive of all economic actors within the system, including external interactions among suppliers, customers, regulators and those who provide knowledge to the system. One of the most important elements in the aerospace NSI and the innovation process is the partnership among enterprises within the industry, between enterprises, and between other agents such as Government and Institutions of higher learning.

4.1.2 Advantages of the relationship between Government and industry

According to Okamoto and Sjöholm (2001), a sound relationship between Government and industry within the NSI could lead to the following benefits towards technology advancement and sustainable development:

- New technology and expertise can be acquired using the channels of foreign experts, and trading enterprises and foreign buyers, which means that trade would be opened, together with increased investment and skilled labour leading to improved industrial technology development.
- Acquisition, upgrade, and dissemination of technology and expertise can be achieved, which lead to improvements of the technology ladder.
- Foreign Direct Investment (FDI) is important for technology advancement. It can be utilised as a tool for introducing new technologies, job creation, product expansion and exports. It can also be utilised to support Government funding where there are constraints, though not necessarily leading to technological upgrading.
- Development of infrastructure, inclusive of technological, managerial and institutional infrastructure, which promote technological development.

4.1.3 The aerospace industry's contribution to NSI

The aerospace industry and Government both aim to improve industrial capabilities within the NSI, thus improving the general national industrial competitiveness which are discussed below.

Technologies and capabilities developed in the aerospace industry have been widely used to reach associated sectors, especially the ICT and the automotive sector of the economy. A comprehensive study by the Department of Trade and Industry assessing the contribution by aerospace industry to the economy found that the industry contributes approximately R5 Billion in the form of annual sales to the national economy and employs almost 12 000 people. The study also indicated that approximately 25% of the products manufactured by the industry are used for defence applications (TISA, 2012).

The industry's functionality is enhanced by the fact that it does not operate in isolation. Most of the work is further subcontracted to enterprises in other sectors, therefore stimulating interactions with other industries. Most enterprises in the industry have competencies in aircraft maintenance and possess a high level of skills in this regard. According to Mayindi (2009), the local market is not sufficient to support its aerospace industry, and consequently enterprises are not building capabilities in the aerospace industry that focus on demands from domestic customers – they rather focus on international market demands. Some enterprises in the aerospace industry collaborate for technology development purposes and continuously share information and exchange knowledge, which lead to an improved competitive edge for the local industry. An example of such information flow and technology development is the relationship between Denel and Aerosud in the manufacture of aerostructures/airframes and components for the interior of aircrafts, which is complementary for both companies (Mayindi, 2009).

Cohen and Levinthal (1990) indicate that the use of external resources reduces the responsibility of production factors required in the innovation process. For the receiving enterprises, the use of external resources leads to a better quality of factors of production. Depending on how effective enterprises are in adopting new technologies, enterprises in the aerospace industry can improve their abilities for

product development and processes through the adoption of newly developed products resulting from R&D activities in the NSI (Klevorick *et al*., 1995). However, enterprises must strive to reduce their dependence on R&D activities emanating from other actors and should attempt to invest in their own R&D activities (Feldman, 1993).

4.1.4 The role of Government in support for innovation in the aerospace industry NSI

According to Inzelt (2004), it is Government's responsibility to support collaborations in research and development within different economic sectors, because industry is often reluctant to invest given the risk associated with R&D. Internationally, policy programmes emphasises the importance of collaboration and interactions, and R&D and innovation policy programmes are essential coordinating forces in the area of Government-subsidised research. Government support programmes can encourage the aerospace industry by minimising the risk of partnership-building with a strong scientific base. The following section discusses the role of Government in supporting innovation in the aerospace industry.

Government, through its policies on capital markets, education or issuing of subsidies, can influence or shape competitiveness of the NSI. The effort of the South African government in developing a policy for the development of the civil aerospace industry, and also in providing funding in that regard, have a major effect on the capacity-building and the competitiveness of local enterprises. It is the responsibility of National Government to impose standards and regulations, encourage interactions among local enterprises, to provide communication infrastructure and institute adequate formal education (Calliano & Carpano, 2000).

The two mostly active Government departments that support the aerospace industry are the Department of Science and Technology, which is responsible for R&D, Science and Technology development policies, and the Department of Trade and Industry, which is responsible for ensuring that tangible technologies are commercialised through industrial development policies.

In order to address and maintain R&D activities in the county, the South African government established the Council for Science and Industrial Research (CSIR) in 1945 to act as the main industrial research institution (Gerryts *et al.*, 2008). As an industrial research institution and an agency of Government (agency of DST), the CSIR supports the local aerospace industry in conducting primary research because it is capacitated to perform such high-tech activities.

The aerospace industry is characterised by advanced technology which is often considered to be a national security matter, and governments across the world are involved in supporting the sector. According to Gerryts *et al.* (2008), the aerospace industry is generally considered to be high-tech based, due to the degree of R&D investment by the sector. They also indicate that it is highly competitive and technology is a key differentiator and essential for competitiveness.

Grerryts *et al.* (2008) further propound that the role of Government in support of innovation is crucial as Government often funds the process of technology development in the early high risk phase where other enterprises are not prepared to take suck risks. This closes the gap between local enterprises and research conducted at science councils.

Government has recognised the importance of sustaining the aerospace industry and has, over the past decade, actively supported the industry and collaboration efforts through interventions such as the National Industrial Participation Programme (NIPP) and the Defence Industrial Participation (DIP), and has also assigned certain roles to various departments such as the Department of Trade and Industry (DTI), the Department of Public Enterprises (DPE), the Department of Science and Technology (DST), the Department of Defence (DoD), and furthermore established industry support initiatives such as the Aerospace Industry Support Initiative (AISI), an initiative of the Department of Trade and Industry and Centurion Aerospace Village (CAV). These are both initiatives of the DTI (IPAP 2016). Some of the policies aimed at supporting the aerospace industry include, but not limited to:

4.1.4.1 Support Programme for Industrial Innovation (SPII)

One of the support programmes aimed at stimulating industrial innovation is the SPII, which is designed for the promotion of technological development in South Africa's industry. The scheme was also designed to provide financial assistance for the development of innovative products and/or processes. The SPII is focused specifically on the development phase, which begins at the conclusion of basic research and ends at the point when a pre-production prototype has been produced (DTI, 2013).

4.1.4.2 Technology and Human Resource for Industry Programme (THRIP)

The Technology and Human Resources Programme (THRIP) is a flagship research and development programme of DTI managed by the NRF. This Government-private sector partnership programme was established in response to the recognition of the shortage of high-level technical skills for industry and the need to improve the competitive edge of South Africa's industry through the development of advanced technologies and highly skilled people (DTI, 2005).

THRIP is unique as it addresses one of the most fundamental weaknesses in the National System of Innovation (NSI), namely the shortage of technically trained personnel (Mani, 2001). This incentive scheme was established to enable South African industries, including aerospace, to respond to technological needs and to introduce a flow of highly skilled researchers and technology managers with a sound understanding of R&D, the development of technology, and technology diffusion in relation to industry and academic institutions.

THRIP is an instrument that offers technical training and educational requirements in complex activities within the NSI for development and diffusion of new technologies. THRIP is also a programme aimed at enhancing science, technology and engineering training. It contributes towards economic development through the support of research in technical and scientific areas that are regarded as major contributors to the economy (DTI, 2007).

A report developed by the Department of Trade and Industry (2007) indicates that where technology policy is deemed necessary, it is the role of Government to provide support to promote, coordinate and encourage technology development to further consolidate the overall industrial policy. According to Mayindi (2009), it is key for Government to provide a technology and innovation policy framework that encourages the coordination of technology development activities within sectors believed to be key for the development of industry and overall competitiveness.

4.1.4.3 Science, Technology and Innovation policy development

South Africa's targets for competitiveness improvement and growth of the economy rely, to a certain extent, on science, technology and innovation policy. It is the duty of Government to develop such policies especially at a national level. Government's developmental goals can be accomplished if policies support a knowledge-based economy in which science and technology, information, and learning are the main economic activities developed. According to Hornidge (2011), changes in scientific conceptualisations of ST&I have been coupled with modifications in science, technology and innovation policies. Based on concepts of the knowledge society or economic innovation, Government has the responsibility of developing concrete policies as a part of a national development agenda.

Policies developed by Government aimed at the improvement of science, technology and innovation require a significant investment and must address a wide range of national priorities. Resulting from the investment should be more social and economic transformation, because ultimately, such investment will contribute to more rapid economic and social transformation. According to the Ten-year Plan for Science and Technology (2008), the South African Government is investing in human capabilities that will serve its needs well into the future by committing to the growth of the science and engineering base in areas that are believed to be sustainable in the long run. By directing expansion and new globally competitive industries such as aerospace and automotives, the country aims for independence on technology from foreign countries, and become more self-sustainable.

The following trends have been identified as main technology policy objectives (DTI**,** 2007):

- Identifying, promoting and encouraging the development of technologies relevant to the needs of the country.
- Developing a technology infrastructure to meet existing and future needs of industrial development and global competitiveness.
- Developing mechanisms for collecting, analysing, evaluating, selecting and disseminating technology information, thereby ensuring there is a regular flow of vital technology information to key sectors of the economy.
- Employing technology for the efficient utilisation of the nation's resources.
- Providing standardisation and quality systems in the manufacturing of goods and services for the enhancement of competitiveness in local and foreign trade.
- Promoting the educational and professional development of human resources to support the needs of the scientific technology community.
- Improving the quality of life of citizens and protecting and conserving the natural environment.
- Supporting the integration of technology in macro-economic planning.
- Promoting the inclusion and advancement of all social groups in the technology application.
- Increasing public awareness and acceptance of technology.

4.1.4.4 Support for commercialisation of innovations

According to Rasmussen (2008), there have been developments in international research systems that aim to improve the rate of commercialisation of new technologies and innovation. According to Lehrer and Asakawa (2004), policy and changes to the legislative environment have increased expectations requiring institutions of higher learning’s contributions to commercialisation. Lockett and Wright (2005) indicate that a number of policy developers, mostly at institutions of higher learning and regional levels, are beginning to allocate resources to create an

environment where research results from institutions of higher learning could lead to spin-offs in industries.

4.1.4.5 Support for enterprise-led R&D

There are various ways in which Government supports enterprise-led R&D. A report by the World Bank (2010) highlights that a government can support R&D led by enterprises through instruments such as tax allowances, non-repayable financial assistance (grants), accelerated depreciation on R&D equipment, duty exemptions on imported equipment and other research inputs, and venture capital to support high-technology start-ups. According to OECD (2010), many governments do not only consider incentives support; they also focus on tax breaks to support targeted interventions. The World Bank (2010) further indicates that governments can also support enterprise-led R&D more generally by developing human capabilities and promoting linkages between enterprises and public R&D laboratories.

4.1.4.6 Stimulating cooperation between industry and institutions of higher learning

Institutions of higher learning and industry should take their responsibility to work collaboratively seriously, and should recognise the interplay between their innovation activities and global contexts of innovation (Taylor, 2016). Mowery and Rosenberg (1993) allude to the importance of interventions by Government and the role it plays in enhancing the supply of potential innovations in the aerospace. According to Mayindi (2009), government policies have an impact on the demand for innovation by the aerospace industry by providing substantial incentives for rapid adoption of innovations. Furthermore, Taylor (2004) indicates that Government can assist this by incentivising collaborative behaviour between institutions of higher learning and industry to stimulate cooperation between them.

4.1.4.7 Infrastructure

Infrastructure, especially transport infrastructure, plays a very important role in ensuring that products and information move efficiently among those who would

want to work together within the NSI. According to Ejermo (2004), well-built infrastructure in functional industries and regions leads to shorter travel times and may stimulate knowledge production. Braunerhjelm and Feldman (2006) indicate that most innovations are dependent on geographical infrastructure and the capability of mobilising all inputs such as technical resources and knowledge needed in the innovation process. Furthermore, Braunerhjelm and Feldman (2006) emphasise that clusters bring higher innovation levels because they create economies of scale and they shorten interaction distances in general. They further highlight that one of the most important features of clusters is the level of technological infrastructure within the NSI. Since it is costly for individual enterprises to develop infrastructure such as freeways, airports and railways, it is the duty of Government to ensure that such infrastructure is in place to allow sufficient movement within the NSI.

It is important to highlight that the South African government has envisaged having a cluster for the aerospace industry since 2006, namely the Centurion Aerospace Village, but to this date there seems to have been delays due to bureaucratic challenges and corruption. This prevents the growth of the industry, because enterprises that should be taking advantage of such initiatives often opt for alternatives to enhance their competitiveness.

4.1.4.8 Incentives

Incentives schemes can be stimulated by both private and government expenditure. According to Anderson *et al*. (1994), incentive systems aim at adding greater value to the country's R&D efforts to increase the rate at which enterprises innovate. Incentive schemes may include tax breaks and spending by Government or private enterprises. Tax rebates allows the industry to conduct more R&D activities, because the more R&D activities performed by an individual enterprise, the more rebate they will receive from Government. However, Hall and Reenen (2000) indicate that fiscal incentives are ineffective because the response elasticity from the private sector is very low. Another problem identified by Hall and Reenen (2000) is that financial incentives change very often and this creates uncertainty among enterprises.

Government frequently experiences difficulties when administering financial incentives for innovation. Anderson *et al.* (1994) indicate that Government faces adverse selection challenges in ensuring that he incentives provided achieve their objectives, and generic misinformation on the projects that should be supported. This leads to support given to worst performing enterprises an industry.

Smaller enterprises in the aerospace industry also find it difficult to access the incentives offered by Government, mainly because they do not have the capacity to adhere to the requirements stated in the application processes. For larger enterprises, it is easier because they employ the services of consultants to deal with the application processes. This has a negative impact on smaller enterprises and leads to them often closing down due to financial challenges, especially since they depend on sub-contracting work from larger enterprises.

4.1.4.9 Education and training

The aerospace industry is driven by technology and requires highly skilled and educated personnel. However, Anderson *et al.* (1994) indicate that the linkages between higher education and innovation are rather very weak. According to Kalaitzidakis (1997), it is not only the responsibility of Government to invest in education and training; it is also the responsibility of the industry. Training improves employees' productivity because they become more efficient. Acemoglu (1997) highlights the importance of appropriate training for employees when adopting innovations and technologies and that it benefits not only the involved organisations, but the entire NSI.

4.1.4.10 Foreign policy

There are mainly three ways in which local enterprises can participate in the export market and improve their productivity growth. Anderson *et al*. (1994) identify these as (i) learning by doing (exporting), (ii) competing in the international market, and (iii) mass production to exploit economies of scale. Smaller enterprises beginning to export are believed to be more willing to invest in R&D in order to adopt foreign technologies and best practices. Baldwin and Johnson (1995) indicate that

enterprises participating in the export market use advanced technologies and improve the novelty of the innovations that are introduced.

Since no enterprise can operate in isolation within the NSI, some would import technologies to be used in their processes. Johansson *et al.* (2006) indicate that the import of foreign technology shows that enterprises are interdependent, and therefore enterprises in should adopt foreign technologies and add value by their own efforts on R&D. Imported technologies can assist in stimulating the competitiveness of local industry since these reduce monopolistic innovators and market power Baldwin (1999).

4.1.5 The role of institutions of higher learning and training in aerospace industry interactions

According to Martin (2000), the role played by institutions of higher learning in the innovation process has improved dramatically in our time. As a result, new products and technologies have been introduced due to scientific research conducted by institutions of higher learning. The introduction of new products and production processes demonstrates the growing importance of collaborative R&D and interrelations of basic research and applications in industry. Mansfield (1995) concurs that essential innovation impulses in key technologies used in technology intensive industries are derived from technology research conducted at institutions of higher learning with interactions and collaborations with industry.

Research conducted by institutions of higher learning for the aerospace industry plays an important role as a source of fundamental knowledge and, occasionally, industrially important technology in modern knowledge-based economies. Many of the initiatives aim to improve local economic development based on research from Institutions of higher learning, for example by creating science parks such as the Centurion Aerospace Village located nearby research institutions of higher learning campuses in Pretoria, support for business incubators and public seed capital funds, and the organisation of other forms of bridging institutions that are believed to link institutions of higher learning to industrial innovation.

Another important role played by institutions of higher learning is that the research they conduct is of particular importance to enterprises in the R&D intensive industry sectors such as the pharmaceuticals and aerospace. According to Klevorick *et al*. (1995), enterprises in these industries use results from such research and engineering to further improve their products and processes.

Freeman (1991) indicates that both formal and informal networks among institutions of higher learning have played an important role in innovation for decades. According to Lundvall and Johnson (1994), the emergence of the new economy, which occurred during the 1990s, is altering relationships among science, technology, innovation and economic performance. Edquist (1992) further highlights that a collaborative mode of innovation always involves external interactions among customers, suppliers, regulators and knowledge providers.

4.2 NSI IN SOUTH AFRICA: A POLICY PERSPECTIVE

Policies guide documents that expedite the relationship between Government and actors within the aerospace NSI. It can be argued that most of the policies applicable to the aerospace industry are proactive policies. According to Torjman (2005), public policy aims to achieve a desired goal that is in the best interest of all members of society. Furthermore, Torjman, (2005) indicates that a public policy is a deliberate and careful decision that provides guidance for addressing selected public concerns.

The reasoning behind most innovation policies is that they are aimed at enhancement of technological change, which is highly considered as a basis of economic growth, social development, and environmental adaptation. According to the World Bank (2017), nations have different assets and capabilities; however, developing countries such as South Africa face various limitations such as inadequate infrastructure and a lack of resources. It is therefore crucial to provide orientations to encourage the effectiveness of innovation policy in diverse policy settings, including the most challenging ones.

The policy framework that guides the NSI in the aerospace industry is discussed below:

4.2.1 The White paper on Science and Technology

The 1996 White Paper on Science and Technology introduced the concept of a 'National System of Innovation' into South Africa's formal public policy discourse, resulting in the White Paper becoming the cornerstone of Government policy on science and technology (DACS & T, 1996). The White Paper conceptualises the National System of Innovation (NSI) as a mechanism through which a country seeks out the creation, acquisition, diffusion and implementation of new knowledge that will aid in the achievement of the country's collective goals. The definition of an NSI further entails the development intent of a country's science and technology policies, thereby setting the scene for a system that focuses mainly on generating and applying knowledge for the nation's social and economic development (Manzini, 2012).

4.2.2 The National R&D Strategy

The new R&D strategy is based on the National System of Innovation (NSI) adopted in the White Paper on Science and Technology in 1996. It highlights the short and long-term performance measurement framework of the Science and Technology system. The strategy further indicates that innovation is the vehicle through which economic growth and wealth creation can be achieved. Government plays a vital role in innovation in supporting the technology development process by targeting resources at areas of great potential and ensuring that there are adequate financial resources (DST, 2012).

4.2.3 Ten-Year Innovation Plan

The Ten-Year Innovation Plan (2008) aims to assist in driving South Africa's transformation towards a knowledge-based economy, in which economic growth is derived from the production and dissemination of knowledge for the enrichment of all the citizens of the country. A report on the innovation policy by the World Bank indicates that innovation is significantly dependent on overall conditions of the economy, education, governance and infrastructure. The World Bank (2010)

highlights that innovation is different from research, and, in fact, need not result from it. Innovation is achieved by entrepreneurs who make it possible and this notion hinges on a society's receptivity to such efforts. Therefore, innovation is essentially a social process.

4.2.4 National Industrial Policy Framework (NIPF)

The NIPF supports and encourages the diversification of the economy away from its traditional dependence on minerals and mineral processing towards improved value-added per capita, characterised by increased downstream of higher value-adding activities and technological leadership. It focuses on industrial development by utilising Government strategic programmes such as industrial financing, industrial infrastructure, leveraging on Government procurement, and also innovation and technology programmes (NIPF, 2010).

The quality of the public research infrastructure and its links to industry may be one of the most significant national assets for promoting innovation. Institutions of higher learning and training and government-supported research institutes are key role-players in generic research. These institutions offer a body of basic knowledge for industry as well as sources of new techniques and valuable skills. The research conducted at these institutions is increasingly being reinforced by enterprises that are collaborating with the public sector technology projects, contracting specific research or financing staff and researchers (OECD, 1997).

4.3 ASSESMENT IN PRACTICE: EMPIRICAL RESULTS

The following section presents an analysis of the results of the data collected from the questionnaire.

4.3.1 Questionnaire results

4.3.1.1 Research subjects

The research subjects consulted in this study are senior representatives from enterprises that have manufacturing activity of components that are used by the aerospace industry and are based in the Tshwane Municipality. The questionnaire was sent to 15 enterprises, but only 11 (73.33%) responded. All 11 respondents (100%) have been with their respective organisations for 10 years or more and have extensive experience in the aerospace industry.

The first question asked was whether they have interacted with Government in request for support. All the respondents (100%) indicated that they have indeed done so. The assistance required could be financial incentives offered by the different Government departments in support of the aerospace industry. Alternatively, Government also offers other non-financial assistance to the aerospace industry such as support for export marketing through EMIA as administered by the DTI. Other Government agencies may also have been approached with requests for assistance, especially the South African Revenue Services (SARS) and the International Trade Administration Commission (ITAC) for issues pertaining to international trade and tariffs on importing and exporting of components manufactured by the industry.

The second question asked whether respondents have ever interacted with other local actors (firms) within the NSI, and 100%of the respondents indicated that they have been involved in some kind of interaction with a local player. The interaction among players, as indicated by the responses, shows that there is some level of collaboration within the industry/ However, the relations are negatively impacted by larger enterprises that dictate the direction of the relationship, especially when collaborating with smaller enterprises

Enterprises in the aerospace industry not only interact with Government in request for financial incentives. From time to time they also interact with regard to issues relating to market challenges such as increasing import duties for protection of local

industry. Government also supports the industry to market their products abroad by assisting them to participate in international exhibitions such as the Latin America Aerospace and Defence and the Africa Aerospace and Defence to showcase their capabilities and product offerings.

The section below represents the results using figures

Figure 4: Interaction with local university or Research and Science Council

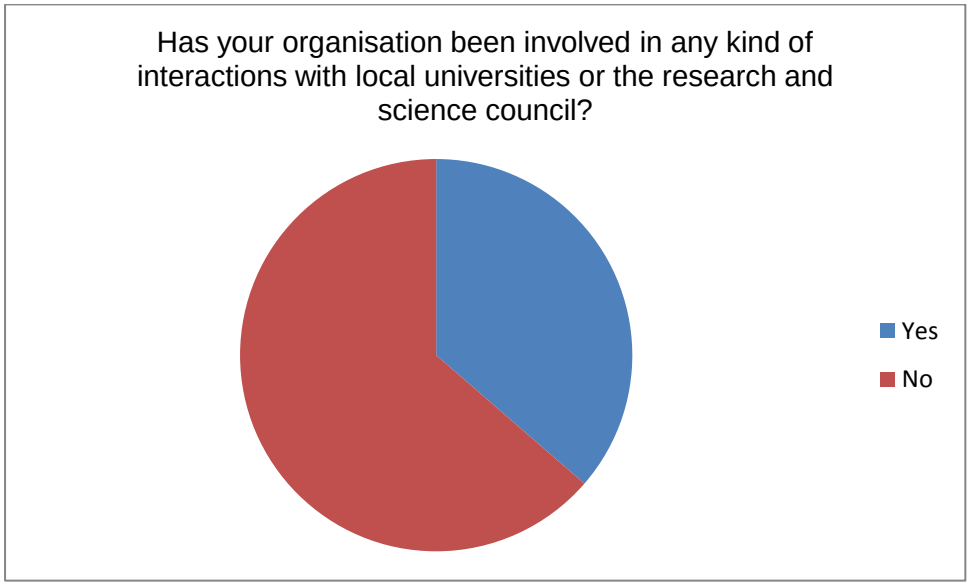


Figure 4 shows that out of eleven (11) respondents, nearly two thirds indicated that their organisations have been involved with either a local universities or the research and science council. The remaining 36% indicated that they had not been involved in any interaction with the institutions in question. The figure further indicates that there is some level of collaboration between local enterprises. Since the respondents are based in the Tshwane Metropolitan Municipality, it can be argued that of those agreeing to have interacted with the research institution simply means that they have interacted with the CSIR as it is the only research institution within the metropolitan with research activities related to the aerospace industry.

The University of Pretoria's mechanical and aeronautic engineering department has collaborated with a number of local enterprises such as the Aerospace Industry Support Initiative for the development of fuel slush for smaller aeroplanes. This project is still in the research phase and it is proof of how the industry and universities can collaborate.

The remaining 36% indicating that they have not interacted with either the university or the science council are smaller enterprises which may not be able to afford cost related to services offered by the research council. One of the challenges identified in this research is that, although small enterprises may have innovations that they would like to research further or commercialise, they often abandon the process because of the cost associated with such activities and therefore lose opportunities presented by the market. It is important to note that the science council adopts the user pay principle where companies are charged an hourly rate for services rendered, regardless of the size of the company requesting the services.

Figure 5: Improved processes or introduced a new product (innovate or invent) as a result of Government assistance

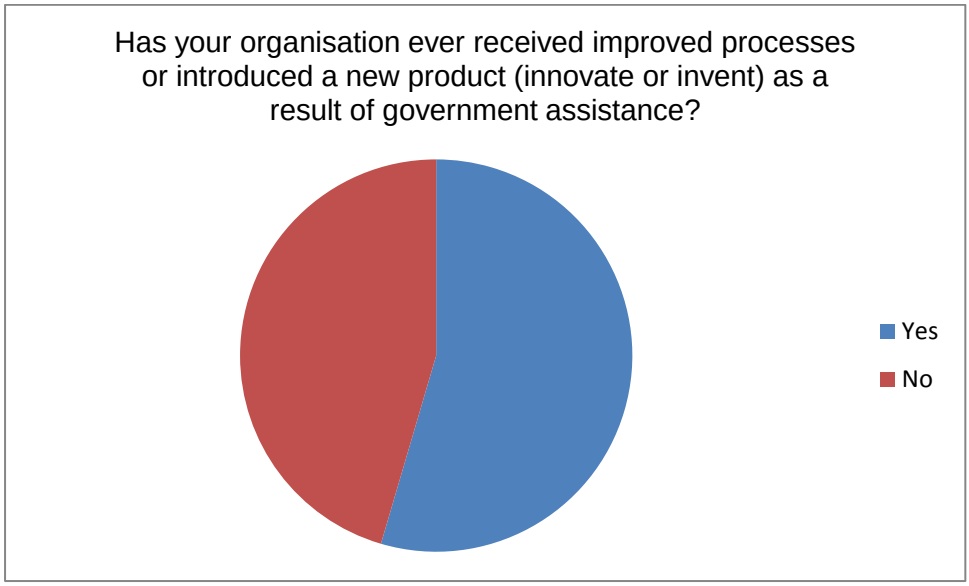


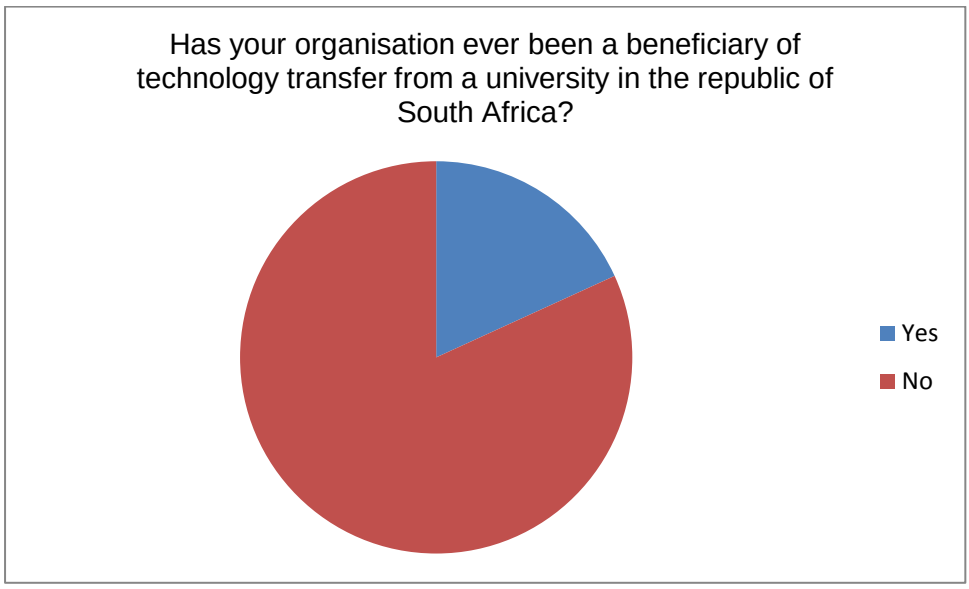
Figure 5 shows how many enterprises within the industry have received improved processes or introduced a new product as a result of government assistance. A little over half (54%) of the organisations having received improved processes or introduced a new product (innovate or invent) as a result of Government assistance, while 46% have never been recipients of improved processes that have resulted in the introduction of innovative products.

It is not clear whether those that did not introduce a new product or process due to assistance from Government requested the assistance or not. Those that have introduced a new product or process all indicated that they have received some form of assistance from Government. Government, through the Department of Trade and

Industry, has a number of financial assistant schemes (incentives) in place, but it is not clear whether they support the aerospace industry sufficiently.

A comparison in this regard can be drawn from the automotive industry as it is closely linked to the aerospace in terms of manufacturing processes. The automotive industry has an industry specific financial assistant scheme called the Automotive Production and Development Programme (APDP) for the promotion of production volumes and component manufacturing within the country. Benefits of the APDP have, to a certain extent, introduced new products and processes as a result of the support received, but the same has not happened in the aerospace industry. Under the APDP, OEMs in the automotive industry importing input components can apply for a rebate from the South African Revenue Services and can also apply for a refund for importing certain components. It is not clear whether the aerospace industry will also be the recipient of a newly introduced industry-specific incentive scheme by Government.

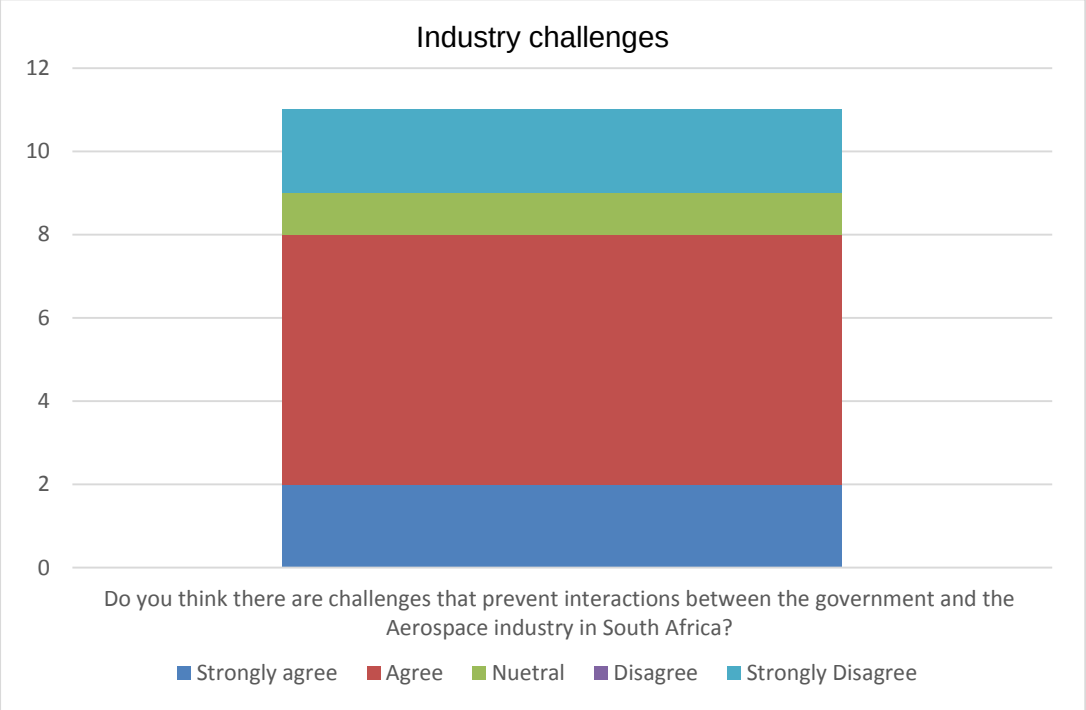
Figure 6: Beneficiaries of technology transfer from a university in the Republic of South Africa



When asked if their respective organisations have ever been beneficiaries of technology transfer, 82% of respondents said no, while the other 18% said they have benefited from technology transfer initiatives.

The figure above indicates lack of technology transfer from universities to organisations. Respondents who indicated to have been beneficiaries of technology transfers are mostly large enterprises. It often takes time for a research developed at a university to be transferred to industry, and small enterprises often cannot wait for a long time due to competitiveness in the industry. The majority indication of a lack of benefits of technology transfer again can be attributed to a lack of knowledge by the industry about activities conducted by universities in relation to the aerospace industry.

Figure 7: Challenges within the industry



The above figure indicates challenges within the industry relating to interaction between industry enterprises and Government. When asked if there are challenges that prevent interaction between Government and the industry, over two thirds, about 65% of the sample, agreed (a combination of strongly agree and agree) and a little over 20% strongly agreed, with less than 10% choosing to remain neutral on the matter.

The majority of respondents agreed the lack of interaction among players is a significant contributing challenge. This has affected the industry and has made the industry less competitive with international peers. The lack of support from

Government has also been identified as one of the most salient challenges. The international comparison presented in Chapter Two indicated how governments across the world intervene to assist their aerospace industries, but the South African government seems to be offering a little in support of the industry, especially in terms of financial assistance.

Government, through the Aerospace Industry Support Initiative, has been supporting the industrial capabilities and facilitating technology transfers both from enterprise to enterprise and research institutions to enterprise and university to enterprise. This, however, has not eliminated the many challenges faced by the industry in terms of competitiveness against international enterprises such as high input costs, among others.

Figure 8: Industry challenges

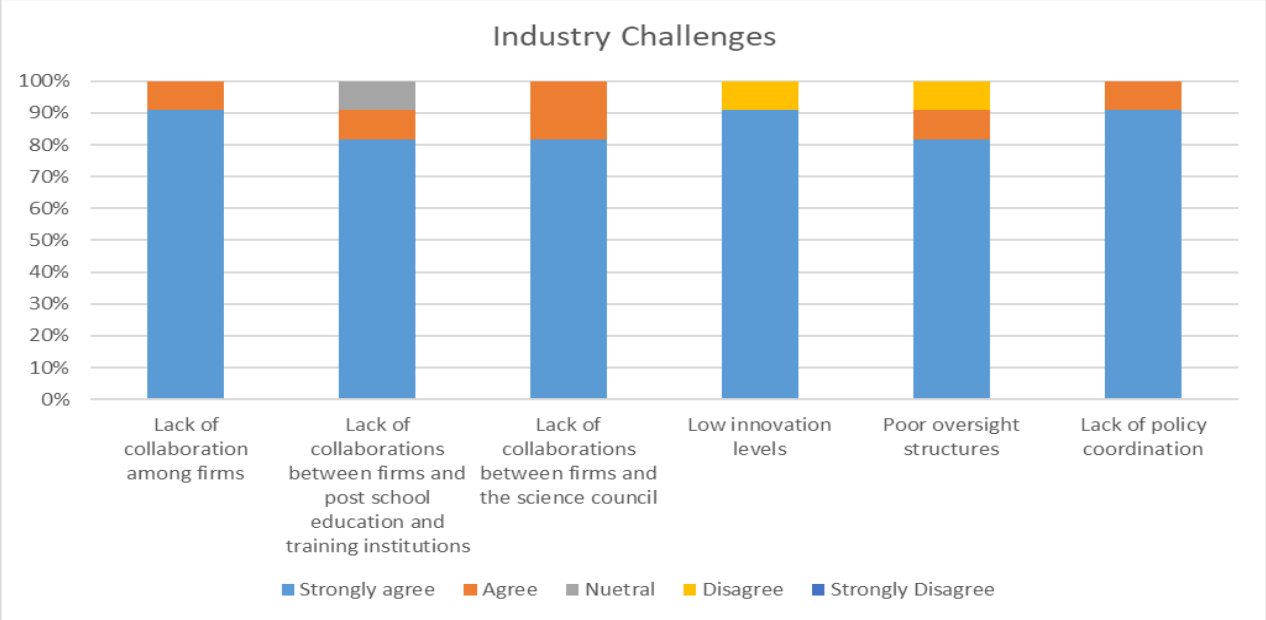
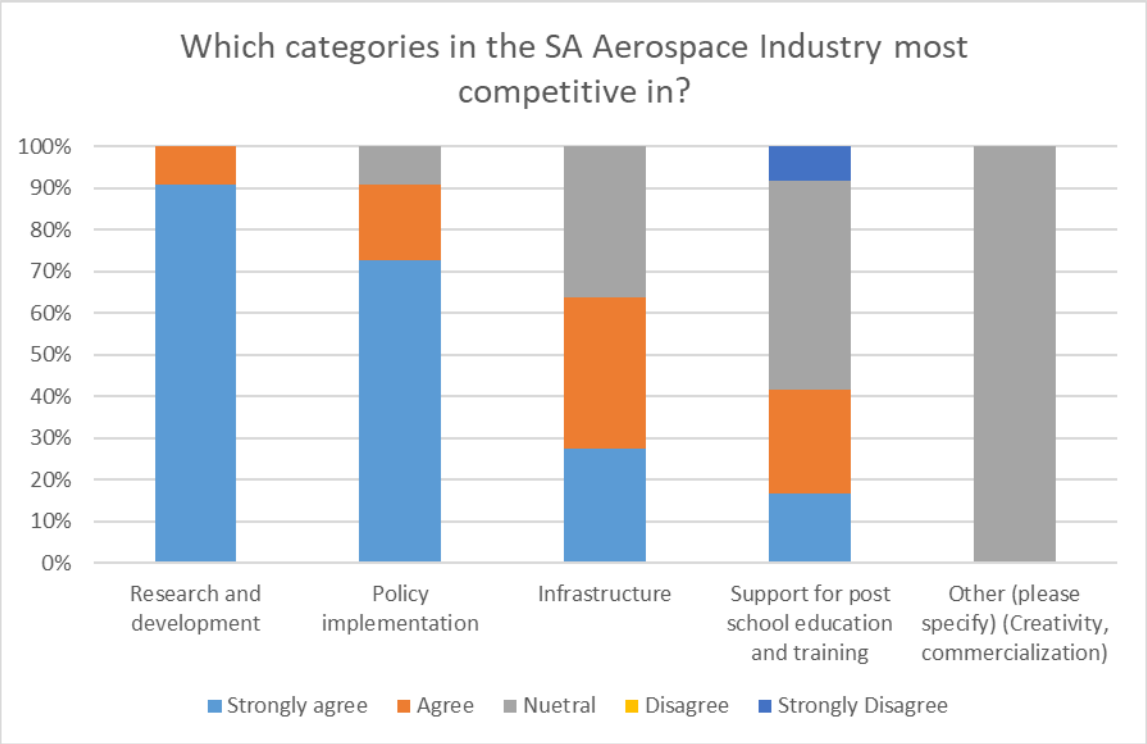


Figure 8 is a depiction of the responses of the sample with regard to questions related to areas where the industry faces challenges. Approximately 90% of respondents strongly believed that there is lack of collaboration amongst enterprises in the aerospace industry, whilst there is also evidence from respondents' responses (80%) that there is lack of collaboration between enterprises, post-school education and training institutions. Over 80% strongly agreed that there is a lack of collaboration between enterprises and the science council. Furthermore, over four quarters of respondents strongly agreed that there are low levels of innovation and

poor oversight in the industry. The lack of policy coordination is confirmed by approximately 90% of the sample strongly agreeing to the construct about lack of policy coordination. An average of 80% across areas within which the industry is facing the most challenges can be seen.

The above figure indicates that the majority of the respondents indicated that enterprises within the aerospace industry do not collaborate. The lack of collaboration among enterprises within the industry is a concern, because the three major enterprises in the aerospace industry are based in the City of Tshwane Metropolitan Municipality. The data shows that enterprises in the aerospace industry (over 80% of respondents) have not collaborated with the science council, and this should also be a concern since the science council is in the Tshwane Metropolitan Municipality. The lack of collaboration among the science council and industry can also be the result of industry having to pay to use facilities of the science council and they often find it expensive to utilise these.

Figure 9: Industry competitiveness



The above graph shows categories in which respondents felt that industry is most competitive. Approximately 90% of the sample strongly agreed that research and development in the industry is very strong, while a little over 70% strongly agreed

that policy implementation in the industry remains strongly competitive. About 20% of the sample agreed to this fact as well, while the remaining respondents were neutral. It is also evident that infrastructure within the industry is competitive with about two thirds of respondents agreeing with this statement while about 45% of respondents were neutral on the matter. However, only 42% of respondents believed that support for post-school education and training is competitive, while approximately 50% of respondents were neutral and 8% strongly disagreed that this category is competitive.

Based on the responses received, 90% of respondents agreed that the aerospace industry is competitive because the industry has a rich history that was supported by the apartheid government for R&D activities. The R&D facilities established during the apartheid regime are still evident but dilapidating at the CSIR. Implementation of policies such as IPAP and the AMTS contributed to the respondent's agreement with 80% of respondents indicating that policy implementation is competitive. The challenge currently facing the industry and Government is the lack of funds for the implementation of the defence review, which would contribute positively to the entire industry and spill over to related industries. Fewer than half of the respondents agreed that Government is doing enough in terms of supporting post-school education and training. It is, however, not clear how Government is trying to resolve the problem of the mismatch between graduates produced by the education system and what is required by the industry. One respondent indicated that there is lack of creativity and commercialisation and that the industry is still traditional and relies on old manufacturing processes and do not commercialise new products rapidly enough.

Figure 10: Interventions to address industry challenges

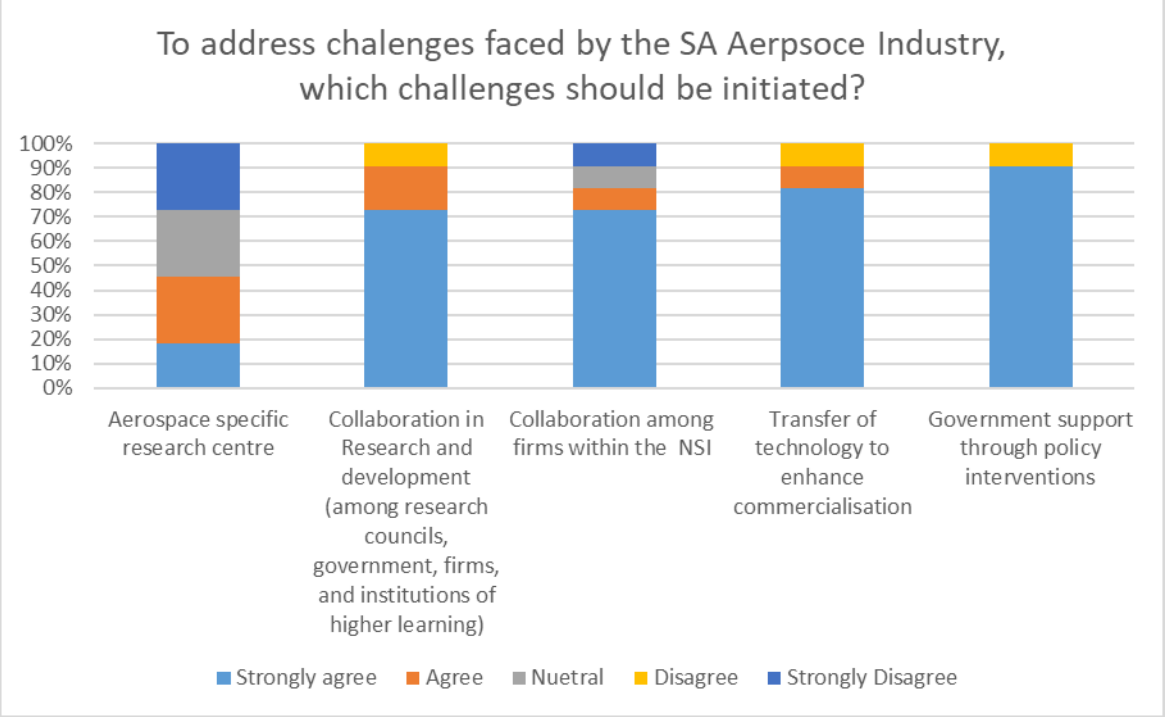
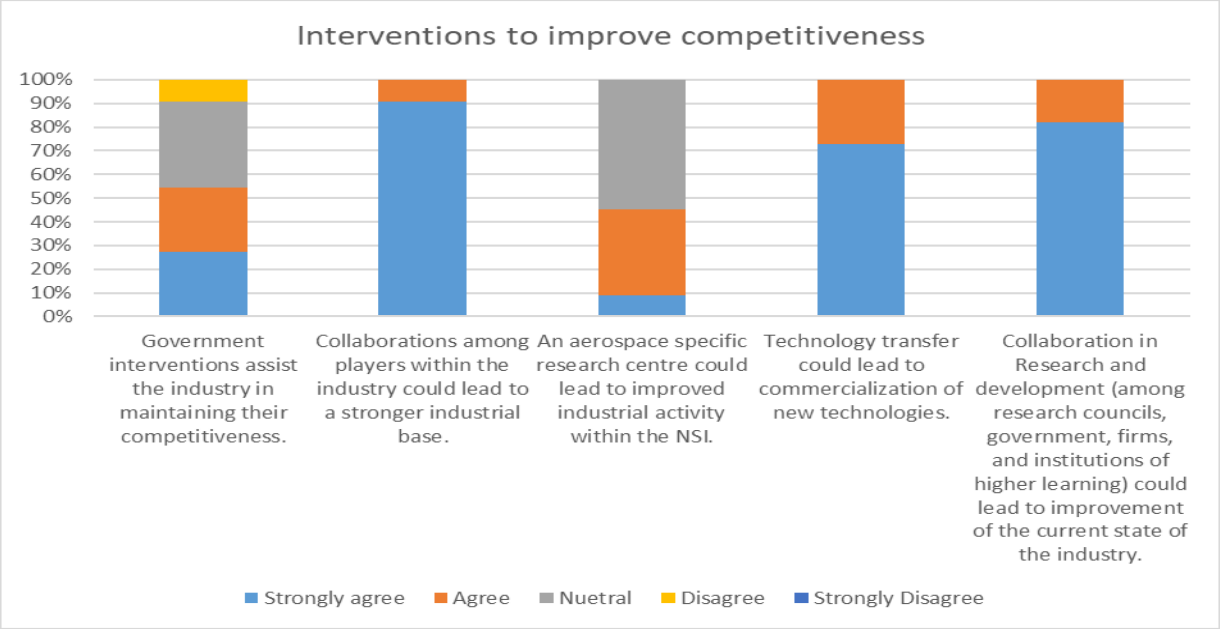


Figure 10 shows responses of participants towards interventions that should be initiated to address challenges faced by the industry. Of these, 45% agreed that an aerospace-specific research centre could be effective in addressing industry challenges, while 23% strongly disagreed and the remainder was neutral on the matter. As much as 90% of the sample agreed with collaboration in research and development (among research councils, government, enterprises, and institutions of higher learning) being an effective intervention while the remaining 10% disagreed. Eighty two per cent of respondents strongly agreed that collaboration among enterprises within the NSI, 8% simply agreed and 10% were neutral and the remaining 10% strongly disagreed. A large percentage (90%) strongly agreed that transfer of technology to enhance commercialisation could be an effective initiative to address industry challenges while 10% strongly disagreed.

More than 25% of respondents where neutral regarding the need for an aerospace-specific research centre to address competitiveness. A majority of the respondents strongly agreed that collaboration among industry players could lead to a stronger industrial base. Government should adopt the South African Inc. approach in the aerospace industry because the industry is too small to compete against itself. Local enterprises should collaborate for international contracts, thereby contribute

positively to the economy. A majority also strongly agreed that the industry needs to collaborate with the science council. The researcher's view in this regard is that the science council should lower their costs for SMMEs to access their services. Alternatively, Government should subsidise smaller enterprises to afford them an opportunity to utilise the services of the science council.

Figure 11: Interventions to improve competitiveness

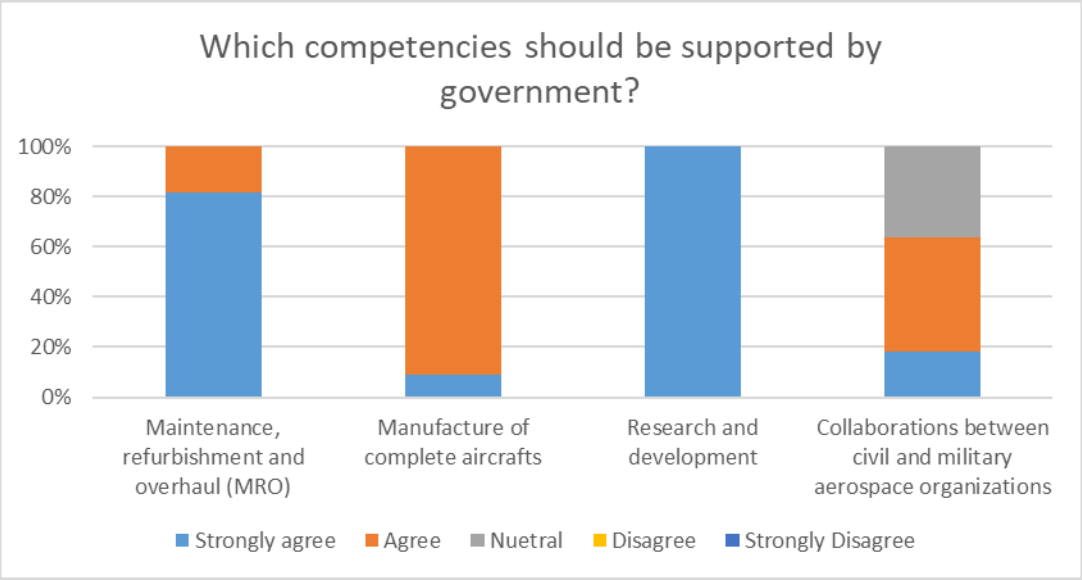


The need to improve competiveness in the industry has been identified as the majority of respondents agreed on this issue as indicated in figure 11 above. Respondents were asked to indicate how much of each construct can contribute towards improving competitiveness of enterprises within the industry. Over 50% of the sample agreed that Government interventions assist the industry in maintaining their competitiveness, while over 35% decided to remain neutral about this construct and 10% disagreed with this statement. As much as 90% strongly agreed that collaboration among players in the industry could lead to stronger industrial base. Approximately 42% agreed (a combination of strongly agree and agree) that an aerospace-specific research centre could lead to improved industrial activity within the NSI, while the remaining number were neutral. Over 70% strongly agreed that technology transfer could lead to the commercialisation of new technologies and approximately 82% of the sample strongly agreed that collaboration in research and development (among research councils, Government, enterprises, and institutions of

higher learning) could lead to improvement of the current state of the industry, with the remainder agreed with this statement.

Ten per cent of respondents disagreed that Government's interventions do assist the industry may be due to them needing assistance but did not approach funders because of unknown reasons. Applications for assistance by enterprises are often rejected for a number of reasons, including non-compliance to BBBEE. The aerospace industry is one of the less transformed in the country, and most enterprises are reluctant regarding compliance with some stating that international requirements in terms of standards which is difficult for SMMEs to accomplish. Over half of the respondents indicated that, should technology transfer be strengthened, the industry can introduce a number of new products through commercialisation.

Figure 12: Government support



Respondents were asked to indicate which competencies within the industry should be supported by Government. Eighty per cent of the sample strongly agreed with the support of maintenance, refurbishment and overhaul, and 100% agreed with the support of research and development. Less than 10% strongly agreed that manufacturing of complete aircrafts should be supported by Government, with the other 90% agreeing with this idea. When asked about support for collaboration between civil and military aerospace organisations, approximately 35% of the sample decided to remain neutral on the subject with over two thirds agreeing strongly with the need for Government support in this area.

Of the competencies that should be supported further by Government, majority of the respondents agree that MRO and R&D should be given priority. The respondents do not seem to strongly agree with the support of manufacture of complete aircraft since most of the capabilities where in the military sector. Collaborations among civil and military organisations have been one area that the respondents believe it must be supported. The support for such collaborations will lead to a diverse market and minimise the challenge currently faced by the defence industry due to defence budget cuts by the government.

4.4 SUMMARY

This chapter presented and analysed both qualitative data from sources that are available in the public domain and used the results from the questionnaire for quantitative analysis in the latter part. The first part of the chapter comprised of information that was sourced from websites of different organisations. The questionnaire information was sourced through responses from representatives of enterprises that have activities in the aerospace industry based in the Tshwane Metropolitan Municipality. The respondents indicated that there is minimal coordination for interactions between Government and the industry, which often leads to the industry being uncompetitive.

The industry shows little levels of collaborations especially with the science council. There is also dependence on international contracts which leaves the industry in a disadvantaged position because National Government has reduced the budget to focus more on socio-economic challenges such as inequality and poverty alleviation. International contracts afford the local industry an opportunity to participate in global collaborations and therefore help the industry to become globally competitive.

CHAPTER 5: CONCLUSION

5.1 INTRODUCTION

This study analysed the main question which is whether there are any interactions between Government and the aerospace industry with emphasis on the civil sector. This chapter presents a summary and draws conclusions regarding findings of the research that gave rise to recommendations for further research. The achievements of the research are also discussed and recommendations relevant to the study are presented.

5.2 RELEVANCE OF STUDY IN RESPONSE TO RESEARCH QUESTIONS

The main question for this study was to establish whether there are interactions between the Government and industry players with specific reference to the Aerospace industry in the Tshwane Metropolitan Municipality.

From the results of the questionnaire, it is evident that there is a limited level of interaction between the government and Industry and the interactions are not coordinated. This is evident in the industry in a sense that the industry lack behind in terms of competitiveness with enterprises from countries analysed. Below is the summary of findings based on the initial research questions.

- What is the role and effect of interactions between the Government and Industry on the Aerospace NSI?

The research finds that the role of Government includes but not limited to, policy formulation and provision of incentives in order to enhance competitiveness and improvement of the Aerospace industry. The aerospace industry plays an important role in providing the training and absorption of innovations that may arise from other players such as the research council. Enterprises that were consulted seem to have limited or no knowledge of incentives and other policies that Government in currently undertaking for the industry.

- What is the relationship and contribution of the aerospace industry to the NSI?

The results show that the aerospace industry contributes positively to the NSI through contribution towards training. Technologies developed in the aerospace industry are also used in other related industries and enterprises in the aerospace industry engage with their international counterparts for technological advancement purposes.

- What role does Government play in supporting R&D and innovation activities in the aerospace industry?

The research found that the government plays an important role in support of R&D and innovation activities in the aerospace industry. the provision of financial incentives serves as a monetary support for R&D and innovation activities in the industry. Furthermore, as a government entity, the research council does to a certain extent assist enterprises in the industry although at a certain fee.

- What are interactions among actors in the aerospace industry, and what gaps exist in interactions among institutions of higher learning and training, research institutions, enterprises, the government and other innovation agents involved in the NSI?

This question was addressed by asking whether the indusrty players have interacted with each other. The study found that actors within the aerospace indusrty interact with each other but the interactions are limited due to reasons such as confidentiality and sensitivity of information. There are limited collaborations between research institutions, especially the CSIR and the enterprises.

5.3 SUMMARY OF RESEARCH

At the beginning of the research, the researcher indicated that smaller enterprises in the aerospace industry depend on contracts from large OEMs such as Aerosud and Denel; however, without Government support, these smaller enterprises are unable to compete with their international peers. The literature indicated that the local industry is a bit behind in terms of R&D, innovation and technology enhancement.

The findings indicate that the lack of Government support for smaller enterprises prevents them from conducting more research and development work, and therefore they lag behind in terms of market penetration.

Research and development work undertaken by the CSIR often do not find its way to the market, because there are no coordinated collaborative activities among the actors within the aerospace industry. The industry is relatively small compared to peer countries and local enterprises compete for similar work packages instead of sharing the work. The association of the aerospace industry with the defence makes it difficult for enterprises to receive assistance from Government as military products are not supported by most of the Government's industry support initiatives.

5.4 RESEARCH ACHIEVEMENTS

This research project found that although Government has financial incentives and other support mechanisms for technology development and enhancement, there is no coordination in the relationship between Government and the aerospace industry. The industry contributes positively to the National Systems of Innovation through human capability improvement and the development of scientific and technical skills.

In answering the question on how the industry contributes to the NSI, the research found that a number of highly qualified engineers are employed by enterprises in the aerospace industry, and therefore the relationship makes a positive contribution to the NSI. Institutions of higher learning have an important role to play in the development of the aerospace industry by producing engineers and scientists; however, the research has found that graduates coming from institutions of higher learning do not have the skills required by the industry and therefore there is a mismatch between graduates and the level of skills required by the industry.

Another question that the research sought to answer was the role of Government in supporting R&D and innovation activities in the aerospace industry. From the questionnaire, it can be concluded that although Government has initiatives and financial incentives in place, some of the enterprises are not aware of this assistance available from Government. The lack of information sharing and collaboration

contributes negatively to the interactions, as there are no coordinated information-sharing channels between the industry and Government. Government has institutions such as the CAV and the AISI to support the aerospace industry, but smaller enterprises that responded to the questionnaire for this study were either not aware or have limited knowledge of such interventions from the government.

The researcher also looked at the relationships among actors in the aerospace industry to identify gaps that exist in interactions among institutions of higher learning and training, research institutions, enterprises, Government and other innovation agents involved in the industry. The findings indicate that respondents feel that they have limited engagements with Government and research institutions. The respondents further indicated poor political will from Government as a negative factor prohibiting industrial development.

The research found that smaller enterprises do not collaborate with each other within the NSI, basically because they cannot afford the cost related to research activities at the early stages of their products. Interactions with the research council are minimal because smaller enterprises cannot afford the user pay principle applied by the research council. Some respondents indicated the need for coordination of interactions with the science council and Government to ensure that Government intervenes in cases were smaller enterprises cannot afford to pay for the services. This, however, is a challenge since most of the smaller enterprises are not aware of services offered by Government and the science council.

5.5 OPPORTUNITIES FOR FURTHER RESEARCH

The research was exploratory in nature as it explored the interactions between Government and the aerospace industry in the Tshwane Metropolitan Municipality. The respondents to the questionnaire were employed by enterprises based in the municipality and further research can be conducted to investigate such interactions countrywide.

The aerospace industry's sources are only available from developed nations and there is limited information about developing nations, which was a challenge for the

researcher while conducting this study. Further research needs to be conducted regarding developing and less developed nations since they play a limited role, especially in areas such as MRO and air traffic management.

There is also a lack of information regarding opportunities arising from the aerospace industry, but new technologies present a great opportunity for further development. Unmanned Aerial Vehicles (UAVs) are becoming widely used in the world and they are proof that technologies from the aerospace industry can be used in other industries. UAVs are currently used to record movies and in the agricultural sector to monitor cultivations in farms across the world.

The international aerospace industry is also opting for aeroplanes that are fuel-efficient and environmentally friendly. This presents an opportunity for R&D activities within the industry to innovate new components that are lighter and fuel types that are focused on lowering gas emissions. The R&D required also presents an opportunity for local players to interact and collaborate with international players to share knowledge and to assist each other in capacity-building.

The researcher believes that strategies should be developed to encourage an industry association that provides a single, unified opinion and approach to developing the industry. The strategy should also enhance the collaborative approach with educational institutions and scientific players to produce capabilities and to provide guidance to investments that must be made by Government. To further support collaboration and interactions within the industry, seed funding for flagship programmes could be used this to leverage other funding sources and develop international collaborations.

5.6 RECOMENDATIONS

Government support to the industry, through incentives and policy interventions, is critical for industrial competitiveness. The industry is technologically-intensive and therefore more collaboration initiatives must be encouraged among enterprises in the industry and post-school education and training institutions.

Incentives and industrial support programmes such the Technology and Human Resource for Industry Programme (THRIP), the Support Programme for Industrial Innovation (SPII) and the Innovation Fund (IF) must be offered to more actors within the NSI.

If the industry is to grow or compete with international counterparts, the players within the NSI must collaborate more, especially for R&D related activities. A conclusion can be drawn that there is limited or little support from Government for R&D in the aerospace industry and the researcher recommends that Government should subsidise these, especially SMMEs for R&D purposes.

In the international context, South Africa has entered into a number of bilateral air services agreements with the international community. These bilateral agreements should allow for easy access of different international markets by South African manufactured components. Some of these agreements are too old and they need to be amended and expanded to incorporate new developments in the aerospace industry internationally.

The challenge of shortage of engineers and technically skilled workforce needs to be addressed by all the stakeholders involved in the industry. Enterprises should collaborate with institutions of higher learning and training to ensure that they produce graduates that will be easily absorbed by the industry. Government, on the other hand, should encourage mathematics and science from primary level. Funding directed to industrial development initiatives such as the AISI should be increased as these hone the industry's competitiveness.

It is clear that the aerospace industry has a rich history of competitiveness in terms of skills, but the industry plays a limited role in the NSI. The skills base comprises of old and previously advantaged white people nearing retirement, and efforts should be made to transfer these skills to the previously disadvantaged groups to allow equal participation for all in the industry.

5.7 SUMMARY

This chapter summarised the results of the research conducted on data from reports and the questionnaire. The achievements of the research were also discussed and recommendations relevant to the study were presented. Recommendations for further studies in future were also included in this chapter.

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APPENDIX: QUESTIONNAIRE

Research questionnaire for Industry players

Area of Study: NSI Interactions between government and industry: The Case of the South African Aerospace Industry.

Research Conducted by:

Phemelo D Mokumo

The information provided by the interviewee remains confidential and shall not be disclosed in any way to any other persons

NAME OF INTERVIEWEE:
ORGANIZATION:
JOB TITLE:
TELEPHONE NO:
FAX NO:
EMAIL:

Number	Question	Yes	NO
1.	Has your organisation previously interacted with the South African government in request for support?		
		Yes	**No**
2.	Has your organisation been involved in any kind of interactions with other		

	local players (firms) within the NSI		
		Yes	**No**
3.	Has your organisation been involved in any kind interactions with local universities or the research and science council?		
		Yes	**No**
4.	Has your organisation ever received improved processes or introduced a new product (Innovate or invent) as a result of government assistance		
		Yes	**No**
5.	Has your organisation ever collaborated with an international organisation for any project?		
		Yes	**No**
6.	Has your organisation ever been a beneficiary of technology transfer from a university in the republic of South Africa?		

		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

7.	Are there challenges that need to be addressed to ensure competitiveness of the industry					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
8.	Do you think there are challenges that prevent interactions between the government and the Aerospace industry in South Africa?					

9.	**The following areas have been identified as some of the major challenges that are faced by the industry?**					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
9.1	Lack of collaboration among firms					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
9.2	Lack of collaborations between firms and post school education and training institutions					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
9.3	Lack of collaborations between firms and the science council					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

9.4	Low innovation levels					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
9.5	Poor oversight structures					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
9.6	Lack of policy coordination					

10.	**Do you think the South African aerospace industry is competitive enough to compete in the following categories?**					
10.1		**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
10.2	Research and development					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
10.3	Policy implementation					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
10.4	Infrastructure					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
10.5	Support for post school education and training					
10.6	Other (please specify) (Creativity, commercialization)					

11.	**To address challenges faced by the aerospace industry, the following interventions must be initiated.**

11.1		**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
11.2	Aerospace specific research centre					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
11.3	Collaboration in Research and development (among research councils, government, firms, and institutions of higher learning)					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
11.4	Collaboration among firms within the NSI					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
11.5	Transfer of technology to enhance commercialisation					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
11.6	Government support through policy interventions					

12.	**Please indicate the extent to which you agree with the following statements?**					
12.1		**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
12.2	Government interventions assist the industry in maintaining their competitiveness.					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
12.3	Collaborations among players within the industry could lead to a stronger industrial base.					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
12.4	An aerospace specific research centre could lead to improved industrial activity within the NSI.					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
12.5	Technology transfer could lead to commercialization of new technologies.					
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
12.6	Collaboration in Research and development (among research councils,					

	government, firms, and institutions of higher learning) could lead to improvement of the current state of the industry.					

13.	**These aerospace industry competencies should be supported by the government in South Africa.**					
13.1		**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
13.2	Maintenance, refurbishment and overhaul (MRO)					
13.3	Manufacture of complete aircrafts					
13.4	Research and development					
13.4	Collaborations between civil and military aerospace organizations					