the dti
Department:
Trade and Industry
REPUBLIC OF SOUTH AFRICA

SOUTH AFRICAN AERONAUTICAL INDUSTRY DEVELOPMENT STUDY
PART 1: SURVEY AND CRITICAL ANALYSIS

Date of Issue: October 2019

Final Report

Document compiled by the CSIR

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Contents

Table of figures

Table of tables

Nomenclature

3D	Three Dimensional
A	Asian
Al	Aluminium
A/C	Aircraft
ACA	Airport Carbon Accreditation
ACI	Airports Council International
ACSA	Airports Company South Africa
AHRLAC	Advanced High Performance Reconnaissance Light Aircraft
AIC	Canadian Aerospace Industry of Canada
AIM	Aerospace Industry in Mexico
AISI	Aerospace Industry Support Initiative
AMD	Aerospace Maritime and Defence Industry Association
AMTL	Adaptronics Advanced Manufacturing Technology Laboratory
AMTRP	Advanced Manufacturing Technology Roadmap Project
ANSP	Air Navigation Service Provider
AS9100	More stringent version of ISO9001 for application in the aerospace industry
ASECNA	Agence pour la Securité de la Navigation Aerienne en Afrique et Madagascar
ASKs	Available Seat Kilometers
ATNS	Air Traffic Navigation Services
ATT	Arms Trade Treaty
AU	African Union
B	Black
BASA	Bilateral Air Safety Agreement
BEE	Black Economic Empowerment
BBBEE	Broad Based Black Economic Empowerment
BBSDP	Black Business Supplier Development Programme
BRICS	Brazil, Russia, India, China and South Africa trade bloc
C	Coloured
CAD	Computer Aided Design
CAE	Computer Automated Engineering
CAM	Computer Aided Manufacturing
CAMASA	Commercial Aviation Manufacturing Association South Africa
CAPEX	Capital Expenditure
CASA	Construcciones Aeronáuticas SA
CASIA	Centro de Asistencia y Soporte para la Industria Aerospacial (Aerospace Industry Assistance and Support Centre)
CATIC	China National Aero-Technology Import and Export Corporation
CAV	Centurion Aerospace Village
CCIA	Mexican Federal Government Aerospace Advisory Board
CDCQ	Composites Development centre of Quebec
CDP	Cluster Development Programme
CFD	Computational Fluid Dynamics
CFM 56	Predecessor to the CFM LEAP engine
CFM LEAP	CFM International is a joint venture between GE Aviation, a division of General Electric of the United States, and Safran Aircraft Engines, a division of Safran of France. The LEAP Engine is their latest engine variant.
CIADI	Concordia Institute of Aerospace Design and Innovation
CIDESI	Centre for Engineering and Industrial Development

CIDETEC	Centro de Investigación y Desarrollo Tecnológico en Electroquímica
CINESTAV	Center for Research and Advanced Studies of the National Polytechnic Institute
CEDIA	Centre for Aviation Industry Development
CFD	Computational Fluid Dynamics
CFTA	Continental Free Trade Area
CIIIA	Centro de Investigación e Innovación en Ingeniería Aeronáutica
CIP	Critical Infrastructure Programme
CIS	Co-operative Incentive Scheme
CHPC	Centre for High Performance Computing
COMAC	Commercial Aircraft Corporation of China
COMFEI	Mexico-France Entrepreneurship and Innovation Council
Conacyt	Mexican National Science and Technology Council
CONALEP	National College for Professional Technical Education
CPFP	Capital Projects Feasibility Programme
CRIAQ	Consortium for Research and Innovation in Aerospace
CSIR	Council for Scientific and Industrial Research
CSN	Casting Simulation Network
CTA	Brazilian Aeronautics Technical Centre
DIP	Defence Industrial Participation
DIPP	Defence Industry Productivity Program (Canada)
DoD	Department of Defence
DPSA	Defence Production Sharing Agreement
DPSS	Defence, Peace, Safety and Security, an Operating Unit of the CSIR
DST	Department of Science and Technology
EADS	European Aerospace and Defence Company
EASA	European Aviation Safety Agency
EC	EuroCopter
EIP	Enterprise Investment Programme
EIU	Economic Intelligence Unit
EMBRAER	Empresa Brasileira de Aeronautica SA
EMIA	Export Marketing and Investment Assistance
EU	European Union
FAA	Federal Aviation Authority
FAB	Brazilian Air Force
FDI	Foreign Direct Investment
FIG	Foreign Investment Grant
FIR	Flight Information Region
FEMIA	Mexican Federation of Aerospace Industry
FPS	Flexible Production Systems
GCI	Global Competitiveness Index
GCIP	Global Cleantech Innovation Programme
GDP	Gross Domestic Product
GD&T	Geometric dimensioning and tolerancing
GE	General Electric
GIMAS	Groupement des Industries Marocaines Aeronautiques et Spatiales
GKN	GKN plc is a British multinational automotive and aerospace components company. The company was formerly known as Guest, Keen and Nettlefolds.
HALE	High Altitude Long Endurance
HCC	High Cost Country

HCD	Human Capital Development
HEI	Higher Education Institute
HR	Human Resource
IAR	Institute for Aerospace Research
IAT	Institute in Advanced Tooling
ICIA	Institut de conception et d'innovation en aérospatiale
ICAO	International Civil Aviation Organisation
IDC	Industrial Development Corporation
IDZ	Industrial Development Zone
IES	Innovation Enabling Support
IFC	International Finance Corporation
IICAP	Institute of Innovation and Conception in *Aerospace* of Polytechnique
IMA	Morocco-based Aviation Professions Institute
IMMEX	Mexican Government Incentive Scheme for Manufacturing in Mexico
Inadem	Mexico's National Entrepreneurship Institute
INEGI	Mexican National Institute of Statistics and Geography
IP	Intellectual Property
IPAP	Industrial Policy Action Plan
IPR Act	Intellectual Property Rights from Publicly Financed Research and Development Act
IPTN	Industri Pesawat Terbang Nusantara
IoT	Internet of Things
IRAP	Industrial Research Assistance Programme (Canada)
ISO9001	International Standards Organisation standard for quality assurance
IT	Information Technology
ITA	Brazilian Technology Institute of Aeronautics
ITAR	International Traffic in Arms Regulations
ITP	Spanish Turbine Engines Company
JASC	Joint Aerospace Steering Committee
MACH	Name of an initiative to support the aerospace sector long term growth
MACRO	Macro Economic Competitiveness Indicators
MCEP	Manufacturing Competitiveness Enhancement Programme
MCTS	Metal Casting Technology Station
MD	McDonnel Douglas
MICRO	Micro Economic Competitiveness Indicators
MIDCAPS	Middle Sized Enterprises
MIP	Manufacturing Investment Programme
MIT	Massachusetts Institute of Technology
MRO	Maintenance, Repair and Overhaul
MSM	Materials, Science and Manufacturing, an Operating Unit of the CSIR
MTCR	Missile Technology Control Regime
N	No
N/A	Not Applicable
NAC	Nouasseur Aerospace City, Morroco
NADCAP	National Aerospace and Defence Contractors Accreditation Program
NCPC	National Cleaner Production Centre
NCACC	National Conventional Arms Control Council
NFTN	National Foundry Technology Network
NIPP	National Industrial Participation Programme
NIPMO	National Intellectual Property Management Office

NL	National Laboratory or Nuevo León
NMU	Nelson Mandela University
NPC	Non-Proliferation Council
NRC	National Research Council
NRF	National Research Foundation
NSG	Nuclear Suppliers Group
NUS	National University of Singapore
LCC	Low Cost Country
OECD	Organisation of Economic Cooperation and Development
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditure
OTR	Overberg Test Range
PCB	Printed Circuit Boards
PDI	Previously Disadvantaged Individual
PDTS	Product Development Technology Station
PEET	Process Energy and Environmental Technology Station
PFMA	Public Finance Management Act
PII	Partnership in Industrial Innovation
PLM	Project Life-cycle Management
PPCI	Industrial Productivity and Competitiveness Program
PPP	Purchasing Power Parity or Public Private Partnership
PPPFA	Preferential Procurement Policy Framework Act
PT Digantara	Indonesian aircraft industries
PvT	Private (not state owned)
PW	Pratt and Whitney
PYMES	Mutual Recognition Agreements
R&D	Research and Development
RAM	Royal Air Maroc
RDM	Rheinmetall Denel Munitions
RFQ	Request for Quotation
RMPTS	Reinforced and Moulded Plastics Technology Station
RPKs	Revenue Passenger Kilometers
RSA	Republic of South Africa
RSAF	Royal Singapore Air Force
SA	South Africa
SAA	South African Airways
SAAB	Svenska Aeroplan AB (Swedish Aerospace and Defence Company)
SAAF	South African Air Force
SACAA	South African Civil Aviation Authority
SADI	Strategic Aerospace and Defence Initiative
SAI	Singapore Aircraft Industries
SANREN	The South African National Research Network
SARA	Small African Regional Aircraft
SARChi	South African Research Chair
SARP	Standards and Recommended Practices
SARS	South African Revenue Service
SC	State Company
SDP	Aerospace Sector Development Plan [1]
SEDA	Small Enterprise Development Programme

SET	Science, Engineering and Technology
SEZ	Special Economic Zone
SIC	Standard Industrial Classification
SKA	Square Kilometre Array
SME/SMME	Small, Medium and Micro Enterprises
SOC	State Owned Company
SOE	State Owned Enterprise
SPII	Support Programme for Industrial Innovation
SPV	Special Purpose Vehicle
SSAS	Sector Specific Assistance Scheme
STEM	Science, technology, engineering, and mathematics
STP	SEDA Technology Programme
SU	Stellenbosch University
SWTAP	Sector Wide TAP
TAP	Technology Assistance Package
the dti	The Department of Trade and Industry
TD	Technology Demonstrator
TDG	Technology Development Grant
THRIP	Technology and Human Resource for Industry Programme
Ti	Titanium
TIA	Technology Innovation Agency
TICPS	Technology Innovation Cluster Programme
TLIU	Technology Localisation Implementation Unit
TPC	Technology Partnership Canada
TREMEC	Transmission manufacturing plant research centre
TSE	Technology Station in Electronics
TSPMT	Technology Station for Materials Processing Technology
TT	Technology Transfer
TUT	Tshwane University of Technology
TVC	Technology Venture Capital
TWIB	Technology for Women in Business
UAV	Unmanned Aerial Vehicles
UAS	Unmanned Aerial System
UCT	University of Cape Town
UIF	Unemployment Insurance Fund
UIMM	Moroccan Union of Metallurgical Profession Industries
UK	United Kingdom
UNIDO	United Nations Industrial Development Organisation
US or USA	United States of America
USD	United States Dollar
UTC	United Technologies Corporation
VAT	Value Added Tax
W	White
WA	Wassenaar Arrangement
WCP	Workplace Challenge Programme
WSU	Walter Sisulu Univeristy
Y	Yes
YTIP	Youth Technology Innovation Programme

Executive Summary

Aim

This study is in response to The Department of Trade and Industry (**the dti)** terms of reference for a commercial aerospace industry development strategy study and is aimed at achieving the following goals:

- A limited review of the industry, locally, regionally and internationally.
- A determination of the socio-economic case for aerospace investment by the South African government based on questionnaires which will in parallel be used to map industry capability.
- A policy review with a goal of doubling the aerospace sector in 5 years.
- An evaluation of the transformation potential in the sector.
- An evaluation of the value of a public/private partnership in the sector.

In line with the Terms of Reference the scope is limited to the following industry sub-sectors:

- Aerostructures and propulsion for all aircraft types
- Avionics, surveillance and other aviation related electronics both ground-based and airborne.
- Maintenance, Repair and Overhaul (MRO).

All industry tiers are included to ensure an understanding of the full supply chain. The Aerospace related defence industries are also included as they are in many ways interwoven with the commercial business and the commercial business is, on its own relatively, small.

Summary of Results

Locally the aerospace industry is a small but significant element of the South African manufacturing sector comprised of at least 104 companies. In total the industry size was determined to be in the order of R9.5 Billion and employ nearly 10 000 individuals or just 0.5% of total production in the SA economy. The terms of reference of this study, which refers to a doubling of the industry and more specifically to a doubling of the commercial aerospace industry are unambitious, as this would have little or no effect on the economy of South Africa as a whole at a macroeconomic level. Doubling an industry that is only 0.5% of production would at best yield one that is 1% of total production. Interventions to expand the industry tenfold would begin to place the industry in the spotlight by raising its impact into whole number percentages of the economy. An intervention at this level is however not an insignificant undertaking and without risk.

While its overall value may be small, its highly skilled workforce represents one of the highest earning segments earning nearly 6 times the average of the manufacturing sector in South Africa and generates a large export income value for the economy in comparison to its size, estimated to be >55% of direct turnover as compared to 34% of turnover for the automotive industry in 2017. In addition, it has a large tertiary or induced economic value to the economy as a result of its highly skilled and paid workforce who generate an estimated R570 Million in tax revenues for the state which far exceeds the value of current support mechanisms deployed to support the sector. Furthermore, comparing the typical levels of support internationally, South Africa is estimated to lag behind the levels found in the UK, as an example, by a factor of ten if one scales their investment based on either employee numbers or turnover.

Internationally the aerospace industry is seen as a key element in the manufacturing sector of the economy. As a highly regulated sector with high technology requirements the sector is seen as an enabler for the balance of the manufacturing industry in the country, uplifting skills and capability that spills over into other sectors. The growth in commercial aviation has led to a consistent growth in demand for aircraft compounded by strong competition which has led to a demand for the most economically and environmentally efficient and therefore newest aircraft. The defence sector is quite different to the commercial sector however, it is more layered, and as a result there can be fewer barriers to entry rather than more, which is counterintuitive, and in South Africa the infrastructure and funding in the defence domain has been in place and sustained over a long period which has resulted in a sizeable and capable defence sub-sector. In the defence sector the technology is highly controlled and processes to export such technology can be extremely bureaucratic and funding is based more on strategic imperatives than on economic ones.

There is not particular international best practise that can be identified from literature for the support of an aerospace industry but instead there are a range of measures in common practise: These include:

- clusters with advantages such as common logistics pathways, air-side access, access to sponsored training schools and technical institutes as well as tax incentives,
- Tariff rebates and even protective tariffs on key input materials,
- Signing of international agreements to facilitate exports and certification,
- Assistance to foreign investors and start-ups to ease the bureaucratic burden of starting a company
- Financial assistance for R&D, Commercialisation and innovation – often with emphasis on SMME support,
- Active government support in attracting foreign direct investment in the sector,
- Funded flagship projects.

Although the international aerospace industry is quoted as having extremely advantageous economic multipliers and the evidence from the Rooivalk case study [3] clearly indicates a strongly advantageous result for government investment in aerospace projects in the long term; it may be overstating the value of the aerospace industry to the South African economy to apply these multipliers to the local industry. This is because the industry is clearly heavily dependent on imported raw materials and components and as such, the indirect industry is unlikely to reach the economic potential of that in competing overseas countries.

Workshops were held with representatives of the different technology streams of the industry and a collation of these conversations and the nine major points raised by the industry is provided which yield both financial and non-financial options to government. It is clear from both the literature and the industry engagements that the aerospace industry is not independent of government support and that no clear strategy consisting of easily identifiable projects exists within industry to achieve a goal of doubling the sector.

Transformation in the aerospace sector remains a challenge, especially as the sector is in decline. Industry has suggested increased support for SMME entrants as a solution, but outside of industry this solution is not seen as bold enough.

The aerospace industry internationally is highly competitive and sought after in many developing economies for its tertiary and skills benefits, and as a result, it is both highly protected and supported by governments. In SA many government incentives exist to support industry but few have been successfully deployed to the support of the aerospace industry with the notable exceptions of the underfunded AISI, and the NIPP/DIP obligations on large government capital expenditures. The latter is, however, not sustainable without new capital expenditures.

It is clear therefore that government should act decisively to support the industry based on a clear strategic intent and sustain this support over the long term should it wish to protect this small but high throughput, highly-skilled sector of the manufacturing economy. Furthermore, different mechanisms are required to support the different sub-sectors of the aerospace industry according to their needs and characteristics.

1 Introduction

An aerospace capability plays an integral role in the achievement of South Africa's priorities and are fundamental to building the nation's economy, security and transportation network. In the defence sector, aircraft manufacturing generally accounts for a large share of defence equipment expenditures for any modern military. The industry is seen as a technology driver, including in manufacturing techniques, that also encompasses other high-technology sectors such as electronics, advanced materials, and sensors. Since manufacturing is characterised by a long project life cycle spanning R&D, engineering design, manufacturing, assembly, maintenance, repair and overhaul, the government recognises the aerospace sector as a key industry for growth and innovation. The industry however requires large capital investments and government's commitment to increased and sustained investment.

The Aerospace industry is widely regarded as a key industry in many developed and developing countries with the benefit of spill over of skills and capability into other industry sectors, in other words a 'technical university' for the other industries. This alone is often cited as enough of a reason to actively support the aerospace manufacturing sector of a country. Moreover aerospace industry studies in many economies have shown excellent return on investment of government support instruments from these industries in terms of economic impact multipliers (often quoted to be in excess of 2.6 as per the SAAB Gripen study released by Eliasson [2] and in terms of highly skilled jobs grown and retained. A 2014 study of the Rooivalk Attack Helicopter development in South Africa (SA), aimed at calculating the impact multipliers for South African economy but could only conclude that the programme was a 'significant force in producing nationally competitive technologies and capabilities' as a result of a lack of coherent economic data [3]. The United Kingdom (UK) Aviation Industry Socio Economic report [4] talks of £7 economic benefit to the UK over the next decade for every £1 spend on Research & Development (R&D) in the aerospace sector and a 60% higher than average gross value add to the Gross Domestic Product (GDP) of £84 000 per employee in the sector. Numbers such as those in the UK study are far more accessible and tangible than the more abstract economic multiplier construct and it is this form of socio economic impact that this study is aimed at generating for the South African Commercial Aerospace industry.

The origins of the Aerospace industry in SA are defence related, stemming from large investments in the 1980's. The resultant industry, both state owned and private were then in a position, by the mid-1990s, to take part in offset deals on the defence packages, SAA fleet purchases and Airbus A400M programmes through the skills, capabilities and infrastructure built up through considerable government investment. These capabilities are extensive and by the mid-1990's covered: Aerostructures, propulsion (although this sector was the least developed), Avionics, Surveillance and Sensors as well as MRO activities. In 2012 the aerospace Sector Development Plan (SDP) commissioned by the Department of Science and Technology (DST) and **the dti** [5] advocated the establishment of an intergovernmental committee to provide a strongly co-ordinated governance structure to ensure that future investments, be they via countertrade or direct investment, were directed to achieve the highest gains for the industry. The Sector Development Plan (SDP) further advocated large flagship projects to stimulate the industry, following the model of the Rooivalk project. The South African economic situation has however changed quite dramatically in the interim.

With the large government capital expenditures in the area of aerospace coming to an end, the lack of confidence created by withdrawal from the Airbus A400M purchase, dramatic declines in defence technology spending and with little in the way of incentives to the industry that might attract the large OEMs, the aerospace sector has seen a steady decline in turnover, jobs and a slow but inexorable decline in capability. The outcome of the SDP has been the establishment of the JASC but no meaningful flagship projects have emerged and the SDP report itself was never formally published.

The only government support initiative dedicated to the aerospace industry is the Aerospace Industry Support Initiative (AISI), an initiative of the **dti**. This initiative aims at supporting the industry through assistance with certification, standards and accreditation as well as directly funding higher readiness level development projects particularly where SMME's are involved in order to stimulate and subsidise new product offerings. The AISI's funding is however only 1/10th that available in the UK on a per employee, or turnover basis putting the industry sector far below the levels of support that the global aerospace industry operates.

While a broad selection of other mechanisms with the potential to support the Aerospace industry in SA do exist they have had little effect on the industry to date.

Against this backdrop, **the dti** has commissioned a further study of the aerospace manufacturing sector aimed at determining:

1. The value of the aerospace manufacturing sector to the South African economy.
2. The best way to grow and transform the sector over the next 5 years with an aim of doubling the sector's turnover.
3. An effective mechanism to improve transformation in the sector.
4. The possible benefits of public/private partnership in the sector.

Part 1 of this report is aimed at quantifying the sector economically as far as is possible and gathering information from the industry, while Part 2 will look at the data and suggestions from industry, draw conclusions and propose a strategy to support the industry sector within Government.

1.1 Study Methodology

This study relies on previous studies and the vast collection of literature available on the development of the aerospace industry in other countries as well as the projections for future growth in the sector. No first hand data collection was required in this regard. The first element of the study therefore relies on the previous studies and freely available literature to examine the international nature and projections for economic and technological growth in the sector.

Secondly a survey of the industry sector was conducted to determine the true nature, scale and value of aerospace manufacturing to the South African economy at present. This was performed using a questionnaire specifically developed for the purpose and followed up with workshops with targeted groups within the industry in order to focus on garnering fresh ideas and buy-in from industry on how best to support their growth. Due to the poor response rate to the initial questionnaire the respondents to the initial survey where utilised in the workshop phase and the survey was adjusted to reduce the overhead and a telephonic campaign used to gather sufficient data for the industry sizing.

This report is therefore the product of a summary of the available literature, and an analysis of the data gathered from the industry and the outputs of the workshops held with relevant industry parties. This report is therefore skewed towards the sizing and views of the local industry and does not include any engagements with relevant Government stakeholders outside of those represented on the study committee.

1.2 Scope

The Terms of Reference is an extremely wide-ranging document and for the purposes of this study the following goals have been distilled and the scope of this proposal is therefore limited to the following:

- A limited review of the industry, locally, regionally and internationally
    - this will include aspects of clusters as one possible instrument as requested by the study committee.
- A determination of the socio-economic case for aerospace investment by the South African government based on questionnaires which will in parallel be used to map industry capability
- A set of guidelines for a national strategy with a goal of doubling the aerospace sector in 5 years and achieving transformation in the sector,
    - This will include a description of existing policies and legislation (including the use of government procurement programmes) and will show how this compares to international legislation and policy,
- An evaluation of the value of a public/private partnership in the sector.

In line with the Terms of Reference, the scope is further limited to the following industry sub-sectors:

- Aerostructures and propulsion for all aircraft types,
- Avionics, surveillance and other aviation related electronics both ground-based and airborne,
- Maintenance, Repair and Overhaul (MRO).

All industry subsectors are included to ensure an understanding of the full supply chain. Space is excluded, however the defence sector is so intertwined with the commercial sector that it is proposed to include this sector in the study in the sections already displayed above.

Additional requests from members of the steering committee have included requests for the team to engage with labour unions and the Department of Labour's SETAs. While the importance of dedicated vocational training is of great significance to the industry the study team will not engage directly with labour or the SETAs, but will provide guidelines from international best practice in regard to training.

2 The South African Aerospace Industry

In this section the outcomes of four studies of the South African aerospace and defence industry are summarised for the convenience of the reader. These are:

- The sector development plan [5].
- The Rooivalk case study [3].
- The defence review [6].
- The advanced manufacturing technology roadmap [1].

2.1 Sector Development Plan

The South African Aerospace SDP [5] defined the aerospace industry as the research, design, manufacturing, operations and maintenance of aircraft and spacecraft. The aerospace industry includes commercial aviation, private aviation and defence applications. It makes use of the highest levels of technology and skills and produces, operates and maintains aircraft, missiles, engines, and numerous components and associated equipment. The aerospace industry is described as technology intensive and generates economic wealth and in doing so relieves poverty and unemployment. The aerospace industry has been identified as one of seven industry sectors that has a big impact on the manufacturing capability in SA.

Graphically the aerospace subsectors is depicted in Figure 1 according to the SDP [5]. The segment model considers three perspectives namely:

- Military and civil aerospace.
- Aerospace product centric view of the sector.

In addition the technology stream centric view of the sector is defined in Figure 2.

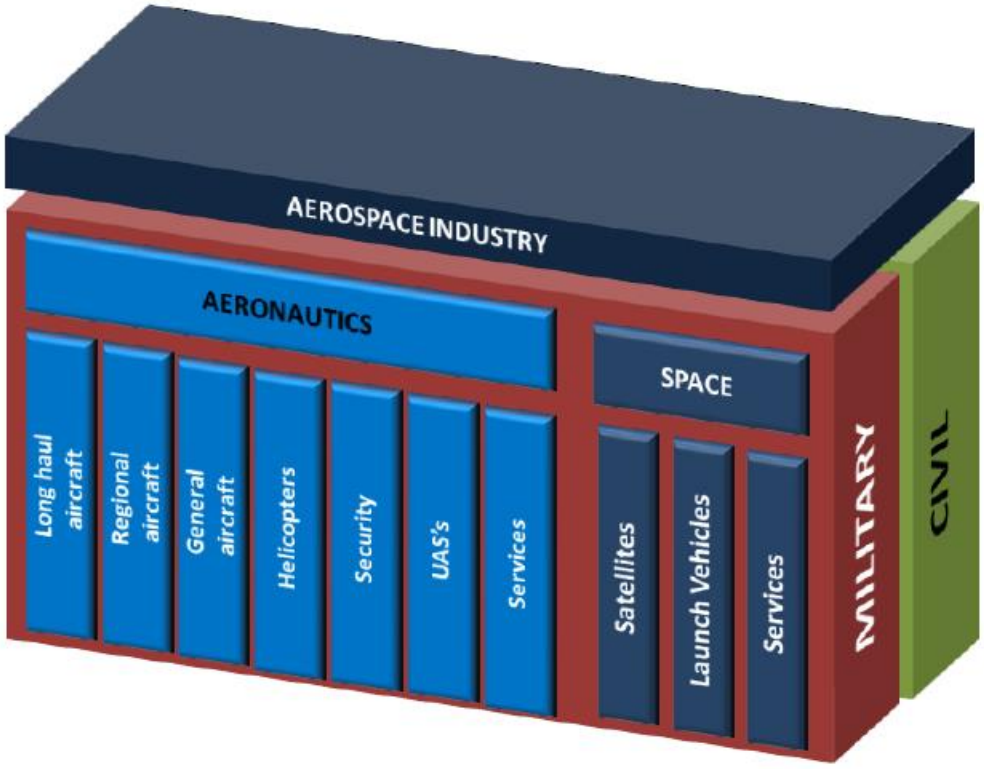


Figure 1: Aerospace sector segmentation model for the SDP [5]

The product centric view of the aerospace industry shows that the sectors are comprised of aeronautics and space which can each be subdivided into a number of product markets. This is shown in Figure 2. The technology streams are applicable to all products across the product markets.

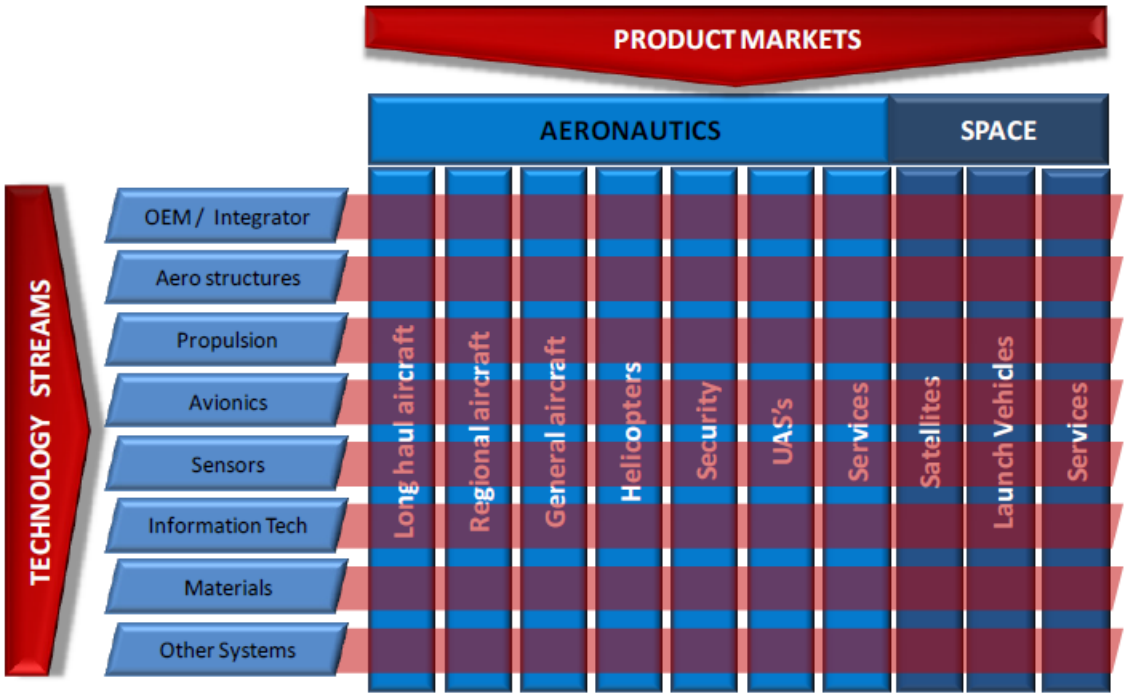


Figure 2: Aerospace product and technology matrix for the SDP [5]

The tiered levels of technology adopted by the SDP is represented in Table 1 and provides a good description of the levels of complexity and responsibility for the complete supply chain of the aerospace industry.

Table 1: Aerospace supply chain tier [5]

TIER	NAME	DESCRIPTION
Tier 0	**Integrator/OEM**	Complete system (finished product) delivery including overall design, system integration and assembly. Examples include Airbus, Boeing etc.
Tier 1	**Major subsystems**	Delivery of a major sub-system of a product. Includes overall design, integration, assembly and some manufacture of sub systems. Tier 1 partners have become major risk sharing partners with the Tier 0 OEM/integrator. Examples include engine manufacturers (such as Rolls-Royce, General Electric), wing manufacturers (such as GKN and Spirit Aerosystems) etc.
Tier 2	**Minor subsystems**	Delivery of a minor sub-system or a product as part of a Tier 1 sub-system. Includes design, integration, assembly and some manufacturing - typically on a limited risk sharing basis.
Tier 3	**Components**	Manufacturing and assembly of components for Tier 2 subsystems. May include design, integration and assembly. Typically non-risk sharing.
Tier 4	**Parts**	Build to print manufacturing of parts for components. Typically non-risk sharing.

The following statements contained in the SDP are worth noticing:

- *"An aircraft and its support infrastructure is a highly complex system with a long life that requires an immensely complex and distributed production and support organisation."*
- *"The countries that are creating the market/demand for new aircraft are demanding workshare packages from OEMs for the development of domestic aerospace industries."*
- *"Globalisation of the aerospace industry has placed a renewed emphasis on determining what is considered strategic to each of the players in the value chain. The most critical of these choices vest with the OEM and determines the areas of the value chain that the OEM chooses to retain in a new aircraft programme and those for which risk and responsibility are transferred to supply chain partners."*
- *"This development (see bullet point above) is reflected in the consolidation around tiers in the supply chain and the emergence of dominant suppliers, such as Rolls-Royce and General Electric that supply engines to both Airbus and Boeing."*

The industry trends and implications (see Table 2) as identified by the SDP is worthwhile repeating even considering that the SDP was generated in 2012.

Table 2: Industry trends extracts from [5]

INDUSTRY TRENDS	
TREND	IMPLICATION
Aerospace is truly global in nature with financials as the key driver for globalisation. Technological complexity increases non-linearly for each new product cycle whilst cost escalation does not.	Construct and operate aerospace firms with a global perspective. Business planning must take increased systems complexity into account, and plan for achieving the continuous cost reduction requirement for sustainability.
Aerospace has long business cycles and enduring supply chain relationships.	Short term business planning in the aerospace sector requires a long term perspective.
Risk sharing for suppliers with OEMs have become the norm in the global aerospace supply chain.	Ensure that aerospace programmes are supported via consortiums or government support to enable risk-revenue sharing and affordable programmes.
Aerospace clusters are a common occurrence as they offer competitive positioning benefits.	Aerospace clustering must be an integral part of the Aerospace sector strategy.
DEFENCE TRENDS	
TREND	IMPLICATION
Other than the USA which is still closed, Defence is rapidly becoming a globalised business.	Become part of the global defence industry supply chain.
Consolidation of defence OEMs resulting in dominant players.	Adopt strategic positioning in markets and the aerospace supply chain to deal with the globally dominant firms.
A shift in defence doctrine has and continues to take place globally.	Adopt new positioning to declining historical markets and the rise of rapidly growing new ones.
CIVIL TRENDS	
Civil aerospace program funding will be largely private with regulated indirect state support.	SA must align with global aerospace funding frameworks to ensure smooth global integration.

PRODUCT LINE/MARKET TRENDS	
TREND	IMPLICATION
Large & medium commercial aircraft, the biggest aerospace market segment - currently dominated by 4 players.	Participation in the global civil aerospace supply chain currently implies a partnership with one or more of the 4 major OEMs.
The majority of new large commercial aircraft are going to Asia Pacific region for the 2009 – 2028 period.	The Asia Pacific region is considered strategic by the OEMs, and Asian suppliers will demand aerospace supply chain participation from the OEMs.
The rise of China (Asia Pacific) as an aerospace OEM.	Strategy must be cognisant of the rise of Asia Pacific as a capable aerospace complex.
Environmental compliance (going 'Green') will hasten commercial aircraft replacement.	Green compliance will play an increasingly important role in the aerospace supply chain.
The robotics revolution has crossed the adoption chasm and will be major market segment in future.	Robotics must be included as an integral component of product and business strategy.
TECHNOLOGY STREAM TRENDS	
TREND	IMPLICATION
R&D is increasingly being outsourced (Globalisation of R&D) to maximise the investment in R&D.	National R&D activities can build global networks and earn foreign revenue – to the benefit of local industry and national goals.
Use of composite materials and related metals are increasingly dominant with each new development cycle.	The dominance in the use of composite materials (with downstream metal impacts) should be integral to aerospace business planning.

In 2018 Airbus acquired a 50.01% stake in Bombardier. Boeing has acquired a majority stake in Embraer which might indicate that the number of airframer OEMs has reduced to two. However, Comac (China) with its C919 is making inroads in this market. Another civil airframer OEM that is growing is Sukhoi with its Superjet 100. Besides the previous statements the trends identified in Table 2 are still valid today.

Arguably the most important aspect highlighted in the SDP is that the Aerospace is truly global in nature. This implies that the South African aerospace industry perspective needs to be globally focussed and that it must partner with OEMs or large Tier 1 entities (this includes companies like Spirit AeroSystems). This also implies that currently South African owned companies might be owned by international partners in future.

2.2 Rooivalk

The Rooivalk attack helicopter was developed during the apartheid/sanctions era and was intended as a force multiplier [3]. It was arguably one of the most complex systems ever developed in SA. The Rooivalk programme was a system of systems as it consisted of airframe, weapons system, propulsion system and avionics systems. It required the development and implementation of systems engineering. The Rooivalk was never intended to act as a force for industrialisation but the companies and technologies that were spun off show that it benefitted SA economically in the long term. The following are relevant extracts from [3]:

- *"The (Rooivalk) programme has cost about R 6.208 Billion in 2014 prices. Revenues of about R 22 Billion in nominal terms have been estimated to be earned from spin off companies."*
- *"The programme was key in establishing skills and capabilities that supported ongoing national industrial competitiveness."*
- *"Former Rooivalk engineers have been key actors in projects such as PBMR, Meerkat and Salt telescopes."*

- *"The development of Rooivalk was premised on the expertise of previous programmes that formed the building blocks of the Rooivalk and included technology demonstrator programmes."*
- *"Bespoke technologies were developed for Rooivalk including composites technologies, gas turbine component repair technologies, integrated management systems, weapons computers, Computational Fluid Dynamics (CFD), etc."*
- *"Years after the development had been completed companies earning export revenues can trace back their existence to the Rooivalk programme."*

Denel is/was the OEM for a number of aircraft but their biggest involvement during the complete lifecycle of an aircraft was the Rooivalk attack helicopter.

2.3 Defence Review

The Defence Review [6] states that SA possesses the specialised capabilities in the public and private sectors to maintain SA's position at the forefront of science and technology and aerospace capabilities. The defence review states that a defence industry will provide the opportunity to leverage economic benefits and that it would be feasible to align the defence acquisition strategy with the industrial development strategy. The aerospace sector is identified as a key sector as there is a real potential to develop a viable product or service.

The Defence Industrialisation Participation (DIP) programme is intended to obtain a balance between DIP and NIPP obligations. Government will support export sales, Technology Transfers (TTs) and joint ventures by the South African defence industry in all areas and domains, provided that the exports, TTs or joint ventures do not compromise national security or international or national laws.

In summary, according to the Defence Review [6] "*The success of the defence industry will be its integration into mainstream South African industrial policy as a distinct and supported sector in the wider industrial base. Defence thus has an onerous responsibility to work together with all stakeholders towards this end, and specifically the integration of the defence industry sector into the Industrial Policy Action Plan*".

2.4 Advanced Manufacturing Technology Roadmap Project

The advanced manufacturing roadmap [1] study was commissioned by DST to develop an aerostructures technology roadmap for SA as part of a larger Advanced Manufacturing Technology Roadmap Project (AMTRP).

The following vision was developed for the aerostructures sector during the visioning workshop: "To establish SA as a supplier of medium to large assemblies for global aerospace and as a world class aircraft OEM".

Strategic objectives to support attainment of the vision were set as follows:

- Double the export revenue of the aerostructures sector in 5 years and quadruple it in 10 years.
- Increase the number of long term contracts at Tier 1 level.
- Increase the number of local Tier 2 companies.
- Become a preferred supplier to the global aerospace market.
- Supply commercial and value added products.
- Accelerate job creation and transformation.

The following key trends and drivers were identified:

- Growth of global and African markets.
- An increasingly competitive global market.
- Scarce SA public funding and the requirement for increased risk sharing by global aerospace OEMs.

- Dual supplier sourcing by global aerospace OEMs for increased production rates and reduced risk.
- Cost and weight reduction of commercial carriers in the interest of reducing travel cost as well as reducing greenhouse gas emissions.
- Increasing regulatory compliance in terms of greenhouse gas and noise emissions.
- Advancing manufacturing technologies.
- Increasingly high skills demand in specific fields as well as increasing mobility of highly developed skills.
- Pressure and urgency to transform the local aerospace sector.

This should be seen against SA's geographic location to market which poses a challenge in terms of delivery time and cost of final product.

Eight applications were identified and prioritised during the stakeholder engagement. In order of preference of the stakeholder group these are as follows:

1. R&D.
2. SA as an Aircraft OEM.
3. SA as a supplier of medium to large aerostructure assemblies to global aerospace companies.
4. Training and skills development.
5. MRO.
6. Materials.
7. Developing a database of modern materials.
8. Non-destructive testing.

The highest system level offerings were prioritised for further Roadmap development, namely:

- SA as a supplier of medium to large aerostructures assemblies to global Aerospace companies.
- SA as an Aircraft OEM.
- SA as a supplier of global MRO services.

The first two were selected for further workshopping, with a view that MRO should be considered at a later stage, especially since the room for advanced manufacturing technology advancement in MRO is limited.

Regarding "Establishing South Africa as a global supplier of medium to large aerostructures" the prioritised product classes for the medium term (1 to 3 years) were identified to be:

- Engine cowlings.
- Fuselage shells.
- Doors for ram air turbines and landing gear.

For the longer term (4 to 10 years), the priorities were identified to be:

- Engine pylons.
- Wings for private jets.
- Large UAVs.

Regarding "Positioning South Africa as a world class OEM" the development of the following niche aircraft systems was prioritised:

- A uniquely SA regional aircraft.
- A Rooivalk upgrade.
- A high altitude unmanned system.

Technologies required to enable the development of such systems fall into the generic categories of:

- Engine.
- Aerostructures.
- Avionics.
- Aerodynamics.
- Testing, certification and qualification.

2.5 Industry Framework

For the purposes of this study the industry structure proposed as part of the SDP [5] has been modified primarily to fit the technology streams included in the terms of reference, but at the same time additional changes to generalise the product markets and add testing, certification and airworthiness, as well as policy and strategy to the diagram have been proposed. The third dimension of the Industry supply chain tiers has likewise been added and adopts the same form as that used in the recent space sector study commissioned by the DST. See Figure 3 for the full diagram, while Figure 4, Figure 5 and Figure 6 are included to give better legibility.

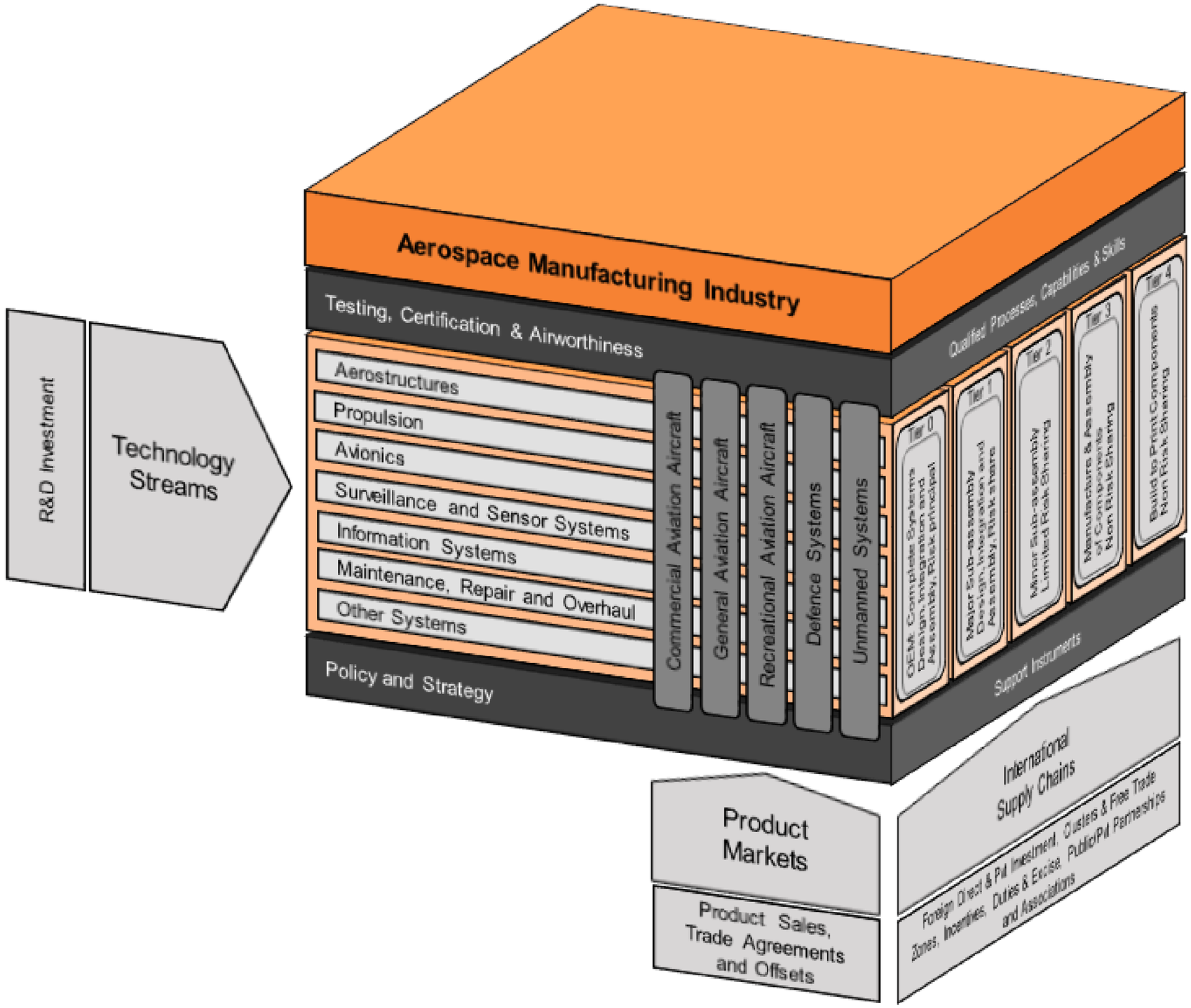


Figure 3: Proposed industry structure

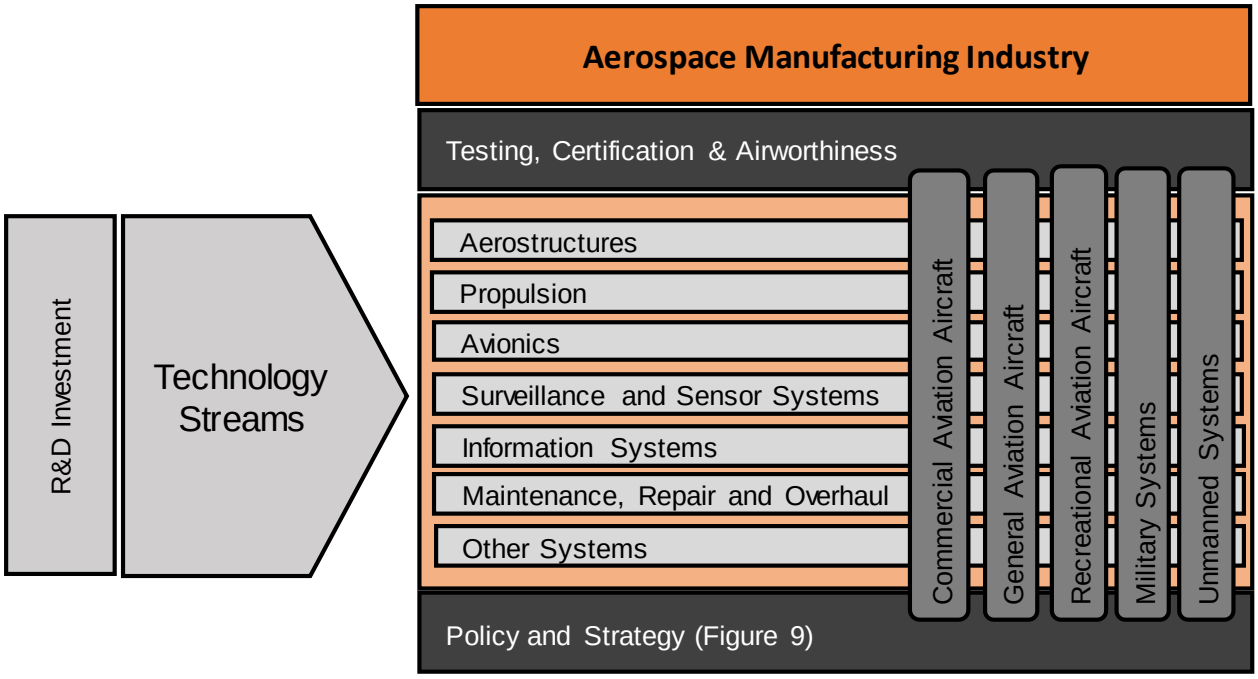


Figure 4: Technology streams and product market details

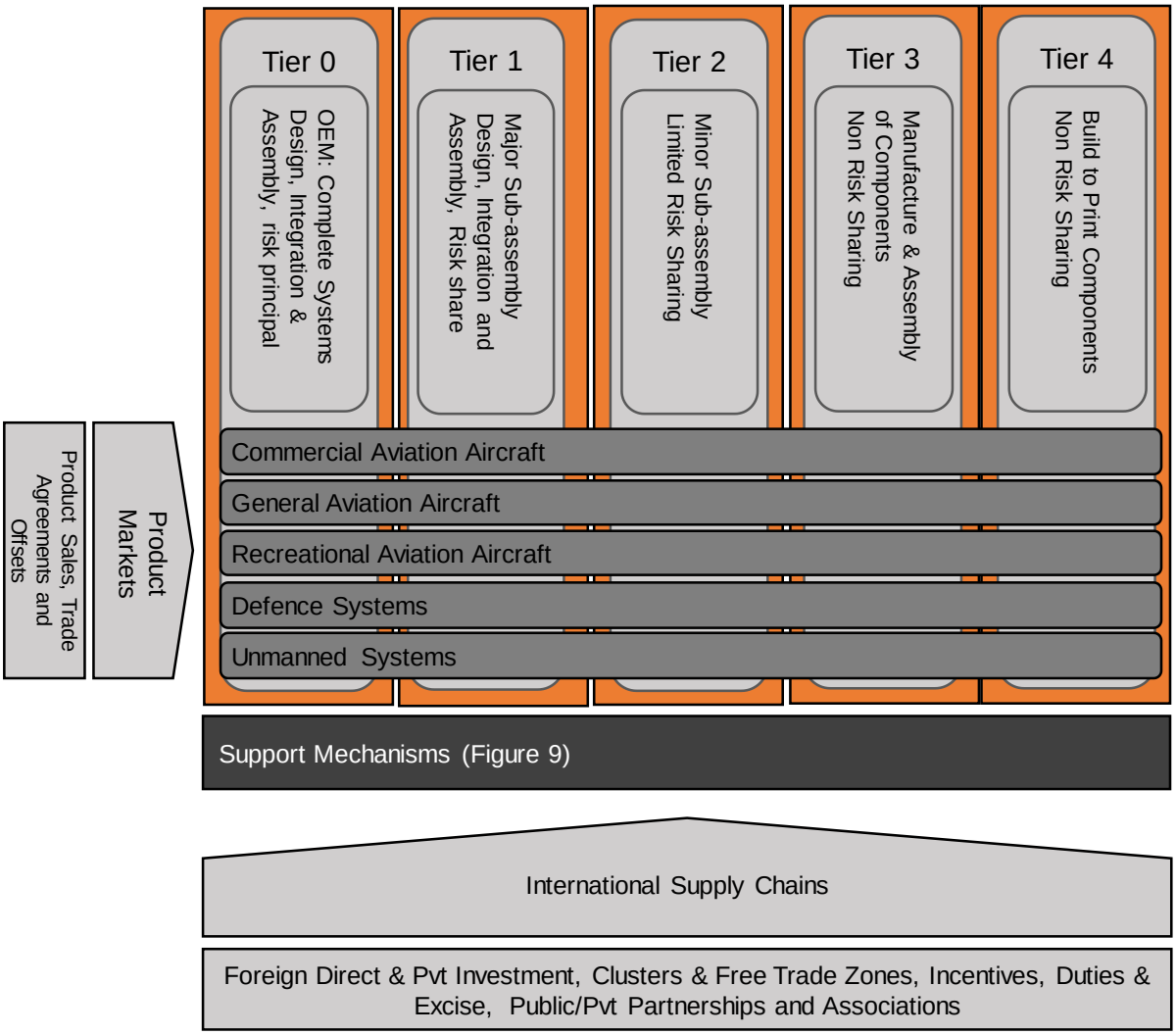


Figure 5: Product markets and industry supply chains details

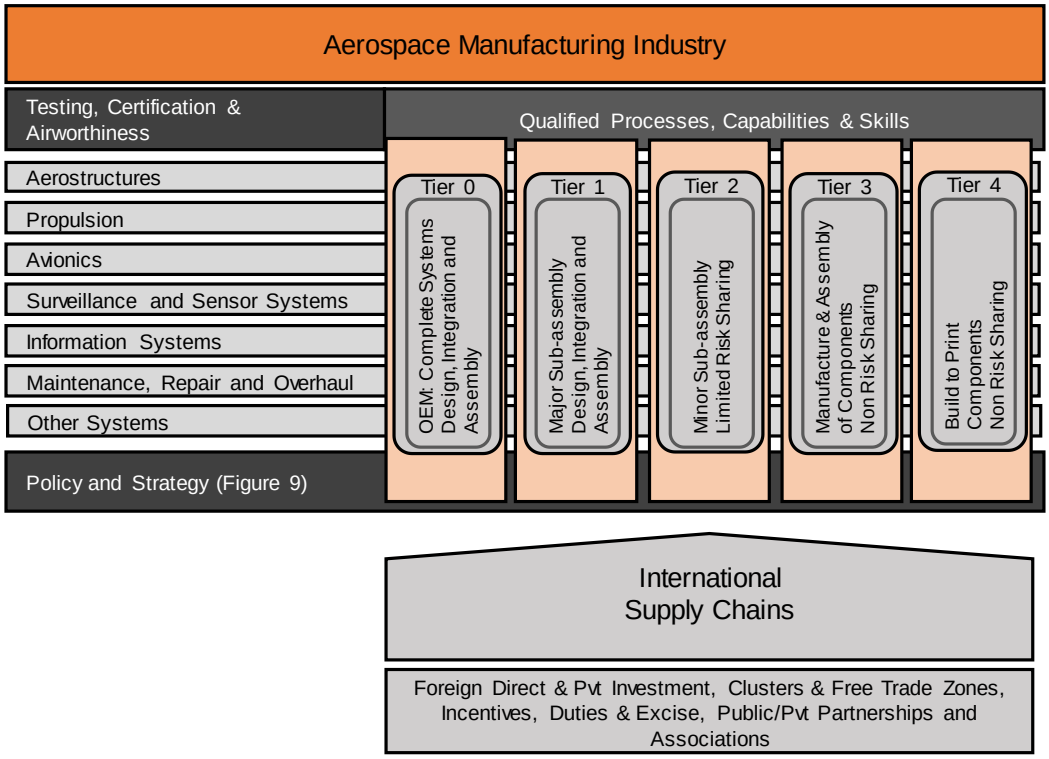


Figure 6: Technology streams and industry supply chain details

2.6 South Africa's Aerospace Policy Frameworks

2.6.1 Introduction

The Terms of Reference require that the report also reflect on the local and international Aerospace Sector regulatory environment and identify specific regulatory issues and constraints that impact on the growth and development of the local commercial Aerospace Manufacturing Sector.

The aim is to identify and analyse relevant frameworks that aid the current investments in the aerospace sector in South Africa. The methodology used is a synthetic overview of "law and society" incorporating a principle of socio-legal research, by providing an orientation to the possible forms of analysing existing knowledge, in particular, frameworks underpinning the domestic aerospace sector.

The analysis is not quantitative but rather focuses on policy measures and scenarios that support aerospace development. The analysis will look at value chains from different, but correlated, perspectives to cover the strategic positioning of the country in relation to membership in international organisations; current policies and strategies affecting the value chain; the governance models and the formal and/or informal rules governing the value chain governance.

2.6.2 Areas of Consideration

The following three (3) broad aspects are key: -

- The application of international laws and regulations (Relevant International Conventions, Agreements and Standards and Recommended Practices) to the Aerospace Sector;
- South Africa's commitment to commercial Aerospace sector development including the governance models; and
- Current public policy programmes designed to encourage aerospace industry growth; (i.e. what exists {support instruments, institutions and programmes).

2.6.3 International Laws and Regulations and its Application to the South African Aerospace Industry

South Africa operates a dualistic system of international law because it constitutes firstly, the ratification of the international treaty by Parliament and secondly, incorporation of the treaty obligations into domestic law. This means that the obligations do not automatically become part of the domestic law by mere ratification, but have to be incorporated into domestic law. According to Section 231 (4) of the Constitution of the Republic of South Africa, No. 108 of 1996 (the Constitution), "*any international agreement becomes law in the Republic when it is enacted into law by national legislation*".

The rights and obligations arising out of the international space treaties ratified by South Africa are incorporated in various national laws and relevant support frameworks. The frameworks serve as the building block for South Africa's involvement in aerospace and establish the current regulatory structure to support aerospace programmes.

2.6.4 Foundation for the Aerospace Sector

It is an acceptable International practise and understanding that, a coherent framework that covers the following aspects is integral to a successful aerospace programme;

- Regulations which covers international and national laws and standards;
- A Policy which set the long term vision for the development of the aerospace industry;
- A Strategy which outlines priorities to achieve the policy objectives and allocation of resources, and
- Implementation, which constitutes roles and responsibilities, resources and initiatives, programmes or interventions to support or incentivise the Industry.

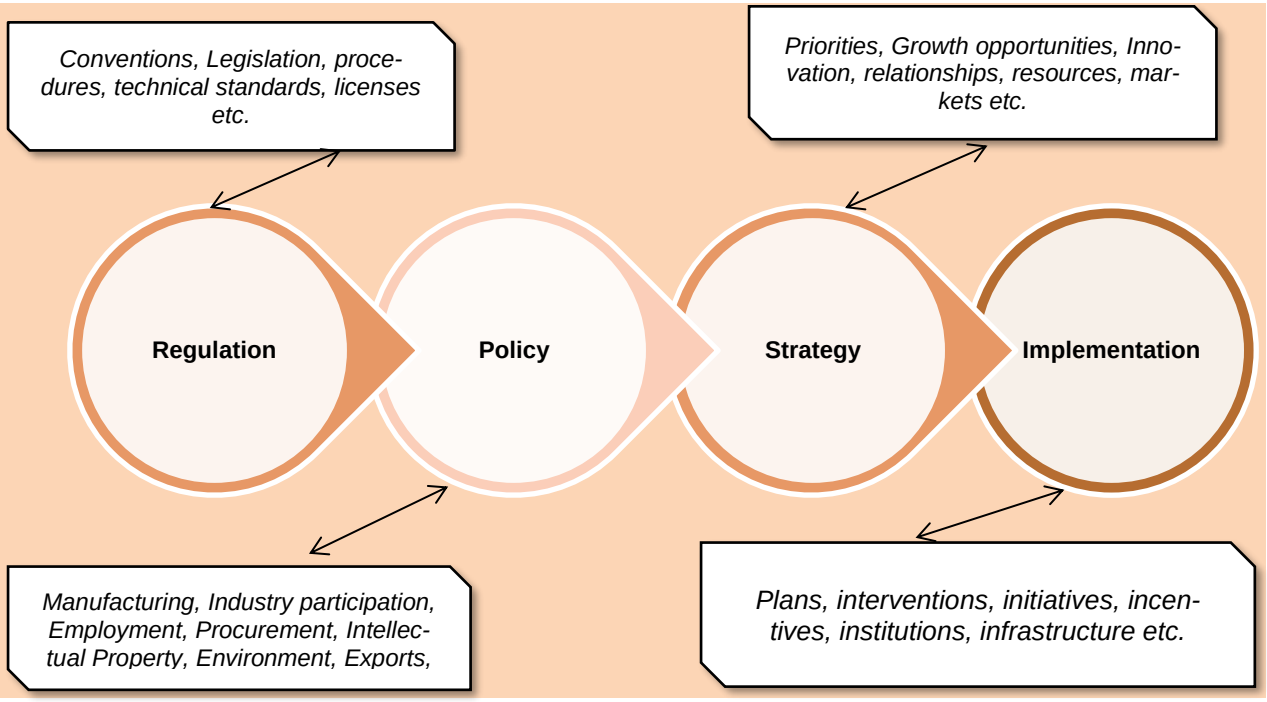


Figure 7: Foundation for the aerospace sector

2.6.5 Existing Frameworks

Relevant national and international aerospace regulatory frameworks, encompassing instruments, initiatives and mechanisms aimed at ensuring a progressive level of regulations, predictability and development of aerospace sector exists particularly in the defence and aviation sector. These are critical in highlighting South Africa's commitments and approach to aerospace sector growth.

Figure 8 below outlines a high-level overview of the various existing framework categories.

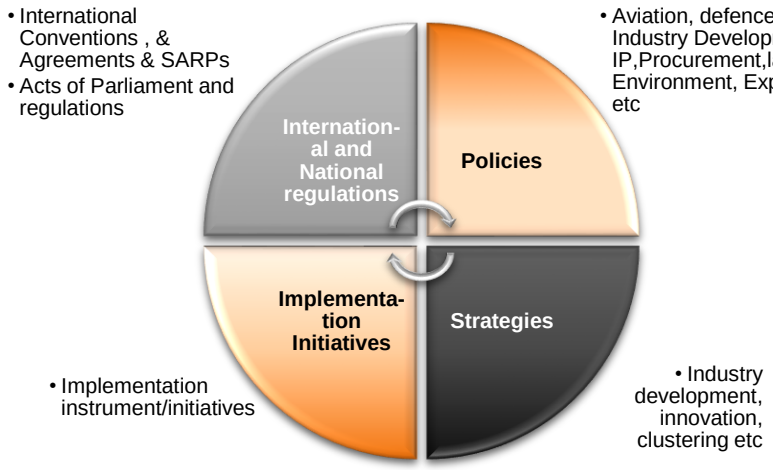


Figure 8: Aerospace regulatory frameworks categories

2.6.6 International Regulation

Regulation in the aerospace sector is set globally via treaties and conventions that mostly govern flight, air travel, and associated legal and business concerns with very minimal focus on commercial aerospace manufacturing [7]. The Convention on International Civil Aviation, also known as the Chicago Convention, established the International Civil Aviation Organisation (ICAO), a specialised agency of the United Nations charged with coordinating and regulating international air travel. The Convention establishes: rules of airspace, aircraft registration and safety, and details the rights of the signatories in relation to air travel. The primary aims of ICAO are to develop principles and techniques of international air navigation and to foster the planning and development of international air transport so as to ensure the safe and orderly growth of international civil aviation throughout the world.

The convention also constitutes uniform rules and procedures referred to as Standards and Recommended Practises (SARPs) which do not have the same legal binding force as the Convention itself, but are universally accepted and implemented to ensure safety of civil aviation. SARPs cover all technical and operational aspects of international civil aviation, such as safety, personnel licensing, operation of aircraft, aerodromes, air traffic services, accident investigation and the environment. SARPs are continually revised, so that regulations keep pace with the rapid technological and operational transformation of civil aviation through a consultative process with Contracting States, international aviation organisations and industry representatives. South Africa became a member in 1947, having ratified the Chicago Convention of 1944, on 1 March 1947. South Africa fully participates in ICAO through the Department of Transport.

The international conventions, regulations and practises are implemented locally through national legislation, standards, policies and mutual beneficial agreements. Due to the cross-cutting nature of the aerospace in the areas such as aviation, space science, electronics, defence etc. and the aerospace sector governance is spread across various government departments according to their mandates such as the Trade and Industry, Transport, Science and Technology and Defence, etc.

South Africa is bound by the International laws and regulations that it have been adopted and incorporated into its national legislation as can be seen by the number of laws in Civil Aviation. However, the high standard of compliance to these standards can sometimes be burdensome to the local industry considering the extent of legal oversight and the resources required to meet the acceptable standards of compliance and compete with established regulatory regimes and global players. Much remains to be done to facilitate mutually beneficial agreements with countries that have established aerospace programmes and government interventions in order to pave the way for the aerospace industry in forming global partnership. The two main organisations that regulate aviation are the FAA in the USA and EASA in Europe. Although the EASA regulations are based on those of the FAA and the SACAA's regulations in turn are based on those of EASA, there are some significant differences, particularly at the level of light sport/recreational aircraft, which is arguably the most important area for the South African OEMs (Airplane Factory, Jonker Sailplanes, Adept Airmotive, etc).

In addition to the Convention there are other International regulatory frameworks which apply to the Aerospace sector in particular the following:

- The Wassenaar Arrangement (WA) on Export Controls for Conventional Arms and Dual-Use Goods and Technologies;
- The Nuclear Suppliers Group (NSG), for the control of nuclear related technology;
- The Missile Technology Control Regime (MTCR) for the control of rockets and other aerial vehicles capable of delivering weapons of mass destruction; and
- Arms Trade Treaty (ATT), to prohibit irresponsible arms transfers and prevent the shipment of arms to conflict zones where they are likely to exacerbate violence and contribute to repressions and human rights abuses.

These frameworks are aimed at achieving international security and stability by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies in particular by putting limitations or control measures on the acquisition, production, deployment and use of conventional weapons. Conventional weapons encompass a wide range of equipment including armoured combat vehicles, combat helicopters and aircraft and South Africa is a party to all four agreements (WA, NSG, MTCR and ATT). However, it should be noted that only the recently adopted ATT is binding, while the WA, NSG and MTCR global rules are non- binding and voluntary in nature. These rules are implemented through various national regulatory structures as highlighted in the section 2.6.7.

2.6.7 National regulations

Due to the cross-cutting nature and strategic importance of the aerospace for various sectors, the leadership and responsibility for the aerospace is dispersed among different government departments, implementing organisations and industry bodies according to their mandates in defence, aviation and trade who assume a critical role in supporting the aerospace industry and encouraging the development of a critical mass of capabilities, technologies and suppliers. These departments have various regulatory and policy frameworks to support the sector and often, deal with aerospace related issues independently with less coordination. Only a strong and coherent leadership can drive a sustained aerospace industry**.**

Based on the various mandates, a number of government regulations and policies exist in support of the aerospace industry. The sectors with established legal regimes are the civil aviation, defence and space of which space is excluded in this report. The Department of Transport has enacted a number of laws, regulations in support of the aviation Industry covering the civil aviation, air service licensing, carriage by air, aviation offences acts and standards. The short and long term vision for the aviation sector is outlined in the White Paper on National Civil Aviation Policy which is the primary framework that deals with aspects of broader aspects aviation and the aviation industry (which includes the business sector dedicated to manufacturing and operating all types of aircraft).

The Departments of Defence, -Science and Technology and Trade and Industry have also developed support policies for the aerospace sector particularly the National Defence Policy and Review, AS-SEGAI, Aerospace Sector Development Plan, IPAP supported by various other public service legislation relating to procurement of aerospace technology, funding, exports and licensing, intellectual property rights and management and so forth.

The South African government has recognised the strategic importance and value of having a local defence industrial capability. The White Paper on Defence initialised a Defence Review, the aim of which was to elaborate on the policy framework through comprehensive long-range planning on such matters related to the defence industry and "defence-related industries" support, armaments, equipment, human resources and funding, since there is a growing number of companies producing defence equipment to make use of civilian technologies, or to manufacture dual-use products which can be sold to both defence and non-defence markets A high-level policy and strategy for defence is the Defence Review which provides a robust platform for the Minister of Defence to argue the defence case with a particular focus on matters related to Aerospace and Defence capabilities, Defence structural arrangements, and accounting for resources provided.

Note: There is an increasing overlap between defence and civilian production within companies, both nationally and internationally.

South African defence-related industries are defined as those clusters of organisations in the public and private sector, and commercial companies and business units of such organisations, which are directly or indirectly active in the provision of goods and services to security forces which are defined as armaments. This provision can include research, design, development, production, assembly, test, evaluation, upgrading, procurement, export, import, maintenance, logistical support, human support or project management. Whereas armaments are defined as any vessels, vehicles, aircraft, ammunition and weapons, as well as substances, materials, raw materials, components, equipment systems, articles, techniques or services, that are designed, modified or adapted to be utilised to equip, maintain or support security operations, or which are used in the development, manufacture or maintenance of such armaments.

The national regulation for conventional arms is contained the National Conventional Arms Control (NCAC) (Act No. 41 of 2002) under the Ministry of Defence and the Non-Proliferation of Weapons Mass Destruction (Act, No. 87 of 1993) under the Ministry of Trade and Industry and their relevant policies. The NCAC Act established the NCAC Committee to amongst other things, "*ensure compliance with the Policy of the Government in respect of arms control; and the implementation of a legitimate, effective and transparent control process*… whereas the Non-Proliferation of Weapons of Mass Destruction (Act, No. 87 of 1993) establishes the Non Proliferation Council (NPC) to control and manage matters relating to the proliferation of such weapons.

The difference between the two bodies is that the NCACC is responsible for the compulsory registration of all companies and persons dealing in arms in South Africa and issues permits to trade in conventional arms, whereas the NPC is responsible to identify all goods to be declared controlled goods and issue permits related specifically to *"the manufacture, procurement in any manner, use, operation, import, export, re-export, transit, transport or disposal by any means of specified goods".*

The Department of Trade and Industry (**the dti**) is responsible for creating an enabling environment for South Africa's industrial base, its general trade and contribution to economic growth, and establishing and promoting trade relations within the international community. The major focus of industrial policy is towards providing long-term improvements in employment and wealth creation in South Africa, through the creation of a sustainable, internationally competitive industrial base. In order to achieve this, industrial policy has shifted from demand-side incentives towards supply-side measures, which are designed to lower cost of doing business, and encourage firms to invest in products and processes that are internationally competitive. Examples of these cost sharing initiatives include the Support Programme for Industrial Innovation (SPII), Critical Infrastructure Programme (CIP), Manufac-

turing Competitiveness Enhancement Programme (MCEP), Sector Specific Assistance Scheme (SSAS) and others.

A number of other initiatives exists to support the manufacturing industry within the Defence and Trade and Industry space in particular the NIPP and DIP Programme. These initiatives are seen as a means to building partnerships with international companies and to positioning South Africa within the global supply chain. One of the main aspects of the NIPP has been to find a sustainable portfolio of opportunities for foreign suppliers/investors, searching in the local market for enterprises/industries able to receive and execute the IP obligations derived from government contracts. Whereas the DIP policy aims to govern all IP proposals and projects/activities directly linked to a defence purchase managed and administered by Armscor on behalf of the Ministry of Defence. The Armscor defines DIP as "the process where purchases of the Department of Defence are used as a leverage to oblige a foreign seller of defence commodities/services to do defence-related business in South Africa on a reciprocal basis in order to advance military strategic and defence-related industrial imperatives".

A significant difference between the NIPP and DIP is that DIP requires the total industrial participation contract to involve at least 20% in activities directly connected to the defence purchase and 70% on indirect activities that may be unrelated, but are relevant to the defence industry as a whole which includes aerospace industry. A more complete list of instruments can be found in Section 6 below and outlines the plethora of available government support instruments which are further described in Appendix A.

Figure 9 highlights the different regulatory structures, laws, policies and support instruments.

Based on South Africa's National Aviation, Defence and Industry-related policies the national commitments and priorities for the aerospace sector can be summarised in the categories highlighted below in no particular order:

1. **To ensure compliance with international regulations in line with the International laws and conventions, Standards and Recommended Practices.** Aerospace manufacturers operate in a highly regulated environment and have to comply with a wide range of International regulations, restrictions and standards. These are mostly driven by political factors and a changing international environment over which the local industry has no control. Particularly, laws and standards relating to licensing and exporting of products and services, Intellectual Property, aircraft design, maintenance and operation, originate from countries to which the product are produced. These laws vary from one country to another and exposes the industry to risks of potential law violations.
2. **To maintain a dynamic regulatory environment capable of responding to changing circumstances.** Aerospace companies operate in a highly regulated environment with wide range of requirements to ensure manufactured products meet quality standards. Such requirements cover inspection of both products and establishments that manufacture products, product testing, component part testing, testing for product registration, good manufacturing standards, quality control procedures, handling and disposal of waste materials. Furthermore, there are requirements to comply with a wide range of public sector regulations and restrictions ranging from procurement, intellectual property, environmental, Occupational Health Safety standards etc., which pose an additional level of compliance by the industry.
3. **To build aerospace infrastructure that meets the user needs.** The aerospace manufacturing industry involves high-end technologies and engineering including complex manufacturing and system integration processes, which require large financial investment. The government and industry bodies play a key role in supporting the industry and encouraging the development of a critical mass of capabilities, technologies and suppliers that are relevant to the current needs including the upgrading of old facilities and advancement of manufacturing process.
4. **To promote of safety and reliability of aerospace systems that are environmentally and economically sustainable.** Aerospace systems/capability are critical to SA's national safety

and security requirements and instrumental in maintaining security. Aerospace manufactures are under pressure to deliver products in a timely manner whilst maintaining the quality and keeping costs under control.

5. **To contribute to social and economic development of SA and the Africa region.** The potential of the Aerospace Industry to achieve the social and economic development imperatives is high. Historically, the economic growth has shown the correlation with the growth in the manufacturing sectors due to the both manufacturing value added and manufacturing employment shares.

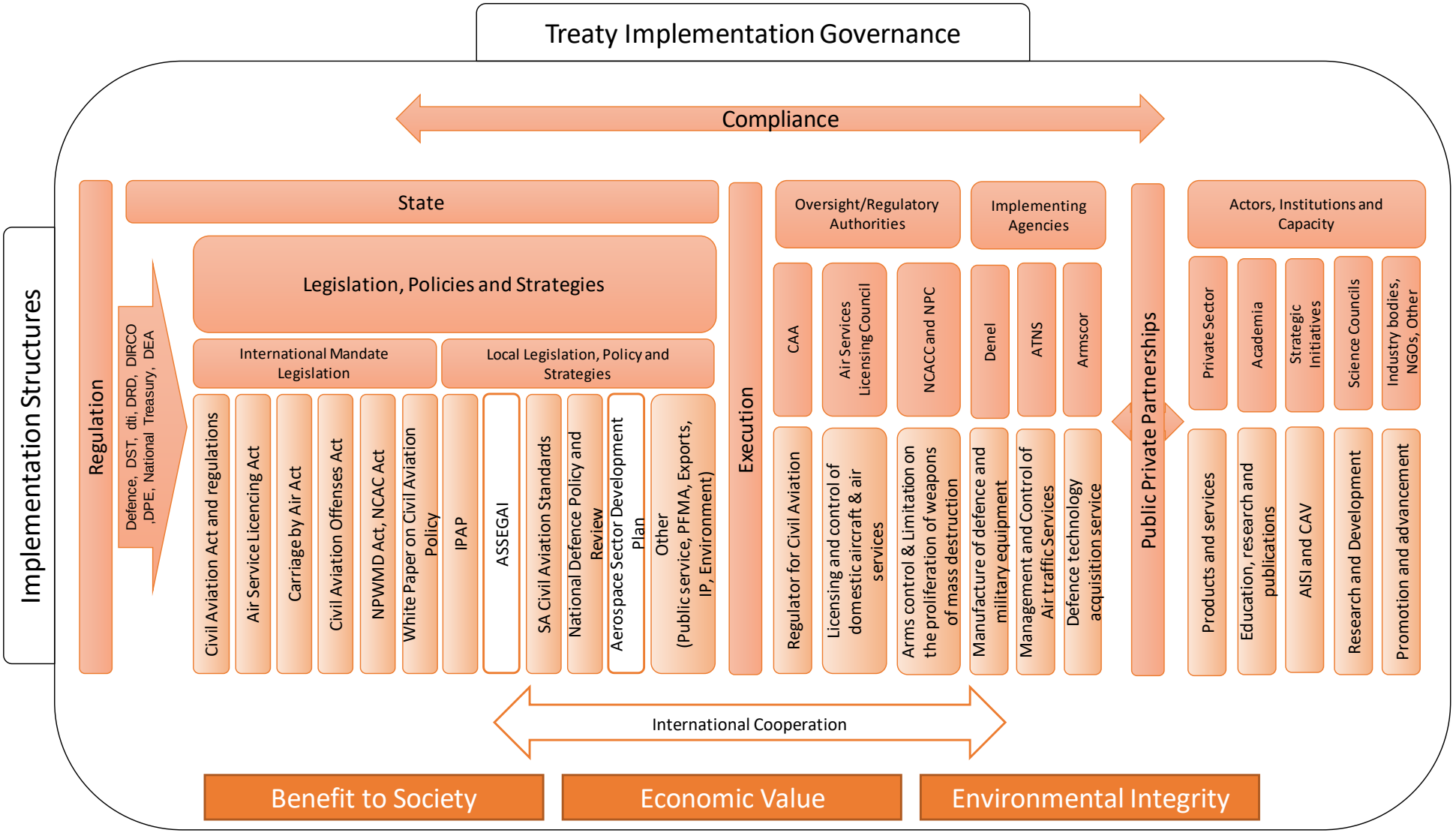


Figure 9: Regulatory, policy and implementation framework

6. **To transform the aerospace industry through broadening of economic participation. Aerospace programmes require massive capital investment and the demand for funding continues** to exhaust the allocated/limited resources, and impact on the continued success of the aerospace sector. Support programmes facilitating access to funding opportunities targeting entities or individuals who struggle to access funding from other financiers due to lack of proof of market for their innovative products/processes including SMMEs, BBBEE, women, people with disabilities are critical for the aerospace manufacturing sector.
7. **To develop of an aerospace industry capable of competing domestically and internationally.** Aerospace manufacturing involves greater emphasis on innovation, physical infrastructure and a skilled manufacturing workforce that can meet the local and international demands. The local industry players face high levels of competition from large players.
8. **To foster collaboration through mutually beneficial partnerships and agreements.** Identification of opportunities that complement current products, technologies, services and customer base are critical in expanding offerings to new markets and attracting meaningful partnerships including technology transfer.

2.6.8 Existing Government Policy and Instruments that Influence the Aerospace Industry

An excellent resource for discovering and applying for both local and national government funding incentives can be found at http://www.investmentincentives.co.za/. The list below represents only those from National Government with some relevance to the aerospace industry. The list represents a very broad range of incentives and instruments with a non-sectoral intent. In practise only the NIP, DIP, AISI, THRIP, Support Programme for Industrial Innovation (SPII), DST R&D Incentive and IDC Capital have really been deployed within the aerospace industry members who participated in this study. Furthermore the THRIP incentive has undergone a significant change in management and approach and has largely fallen out of use while NIPP and DIP are dependent on large government expenditures which are currently suspended given the defence budget constraints and SAA's financial predicament and approach to leasing aircraft rather than buying. In addition the instruments listed below are heavily focused on small companies and to the promotion of BBBEE as these are strategic priorities for the South African government. Furthermore these instruments are perceived to be extremely bureaucratic and often the funding levels are well below what is advertised or required by the Aerospace industry while several industry entities complained of misalignment between government initiatives and industry requirements.

- **National Treasury:**
  - Preferential Procurement Policy Framework Act (PPPFA).
- **DoD:**
  - Defence Industrial Participation (DIP).
- **the dti:**
  - The Aerospace Industry Support Initiative (AISI),
  - The Centurion Aerospace Village (CAV),
  - National Cleaner Production Centre (NCPC),
  - National Foundry Technology Programme (NFTN),
  - Critical Infrastructure Programme (CIP),
  - Capital Projects Feasibility Programme (CPFP),
  - Export Marketing and Investment Assistance (EMIA),
  - 12I Tax allowance incentive,
  - Manufacturing Investment Programme (MIP),
  - Enterprise development Programme for SMME development,
  - Special Economic Zones (SEZs),
  - National Industrial Participation Programme (NIP),
  - Support Programme for Industrial Innovation (SPII),
  - Sector Specific Assistance Scheme (SSAS),
  - Workplace Challenge Programme (WCP),
  - Cluster Development Programme (CDP),

- Manufacturing Competitiveness Enhancement Programme (MCEP),
- Technology and Human Resource for Industry Programme (THRIP).

- **Economic Development Department:**
  - Industrial Development Corporation (IDC):
    - Technology Venture Capital (TVC) fund,
    - Sustainable job creation (UIF II),
    - Youth pipeline development fund,
    - European Investment Bank SME and MIDCAPS (2-10 Billion USD capitalisation enterprises) fund.
- **DST:**
  - R&D Led Industrial Development Strategic Objective:
    - Collaborative Programme in Additive manufacturing,
    - Collaborative Fibre Composites Research, Development and Innovation Programme,
      - Composites Innovation Centres (TUT and NMU),
  - Advanced Materials Initiative – Light Metals
  - Synthetic Appeture Radar Development
  - Ground Based Steering and Classification Radar
  - R&D tax incentives,
  - The South African National Research Network (SANREN),
  - High-End Infrastructure Fund
  - The Centre for High-Performance Computing (CHPC),
  - The CSIR:
    - DPSS and MSM units,
    - Titanium centre of competence,
    - National Laser Centre (NLC).
  - The Technology Localisation and Implementation Unit (TLIU),
  - Technology Innovation Agency (TIA):
    - Seed Fund Programme,
    - Youth Technology Innovation,
    - Innovation Skills Development,
    - Technology Stations Programme (TSP),
    - Bio-Technology platforms,
    - Technology Innovation Cluster Programme (TICPS),
    - Global Cleantech Innovation Programme.
  - South African, European Union Science and Technology Cooperation (ESASTAP),
  - NRF:
    - DST NRF internships programme,
    - Freestanding, innovation and scarce skills masters and doctoral bursaries,
    - A variety of research infrastructure and researcher assistance funds,
    - Industrial CFD, SA Research Chair Initiative,
    - Country to country travel, collaboration and exchange programmes.
- **Small Business Development Department:**
    - Black Business Supplier Development Programme (BBSDP),
    - Co-operative Incentive Scheme (CIS),
    - Small Enterprise Development Agency (SEDA).

2.7 Summary of the South African Policy Guidelines

In summarising the above sections it is evident that Aerospace is thus a truly global industry where technological complexity increases rapidly which in turn requires highly skilled personnel. Risk sharing is the norm if the local aerospace industry wants to become part of the OEM supply chain.

The South African aerospace industry originated from the defence industry and has adapted to play in the commercial aviation sector. The policies described in the previous sectors all support the South African aerospace industry but are not very specific. Flagship programmes (SARA or perhaps a Rooivalk mid-life up-

grade) have been suggested but have not come to fruition. The documents also show that SA wants to act as an OEM or a supplier of medium to large (complex) assemblies. There seems to be less of a focus on manufacturing of components or simple assemblies. However, some South African companies are very successful in manufacturing less complex assemblies or components. One thread that seems to run through is that government financial assistance is required. When some of these documents were generated the economy was generally stronger, the situation in 2018/19 is not nearly as positive and a lack of funding is the reality which suggests a different paradigm and approach may be necessary.

3 International Industry Benchmarking

3.1 International Industry Benchmarking: Countries

The purpose of this section is not to provide an exhaustive benchmarking against all competitors. Instead the steering committee was asked to define a minimum set of countries against which to benchmark. This caused considerable debate within committee and in the end no succinct set of criteria could be articulated but it was agreed that the following set of countries would be included:

- Mexico.
- Morocco.
- Tunisia.
- Brazil/Canada.
- An emerging Asian economy, for example Singapore or Indonesia.

3.1.1 Mexico

Mexico has become firmly established as a global leader in the aerospace sector according to a ProMexico report [8]. It has recorded annual growth of 17.2% during the last nine years. There are currently 287 companies and support entities, the majority with certification from the National Aerospace and Defence Contractors Accreditation Programme (NADCAP) and ISO9001 and AS9100 standards specific to the aerospace industry. They are located mainly in five states and employ more than 32,600 high level professionals. Mexico currently ranks fourteenth as global aerospace supplier and is the sixth biggest supplier to the United States. The country has developed a solid industrial platform of aerospace-related companies. According to INEGI, between December 2012 and December 2013 aerospace equipment manufacturing personnel grew by 9.3%, growth for which the development of industry-specialised training centres was a key factor.

The Mexican tertiary education system delivers more than one hundred thousand engineering and technology graduates every year, capable of supplying both aerospace and other medium and high technology industries. While the relevance of engineering graduates is not aligned with specific industry needs, their skills are such that they can be quickly trained at more competitive costs than in first-world countries.

Mexico was admitted to the Wassenaar Arrangement and the Group of Nuclear Suppliers in 2012, and to the Australia Group in 2013. Mexico is thus part of three of the four main export-control regimes in the world, and is in the process of applying the Missile Technology Control Regime.

The Mexican government has rolled out a series of programmes to boost international trade activities and thus help the integration of local and global supply chains. These programmes include IMMEX, an instrument which allows the temporary import of goods required for an industrial process or service without paying import taxes, and Drawback, which allows beneficiaries to recover the cost of import taxes paid on goods, raw materials, components, parts, and other materials used in exported products.

Mexico's strategic geographic location—close to the most important market in the world in aerospace and defence production and consumption, the United States— makes the country a natural magnet for leading companies and high-value projects, enabling entry and consolidation in that market.

The Mexican aerospace industry has five main hubs (clusters) located in the states of Baja California (Tijuana-Mexicali), Sonora, Chihuahua, Queretaro, and Nuevo León. Currently over 50,000 people are employed in these 5 hubs. These states have managed to get their public, private and educational sectors working together to form specialised clusters, which, in turn, have fostered the development of the industry on a regional level. Work groups have put together an agenda of strategic topics, such as the attraction and consolidation of fresh investment, specialised training, support for certification processes and R&D.

The development of, for example, Nuevo León, is ongoing. The state government is working on two further projects to develop infrastructure; the first is the Nuevo León, Knowledge Economy and Society, which includes actions to link academia with technology companies. The second project is Interpuerto Monterrey (capital of Nuevo León), which seeks to position Nuevo León as a logistics platform among the world's trade networks through a multimodal logistics park that will become a full-service dry port (with offices, trade, and hotel infrastructure) to accommodate the needs of its clients.

The roadmap and projects for this area is graphically shown in Figure 10. The number of OEMs and Tier 1 companies is increasing. These aerospace hubs receive new aerospace companies due to logistical advantages, labour costs, workforce quality and technical training, and government incentives. The Monterrey bases aero cluster has chosen to focus its training and certification efforts on strategic areas such as aircraft maintenance, repair and operation, assembly, the forging of aircraft engine rings and the machining of parts and components. These are strategies that have been adapted to the cluster's members — 20 of them are Tier 1 (direct) and Tier 2 (indirect) suppliers.

In summary, over the last two decades the state of Nuevo León and the Monterrey cluster have been able to reconvert their metal-mechanical manufacturing know-how and make the transition from the automotive, energy and home appliance sectors to the aerospace sector that demands high quality manufacturing and technical knowledge. Nuevo León transport capacities, through the state's road and railroad networks, give it access to the major ports and cities of Mexico and North America.

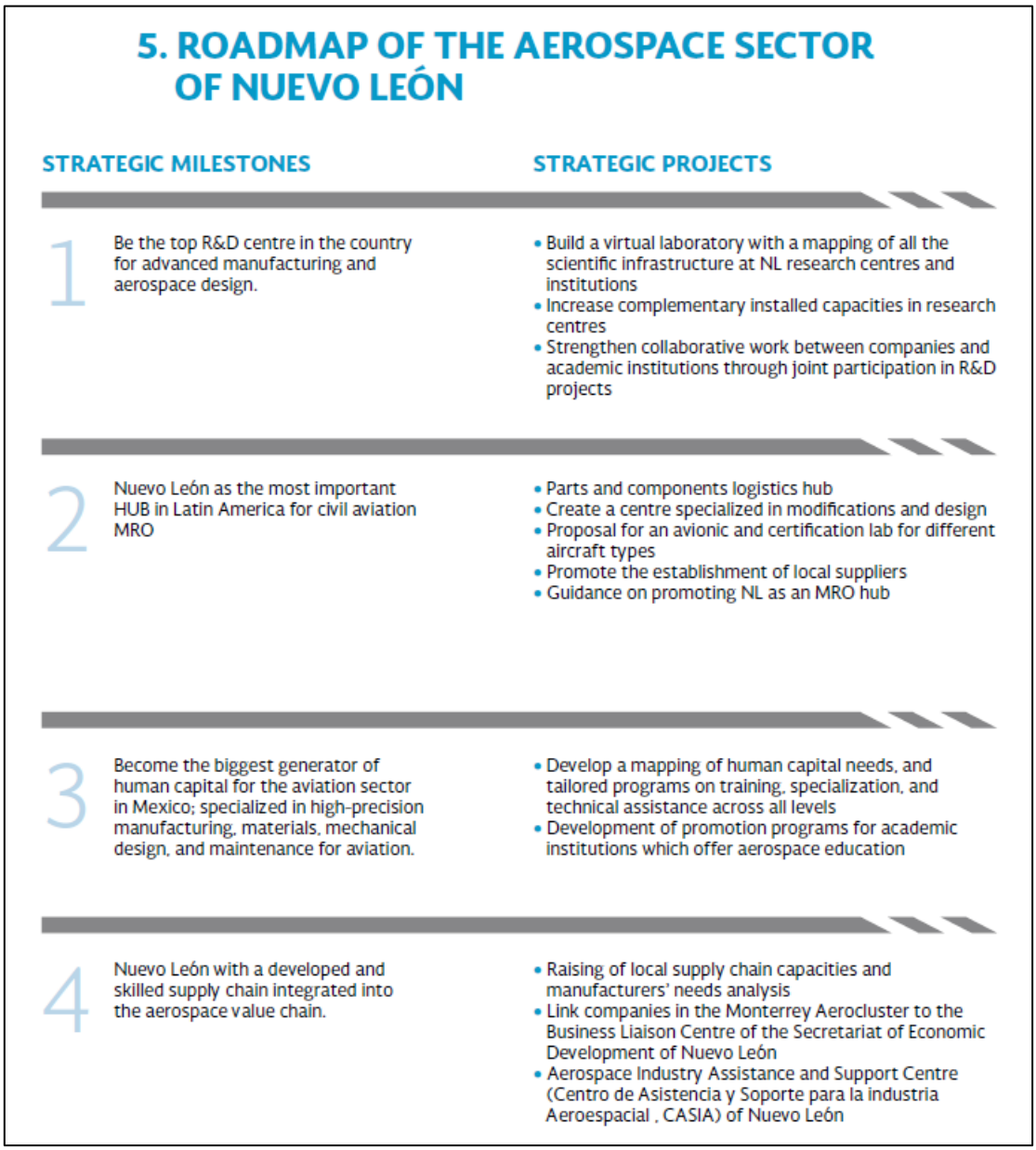


Figure 10: Nuevo León roadmap (from ProMexico [8])

Mexico has improved its aerospace manufacturing capabilities, moving from production of components, small parts, and harnesses, to manufacturing of airframes, flight surfaces, and flight control and avionic assemblies. The following companies are located in Mexico:

- Aernnova produces airframe and flight structures.

- GE and Rolls Royce develop new turbine systems.
- Fokker aerostructures manufactures wings for jets.
- Safran Group—with seven facilities in the State of Queretaro—manufactures landing systems, engine parts, jet engine components, and jet housings, among many other components.

The Mexican Aerospace Industry [9] shows that there often is a strong country to country relationship that was fostered which benefits the economies of both countries. Mexico and France share a long history. One of the sectors where Mexico and France have co-operated is the aerospace industry. Today the aerospace industry is one of the main drivers of the Mexican economy: not only does it attract investment and create jobs, but it has incentivised Mexico's participation in high value-added activities in this and other sectors like the space industry. France in particular is a major player in Mexico's aerospace industry. Practically all the leading French aerospace groups have a presence in the country and are among the companies that invest the most and create the most jobs in the sector.

The product of talks between Mexico's National Entrepreneurship Institute (Inadem) and the French economic development agency Business France, the Mexico-France Entrepreneurship and Innovation Council (COMFEI) was one of more than 60 cooperation agreements signed in the areas of education, transportation and investment, among others. The working agenda COMFEI has drawn up in conjunction with Business France includes a series of events to link Mexican entrepreneurs up with French investors, with a view to promoting the internationalisation of Mexican companies in France and facilitating their access to markets in other EU countries COMFEI was set up for the specific purpose of promoting and developing innovation and entrepreneurship between Mexico and France in strategic sectors.

About 72% of companies that make up Mexico's aerospace sector are engaged in manufacturing activities, 11% in MRO, 13% in the design and engineering side, and the remaining percentage is devoted to academic activities (universities and research centres).

The federal government set up the Aerospace Advisory Board (CCIA) by the Ministry of Economy. Comprised of representatives of the aerospace industry, academia and related government agencies, this board follows up on strategic actions in key areas, such as the promotion of foreign direct investment and the development of suppliers, human capital and technology.

The 2012-2020 Strategic Aerospace Programme (Pro-Aéreo) sets out four priority goals:

1. Position Mexico as one of the top ten countries in the world in terms of the value of its aerospace exports.
2. Export more than 12 Billion USD in aerospace goods a year.
3. Create over 100,000 direct jobs —30%-35% of which are advanced engineering positions.
4. Increase the national content of goods manufactured for the aerospace industry to a minimum of 50%.

The Mexican government, aerospace companies and FEMIA are developing the industry's supply chain by identifying future OEM purchases, Tier 1 and Tier 2 companies. The Ministry of Economy's Industrial Productivity and Competitiveness Programme (PPCI) provides year-round assistance with specific certification processes, like NADCAP and AS9100. The National Science and Technology Council (Conacyt) supports innovation in the aerospace industry and its technological development with initiatives like the Innovation Incentive Programme (PEI), which can generally be applied for once a year. Companies may also qualify for tax credits if they can prove they have invested in innovation and R&D.

Public-sector efforts have focused on technical and higher education. For example, the National College for Professional Technical Education (CONALEP) has technical programmes designed to cater to the needs of the aerospace industry in different parts of the country. Likewise, the Aeronautical University in Querétaro offers technical and engineering Bachelor's and Master's degree courses.

Mexico has started with its move to Industry 4.0. However, education for advanced manufacturing is much more complex than for regular processes, especially in the aerospace sector. To address this educational need, many institutes have incorporated advanced manufacturing into their programmes. Some have creat-

ed research centres dedicated to advanced manufacturing or the aerospace sector. Furthermore, international companies are investing in Industry 4.0 practices in Mexico. Safran is now building its 13th manufacturing plant in Querétaro, which will manufacture parts for the CFM LEAP engine developed in collaboration with GE.

These engines required the use of new and upgraded facilities that incorporate today's most advanced manufacturing technology. While international aerospace companies are making large investments to incorporate advanced manufacturing principles into their production lines, small companies may face an entry barrier in the shape of high equipment and software costs.

Baja California's aerospace cluster began fifty years ago and has evolved into the largest aerospace cluster in Mexico today according to a Global Business Report [10]. There are more than 80 aerospace companies which are spread between the clusters of Tijuana and Mexicali and the cities of Ensenada and Tecate. The following companies are located there:

- Honeywell.
- UTC.
- GKN.
- Eaton.

The focus is on:

- Electrical and electronic systems.
- Engine parts.
- Assembly of interior and seats, control.
- Navigation instruments.
- Engineering and design.

Chihuahua's aerospace cluster is relatively new and houses five of the seven OEMs in Mexico—Cessna, Beechcraft, Textron International, Honeywell aerospace, and EZ Air Interior Ltd.—the state's capabilities range from interiors, to emergency evacuation systems, to aerostructure assembly for aircraft and helicopters.

Today 80% of the companies with operations in the aerospace industry in Monterrey are Mexican-owned companies. One exception is the state's only OEM, Monterrey Aerospace, which is a wholly owned subsidiary of MD Helicopters.

3.1.2 Morocco

Morocco is located at the union of Europe, Africa, and the Arab World (Harvard Business School [11]). It is a gateway from both the Mediterranean and Atlantic. Since 2000, the Moroccan economy has shown the following trends:

- It has been growing on average by 4.7% per annum.
- The GDP growth rate has almost doubled from an average of 2.6% per year from 1990 to 1999.
- The volatility of the growth rate has been dramatically reduced during the last decade from a 19% range (1990-1999) to a 5 % amplitude (2000-2009).
- In the last decade, the GDP has more than doubled to reach USD 100 Billion in 2011 (USD 148 Billion in PPP terms), or USD 3,125 per capita (USD 4,625 in PPP).

The country has chosen during the last decade tor:

- Increase political pluralism and openness.
- Liberalise the economy (privatisation policy and Free-Trade Agreements with the EU, US, Turkey and several Arab nations).
- Implement structural reforms (labour market, justice, education, competition policy.
- Create an independent monetary policy.
- Consolidate public finances in addition to massive public and private investments on infrastructure and logistics projects (roads, airports, ports, public transport, sanitation, telecommunication networks, and high-speed rail).

These efforts were facilitated by the European Union standards and regulations following the Advanced Status Partnership granted to Morocco (the country's exports enjoy among other privileges unrestricted customs-free access to the EU single market and financing through the European structural funds and the European investment bank loans).

Some competitiveness factors and trends are:

- Morocco's ranking for 2012 according to EIU was 62 on the New Global Competitiveness Index (GCI).
- Ranked 64 for Micro-Economic Competitiveness (MICRO) indicators.
- Ranked 58 on the Macro-Economic competitiveness (MACRO) indicators.
- Morocco is ranked (48) on the Monetary and Fiscal Policy (MFP) category, but the challenge is to keep government deficit and government debt under control.
- Morocco was ranked 64 on the overall micro competitiveness.
- The ranking on the category of company operations & strategy was poor (81), due mainly to the weak capacity of firms to innovate and internationalise.
- Morocco made an improvement in the category of starting a business (up to 56 from 94), bringing the number of procedures down to 6 and the number of days to start a business down to 12 – all of which are numbers comparable to OECD countries.
- Despite its geographical location close to the world's largest economy (EU) and the fast growing African economies, Morocco has to address the quality of education and skill mismatch; labour law rigidity, and the acceleration of the diversification of the economy to include higher added-value clusters.
- The seaport of Tangier (ranked 12th in the world and is the largest container port in the Mediterranean and Africa), the first high speed railway in Africa, a network of highways that span 1500 km covering the kingdom, and Casablanca Airport contribute to the availability of a reliable infrastructure.
- Morocco has the fastest internet connection in Africa (broadband). However, the challenges are greatly in the quality of education, the skill mismatch, and the weak innovation infrastructure.
- The country has an advantage of being French the first language, so it can have a better approach to its trade relations with France.
- The government and company expenditure on R&D is low.
- The access to finance for SMME's is another challenge.

The government has a clear economic development plan, which includes the following:

- Improving the competitiveness of the business environment to support its national industrial strategy "Emergence".
- The establishment of:
    - Free trade zones.
    - Trade treaties.
    - The absence of restrictions on foreign currency money transfers.
- Actively improving the competitiveness by relaxing the rigid labour practices.
- Generate 1.6% in annual GDP growth.
- Generate 22,000 industrial new jobs to enhance its unemployment.
- Increase FDI.
- Knowledge transfer.
- Boost exports.
- Enhance the budget.
- Serious effort to enhance the investment climate to attract foreign investors.
- A network of dedicated training institutes is being set up by the Department of Employment and Vocational Training to meet the needs of automotive suppliers, aeronautics assemblers, and IT specialists. The fact that the main investors and trading partners are from Europe, is greatly enhanced by the French speaking workforce and their cultural proximity.

- The competitive wages from Morocco (as compared to its neighbours and Europe), can further enhance the competitiveness; however long-term competitiveness can only be achieved if there is a sustained knowledge transfer process from foreign investors that can help to build the skill-set needs.

The Moroccan aerospace industry started with the following companies:

- **Royal Air Maroc/Pioneering maintenance activities:** The aeronautics industrial history started in Morocco with the creation of the national carrier Royal Air Maroc (RAM) in 1957. The state-owned company developed soon after its first aircraft maintenance activities at the Casablanca International Airport. This would soon become the embryo of a future aeronautics industry.
- **Maroc Aviation:** The other historical protagonist is Maroc Aviation, a subsidiary of the former Aerospatiale (a French aerospace manufacturer now part of Thales), present in Morocco since 1951 to carry out maintenance of the instrumentation devices for the Moroccan Royal Air Force Hercules C130 (Lockheed military transport aircraft) and Super Puma helicopters. Since 1993, the company is owned by EADS Sogerma and as such operates as an equipment supplier to Airbus.
- **Snecma Morocco Engine Services:** Snecma Morocco Engine Services was founded in 1999 as a subsidiary owned 51% by Snecma and 49% by Royal Air Maroc. Snecma Morocco Engine Services specialises in the maintenance and repair of commercial aircraft engines (CFM 56 engines powering the Boeing 737).

The link between these companies and its parent companies ensured that the national aviation industrial cluster became compliant with the most stringent European and American standards of quality for both civil and military operations. The following companies are currently active in Morocco:

- **SAFRAN:** Safran is a leading international high-technology group with three core businesses: aerospace, defence and security. In Morocco, Safran has 2,700 employees, with more than 70% women, and accounting for nearly one-fourth of the aerospace industry jobs in the country.
- **EADS:** EADS Socata work on subassemblies for the TBM 850 turboprop single and for Socata's aerostructure business. This includes elements for the Eurocopter AS 350/355 and Dassault Falcon 7X.
- **BOEING:** Boeing is already a shareholder in MATIS, a Moroccan company specializsng in aerospace wiring and harness products.
- **UNITED TECHNOLOGIES:** UTC Aerospace Systems inaugurated last year a new Propeller Systems facility in Casablanca.
- **BOMBARDIER:** Bombardier of Canada, the world's third largest aircraft manufacturer, is investing USD 200 Million in new manufacturing facilities in Morocco. It started in 2013 a transitional manufacturing facility in the Casablanca Aerospace City and is currently producing simple structures including flight controls for the *CRJ* Series aircraft.

An aerospace cluster called "Nouasseur Aerospace City" (NAC), an integrated industrial platform is located next to the Casablanca international airport that combines the benefits of a free zone and a special development zone. The following advantages are available to companies that locate to this cluster:

- An aeronautics company choosing to locate to NAC benefits from: A flexible and customised real estate; The "Institut des Métiers de l'Aéronautique", a vocational training center created for the aeronautics industry.
- Morocco has decided to streamline key administrative processes (customs, visa, tax…) for companies locating in NAC. This was made possible by increasing the authority given to the operator of NAC.
- Tax advantages (no corporate tax for the first 5 years and 8.75% for the following 20 years, no VAT, no custom duties) and financial support for training local technicians. Morocco has increased the intake of specialised engineering schools and vocational training programmes.

- Morocco has lifted all restrictions on foreign capital investments for aeronautics companies locating in NAC, as long as they are export oriented. Aeronautics companies in Morocco are export oriented and focus primarily on the French and European markets.
- The aeronautics cluster is supported by the existence of a growing logistics cluster in Morocco and a thriving automotive cluster. The development of the logistics cluster has allowed the fast development of the transportation infrastructure, which enable aeronautics companies to quickly ship their goods to Europe.
- The Moroccan aeronautics IFC is GIMAS, which stands for "Groupement des Industries Marocaines Aeronautiques et Spatiales". Its focus is on developing the overall strategy for the sector and representing the interests of aeronautics companies with the Moroccan government and foreign governments.

The intention and priorities defined by government for the Moroccan aeronautics cluster is:

- Priority 1: Maintain macroeconomic stability.
- Priority 2: Enhance Productivity by improving the education system.
- Priority 3: Enhance Competitiveness by improving the investment climate.
- Priority 4: Develop SMMEs and improve access to capital.

Cluster level recommendations are:

- Priority 1: Diversify mix of companies.
- Priority 2: Develop an electronics cluster.
- Priority 3: Strengthen GIMAS.
- Priority 4: Invest in R&D.

3.1.3 Tunisia

The aerospace industry is now experiencing double-digit annual growth and it's also one of the few sectors to have created jobs in recent years according to African Aerospace [12]. It is scheduled to provide more than 1,000 new positions annually over the next five years. Tunisia promotes public/private partnerships through assisting in the simplification of customs procedures and promoting the development of human resources and training. It has also created a fiscal incentive framework to encourage foreign investment. This new law makes it easier not only for foreign companies to invest in Tunisia but also for Tunisians to invest in their industry. Following its democratic transition, Tunisia has introduced reforms to move from a low-cost economy to a manufacturing hub with a diversified economic structure. The aeronautics sector is a key part of this initiative and the government aims to enhance the governance of the sector through the creation of national aerospace clusters.

According to a survey carried out, there were a dozen aeronautical companies in 2004 and this has now grown to around 80. Several major groups have established themselves in Tunisia: Latecoere in 1998, Sabena Technics in 2002, Zodiac Aerospace in 2005 and Stelia Aerospace in 2011. More than 85% of aerospace companies located in the country are foreign-owned with France remaining Tunisia's largest partner, comprising around two-thirds of the total. Tunisia now offers a variety of aerospace engineering services, production facilities and manufacturing solutions, including the production of parts and subassemblies for Airbus' A320 and A330 families of airliners. These are produced at the El Mghira industrial centre in the southern suburbs of Tunis and extend over an area of more than 200 hectares, of which 20 are dedicated to the aeronautical park.

Aerospace Industry in Tunisia [13] provides additional details of the current industry. It states that there are 80+ aerospace companies in 2018 (up from 12 in 2004) and that the number of jobs created is 17 000 in 2018 (up from 1 310 in 2004). Engineering and production capability is available through a number of international companies (Stelia, Safran, Eurocast, Sagem, etc). MRO facilities are also available (Boeing 737-500 and -600). The document also makes the statement that a training programme tailored to the aerospace industry is in existence. The offered training spans universities to technical education.

3.1.4 Brazil, Canada and Mexico

3.1.4.1 Brazil

Flores and Villareal [14] attempt to draw a comparison between the aerospace industries of Canada, Brazil and Mexico focusing on the public policies that were instituted by the respective countries. The focus of the study was TT but the development of the aircraft industry in each country provide a good insight. Flores and Villareal [14] was the only reference material that drew direct comparisons between national aircraft industries in different nations.

Import substitution was the main driving force behind the Brazilian aerospace industry. It led to the creation of Empresa Brasileira de Aeronautica SA (Embraer). Embraer's aim was to manufacture small combat aircraft and the company was managed by the Air Force. Where regional jets are concerned Embraer is currently regarded as one of the most viable businesses and competes with Bombardier, a Canadian company also in the business of designing and manufacturing regional jets and now owned by Airbus.

The development of the aerospace industry in Brazil focussed on two aspects namely building up of the national capabilities in strategic technologies (this was a military strategy), and to modernise the national industry (this was an economic strategy). These two guidelines directed the construction of an institutional framework of support for the sector.

The Brazilian national development goals and the need to respond to the countries needs governed the priorities. The Aeronautics Technical Center (CTA) was requested to develop the IPD-6504 project (Bandeirante), which was technologically challenging. The development took 3 years and during that time, the domestic industry had the opportunity to become familiar with the traits of the sector and to acquire the skills needed to mass produce the aircraft and the strategies to follow. The national business community was invited to participate in the project, but uptake was very low, even though the state guaranteed most of the technological infrastructure, financial support for R&D, and the acquisition of the first 80 aircraft produced.

The development path and policies employed by the Brazilian aerospace industry is shown in Table 3.

Table 3: Brazilian aerospace industry development path (from [14])

YEAR	AGENT	PROJECT	CHANNEL	TRIGGER	BENEFIT
1970	Aermacchi	Production of 112 Xavantes planes	License	Aeronautics department: FAB acquisitions programme to renew their equipment	Knowledge transference (referring to industrial methods and processes) through personnel interchange
1973	Northrop Aircraft Corporation	Components production	Outsourcing	Aeronautics department: FAB acquisitions programme to renew their equipment	Technology acquisition through wing production and assembly.
1974	Piper Aircraft Corporation	Production of single motors and dual motors	License	Increase in demand	Progressive participation in components manufacture, no royalties payment, design modification, development, manufacturing
1981	Aeritalia Aermacchi	Co-design and produce a combat mo-del	License	Interest in building a lightweight combat aircraft	Project management capabilities, integration systems, manufacturing, pressurisation and design of medium airplanes
1983	Sikorsky	Acquisition of compound material tech-nology	Technology transfer agreement	Technology acquisition	Compound material technology

YEAR	AGENT	PROJECT	CHANNEL	TRIGGER	BENEFIT
2001	Saab AB	Acquisition of fighter type airplanes	Industrial cooperation contract	Interest in producing fighter type airplanes	System and equipment production for fighter airplanes

In the Sao Paulo aerospace cluster companies are being spun out regularly by former Embraer employees, and graduates of the university. Technical support to the start-up companies is provided through CTA and other specialised institutions. TT from Embraer to the local businesses needs to be improved. There is a need to improve the links between small and medium-sized businesses (SMMEs), universities, and public research centres but also for them to receive more financial support.

3.1.4.2 Canada

The second country that is discussed by Flores and Villareal [14] is Canada. Canada is a major player in the aircraft industry. It is responsible for design and production of regional aircraft, propulsion systems, flight simulators, landing gear, environmental control systems, and civil aircraft. The three major aerospace clusters are located in Montreal, Toronto, and Vancouver. Montreal is considered as one of the three international aircraft industry capitals, given the concentration of different enterprises at different levels of the supply chain.

Aerospace Industry of Canada (AIC) was developed during World War II. The conflict made possible the signing of two cooperation agreements with the United States that benefited the sector:

- The Ogdensburg Agreement (1940), which affected the supply of qualified human capital and TT in the sector.
- The Defence Production Sharing Agreement (DPSA) (1956), which optimised the industrial, scientific, and technological resources of both countries for the benefit of the defence sector.

A government initiative, the Defence Industry Productivity Programme (DIPP), was launched to reap the benefits of industrial cooperation agreements, focused at first on the defence sector and later, on the development of dual-use projects (military–civilian).

The DIPP came to an end after the privatisation of companies belonging to the British Crown (Canadair and de Havilland). The Technology Partnership Canada (TPC) (1996) was implemented as a strategic programme to support investments in R&D. Due to this programme, the AIC accomplished the following: the Canadair regional jet; the Pratt & Whitney Canada PW308; the development of sustainable coatings for landing gear resulting from collaboration between Heroux-Devtek, Messier-Dowty, and BF Goodrich; and the simplification of the CAE operating systems.

The Strategic Aerospace and Defence Initiative (SADI) (implemented in 2007), focused on process, products, or service innovation. The advantage to industry was that it provided refundable support to R&D projects. The programme was aimed at the space, aviation security, and defence sectors. To help the competitiveness of the national business community, the National Research Council Aerospace (NRC Aerospace) offers support to businesses in research and technological development activities.

Priorities set by the Canadian government included the following:

1 Prioritise the aerospace industry in the science and technology strategy to maximise the benefits (public and private) from investing in this industry.

2 Give priority to investment in technology to increase national competitiveness and capabilities.

3 Establish R&D risk mitigation programmes by SMMEs and science councils.

4 Prioritise the economic importance of the aerospace industry by improving access to foreign markets and promoting government aerospace agencies

5 Support SMMEs capabilities so that they can join the supply chain.

6 Recognise the importance of intellectual property rights and TT transfer for the industry.

7 Assist the aerospace industry in export control and certification regimes.

8 Provide training for workers and students.

9 Establish national priorities that are clear and correspond to the space industry.

10 Stabilise the Canadian Space Agency.

3.1.4.3 Mexico

Although the Mexican aerospace industry was already discussed in section 3.1.1 the focus of Flores and Villareal [14] is slightly different and this reference document's description of the Mexican scenario will be included in this report.

External factors were important in the establishment of the aircraft industry in Mexico. These included cost reduction through the decentralization of assembly manufacturing activities and aerospace components, and the geographic proximity to the United States and Canada. The aerospace industry is considered as strategic because of its possible contribution to national technological development and its effects on the productive capabilities of the local businesses community.

Mexico intends to address the full cycle of an aircraft (design and engineering, manufacturing of parts and components, assembly, maintenance and recycling, and conversion). However the possibility of creating a national company to develop an internationally competitive aircraft is not being considered. The plan is to develop competitive human capital, which would attract other companies in the industry, generating jobs and increasing the amount of FDI.

The aerospace industry in Mexico was established before World War II but the present-day history of the sector began in 1998. Queretaro was developed as an engineering and manufacturing hub. Due to the contribution of the aircraft industry in terms of employment, investment, and exports, in 2003, the Federal Ministry of Economy proposed to develop Queretaro by attracting international companies as anchor companies for smaller companies. In 2012, the National Strategic Aerospace Programme was published, with the goal of developing the industry to position the country in the top 10 internationally in terms of exports, employment, and productivity.

From 2008–2012, the Programme for Certification of Special Processes to Boost Integration of SMMEs was implemented. Its objectives were to achieve 40 certifications of special processes for Mexican SMMEs—establishing a TT model between certifying bodies and the Mexican Federation of Aircraft Industries (FEMIA), to ease access to certification methods. The objective was to increase trade between Mexico and the European Union. The sub-programme Alliance with Transnational Companies was implemented in 2011, promoting integration into the sector's supply chain, identifying imported products by OEMs, and detecting certified and qualified local alternatives and integrating these into the supply chain. Aerospace clusters formed organisations that linked the industry to institutions of higher education and research.

The public policies employed by Brazil, Canada and Mexico can be seen in tabular format in Table 4.

Table 4: Public policy for the development of the aircraft industry: Brazil, Canada, and Mexico (from [14])

BRAZIL	CANADA	MEXICO
GOVERNMENT SUPPORT		
a) State as a main client. b) Tax exemption on imported aircraft parts and industry profit. c) Support for exports. d) Credit options for supply and demand. e) Support for the creation of productive capabilities. f) Support for internationalisation. g) Protectionist policies on im-	a) Sector control in times of international conflict. b) Encouragement for exports, their control and certification regimes. c) Financial support for R&D, innovation (processes, products, services), commercialization, and sustainable development. d) Encouragement of coopera-	a) Establishment of industry strategic milestones. b) Signing of international accords. c) Development of human capital. d) Attracting leading businesses. e) Creation of research centres. f) Support for national busi-

BRAZIL	CANADA	MEXICO
ports. h) Offsets policy. i) Signing of international accords to promote the creation of human capital and TT.	tion between institutions, universities, and the private sector. e) Technology investment. f) Joint risk for investment in SMMEs R&D. g) Protection to direct public investment and TT: h) Human capital training i) Offsets policy. j) Signing of international accords to promote the creation of human capital and TT.	nesses certification. g) Identifying the best company practices. h) Support for the formation of clusters.
SPECIFIC ACTIONS FOR THE PROMOTION OF TECHNOLOGY TRANSFER SECTOR		
a) Development of research centres: MIT-CTA, ITA b) Multinational companies–Embraer: Co-production accords and alliances with foreign companies in line with the acquisitions programme of the FAB. Offsets policy. c) SMMEs - Embraer: Fiscal subsidies for R&D investments Complementary industrial programme.	a) Research centres CTA, CRIAQ, CDCQ, CIADI, ICIA, IICAP, McGill University, NRC Institute for Aerospace Research (NRC–IAR) b) Multinational companies – Bombardier: Offsets policy. c) Multinational companies – PYMES: Coproduction accords in the consolidation stage of the industry. Offsets policy. Aero Montreal MACH initiative	a) Research centres: CIDESI, CIDETEC, CFTA, TREMEC, CINESTAV, CIIIA, CEDIA b) Multinational companies – SMMEs: Programme for the certification of special processes. Interest in establishing an offsets policy

Although Flores and Villareal [14] as stated before, focused on TT issues the characteristics and efficiencies identified for the aircraft industry remain relevant. For the Mexican case these are indicated in Table 4.

Table 5: Deficiencies in the Mexican contest

ACTIONS	IMPACT	DEFICIENCIES
Public research centres	Creators, emitters and receptors of knowledge and technology; transfer capability toward national economy.	Uncoordinated scarce linkage to the Mexican private initiative. Limited existence of specialised human capital
Accords, compacts, and international alliances	TT from international organisations.	Lack of agreements that promote the transfer of capabilities and technology.
Offsets policy	TT from the receiving enterprise of the purchase offer.	This policy has barely been announced as a milestone.
Industrial links	Incrementing the national business community's participation in the industry. TT as a result of supplier development programmes.	Limited participation of Mexican local business in the sector. Participation of Mexican business mainly simple manufacturing activities.

3.1.5 Singapore

During the late 1970's the Singaporean government decided to focus on the development of an aerospace industry (see [15]). At this stage the manufacturing sector was already well established due to:

- Political stability,
- Investor friendly business climate,
- National security was a high priority,
- Centralised decision making that set as priority economic competitiveness,
- Fighting of corruption.

The following actions were taken:

- The Economic Development Board was established in 1961 for strategic planning and investment promotion,
- An Export Promotion Centre was created in 1965 to provide export financing and credit insurance to exporters,
- Trade unions were kept under control,
- Workers were incorporated in long-term growth negotiations,
- Workers subscribed to investor-friendly reforms given a culture that valued thrift, readiness to change and social mobility, a free enterprise market, and consistent, predictable and rational policy making,
- Education reforms aimed at improving science and technology knowledge and qualifications.

These policies led to:

- High growth rate,
- Increased GDP, also in the manufacturing sector,
- Half of domestic investment was financed by national savings,
- Foreign direct investment,
- Export focused industries.

Vertesy and Fermi [15] states that the Singaporean economy undertook two major transformations over the last 40 years. In the late 1970's it transformed the labour-intensive economy to a capital intensive high-value-added manufacturing economy. However, Singapore experienced increasing competition in the region and lacked natural resources. This forced Singapore to the realisation that a second transformation to knowledge-intensive activities and services was required. During the beginning 1990's innovation policies and strategies were devised to aid the latter transformation.

In order to attract investment the government took the following steps:

- Incentives to invest in the priority industries, including corporate tax exemption for the first five years after production start-up,
- In order to attract skilled labour force, a corrective wage policy was implemented,
- Education and training institutions were expanded, especially in science and engineering fields,
- A bilateral Airworthiness was established.

Three characteristics of the emergence of the Singapore aerospace industry were:

1. From Vertesy and Fermi [15] it can be shown that unlike Brazil or India, Singapore did not establish public research organisations or training institutes entirely earmarked to aeronautical engineering. It was realised that MRO activities and parts manufacturing do not require as complex technological capabilities as designing and producing aircraft. The long term view of Singapore was to make it attractive for firms to locate in Singapore and for them to invest in technological capabilities. This was only possible by an active governmental role which provided incentives, monetary and non-monetary. Government's role was to use the strategic location of Singapore and transform it into an ever growing global transportation hub and a regional financial centre. This provided the basis for a constant demand for air transport related services and MRO with the associated economies of scale.

2. Other tasks performed by government included:

a. Facilitating tax incentives for firms, public procurement (including military procurement),
b. Facilitating favourable immigration policies,
c. Investing in education and training.

The financial incentives, the intensive flow of knowledge and technology provided the foundation for the Industrial activities to develop at the Changi/Loyang and Jurong aerospace clusters.

3. The technological learning process required close collaboration between the MRO providers and parts and component suppliers. This close co-operation within the sector benefitted the innovation system by adopting the newly found knowledge and then diffusing the state-of-the-art technological knowledge by the stakeholders. The high public defence spending on RSAF fleet expansion and maintenance, and also the proximity of related industrial activities (electronics, precision engineering) benefitted SAI. The role of Economic Development Board as an efficient adjudicator between government policies and industry requirements made it also a principal participant in the emerging sectoral innovation system.

The size of Singapore's domestic market was limited but the growth potential for the Asia pacific region was identified. The government partially privatised Singapore Technologies Aerospace (ST Aerospace) and also did the following:

- Opened a maintenance facility in the USA,
- Established operations in Los Angeles by acquiring a local sheet-metal supplier of Boeing with an aim of moving closer to its customers,
- It signed a deal with Eurocopter and China National Aero-Technology Import and Export Corporation (CATIC) to jointly develop a five-seat helicopter, the EC-120.

By the mid 90's the major companies such as GE, Goodrich, Hamilton Sundstrand16, Liebherr, Rockwell Collins or Rolls Royce Engines had established a presence, expanding the aircraft and engine subsystems and avionics production and repair knowledge base in the country.

Almost two-third of all researchers in Singapore (60% to 64%) are active in the field of engineering and technology in the last decade. Both the National University of Singapore (NUS) and the Nanyang Technological University offer education and research in science, engineering and management. Singapore tertiary education institutions succeed in attracting new talent: by attracting foreign staff and students through favourable immigration policies and often subsidised studies instead of restrictive admittance and immigration regulations, and by investing in facilities through effective cost sharing, fundraising and collaboration with industrial partners.

3.1.6 Indonesia and Singapore

Hill and Fong [16] provides an overview of the aerospace industry in both Indonesia and Singapore, highlighting the different approaches taken. It does not refer to aerospace industry clusters but the different approaches taken by the two countries is insightful nonetheless.

Government involvement in the aerospace industry in Indonesia and Singapore has been extensive due to the fact that:

- The industry is both capital and skill-intensive.
- The industry is highly R&D intensive, reflecting its major production characteristics: stringent quality control, minute tolerances, rapidly changing raw materials usage, and the use of advanced equipment.
- Aerospace production exhibits greater international concentration than any other major industry.
- The industry comprises a diverse range of outputs, including not just manufacturing activities but also services, such as repair and maintenance, design and computer assisted inputs.

The aerospace industry is a good case study for the design and implementation of industrial policy. Government intervention includes financial assistance to facilitate export deals and regulation of the international aviation industry. The benefit is not only defence and strategic considerations but exports and employment. The aerospace industry development in Indonesia and Singapore differed markedly.

The following characteristics are identified for Indonesia and Singapore respectively:

- **Singapore**
  - Followed a strategy aimed at attracting high-tech industries and phasing out labour-intensive industries.
  - Singapore policy has been to operate through market forces (not state intervention).
  - Singapore, has not invested state capital in trying to develop a commercial aircraft manufacturing capability.
  - Singapore has a state-owned firm (assembly of jet trainers and helicopters refurbishing).
  - The government's initial efforts at promoting the industry met with only limited success due to the fact that:
    - There was a lack of a regional market for aircraft component manufacturers.
    - Difficulty in sourcing raw materials.
    - Aircraft components made in Singapore and intended for the US market had to be approved by the US FAA.
    - Manufacturers were uncertain about availability of skilled labour.
  - Government promptly introduced a package of reforms to address the above through:
    - A corrective wage policy,
    - Incentives for priority industries,
    - Educational and training institutions
    - Government signed the Bilateral Air worthiness Agreement which meant that aircraft components made in Singapore satisfy international standards (no re-testing required when components are exported to the USA).
  - There are foreign-owned and state-owned firms in the industry. Most foreign-owned firms are from the United States and the only state-owned firm, the Singapore Aircraft Industries (SAI), is a holding company with seven subsidiaries and associated companies, some located in the USA.
- **Indonesia**
  - Government interventionist approach.
  - Indonesia invests state resources to develop a capability to manufacture aircraft, even though its industrial support base is small.
  - Rather than developing technology capacity over a long period of time, through components manufacture and a service maintenance expertise, Indonesia opted for full assembly (through IPTN). This approach necessitated an expensive aircraft assembly tooling up process, especially as a number of projects were being run in parallel (e.g. CASA 212 Aviocar and NBO-105 helicopter). Investment rose sharply again when work began for production of the CN-235 for which there was no immediate return on investment. Indonesia effectively imported technology at a high cost to assemble aircraft and it needs to be considered carefully if it makes financial sense to embark on such an ambitious programme so rapidly.
  - The IPTN quickly obtained permission to assemble aircraft from two European manufacturers.
  - IPTN has imported much foreign technology, through technical licensing agreements.
  - IPTN has a captive domestic market. Not only have most of its sales been domestic (see Table 3), the major customers have been government instrumentalities.
  - IPTN has been bank-rolled by the government from the start.

The two countries' approaches to the development of their aerospace industry differed completely. In the case of Singapore, the government's long-term aim is to develop the country into the aviation support centre of Asia, including a role as a repair and overhaul centre, as an aircraft component manufacturing base, and as international headquarters for the regional market. IPTN has set its sights mainly on the Asian market, and here the barriers may be more substantial. As we have seen, several industrially more advanced countries in the region have ambitious expansion programmes.

3.1.7 Indonesia

Suharto [17] describes the development of the Indonesian aircraft industry but focusses on the technology development and the marketing requirements. As was described in the previous section the unusual approach taken by the Indonesian aircraft industry (mainly IPTN which changed its name to PT Digantara) was as follows:

- Assembling final products (first phase).
- Manufacturing components for assembly (second phase).
- Designing product components (third phase).
- Producing new systems (fourth phase).

First production was the CN-212 (12 seater), followed by the CN-235 (35 seater) and the intention was to produce a completely new 100 seater aircraft. However, as a result of the economic crisis in 1998 the government was forced to stop additional investment. At this stage it as also clear that the competitiveness of the Indonesian industry was not very high. Dirgantara continued to have liquidity problems. The IMF recommended closure of the company. A task force recommended that "*product development should not be made on the basis of State power or influence (power approach). Technology push strategy changed to market pull strategy. Production should be determined based on analysis of market demand and competitive ability not determined by the taste of management on certain kind of technology that they like the most*". From 2004 the following steps were taken to save the industry:

- Formulate a business reorientation, restructuring of human resources, financial restructuring and improving corporate performance.
- Focus on the production of spare parts and components for world corporate giants like Boeing, Airbus, British Aerospace, etc since at that time, Dirgantara Indonesia was already well known for its competitive parts and components production.
- Structural changes in the company (management based on technical skills).

The Indonesian example seems to indicate that the correct technology strategy should go hand in hand with the correct business strategy.

3.2 Summary of Best Practice Strategies, Policies and Incentives

Based on the information detailed in section 3.1 the following best practices can be identified:

- An industry advisory group that consists of government, industry and academia needs to be established. This organisation needs to speak with one voice when communicating with government. It needs to have "teeth" so that it can "get things done". As a minimum it follows that this group needs to be funded sufficiently to operate efficiently and independently.
- The link between academia and industry can't be over emphasised. If the skillset required by industry changes academia needs to be able to adapt quickly to deliver said skillset. This applies to university training but equally artisan training.
- The aerospace requires some the highest skilled/educated individuals. The training centres need to be able to deliver at the correct skills level and quantity.
- An aerospace cluster needs to have a clear advantage. This could be location (close to an OEM), a critical mass in terms of companies or strong links to an OEM or Tier 1 company.
- Financial incentives are imperative, be it tax incentives or reduced labour costs.
- Reliable labour is also very important.
- Make doing business easy (limited red tape).
- An observation based on section 3.1 is that typically a local aerospace company is bought out by Boeing, Airbus, Swift, etc during the development of an aerospace cluster. The perceived loss of strategic independence of the company is arguably less important than the benefits of an intimate relationship (even ownership) with an OEM company.
- Government to government agreements being in place are vitally important (e.g. 4 main export-control regimes).

From on international perspective, the numbers of passenger aircraft being sold due to airline demand is on an upwards trend, especially in the eastern and far eastern parts of the globe and China. These economies

are becoming directly involved with the major OEM's by demanding a workshare. This does imply also an opportunity for the South African aerospace industry to play a part.

Many of the countries listed in the previous sections originally had very little industrial aerospace capacity but have developed a thriving aerospace industry generating income, jobs and knowledge once a strategy to do so was implemented. SA is in the envious situation in that there is an aerospace industry with a well-developed supply chain. A second advantage is that SA does not only have manufacturing know-how but it also has design know-how of complete, complex systems. The latter is not always readily available in some of the countries mentioned above and this advantage needs to be emphasized and exploited for it will otherwise be eroded and ultimately lost.

Table 6: Cluster criterion country comparison *

Criteria	Mexico	Morocco	Brazil	Singapore	Indonesia	South Africa
International agreements	Y		Y	Y (also technical [1])		Y [2]
Improved tertiary education system	Y	Y		Y		
Tax incentives		Y				
Reduced import duties	Y	Y				
Government support	Y	Y		Y	Y [3]	Y [4]
Counter trade						Y
Favourable location	Y	Y		Y (MRO)		N
Advisory board	Y	Y	Y	Y		
Long term projects/plans	Y	Y		Y	Y	N [5]
Ease of doing business (position)	49	69	125	2	72	82
Multinational companies	Y	Y	Y	Y		Y [6]
Establish research centres	Y		Y	Y		Y [7]
Export focused industries	Y	Y	Y	Y		
Focussed initially on components	Y	Y	N	Y	N	N [8]
Focussed initially on aircraft assembly	N	N	Y	N	Y	Y [8]

1 Federal Aviation Authority
2 Wassenaar Arrangement, Nuclear Suppliers Group, Missile Technology Control Regime (MTCR)
3 Includes tooling up cost for costly aircraft assembly.
4 AISI (restricted budget), and a plethora of other mechanisms applicable to all sectors THRIP, TIA, SPII, PPPFA etc
5 Plans exist but a lack implementation.
6 Turbomeca, SAAB, Hensoldt, but the former two examples have since divested due to a rarity of reasons including a lack of sustained sales and support.
7 The CSIR not focussed towards industry needs?
8 License building of Mirage aircraft, Rooivalk. Later subassemblies for Hawk and A400M.

- Note that if a field is left blank it indicates that no firm confirmation could be found for that criterion

4 International Industry Trends

The following section aims to highlight a limited selection of non-technical aviation industry trends.

- The African aviation market is briefly described from an Airbus and also from a European point of view.
- Characteristics for the manufacturing of aircraft components in low cost and high cost countries is compared and a number of companies manufacturing components of varying complexity are listed.
- Countries where SMMEs are supported through government initiated programmes are listed.
- Another aspect that is investigated is the country rankings for manufacturing attractiveness. The factors that contribute to this ranking are itemized in detail.
- The most important factors that motivated a company to join a cluster are described. Included are the incentives, financial and otherwise, provided by different the countries to these companies to convince them to become part of a cluster.
- Lastly the potential effects of Industry 4.0 are briefly deliberated.

4.1 Manufacturing in Low Cost Countries

Counterpoint [18] provides valuable characteristics pertaining to manufacturing in low cost countries (LCC). Mexico, North Africa, Vietnam and India are regarded as LCC. The following statements are extracted from the Counterpoint [18] study:

- Of the 169 aerostructures suppliers 43 are suppliers located in LCC.
- Of the remaining 126 suppliers 35 have set up factories in LCC but some just subcontract there.
- Low cost countries are not always low cost in practice due to, for example, slow and inefficient production.
- Mexico is a popular low cost country although China is less popular. Perceived manufacturing costs in China are higher than in highly automated European countries.
- Vietnam and India are regarded as growth areas.
- North African suppliers (Morocco) and East European suppliers are highly regarded due to the proximity to Airbus.
- Certain components are typically manufactured in low cost countries. A breakdown (from Counterpoint [18]) is shown in Figure 11.

	Wing	Fuselage	Doors	Cockpit	Empennage	Nacelle	Wiring
Boeing	HCC	HCC	LCC	HCC	LCC	HCC	LCC
Airbus	HCC	HCC	LCC	HCC	LCC	HCC	LCC
Embraer	HCC	LCC	LCC	HCC	HCC	HCC	LCC
Bombardier	HCC	HCC/LCC	HCC/LCC	HCC	LCC	HCC	LCC
Dassault	HCC	HCC	HCC/LCC	HCC	HCC	HCC	LCC
Gulfstream	HCC	HCC	HCC/LCC	HCC	HCC/LCC	HCC	LCC

Outsourced

In-sourced

Combination outsourced and in-sourced

Figure 11: LCC vs HCC component manufacture (Counterpoint [18])

- When smaller structures are manufactured low cost countries suffice. Manufacture for large scale structures can be done effectively/cheaply via automation.
- As low cost countries acquire more capability their costs increase and they become less competitive.

4.2 Airbus Report

"The great enabler – Aerospace in Africa" report [19] details the Airbus vision for the aerospace industry in Africa. The document attempts to indicate that the aerospace industry can be used not only for economic development but also social development. A summary of the content of the report will be provided in the sections below.

4.2.1 Human Capital Development and Education

The report [19] states that the public and private sectors need to improve their interaction and create an environment where the individuals with ideas can interact with the individuals with funding. It needs to be acknowledged that there is a severe skills shortage, especially as these skills pertain to those required in the aerospace industry. Airbus [19] draws the correlation between the quality of a country's primary, secondary and higher education institutions and its competitiveness. Less than 25% of the students who graduate from African universities have degrees in science, engineering or technology.

4.2.2 Business Environment

In order to create an aerospace industry (or any industry for that matter) governments need to address policy and investment challenges by correcting infrastructure, education and workforce development. SA, Morocco and Tunisia have an aerospace industry. An emerging aerospace player is Ethiopia, where the Growth and Transformation Plan has led to increased GDP, improved infrastructure, social development and capacity building. As a direct result of this Ethiopian Airlines has shown tremendous growth. Cote d'Ivore has implemented an economic development policy model that has been successful in driving foreign investment to the country and created interest in its aerospace potential.

An attractive business environment is imperative to attract investment. One way is to establish public-private partnerships (PPPs) and hence attract FDI. There is a positive correlation between FDI inflows and those African countries that have taken steps to lay the groundwork in either aerospace or advanced manufacturing capacity. New legislation on PPPs in Tunisia, a notable manufacturing hub and growing aerospace ecosystem, kept FDI inflows relatively stable at nearly $1 Billion in 2017. In Morocco, another country where government incentives and investments have been offered to aerospace and other advanced manufacturing sectors, FDI inflows across industries actually increased by 23% to $2.7 Billion in 2017. Countries with established or emerging national air carriers, such as Ethiopia, Morocco, and Egypt, were among the top five African host economies for FDI in 2017.

4.2.3 Aerospace Capacity and Challenges

SA, Tunisia, and Morocco are among the 45 largest aerospace manufacturing nations in the world, when components manufactured for export are the criterion. SA's aerospace sector directly employs around 15,000 highly skilled engineers and is estimated to support at least 60,000 further skilled jobs in the economy.

Infrastructure, human capital and access to finance is required for an aerospace industry.

Countries like Tunisia invest massively in the development and provision of:

- Free zones.
- Industrial areas.
- Ports.
- Airports.
- Highways.
- Energy generation.

To host new entrants to the sector. Morocco boasts many economic free zones that provide an important platform for the country's growing aeronautics sector.

In order to develop human capital, the Morocco-based Aviation Professions Institute (IMA), which gives

- vocational training for professionals in the sector,
- and aims to train 800 aviation and aerospace professionals per year.

The institute is the result of a partnership between a) the Government of Morocco, b) the Group of Moroccan Aviation and Aerospace Industrialists (GIMAS) and c) the Union of Metallurgical Profession Industries (UIMM).

Lastly, access to finance will only be available if the perceived risks are less than those in other emerging markets. Competition is thus severe.

4.2.4 MRO Outlook

African carriers will need over 1 000 aircraft and freight aircraft to meet the rising demand by 2036. The Nigerian government has calculated that the repair of aircraft in Nigeria will save about $ 1 Billion annually. Ethiopian Airlines has expanded its MRO operations from Addis Ababa to other parts of Africa.

4.3 The African Air Transport Market

The annual analysis of the EU transport market [20] documents a European Commission study evaluating the European air transport industry. However, useful information regarding the African air transport is detailed. The report is subdivided into 9 chapters which will be elaborated upon in the next 9 sections as they pertain specifically to Africa or provide insight into the global aviation market. The information will be listed in bulleted format.

4.3.1 Air Traffic Trends

- Global passenger airport throughput was up 6.4% compared to 2014. However, a sluggish economy and safety concerns limited the growth in Africa to 0.6%.
- The African GDP share is expected to grow and reach 10% in global GDP by 2050.
- The Americas and Asia/Pacific regions recorded a 6% increase in international tourist arrivals but in Africa it declined by 3%.
- Africa registered a 0.9% increase in passenger growth (for comparison, the Middle East grew by 9.6%.
- Carriers in Africa and Latin America saw slower growth in 2015 due to softer commodity prices that had an impact on economic performance, as well as increased political challenges.
- Hub connectivity between Europe and Africa recorded the highest loss, strongly affected by the ongoing tense political situation across many African countries.
- South African Airways, once the major healthy airline of the African region, now faces a prolonged restructuring period that could enable the carrier to grow once more. As a result, the airline has lost its first spot in RPKs and ASKs flown to Ethiopian Airlines,

4.3.2 Airlines

- African carriers also presented losses in 2015 and are expected to remain in the red throughout 2016. The African region suffers from weaker operating airlines as well as higher political instability impacting important tourism markets in the North of the continent.
- Despite good performances, i.e. Ethiopian Airlines, most African carriers continued to struggle in 2015. Air traffic liberalisation in the continent is very much needed for air traffic to develop to its full potential.

4.3.3 Airports

Airport revenues recorded strong growth across all regions with Latin America and Caribbean recording a 25.9% increase in revenues against 2013 followed by Africa (1%) and the Middle East (13%).

4.3.4 Aircraft Manufacturing and MRO

Looking at the MRO global market share by region, North America claimed the largest share in MRO activity (29%), with Asia-Pacific (28%) and Europe (26%) following close. Based on current aircraft orders, the Asia-Pacific share of the global MRO market is expected to increase and potentially become the largest global region for MRO activity in the coming years.

4.3.5 Air Traffic Management

- Several additional ANSPs announced that they would be using the Aireon solution for surveillance, including South African ATNS, where the Johannesburg FIR and Cape Town FIR and surrounding area account for 10% of world airspace.
- Given the earlier announcement of Aireon collaboration with the ASECNA group of ANSPs and a more recent commercial agreement with the Southern African Development Community, this will further enhance surveillance across Africa where existing radar provision has always been fragmented.

4.3.6 Environment and Sustainable Development

Airports Council International (ACI) ran its Airport Carbon Accreditation programme (ACA) for the sixth year in 2014/15. The programme aims to "*reduce carbon and increase airport sustainability"*. This aim is achieved through an accreditation scheme that incentivises carbon management activities based on the operational and public relations benefits of being accredited. The number of airports in the scheme in Africa has stayed the same. In total the Scheme now covers 125 airports representing 28% of global air passengers

4.3.7 Aviation Safety and Security

Due mainly to turboprop aircraft related fatalities, the African region shows the highest fatality risk.

4.3.8 Consumer Issues

Passengers currently have to file complaints with the airline but an industry code is being developed to protect consumer rights.

4.4 International Programmes Supporting SMMEs

Ezell and Atkinson [21] detail international programmes to support SMMEs, especially manufacturing. Such programmes are well established in Argentina, Australia, Canada, China, Germany, Japan, Korea, Spain and the UK. This chapter will focus on Canada as it is one of the countries that has been described in section 3.1.4 as having an aerospace industry cluster. The programme is called IRAP (Industrial Research Assistance Programme) and consists of a staff of 220 persons located in 150 offices. Potential SMMEs are supplied with vouchers that allow them to connect with researchers at universities or companies. The programme assists with the following skills:

- Business advice.
- TT and commercialisation assistance.
- Assists with diffusion of knowledge from universities.
- Finding funding grants.
- Teaches new product development skills.

Canada's IRAP provides direct financial support for Youth Employment in Canadian SMMEs, funding up to $30,500 in salary for six to twelve months for recent college or university graduates employed by SMMEs. As a share of GDP Canada spends 10 times as much on manufacturing support than the USA.

4.5 Aerospace Manufacturing Attractiveness Ranking

The latest PWC report on manufacturing attractiveness [22] world-wide states that the aerospace and defence industry reported higher profits in 2016 compared to 2015. Air travel increased and this caused demand for aircraft. The 2017 aerospace manufacturing attractiveness ranking attempts to provide aerospace companies with information to rate their manufacturing attractiveness against their competitors. The following measures were considered:

- Labour - Consisting of (not exhaustive):
  - Labour force,
  - Advanced education,
  - Union flexibility.
- Infrastructure - Consisting of:
  - Quality of roads,
  - Internet usage,
  - Quality of electrical supply.
- Industry - Consisting of:
  - Industry size.
- Industry maturity.
- Economy - Consisting of:
  - GDP,
  - FDI,
  - Debt.
- Cost - Consisting of:
  - Operating and capital expense,
  - Labour costs,
  - Labour productivity.
- Tax policy - Consisting of:
  - Overall tax ranking.
- Geo-political risk - Consisting of:
  - Population growth,
  - Political risk,
  - Climate risk.

SA is ranked in position 39 and labour issues are stated as a reason for concern. The report does not detail which of the stated labour contributors (see first bullet as listed above – “Labour”) is responsible for the bad rating. This is indicated in Figure 12.

Complete country rankings

Country	Overall Rank	Cost	Labor	Infra-structure	Industry	Geo-political Risk	Economy	Tax Policy
United States	1	11	2	6	1	2	16	36
Switzerland	2	18	9	11	18	5	7	18
United Kingdom	3	23	16	5	4	7	28	10
Australia	4	13	11	20	16	1	17	25
Canada	5	24	8	13	8	13	26	17
Taiwan	6	7	6	17	22	18	14	30
Hong Kong	7	16	18	1	18	39	20	3
Japan	8	8	3	10	6	10	12	70
Denmark	9	5	13	8	51	25	15	7
Germany	10	19	7	6	5	4	38	48
Singapore	11	43	1	2	11	31	33	8
Sweden	12	25	21	14	24	20	2	28
Netherlands	13	4	5	3	25	9	71	20
Ireland	14	27	17	19	17	43	27	5
New Zealand	15	41	12	24	39	12	18	11
Spain	16	10	30	12	15	24	32	37
Norway	17	6	10	21	30	15	58	26
France	18	12	27	4	2	6	53	63
Malaysia	19	50	22	22	13	8	8	61
Belgium	20	3	14	15	27	23	67	66
Austria	21	14	15	23	56	11	61	42
Qatar	22	32	25	50	34	70	25	1
China	23	22	26	33	2	30	1	131
Portugal	24	1	29	16	51	33	81	38
Czech Republic	25	38	46	37	32	27	21	53
Finland	26	28	4	9	46	42	114	13
Poland	26	40	43	41	35	37	13	47
South Korea	28	9	35	18	9	174	4	23
United Arab Emirates	29	46	19	34	29	123	24	1
Israel	30	15	20	29	23	96	10	96
Indonesia	31	47	34	56	26	22	9	104
Italy	32	2	41	28	14	28	65	126
Thailand	33	51	40	44	37	29	6	109
Chile	34	29	31	30	37	26	47	120
Mexico	34	34	61	48	12	17	34	114
Russia	36	30	39	51	7	119	40	45
Philippines	37	49	49	84	20	14	3	115
Luxembourg	38	80	54	25	76	16	88	16
South Africa	39	26	112	32	32	56	50	51
Romania	40	42	51	69	54	53	41	50
India	41	37	45	45	28	36	5	172
Slovakia	42	39	76	64	47	46	49	56
Slovenia	43	70	36	39	76	38	96	24
Hungary	44	48	67	61	44	34	56	77
Costa Rica	45	54	33	83	59	54	43	62
Vietnam	46	44	65	59	41	3	19	167
Peru	47	20	95	71	59	32	31	105
Turkey	48	21	58	36	21	122	30	128
Iceland	48	108	37	47	76	57	62	29

Figure 12: Aerospace manufacturing attractiveness ranking – from PWC [22]

4.6 Cluster priorities, cluster incentives and national incentives

Clustering is a worldwide trend and the popularity thereof can only be attributed to a distinct perceived advantage to those companies who are participating in a cluster. Studies have shown what are regarded to be the main drivers and advantages as perceived by these companies. Martinez [23] investigates the factors attracting business to Mexican aerospace clusters. The factors that were included are: labour, industrial areas, suppliers, clients, policy, co-location, infrastructure, universities and research centres, financial ad-

vantages and incentives. The most important drawcard to the cluster was “infrastructure” indicating that infrastructure (including transportation and telecommunication capability) was regarded as an advantage. The second most important factor was well-developed ”industrial areas”. The third most important factor was “labour”. Important aspects of labour were 1) the correct skills level, 2) the labour force being used to a factory and aerospace production environment and 3) low labour costs. The fourth most important factor was “universities and research centres”. However, the university” aspect was deemed much more important than the “research centre” aspect.

The items that received less positive answers were incentives, clients, financial aid, and suppliers. Regarding clients and suppliers (mainly US or European based companies) in the Mexican context these are not located in Mexico and are not regarded as an advantage. Unexpectedly “incentives” do not rate very highly as an advantage to draw a company to a cluster. The study indicates that by “policy measures” the broad vision behind government systematic actions is meant, while by incentives reference is made to specific instruments to accomplish that vision. It should be noted that certain incentives are not cluster specific or even industry segment specific but available nationally. This puts all clusters irrespective of location on an even footing as far as incentives are concerned.

The available incentives are listed as: R&D fund support labour training support, promotion support and subsidies. Labour support was rated as most important followed by R&D support.

Incentives are used by governments and clusters to attract companies, making it attractive, financially or otherwise, for these companies to operate from a country or cluster. The focus of the study described in “Government incentives and support programs for the aerospace industry in key Asean nations” [24] was to understand the various support initiatives taken by governments for aerospace industry development in key ASEAN countries, namely, Singapore, Malaysia, the Philippines, and Thailand. It is admitted in this study that it is difficult to estimate what would have happened if government initiatives and policies were not in place. A summary of the incentives is shown in Table 7. Also included in this table is comparative information for Mexico, Morocco and two South African initiatives.

A study of the above conclusions and of Table 7 reveals no clear recipe for success in the promotion of the Aerospace sector through clustering internationally. Instead a cluster and the incentives and initiatives around it should address the specific weaknesses of the country concerned as perceived by potential foreign investors. Locally the CAV is clearly underdeveloped as a proposition while the Dube Tradeport SEZ reads like a blueprint for the international best practise model for clusters but may lack a training aspect and an existing aerospace activity. Additionally the Dube Tradeport SEZ specifically lists Aerospace as a potential growth area, which immediately suggests that the promotion of an additional SEZ in the aerospace may be difficult to achieve.

Table 7: Incentive programmes in Asean countries, Morocco, Mexico and comparison with representative South African initiatives

Country	Singapore	Malaysia	Philippines	Thailand	Morocco	Mexico [25]	South Africa	
							Intended CAV Cluster	Dube Tradeport SEZ
Focus & strategy	• Promoting and establishing Singapore as a "total business centre" and developing high-tech and high value-added manufacturing and related services. • Diversifying industry clusters for a balanced and mix of industries and markets; promoting innovation; developing local talent and attracting foreign talent; and creating a business-friendly environment and infrastructure.	• Aerospace industry growth by investing in aerospace training and development and attracting foreign companies to facilitate technology transfers.	• Becoming a regional hub for manufacturing and aftermarket services in the aerospace industry through government programmes, incentives, and training scholarships	• 15-year aviation industry development plan, which establishes regulatory frameworks and offers incentives that will support the growth of aircraft maintenance and spare parts production in Thailand.	• The government has an economic development plan, which includes improving the competitiveness of the business environment to support its national industrial strategy and the establishment of free trade zones, trade treaties and the absence of restrictions on foreign currency money transfers	• The national programme called Maquiladora allows for cross-border manufacturing not subject to import/export duties. Specifics are listed below.	• The Centurion Aerospace Village (CAV) is an initiative of the Department of Trade and Industry (**the dti**) in developing a sustainable Industrial Supplier Park to support South Africa as a Global Player in the Aerospace and Defence Industries' value chains thereby attracting foreign & domestic direct investment in the CAV. • CAV is an intended Hi-Tech Advanced Manufacturing Cluster with maintenance, repair, overhaul (MRO), innovation and R&D capabilities aimed at attracting and retaining key industry leaders as anchor tenants and service providers. • CAV intends to support the aerospace and defence industries through economies of scale and agglomeration, improved processes, increased productivity and cost competitiveness of local manufacturers. Facilities and services would promote, develop and mentor SMEs & BBBEEs, create business opportunities in the area and benefit communities by supporting job creation and strengthening the industries in general	• Industrial real estate: premium, fully-serviced • Long term leases: up to 49 years, option to renew • Connectivity: multi-access road system • SEZ incentives: for qualifying enterprise **DUBE TRADEZONE 1** • 26 hectares (64 acres): 100% let • Sectors: air-related logistics, distribution and light manufacturing • Dube Trade House: ○ Integrated office and warehouse space ○ Linked to Cargo Terminal via 320m airbridge **DUBE TRADEZONE 2** • 43 Hectares (106 acres): investment opportunities from 2019 • Targeted sectors: ○ Medical and pharmaceutical ○ Electronics ○ Clothing and textiles ○ Aerospace and aviation-linked ○ Logistics and distribution **AUTOMOTIVE SUPPLY PARK** • 1 000 Hectares (2 471 acres) •Undertaken by Dube TradePort, eThekwini and EDTEA • Close proximity to OEM's • Efficient inbound and outbound distribution and road networks • Minimised out-of-stock occurrences • Effective advantage with shorter customer order cycles **Additionally:** **DUBE CARGO TERMINAL** and **DUBE AGRIZONE**

Country	Singapore	Malaysia	Philippines	Thailand	Morocco	Mexico [25]	South Africa	
							Intended CAV Cluster	**Dube Tradeport SEZ**
Incentives	• Cluster development fund. • Co-investment programme with foreign companies in joint ventures • National technology plan including private sector R&D. • Innovation programme.	• Strengthen the supply chain by nurturing Malaysian companies to become vendors/suppliers to multi-national corporations. • Encourage public-private partnerships by focusing on new capabilities that can enhance industry competitiveness. • Enhance the effectiveness of institutions. • Facilitate and encourage Malaysian companies to obtain certifications and standards. • Offset programme that stipulates 100% investment (implying that for every dollar spent on aerospace purchases, the vendor must also invest one dollar in domestic aerospace programmes). • The National Aerospace Industry Coordination Office (NAICO) was established as the main coordinating body for the above.	• Provide training that will assist companies in implementing aerospace quality management systems (AS9100 certification). • Investment in skills/education as well as in innovation and R&D. • Skills development in conjunction with: • Moog control corporation. • Aerotechnik services. • Mechatronics robotics society of the Philippines. • Non-tax incentives. • Special economic zone incentives (simplified procedures on imported equipment like spare parts, suppliers, raw materials). • Tax deductions on training and labour expenses.	• Import duty exemption, • Corporate income tax exemption, • Double deductions on utility expenses and deductions on infrastructure cost for specific activities in aerospace, which includes the manufacturing and repair of aircraft parts, manufacture of aerospace devices and equipment, and repair of on-board devices and vocational training institutes. • Tax holidays for R&D projects and new technologies. • Land ownership rights, permits to employ foreigners, no export entry, and work visa facilitation. • Subsidies towards enhancing competitiveness • Civil aviation training center to supply qualified aerospace manpower • Establishing a specialized aerospace industrial estate to make Thailand a regional MRO hub.	• Tax advantages (no corporate tax for the first 5 years and 8.75% for the following 20 years, no VAT, no custom duties) and financial support for training local technicians. • Morocco has decided to streamline key administrative processes (customs, visa, tax…) for companies locating in NAC. • Morocco has lifted all restrictions on foreign capital investments for aeronautics companies locating in NAC, as long as they are export oriented.	• Duty-free imports for up to 18 months for raw materials and supplies for IMMEX certified companies; • A zero rate value-added tax on exports, even when physically exported to a third party; • Value-added tax refunds within a 20 working day period for IMMEX certified manufacturers, rather than the customary 90 working days; • Import duty refunds for inputs integrated into finished products exported by the manufacturer or sold to another entity for export; • Streamlined security for supply chains, including shipment security, reduced number of inspections, access to exclusive FAST lanes at the border, reduced shipment times, etc; • Preferential support from the Foreign Trade Bank for loan guarantees, export policy/programme development assistance, financial assistance for direct exporters.	• None to date • Negotiations are ongoing to transfer CAV to Gauteng Local government to facilitate the application of national government incentives. • Basic infrastructure development has begun on the site in 2019.	**Dube TradePort SEZ benefits include:** • Preferential 15% Corporate Tax for qualifying entities; • Building Allowance: 10% per annum for qualifying buildings and fixed structures; • Employment Incentives for low salary workers; • Customs Controlled Area: Import duty rebates for production-related and exported products, and VAT exemptions under specific conditions for supplies procured in South Africa; • Enhanced 12i Tax Incentive: designed to support greenfield investments, as well as brownfield investments; • High End Infrastructure: funded through the provincial government and SEZ Fund; and • The Black Industrialist Programme: offered by the KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs (EDTEA) and the Department of Trade and Industry (**the dti**).

4.7 Fourth Industrial Revolution

The Fourth Industrial Revolution (FIR) is characterized by a fusion of technologies that blurs the line between physical, digital and biological spheres. Some of the enabling technologies that can be included are cloud computing, robotics, cyber security, additive manufacturing. Artificial Intelligence, nanotech, etc. This is made feasible by the internet connectivity between all these technologies and devices.

According to Shroder [26] Germany is one of the main drivers for the FIR specifically for the manufacturing industry, although in Germany it is also known as Industry 4.0. The aim is to amalgamate the world of the internet with the world of industrial production because the current leaders in the digital area will otherwise take over industrial production. The objective is to position Germany's manufacturing industry, with political support, as the world's leading user and provider of digitalised production technologies.

The German service- and science-based society sector has for a long time been seen as the first benefactor of digitalisation. However, Germany has now focused on how digitalisation changes the manufacturing industry. The fact that of people, machines and objects are connected changes production processes along the entire industrial value-added process. The connectivity presents opportunities for increasing the efficiency in production of all elements of the value-added process, starting from the raw materials and pre-products through to customer interconnection and the associated logistics and service processes. The digital data information available in this productivity chain is available at any time, from any location and by all participants. This timeous, available information allows for production and sales processes to be optimised. At the same time, new markets and business areas are created. Enabling technologies include cloud computing, robotics, cyber security, additive manufacturing, artificial intelligence, nanotech, etc.

The prospects of digitalisation for increased competitiveness of Germany's manufacturing industry are suggested to be:

1. *Production process:* Digitalisation enables more efficient production processes and therefore cost savings thanks to resource optimisation.
2. *Logistics:* Digitalisation enables more efficient flows of goods and information, lower stocks and plant efficiency. It also opens up new business opportunities.
3. *Customer retention:* Digitalisation enables closer customer ties. This results in a more targeted consideration of customer needs.
4. *Hybrid products* and the associated *smart services*: Providing the data on machine monitoring, fault rectification, repair and maintenance via *smart services* justifies higher prices. This, in turn, allows expanding Germany as a high-quality production country in the sense of upscale industrial products.

It is expected that FIR will change the labour landscape. Additional skills will be required to function in the new environment. With digitalisation, not only labour and production processes, but also the professional requirement profiles are becoming more demanding, interconnected and more complex.

According to Barbosa and Aroca [27] FIR will be enabled by the Internet of Things (IoT). IoT will transform manufacturing processes, products and services. The "Smart Factory" is intended to bring lower costs and higher productivity. Manufacturing will bring increased use of automation and robotics, or the use of new tools such as augmented reality or 3D printing. This type of precision manufacturing is a requirement of the aerospace manufacturing domain.

The major improvement of the "Smart Factory" is the increased connection and integration of different connected components. Aircraft engines and other subsystems are already fitted with numerous sensors which monitor system health continuously. A requirement for maintenance can thus be identified and broadcast in near real time. Adding connectivity to these enables the emergence of new services through the connectivity itself (remote control and monitoring applications) or through the data generated by the devices.

Barbosa and Aroca [27] list the opportunities provided by IoT solutions as:

- **The connected factory:** The use of IoT technologies in aeronautics manufacturing provides increased labour efficiency by providing relevant, up-to-date information to personnel.

- **Precision manufacturing:** The automotive industry relies heavily on automation and robotics, the use of these is less intense in the aeronautics industry. The key toward “Smart Factory” in the aeronautics manufacturing is thus in supporting human workers with digital enhanced tools that increase their productivity.
- **IoT enhanced tools:** By connecting the human worker and their tools to an IoT platform, manufacturing accelerates as important information is available across the assembly line. An Airbus employee on the factory floor who can use a tablet or smart glasses to scan an airplane's metal skin can determine what size bolt is needed in a given hole, and the torque necessary to install it. That information can be automatically sent to a robotic tool, which completes the task.
- **Location tracking:** The “Smart Factory” will be able to keep track of manufacturing equipment locations in real time with precision and across the factory floor and value chain. It will be able to identify where every tool is on the factory floor but also to keep track of operator usage data and behaviour.
- **New services transforming the industry:** The integration of IoT into the aeronautics industry will provide considerable benefits as new services enable optimisation of airline operations and asset management.
- **Preventive maintenance:** Large numbers of sensors are now deployed in the aircraft. They monitor in real time critical performance parameters and thanks to the IoT, the data can be transmitted in near real time. This information will allow for preventive maintenance services which will help reduce aircraft downtime and increase the safety of the industry. It assists ground staff to analyse the data rapidly, detect any potential aircraft problem and quickly take corrective action. Overall it reduces both the time and the cost of maintenance.
- **Increased fuel efficiency:** Monitoring of engine performance combined with data analytics and predictive maintenance can result in important gains in fuel efficiency.
- **Optimisation services:** Connected items enable the development of entirely new lines of services dedicated to using the data collected to optimise airline operations.
- **Products as a service business model:** The development of connected products is enabling the transformation of traditional way of doing business to a service offering. Key parts of the airplane are no longer owned by the airlines but rather rented as a service. Business model and “Total Care” service are well representative of a transition toward “product as a service” offering with service revenues four times better than the original product cost. The data gathered from the motors has enabled Rolls Royce to take engagement on fuel consumption reduction with airlines, generating new service revenue opportunities.

Certain concepts of the factory of the future are highlighted in Jackson *et al.* [28] and is listed in no particular order:

- *The concepts of machine and system modifiability and the modularity of key operational functions and components are key elements of a reconfigurable manufacturing system and both of them are prerequisite for product and volume flexibility”.* An assembly line that can easily be modified to accept a number of product varieties requires flexible machines and reconfigurable systems. These are benefits but these assembly systems are expected to be complex.
- It is envisioned that different factories within a company will be connected to one another and all can be connected to the suppliers. Staff will be multi-skilled to operate multi-product machines and will be supported by intuitive information distribution systems, and intelligent product delivery systems. These intelligent product delivery systems will be capable of uploading product, process and operation data to the cloud using an array of embedded sensors. In addition, metal additive manufacturing machines will be connected, allowing business units to share assets and facilities across an organisation. Factory data will be analysed providing historical traceability of products, machines and operators. Predictive algorithms will be applied for short and long term optimisation of shop floor operations, allowing the factory to improve itself over time.
- “*Assembly instructions will be provided to the operator through a digital display. Text based descriptions of the instructions can be accompanied by videos, CAD models and drawings or*

even more advanced techniques such as augmented reality (laser projection).” The Airbus example described in an earlier section where instructions can be viewed through smart glasses reinforces the point.

- Communication between the supplier and the factory will allow the supplier to use the factory portal to provide an update of any change in the delivery of an order. The effect of the change can immediately be evaluated to assess the impact on the factory delivery dates.
- Scheduling of human workers and tools/machines will be performed by an algorithm that allocates resources to jobs trying to optimise a number of production lines simultaneously.
- The above mentioned automatic scheduling will be able to factor in machines breakdowns, product reworks as well as the variability associated with operators and suppliers’ potential delays.

4.8 Summary

This chapter focussed on selection of international trends in the aviation industry. Aspects dealt with in detail in previous sections of this chapter included cluster priorities and incentives, manufacturing costs and attractiveness rankings for countries. However, clustering in South Africa and the impact that FIR might have on South Africa warrants additional comments.

As the demand for passenger travel is increasing, the aerospace industry continues to be generally profitable and growing. The international supply chain for the aerospace OEMs are thus also in a position to benefit if aligned properly and if they are competitive. As was shown above, a number of countries have successfully developed a profitable aerospace industry by co-operation between suppliers and OEMs. Typically the manufacturing hubs are concentrated in a cluster as these offer tangible advantages and some examples are listed above which, where applicable, could be adopted by the SA aerospace industry. These include cluster and national incentives, tax incentives, making it easy to do business in South Africa and having reliable and skilled labour. In short, a very clear advantage that leads to a financial benefit for the producer is imperative.

A number of countries including the USA and especially Germany are placing emphasis on the implementation of FIR. If successful, it is to be expected that cost of automated manufacturing will be reduced and the quality of manufacturing (and indeed services) will be improved. Another potential advantage is that distributed manufacture (e.g. print on site/demand) will become more accessible. However, the disadvantage (arguable short term) of FIR is that it will be capital intensive to implement. One of the references indicated that China, with its low labour cost rate, is already not necessarily cheaper than the highly automated European manufacturers. A component of SA’s offering is lower labour costs but South African aerospace industry needs to take heed of the FIR threat. However, if the South African aerospace industry can make the jump early to the envisaged highly automated industry it could offer a distinct competitive advantage compared to low cost countries. Due to the expected high level of automation which will be brought about by FIR, low-skill jobs are likely to be lost. This factor needs to be anticipated so that personnel can be reskilled timeously. It is projected that the upskilling will lead to the affected personnel being trained to work at a higher technological level.

5 Socio Economic Impact Assessment

According to the Air Transport Action Group [29] the contribution of air transport to the economy includes direct, indirect and induced impacts, which are related to the total revenues of the air transport industry. The catalytic impacts of the industry are “spin-off” effects on other industries. These cover employment and activity within the industry such as aircraft maintenance and activities directly serving activities in the industry.

Direct impacts also include the activities of the aerospace manufacturers selling aircraft and components to airlines and related businesses. The indirect impacts include employment and activities of suppliers to the air transport industry, for example, jobs linked to aviation fuel suppliers; construction companies that build additional facilities; the manufacture of goods sold in airport retail outlets, and a wide variety of activities in the business services sector (call centres, IT, accountancy, etc.). The induced impacts include spending by those directly or indirectly employed in the air transport sector that supports jobs in industries such as retail outlets, companies producing consumer goods and a range of service industries (e.g. banks, restaurants, etc.).

The focus of this study is on the aerospace manufacturing sector and not the air transport sector but the method remains analogous.

5.1 Methodology

The guidelines for the analysis and reporting on the impact of the commercial aerospace industry will be centred on the adopted industry structure illustrated in Figure 3. For the purposes of this study the aeronautics sector will be broadly sub divided into five product markets comprised of commercial aviation aircraft, general aviation aircraft, recreational aviation aircraft, defence systems and unmanned systems.

The methodology of this study will be based on an exhaustive and complete mapping of the South African aerospace industry using Figure 3 as a reference and guideline. This will form the basis of the project going forward, and will ensure that the entire industry value addition is taken into account.

Where the data allows, an in-depth analysis of the industry will be carried out and segments of the matrix will be used inter-changeably to capture all the information relating to the industry.

The understanding of the commercial aerospace industry requires mapping of the industry which for this study the industry structure in Figure 3 will be used to map the industry. The mapping includes identifying and classifying the various organisations at the different supply chain tiers and the different technology streams.

5.1.1 Data Collection and Analysis

Quantitative methods were utilised to identify and collect primary data from the various organisations using questionnaires and telephonic engagements as well as a limited set of in-person interviews. There are also existing government documents and company websites that were used to guide the identification of organisations and mapping them on the technology streams and supply chain classification. The questionnaire (Appendix B) that requires socio-economic inputs for the organisations were distributed to the identified organisations, the questions are aligned to the set of indicators that are used to measure the economic impact of various industry sectors.

In practise the response rate to the questionnaires was very low. This led to a campaign to attempt to find alternative sources for the data or at least some subset of the data.

SARS and Statistics SA were both approached and while Statistics SA was extremely helpful (and obtain some of their data from SARS) their data is largely based on a dated set of Standard Industrial Classification (SIC) codes and the only useful report covers ‘aircraft parts’ and is published every 5 years, the next report being due in late 2019. All other reports aggregate data over broader definitions of the SIC codes meaning that aircraft components will be lumped together with any other transport sector manufactured goods. In addition much of the data in these reports are sample based statistics which do not necessarily take into account the complexity of the aerospace industry. As such Statistics South Africa data was not used for the purposes of this study other than to quantify the overall manufacturing industry statistics.

This then led to an email and telephonic data collection campaign for a much reduced set of data:

- Turnover.
- Number of employees.
- Percentage of turnover that represents labour cost.
- Percentage of turnover derived from the aerospace sector.

With this set of data it was hoped that responses rates would be better as it reduced the effort required on the part of the industry member, removed sensitive information like margin and eliminated information that could be linked to BBBEE demographics which had been identified as a sensitive issue in the campaign to get answers on the questionnaires. This data would, at least, allow for a sizing of the industry and determine its value to the South African economy. The telephonic aspect of the campaign would also allow for the gathering of additional extraneous inputs.

In the time available more than 60% of the listed companies had responded to either the reduced list or full questionnaire or their data could be extracted from public sources and importantly most of the larger entities in each sector have been accounted for. Reasons for non-response include:

- The data has been given to a variety of government entities and industry associations with an unreasonable frequency and with no meaningful return to the industry member, be it in terms of communication of meaningful support.
- Many of the entities whose business is primarily for export or who are internationally owned were suspicious of the intentions behind the study and particularly mindful of government's intentions with regard to BBBEE.
- Some entities, particularly those in the MRO and defence sectors did not feel that their data was relevant to the study even after the terms of reference had been explained.
- SOEs were particularly unforthcoming given the state of their finances at present and were highly suspicious of yet another enquiry into their business and financial situation.

The data available to this study is therefore split into two distinct subsets:

- That gathered with relatively high definition from the original questionnaires;
- and the majority of the responses which are based on the response to just the limited set of questions.

As a result the size and impact of the industry will be reported on based on the data from the limited set of questions as well as that obtained from the questionnaires and the remaining, in-depth, data available from far fewer companies based on the responses to the questionnaires will be used to determine sector specific trends to facilitate a limited extrapolation of the data to characterise each sector but also to act as a set of case studies. These case studies must however be approached with some caution as the data is all obtained under strict non-disclosure conditions and therefore the companies cannot be identified, even unintentionally as part of the study. It is also clear that there is a great deal of overlap in the results from the case-study approach and that of the industry workshops.

5.1.2 Assumptions for the purposes of the study

Industry Definitions

Commercial
"Commercial" aerospace can be defined as all civil aviation (both general aviation and scheduled airline services) sectors that involves operating aircraft for hire to transport passengers or multiple loads of cargo. In the case of the manufacturing sector this implies that only those companies producing civilian aircraft or components are classified as part of this sector. Due to the difficulties in separating income streams at some of the companies in this study, a broader definition has been applied here. 'Commercial' therefore is taken as any company operating in the aerospace sector in SA with saleable intent.

Propulsion
Aircraft engines, both reciprocating and gas turbines. Rocket motors were excluded and hence companies such as Rheinmetall Denel Munitions were not included or approached.

Research and Development

No dedicated R&D organisations such as universities or the CSIR have been included in this study.

Manufacturing and value add industry only
During data collection the authors were careful to exclude companies that merely import and warehouse components, as well as to exclude the operations of many of the MRO companies where they include the operation or leasing of aircraft.

A400M
The aerostructures work done for the A400M programme has been included as commercial and not military aerospace.

Data Extrapolation

In order to extrapolate from the known 60% of the listed companies who responded to the survey to obtain a full industry sizing and value, the average size of similar companies was assumed for the unknown entities or failing the availability of suitable comparisons on that basis, judgement was used, based on the knowledge of the company and the experience of the author. In this case the extrapolation does not rely on unknowns in the larger companies operating within SA and hence is judged accurate and possibly conservative.

Data Extraction

All data reported is that received with a few notable exceptions:

- In a few instances only partial data was provided in which case data from similar companies was used to estimate values or the more colloquial evidence provided by the company in question was used to estimate the data.
- In the case of the Denel Group however there were significant challenges in estimating the size of the business and the split between entities within the group. This was done with the information available from the group for previous financial years and where necessary scaled to the current year in question.
- SAA technical results are based entirely on the 2016/17 year statements.

5.2 Mapping the Industry Structure

Using the industry structure decided on in Figure 3 the complete list of companies identified as part of this study has been listed and mapped in Table 8 below and their geographic clustering is displayed in Figure 13.However, the following aspects need to be taken cognisance of:

- All companies listed in Table 8 were sent questionnaires and were requested to supply the requested information. Subsequently these companies were reminded via email to fill in the questionnaires. Following that the companies that had not responded were each phoned and requested to do so, if no response was elicited then they were placed in the matrix after reviewing publically available data,
- Despite the above mentioned interventions the response rate was still extremely low. The service provider then made a selection based on the categories as shown in Table 8 by studying publicly available information (mainly company websites),
- For the “Technology streams” (dark orange) companies were requested to make a single selection. For the ”Product markets” (medium orange) the respondents could select more than one option. For the “Supply chain tier level” (light orange) the tier level selected was the highest level that the company participated in,
- The “Technology streams” and ”Product markets” were generally selected by the repondents, however the “Supply chain tier level” was not compulsory to be filled in,
- The company’s names in the table below are hyperlinked to their websites for the reader’s convenience if underlined.

Table 8: List of SA aerospace companies considered as part of this study

NAME OF COMPANY	Aerostructures	Propulsion	Avionics	Surveillance and Sensor Systems	Information Systems	Maintenance, Repair and Overhaul	Other Systems	Commercial Aviation Aircraft	General Aviation Aircraft	Recreational Aviation Aircraft	Military Systems	Unmanned Systems	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
208 Aviation Aircraft Maintenance Organisation						●			●								
AAT Composites	●							●								●	
Absolute Aviation Group						●			●								
Accutronics				●							●						●
Adept		●								●				●			
Aerios Global Aviation						●			●								
Aero electrical						●			●								
Aero Inspections						●			●								
Aero Maintenance						●			●								
Aero Services	●							●								●	

NAME OF COMPANY	Aerostructures	Propulsion	Avionics	Surveillance and Sensor Systems	Information Systems	Maintenance, Repair and Overhaul	Other Systems	Commercial Aviation Aircraft	General Aviation Aircraft	Recreational Aviation Aircraft	Military Systems	Unmanned Systems	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
Aeronautical Instrumentation						●			●								
AeroStruct Consulting	●									●							
Aerosud Aviation	●							●							●		
African NDT Centre	●							●									●
Aircraft Powerplant Company						●			●								
Air-Tec Global						●			●								
Alti UAS	●											●		●			
AME Technologies							●	●	●	●	●	●					
Aselsan South Africa				●							●					●	
Astra Operations	●								●				●				
Aztec Electronics							●		●								●
Base 4 Aviation						●			●								
Bat Hawk (Micro Aviation SA)	●									●			●				
Big Ideas 3D printing	●							●	●	●	●	●					●
Bristell SA	●									●				●			
Bronberg Dynamics	●							●	●	●	●	●					
BSAS International (Pty) Ltd						●			●								
Cape Aerospace Technologies		●										●		●			
Century Avionics			●						●								
Cliffs Way Aerospace	●							●									●
CN Lighting							●		●							●	
Cobham Satcom			●					●								●	
Compumach Engineering	●							●									●
Creative Product Solutions	●							●									●
Cybicom Atlas Defence							●				●					●	

NAME OF COMPANY	Aerostructures	Propulsion	Avionics	Surveillance and Sensor Systems	Information Systems	Maintenance, Repair and Overhaul	Other Systems	Commercial Aviation Aircraft	General Aviation Aircraft	Recreational Aviation Aircraft	Military Systems	Unmanned Systems	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
Daliff Precision Engineering	●							●									●
Delta V Aerospace		●										●		●			
Denel Aeronautics	●							●						●			
Denel Aviation						●					●		●				
Denel Dynamics							●				●			●			
Desert Wolf	●											●		●			
ECM Technologies				●							●						●
Electro Thread			●					●									●
Epsilon Engineering Services	●										●					●	
ExecuJet Aviation						●			●								
Fields airmotive						●			●								
FlyH2 Aerospace	●											●		●			
GEM Aircraft	●								●				●				
Golden Wings						●			●								
Hensoldt				●							●					●	
Incomar Aeronautics							●				●					●	
Jan Hugo Precision Engineering	●							●									●
Jonker Sailplanes	●									●			●				
Kitplanes for Africa	●									●				●			
Kutleng Engineering Technologies				●							●					●	
Lanseria Jet Centre						●			●								
Lantern Engineering			●								●					●	
Laser Cut Varios	●							●									●
Light Weight Structures	●							●									●
Logo Punch	●							●									●

NAME OF COMPANY	Aerostructures	Propulsion	Avionics	Surveillance and Sensor Systems	Information Systems	Maintenance, Repair and Overhaul	Other Systems	Commercial Aviation Aircraft	General Aviation Aircraft	Recreational Aviation Aircraft	Military Systems	Unmanned Systems	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
M Tek			●								●					●	
Metal Heart Additive Manufacturing	●							●	●	●	●	●					●
Micromax	●							●									●
Milkor	●											●		●			
NAC						●			●								
On-Track Technologies	●									●							
PaR Systems							●	●								●	
Paramount Aerospace Systems						●					●						
Paramount Advanced Technologies			●								●	●		●			
Paramount ARHLAC	●										●		●				
Pilatus Centre SA						●			●								
Precision Aviation Services (Pty) Ltd						●			●								
Rapid 3D	●							●	●	●	●	●					●
Reutech Communications			●								●					●	
RGC Engineering	●							●									●
Robin Coss Aviation	●									●				●			
Rost engineering	●							●									●
RRS				●							●			●			
S Plane Automation			●									●			●		
SAA Technical (SOC) Ltd						●		●									
SAAB Grintek Defence				●							●				●		
Safomar aviation						●		●	●	●	●	●					
SatAuth			●					●								●	
Savannah Aircraft	●									●			●				
Shrike Marine			●								●						●

NAME OF COMPANY	Aerostructures	Propulsion	Avionics	Surveillance and Sensor Systems	Information Systems	Maintenance, Repair and Overhaul	Other Systems	Commercial Aviation Aircraft	General Aviation Aircraft	Recreational Aviation Aircraft	Military Systems	Unmanned Systems	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
Simera Technology Group	●											●		●			
Skytech Aviation						●			●								
Slick Aicraft	●									●			●				
Sondor Industries	●							●									●
Sport Plane Builders	●									●					●		
Star Air cargo						●			●								
Tellumat			●								●			●			
Thales SA						●		●	●	●	●	●					
Thata uBeke Manufacturing (Pty) Ltd			●								●						●
The Airplane Factory (Sling)	●								●				●				
Titamed	●							●									●
TMI Dynamatics							●				●						
TraX Interconnect			●								●						●
Trio Helicopters						●			●								
Vector Aerospace						●			●								
Vliegmasjien (Pty) Ltd	●									●			●				
Warbird Aircraft Services CC						●					●						
West Engineering	●							●									●
Whisper Aircraft	●									●			●				
	45	3	13	7	0	28	8	31	35	20	31	16	11	16	4	15	25

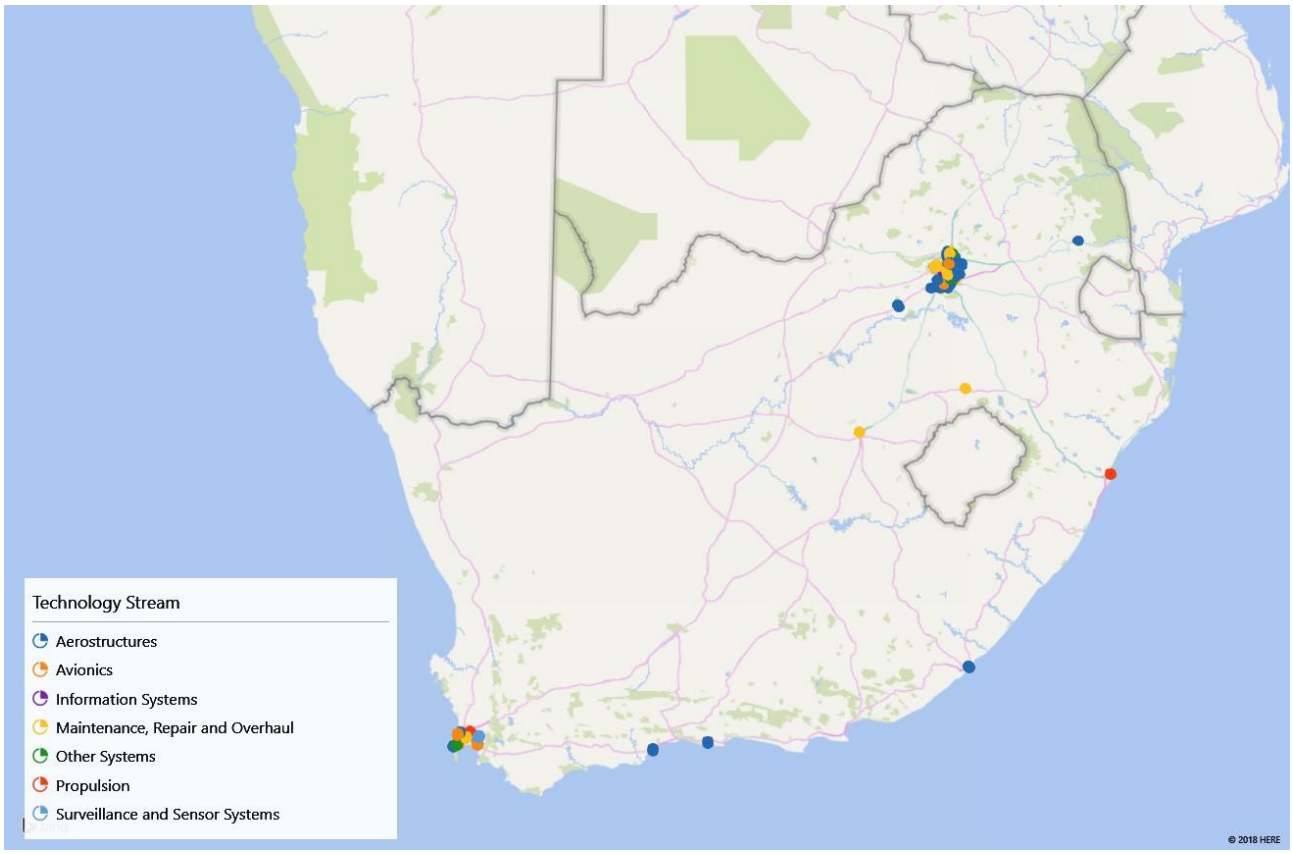


Figure 13: Location of the companies included in this study coloured according to their sector

5.3 Industry Size

From the results of the survey the size of the aerospace manufacturing and MRO industry in SA in 2017/18 was as follows in Table 9. The numbers are provided in conjunction with a confidence level variance.

Table 9: Aerospace manufacturing and MRO industry sizing 2017/18

	NO. OF COMPANIES	TURNOVER (R Billion) (A)	NO. OF EMPLOYEES (C)	LABOUR COST (R Billion) (B)	AVERAGE ANNUAL SALARY (R Thousands) (B/C)	AVERAGE ANNUAL THROUGHPUT (R Thousands) (A/C)	COMMENT
Total	104	9.5±0.53	9440±420	3.400	354	1010	Confidence levels estimated at 25% of difference between known respondent values and extrapolated values
Aerostructures (all)	45	1.67±0.07	2430±155	0.636	262	687	2 Large entities, both with accurate data, large no. of small entities with moderate response rate
Propulsion	3	0.50±0	60±0	0.023	417	901	Both entities accounted for
Avionics	13	1.46±0.08	1120±70	0.504	449	1300	2 Large entities, good response rate
Surveillance and Sensors	7	1.93±0.07	1230±55	0.762	619	1570	3 Large entities with good response rate generally
Maintenance, Repair and Overhaul	28	3.08±0.5	3800±140	0.775	204	810	Highly dependent on SAA's and Denel Aviation's figures (50% of total together)
Other Systems	8	1.34±0.01	800±10	0.637	799	1676	Largely comprised of Denel Dynamics
Total (Respondents only)	64	7.411	7763				
SA Manufacturing Totals/Averages		551.6	1 190 000	71.97	60.5	464	
Aerospace as a percentage of SA Manufacturing		1.7%	0.8%	4.7%	585%	218%	

These values are depicted graphically in Figure 14 to Figure 17.

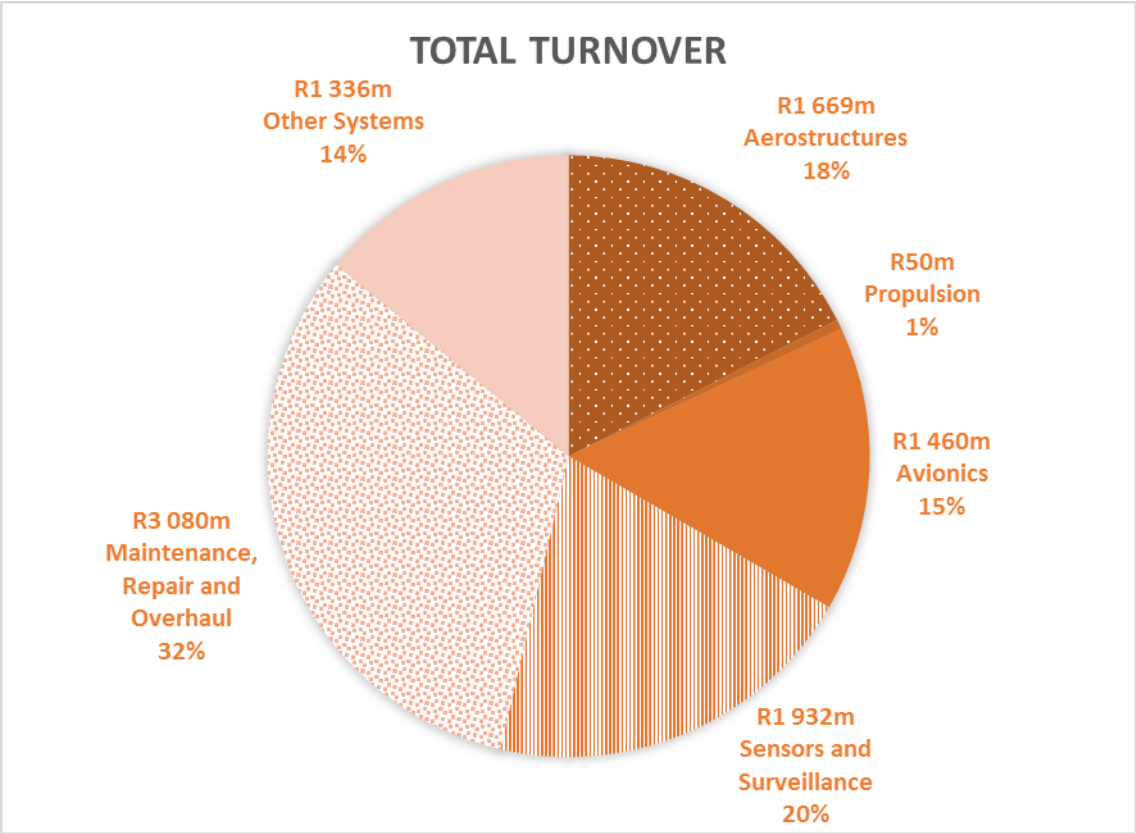


Figure 14: Total industry turnover by Sector

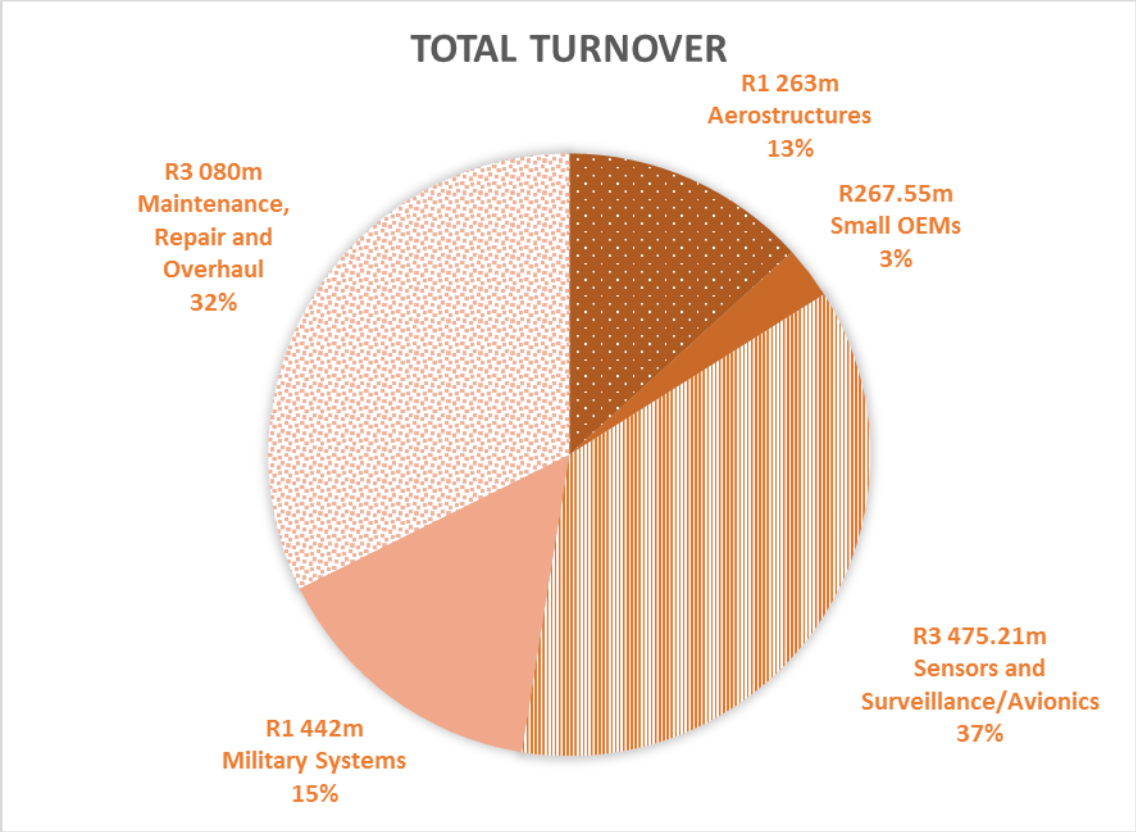


Figure 15: Industry turnover by revised sectors according to the industry engagements

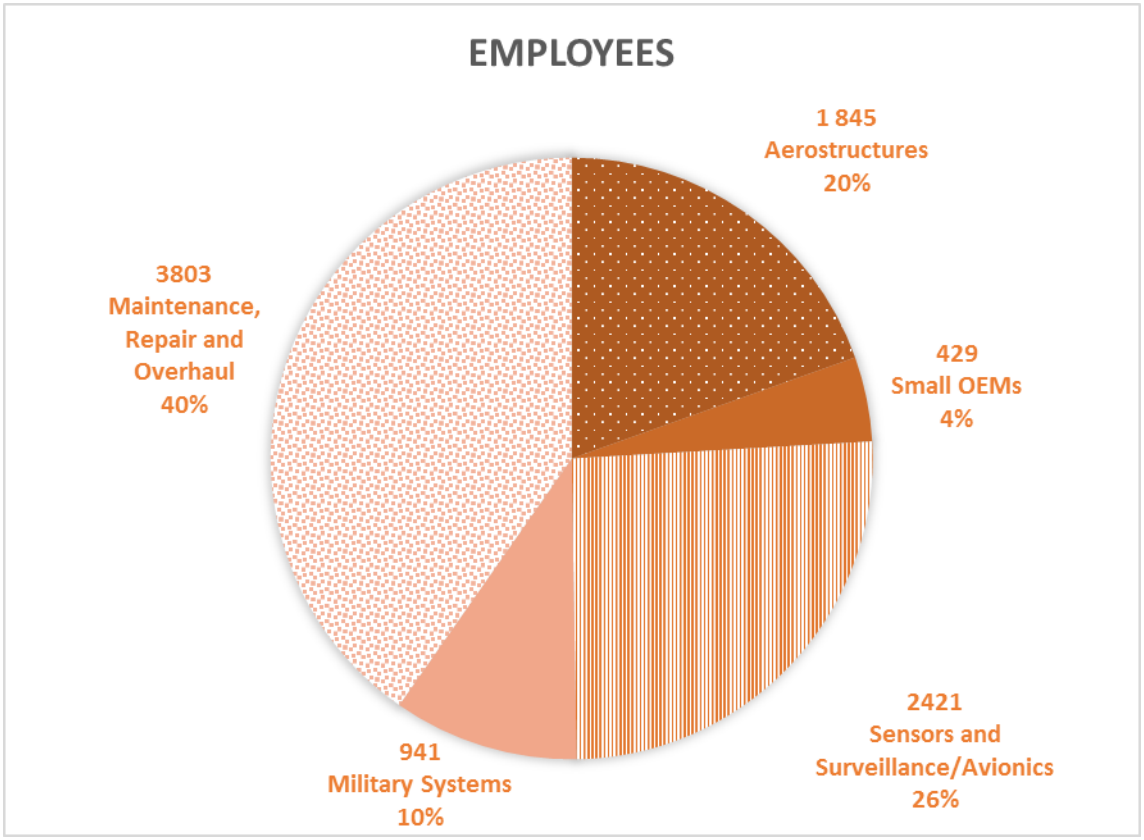


Figure 16: Employees per sector

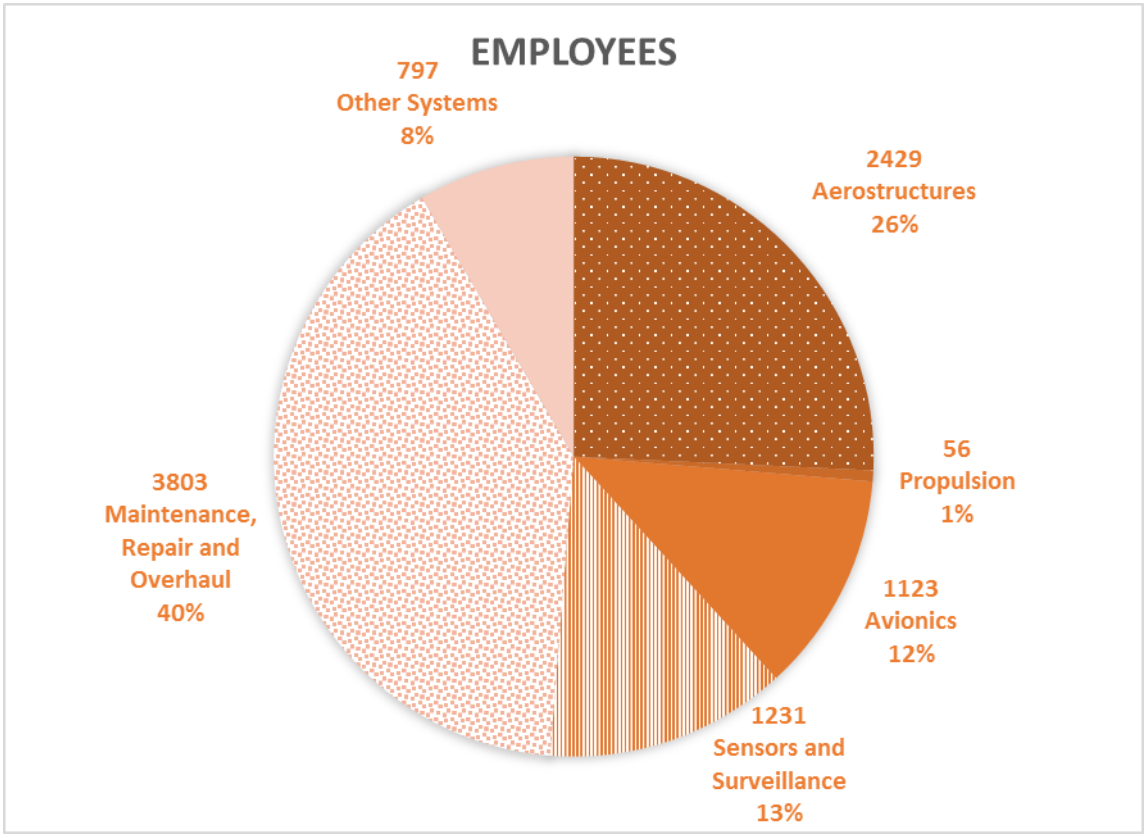


Figure 17: Employees per revised sector according to industry engagements

5.3.1 Trends in Turnover

From the limited data available from detailed responses to the questionnaires it is apparent that most sectors are stagnant or growing at below inflationary rates, however the following exceptions are notable:

- The aerostructures industry that forms part of the global supply chains of Boeing and Airbus grew steadily before 2017/18 but has seen a sharp decline (30%) in 2017/18 at the higher tiers. At the lower tiers where the entities have a more diversified portfolio or have been able to diversify quickly in response to falling demand a 10% decrease is evident. This sharp decline correlates with the end on DIP contracts with major OEMs and the need for the industry to find work independent of any government support mechanism.
- The MRO market is flat but this is strongly influenced by the limited data available from SAA Technical and the operation of the Rooivalk in peacekeeping missions. Neither of these situations are necessarily accurate or sustainable. In addition there are several pieces of evidence that suggest that SAA itself may be forced operationally to move away from servicing aircraft at SAA Technical and that Comair has signed with Lufthansa for the servicing of their new Boeing 737Max aircraft. On balance however, it is assumed that the new market entrants will take business away from SAA but that the industry will remain roughly the same size.
- The electronics industry sectors are more turbulent with some established entities experiencing significant reductions in income of up to 30% in the last year while the lower tier entities have also experienced sharp declines, but as with aerostructures industry, the magnitude is lower (15%) although the mechanisms are different and likely to be increased competition from international sources. Some major players in this sector are stable, these include entities that have a high degree of international ownership, industries that have been able to diversity into mining in particular and small highly entrepreneurial entities.
- One encouraging sector is the small aircraft OEMs where growth is approaching 20% year on year. Many of the entities in this sector are not hampered by sales but by other externalities such as certification challenges and rising cost of input materials and factory floor space limitations. Of course while the growth is encouraging it remains a small sector, but as Tier 0 entities, they represent not only significant technical achievements to aspire to but also have important significance in achieving high levels of value add to the economy. Furthermore, in the subsequent workshops it is clear that the time is ripe to assist these entities as they begin to subcontract their component manufacture as a result of floor space and throughput limitations to ensure that the full value of these entities is exploited within the SA economy and that they do not import additional components.

5.3.2 Income Sources

In all cases except MRO the South African industry is highly dependent on international business and contracts and is an export earner for SA. The MRO business is the opposite, highly dependent on local demand which is a function of market forces such as tourism and the SA economy (only wealthy people with excess income can afford to fly their own aircraft) as well as the aircraft types that can be serviced.

5.3.3 Cost Drivers

By asking for information regarding the cost drivers in the industry one of the questions the authors hoped to address was the degree to which the distance between SA and the overseas OEMs hampers the local industry. And while the direct answer from the responses ranges from 1 to 10% of turnover it is not clear how much of the cost of imported material is transport related. What is clear is that the largest costs are labour, material from international sources, local suppliers and then transport, in that order, with labour and international suppliers often being of similar magnitude.

In the next section the value of the industry to the South African economy will be looked at in more detail. From the above data it is clear that the overwhelming dependence of the industry on international sources of supply as it currently stands would imply that the traditionally high industry multiplier effect of the aerospace industry is not being realised in SA. This represents a huge opportunity to increase the overall value of the

industry through the localisation of supply of relatively simple (technologically speaking) input materials such as aviation grade materials, paints, fasteners and for the newer additive processes, powders.

5.4 Value to the SA Economy

While the aerospace industry's turnover equates to less than 0.5% of the total production in the SA economy based on figures from Statistics SA [30], it contributes 1.7% to the manufacturing sector production and is 3% of the transport and electronics sectors in which the industry is aggregated by Statistics SA in terms of the SIC codes. Interestingly the gross income of its employees is near 5% of that for the entire manufacturing sector, almost 3 times the value of its production contribution. The sector is however small in comparison to the automotive industry at just 1/30th of the turnover.

The estimated total of turnover of the 104 companies included in this survey of the sector is R9.5 Billion. These numbers do not account for the true spill over effect from the aerospace industry as there are a large number of companies that have not been included that supply the aerospace sector, including tool suppliers, software vendors and raw materials suppliers. If the economic multipliers typical of the manufacturing sector (Mukandila [31]) in SA were to be applied then the combined value of the industry might well approach R40 Billion, however this number should be treated with extreme caution given the concerns raised regarding the lack of localised supply chains as well as the lack of data from Statistics SA to support an accurate account of the input/output data in aerospace sector of the economy.

The induced value of an industry sector is inextricably linked to the wage bill of an industry and how far above the average that wage bill is. Aerospace is well known for its relentless demand for highly skilled workers and professionals and we can therefore expect that the average salaries are higher. Table 9 shows the calculations and sectoral breakdown of annual salaries for the data obtained as part of this study and compares it to the manufacturing sector according to information freely available from Statistics SA [30].

The annual compensation to workers in the Aerospace sector indicated in Table 9 in is on average nearly 6 times that in the rest of the manufacturing sector. This is in part due to the international mobility of the sector's workforce but has clear advantages in terms of the induced benefits to the South African economy. Similarly the throughput is between 1.5 and 4 times that of the manufacturing sector average and shows the attractiveness of the value addition this industry sector offers. Breaking down the aerospace industry further as per Table 9 shows that MRO represents the lowest paid workforce in the sector and the electronics industry the highest. This is also backed up by the fact that the electronics and military (other) systems sector represents the highest tier of suppliers of sub-systems with full design authority over those sub-systems, a trend that is evident throughout the international industry [32].

Finally if one attempts to examine the value of tax revenues from the aerospace sector in relation to the direct government support to the sector, one runs into a number of difficulties:

- There is little data available from government of industry with regard to what government support has been offered beyond the AISI.
- Many of the more prominent support mechanisms such as NIPP and DIP are difficult to quantify, it is simplistic to say that the procurement of the defence packages benefited the industry at no additional cost to the DoD for example.
- Few companies gave tax information and very few companies in the sector are currently profitable to the extent that they pay significant companies tax.
- Finally how does one account for government support to loss making SOEs?

The data regarding employee costs however would suggest that the annual tax revenues from employees in the sector reaches ±R570 Million which far exceeds the AISI budget of approximately R20 Million annually (a budget that includes the space sector) and anything reported by the industry over the five years of requested input to the questionnaires.

5.5 Skills

Very little data was made available by the industry in this area. However, the labour cost per employee data shows a high value per employee, indicating the highly skilled nature of the workforce. MRO activities rely on skilled and certified individuals but does not require professionally qualified skills, aerostructures requires

both with a greater proportion of university qualified skills being required at the higher tiers. Trade and artisanal skills are critical to these industry sectors. The electronics and military sub-systems sectors clearly employ the highest proportion of university qualified personnel and is reliant on the universities for highly qualified personnel.

5.6 Physical Clustering

Figure 13, and Figure 18 to Figure 25 provide an overview of the location and relative value and number of employees and type of organisation spatially within SA. Clearly there are two centres to the aerospace industry in SA, Gauteng and the Western Cape. On balance the aerostructures industry is based in Gauteng with some notable exceptions, as is MRO. Likewise the electronics based industries, Surveillance and Sensors, and Avionics are based in the Cape with the exception of SAAB Grintek and other systems (essentially Denel Dynamics) in Gauteng.

Location near transport hubs is a clear requirement for the success of the aerostructures industry, something that is clearly articulated in both the international literature and in the input received from the industry locally. The physical location of these companies in Figure 18 tends to bear this out as all such industry entities are located near major highways, but only those based at OR Tambo airport in the Ekurhuleni Aerotropolis are collocated at a natural export transport hub. Perversely it would make more sense for today's aerostructures industry sector to be located in Cape Town or another port city to facilitate the export of larger structures as is the case in Tunisia for example, but for historical reasons (military industry, skills and customer base) this is not the case. Electronic sub-systems are smaller and lighter and readily air transportable, and yet the industry is located in a port city. There is currently no compelling argument for the location of the CAV to service the aerostructures industry, other than its co-location with Aerosud. The original reasoning behind its location was:

- The create a globally integrated Tier 1 supplier with Aerosud as an anchor
    - Denel Aerostructures was to move to the site.
- Airports Company SA was to build an additional runway and Air Force Base Waterkloof was to be opened to make air side operations possible.

These would make the CAV a small but viable cluster, to date however, Denel has decided not to move, the military have not yet agreed to open the base and insufficient government investment and a lack of appropriate incentives have seen no meaningful growth on the site.

MRO activities are predominantly located at OR Tambo, Lanseria and Wonderboom Airports, servicing the Commercial, Commercial and General, and General and Recreational aviation sectors respectively and are essentially clusters in their own right for these services.

Small SMMEs and start-up companies are located in a variety of locations, more often associated with access to cheap hangar space, air-side operations, and/or skills (this is classically represented by Jonker Sailplanes in Potchestroom or Adept in Durban). They are seldom located near existing and established entities in the industry and the danger of this is that there is a resulting disconnect with the rest of the local supply chain. Essentially this is the argument for a combination of a catapult approach to SMME development and a cluster approach; the lack thereof has led to the above dis-connect.

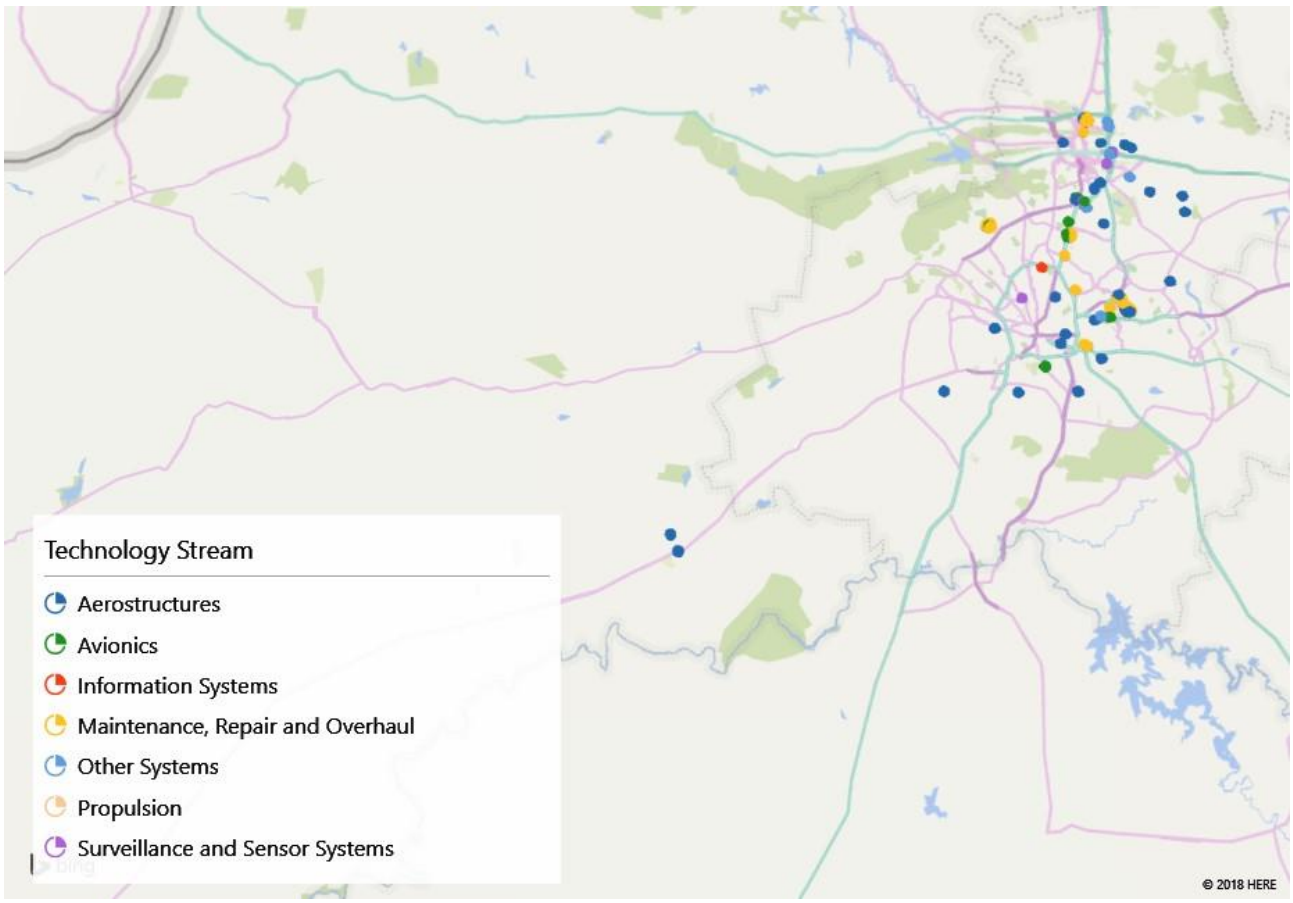


Figure 18: Physical location of industry per sector in the Gauteng region

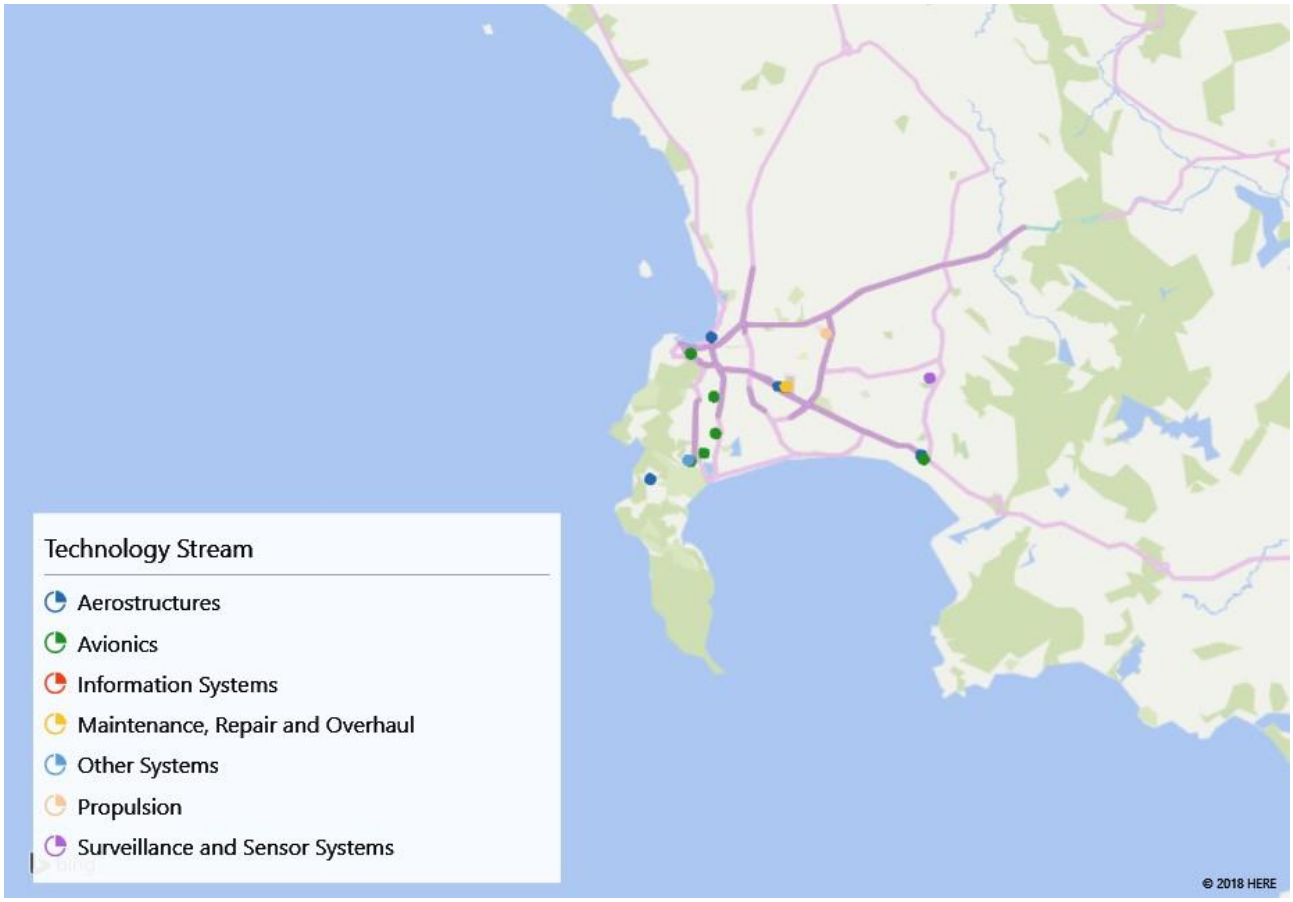


Figure 19: Physical location of industry per sector in the Cape Town region

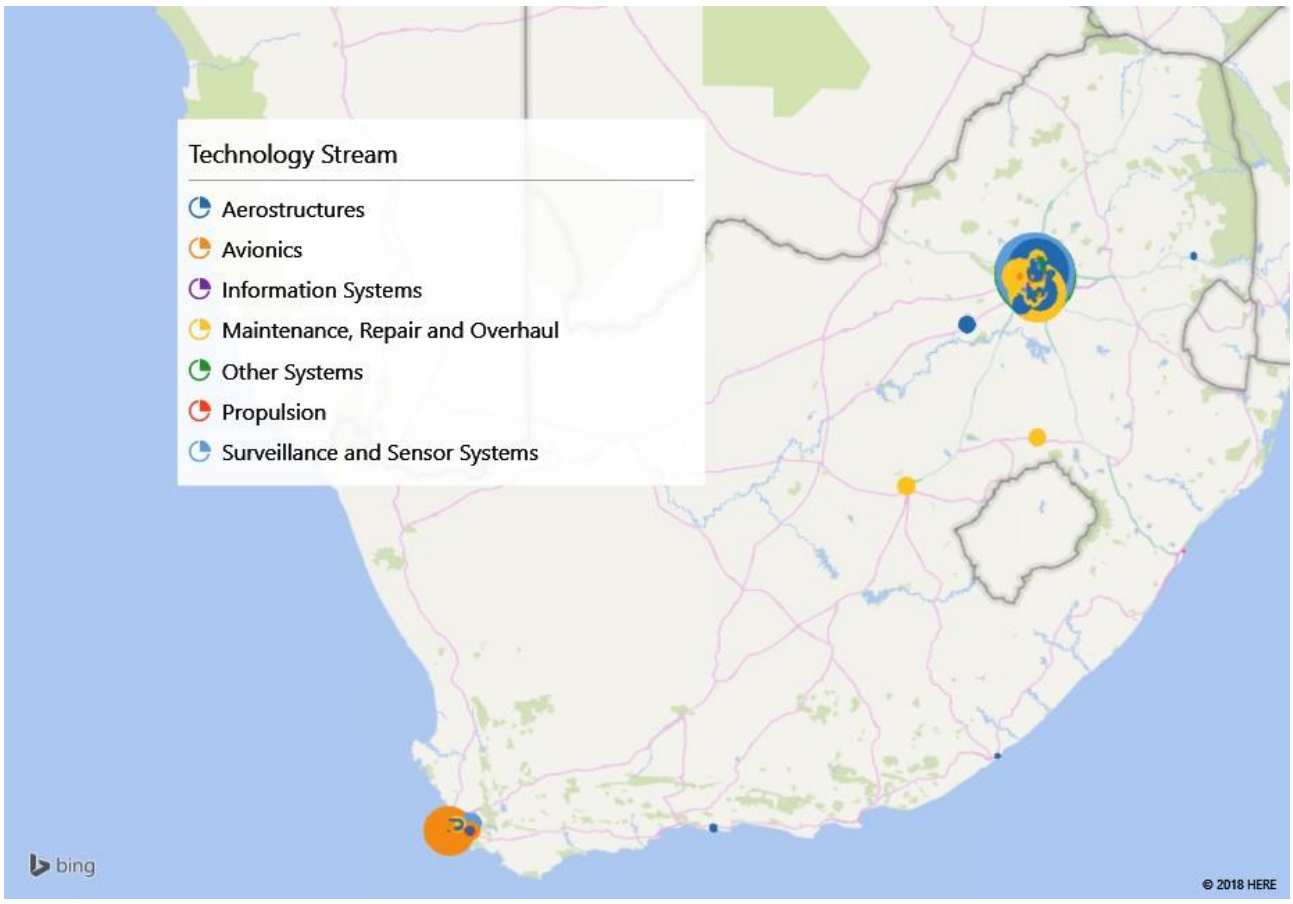


Figure 20: Industry value and physical location per sector, country-wide

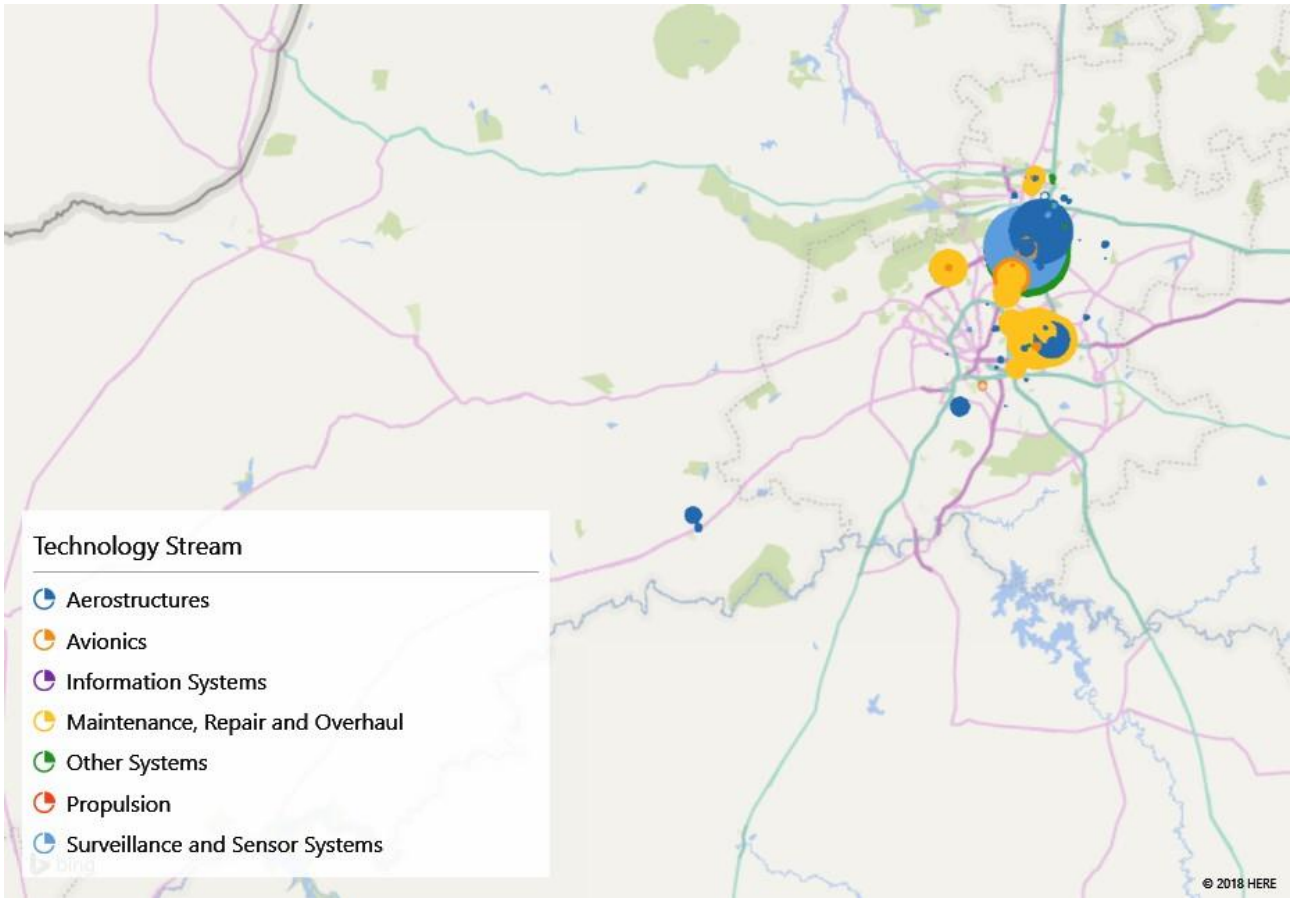


Figure 21: Industry value and physical location per sector in the Gauteng region

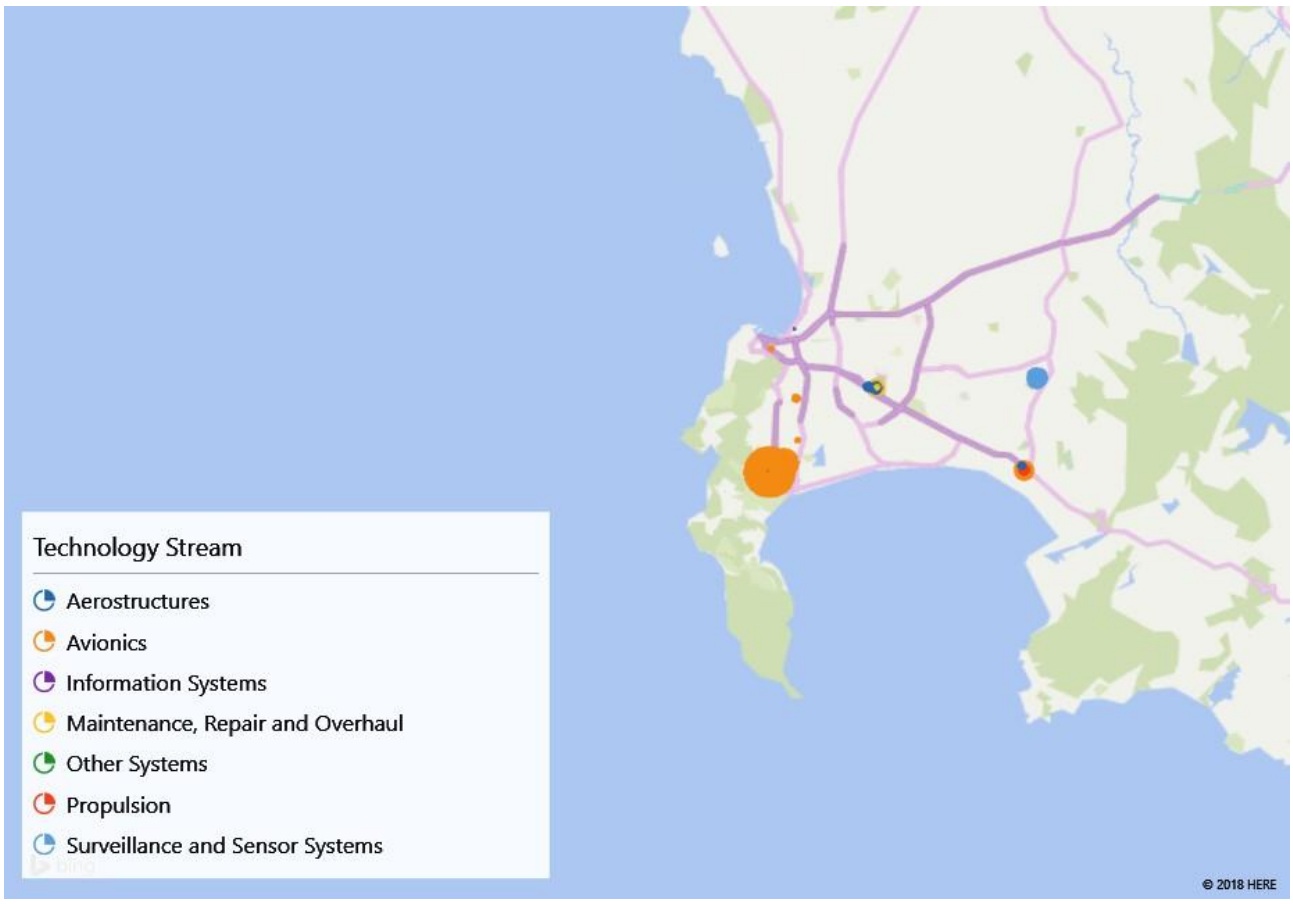


Figure 22: Industry value and physical location per sector in the Cape Town region

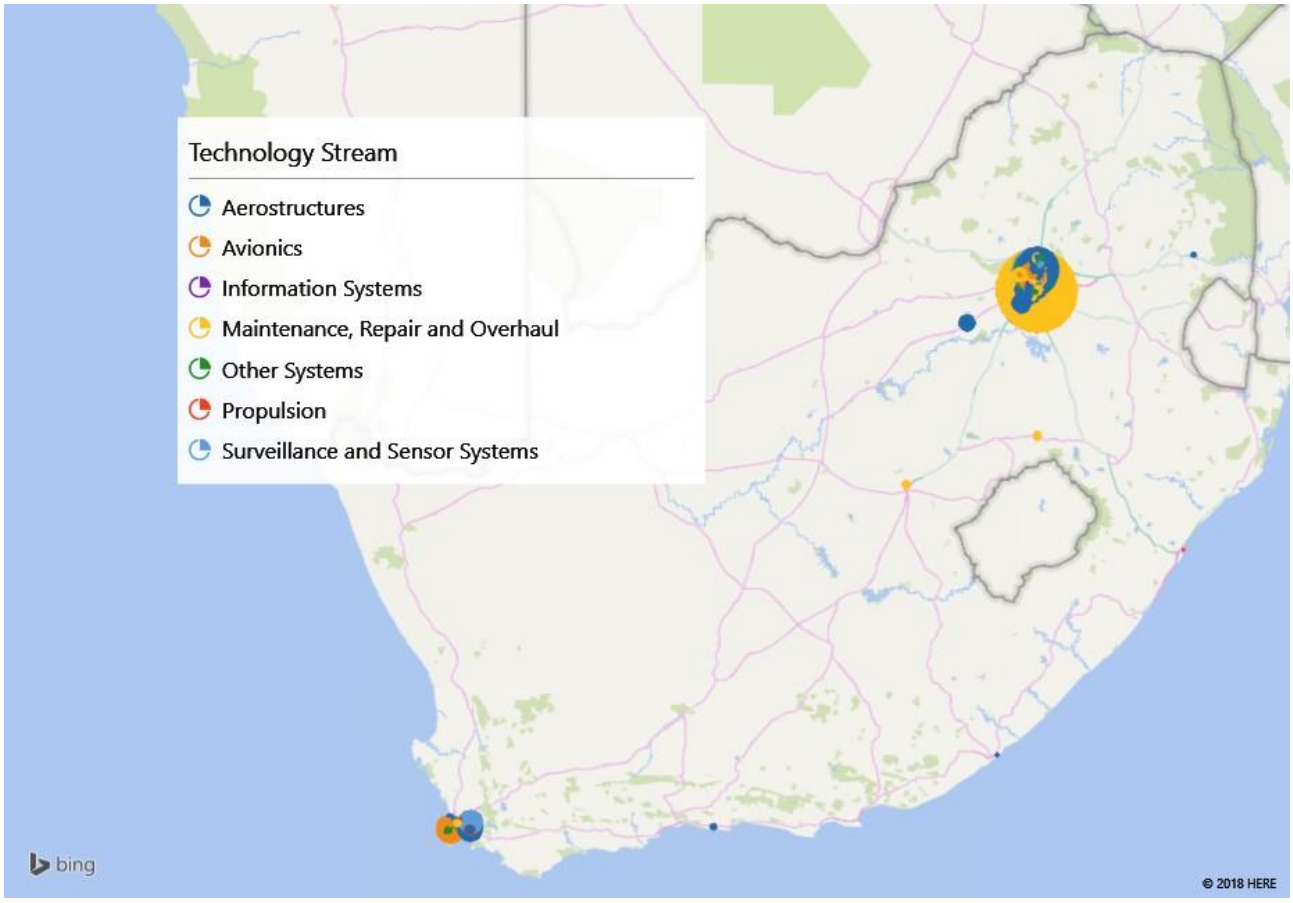


Figure 23: Physical location and number of employees per sector, country-wide

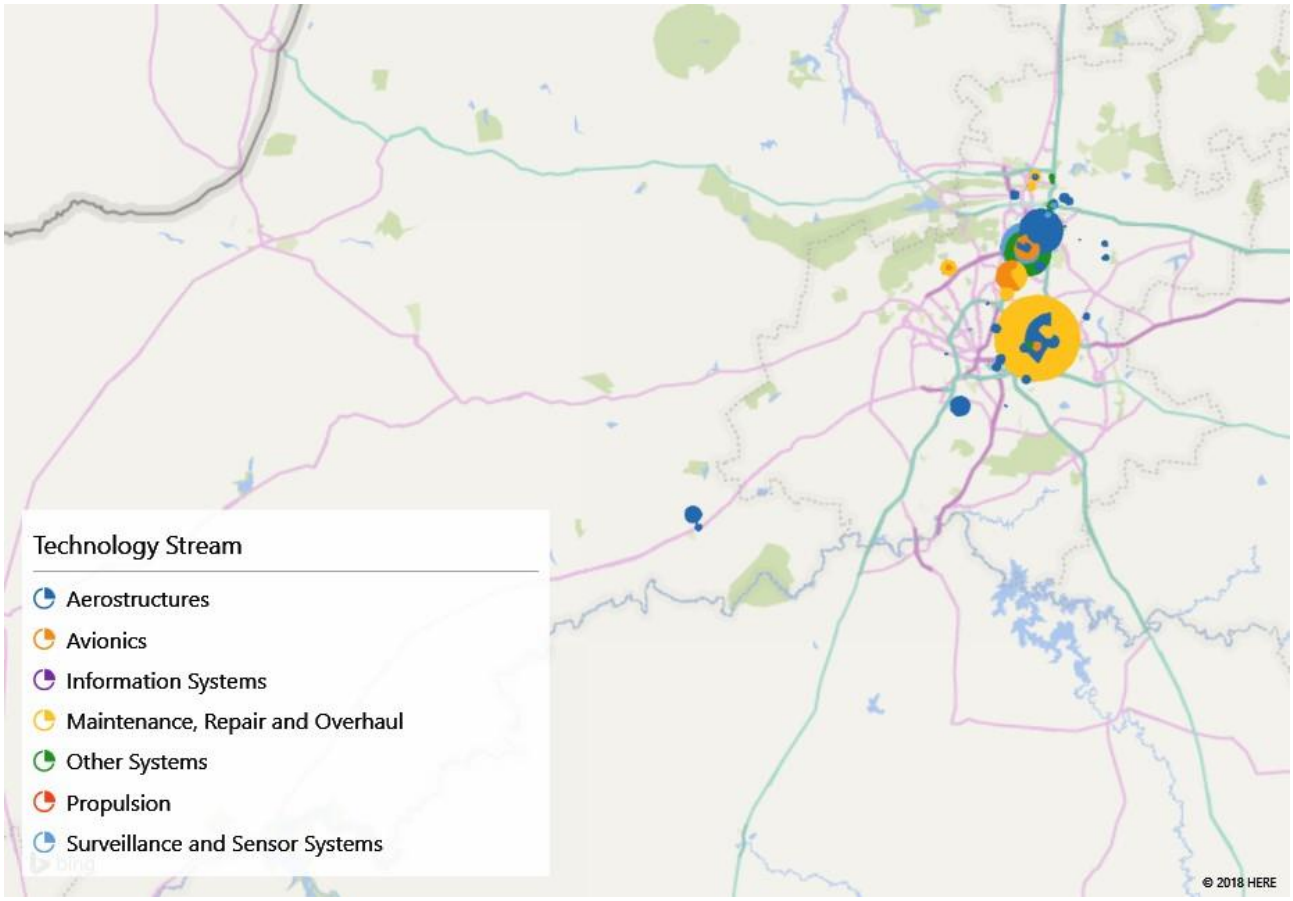


Figure 24: Physical location and number of employees per sector in the Gauteng region

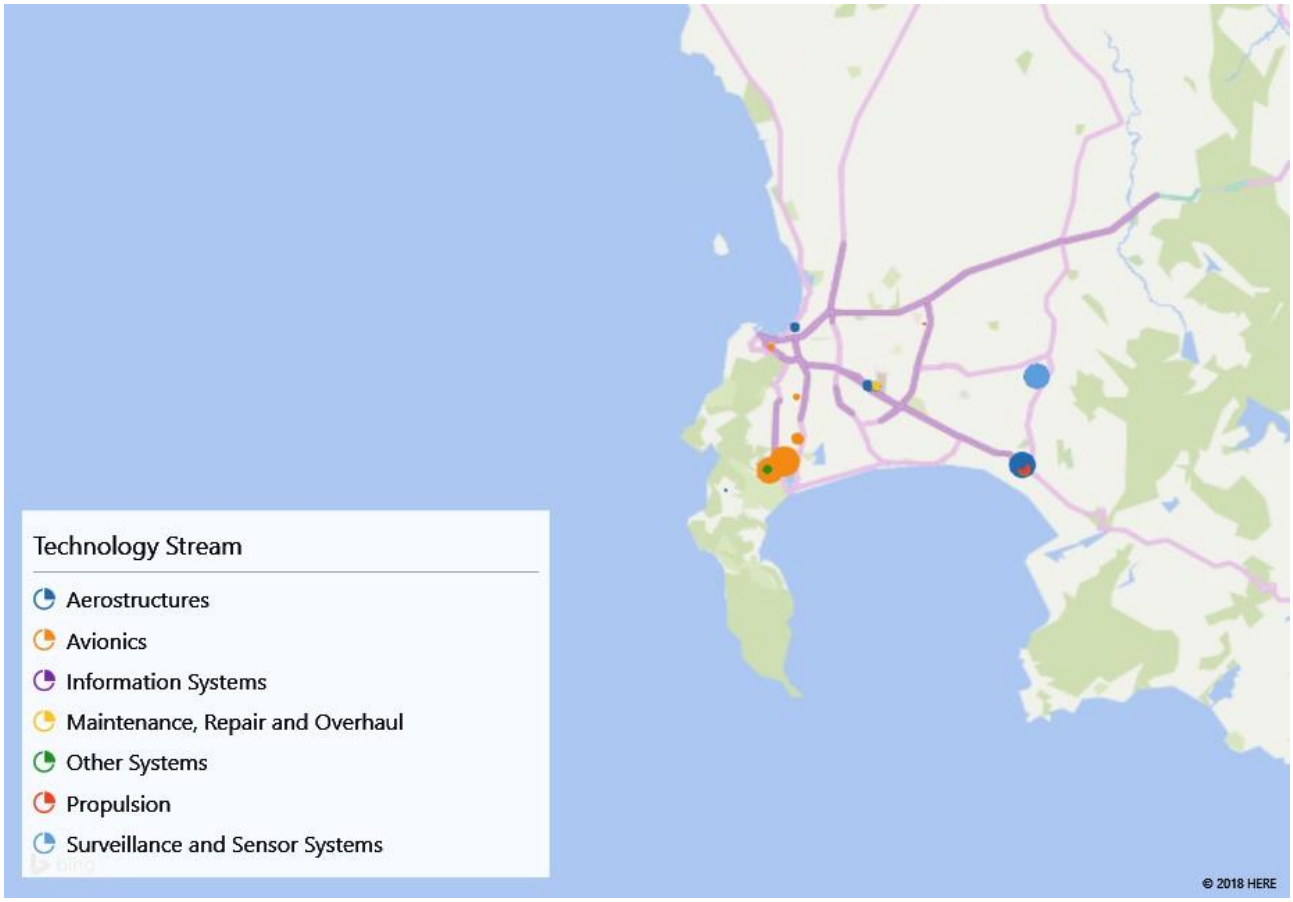


Figure 25: Physical location and number of employees per sector in the Cape Town region

5.7 Industry Structure: Commercial and Defence

Table 10 shows a breakdown of turnover and employee numbers for the total aerospace industry surveyed, that without MRO (Manufacturing only) and for just the Aerostructures component. The latter is included as they represent the main protagonists agitating for the exclusion of the defence sector in this study.

What is quite apparent in the figures shown in Table 10, is that the defence sub-sector dominates the commercial sub-sector until the data is reduced to just that for the Aerostructures stream. The postulation therefore that the commercial business is small on its own holds and would make up less than 0.1% of total production in the SA economy.

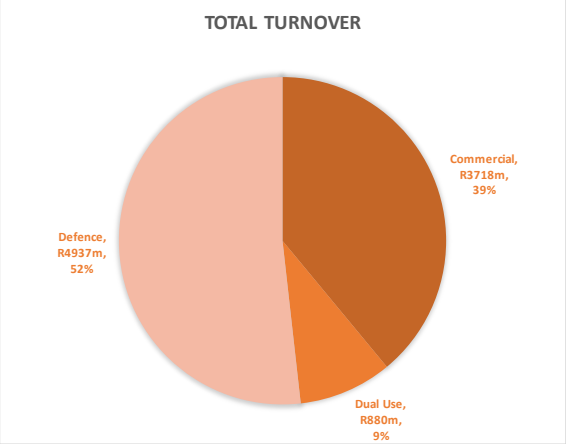
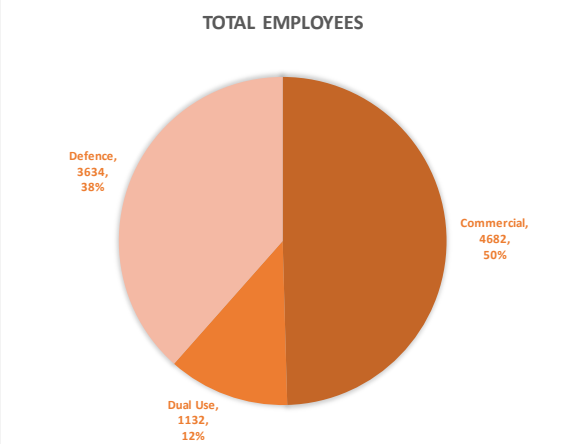
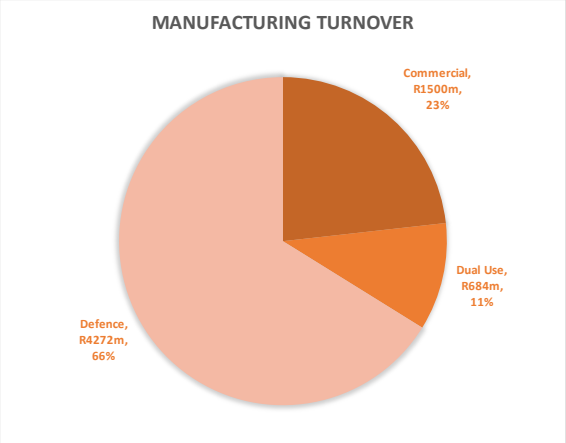
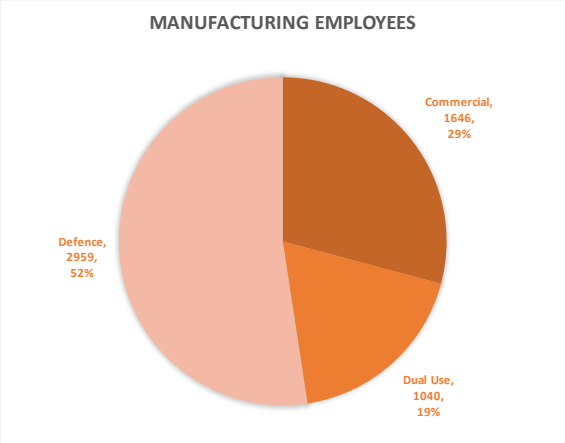
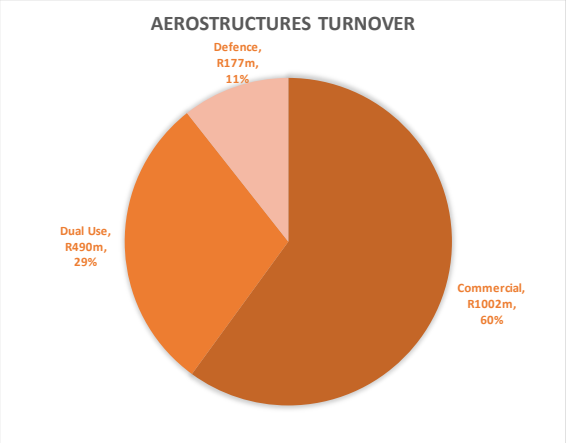
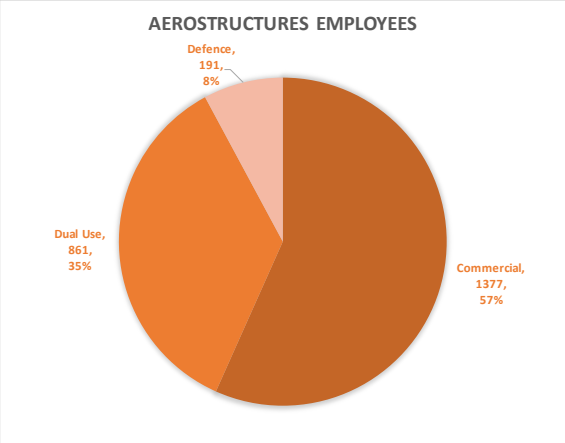
In addition the proportion of dual use activities which are made up a broad spectrum of small to large companies supplying into the industry at many levels is large, 10% of the total make-up of the industry sector growing to between 10 and 20% if MRO activities are removed, and finally if only the Aerostructures stream is considered, over 30%. The dual use industries are a fundamental component of both sub-sectors, contributing key capabilities and expertise to both and cannot be readily separated out. This is particularly true in the Aerostructures sector which has the highest percentage contribution from Dual Use entities.

Note: Denel Aerostructures' data is included as' Dual Use' as at the time of the survey they had contracts for the A400M as well as Commercial contracts for GKN and Honda Jet. Removing Denel Aerostructures does not however change the overall conclusion.

In the process of interviewing and workshopping with various entities within the industry the following explanations for this can be offered:

- The Aerospace industry emerged out of a historical investment in the defence sector which is still known internationally for is innovative and highly cost effective products. Defence products are certified according to military regulations and procedures, which, thanks to the history of the industry and the role of the SANDF and Armscor, are well understood and achievable within the existing facilities, capabilities and expertise. Commercial products are regulated by a different legal framework not readily achievable in South Africa without bilateral agreements with the FAA and EASA as well as significant investments in testing and certification facilities, expertise and regulation limits the ability of the local industry to penetrate the international market. The domination of the defence sector therefore remains.
- In the Aerostructures sector the certification and regulation requirements are manageable through a reliance on supply to OEMs and higher tier entities who only require AS9100 and ISO9001 certification or equivalents, whereas the Defence sector opted to purchase foreign made airframes for the most part. Aerostructures is therefore dominated by commercial work and has different entry requirements – access to capital, cost effective skilled labour, and a compelling case for OEMs to direct work to South Africa.

Table 10: Aerospace sector breakdown of turnover and employee numbers

Turnover	Employees
Total Industry surveyed	
	
Excluding MRO	
	
Aerostructures Stream only	
	

6 Industry Engagements

A total of five workshops were held, each with a small, targeted group of companies within a given sector. Each company was required to give input on the view of the strengths, weaknesses, opportunities and threats to their industry sector and then workshop the industry sector vision, drivers and potential incentives. The workshops ended with a discussion of each participant's single most important idea for incentivising the growth of the industry and finally to transform the industry. The sectors workshopped are the following:

- **Aerostructures**: Suppliers into the larger international commercial aerospace industry and their sub-supplier network. (Aerosud, Daliff, Titamed)
- **Small OEMs:** Manufacturers of light aircraft and engines (Jonker Sailplanes, Adept Manufacturing).
- **Sensors and surveillance:** Manufacturers of electronic equipment for ground based and aircraft applications and their suppliers (Ruetech Radar Systems, Kutleng, Tellumat).
- **Maintenance, repair and overhaul:** Representatives of commercial and military MRO companies (SAA, Lufthansa Teknik).
- **Military systems:** Manufacturers of missiles and UAV systems. This was compiled from individual meetings as the participants were not all available simultaneously (Paramount Advanced Technologies, Denel Dynamics).

The companies were chosen for their willingness to participate in the workshops as well as their having provided completed full length surveys as well as their abilities to represent their sub-sector in the opinion of the facilitation team.

.For brevity, only the consolidated information is presented in the main body of the report, however the individual workshop information is included in Appendix B for completeness, should the reader need to understand the origin of certain comments.

For convenience the size of these sectors of the South African aerospace industry are given in Table 11 below.

Table 11: Industry size in each category workshopped

SECTOR	TURNOVER (R Billion)	NO. OF EMPLOYEES
Aerostuctures (to supply International Tier 0 and 1)	1.26	1850
Small OEMs	0.27	430
Sensors and Surveillance/Avionics	3.48	2420
Military Systems	1.44	940
Maintenance, Repair and Overhaul	3.08	3800

Disclaimer: The views, opinions and conclusions expressed in this section do not necessarily represent those of the authors or the CSIR.

6.1 Industry Vision

- To be a vibrant, growing, export focussed industry.
- To be the preferred supplier of products for domestic acquisitions.
- To collaborate internally to grow the export potential of the industry.
- To be recognised as a provider of niche, innovative and high technology sub-components, products and systems solutions.
- To be the preferred MRO hub for sub-Saharan Africa.

6.2 SWOT Analysis

The items listed here appear in no particular order.

Table 12: Strengths

INDUSTRY

- Long history and track record in aerospace.
- Long term track record of supplying OEMs and tier 1 suppliers.
- SA is competitive, in terms of price and skills, in comparison to other countries across all activities.
- Relatively good infrastructure and facilities across entities, eg. Meerkat (SKA), the CSIR.
- Advanced technology and skills are available.
- Competencies in products and systems.
- Can address military and commercial markets.
- Government incentives do exist.
- Culture and language compatibility exists with much of Europe and the USA.
- Companies who have survived are lean and tough and have learnt the hard lessons.
- SA Industry often characterised as entrepreneurial, innovative and capable of bespoke, best-in-class solutions.

SKILLS

- Quality tertiary education institutes are in place.
- The industry produces engineers that spill over into other industries.
- High level engineering skills and capacity is sufficient: Training exceeds requirements in many areas retention is the issue.

POLITICAL

- Neutral politically (non-aligned).

GEOGRAPHIC

- Time zone is the same as Europe which makes doing business with Europe easy.
- Geographic position for sub-Saharan MRO support.

Table 13: Weaknesses

INDUSTRY

- Stagnation in Advanced Manufacturing: Gap with international competitors widening.
- Lack of re-investment in products is resulting in obsolescence of market offerings.
- Industry is risk averse with respect to innovation (Industry waits for guaranteed sales before committing as they lack the financial resources to suffer a market failure).
- Low capacity for upfront investment – non-recurring costs.
- Reactive not proactive.
- Inconsistent quality.
- Ability to complete products/designs on time is perceived as poor.
- Insufficient turnover, puts pressure on margin and cash flow (Economy of scale is lacking).
- Fragmented/segmented industry (many sub-sectors and little collaboration within or across sectors).
- Poor economy of scale as an industry: Small number of companies in SA.
- Lack of local raw materials suppliers.
- Limited resources dedicated to marketing.

INDUSTRY ASSOCIATION

- Insufficient industry coordination:
    - Industry perceive a lack of a voice to government.
    - Associations are weak:
        - No plan or vision.
        - Should be able to articulate the ambitions of the industry.

- Should be forceful enough to make the industry work together.

SKILLS

- Shortage of apprentices, artisans and composite workers.
- Key skills are lost to other countries.
- Key personnel are approaching retirement and not being replaced (skills base lacks depth).
- Low quality labour force, points to deficiencies in secondary education system or the lack of a school going culture:
    - Skills for the new digital economy.

GOVERNMENT

- Public sector legislative constraints make it difficult for public entities to compete globally (PFMA, PPPFA etc).
- Generation and execution of a national aerospace development plan:
    - National strategy/ies uncoordinated (e.g. SAA purchases and aerospace manufacturing).
    - Opportunistic focused government/DoD support.
    - Very high expectations from government before deploying funding.
    - Political interference vs Technical know-how.
    - Lack of government implementation of policy, plans and strategy:
        - Lack of flagship programmes as recommended in the SDP.
            - Required to give new personnel the opportunity to gain experience and the industry the opportunity to transform its skills base.
- Insufficient government support (the requirement extends beyond funding):
    - Fragmented approach through a myriad of funding mechanisms.
    - Low levels of R&D investment relative to Europe for example.
    - Little funding for risk/revenue sharing (industry not subsidised).
    - SMMEs lack support and capacity to enter a highly controlled and capital intensive market.
    - Country does not show good faith in its own products.
- National marketing:
    - OEMs do not see SA as a preferred supplier.
    - Marketing by the country needs to be improved, especially within the African Union.
    - SA government must back the industry by buying its products.
    - Targeted government to government support is required.
- Certification support:
    - An entity is required that contains all the regulations and testing requirements and can lease in certification engineers as required.
    - A/C certification MRO approvals:
        - Costly to maintain/upgrade and currently limited to older aircraft types.
    - Certification experience in only one or two companies.
    - SA companies are currently forced to go abroad for certification.
    - Certification and qualification facilities lacking.
    - SACAA capabilities declining or variable.
- IPR Act requires review:

  The act fails to account for local requirements and limits ability of industry to work together with research institutions to effectively release products into the industry.

Table 14: Opportunities

GOVERNMENT SUPPORT

- NIPP and DIP for local and export product development.
- Government funding (AISI etc) – A single entity that has the resources for meaningful support across the entire sector that engages with industry rather than remaining passive.
- Manufacturing catapult programme.
- Structured cluster initiatives.

CERTIFICATION

- Bilaterals with EASA and FAA.
- Aircraft design authority:
    - Expanded aircraft MRO for older aircraft.

TECHNOLOGY ADVANCES

- Industry 4.0 – Automation is inevitable and will change the jobs market:
    - Product and quality improvement.
    - Development of new technologies.
    - Making aircraft less expensive to certify.
    - Cloud computing.
    - More flexible design equates to ability to compete for niche market opportunities.

INDUSTRY COOPERATION

- Clustering to quote on global RFQs.
- Pool capability towards product line.
- Co-operation between MRO suppliers, everyone makes money.
- Some of the small OEMs are reaching the stage where they can consider outsourcing.

NEW MARKETS

- Strong global growth forecast for commercial aircraft sales implies opportunities of manufacturing exports:
    - System integration for OEMs, moving up the tier levels.
- Supply of integrated solutions.
- Markets in Asia.
- Drones and automation:
    - UAS at a lower cost.
- SAA/SA Express need to re-equip:
    - BRICS collaboration to license build.
    - Requires AU countries to collaborate-African growth.
    - New NIPP opportunities.
- Rooivalk upgrade/MkII.
- Diversification in terms of models and complementary products.
- Opportunity for SA to be main MRO supplier in Africa.
- Global space industry (±$340B).
- Selected emerging markets:
    - Opportunities in non-end user/ITAR products.
    - Exports and foreign currency.
- Investment in new technologies such as Industry 4.0:
  Leverage off titanium and aluminium beneficiation investments.

Table 15: Threats

INDUSTRY

- Fragmented industry prone to competing rather than collaborating:
  - Failure to acknowledge the need to compete.
  - Public and private sector inertia (slow to react and implement plans and strategy).
  - OEMs losing confidence in SA.
- No Tier 1 suppliers:
  - Makes SA non-competitive.
  - Limits growth.
  - Becoming the equivalent of the auto industry in SA, build to print only.
- OEM control of IP (i.e. maintenance can only be performed by OEM).
- Aerospace is a high CAPEX and OPEX industry with long ROI terms. Investors generally will not invest in such an industry when it is faced with:
  - Forex volatility.
  - Political uncertainty and risk of investment.
- Clear trend indicating a reduction in industry turnover, could result in divestment.

SKILLS

- Industry lacks the capacity to absorb and retain new talent.
- Lack of apprenticeships.
- Loss of capacity and capability.
- Availability of skilled labour.
- Aggressive recruitment of skilled labour by other countries and industries.

BUREAUCRACY

- SA export control processes and restrictions (unpredictable outcome, irregular meeting schedule and lost documents etc.):
  - Capricious foreign policy.
  - Conflict between international clients affects market access, e.g. India/Pakistan.
- SACAA:
  - UAV restrictions.
  - Lack of commonality with categories for both EASA and FAA.
  - Unpredictable audit outcomes.
  - Declining skills and authority due to inappropriate qualifications.
- Import of controlled items, e.g. PCB technologies.
- Dated policies/frameworks, e.g. SACAA and Space.

GOVERNMENT

- Socio-Economic challenges:
  - Budget constraints.
  - Shortage of government funding for capital acquisitions.
  - Unstable currency.
  - Volatile labour market.
- State of SOEs:
  - Lack of public support (brand erosion in SAA in particular but includes Denel).
  - Cash flow challenges at Denel.
- Low economic growth in SA.
- Economic and political uncertainty.
- Data security concerns.
- DoD restrictions:
  - Death of design and development (which was once driven by Defence industry).
  - Military business too dependent on Armscor and diminishing.

MARKET

- Afro-pessimism, perception that products are inferior.
- Lack of faith in local suppliers shown by SA government.
- Competitors in the market with a large global footprint, e.g. Thales.
- Decline in gliding.
- Decline in general aviation.
- Strong competition.
- Brand loyalty to foreign brands.
- High risk industry:
  - Accidents and incidents resulting in legal costs and reputational damage.
- Decline in alternative markets:
  - Mining sector (important source of income for the sensors and surveillance sector) is becoming very competitive.

TECHNOLOGY

- Advanced manufacturing investment stagnated in last 10 years – falling behind international industry:
  - Vulnerable to disruptive technologies.
  - Vulnerable to competitors with newer technology.

SUPPLY

- Supply of raw materials almost exclusively from international sources.
- Unstable currency makes costing difficult.

6.2.1 Industry Trends and Drivers

SHORT TERM (1-3 years)	MEDIUM TERM (3-5 years)	LONG TERM (>5 years)

MARKET TRENDS
• Mergers and acquisitions:
  ○ Boeing and Embraer.
  ○ Airbus and Bombardier.
• Industry 4.0 and smart manufacturing.
• Increasingly competitive market.
• Lower cost competition from the East.
• Increasing localisation and IP protection vs global sourcing/ purchasing.
• Market shift from military to commercial locally.
• Outsourcing of MRO by airlines.
LOCAL DRIVERS
• Political/economic uncertainty and instability.
  ○ Rand volatility.
• Scarce public funding and increased risk sharing requirements internationally.
  ○ Shrinking defence budget.
  ○ Declining counter trade opportunities.
• Insufficient R&D funding.
• Increasing need for localisa-
	MARKET TRENDS
	• Increase in protectionism internationally.
	• China emerging as an OEM.
	• BASA bilateral with FAA.
	TECHNOLOGY TRENDS
	• Additive manufacturing.
	• Miniaturisation of components.
	• Green economy (e-waste).
	• Virtual and augmented reality.
	• Disruptive technologies.
	• Battery technologies (energy density).
	• Smaller more specialised manufacturing entities.
	• Flexible manufacturing.
	• Flexible automation (Cobots, FPS).
	• Complex new aircraft and therefore technology enter commercial service.
		MARKET TRENDS
		• Decline in leisure flying community.
		• Increased regulatory compliance needs.
		• Growth of international and African markets.
		TECHNOLOGY TRENDS
		• Increasing interconnectivity and interoperability.
		• Quantum electronics.
		• New modes of transport.
		• Intelligent infrastructure.

SHORT TERM (1-3 years)	MEDIUM TERM (3-5 years)	LONG TERM (>5 years)
tion/outsourcing of components for small OEMs. • SA could become a maintenance hub in Southern Africa. • New A/C types in the country affecting MRO capability. **TECHNOLOGY TRENDS** • Cost and weight reduction. • Rapid technological changes. • Advanced material development. • Digital twins (PLM). • Rapid prototyping (lean R&D). • Digital disruption. • Open innovation. • Automation/advanced manufacturing/machining technology. • Industry 4.0 and IoT. • Distributed innovation. • Streamlined production and planning. • Strengthening supply chain: Inventory optimisation. **SKILLS DRIVERS** • Skills shortage particularly amongst previously disadvantaged groups. • New technologies require a shift in the type of skills and the education and training requirements. • Need for more base maintenance capacity. **CERTIFICATION TRENDS** • Certification requirements (both FAA and EASA but moving towards EASA). • Design/development of product [supplemental type certificates].	• Requirements changing becoming more complex. • Electrical propulsion with new supply and MRO chains **SKILLS DRIVERS** • Methodology of training moving into the digital age (incl. technology). • Secure new human capital as the previous generation leave the job market **CERTIFICATION** • Certification and testing of new systems is required.	

6.3 Roadmap

The information below represents the collated input from the workshops prior to prioritisation or consolidation which is done in the section which follows.

Table 16: Proposed Initiatives and Projects

SHORT TERM (1-3 years)	MEDIUM TERM (3-5 years)	LONG TERM (>5 years)
• Develop a properly phased strategy (short, medium and long term) • Fund life line projects to aid the survival of the industry in the short term.	Strategy and planning. Develop further long term strategy/ budget. Ramp up projects as the economy recovers. Implement Defence review.	Implement long term strategy/ budget in a recovered economy.

SHORT TERM (1-3 years)	MEDIUM TERM (3-5 years)	LONG TERM (>5 years)

• Start medium term strategy/ budgeting.
• A return to the ASSEGAI type approach of a 10 year development plan which provides an integrated Space, Aero and Defence plan.
 	
SKILLS
• Development of especially technical skills: Artisans and GD&T skills in particular
• Awareness of careers in aviation
• Directed industry specific training and development
• Address skills and workplace of the future as types of skills required change
• Free tertiary education for targeted skills on a merit and retention basis
 	
GOVERNMENT SUPPORT
• One stop aerospace incentives agency.
• Fundamental and focussed R&D support.
• New product support.
• Localisation.
• Maintain critical infrastructure/capabilities for use by industry (material testing and flutter prediction were mentioned as two typical examples).
• SMME development:
  ○ Start-up support.
  ○ Targeted government support – “catapult” model.
  ○ Access to technical information and capabilities.
• Export promotion and support.
• Support with inter-country ‘strong-arm’ tactics, e.g. trade tariffs.
• Strengthen organisations and institutes for test/certification/technical support e.g. the CSIR (South African one-stop-shop for certification services).
• Composite material characterisation.
• Targeted HR development tax incentives, THRIP is dysfunctional.
	SKILLS
	• HCD/skills pipeline.
	• Government STEM talent expo.
	
	GOVERNMENT SUPPORT
	• Industry designation.
	• Industrialisation.
	• Invest in product maturation.
	• Technology.
	• Industry 4.0 implementation.
	• Fund innovation programmes.
	• Incentivise appropriate sector clusters.
	• Support maintenance capacity in SA.	

SHORT TERM (1-3 years)	MEDIUM TERM (3-5 years)	LONG TERM (>5 years)

• Flagships programmes:
  ○ Fund the development of a low risk airliner development (integration of existing technologies).
  ○ Use the programme to develop lower tier suppliers and promote them to high level systems in future.
• Advanced manufacturing capability needs development.
• Industrialisation support.
• Government incentives to grow and perform, SEZ type model.
• Support advanced manufacturing uptake.
• Software leasing platform (CAD, CAM, CAE, Vericut, Industry 4.0).
• Reinstate funds such as the MCEP Green Energy Fund and Capital and Technology Investments fund (this would allow industry to upgrade to international standards).
• Develop local material supply.
• Influence export council and show selection for attendance.
• Relieve constraints:
  ○ BBBEE policy/ PFMA, PPPFA.
• Implementation of policy with funding (by government).
• Focus NIPP projects within the sector.
• Funded industry collaboration project sovereign capability.
• Collaborative ventures with OEMs.
• Promote stronger links with global aerospace manufacturers.
• Promote long term partnerships with international OEMs.
INDUSTRY ASSOCIATIONS
• Revitalise a JASC like forum as a PPP forum.
• Industry forum: Speak with “one-voice”.
• Establish best practise advanced manufacturing and certification processes.
• Industry secretary to facilitate collaboration.		

SHORT TERM (1-3 years)	MEDIUM TERM (3-5 years)	LONG TERM (>5 years)
• Start with Aerospace Maritime and Defence Industry Association (AMD)? • Effective industry forum. • "Industry voice". • Industry collaboration for the importing of raw materials. • Setup a certification body. • National UAV programme for the Integration of UAV's into civilian airspace. • Development of product [supplemental type certificates] (value chain). **INDUSTRY** • Focus on small wins and build confidence.		

6.3.1 Key Initiatives to Assist Industry

After collation and consolidation the projects and initiatives proposed by industry can be summarised as follows:

1. In the short term, fund stalled DoD acquisition programmes (move forward with the projects already defined).
2. Implement strategies for the retention, rescue and long term viability of the key elements of SAA Technical and Denel that:
   - Allows them to grow, earn export income and reinvest.
   - Retain niche manufacturing capabilities that enable other industry entities.
   - Allows them to partner with OEMs and Tier 1 suppliers to benefit the industry as a whole.
   - Alleviates procurement regulations that drive unsustainable input costs.
   - Provides a supply of key skills to the benefit of the industry at large.
3. Create an economic environment that stimulates business confidence.
4. Create a single aerospace fund:
   - One organisation who engages industry.
   - That can fund R&D, industrialisation, SMME "catapult" incubator etc.
   - Retains and maintains key infrastructure.
   - With in-house expertise and an industry advisory board.
   - The capacity (people and funding) and capability (knowledge and freedom to act) to implement a strategy to grow the industry as a whole.
5. Certification:
   - Review the SACAA:
     From every industry workshop it is apparent that the SACAA is not meeting industry expectations and needs. Ultimately the SACAA can be seen as a genuine brake on industry growth. Processes are bureaucratic; often run by personnel without the relevant authority stemming from inappropriate education or training. The result is unpredictable and delayed outcomes to certification audits. This is exacerbated by the mismatches between SACAA, EASA and FAA type classes and the lack of bilaterals with FAA and especially EASA to facilitate the export of type certified aircraft and major sub-systems.
   - Setup an SA/EASA Design Organisation

- Secure Bilateral agreements with EASA and FAA that includes type and non-type certified aircraft
- Investigate extending certification capability to address safety radars.

6. Provide promotion of the industry at the highest level (presidential project, embassy focus etc):
   - OEM and tier 1 deals in both the aerostructures and MRO domains).
   - Fund a bilateral growth agreement to attract OEMs to participate in the expansion of the local industry.
7. Provide seed funding for flagship programmes at a sufficient level that industry could potentially use this to leverage other funding sources and develop international collaborations.
8. Enable and insist on an aerospace industry association that:
   - Provides a single, unified opinion and approach to developing the industry.
   - Forces a collaborative approach with education, scientific and industry players to produce capability.
   - Provides guidance to government investment.
   - Whose opinion is sought and acted upon.
9. Review of the IPR Act:
   - Many perceive the IPR Act as inhibiting the ability of the industry to collaborate internationally especially as some of the key stakeholders in the industry remain parastatal.
   - In addition it was felt that the IPR Act inhibits access to commercialisable IP held within parastatal institutions that could unlock the growth potential of SMME's.

6.4 Key Initiatives to Address Transformation

Disclaimer: The views, opinions and conclusions expressed in this section do not necessarily represent those of the authors or the CSIR.

Transformation requires business growth by concentrating on building a strong economy, transformation will happen naturally. Stated another way, no growth equates to no uptake of highly skilled graduates and the industry cannot transform.

Negotiate flexible BBBEE terms for the industry to facilitate access to government funding which would in turn facilitate growth and transformation.

BBBEE should be focussed on outcomes to address industry gaps/needs not the replacement of existing entities, creating competition in an already stressed market. Too often funding is perceived not to go to projects of technical and transformative merit.

One effect of the bad publicity around the SOEs and the flag of exciting flagship projects is the inability of the industry to attract and retain new talent which hampers efforts to transform. It was felt that for transformation to take hold in the industry it was important that the negative public perceptions of the sector resulting from the challenges at SAA and Denel be addressed quickly and projects highlighted to make the youth see the attractiveness of the industry and to be 'Proud to be South African' once again.

6.4.1 SMME Development to Enable Transformation

Perceptions reported were that SMMEs require more than financial support, particularly in aerospace with stringent certification and quality requirements. Two suggestions in this regard were:

- An incubator programme.
- SMMEs should not be supported to directly supply into export markets but to supply local higher tier companies. The higher tier entity could be contractually obligated to support local SMMEs.
- Investment in education programmes that would enable the requisite skills to enable SMMEs.

One interviewee suggested that Small and medium enterprises could be created by:

- Unbundling vertically integrated industries (Denel) and using this as an opportunity for black empowerment companies as well as making the capabilities of the new entity available to a broader spectrum of the aerospace sector.
- Release nascent products from within the CSIR for commercialisation by black industrialists.

7 Conclusions

Internationally the aerospace industry is seen as a key element in the manufacturing sector of the economy. As a highly regulated sector with high technology requirements the sector is seen as an enabler for the balance of the manufacturing industry in the country, uplifting skills and capability that spills over into other sectors. The growth in commercial aviation has led to a consistent growth in demand for aircraft compounded by strong competition which has led to a demand for the most economically and environmentally efficient and therefore newest aircraft. The characteristics of the aerospace industry internationally include:

- High value-add sector,
- Strong demand for highly skilled highly paid work force,
- High levels of Foreign Direct Investment,
- Global footprint,
- Highly competitive,
- Highly protected,
- Strongly incentivised by governments,
- Highly regulated,
- High entry costs.

The defence sector is quite different to the commercial sector however, it is more layered, and as a result there can be fewer barriers to entry rather than more which is counterintuitive and in South Africa the infrastructure and funding in the defence domain has been in place and sustained over a long period which has resulted in a sizeable and capable defence sub-sector. In the defence sector the technology is highly controlled and processes to export such technology can be extremely bureaucratic and funding is based more on strategic imperatives than on economic ones.

There is not particular best practise that can be identified from literature for the support of an aerospace industry but instead there are a range of measures in common practise: These include:

- clusters with advantages such as common logistics pathways, air-side access, access to sponsored training schools and technical institutes as well as tax incentives,
- Tariff rebates and even protective tariffs on key input materials,
- Signing of international agreements to facilitate exports and certification,
- Assistance to foreign investors and start-ups to ease the bureaucratic burden of starting a company
- Financial assistance for R&D, Commercialisation and innovation – often with emphasis on SMME support,
- Active government support in attracting foreign direct investment in the sector,
- Funded flagship projects.

Locally the aerospace industry is a small but significant element of the South African manufacturing sector comprised of at least 104 companies of varying sizes across 6 technology streams, namely: Aerostructures, Propulsion, Avionics, Sensors and Surveillance, Maintenance, Repair and Overhaul (MRO) and Other Systems. In total the industry size was determined to be in the order of R9.5 Billion and employ nearly 10 000 individuals. This is just 0.5% of total production in the SA economy however. While its overall value may be small, its highly skilled workforce represents one of the highest earning segments earning nearly 6 times the average of the manufacturing sector in South Africa and generates a large export income value for the economy in comparison to its size, estimated to be >55% of direct turnover as compared to 34% of turnover for the automotive industry in 2017. In addition, it has a large tertiary or induced economic value to the economy. Furthermore, the skills generated within the industry are well known to be a critical supply of spill over skills to the rest of the industry.

Locally the industry is roughly 1/3rd MRO based with the aerostructures, avionics, sensors and surveillance and the other (military sub-systems) sectors being roughly equivalent to each other in terms of their turnover. The propulsion component of the industry is largely insignificant with only relatively small start-up companies currently in operation. Annual compensation to workers in the local aerospace sector is on average nearly 6 times that in the rest of the manufacturing sector. This is in part due to the international mobility of the sector's workforce but has clear advantages in terms of the induced benefits to the South African economy. Similarly the throughput is between 1.5 and 4 times that of the manufacturing sector average and shows the at-

tractiveness of the value addition this industry sector offers. The sensors and surveillance sub-sector represents the highest value add and MRO the lowest.

Although the international aerospace industry is quoted as having extremely advantageous economic multipliers and the evidence from the Rooivalk case study [3] clearly indicates a strongly advantageous result for government investment in aerospace projects in the long term; it may be overstating the value of the aerospace industry to the South African economy to apply these multipliers to the local industry. This is because the industry is clearly heavily dependent on imported raw materials and components and as such, the indirect industry is unlikely to reach the economic potential of that in competing overseas countries.

With respect to government incentives versus tax revenues from the sector the following can be concluded:

- There is little data available from government of industry with regard to what government support has been offered beyond the AISI.
- The benefit of many of the more prominent support mechanisms such as NIPP and DIP are difficult to quantify, it is simplistic to say that the procurement of the defence packages benefited the industry at no additional cost to the DoD for example.
- Data regarding employee costs suggest that the annual tax revenues from employees in the sector alone reaches ±R570 Million which far exceeds the AISI budget of approximately R20 Million annually (a budget that includes the space sector) and anything reported by the industry over the five years of requested input to the questionnaires.

Furthermore, comparing the typical levels of support internationally, South Africa is estimated to lag behind the levels found in the UK, as an example, by a factor of ten if one scales their investment based on either employee numbers or turnover.

Looking at the structural duality within the industry in South Africa between the commercial and defence components of the industry it is clear that there are different requirements for the development of commercial aerospace manufacturing versus the defence component and that this are driven by differences in the certification and capital investment requirements.

The outcome of the industry workshops and engagements in terms of required government interventions confirms this duality but can be summarised as follows:

- Financial
    - For DoD technology projects and seed funding for flagship projects,
    - The creation of a single aerospace fund in a similar fashion to dedicated automotive sector funds,
    - Implement strategies for the retention, rescue and long term viability of the key elements of SAA Technical and Denel,
    - Capital investment to support the commercial aerospace manufacturing sector and existing initiatives such as the CAV.
- Non-financial
    - Certification support, facilitation and implementation of BASA agreements
    - Active government support for the sector and support for industry associations
    - Unlocking of state owned IP for exploitation by SMMEs and others.

It is clear from both the literature and the industry engagements that the aerospace industry is not independent of government support and that no clear strategy consisting of easily identifiable projects exists within industry to achieve a goal of doubling the sector.

Transformation in the aerospace sector remains a challenge, especially as the sector is in decline. Industry has suggested increased support for SMME entrants as a solution, but outside of industry forma this solutions is not seen as bold enough.

The aerospace industry internationally is highly competitive and sought after in many developing economies for its tertiary and skills benefits, and as a result, it is both highly protected and supported by governments. In SA many government incentives exist to support industry but few have been successfully deployed to the support of the aerospace industry with the notable exceptions of the underfunded AISI, and the NIP/DIP obligations on large government capital expenditures. The latter is, however, not sustainable without new capital expenditures.

It is clear therefore that government should act decisively to support the industry based on a clear strategic intent and sustain this support over the long term should it wish to protect this small but high throughput, highly-skilled sector of the manufacturing economy. Furthermore, different mechanisms are required to support the different sub-sectors of the aerospace industry according to their needs and characteristics.

The terms of reference of this study, which refers to a doubling of the industry and more specifically to a doubling of the commercial aerospace industry are unambitious, as this would have little or no effect on the economy of South Africa as a whole at a macroeconomic level. Doubling an industry that is only 0.5% of production would at best yield one that is 1% of total production. Interventions to expand the industry tenfold would begin to place the industry in the spotlight by raising its impact into whole number percentages of the economy. An intervention at this level is however not an insignificant undertaking and without risk.

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Appendix A: Existing National Support, Funding and Incentive Schemes

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
Standards and accreditation	the **dti**	AISI	SMMEs only	4-9	Funding covers external auditor's costs	Assist industry to obtain certification to standards necessary to participate in the international aerospace supply chain	AS9100 and ISO9001 at a variety of companies	https://aisi.csir.co.za
Industry Development and Supplier Development			1-4		<R750k/project	Bottom-up projects for product and process development and improvement	Cape Aerospace Technologies amongst others	
					<R1.5M/project	Projects emanating from a comprehensive firm level roadmapping exercise aimed at developing a long term strategy for interventions with companies identified through EoI	Trax, Lantern, Jonker Sailplanes, Aerosud and others	
Process Optimisation			SMMEs only	Not applicable	Funding covers external service provider's costs	Assisting SMMEs with process improvement interventions such as lean manufacturing, theory of constraints and production planning and control	Process interventions at a variety of SMMEs including Daliff Precision Engineering, Micromax and Cliffsway	
Firm/foundry level		NFTN	Foundries only	Not applicable	R500-750k	The scope of the NFTN is guided by the requirements of, and relevant to, the local cast metals industry. The key areas identified for support include: • Competitive Improvement: such as reduction of scrap, energy efficiency, improved man-hours per ton, quality improvement and increased productivity initiatives. • Human Capital Development: such as skills training to employees, in-house training, artisan training and placement of interns. • Cleaner Production: assistance with environmental requirements in terms of foundry spent sand and air emissions, assistance on improving housekeeping and energy efficiency support.	None	https://nftn.csir.co.za/
Cluster/supply-chain level								

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
Industry level						• Expansion of Foundry Industry: this is to assist the foundry industry to attract inward investment and yield a reasonable return on investments as well as responding to identified local and international markets. • Science, TT and innovation: assisting foundries to upgrade and modernise through relevant science, technology and innovation. • Cooperation for industry competitiveness: facilitating cooperation between public and private stakeholders to address system level issues in order to improve the overall performance of the foundry industry		
NIPP		the **dti**	Yes	Not applied	Negotiable	Local content promotion on government procurements of a value greater than USD10M.	Airbus A400M with Denel, Thales SMME development, Aerosud and Denel capacity development through countertrade with Boeing	0861 843 384
NCPC		CSIR	Any	Not applied	Paid to consultants	Cleaner production and resource efficiency	Not known	http://ncpc.co.za/
EIP (Enterprise Investment Programme)		the **dti**	Yes	Not applied	Grant of between 15-30% of qualifying investment cost. Upto R30M grants.	The EIP makes targeted grants to stimulate and promote investment, BEE and employment creation in the manufacturing and tourism sectors.	Not Known	http://www.thedti.gov.za/financial_assistance/financial_assista...
CIP			1-4	Not applicable	The grant covers between 10 - 30% of infrastructure development costs. It is tax-free	CIP supports the construction of infrastructure that enables the establishment or continuing operation of industrial projects. Its key objectives are to improve competitiveness by lowering costs and risks, leverage strategic investments and stimulate linkages	Aerospace infrastructure recently added	

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CPFP			Yes	Not applied	A grant of between R100 000 and R5 Million.	The CPFP makes targeted grants that contribute to the cost of feasibility studies into projects outside South Africa that are likely to increase local exports for South African capital goods and services.	Not known	
EMIA			None	Not applied	*Individual Exhibition Participation* Assistance with costs of participation, including travel, accommodation and exhibition fees. *Primary Market Research & Foreign Direct Investment* Assistance with costs, including travel, subsistence and marketing material. *Individual Inward Missions* Assistance with costs, including foreign registration of patent, travel, subsistence and rental of exhibition space	EMIA scheme develops export markets for South African products and services and to recruit new foreign direct investment into the country.	Not known	
12I Tax Allowance Incentive			Limited requirements for procurement spend (10%)	Not applicable	*Greenfields:* New manufacturing projects. Minimum investment R200M, Additional depreciation allowance of up to 55%. Additional training allowance. Maximum investment deduction R900M. Maximum training deduction R30M. *Brownfields* Manufacturing expansions & upgrades. Minimum investment R30M. Additional depreciation allowance of up to 55%. Additional training allowance. Maximum investment deduction R550m. Maximum training deduction R30m.	S12I is intended to support Greenfield investments (new industrial projects that utilise only new and unused manufacturing assets and Brownfield investments (expansions or upgrades). The incentive supports both capital investment and training.	Not known	
MIP		Suspended						

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
FIG			None	Not applied	A cash grant, calculated as the lesser of: 15% of the value of new machinery and equipment; or The actual relocation cost of new machinery and equipment; to a maximum of R10 m	FIG compensates qualifying foreign investors for costs incurred in moving qualifying new machinery and equipment (excluding vehicles) from abroad to South Africa Foreign investors that have been approved for the Manufacturing Investment Programme (MIP).	Not known	www.thedti.gov.za/financial_assistance/financial_assistance.jsp
SEZs or IDZs			None	Not applicable	VAT exemptions under special conditions for supplies procured in SA. Duty suspensions on imports of certain production-related supplies, including assets used in export-focused production. Dedicated SARS officials to provide customs and VAT support. World-class industrial infrastructure linked to an international port of entry	To provide industrial infrastructure linked to international sea- or airports for fixed direct investment into value-added and export-oriented manufacturing industries. Ministerial permit required.	None.	
SPII		the **dti**	Limits grant proportion	2-8	Product Process Development Scheme Maximum of R2m grant Matching Scheme Maximum of R5m grant.	SPII This incentive was designed to provide financial assistance for the development of commercially viable, innovative products and or processes and facilitate commercialization of such technologies.	Jonker Sailplanes JS2	luckyt@idc.co.za
			None	2-8	A minimum grant of R10m. If the project is successful, the grant is repayable under pre-negotiated conditions.	Partnership in Industrial Innovation (PII) This incentive was designed to provide financial assistance for the development of commercially viable, innovative products and /or processes and facilitate commercialization of such technologies PII is suitable for large R&D projects	Not known	

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
SEDA Technology Programme (STP)		SEDA	Not known	Not applied	50% grant for the cost of approved tools, machinery and equipment to a maximum of R800,000; and 80% grant for approved training and business development services to a maximum of R200 000.	The STP is part of an over-arching strategy to consolidate small business support activities, formerly spread across 6 projects: the Godisa Trust, the National Technology Transfer Centre, the 3 business incubators of the dti, the Technology Advisory Centre, the technology-transfer activities of the Technology for Women in Business (TWIB) programme and the support programmes for small enterprises of the South African Quality Institute.	None known	rmoodley@seda.org.za
SSAS		the **dti**	Additional funding for specified activities	Not applicable	Generic Funding - R50 000 grant for establishing export council. Grant for marketing, advertising and publicity costs on a 2:1 basis, to a maximum of R1m. Project Funding – 80:20 cost-sharing grant for projects to develop particular sectors, find new export markets and promote black SMMEs, women, youth and people with disabilities. Project Funding for Emerging Exporters – Travel & accommodation, exhibition costs, transport of samples and marketing materials, to a maximum of R1.5 Million.	This is an export-focused incentive that encourages industrial sectors prioritised by the **dti** to pursue export markets Beneficiaries: Non-profit business sector organisations, such as Export Councils, Joint Action Groups and industry associations.	Not known	http://www.thedti.gov.za/financial_assistance/financial_assistance.jsp
WCP		Productivity SA	Additional Benefits	Not applied	Black owned SMEs smaller than 50 employees – 90% subsidy. The enterprise pays 10% to Productivity SA, based on the number of coaching / support days needed Small enterprises between 15 to 100 employees – 78 to 76% subsidy. The enterprise pays 22 – 24%. Medium enterprises between 101 to 400 employees – 67 to 64% subsidy. The enterprise pays 36 to 33%. Large enterprise between 401 to 700 employees – 53 to 49% subsidy. The enterprise pays 47 to 51%.	The WCP is a focused supply side intervention of the **dti**, managed by Productivity South Africa, aiming to actively encourage and support negotiated workplace change towards enhancing productivity and world-class competitiveness, best operating practices, continuous improvement, lean manufacturing, while resulting in job creation. The WCP assists South African manufacturing, agriculture and agro processing, mining and beneficiation busi-	Not known	

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
					Corporate enterprises between 701 to larger than 900 – 40 – less than 38% subsidy. The enterprise will pay more than 60%, based on a customised quote.	nesses. WCP is operated in the context of enterprises participating in regional clusters that are made up of five to seven companies in the industrial areas of all of the provinces. The clusters are facilitated over a period of 24 months by Productivity SA coaches called Change Facilitators. The WCP is a joint initiative of the National Economic Development Labour Council (Nedlac) and the Department of Trade and Industry (the **dt**i)		
CDP		Suspended						
THRIP		the **dti**	Affects grant percentage	2-4	50:50 cost-sharing grant, to a maximum of R8m per annum, across any number of projects	THRIP aims to boost SA industry by supporting research and technology development, and enhancing the numbers of appropriately-skilled people. THRIP brings together the best of SA's researchers, academics and industry players. Beneficiaries: All companies undertaking science, engineering and technology (SET) research, in collaboration with educational institutions, and with the aim of addressing the participating firms' technology needs.	Jonker Sailplanes and Denel Aviation amongst others	http://www.thedti.gov.za/financial_assistance/financial_assistance.jsp
R&D Tax Incentives	DST	DST/SARS	None	Not applied	Operating Expenditure Up to 150% of qualifying expenditure incurred. Depreciation Allowance Accelerated depreciation: 50/30/20 basis.	This incentive was designed to encourage private-sector investment in scientific and technological R&D activities. It was introduced to help the country achieve a target for R&D expenditure of 1% of GDP.	Aerosud	www.dst.gov.za/index.php/services/the-rad-

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
TLIU		CSIR	Not specified	Not applied	Firm Level TAPs TLIU develops TAPs at a firm intervention level, which are used to provide interventions to migrate the supplier to higher level of capability and capacity. Sector Wide TAPs (SWTAP) A SWTAP aims to create an environment where specialised services or common technologies are available to companies in that sector. A SWTAP could lead to the development of a new enterprise or act as a shared facility that can then be utilised by industry stakeholders to complement their normal operations. *Casting Simulation Network: How to use this facility* Foundries should contact the relevant Casting Simulation Network (CSN) contacts. The intern will then set up a meeting with the foundry to discuss the simulation procedure and to sign the necessary documents. *Supplier Development* The concept of holistic supplier development is a critical area. The TLIU will create strategic partnerships to deliver supplier development interventions that would fall outside the borders of technology interventions. The benchmarking function of the TLIU is a programme that will fulfil supplier development needs to all companies on the TAP programme. The aim of supplier development is to introduce the concept of continuous improvement into the business environment. When the benchmarking exercise is completed for a company, several areas are identified, which require improvement in order to enhance the competence and competitiveness of	Localisation of government procurement spend through support to local companies with import substitution opportunities	Cybicom Atlas Defence and Fabrinox are benefiaries.	https://www.tliu.co.za/welcome

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
					the business. Not all of these areas will relate to technology interventions. To realise the full effect of technology interventions, there is a need to improve the effectiveness of all related areas. The supplier development plan addresses areas that require interventions to develop the process and performance of the business. Tools include: • lean manufacturing • process modelling and optimisation • six sigma • quality systems • theory of constraints • production systems *SET Internship Programme* The key objective of the TLIU SET Internship programme is to increase the graduation rate of science and engineering students through the provision of structured practical work exposure and training (in fulfilment of P1/P2 University requirement), either at affiliated institutions linked to industry or directly in industry itself. Students from science, engineering and technology (SET) related fields of study may be considered for participation in the TLIU SET Internship programme. These include: • Mechanical Engineering • Electronics Engineering • Electrical Engineering • Industrial Engineering • Civil Engineering • Metallurgy Engineering TLIU programme is a national programme and therefore students would need to be placed in at least four provinces: Western Cape, Gauteng, Eastern Cape and KwaZulu-Natal. *Technology Development Grants (TDG)*			

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
					The aim of the TDG is to develop local intellectual property in support of the government and SOE's localisation strategies. The process to be followed in identifying possible technologies is as follows			
Seed Fund Programme			Minimum of 20% equity ownership by a SA entity and B-BBEE requirements	3-7	Max R650000	To assist HEIs, SCs and SMMEs to advance their research outputs and ideas to develop prototypes, proof of concept and business cases that could be used for further development To de-risk research outputs by enabling the entrepreneur, researcher and SMME to inform their opportunities that will bring them closer to securing follow on funding from TIA and/ or other funders Funding Mandate fit with the relevant Seed Fund sub-programme	None known	
Youth Technology Innovation			Individuals	Not applied	<R1M	YTIP was created in order to accommodate young innovators who may not necessarily be directly linked to any SCs, HEIs and SMMEs. This programme is designed to assist young innovators to access risk funding, mentorship and business skills support. YTIP seeks to play the connector role in supporting the development of new technologies by the youth, which can be taken to the market to solve various social and technological challenges. In addition, it contributes to delivering on a pipeline of innovative technologies for various TIA programmes. YTIP is targeted at youth between the ages of 18 and 30, who are currently not funded by any of the other TIA funding instruments.	None Known	
Innovation Skills Development		TIA	Targets PDI	Not applicable	Training costs at colleges and universities	The programme aims to stimulate a culture of innovation thinking within the national system of innovation, thus increasing the rate of translation of innovative ideas into novel technologies, products and services. The Programme provides focused and targeted training interven-	None known	https://www.tia.org.za

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
						tions to strengthen entrepreneurial capacity of researchers and innovators towards the commercialisation of their research outputs.		
Technology Stations			None	Not applicable	Access to advanced manufacturing technologies	The Programme provides access to world-class infrastructure and expertise that would otherwise not be available to stakeholders in the NSI, to enable them to engage in technology innovation. They are established in partnership with higher education institutions with TIA funds. The ultimate beneficiaries are the clients who receive services from the Technology Stations to develop products, processes and services. It enables universities to provide technology services to SMMEs. TIA provides financial support to Technology Stations to provide innovative Science Engineering and Technology solutions for complex engineering challenges within the relevant industrial sectors. • Technology Station in Electronics (TSE) - Tshwane University of Technology • Metal Casting Technology Station (MCTS) - University of Johannesburg • Technology Station for Materials & Processing Technology (TSPMT) - Vaal University of Technology • Product Development Technology Station (PDTS) - Central University of Technology • eNTSA- Nelson Mandela Metropolitan University • Reinforced and Moulded Plastics Technology Station (RMPTS) - Durban University of Technology • Institutes of Advanced Tooling (IAT's) • Institute for Advanced Tooling - Tshwane University of Technology (IAT-TUT) • Institute for Advanced Tooling - Walter Sisulu University (IAT-WSU) • Institute for Advanced Tooling - Stellenbosch	See Intention	

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						University (IAT-SU) • Adaptronics Advanced Manufacturing Technology Laboratory (AMTL) - Cape Peninsula University of Technology • Process Energy and Environmental Technology Station (PEET) - University of Johannesburg		
Technology Platforms			None	Not applied	Infrastructure and expertise access	The TPP has been designed by TIA to fund and support the establishment and operations of technology platforms that facilitate access to key infrastructure and expertise for technology innovation in targeted technology areas. Their outputs are the provision of scientific and technical services not traditionally provided by universities to the NSI and that lower the barriers for platform users to engage in technology innovation. The technology platforms must support users to develop technologies with market interest and build relevant technical competencies that will be required either now or envisaged in the future. Technology Platforms are established in partnership with competent and eligible entities such as HEIs and SCs using TIA funds. The funding provided by TIA to the Technology Platforms is in the form of grants directed at supporting operational costs, infrastructure and projects	None applicable to Aerospace	
TICPS			Not known	Commercialisation of innovations	Not specified	The unit aims to fund technology development by facilitating an enabling environment for the advancement of technology innovation and commercialisation by adopting a value chain approach and catalysing collaborations amongst value chain players, such as public research institutions, entrepreneurs, companies, suppliers and manufacturers, both competing and co-operating in a particular industry. By facilitating greater collaboration within the existing ecosystem the industry benefits by leveraging the strengths of the respective partnering groups.		

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						Technology Innovation Cluster Programme (TICPS) address national priorities or areas of strategic social and economic importance through the utilization of technology innovation. Offerings: Funds technology development in a programmatic framework to improve the competitiveness of local technology-based industries Identifies and supports key interventions within the value chain and ecosystem to accelerate commercialization of technologies and facilitate transfer to industry Facilitates the creation and expansion of local manufacturing/production capacity Enhances the collaboration and networking among private sector industry, SMMEs and academia to leverage local excellence and expertise Enables the provision of incubation services in order to encourage and stimulate interest to commercialize developed intellectual property Leverage funds including international funding sources.		
Global Cleantech Innovation Programme			SMMEs	Innovation	Training, Mentoring, Exposure to Venture Capital, Showcasing and cash awards	The GCIP-SA is part of a global initiative aimed at promoting clean technology innovation and supporting entrepreneurs in growing their SMMEs and start-ups into viable, investment-ready businesses. In South Africa, the programme was incorporated into the Technology Innovation Agency (TIA) on 1 January 2018, after four years as a donor-funded project. Founding partners were the United Nations Industrial Development Organization (UNIDO – Project Developer and International Implementer), the Global Environment Facility (GEF – Funder) and TIA (National Implementer and Country Host). The main knowledge partner of the global programme is the USA-based Cleantech Open.		

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
						The key objective of the Global Cleantech Innovation Programme in South Africa (GCIP-SA) is to promote clean technology innovations and entrepreneurship in SMEs and start-ups in the country. The main indicators for success will be the increasing number of SMEs that pursue innovations in clean technologies; additional investment in clean technology innovations due to increased interest in the programme; the number of SMEs that participate as members of the national platform; and finally, the negative environmental impacts directly and indirectly avoided through the application of the supported Cleantech innovations. The GCIP-SA is an annual competition-based business accelerator offering participants extensive training and mentoring to help them get their products investment-ready, and connect them to networks of local and international peers as well as potential partners and funders. The programme primarily aims to promote a cleantech innovation ecosystem in South Africa by: • assisting in the identification and early stage nurturing of the most promising innovative local clean technologies; • coordinating and collaborating with various existing and planned national programmes, funds, competitions etc. relating to the promotion and development of clean technologies, and providing pre-selected candidates and applicants for them and seeking similar benefits from them; • facilitating the local and global linkage and networking of the most promising start-ups of South Africa with mentors and potential business partners. The GCIP continuously enables and stimulates a culture of innovation amongst serious “green technology innovators” and it has been evident during its existence, that it positively contributes to the promotion and strengthening		

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						of a vibrant National System of Innovation (NSI). The programme also contributes to TIA's initiatives in the Bio-economy by accelerating companies in the waste and water economies, whilst also training teams over a four-month period in Business Model Development and Validation. The programme actively looks to support its alumni towards commercialisation and also contributes to TIA's IES Enterprise Development Support efforts.		
DST NRF Internships		NRF	PDI Preference	Research	Monthly salary ranging between R6070.00 and R8050.00 per month	Science, Engineering and Technology (SET) graduates and postgraduates (including those in Social Sciences and Humanities) are offered an opportunity to acquire practical work experience through mentoring and an exposure to a research environment. This opportunity is also offered to those unemployed graduates and postgraduates who are interested in research management; research support and administration through placement at research offices in public higher education institutions and research agencies. Candidates with disabilities are especially encouraged to apply. Applications are invited from candidates who are interested in acquiring work experience in specific areas of specialisation or disciplines	The CSIR has hosted such interns	
Freestanding, Innovation and Scarce Skills Masters and Doctoral Bursaries				Not applied	Free-Standing Masters and PhD Scholarships (For RSA citizens, permanent residents and non-RSA citizens) Value of award: R50 000.00 and R70 000.00 Innovation Masters and PhD Scholarships (For RSA citizens, permanent residents and non-RSA citizens) Value of award: R90 000.00 and R120 000.00 Scarce Skills Masters and PhD Scholarships (For RSA citizens and permanent residents ONLY) Value of award: as above	Masters and Doctoral scholarships are awarded through a competitive process following a merit review process. However, NRF Freestanding Masters bursaries are released as block grants to South African public Universities. These Scholarships are awarded to South African citizens, South African permanent residents as well as to a limited percentage of non-South African citizens registered at a South African public university for full-time studies. In addition, the NRF makes funds available to support a small number of scholarships for full-time Doctoral studies abroad, with the objective of increasing the	Not known	www.nrf.ac.za

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						number and quality of Doctoral graduates in South Africa.		
A variety of research infrastructure and researcher assistance funds					Various	Various	Not known	
SA Research Chair Initiative			None	Research	±R2M+ 30% of running costs and 10% for University overheads	The South African Research Chairs Initiative (SARChI) was established in 2006 by the DST and the National Research Foundation (NRF). It is designed to attract and retain excellence in research and innovation at South African public universities through the establishment of Research Chairs at public universities in South Africa with a long-term investment trajectory of up to fifteen years. The main goal of the Research Chairs initiative is to strengthen and improve research and innovation capacity of public universities for producing high quality post-graduate students and research and innovation outputs. The key objectives of SARChI are to: Expand the scientific research and innovation capacity of South Africa; Improve South Africa's international research and innovation competitiveness while responding to social and economic challenges of the country; Attract and retain excellent researchers and scientists; Increase the production of masters and doctoral graduates; and Create research career pathways for young and mid-career researchers, with a strong research, innovation	Industrial CFD Chair at UCT (Professor Arnaud Malan)	

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
						and human capital development output trajectory. The instrument is designed to bring new research leadership capacity into public universities, while at the same time retaining those that are already at the universities. To this effect a 60/40 target for external vs internal candidates was set to encourage recruitment from outside South African universities, i.e., from industry and abroad, including African scholars and South Africans in the diaspora. Research Chairs are established at the Tier 1 or Tier 2 level based on the candidate's research track record and standing and postgraduate student and postdoctoral fellow training track record. Tier 1 Chairs are for established researchers that are recognised internationally as a leader in their field and/or have received international recognition for their research contributions. Tier 2 Chairs are for established researchers, with a potential to achieve international recognition for their research contributions in the next five to ten years. Candidates from abroad that are willing to spend at least 50% of their time at a South African host university are eligible for consideration at the Tier 1 level. However, international candidates appointed at the Tier 2 level are required to reside full-time in South Africa for the duration of the Research Chair award. Research Chairs are held by a university in partnership with a public research institution such as: another university, a science council, a national research facility or an academic health complex. Since inception, 150 Research Chairs were awarded to 21 public universities across the country in open and directed categories; priority research areas; science and technology for poverty alleviation; innovation, engineering and technology development; and within the national science and technology missions.		

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Country to country travel, collaboration and exchange programmes			Preference PDI	Not applicable	Various	Dependant of country to country agreements	Not known	
PPPFA	National Treasury	N/A	1-2	Any	Dependant on contract value	Requires government departments to force companies receiving orders of greater than R30M from the state to involve Black owned SMMEs to 30% of the budget where possible	None known	www.treasury.gov.za/divisions/ocpo/sc/PPPFA/default.aspx
DIP	DoD	Armscor	25% of all obligations through at least 25% Black equity ownership	Any	Negotiated with international supplier	Local content from large military and SAPS acquisitions	R5793M benefit to date	www.armscor.co.za
MCEP	**the dti**	IDC	None Stated	Not applicable	*Capital investment* This incentive provides support to manufacturers that invest capital to upgrade equipment and undertake expansions, with the aim of assisting in job retention and creation. It offers a cost-sharing grant of between 30 percent and 50 percent of the investment, up to a maximum of R50m. *Green technology and resource efficiency improvement* This incentive provides support to manufacturers investing in	MCEP is a support scheme which offers manufacturing companies incentives to raise their competitiveness and retain jobs. It offers two facilities: a production incentive and an industrial financing loan facility.	None. Applications currently suspended due to high volumes of applications.	http://www.investmentincentives.co.za/mcep

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
					green technology upgrades that will lead to cleaner production. It offers a cost-sharing grant of between 30 percent and 50 percent of the investment, up to a maximum of R50m. *Enterprise-level competitiveness improvement* This production incentive helps companies invest in improved conformity assessments, create better processes and products, and develop relevant skills through the use of business development services. The incentive offers a cost-sharing grant of between 50 percent and 70 percent of the investment, limited to the total amount of the applicant's manufacturing value-add. *Feasibility studies* This production incentive supports feasibility studies that are likely to lead to bankable business and project plans. These projects should result in investment in new components, products or processes that are not currently manufactured or performed by the applicant. The proposed investment project that results from a feasibility study should have a minimum value of R30m. This incentive offers a cost-sharing grant of 50 percent or 70 percent of the cost of the feasibility study, payable according to expected milestones. *Cluster competitiveness improvement* This production incentive provides financial assistance to clusters of enterprises that want to undertake collaborative efforts related to production and marketing. The incentive offers a cost-sharing grant of 80 percent of the costs of the cluster activities, paid on completion of the business-development activities or milestones, to a maximum of R50m. The grant is provided directly to approved applicants based on costs incurred and subject to job retention. To be eligible for the grant, the cluster should have five or more members who are registered tax-paying entities or			

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					non-profit organisations. Clusters may include entities in services sectors related to manufacturing, as well as organisations that provide business development support services to enterprises in the manufacturing sector. *Pre- and post-dispatch working capital facility* Finance is offered to manufacturers at a preferential interest rate, with the aim of improving the competitiveness of an entity by lowering the cost of finance. Pre-dispatch finance covers working capital requirements from receipt of an order to dispatch to customers. It can include production, raw material, and packaging and transportation costs. The post-dispatch finance covers working capital requirements from the date of dispatch of the goods to the date the seller realises the proceeds of the sale. It can include performance bonds and performance guarantees. The programme offers a working capital facility of up to R50m at a fixed interest rate of 4 percent. Applicants who need more than this amount may qualify for IDC financing, based on the corporation's normal risk assessment policies. The finance is available for a term of up to four years and may be revolving. The applicant must be in possession of a confirmed contract or purchasing order. *Industrial policy niche projects fund* Projects that focus on new areas with the potential for job creation, as identified by the **dti** and the IDC, may be eligible for an MCEP grant structured as part of the borrower's equity contribution			
TVC			SMMEs with preference to BBBEE	Not applied	Equity, quasi equity and loans R1-5M	TVC is a fund established by the **dti** and managed by IDC which provides business support and seed capital for the commercialisation of innovative products, processes and technologies. TVC aims to increase the	Not known	craigs@idc.co.za

Fund	Government Department	Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
						number of economically-productive companies in SA, and thus contribute to economic growth and international competitiveness through innovation and technological advancement.		
UIF II			Not specified	Not applied	Upto R150M	To contribute towards sustainable job creation and retention by supporting job creating transactions while providing concessionary funding.	Not known	www.idc.co.za/home/idc-products/special-schemes/uif-ii.html
Youth Pipeline Development Fund			Youth owned businesses	Not applied	Loans and Grants (50:50) max R1.5M	To improve the readiness of potential applicants and thereby increase their probability for IDC consideration.	Not known	www.idc.co.za/home/idc-products/special-schemes/youth-pipeline-development-

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EIB SME and MIDCAPS			SME, MIDCAPS	Not applied	Loans or R1 to 120M	To assist SMEs and MIDCAP companies to access loan financing for CAPEX, medium and long term working capital.	Not known	www.idc.co.za/home/idc-products/special-schemes/smes-and-midcap-companies.html
BBSDP	Small Business Development		Majority black-owned enterprises or those with a predominantly black management team.	Not applied	50% grant for the cost of approved tools, machinery and equipment to a maximum of R800,000; and 80% grant for approved training and business development services to a maximum of R200 000	BBSDP provides grants to small black-owned enterprises. It aims to improve sustainability and competitiveness of majority black-owned enterprises and thereby integrate them into the mainstream economy. Enterprises with a turnover of at least R1 Million and not more than R35 Million; and The enterprise must have been operating and trading for at least one financial year	Not known	www.dst.gov.za/index.php/services/the-rad-tax-incentives-programme

Fund	Government Department Agency	B-BBEE Level supported	TRL Level Supported	Funding available	Intention	Examples of projects supported in Aerospace	Contact
CIS		Registered co-operatives of 5 or more Historically Disadvantages Individuals. The incentive has a bias towards rural and semi-urban co-operatives, and those including women, youth and people with disabilities.	Not applied	A 90:10 cost-sharing grant towards the costs of acquiring competitive business development services, to a maximum of R350 000.	This incentive promotes the formation of co-operatives that support broad-based black economic empowerment and improves their viability and competitiveness.	Not known	www.dst.gov.za/index.php/services/the-rad-tax-incentives-programme

Table 17: Mapping of Incentives to JASC framework

Category	R&D	Product Development	Production	Innovation	Competitiveness/ Market upscaling	Incubators	Clustering
Skills	SARChi THRIP NRF Interns	THRIP TLIU TSP		TIA Innovation Skills Development	THRIP		
R&D	NRF Freestanding Innovation and Scarce Skills	THRIP TDF SPII	THRIP	NRF Freestanding Innovation and Scarce Skills	TLIU THRIP		
Infrastructure		MCEP THRIP SPII TSP	CIP MCEP 12I (Tax Allowance Incentive) FIG SEDA STP		TLIU THRIP MCEP		
Target groups (Youth, Women, Disabled)	YTIP	YTIP SPII	IDC Youth Pipeline Development Fund		WCP	TIA Youth Fund	
Entrepreneurs		TSP SPII THRIP TLIU YTIP TVC TIA Seed Fund	TSP	TVC	TSP EMIA		
SMMEs		AISI TSP, THRIP SPII TVC	AISI NIPP DIP NCPC EIP SPII EIB, SME & MIDCAPS BBSDP	TVC AISI	AISI EMIA SSAS TLIU TCIPS CIS		CAV TCIPS
Medium-large firms	R&D Tax Incentives	AISI SPII THRIP	AISI MCEP NIPP DIP NCPC EIP EIB, SME & MIDCAPS	AISI GCIP SA	AISI CPFP EMIA TCIPS UIF II		Gauteng and Dube Tradeport SEZs CAV TCIPS
Aerospace Sector Focussed		AISI	AISI		NFTN		CAV

Appendix B: Industry Questionnaires

Tier 0-1 Tailored Questionnaire

The AISI is an initiative of the Department of Trade and Industry, managed and hosted by the CSIR. The AISI is currently updating its supplier database for aerospace organisations and would appreciate your assistance with the following information about your organisation.

ORGANISATION NAME	TOTAL REVENUE IN AEROSPACE	NO. OF EMPLOYEES	% BUSINESS CLASSIFIED AS AEROSPACE
Location:			
City: Municipality:			
List reasons why are you based in your current location:			
1. 2.			
Supply Chain Classification ***Please classify your organisation according to the OEM or Tier levels shown in figure 1*	**Certification** ***Please list all the certifications within your organisation (e.g. ISO 9001)*	**Product Market** ***Please select the product market which applies to your organisation from Figure 1*	**Technology Stream** ***Please select the technology stream which applies to your organisation from Figure 1*

How many people does your organization currently employ per functional category (Total/Aerospace)?									
Management	B	C	A	W	Technicians (Technical University Degree/diploma)	B	C	A	W
Support functions	B	C	A	W	Artisans	B	C	A	W
Engineers (University degreed)	B	C	A	W	Operators	B	C	A	W
Scientists	B	C	A	W	Students	B	C	A	W
Other, please specify	B		C		A		W		

Client Sector ***Total % of business to the following sectors*	**% Business (Total/Aerospace)?**	
	Name	%
SOCs		
Private SA	1. 2. 3.	1. 2. 3.
International	1. 2. 3.	1. 2. 3.
	SIC Codes used during export:	

ECONOMIC DATA:

Please provide the following information for the past 5 years:

Category	**2013/14**				**2014/15**				**2015/16**				**2016/17**				**2017/18**			
Total Revenue(R)																				
Total Government Support (included in above) (R)																				
Total Expenses (R)																				
Total Re-investment (R)																				
Total VAT paid (R)																				
Total Companies Tax paid (R)																				
Total PAYE/SITE Tax paid on behalf of employees (R)																				
Total Customs Duties Paid (R)																				
Total Municipal Rates and Taxes Paid (R)																				
No. of employees	B	C	A	W	B	C	A	W	B	C	A	W	B	C	A	W	B	C	A	W
No. of ship sets/products completed																				
%Black Ownership																				

Input Costs (Current): ***Total % spent annually on the following inputs*	**% Expenditure**
Labour	
Transport of Goods	
Local Sources	
International Sources	

Suppliers	
What is your biggest single input cost (excluding labour)?	
List your 5 top suppliers (based on value, strategic or part count):	Name Location 1. 2. 3. 4. 5.

Support Mechanisms:

Central and Local Government support received
List any government funds applied to and type/Rand value of support received 1. 2. 3. 4.

What government regulations impact your business?	
Regulation	Positive/Negative effect
1. Nature of the impact:	
2. Nature of the impact:	
3. Nature of the impact:	
4. Nature of the impact:	

Incentives
What non-financial incentives can local or central government implement to help you grow your business?
What financial incentives can local or central government implement to help you grow your business?

Would you be interested in being part of a cluster, public/private partnership or SPV?
Yes/No Conditions:

Business challenges:

Who are your major competitors?		
	Name	**Location**
1.		
2.		
3.		
4.		
5.		

Business Threat Evaluation Evaluate the relative importance of the following business threats: (1-5, where 1 is the greatest threat)	
New Entries New businesses can easily be started that threaten your business	
Buyer Power Few large buyers that control the market	
Substitution Alternative products or services that can negate your market offering	
Supplier Power Few suppliers of input resources that influence costs	
Competitive Rivalry Do you compete with many competitors?	

Growth drivers:
1. What are the 3 most important issues that need to be addressed in order to grow the industry further? 1. 2. 3.
2. What are the drivers for growth in your industry?
3. What are the most important skills needed to grow the industry?
4. What are the potential barriers to industry growth?
5. How can the industry supply chain/value chain be enhanced?

Technology challenges:

List your top five key capabilities/technologies used	
1	
2.	
3.	
4.	
5.	
List your top five technical or organisational challenges with which you can see AISI interventions assisting your grow your business	
1	
2.	
3.	
4.	
5.	

General:

What other companies in your area do you feel should be part of this survey:	
1	
2.	
3.	
4.	
5.	
What future trends and opportunities do you see for the industry in your local area and in South Africa?	

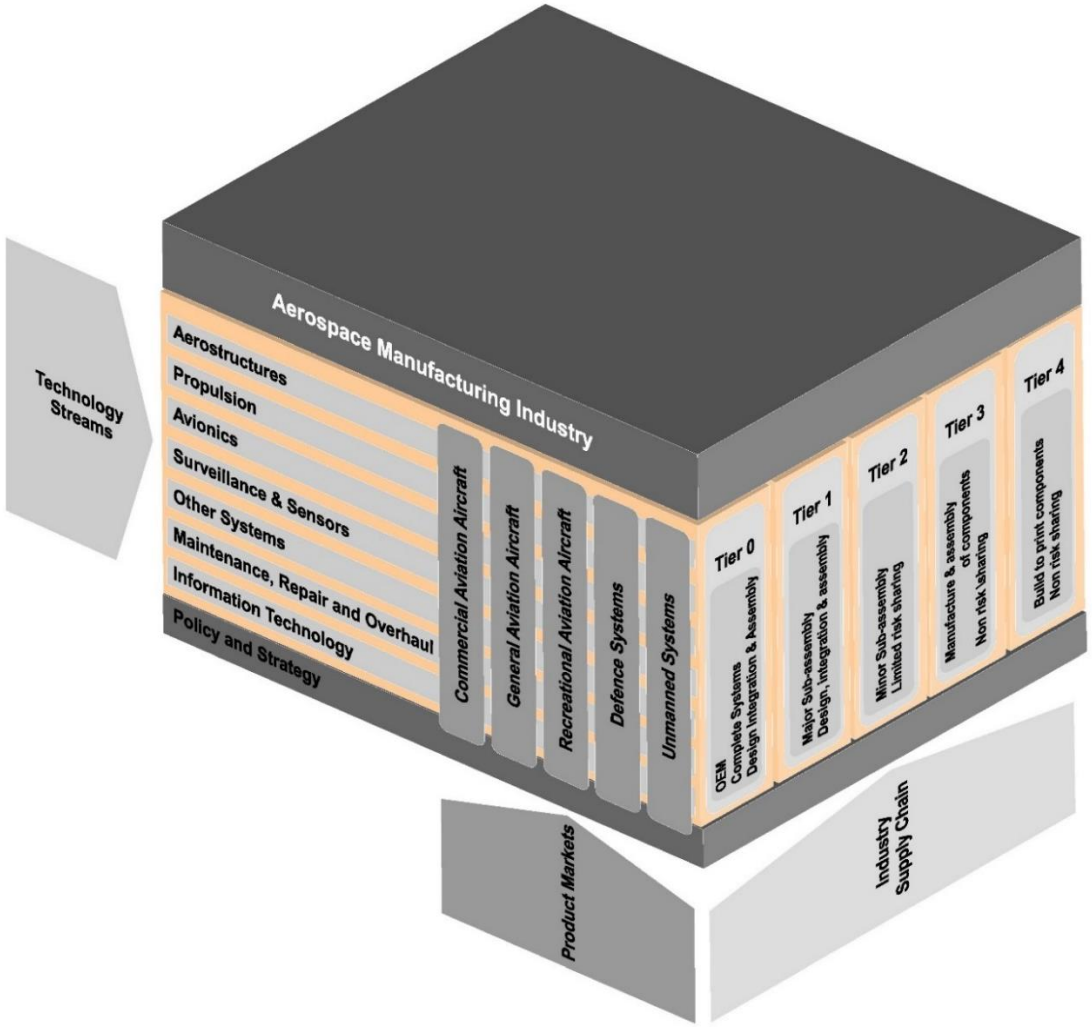


Figure B1: Supply chain tiers

Tier 2-4 Tailored Questionnaire

The AISI is an initiative of the Department of Trade and Industry, managed and hosted by the CSIR. The AISI is currently updating its supplier database for aerospace organisations and would appreciate your assistance with the following information about your organisation.

Organisation Name	**Total Revenue in Aerospace**	**No. of Employees**	**% Business classified as Aerospace**

Location
City: Municipality:
List reasons why are you based in your current location
3. 4.

Supply Chain Classification ***Please classify your organisation according to the OEM or Tier levels shown in figure 1*	**Certification** ***Please list all the certifications within your organisation (e.g. ISO 9001)*	**Product Market** ***Please select the product market which applies to your organisation from Figure 1*	**Technology Stream** ***Please select the technology stream which applies to your organisation from Figure B2*

How many people does your organization currently employ per functional category (Total/Aerospace)?									
Management	B	C	A	W	Technicians (Technical University Degree/diploma)	B	C	A	W
Support functions	B	C	A	W	Artisans	B	C	A	W
Engineers (University degreed)	B	C	A	W	Operators	B	C	A	W
Scientists	B	C	A	W	Students	B	C	A	W
Other, please specify	B		C		A	W			

Client Sector ***Total % of business to the following sectors*	**% Business (Total/Aerospace)?**	
	Name	%
SOCs		
Private SA	1. 2. 3.	1. 2. 3.
International	1. 2. 3.	1. 2. 3.
	SIC Codes used during export:	

Economic Data:

Please provide the following information for the past 5 years:

Category	2013/14	2014/15	2015/16	2016/17	2017/18
Total Revenue(R)					
Total Government Support (included in above) (R)					
Total Expenses (R)					
Total Re-investment (R)					
Total VAT paid (R)					

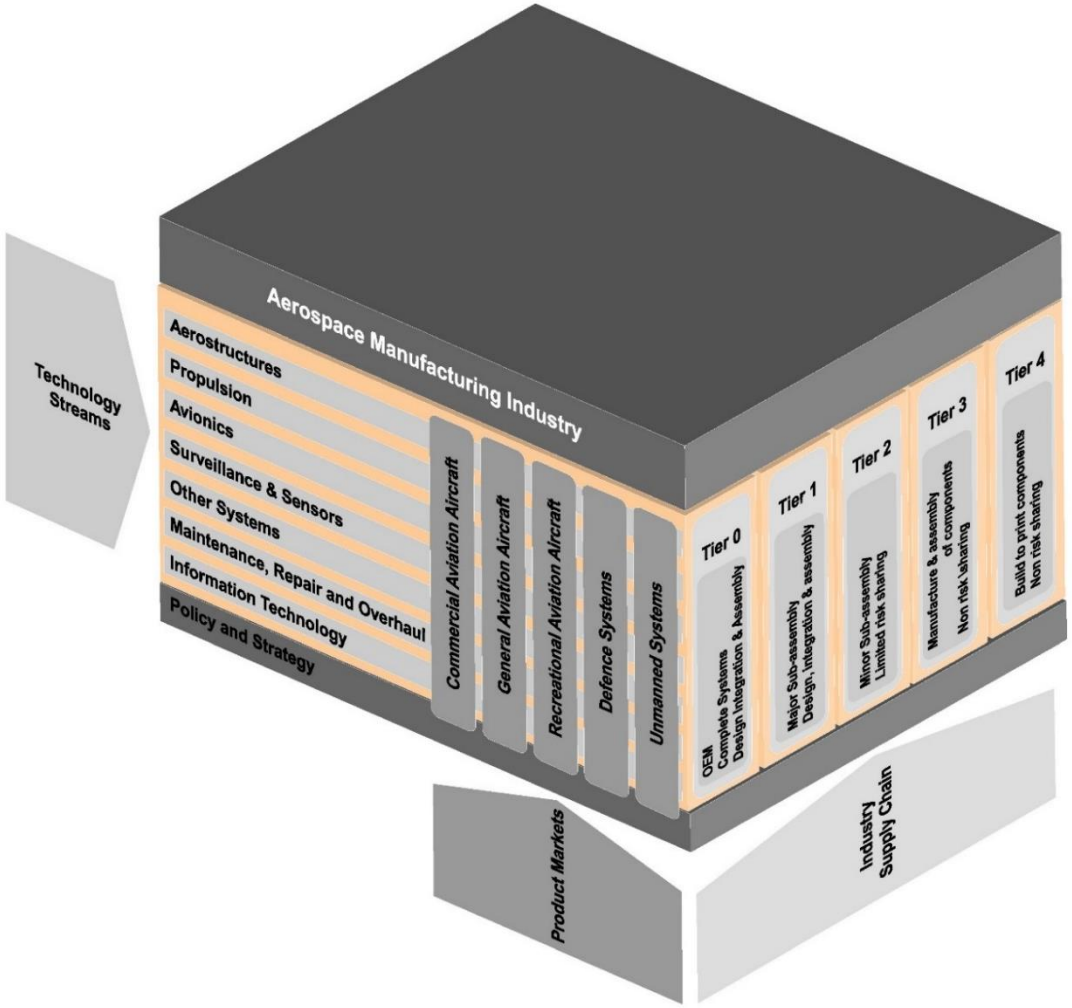
Total Companies Tax paid (R)																			
Total PAYE/SITE Tax paid on behalf of employees (R)																			
Total Customs Duties Paid (R)																			
Total Municipal Rates and Taxes Paid (R)																			
No. of employees	B	C	A	W	B	C	A	W	B	C	A	W	B	C	A	W	B	C	A	W
No. of ship sets/products completed																			
%Black Ownership																			

Input Costs (Current): ***Total % spent annually on the following inputs*	**% Expenditure**
Labour	
Transport of Goods	
Local Sources	
International Sources	

Suppliers	
What is your biggest single input cost (excluding labour)?	
List your 5 top suppliers (based on value, strategic or part count):	Name Location 1. 2. 3. 4. 5.

Support Mechanisms:

Central and Local Government support received
List any government funds applied to and type/Rand value of support received: 5. 6. 7. 8.



Tier 0: Complete Systems, Design Integration & Assembly
Tier 1: Major Sub-assembly, Design Integration & Assembly
Tier 2: Minor Sub-assemblies, Limited risk sharing
Tier 3: Manufacturing & Assembly of Components, Non-risk sharing
Tier 4: Build to print components, Non-risk sharing

Figure B2: Aerospace Manufacturing Industry Matrix

Appendix C: Industry Workshops at Sector Level

Aerostructures

Participants

Aerosud, Daliff, Titamed

Industry Sector Vision

An initial phase of accelerated growth to make the industry sustainable over the next 5 years.
Double the industry size within a realistic but short time frame.
Put in place an effective long term Public Private Partnership that can fund non-recurring costs to allow risk and revenue sharing and greater work share in OEM projects (order of magnitude R200M).
Have in place an effective industry association that unifies the sectors and speaks to Government with “one voice”.

SWOT Analysis

Strengths	**CULTURE AND COMPETITIVENESS:** • SA is competitive in comparison to other countries. • Government incentives do exist. • Vibrant industry with unique capabilities. • Current capability is locally developed. • Operational excellence. • Innovative. • Advanced technology and\skills are available. • Good IP and product ownership. • Has potential to compete internationally. • Long term track record of supplying OEMs and suppliers. **GEO-POLITICAL:** • Neutral politically. • Time zone is the same as Europe. • Culture and language compatibility exists.
Weaknesses	**GOVERNMENT:** • Low levels of R&D investment relative to Europe for example • National Strategy/ies uncoordinated • No clear vision and strategy • Little funding for risk/revenue sharing (industry not subsidised) **INDUSTRY:** • Low capacity for upfront investment – non-recurring costs. • Small number of companies in SA. • Lack of local raw materials suppliers. • OEMs do not see SA as a preferred supplier. • Limited resources dedicated to marketing. • Insufficient turnover, puts pressure on margin and cash flow (economy of scale is lacking). • Fragmented industry (many sub-sectors and they don’t speak with one voice. **SKILLS:** • Particularly artisan training. • Lack of depth.

Opportunities	• Strong global growth forecast for commercial aircraft sales. • Growing opportunities for manufacturing exports in commercial aerospace. • Investment in new technologies such as Industry 4.0. • Ti and Al beneficiation. • Clustering to quote on global RFQs. • Build on Successes.
Threats	• Political and economic trends. • OEMs lose confidence in SA. • Failure to acknowledge the need to compete. • Public and Private sector inertia (slow to react and implement plans and strategy). • Reduction in Industry turnover, lack of growth is the death of private industry.

Roadmap

	SHORT TERM	MEDIUM TERM	LONG TERM
Industry trends and drivers	• Skills. • BBBEE. • Cost and weight reduction. • Scarce public funding and increased risk sharing. • Competitiveness improvement. • Advanced manufacturing/machining technology. • Global sourcing. • Digital twin (PLM). • Industry 4.0 and IoT. • Rand volatility. • Additive manufacturing. • SOEs challenges (Denel/SAA etc). • Declining counter trade opportunities. • Distributed innovation. • Geographical location to market. • Market shift from military to commercial.	• Increase in protectionism. • Smaller more specialised manufacturing entities. • Flexible manufacturing. • Increased OEM relevance in China. • Flexible automation (Cobots, FPS). • Disruptive technologies. • Increasingly competitive market.	• Increased regulatory compliance needs. • Growth of international and African markets. • New modes of transport.

Proposed initiatives and projects	INDUSTRY ASSOCIATIONS • Revitalise a JASC like forum as a Public Private Partnership forum. • Industry forum: Speak with “one-voice”. • Establish best practise advanced manufacturing and certification processes. GOVERNMENT INCENTIVES • Government incentives to grow and perform, SEZ type model. • One stop aerospace incentives agency. • Support advanced manufacturing uptake. • Software leasing platform (CAD, CAM, CAE, Vericut, Industry 4.0). • Reinstate funds such as the MCEP Green Energy Fund and Capital and Technology Investments fund (this would allow industry to upgrade to international standards). • Develop local material supply. • Influence export council and show selection for attendance. SKILLS • Artisans and GD&T skills sets in particular. STRONGER LINKS WITH GLOBAL AEROSPACE MANUFACTURERS • Promote long term partnerships with international OEMs.	Centurion Aerospace Village (clustering)	

Key Initiative to Assist Industry

Promotion at the highest level (presidential project, embassy focus etc):

- OEM and tier 1 deals.

CAMASA want a bilateral growth agreement with government.

Key Initiatives to Address Transformation

BBBEE focussed on outcomes to address industry gaps/needs.

Negotiate flexible BBBEE terms for the industry to facilitate access to government funding.

Above all Government should execute the plans it makes.

Small OEMs

Participants

Jonker Sailplanes, Airplane Factory, Adept

Industry Sector Vision

Best in class innovative first to market products.

SWOT Analysis

Strengths	• Partnerships local industries and universities. • Innovative design. • Entrepreneurial. • Produce engineers that spill over into other industries. • Excellent products/best in class/product of choice design. • Low labour cost and overheads (most particularly in Potchefstroom).
Weaknesses	**SKILLS SHORTAGE** • Technical skills training. • Limited production related skills (artisans and composites workers). • Low quality labour force. • Skills for the new digital economy. Global perception that Africa produces inferior products. Country does not show good faith in its own products. **FAR FROM MARKET** • Low labour cost in Potchefstroom but very remote which affects delivery times. **LACK OF FUNDS/CAPITAL** • Start-up support. • Poor economy of scale as an industry. • Failure in the market will kill the company, no Beta products, small companies lack the development funds to have depth in their product line to overcome a failed development. **LACK OF CERTIFICATION KNOWLEDGE, CAPABILITY, FACILITIES AND ASSISTANCE** • Certification experience in one or two companies. • Forced to go abroad for certification.

Opportunities	**CERTIFICATION** • Bilaterals with EASA and FAA. **GOVERNMENT SUPPORT** • Government funding (AISI etc) – AISI on steroids. • Manufacturing drives exports. • Favourable exchange rates. • Manufacturing catapult programme. • Structured cluster initiatives. Some OEMs are reaching the stage where they can consider outsourcing. **TECHNOLOGY ADVANCES** • Industry 4.0 – automation is inevitable and will change the jobs market. • Product and quality improvement. • Development of new technologies. • Making aircraft less expensive to certify. • Niche market opportunities. **MARKETS** • Diversification in terms of models and complementary products. • Markets in Asia.
Threats	**MARKET** • Decline in gliding. • Decline in general aviation. • Strong competition. • Brand loyalty to foreign brands. • High risk industry. • Accidents and incidents resulting in legal costs and reputational damage **GOVERNMENT** • Uncertain political future • Unstable currency **CERTIFICATION THREATS** • EU company holds type certificate. • SACAA Certification not recognised, no bilateral agreements. • SACAA service and competence is unpredictable. **SUPPLY** • Supply of raw materials. • Unstable currency.

Roadmap

	SHORT TERM	MEDIUM TERM	LONG TERM
Industry trends and drivers	• Political instability. • Insufficient R&D funding. • Advanced material development. • Skills shortage. • BBBEE. • Certification requirements (FAA, EASA). • SACAA capabilities. • Localisation of components. • Rapid prototyping (lean R&D).	• Additive manufacturing. • Increase in protectionism. • Industry 4.0 and smart manufacturing. • Battery technologies (energy density).	• Decline in leisure flying community.

Proposed initiatives and projects	**SKILLS** • Skills development especially technical skills. **GOVERNMENT SUPPORT** • Start-up support. • New product support. • Targeted government support – "catapult" model. • Fundamental R&D support. • Localisation. • Maintain critical infrastructure/capabilities for use by industry (material testing and flutter prediction was mentioned as two typical examples). • Access to technical information and capabilities. • Export promotion and support. • Support with inter-country 'strong-arm' tactics. • Strengthen organisations and institutes for test/certification/technical support eg the CSIR (South African one-stop-shop for certification services). • Composite material characterisation. • Targeted HR development tax incentives, THRIP is dysfunctional. **EFFECTIVE INDUSTRY FORUM** • "Industry Voice". • Industry collaboration – in importing raw materials.	Industry 4.0 Implementation	

Key Initiative to Assist Industry

Single aerospace fund:

- One organisation who engages industry.
- R&D. Industrialisation etc.
- In-house expertise with industry advisory board.
- With the capacity and capability to implement.

Certification:

- Review the SACAA.
- Setup and SA/EASA design organisation.
- Secure bilateral agreements with EASA and FAA.

Key Initiatives to Address Transformation

Incubator programme in association with funding.

Companies should invest in education and not the current BBBEE Model.

Other

CAMASA has 6 projects for certification and are engaging directly with SACAA.

Sensors and Surveillance

Participants

Reutech Radar Systems, Tellumat, Kutleng, Trax Interconnect.

Industry Sector Vision

- To be the first consideration for domestic acquisition.
- To be the preferred consideration for export acquisition.
- To provide collaborative solutions or niche sub-components as SA Inc.
- To be recognised for high tech, high quality, affordable product and solutions.
- To develop human capital, skills, capacity and supply chain to support the vision.
- To contribute towards global development, peace and stability.

SWOT Analysis

Strengths	**INDUSTRY** • Bespoke/differentiated solutions. • Strong culture of Innovation. • Can address military and commercial markets. • Competencies in products and systems. • No foreign ownership *. • Long history and track record in aerospace. • Companies who have survived: Lean and tough and lessons learnt. **NATIONAL CAPACITY AND CAPABILITY** • Manufacturing capability (good, but weakening…) • Relatively good infrastructure, eg SKA. • Quality tertiary education institutes.
Weaknesses	**INDUSTRY** • Stagnation in advanced manufacturing: Gap with international competitors. • Innovation chasm (TD to commercial manufacture). • Re-investment in products – obsolescence. • Risk averse with respect to Innovation (Industry waits for guaranteed sales before committing). • Reactive not proactive. • Inconsistent quality. • Segmented industry. • Lack of a voice to government. • Knowledge and limited budgets in SMME's: ○ Unequal opportunities. • Product life cycle management is poor. **SKILLS** • Lack of apprentices. • Key skills lost to other countries. • Key personnel approaching retirement. **GOVERNMENT** • Opportunity focused government/DoD support. • Very high expectations from government before deploying funding. • Political interference vs. technical know-how.

Opportunities	**GOVERNMENT SUPPORT**
	• NIPP and DIP for local and export product development:
	  ○ Government investment packages recently announced.
	INDUSTRY
	• Companies who survived – lean, tough, learnt the lesson.
	• Manufacture for OEMs.
	• System integration for OEMs.
	• Successes in other countries to learn from.
	NEW MARKETS
	• Drones and automation.
	• UAS at a lower cost.
	• Cloud computing.
	• Supply of integrated solutions.
	• Global space industry huge (±$340B).
	• Undeveloped aerospace network in Africa.
	• SA can become Africa leader.
	• Selected emerging markets:
	  ○ Opportunities in non-End user/ITAR products.
	  ○ Exports and foreign currency.

Threats	**SKILLS** • Losing key personnel. • Lack of apprenticeships. **RED TAPE/ BUREAUCRACY** • Export control restrictions. • Import of controlled items, eg PCB technologies. • Regulatory environment (SACAA, ICASA). • Dated policies/frameworks, eg SACAA and Space. • SA export control processes (unpredictable, lost documents etc.). • SACAA UAV restrictions. **HIGH CAPEX AND OPEX INDUSTRY** • Forex volatility. • Political uncertainty and risk of investment. **GEO-POLITICAL** • Socio-Economic challenges. • State of SOEs, Denel in particular. • Weak Rand. • Budget constraints. • Low economic growth in SA. • Data security concerns. • Conflict between International clients affects market access, eg India/Pakistan. • Shortage of government funding for capital acquisitions. • Military business too dependent on Armscor and diminishing in real terms • Dated policies and frameworks. • Capricious foreign policy. **CULTURAL** • Afro-pessimism, perception that products are inferior. • Lack of faith in local suppliers shown by SA government. **MARKET** • Competitors in the market with a large global footprint, e.g. Thales. **ALTERNATIVE MARKETS** • Mining Sector is becoming very competitive **TECHNOLOGY** • Disruption through technology. • Advanced manufacturing investment stagnated in last 10 years – falling behind international industry. • Competitors with newer technology.

*This is a potential weakness as well. One company admitted that due to partial foreign ownership the foreign owners had limited say in the company. It was indicated that if foreign ownership was > 50% that the products would have been marketed as being in the basket of products of the foreign company and the South African branch would have had access to the complete marketing machine of the foreign company with all the international contacts.

Roadmap

	SHORT TERM	MEDIUM TERM	LONG TERM
Industry trends and drivers	• Global purchasing. • Digital twins (PLM). • Shrinking defence budget. • Certification and qualification facilities. • Rapid technological changes. • Lower cost competition from the East. • Political/economic uncertainty. • Localisation and IP protection. • Automation/advanced manufacturing. • Skills shortage. • Rapid prototyping (lean R&D). • Digital disruption. • Open innovation.	• Additive manufacturing. • Miniaturisation of components. • Green economy (e-waste). • Virtual and augmented reality. • Increase in protectionism internationally.	• Interconnectivity and interoperability. • Quantum electronics. • Intelligent infrastructure. • BASA bilateral with FAA.
Proposed initiatives and projects	Properly phased strategy (short, medium and long term). Life lines (survival). Start medium term strategy/budgeting. Flagships programmes. Industry secretary to facilitate collaboration. Start with AMD? Industrialisation support. Focused R&D support. Advanced Manufacturing capability needs to be developed. Government industry linkages/partnership. Government tech fund.	Develop further long term strategy/budget. Ramp up projects in a healing economy. HCD/skills pipeline. Government STEM talent expo. Invest in product maturation. Industry designation. Implement Defence review. SECTOR CLUSTERS • Specialised R&D. • Industrialisation.	Implement long term strategy/budget in a healed economy.

Key Initiative to Assist Industry

Fund stalled acquisition programmes (move forward with the projects defined).

Catapult programme.

Needs analysis for industry (Trax Interconnect).

Create an economic environment that stimulates business confidence.

Key Initiatives to Address Transformation

Transformation requires business growth.

Stop supporting SMMEs directly in export markets and leave it to (and support) the larger industries.

Concentrate on building a strong economy, transformation will happen naturally.

Do BBBEE without politics (many BBBEE companies remain unsupported as a result of a lack of 'contracts'/not "connected"), but develop skills.

Other

Safety radars (ATNS) ICAO certification requirements 'out of our league' as opposed to defence systems.

Military Systems

Participants

Denel Dynamics, Paramount Advanced Technologies

Industry Sector Vision

Provider of air and space platforms.

SWOT Analysis

Strengths	• Strong local IP *(However, see in conjunction with IP issue under "Weaknesses").* • Strong element of aviation innovation. • R&D infrastructure exists. • Skills and capacity is sufficient: Training exceeds requirements retention is the issue.
Weaknesses	• Lack of government support (the requirement extends beyond funding). *Industry, government and academia must work together:* o SARA for example: ▪ Lack of will. ▪ Lack of funding. • Low labour productivity, failing infrastructure and electrical supply. • Lack of a national aerospace development plan. • Lack of industry coordination: *Post the Strategic Defence Packages the Industry has been in a survival of the fittest mode, fighting each other for funds. Instead Paramount, Denel, Reutech and Thales need each other to survive:* o Associations are a weakness: ▪ No plan or vision. ▪ AMD should be able to articulate the ambitions of the industry. ▪ AMD should be forceful enough to make the industry work together. • AISI should be enabled to give tangible support: o Funding that would enable a small aircraft company to go from making small aircraft to 24 seater jets (e.g. Pilatus). • Certification support: *CAA lacks the requisite knowledge and qualifications to support industry and the lack of appropriate legislation to support military systems and UAVs outside of the SAAF/DoD is severely hampering the local development of systems for export.* o An entity is required that contains all the regulations and testing requirements o And can lease in certification engineers as required o Possibly one that has access to flight test facilities for UAVs • Lack of flagship programmes o They have been identified but lack traction o They are required to give new personnel the opportunity to work up in skill level o They are required to give the industry the opportunity to transform its skills base • Ability to complete products/designs on time • Marketing by the country needs to be improved, especially with in the AU o SA needs to sell finished products o SA Government must back the industry by buying its products o Targeted government to government support is required • IPR Act requires review: Fails to account for local requirements and limits ability of industry to work together and for institutions to effectively release products into the industry.

Opportunities	• UAV's (still):
	  ○ Integration into civil airspace *(but requires SACAA involvement).*
	  ○ HALE.
	• SAA/SA Express need to re-equip:
	  ○ With government support African union countries can also become involved building the market.
	  ○ Could involve a local aircraft development or,
	  ○ A license built aircraft.
	  ○ BRICS collaboration.
	• Space launch: Possibly with a Russian rocket from OTR.
	• Rooivalk upgrade/MkII.
	• Franchising: setting up development and MRO capabilities in foreign countries.
	• Upgrades to older systems utilising small flexible teams and collaborative models (Paramount).

Threats	• Fragmented industry:
	  ○ Too deeply integrated.
	  eg: Navigation engineers in Dynamics could be used on other projects.
	  ○ BBBEE/NIP/DIP have failed to yield the desired results.
	• Industry lacks capacity to absorb new talent.
	• Skills drain because of a lack of orders.
	• Instability in Denel.
	• No tier 1 suppliers:
	  ○ Makes SA non-competitive.
	  ○ Limits growth.
	• Countries like Botswana, Malawi and the UAE who are willing to allow the development and testing of military product in their airspace.

Roadmap

	SHORT TERM
Industry trends and drivers	Mergers and acquisitions: • Boeing and Embraer • Airbus and Bombardier Open architecture avionics: • Integration of systems becoming easier to achieve and putting specialist integrators out of work. OEM's no longer collaborating with third party integrators.
Proposed initiatives and projects	• A return to the ASSEGAI type approach of a 10 year development plan which provides an integrated space, aero and defence plan. • Setup a certification body. • National UAV programme for the Integration of UAV's into civilian airspace. • Fund the development of a low risk airliner development (integration of existing technologies): ○ Use the programme to develop lower tier suppliers and promote them to high level systems in future. • Follow a market driven approach rather than a technology driven one. • Fund key projects on an experimental growth path, small realisable goals that can grow in scale and impact. • Couple business solutions to market driven technology solutions.

Key Initiative to Assist Industry

- Fix Denel
  Not just pumping in money, but remodel Denel to be cost effective.
- SA must articulate a clear *National Strategy and Intent* with strong leadership whose implementation survives across political dispensations:
  - Includes alignment of the efforts of institutions and academia.
- Five flagships are proposed:
  SA government may not be able to fund these projects in total but should provide sufficient seed funds in order to attract partners:
  - UAV's (R10-15M/year to attract others to work in SA).
  - A Launch Vehicle (10-15 year development).
  - 'Exocet' type missile replacement for the Navy (possibly in collaboration with Brazil).
  - Rooivalk MkII (funded by the DoD).
  - SARA or similar license build programme – requires innovative marketing approach and local sales commitments.
- Alternatively small experimental themed programmes (flagships) to pilot the new approach are suggested to:
  - Tackle the legislative and regulatory challenges.
  - Attract additional funding.
  - Attract the younger generation into the industry.

  Similar to the AHRLAC model.

Key Initiatives to Address Transformation

- Unbundle vertically integrated industries and use this as an opportunity for black empowerment companies.
- Release nascent products from within the CSIR for commercialisation by black industrialists.
- No growth equates to no uptake of highly skilled graduates and the industry cannot transform.
- Grassroots interventions at schools and across tertiary education institutions.
- A clear national plan and the implementation of projects would attract new talent into the industry.

Maintenance, Repair and Overhaul

Participants

SAA Technical, Lufthansa Technik, Denel.

Industry Sector Vision

Collaborative MRO hub for Africa.

SWOT Analysis

Strengths	**INDUSTRY**
	• Extensive facilities available across entities.
	• Solution driven.
	• Systems engineering knowledge and capacity.
	• Breadth and past history of capability:
	  ○ Line maintenance (up to A-B checks).
	  ○ Base maintenance (C-D checks).
	  ○ Component maintenance.
	  ○ Engine overhaul (only facilities available anymore).
	  ○ Avionic support.
	• Ability to earn 3rd party revenue.
	GEOGRAPHIC
	• Geographic position for sub-Saharan MRO support.

Weaknesses	**CERTIFICATION**
	• A/C certification approvals:
	  ○ Costly to maintain/upgrade.
	  ○ Currently limited to older aircraft types.
	SKILLS
	• Aging specialists (skills).
	• Skills drain to foreign MRO companies.
	• Unable to retrain (antiquated and outdated machinery).
	GOVERNMENT
	• Lack of government implementation of policy, plans and strategy.
	• Lack of government support.
	• Lack of public support (brand erosion in SAA in particular but includes Denel).
	• Public sector legislative constraints make in difficult for public entities to compete on a global platform.
	INDUSTRY
	• Little collaboration across industry.
	• Singular focus (within Denel).
	• Low cost expectations from local industry (of the public sector entities because they are seen as government funded).

Opportunities	**CUSTOMERS** • New A/C types / fleet rollover within the next years in Africa. AIRCRAFT DESIGN AUTHORITY • Expanded aircraft MRO for older aircraft. **INDUSTRY** • Pool capability towards product line. • Co-operation between MRO suppliers, everyone makes money. • Industry inclusive development. • Sub-system development towards product line. **AFRICAN GROWTH** • Opportunity for SA to be main MRO supplier in Africa. • Growth of MRO industry in Africa.
Threats	**POLITICS** Economic and political uncertainty. Becoming the equivalent of the auto industry in SA, build to print only. Death of design and development (defence industry). No or limited funding. Volatile labour market. **GLOBAL TRENDS** • OEM control of IP (i.e. maintenance can only be performed by OEM or in cooperation with OEM). **SKILLS** • Loss of capacity and capability. • Availability of skilled labour. • Aggressive recruitment of skilled labour by other countries.

Roadmap

	SHORT TERM	MEDIUM TERM
Industry Trends and Drivers	**AIRLINE INDUSTRY** • Outsourcing of MRO by airlines. • South Africa could become a maintenance hub in Southern Africa • Capability and development through projects • New A/C types in the country **MRO INDUSTRY** • Streamlined production and planning. • Strengthening supply chain: Inventory optimisation. • Systems transformation (supply chain management technician/software). • Design/development of product [supplemental type certificates] (value chain). **SKILLS** • Type of skills changing (in future). • Need for more base maintenance capacity in SA.	**TECHNOLOGY** • Complex new technology. • Requirements changing becoming more complex. **SKILLS** • Methodology of training moving into the digital age (incl. technology). • Secure new human capital. **CERTIFICATION** • SACAA moving towards EASA regulations. • Certification and testing of new systems is required. **INDUSTRY** • Optimise contract performance.
Proposed Initiatives and Projects	**INDUSTRY** • Focus on small wins and build confidence. **GOVERNMENT SUPPORT** • Relieve constraints: ○ BBBEE policy/PFMA, PPPFA. • Implementation of policy with funding (by government). • Focus NIPP projects within the sector. • Funded industry collaboration project sovereign capability. • Collaborative ventures with OEMs. **SKILLS** • Awareness of careers in aviation. • Directed [industry] training and development. • Address skills and workplace of the future. **LESSONS FROM GERMANY** • Dual education system. • Free university education.	**LESSONS FROM GERMANY** • Funding innovation programme.

Key initiative to assist industry

Streamline SACAA.
Focus on PPP with OEMs or significant role players.
Capitalise on past investment in Engine overhaul shop.
Remove all politics holding the airline back.
Force collaborative approach with education, scientific and industry players to produce capability on product.

Key initiatives to address transformation

Proud to be South African.
Proud to work (“more than me”).
Training and support, i.e. assistance beyond the initial training phase.