Lighter, greener and as strong: Developing light metals for application in the aerospace industry

Willie du Preez

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Outline of presentation

- Introduction
  - Drivers of the International Titanium Industry
  - Drivers of the South African Titanium Industry
- The South African Innovation Opportunity
- The Titanium Centre of Competence
- Titanium Processing
  - Investment casting
  - Near-net shaping of powder
- Semi-Solid Metal Casting of Aluminium alloys
- Conclusions

Drivers of the International Titanium Industry

Cold War:

Titanium in military aircraft (USA)
Titanium in submarines (USSR)

Space Missions:

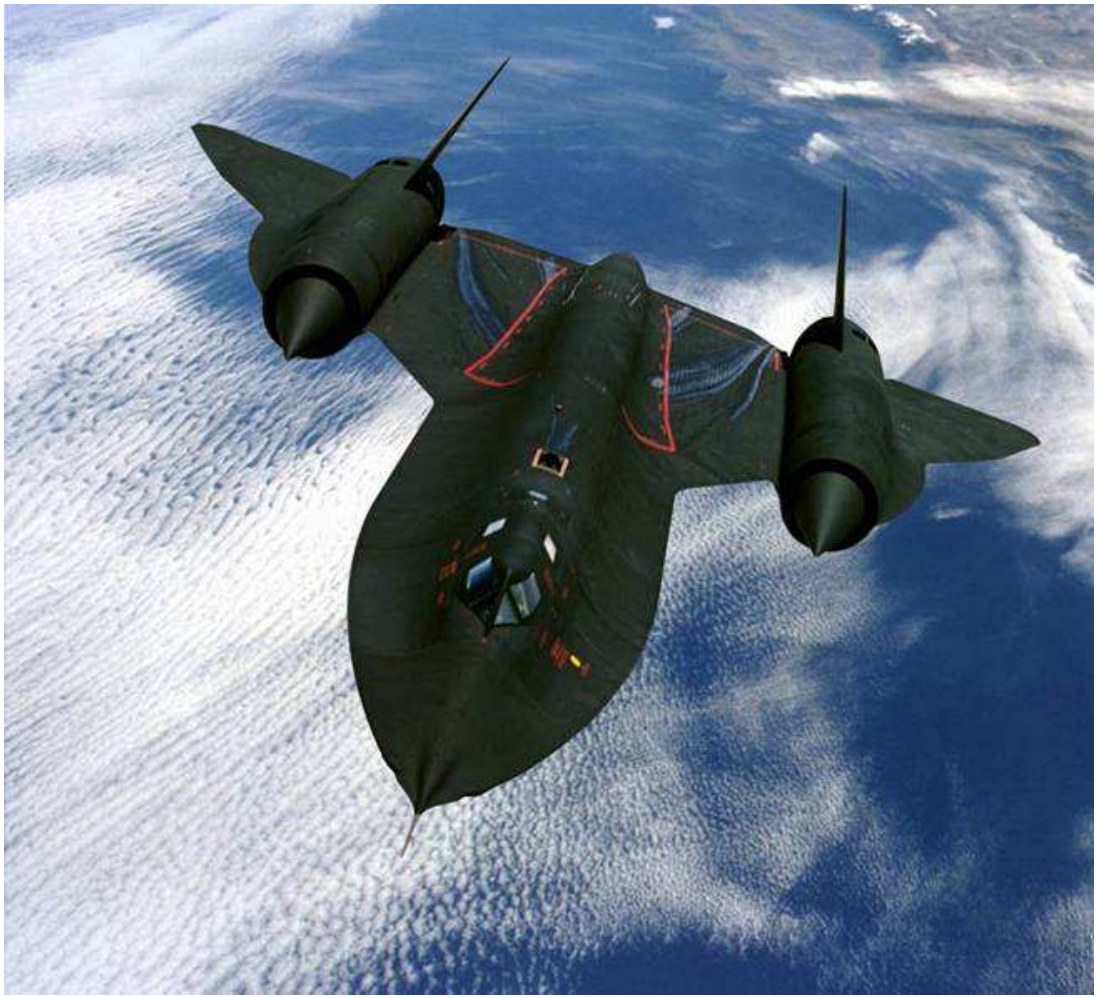
Titanium in satellites
Titanium in launch vehicles

Commercial Aircraft:

From less than 4% in Boeing 747 to >17% in Boeing 787
Similar increase for Airbus
Growth of >50% over next decade

Cold War: Titanium in Military Aircraft of the USA

The SR-71 Blackbird



Designed & built in 1959 - 1963

Fastest airplane ever:
Mach 3.2 (3700 km/h)
at 80 000 ft ~ 24 km
New York - Londen: 1h 55min

Fuselage skin temperature:
200º - 370ºC
Needed to be lightweight

Constructed for 90%+ from Titanium alloys

50 million pounds Ti used during development
67 tonnes per SR-71

Drivers of the South African Titanium Industry

SA's Space Programme (mid '80s – mid '90s):

Titanium (Ti-6Al-4V) in satellites

Medical applications ('90s – present):

Titanium orthopaedic implants
Titanium dental implants

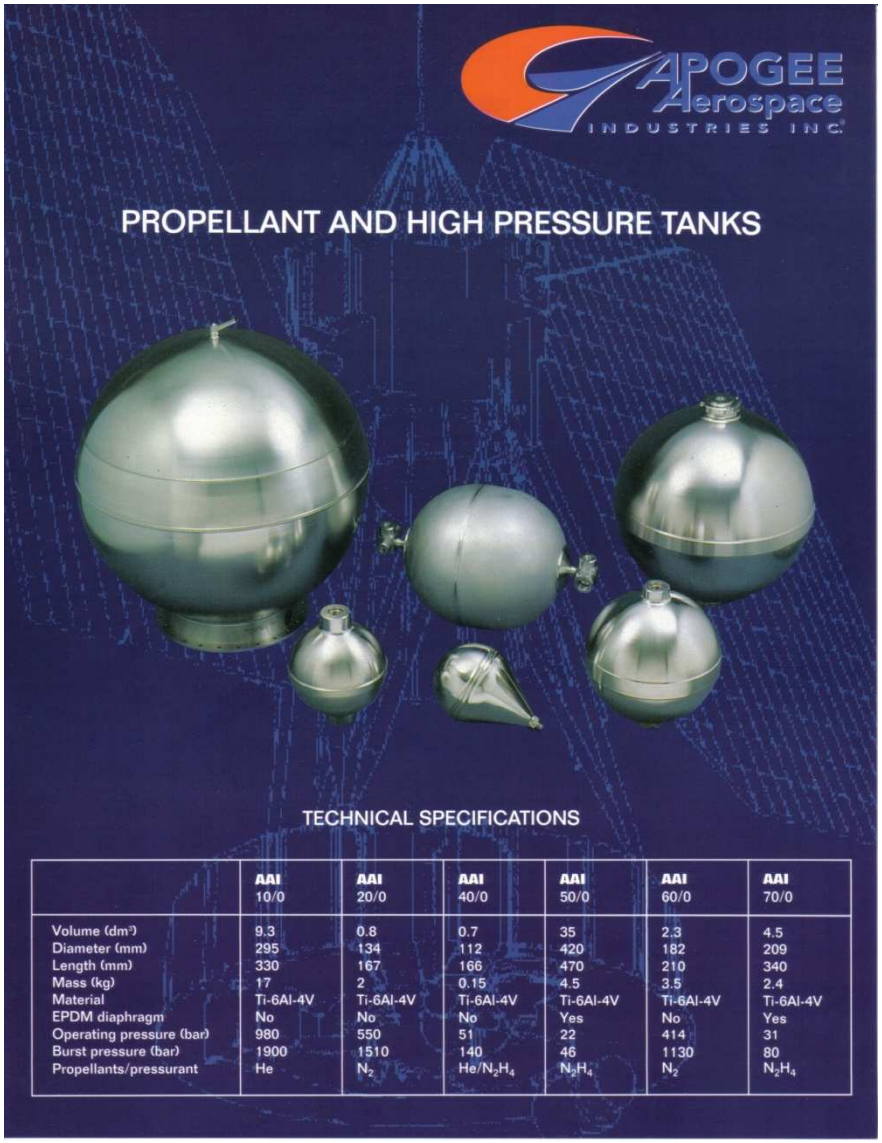
Chemical processing:

Commercially pure Titanium in processing plants (corrosion resistance)

Commercial aircraft industry needs:

Boeing's need for alternative suppliers
Growing relationship with Airbus

South African Ti-6Al-4V products of the early 1990s



	AAI 10/0	AAI 20/0	AAI 40/0	AAI 50/0	AAI 60/0	AAI 70/0
Volume (dm^3)	9.3	0.8	0.7	35	2.3	4.5
Diameter (mm)	295	134	112	420	182	209
Length (mm)	330	167	166	470	210	340
Mass (kg)	17	2	0.15	4.5	3.5	2.4
Material	Ti-6Al-4V	Ti-6Al-4V	Ti-6Al-4V	Ti-6Al-4V	Ti-6Al-4V	Ti-6Al-4V
EPDM diaphragm	No	No	No	Yes	No	Yes
Operating pressure (bar)	980	550	51	22	414	31
Burst pressure (bar)	1900	1510	140	46	1130	80
Propellants/pressurant	He	N_2	He/N_2H_4	N_2H_4	N_2	N_2H_4

Technologies:

Design & analysis
Die design & production
Forging
Superplastic forming
Machining
Electron beam welding
Laser welding
Non-destructive testing (X-Ray microfocus)

Satellite fuel tanks put to the test, Engineering News, Vol12 No.42 (Oct 30 – Nov 5 1992)

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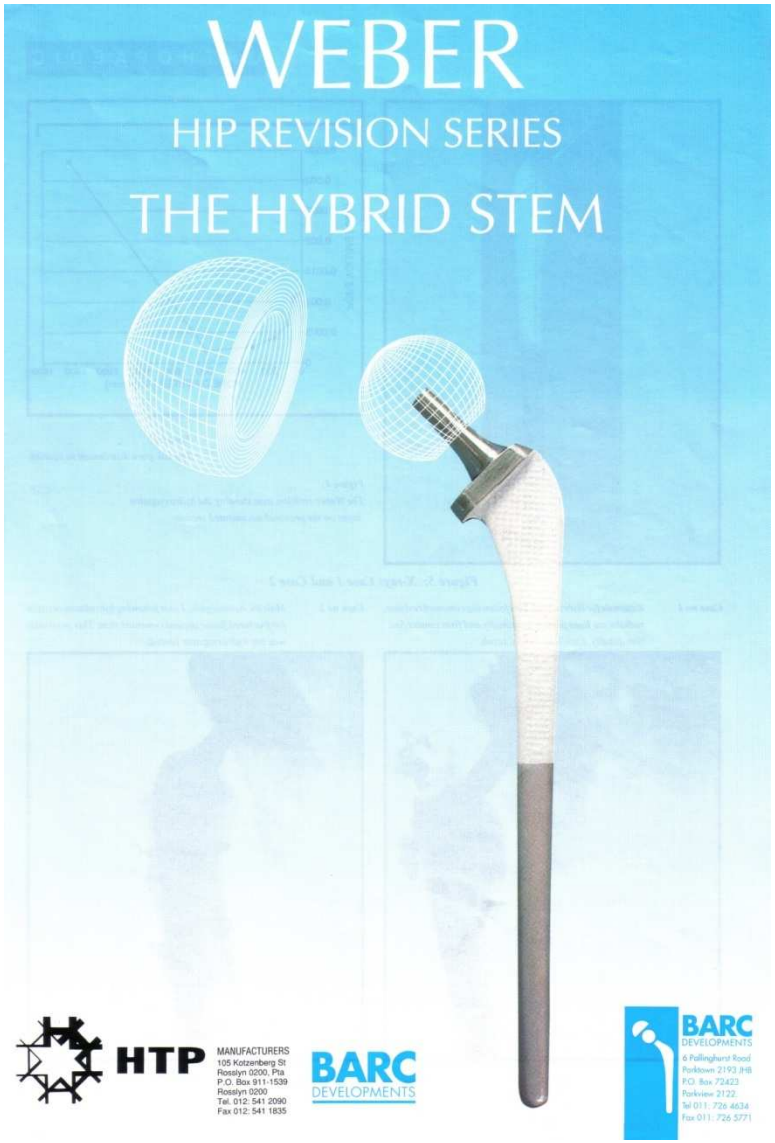
South African Ti-6Al-4V products of the early 1990s



Technologies:

Design & analysis

Die design & production

Forging

Machining

Hydroxyapatite coating

F A Weber, W B du Preez and N D L Burger, *Development and use of the Hybrid stem for upper femoral bone loss in hip revision surgery*, Geneeskunde, Vol 35, No 3, (May 1993) p 14

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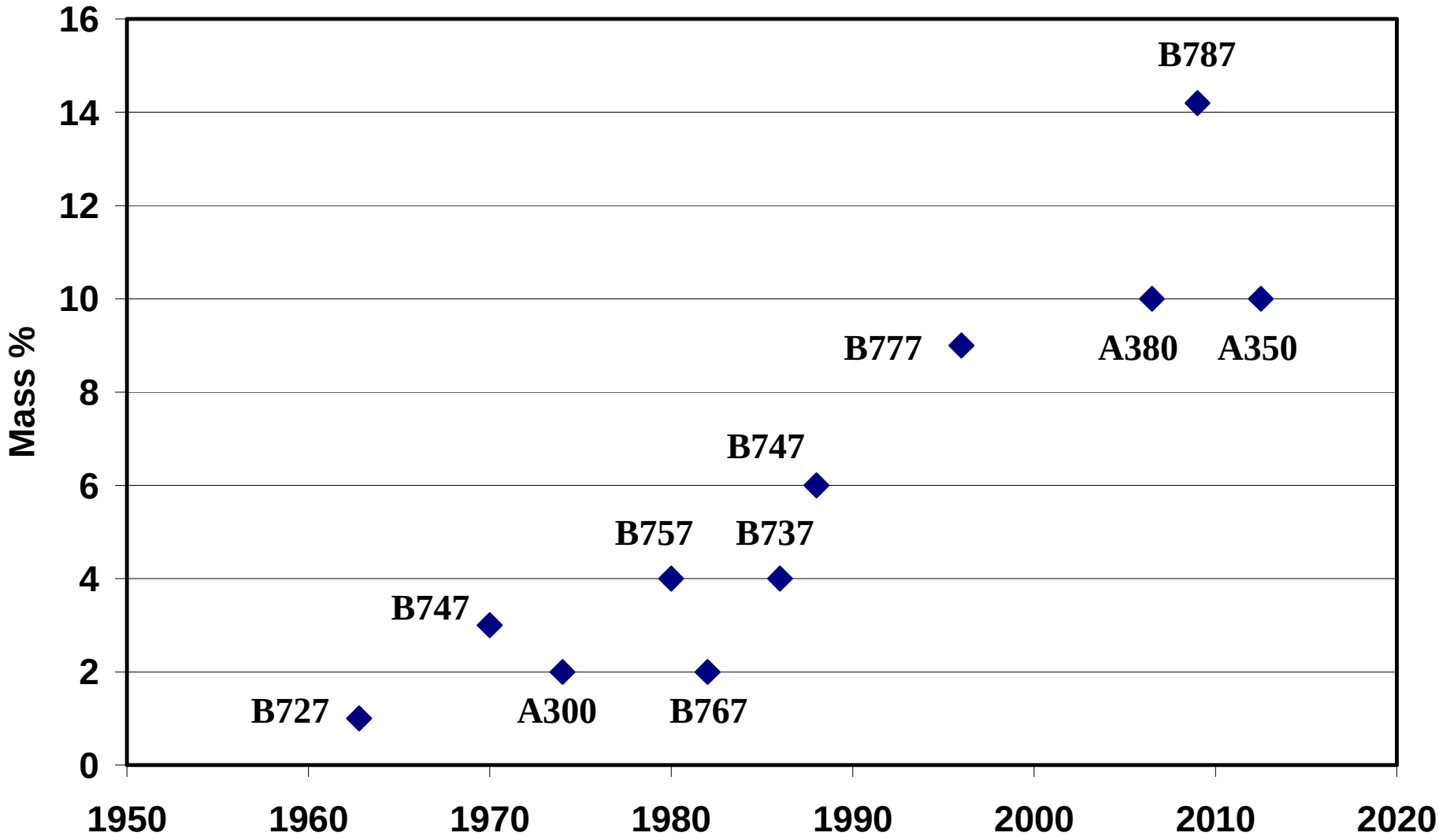
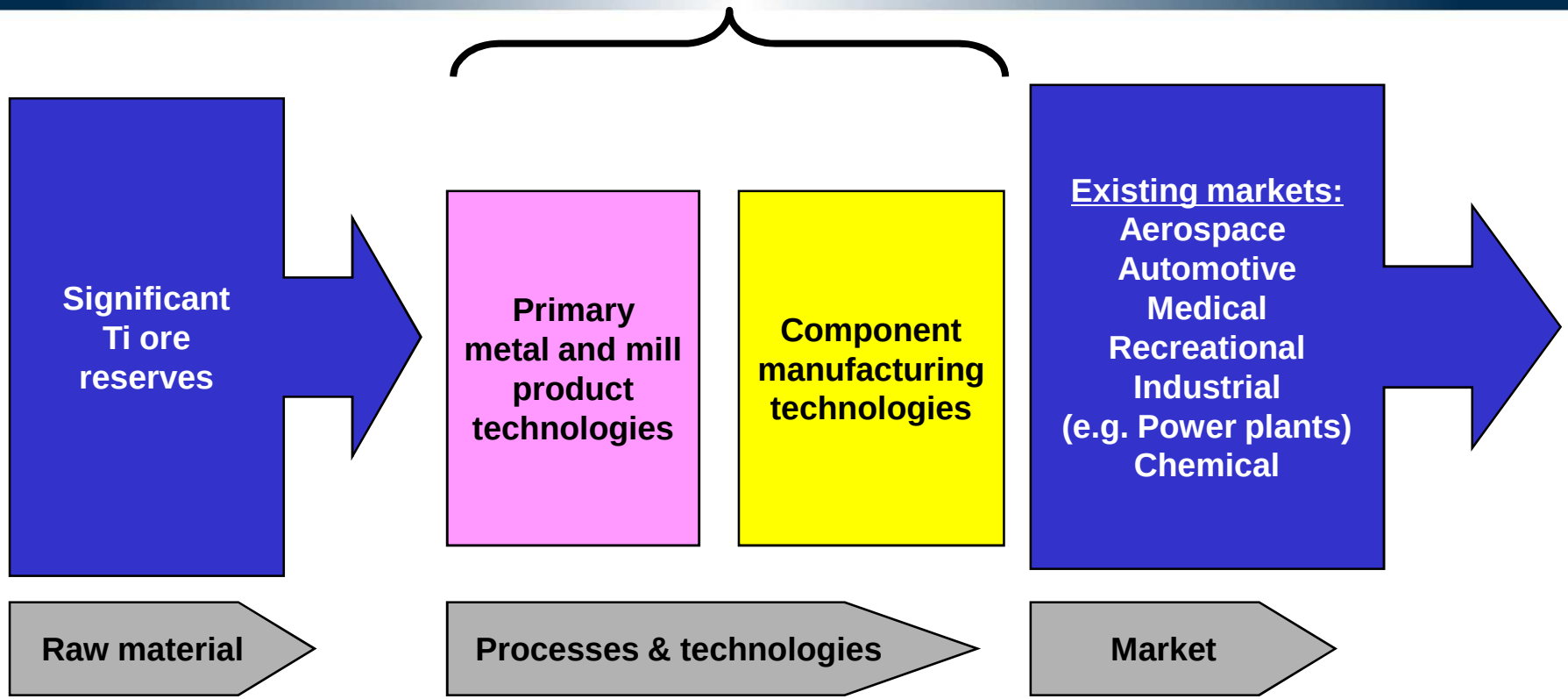
Titanium Content per Airframe

(J. Monahan, ITA Conference, 2006)



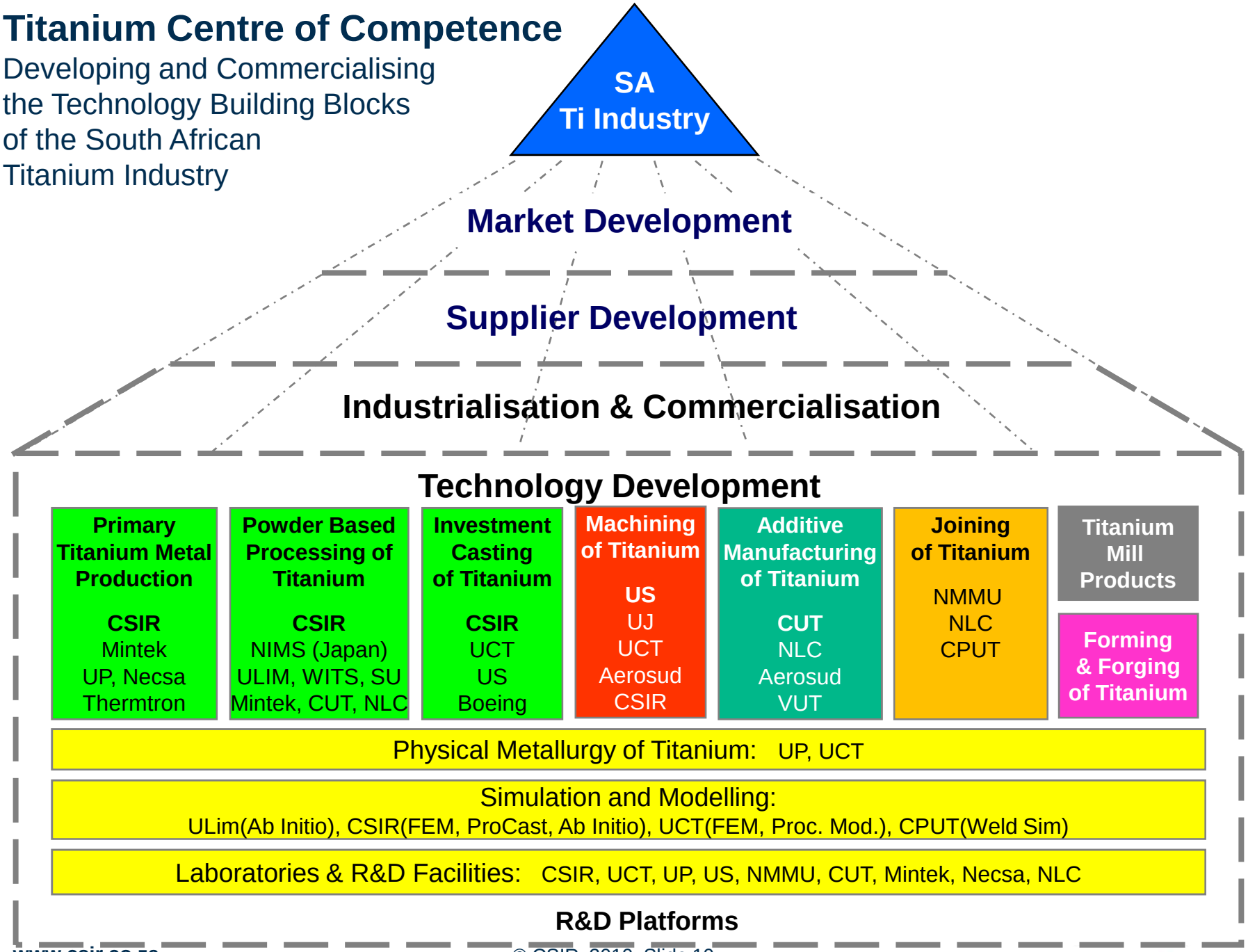
The South African Innovation Opportunity



The Titanium Centre of Competence integrates and coordinates R&D and commercialisation across the value chain

Titanium Centre of Competence

Developing and Commercialising the Technology Building Blocks of the South African Titanium Industry



Titanium Centre of Competence Collaborators

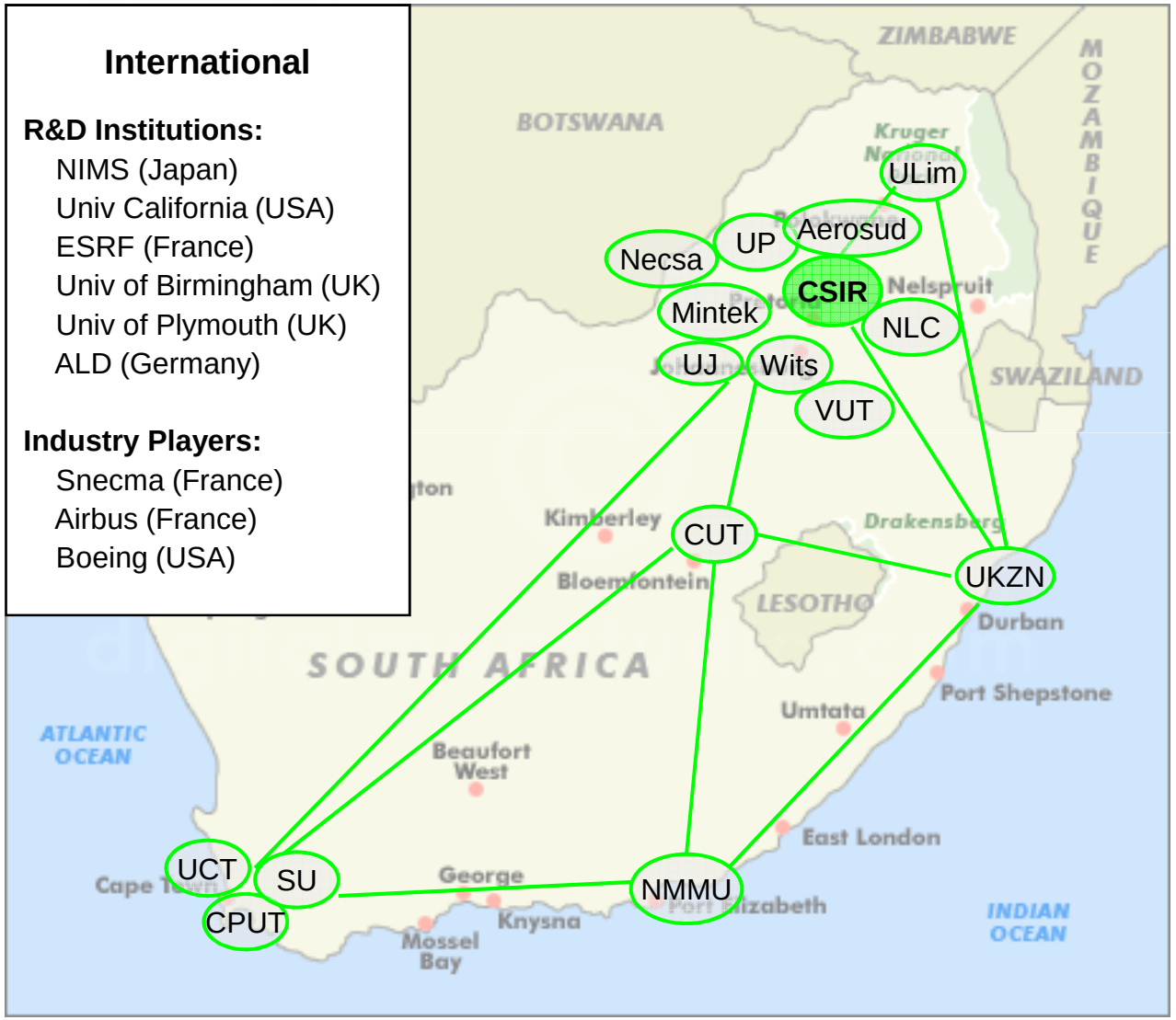
International

R&D Institutions:

- NIMS (Japan)
- Univ California (USA)
- ESRF (France)
- Univ of Birmingham (UK)
- Univ of Plymouth (UK)
- ALD (Germany)

Industry Players:

- Snecma (France)
- Airbus (France)
- Boeing (USA)



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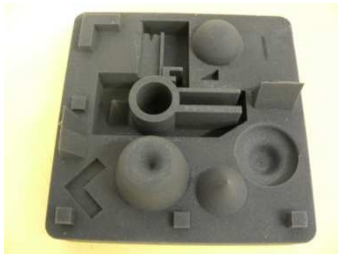
Investment Casting of Titanium Alloys

- Only a few players in the world can cast Titanium successfully on commercial scale
- They handle this as proprietary knowledge and do not publish detail
- CSIR had to develop the key processes in the casting process chain
- We upgraded facilities used successfully in the 1990s for casting turbine blades in Nickel-based superalloys, to enable us to investment cast Titanium alloys

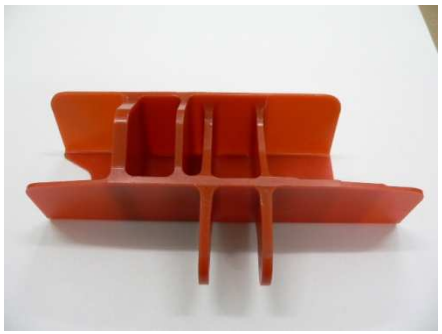
Investment Casting of Titanium Alloys

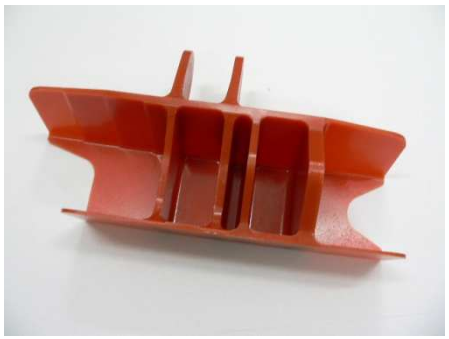
- Developed and packaged the Titanium mouldmaking and crucible melting processes



- Developed and packaged the chemical milling process

- Casting an aerospace part





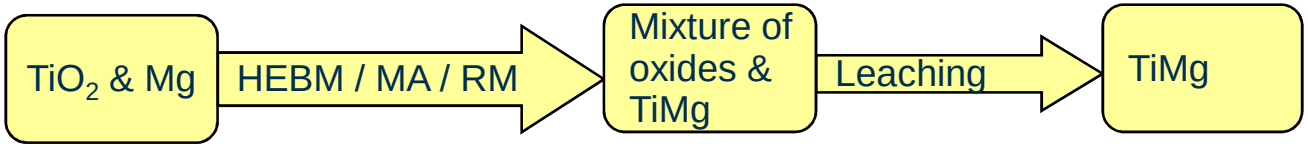
Titanium Powder Processing

- Our primary Titanium metal production process delivers a Titanium powder
- More affordable Titanium powder will unlock a much broader market for Titanium products produced from powder
- Therefore we have been developing a Titanium powder processing competence since 2006
- Through strong support from the DST we have been ale to acquire essential equipment

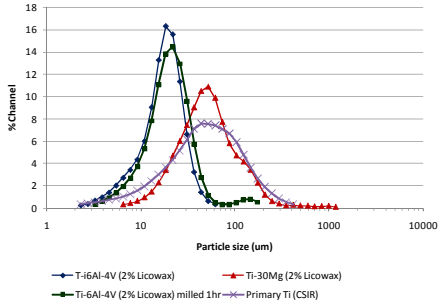
Titanium Powder Processing

- Establishment of our metal injection moulding process with first test samples

- Patent on novel Ti-Mg alloys via direct reduction of TiO_2



- Compaction and sintering of powder produced through the CSIR process



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Semi-Solid Metal Casting of Aluminium

Development of the CSIR Rheocasting System

Establishment of a High Pressure Die Casting cell

Redesigned an automotive component for SSM forming

SSM Forming of Aluminium Alloys

Casting Alloys:

- **A356**
- **A201/206**

Wrought Alloys:

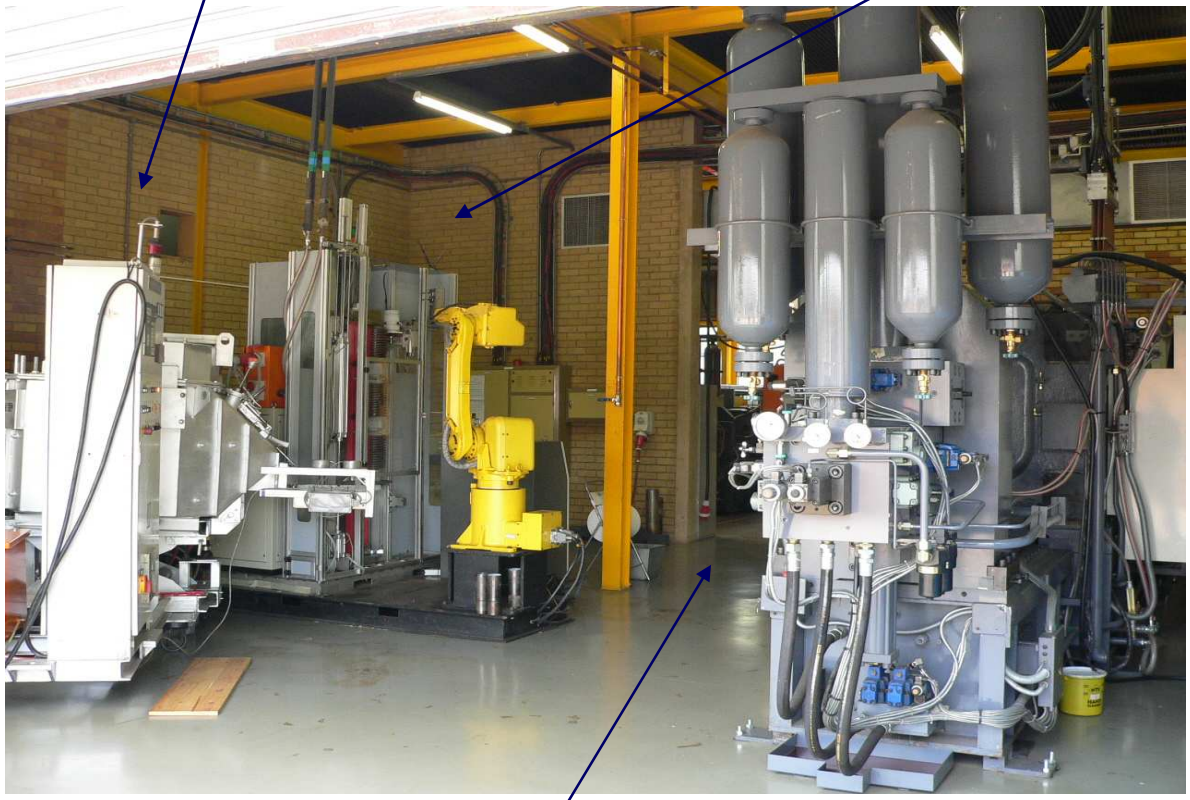
- **7075**

Establishing an HPDC facility with the capability to perform short production runs (industrial simulation)

CSIR Aluminium Rheo Casting Cell

Dosing Furnace

SSM billet machine



650 Ton LK shot control die casting machine

Conclusions

- The Titanium Centre of Competence has successfully aligned Titanium related R&D across the country and focused these strongly on needs of the aerospace industry
- The Investment Casting process for Titanium castings has been successfully developed and packaged and the commercialisation effort has started
- The patented CSIR Rheocasting technology for semi-solid metal casting of high strength Aluminium alloys is also ready for commercialisation and offers interesting opportunities for aerospace application

Acknowledgements

I would like to acknowledge the contributions of my colleagues and their research teams:

- Investment Casting: Pierre Rossouw
- Powder Based Processing: Dr Hilda Chikwanda
- Semi-Solid Metal Casting: Dr Sagren Govender

Thank You