Integrated aviation manufacturing solutions

DDMC 2016 Berlin
Systematic Implementation of Additive Manufacture

AEROSUD

Systematic Implementation of Additive Manufacturing

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- Typical Aerosud products
- Macro South African environment (with regards to Ti and AM)
- Aerosud Additive Manufacturing strategy
- Implementation of Additive Manufacturing (case studies)
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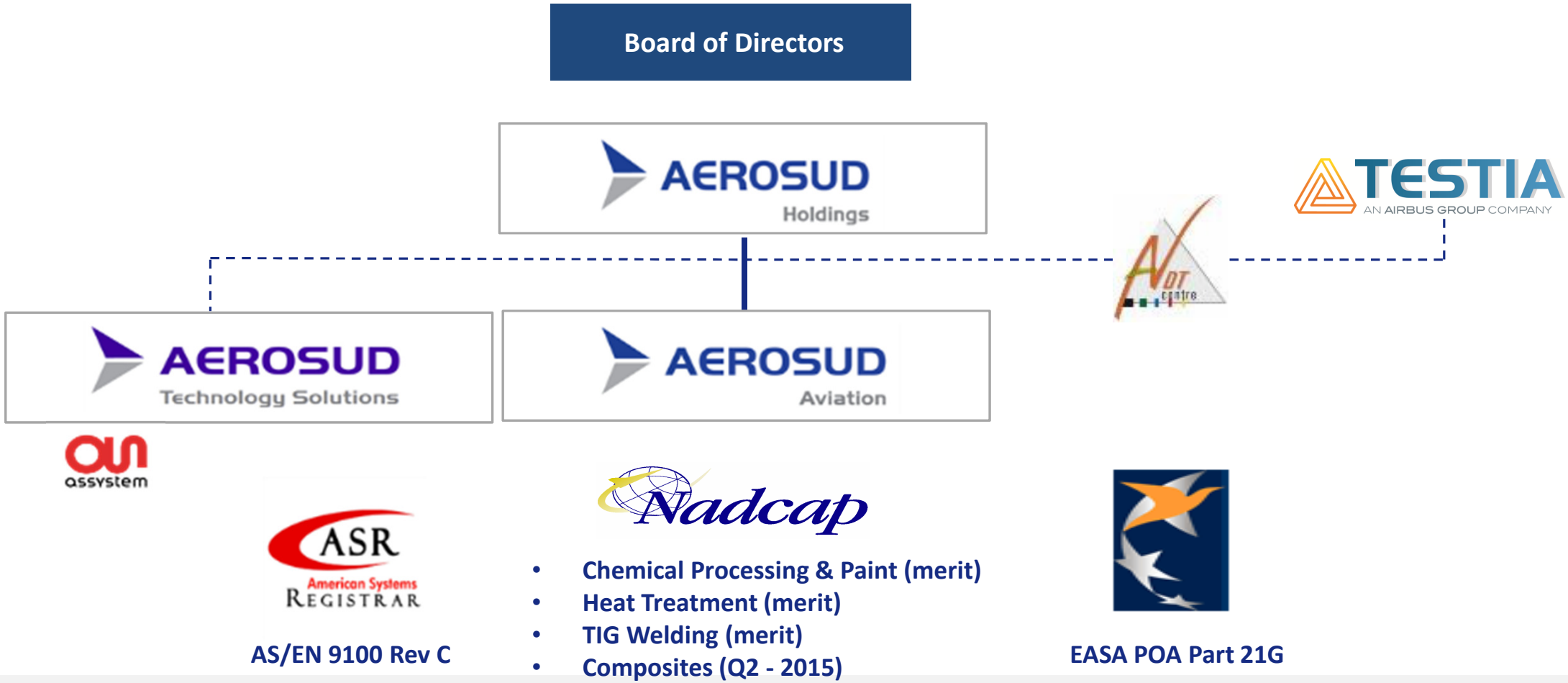
    - Structural components in Ti64 (grade 5)
- Lessons learned
- Closing thoughts

Introduction to Aerosud

Organisation



Introduction to Aerosud: Facilities

Located in Pretoria – 20 minutes by highway to Johannesburg International airport

	2008	2014- 2015
Office Floor space:	3 000 sqm	3 000 sqm
Manufacturing Floor space:	10 000 sqm	13 000 sqm
Warehousing Floor space:	2 400 sqm	2 800 sqm
Off-site Expansion (Kruger Ave)		600 sqm
Receiving facility		400 sqm
Dispatch Facility	120 sqm	300 sqm

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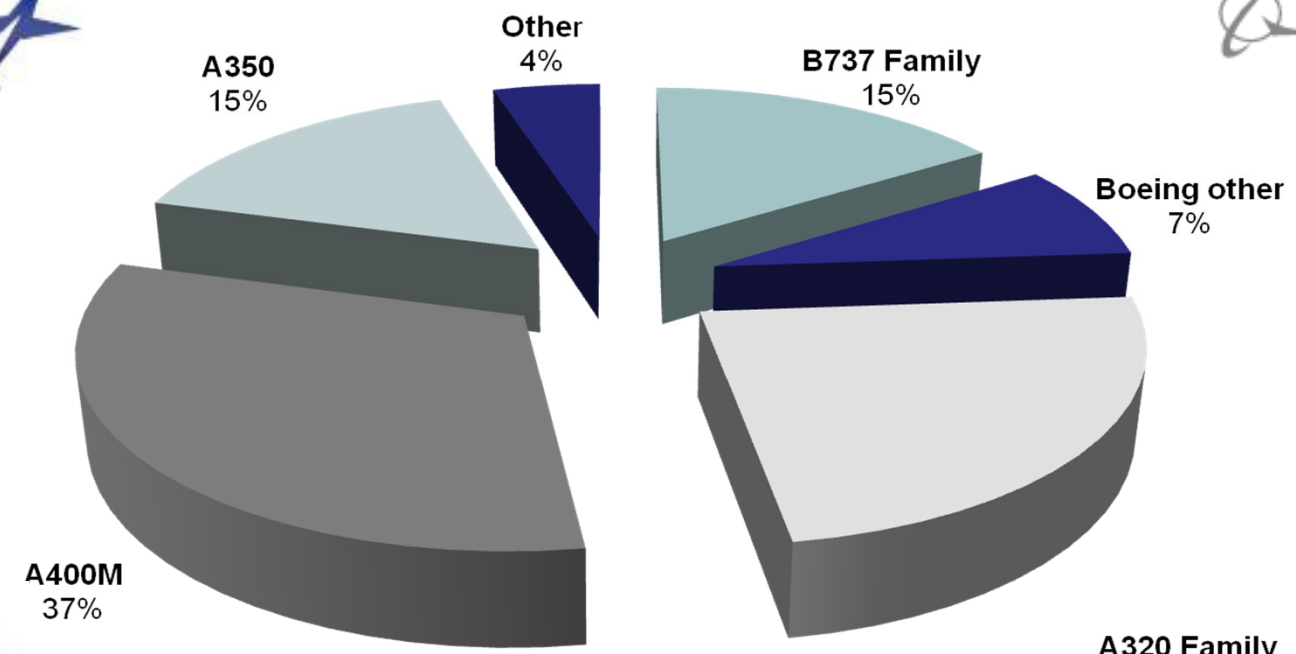
Introduction to Aerosud: Customer Profile

Annual Turnover: 70mUSD (2015) **Staff : 660**



SPIRIT AEROSYSTEMS

BOEING

AIRBUS

AIRBUS DEFENCE & SPACE

SAFRAN Labinal Power Systems

SPIRIT AEROSYSTEMS

AEROSUD Aviation

Typical Aerosud products

Current products

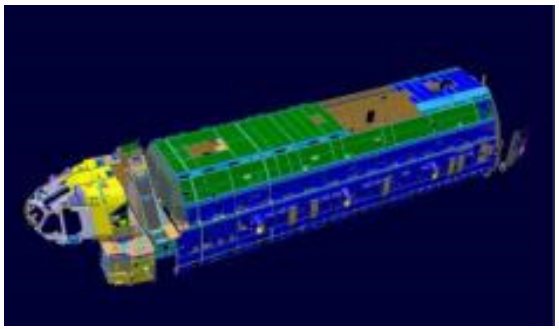
Avionic racks

C-Class components

Metallic Track cans

A350 Frame clips

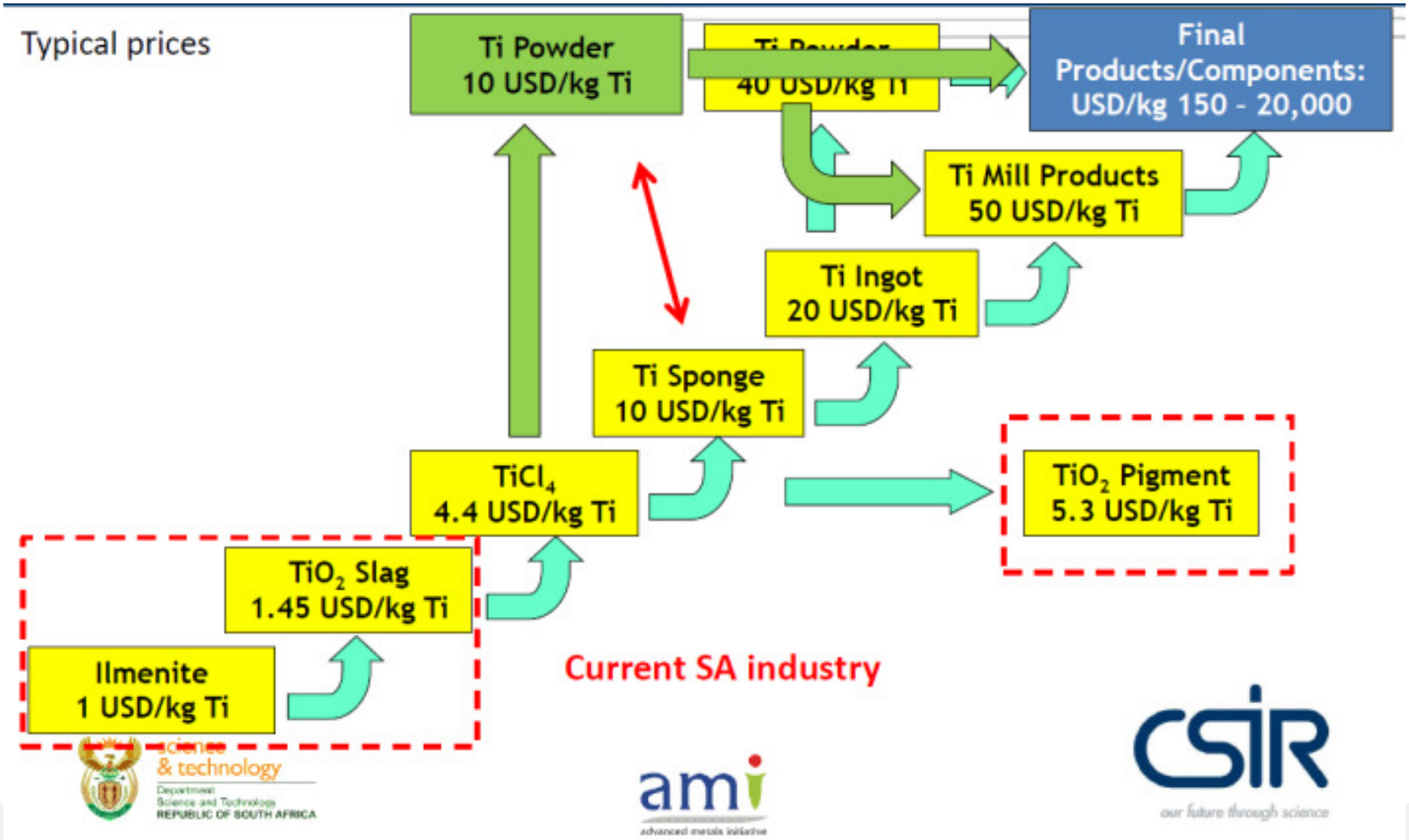
A350 Frame clips installed



A400M Interior

Macro South African environment

Titanium ore and powder production (slide courtesy of the CSIR)



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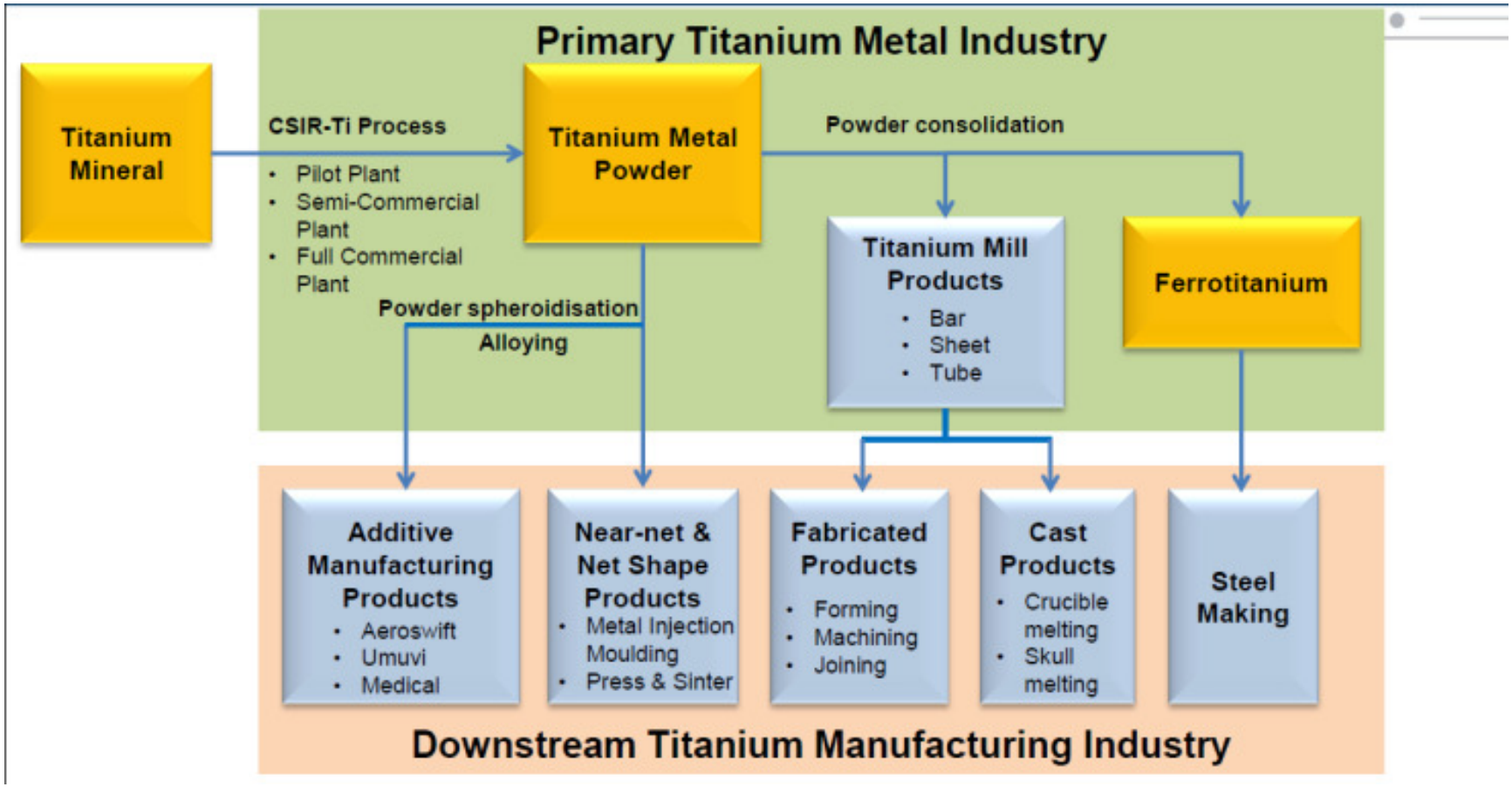
Macro South African environment

Titanium Industry Strategy (slide courtesy of the CSIR)



CSIR
our future through science

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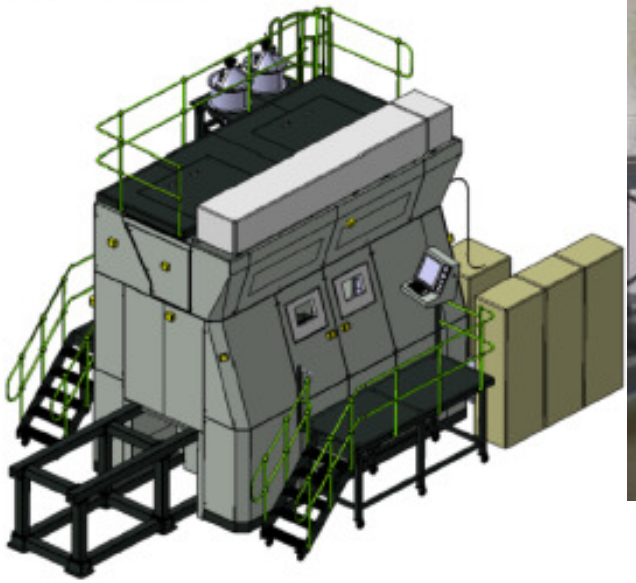
Macro South African environment

Aeroswift

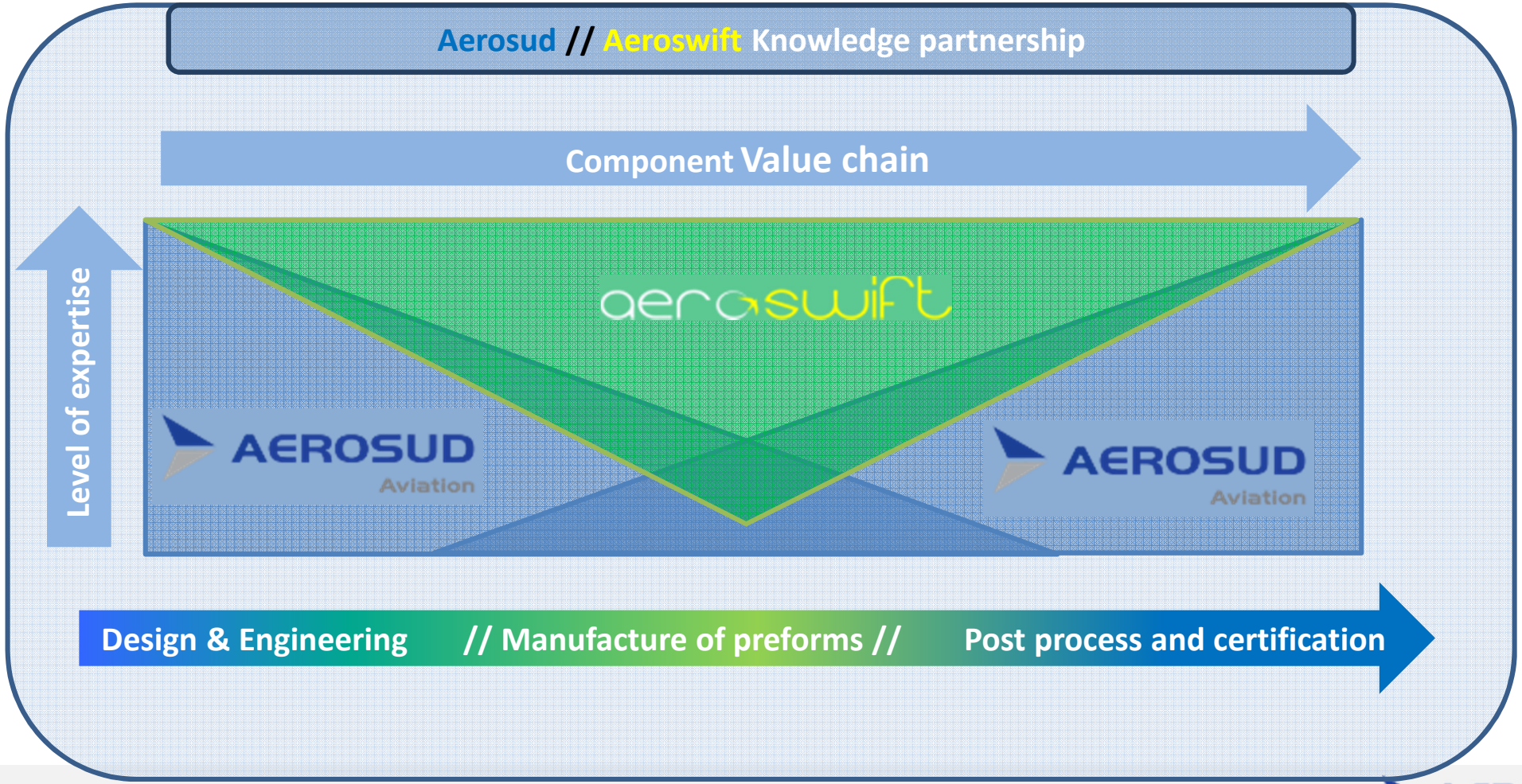
Design and construct a large area, high power, powder bed AM system, for metallic components:

- Powder layer manufacturing – 5kW laser
- High speed system for production of large titanium parts
- Versatile to support optimization of parameter field
- Build volume: 2m x 0.6m x 0.6m
- Scalable build volume
- Scan speed up to 50 m/s
- Preheating at ~600˚C
- Low oxygen atmosphere (Argon)



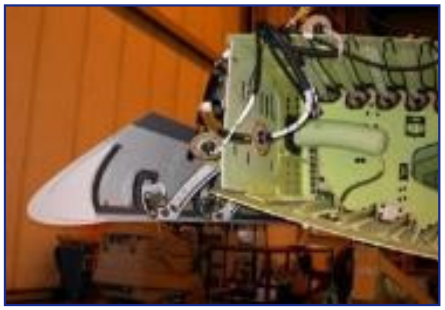
Macro South African environment

Aerosud / Aeroswift positioning for cooperation



Implementation of Additive Manufacturing (case studies)

Cell Core Technology (CCT) Composite “track can” development



Currently made from deep drawn metal components; welded assembly.
Composites could yield a lighter and cheaper assembly

CCT uses a thermoplastic cell as a layup geometry and is then subsequently cured in an autoclave
Cells are normally roto-moulded

SLS Masks was produced to aid with the placement of carbon plies.
Normally performed with laser positioning system

Three test articles successfully built and tested with no capital layout.
Without the SLS intervention, this development would not have been feasible due to capital cost and time to deliver equipment.

Cell Core Technology (CCT) Composite “track can” development

Lessons learned:

1. **It works**
2. **The theory (marketing) and the actual components are the same**
3. **High predictability, good correlation**
4. **No problem…**

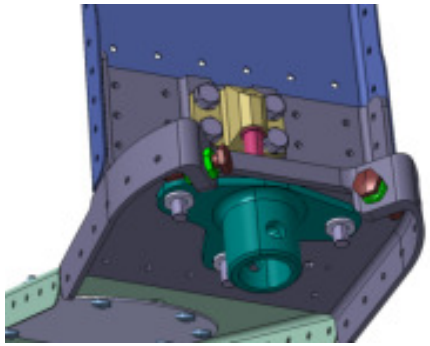
Implementation of Additive Manufacturing (case studies)

Structural components in Ti64 as part of the CFRTP rudder demonstrator

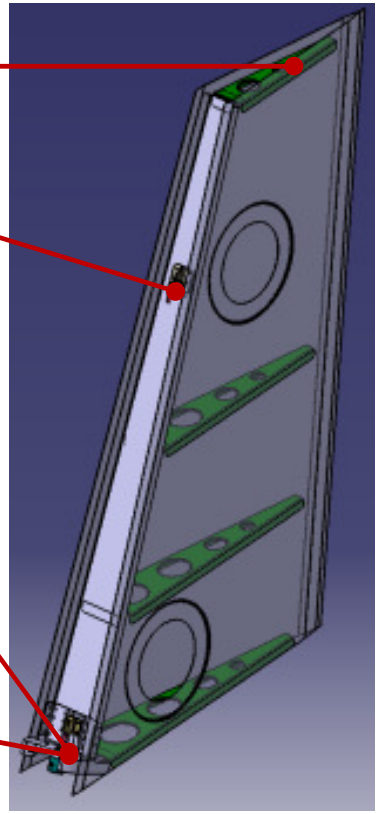
Additive Laser Manufacturing (ALM)

Polymer end cap

Titanium parts



Original design of lower fitting



CAD design of rudder

Harm Alberts from Tencate receiving the demonstrator at the JEC in Paris 2016

Implementation of Additive Manufacturing (case studies)

Optimisation software

To take maximum advantage of the ALM process,
The components must be redesigned

From the Theory (Marketing) this is easy as can be seen from the diagram to the right.

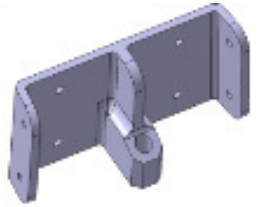
Lesson 1:
The software doesn't deliver on the marketing yet.

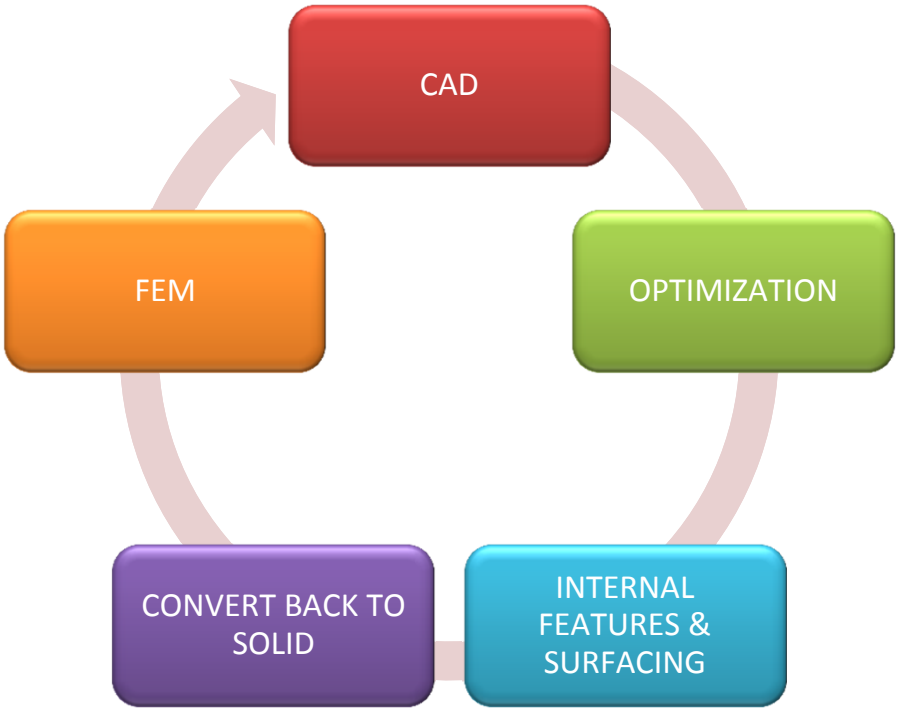
There is no "bamboo button"

Work packages containing thousands of part numbers will take too long to design this way.

Implementation of Additive Manufacturing (case studies)

The Design for Additive Manufacturing General Philosophy





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Implementation of Additive Manufacturing (case studies)

No turnkey software solution exists you have to do your own pairing

CAD

SIEMENS NX

CATIA

PTC creo™

EVOLVE solidThinking / WHERE IDEAS TAKE SHAPE

CAE
Pre / Post & Solver

MSC Patran & MSC Nastran

Altair HYPERMESH & optistruct

INSPIRE solidThinking & optistruct

TENCATE

AISI

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Design Tool Pairings that will work

The software vendors as shown on the previous slide are paired in terms of the design process loop that is feasible.

Row 1 shows the CAD package
Row 2 shows the Pre/Post process and then the solver.

CAD	Catia	Catia	Nx	PTC Creo	Solid Thinking: Evolve	CAD House
CAE	MSC.Patran MSC.Nastran	HyperMesh OptiStruct	Nx MSC.Nastran	Solid Thinking: Inspire OptiStruct	HyperMesh OptiStruct	MSC.Patran MSC.Nastran

Implementation of Additive Manufacturing (case studies)

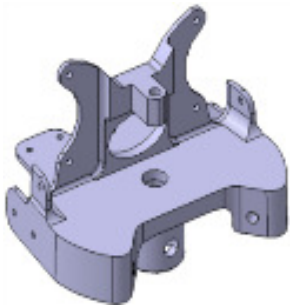
Design Solutions (you can build anything you can design?)

To take maximum advantage of the ALM process,
The components must be redesigned / optimised

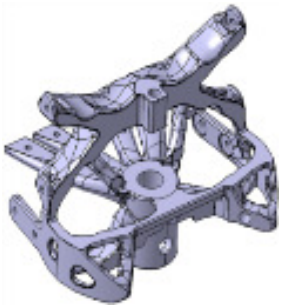
After redesign and drawing your own bamboo structure (refer to lesson 1)

Lesson 2:
Not all geometry is printable in metal.

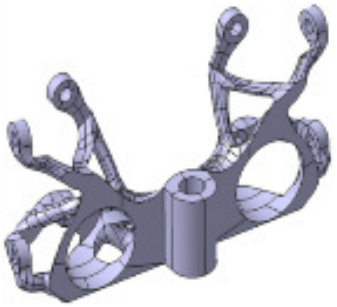
Catia – MSC Patran/Nastran



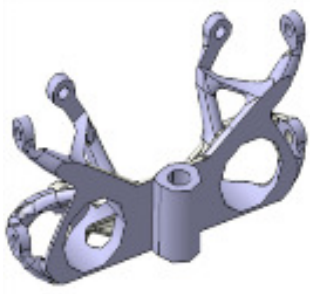
Catia – HyperMesh & OptiStruct



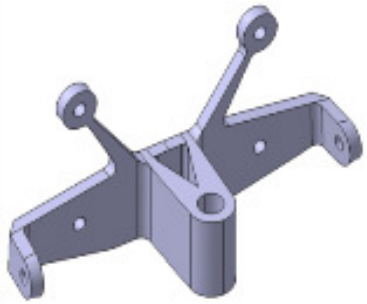
Catia – HyperMesh & OptiStruct



PTC Creo – Solid Thinking & OptiStruct

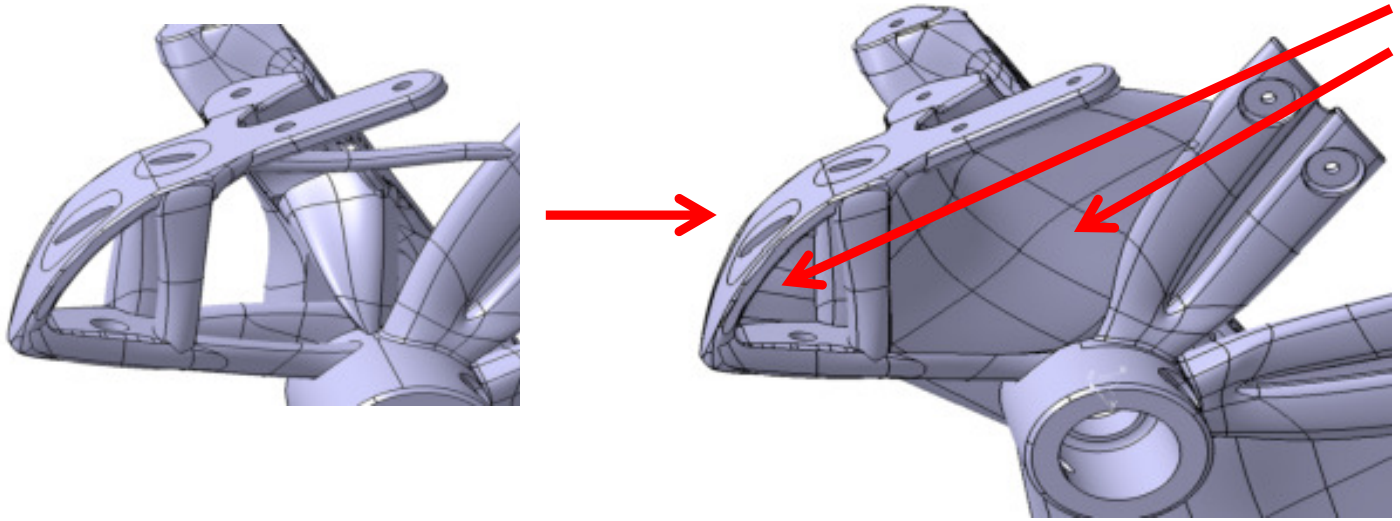


Catia – HyperMesh & OptiStruct



Design Solutions (you can build anything you can design?)

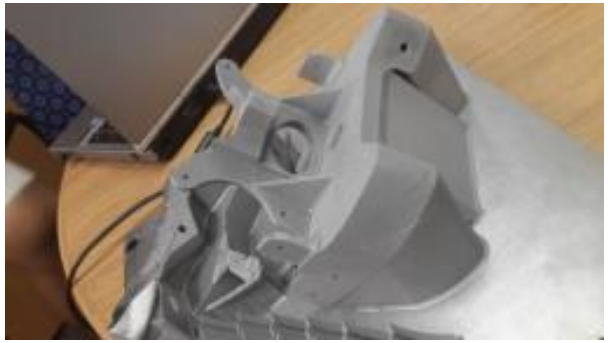
Adding features for printability means adding weight or extra machining operations



Additional webbing required to stabilize the structure during printing.

Implementation of Additive Manufacturing (case studies)

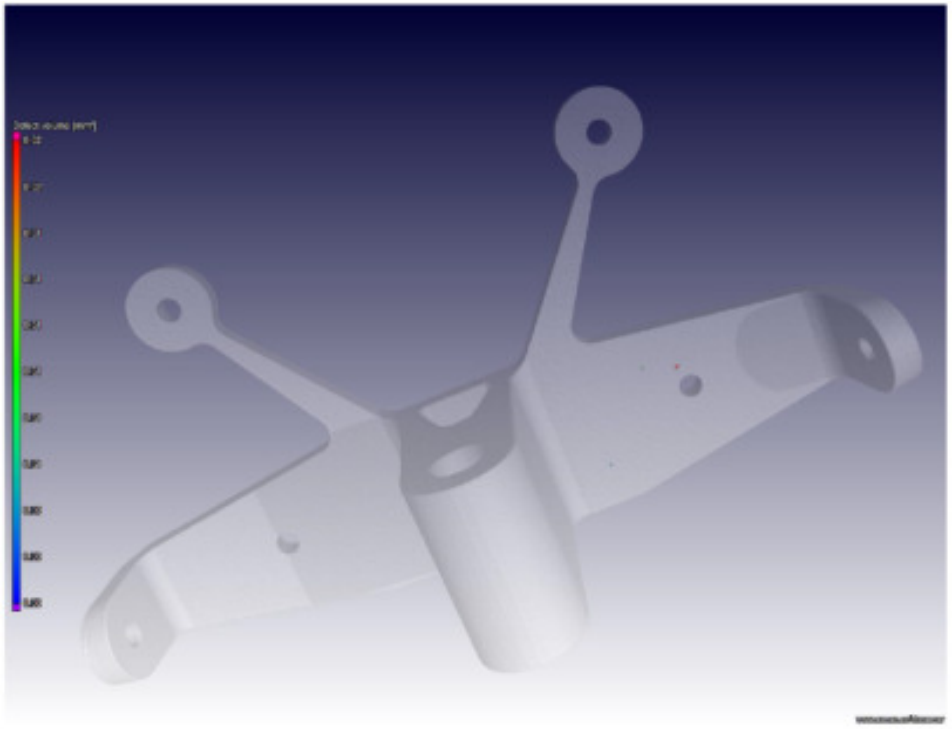
Design Solutions (you can build anything you can design?)

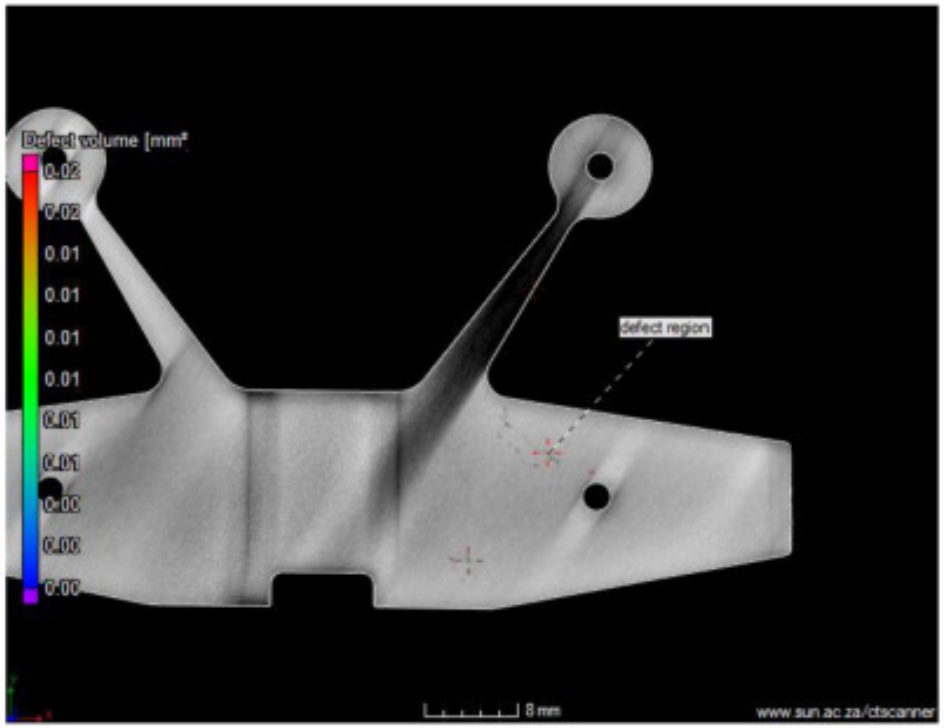


Implementation of Additive Manufacturing (case studies)

Design Solutions (you can inspect anything you build?)

Micro CT scan reveals defects in the components.





What does it mean?

After reading the Micro CT NDT report;
You find yourself asking the question:

What does it mean??

Lesson 3:
There are no published acceptance criteria that will pass components without fatigue testing.

Lesson 4:
Fatigue, what about the surface finish and influence of internal defects?

Implementation of Additive Manufacturing (case studies)

Lessons learned

Lesson 1: There is no "bamboo button"

Lesson 2: Not all geometry is printable in metal.

Lesson 3: There are no published acceptance criteria that will pass components without fatigue testing.

Lesson 4: Fatigue, what about the surface finish and influence of internal defects?

The Gap is too great, we need a more systematic approach to this technology

Systematic solution 1:
Don't use biomimetic structures yet, use prismatic optimisation and retain functional areas of original design.

Systematic solution 2:
Prismatic structures can be built more easily using ALM

Systematic solution 3:
Prismatic designs can be machined while the acceptance criteria is being developed, thereby not delaying the overall certification of the assembly

Systematic solution 4:
Prismatic designs can be machined to clean the rough surfaces.

Conclusion

ALM is not perfect yet, but it is happening and it can not be ignored.

Bridging the gap to the future means that component design must be smart enough to accommodate current and future manufacturing technologies.

Deliberate systematic change to design, engineering and manufacturing processes is the only way to successfully position for the ALM revolution.

Thank you

Questions / comments