




AEL Airborne – NDT challenges

Airborne

- Founded in **1995**
- 200+ employees

Development, manufacturing and maintenance of **composite** structures and components

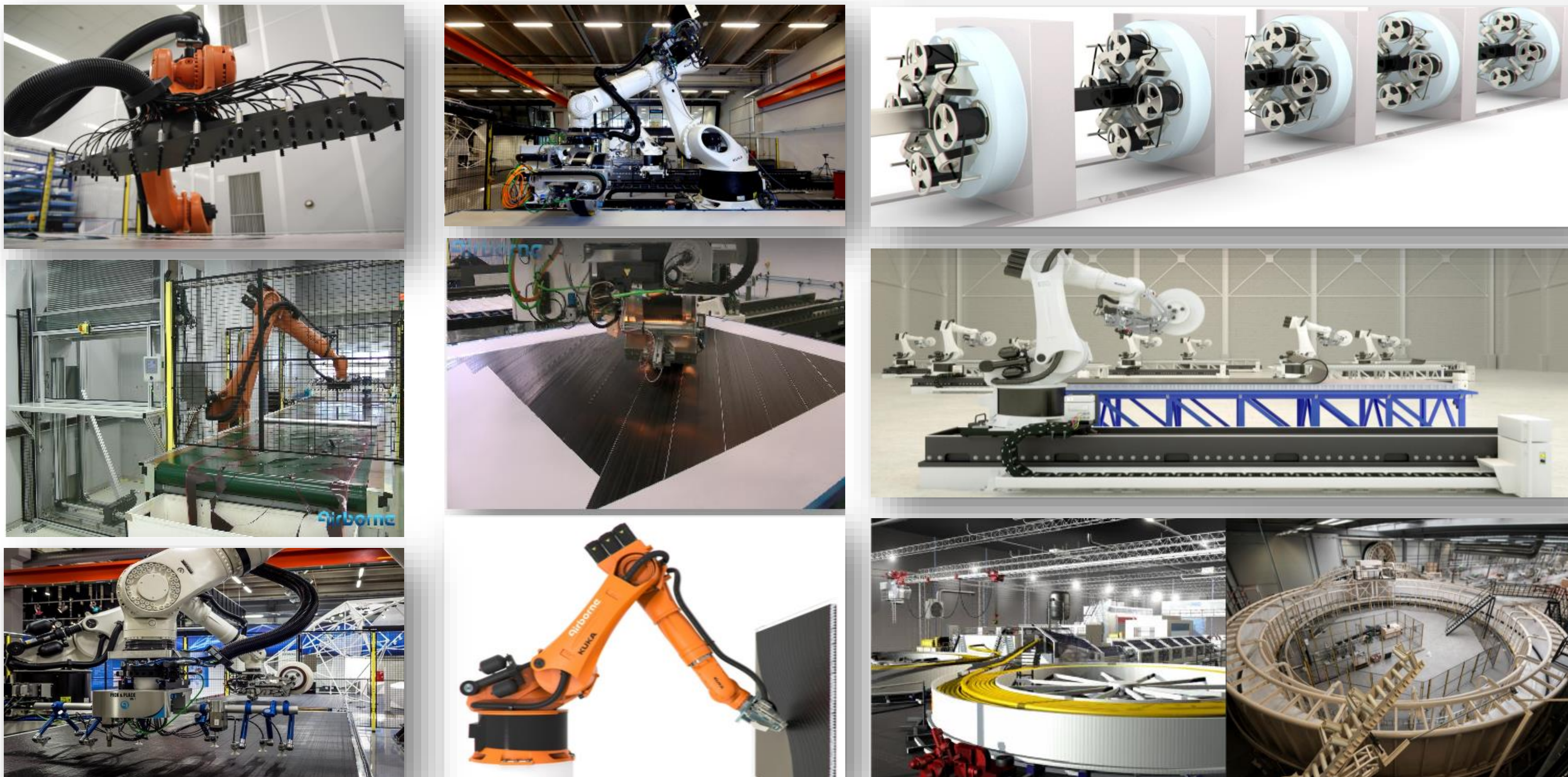
Facilities in the Netherlands, Spain and the UK

4 Business Lines:

- **Aerospace**
- **Marine**
- **Services**
- **Composites Automation**

(Oil&Gas, spin-off 2014)

Experienced in automation – vision to reality



AEL Airborne

formerly Aviation Enterprises Ltd

Previous projects

1992-2005

Development of the “Magnum”
- Composite aircraft
- 100 HP, 160 knts cruising

2002

First tidal turbine blades for Seaflow

2005

Seagen MCT blades

2006

Quiet Revolution VAWT blades

2008

Deepgen 3 (TGL) 500kW

2012

Tocardo

2016

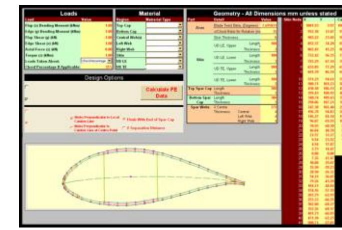
Confidential project

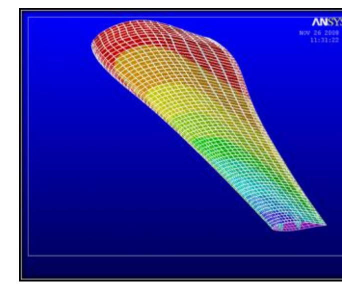
2016+

New tidal energy projects

Design & Engineering

- **Feasibility Studies**
  - E.g Viability of conversion of metallic struture to composite, through ensuring understanding of customer need, providing scenarios/options for customer choice.
- **Conceptual design**
  - E.g Using provided geometry, method of dividing product into smaller productionisable components for easy assembly & assembly methodolgy.
- **Laminate/stress engineering using hand calculations, in-house tools and FEM**
  - E.g Design study for tidal turbine blade including root connection, fatigue and approval.
- **Certication liaison**
  - E.g DNV-GL approval of tidal turbine blade
- **Design-For-Manufacture**
  - E.g re-design of composite bridge module to reduce cost of manufacture, showing evolution of cost with volume (learning curve); options for tooling investment vs piece price; and automation options (investment vs piece price)



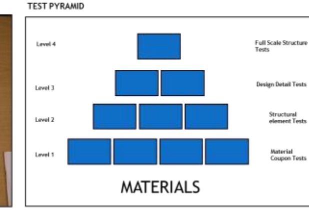


Material Characterisation

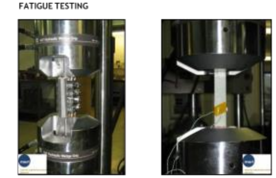
- **Extensive knowledge of long term service in submerged seawater environments through characterised material properties of saturated laminates.**
  - Glass/epoxy infused
  - Carbon/epoxy prepreg
  - Glass/epoxy prepreg
- **Developing experience in degredation of mechnical properties through exposure to chemically agressive environments.**
- **Combination of in-house testing and use of third party laboratories to generate material properties suitable for use by certification bodies**

COUPONS

TEST PYRAMID



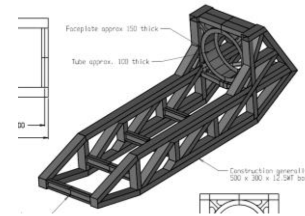
FATIGUE TESTING

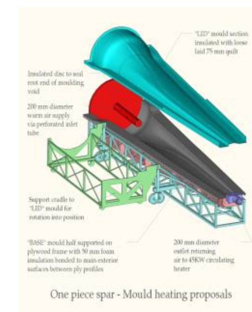


CREEP TESTING

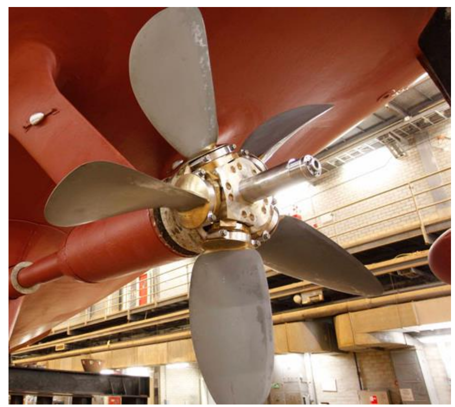
Prototyping and Production

- **Considerable experience building „first off“ parts**
  - Design and contracting of plug manufacture
  - Female moulds including backing frame made in-house
  - Jigs/fixtures made in-house
- **Scale-up and ongoing production**
  - Production tooling
  - Application of mechanisation to reduce labour content
  - 3D scanning; use of DSC; use of FTIR; use of NDT - for QA/QC
- **Understanding of economies of scale**
  - Tooling options – „soft“ vs „hard“ – investment vs return
  - Mechanisation of individual processes to reduce cost
  - Payback calcalations and learning curve rates for volume vs cost.
  - Options for full automation (cutting; pick and place; ply sorting; ply deposition etc)





NDT challenges



Tidal turbine blades

- Designed using saturated material properties
- Typically fatigue-driven designs (20 year life)
- Generally a trade-off between hydrodynamic performance and structural configuration – often means solid, or very thick laminates
- Typically use adhesive bonding (composite-composite and metal-composite)
- Often use carbon, but also glass-only designs.
- Hostile environment and difficult in-service monitoring
- Cost of installation and retrieval is very high
- Prototypes need to work
- Manufacturers want certification
- Little economy of scale yet

Production test questions

- **Does the laminate have the required strength?**

- **Does the laminate have the properties assumed in the design?**
  - Fibre wet-out
  - Void Content
  - Fibre alignment
  - Fibre / ply wrinkling
  - Correct reinforcement materials, stacking sequence, orientation
  - Correct matrix material
  - Degree of cure

- **Can we prove it to the satisfaction of a client without composites experience?**

In Service test questions

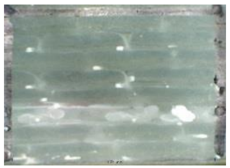
- **Is the laminate still strong enough?**
- **Is the laminate still resistant to the environment?**
  - Fatigue damage accumulation (cracking and delamination)
  - Material strength reduction.
    - Matrix strength reduction
    - Fibre / matrix interface degradation (sizing)
    - Fibre corrosion
- **If it breaks, what caused it.....**

Our Challenges

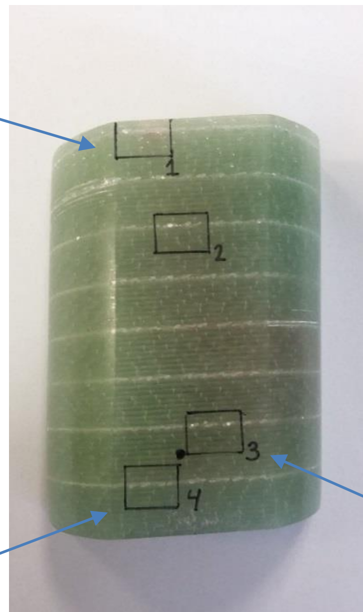
- **General**
  - Heterogenous laminates
  - Not “Aerospace-grade” laminates – some voids are “ok”
  - Thick laminates (100mm-200mm)
  - Large products (5-25m long)
  - Verification of whole part, not just the local area tested.
  - Needs to be quick, cheap, reliable, and credible to non-composites people.

- **In-service specific**
  - In-situ (underwater)
  - In-situ (out of the water, but not disassembled)
  - Coated, potentially with elastomeric material.

Challenges

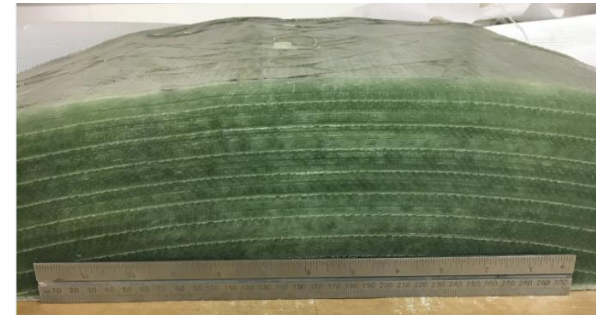


"Poor laminate"



"Good laminate"

"average laminate"



- **Infused glass/epoxy**
- **Different void content allowance by "zone"**
- **Difficult ultrasound penetration**
- **110mm thick laminate**
- **Adhesive joint at the other side of the laminate**
- **Cost effective, quick and easy**

Summary

- **We want/need to be able to:**
  - Differentiate between intentional "non-homogeneity" (e.g layers, lamination features), and non-intentional (dry spots, scissors….)
  - Determine the location of intentional defects in plan and through-thickness
  - Determine the size and identify the type of defect.
  - Achieve this on industrial structures that do not allow for multi-million investments.
  - Needs to be in-process to allow production flow, and prevent defects/scrap from having value-added.
  - Prove to customer that the final product is "good"

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