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Investor Day

Additive Manufacturing Products Division

15th May 2014

Presented by Simon Scott

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Technology definition – Laser Melting

- What is additive manufacturing and 3D printing?
  - 3D printing is a generic term that covers both polymer and metallic layer based manufacturing processes. Industrial machines are usually referred to as additive manufacturing systems – or AM
    - Renishaw AM systems produce functional metallic components from thin layers of atomised metallic powders by ‘laser melting’.
    - They are driven by 3D CAD data that is sliced into two dimensional layers.
    - Each 2D layer of metallic powder is then fully melted using a guided laser beam.
    - The process is repeated layer after layer until a completed 3D object is produced.
    - Unused raw material is then refined and re-used.


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Customer needs

- What are our markets and what are their drivers?
  - Aeronautical, space and defence.
    - Complexity and relative freedom of design
    - Lightweight structures
    - High value materials titanium and nickel alloys

    - AM offers substantial potential benefits to component manufacturers.
      - *GE have published information stating their expectations that up to 50% of manufacturing could be 'touched' by additive manufacturing and 3D printing.*
    - As with all new technologies deployed in aeronautical manufacturing ,barriers to acceptance are high with significant emphasis on process control and materials performance.

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Customer needs

- What are our markets and what are their drivers?
  - Medical
    - Bio-compatible materials
    - Mass customisation, patient specific design
    - Complex geometries to aid integration into the body

    - AM is already widely used in the manufacture of dental restorations where patient specific tooth restorations are regularly carried out using AM manufactured components.
    - Similar barriers to acceptance exist for ‘structural’ orthopaedic *(bone)* implants as do for aero. Traceability, data collection and record keeping are paramount with emphasis on process control technologies to verify component quality and provenance of materials supply chain.

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Customer needs

- What are our markets and what are their drivers?
  - Motorsport and high tech engineering
    - Ability to respond rapidly to design changes
    - High performance Titanium, Nickel and Aluminium alloys
    - Heat transfer devices with conformal cooling

    - AM is used on a number of fronts to allow late freeze of the ‘design window’ allowing designers to fully optimise before committing to manufacture. High performance valves, heat exchangers, exhaust components (pictured) and some structural components are already in use.
    - Materials performance high on the agenda and a dependence on time consuming non-destructive QA techniques limits deployment on a large scale presently.

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Customer needs

- What are our markets and what are their drivers?
  - Tooling – mould and die
    - Improved product quality
    - Technology advances to allow high gloss mouldings
    - Improved efficiencies through conformal cooling of mould tools

    - AM is used to produce conformal cooling channels allowing accurate control of the mould surface temperature on complex tools leading to vastly improved product quality, improved cycle time and reduced waste.
    - Fewer barriers to entry, however mould tool design expertise sparse and market is highly competitive.

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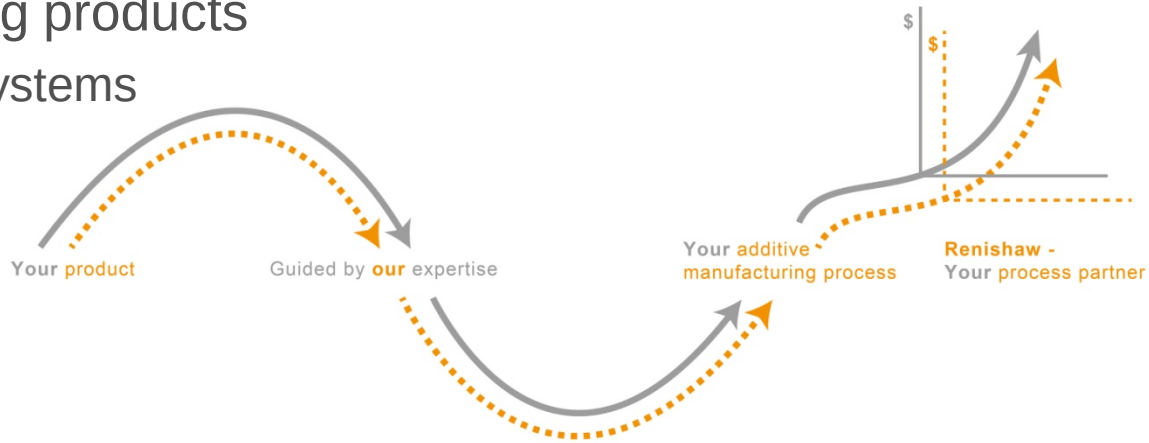
Engineering solutions

- Our Additive manufacturing products
  - Additive manufacturing systems
    - AM hardware - machines
    - Ancillaries - peripherals
    - Software – process tools
  - Expertise/education
    - Materials & process
    - Applications & integration
  - Consumables
    - Supply chain – raw materials
    - Quality – to suitable standards
    - Availability – readily available



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Successful outcomes – Empire cycles

- Partnership project to demonstrate AM applications
  - Public domain project demonstrating.....
    - Topological optimisation, design for process, manufacturing economics, materials testing and robustness, post finish machining and fixturing, heat treatment, adhesive bonding of AM metals, product testing in the lab and in real life!

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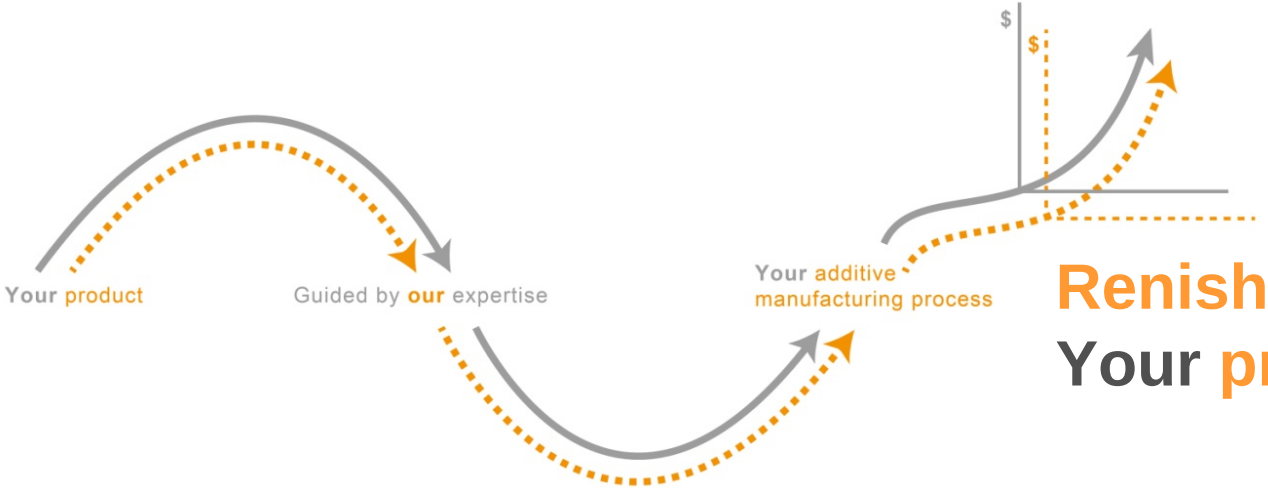
Thank you



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