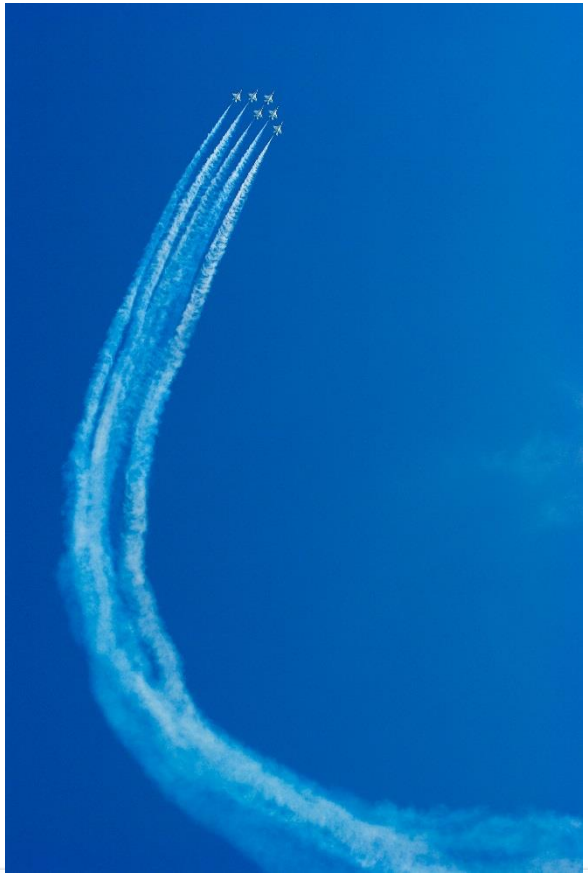

A Systems Engineering Approach to Delivering Manufacturing Growth

Frazer-Nash Consultancy Ltd

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Aerospace Symposium, October 2017

SYSTEMS AND ENGINEERING TECHNOLOGY

FRAZER-NASH CONSULTANCY

Agenda

1. Frazer-Nash Consultancy Overview
2. How Frazer-Nash supports local manufacturing growth
   i. Case study 1 – Birdstrike
   ii. Case study 2 – CREST
   iii. Case study 3 – Airport baggage handling system
3. Conclusions
4. Questions

Who we are and what we do

We are a multi-disciplinary engineering organisation working across many complex industry sectors:

- Aerospace
- Defence
- Power
- Marine
- Transport and Industry

Our vision and heritage

To be a systems and engineering technology business recognised for the highest standards, supporting the development and operation of major projects and facilities.

We aim to be the best in the eyes of our clients and our people.

1920

Our legacy can be traced back to the 1920s. We've always been renowned for our innovative engineering. This passion started with just one man and has shaped the way we operate today.

800

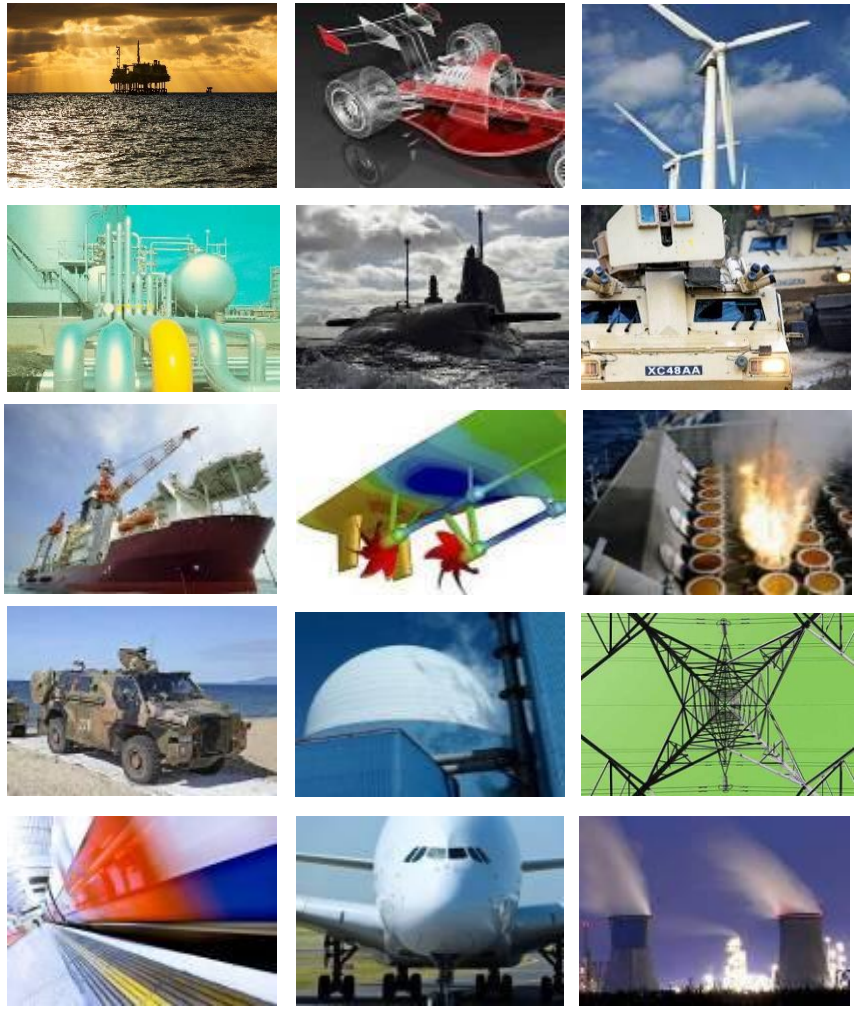
Circa 800 people based in the UK and Australia. Our staff are talented original thinkers who exchange ideas, share knowledge and collaborate enthusiastically.

12

We have 9 offices throughout the UK and 3 in Australia. We strive to build strong relationships with our clients.

Some of our clients

- Aggreko UK
- Airbus
- Atlas
- AWE
- Babcock
- BAE Systems
- Bombardier
- BP
- British Airways
- Cavendish
- Doosan Babcock
- DSTL
- EDF Energy
- GE
- Hitachi
- Horizon
- Jacobs
- Lockheed Martin
- MoD
- Mott MacDonald
- National Grid
- National Physics Laboratory
- Network Rail
- Novartis UK
- Ofgem
- QinetiQ
- RNLI
- Rolls-Royce
- Tata Steel
- Thales
- Ultra Electronics
- Viper Subs
- Wood Group



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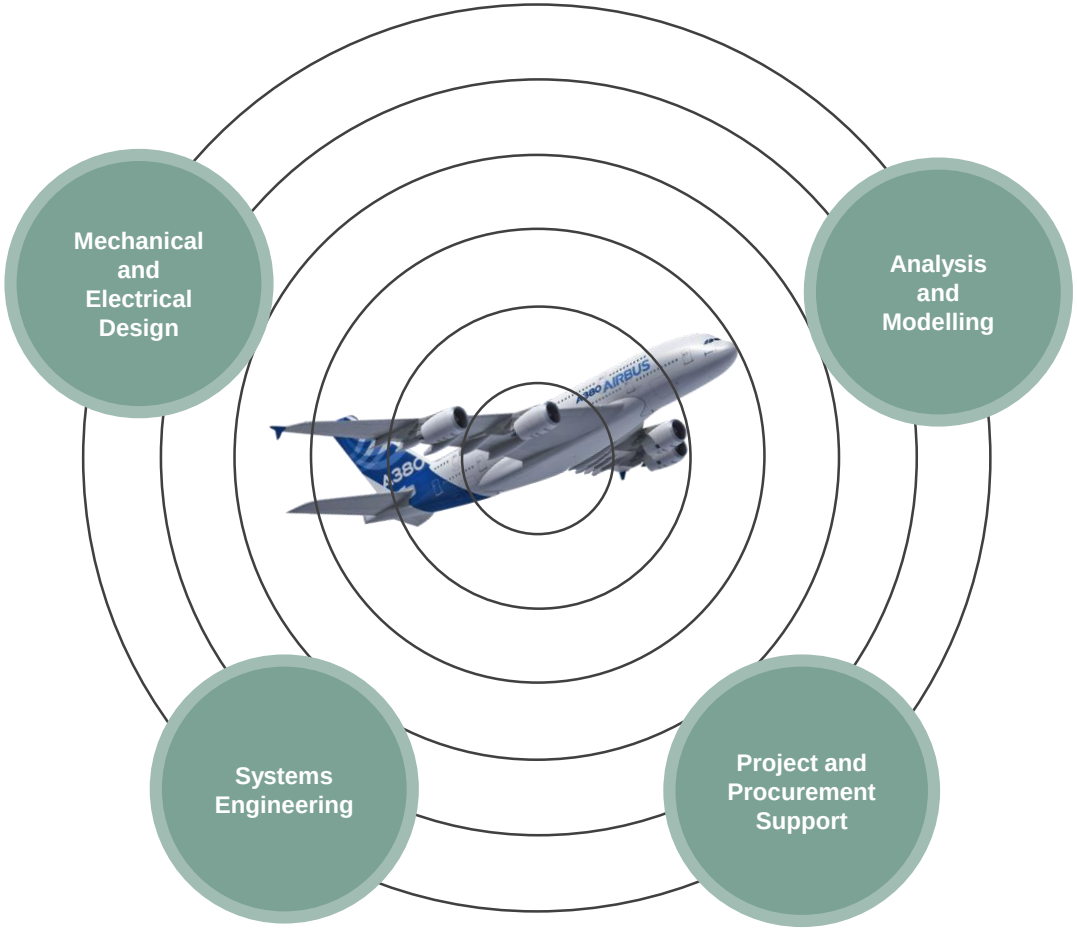
Our capability



Our Approach

1. Define – We define our client's end goal and develop effective solutions;
2. Understand – We assess and improve behaviour of equipment and systems;
3. Integrate – We deliver integrated solutions across the full project lifecycle;
4. Assure – We support critical decisions on safety, the environment and business risk.

- Assisting UK manufacturers using our Systems Approach:
  - Reducing cost of testing and development time;
  - Reduced through-life testing and adoption of improved technology;
  - Increased reliability.
- This is illustrated in the following 3 case studies.

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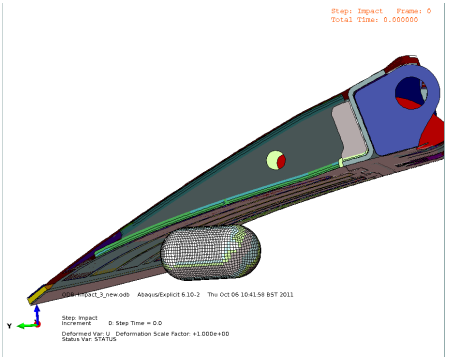
Case study 1 – Birdstrike

Case study 1 – The Challenge

- High stiffness and strength-to-weight ratios of composite materials mean they are a very attractive material for aerospace applications.
- Their use is now commonplace throughout the industry, and increasing.
- Understanding their behaviour, and in particular their failure mechanisms, is crucial if the full benefits are to be exploited.

Case study 1 – The Challenge

- High speed impact events are of particular interest to aircraft manufacturers:
  - Birdstrike;
  - Wheel and tyre failure;
  - Ballistics.

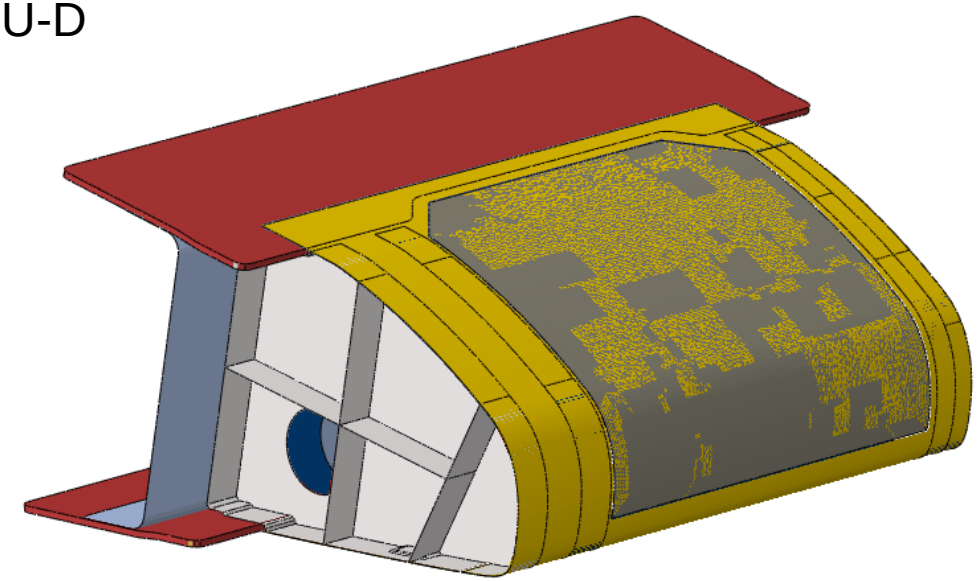


- Full physical testing of composite structures for certification is expensive and programmatically challenging.
- Analysis methods, such as the finite element method (FEM), offer the potential to reduce development timeframes, reduce risk earlier in the design cycle, and reduce cost to the programme. They also offer greater understanding of the behaviour of the system.

Case study 1 – The Solution

- A simplified, but realistic, test specimen was designed to represent a typical Fixed Leading Edge (FLE).

Monolithic U-D skins



Woven carbon fibre panel

Metallic Spar and Ribs

Honeycomb core

Case study 1 – The Solution

- As part of a method development programme using test and simulation to demonstrate the efficiencies of FE.
- We were commissioned to perform:
  1. Pre-test analyses used to steer the impact location and speed to maximise useful output.
     - Results were used to modify the modelling approach:
       - Contact and component interactions;
       - Material damage and failure characteristics.
  2. Post-test analyses used to adjust analyses for actual test conditions.
- Test objectives were to perform:
  - Impacts that isolate individual material failure mechanisms;
  - Impacts that are representative of flight conditions.

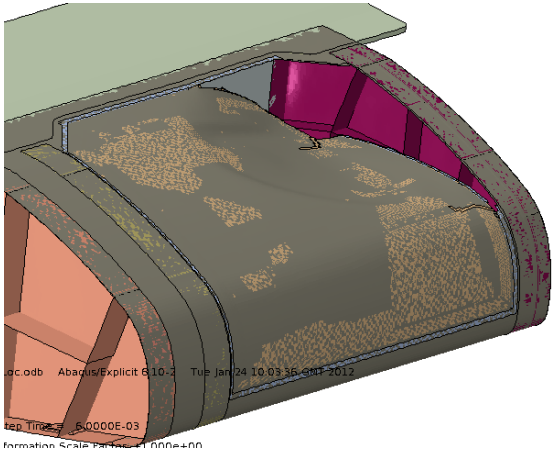
Case study 1 – The Solution

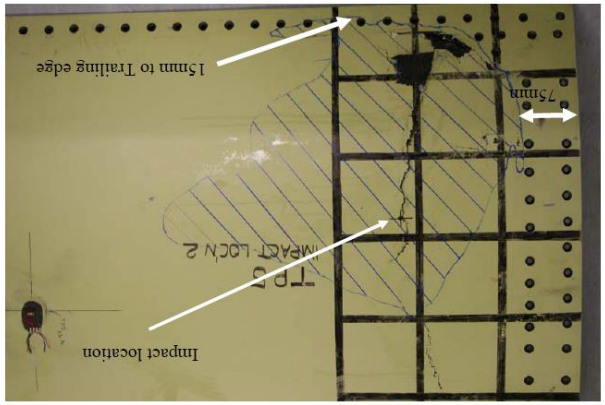
- Location 2

Simulation

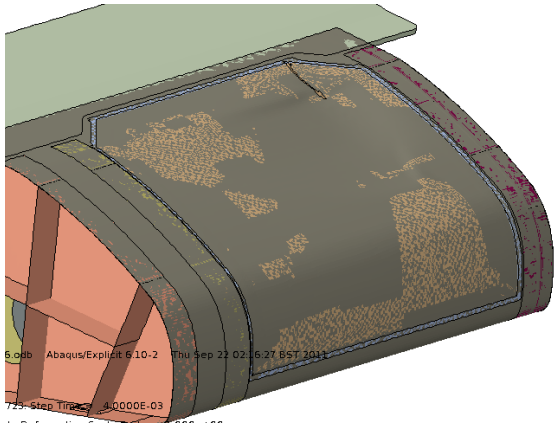
Test

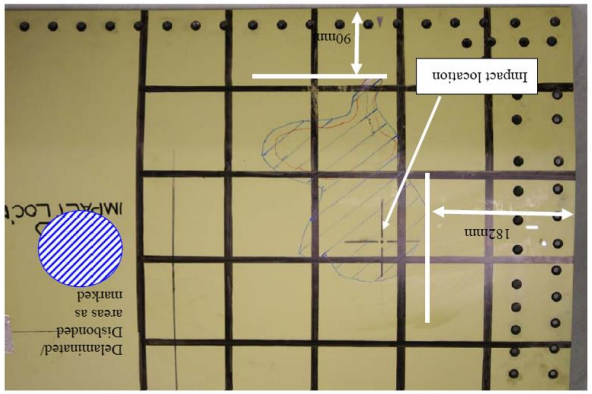
Speed 1





Speed 2

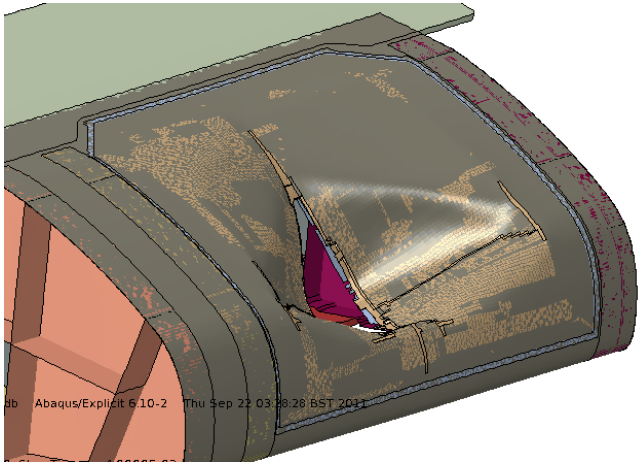




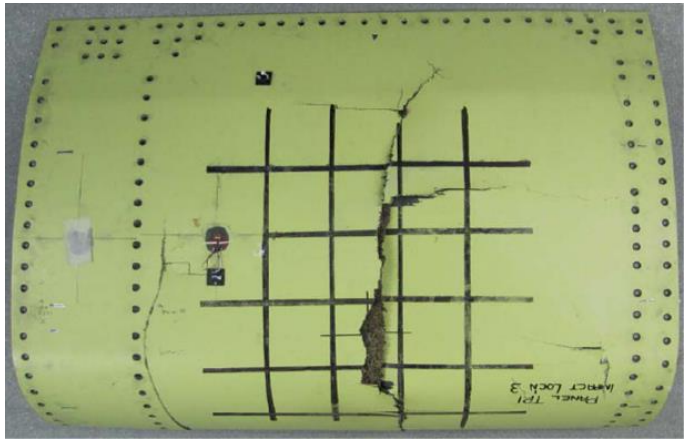
Case study 1 – The Solution

- Location 3

Simulation



Test



- Threshold of failure captured.
- Impacts onto monolithic region predicted penetration.
- Impacts onto honeycomb showed good correlation.
  - Prediction of failure adjacent to rib still conservative.

Case study 1 – Added Value

- Certification of the structure - The FE method can be used with good confidence to predict failure modes reducing the costs and time associated with physical testing.
- Increasing the efficiency of the design process and delivering increased performance.
- Techniques to improve modelling accuracy were identified.

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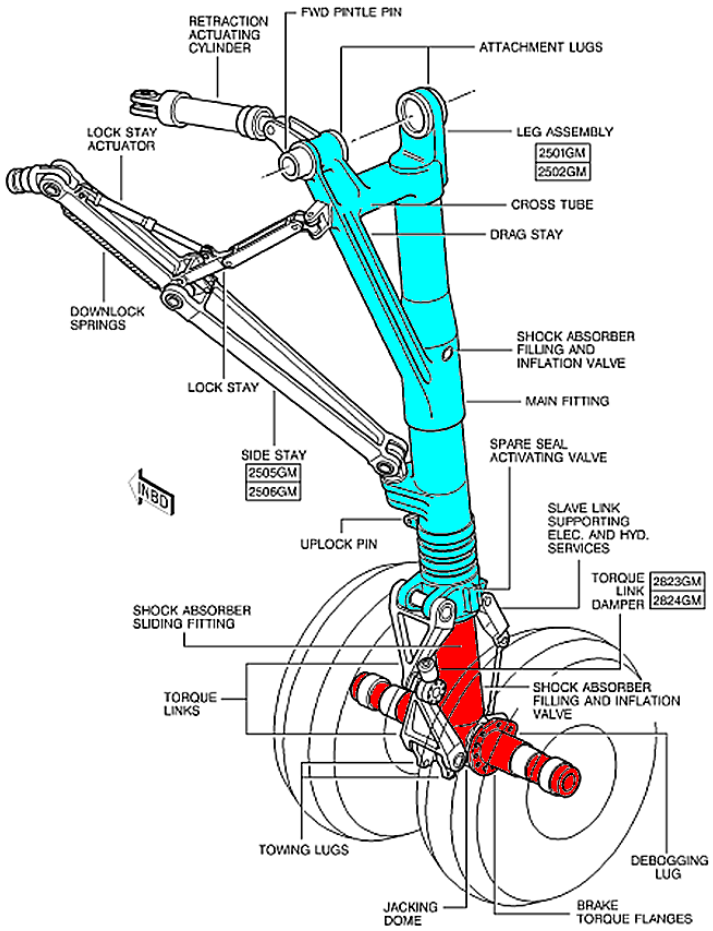
Case study 2 – CREST

Case study 2 – The Challenge

- Corrosion REsisting STeel (CREST) investigated the use of corrosion resistant steels in place of low-alloy carbon steels for use in principal landing gear components.
- This was driven by the discovery of corrosion on the landing gear at overhaul due to the breakdown of protective coatings.
- Cadmium coating is expected to be banned in the near future by EU legislation.
- Low-cost material providing excellent tensile strength, fatigue resistance, and good fracture toughness, while intrinsically corrosion resistant was required.
- Performed a feasibility study for Carpenter Custom 465® stainless steel (C465) main fitting.

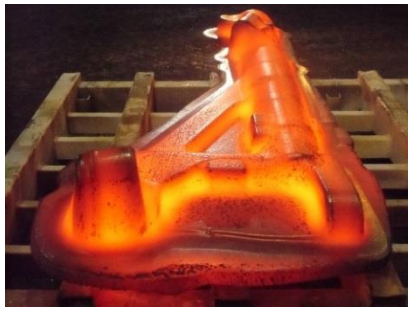


Case study 2 – The Solution

- Maturing the C465 material through to TRL5 for the A320 by:
  - Material properties testing;
  - Material assessment against critical design allowable requirements, including materials interfaces, forging requirements and modelling;
  - Established manufacturing requirements; including machinability trials, assessment of coatings and treatments processes, and production cost estimates;
  - Industrialisation including supply chain strategy and estimating production costs.

Case study 2 – Added Value

- Generated a complete set of material allowables to enable confident design and in preparation for certification;
- Provided corrosion expertise and advice in support of the programme;
- Assembled the evidence from CREST partners to successfully meet the TRL-5 criteria relating to testing in a simulated environment.

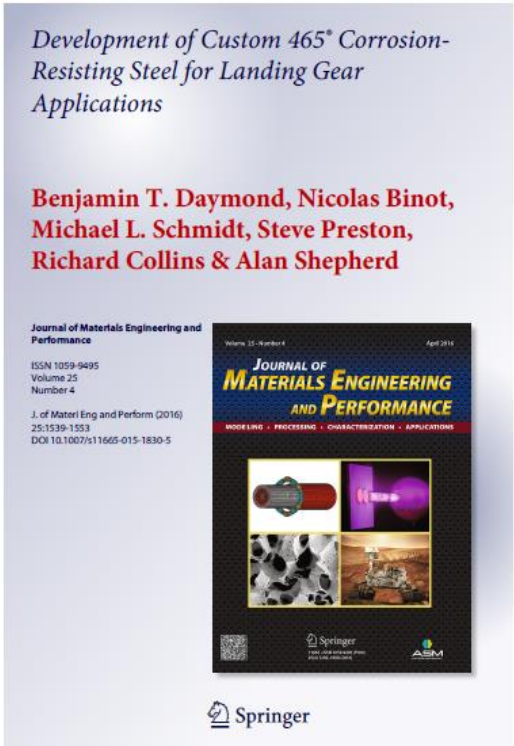


Forged CRES main fitting after closed die operation. (Courtesy of Aubert & Duval)

Fully machined CRES main fitting presented at TRL5. (Courtesy of Airbus)

Case study 2 – Exploitation

- CREST paper on Custom 465® jointly written by Airbus and Consortium members.
- Published in American Society of Materials (ASM) peer-reviewed Journal.
- Publication date April 2016.
- Now publicly available.



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Case study 3 – Airport Baggage Handling System

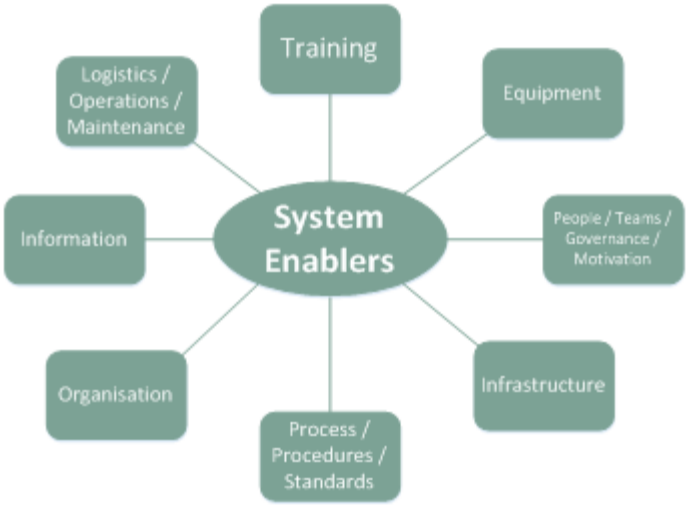
Case study 3 – The Challenge

- Baggage handling system at a UK international airport.
- Results of equipment downtime:
  - Costs due to flight delays;
  - Fines issued by airlines due to missed flights (baggage);
  - Reduced customer satisfaction;
  - Effect on airport reputation.

Tilting sorter

Case study 3 – The Challenge

- Understanding of the system failure modes to improve the risk assessment:
  - Inform planning and decision making;
  - Target investment.
- Applying techniques used in other sectors of Frazer-Nash to this problem.



Case study 3 – The Solution

- Collaborative team (Frazer-Nash, airline, and airport) conducted a serviceability review.
  - Failure modes, effects and criticality analysis (FMECA):
    - Risk based approach;
    - Systematic and auditable.
- FMECA:
  - Identification of critical components;
  - Single points of failure;
  - Human factors, equipment, maintenance, spares holdings and IT.
- FMECA outputs informed a software model with the objective of improving decision making.

Case study 3 – Added Value

- Identification of the effects or consequences of potential failures enabling the development of targeted action plans to reduce costs in such a scenario.
- Increased knowledge of the system for operational managers by reducing uncertainty.
- Mitigation of the root causes to reduce system vulnerability and operating costs, while increasing system reliability.

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Summary

Summary

- Commercial and technical value by:
  - Reducing cost of testing and development time;
  - Reduced through-life testing and adoption of improved technology;
  - Increased system reliability: increasing revenue, reducing costs and improving company reputation.

- Frazer-Nash:
  - Successful completion of traditional and novel engineering projects.
  - A growing company with over 800 people enabling collaboration with academia, research institutes and industrial partners.

www.fnc.co.uk

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