

EC225 Bevel Wheel Vertical Shaft - Lessons Learnt

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Scope

Recap of the Problem

Recap of the Solutions

Lessons Learnt

- Management
- Communications
- Engineering/analysis
- Support/logistic

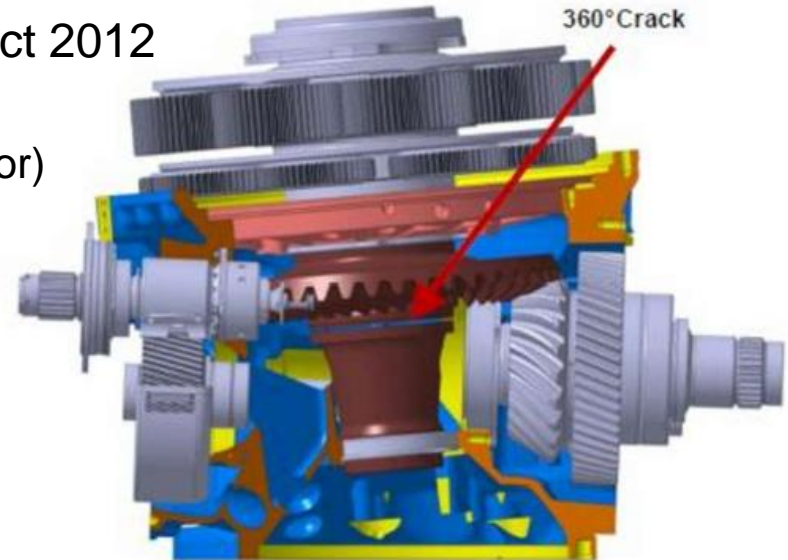
Conclusion



Recap of the Problem

Two EC225 controlled ditchings in May and Oct 2012 due to two separate problems:

- failure of Bevel Wheel Vertical Shaft (causal factor)
- indication of EMLUB failure (contributing factor)



Detailed (~6 month) investigation of 149 potential root causes revealed the cause to be a combination of:

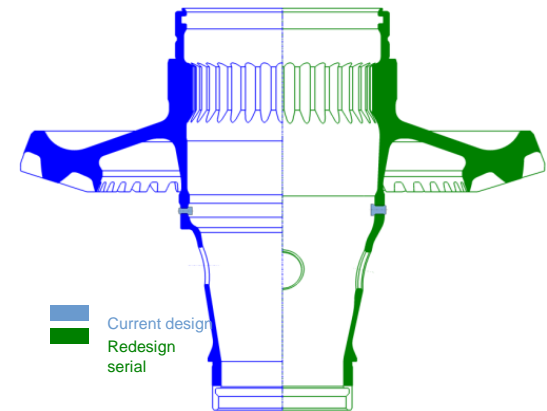
- **Active Corrosion** due to trapped moisture
- **Residual Stress** due to manufacturing process
- **Stress Concentration** (Hot Spots) due to shaft geometry (shape)

Recap of the Solutions

Mid 2013 - Short Term Preventive and Protective Safety Measures implemented to address the root causes and minimise the likelihood or consequence of failure:

- suspect batches (non-conforming hole/chamfer) removed from service
- manual and automatic (oil jet) cleaning
- US NDI – detects a crack on the ground
- MOD45 Monitoring – detects a crack in-flight

Mid 2014 - Permanent Redesign implemented to eliminate all root causes



Lessons Learnt - Management

Rapid Acceptance of Responsibility:

- Eurocopter CEO visited Aberdeen accepting responsibility and expressing concern
- Regular presence of executive management in Aberdeen at appropriate times



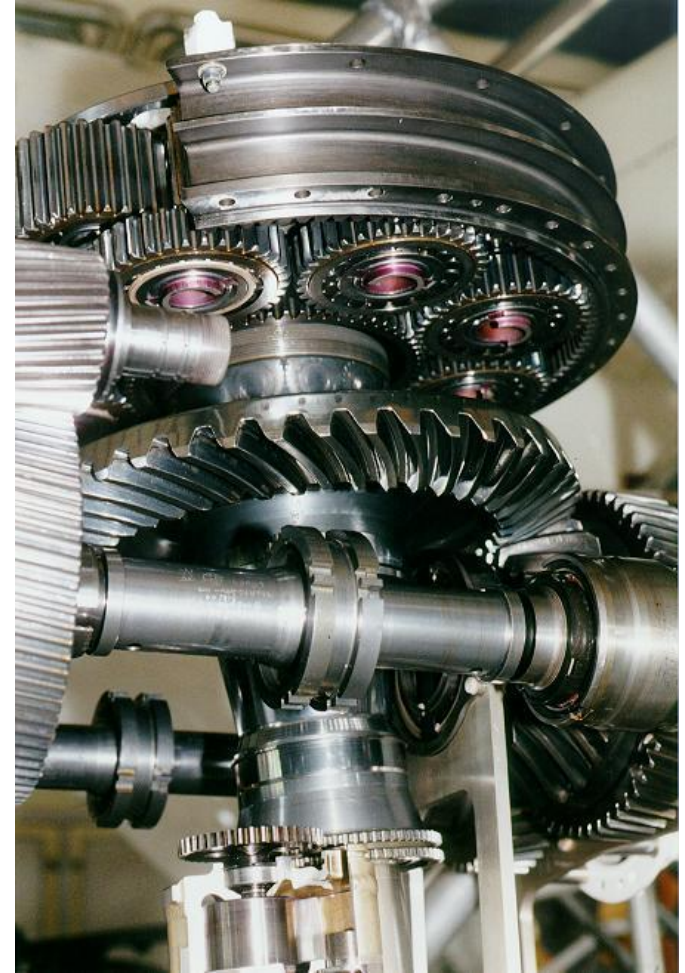
Dedicated Crisis Team:

- Dedicated crisis team leader with full authority
- Dedicated staff for engineering, support, communications, sales
- Dedicated senior manager and communications manager on-site in Aberdeen
- Daily coordination meetings

Lessons Learnt – Management

RTS Process:

- more dependent upon O&G Company 'change' processes than Helicopter Operator readiness
- AH didn't have a good appreciation of the RTS process followed by individual O&G companies (due to lack of direct contact)



Lessons Learnt - Communications

Accessing the Workforce via Step Change's HSSG

- Seen as aligned and independent – therefore trustworthy
- Town Hall sessions gave all stakeholders the opportunity to ask questions

Strengthened Relationship with the Helicopter Operators:

- Main conduit to O&G Companies
- Pilot Briefings provided the real situation 'from the horses mouth' which could then be relayed to passengers

Involving Independent Experts:

- Turbomecca – high speed shaft instrumentation
- Shainin – root cause analysis methodology and verification
- GTRI – crack propagation behaviour
- Professor Burdekin – independent opinion to HSSG



Helicopter
Safety

SHAININ



Lessons Learnt - Communications

Transparency:

- Factual updates released via SIN and IN
- Four Aberdeen stakeholder visits to Marignane
- Dozens of dedicated briefings in Aberdeen
- Materials available on the web-site

Speed of Communication:

- Risky to make public investigation updates due to remaining uncertainty
- Partially overcome by communications with key stakeholders under NDA arrangements

Standard Messages:

- Very detailed technical information was demanded
- Standard Q&A assembled from briefings
- A limited number of selected briefers were deployed world-wide

Safety by design

Redesigned vertical shaft on the EC225

All EC225 operators have resumed flights worldwide. Meanwhile, progress toward a permanent solution has continued:

- Unprecedented engineering efforts
- Collaboration with helicopter customers & external experts
- Solution designed and built with safety at its core

A Redesigned Shaft:

Shattering worn, redesigned lower vertical shafts will be installed on all EC225 helicopters.

Extensive test campaign on new shaft

In order to confirm the robustness of the new shaft and to gain certification by EASA, the campaign entails rigorous tests under a range of conditions, including:

1. Fatigue tests in order to demonstrate the safety margin of the shaft and to extend its service life.
2. Tests in the real main gear box (MGB) with more than 100 hours of tests performed on the "new" shaft, simulating the most stringent flight profiles.
3. Flight tests to check the integrity of the shaft under flight conditions, taking in the new flight envelope.

What about the current safety measures?

The design of the new shaft followed one principal purpose – to remove any and all cracks for a vertical shaft failure.

How do you technically proceed with the exchange?

In general, the entire EC225 fleet will be retrofitted during the upcoming summer. The procedure will be:

- MGB removal by the operator
- Qualified Airbus helicopter specialists
- MGB reinstallation on board by the operator
- MGB full test
- On-site tests by Airbus Helicopters specialists or through ground crew by the operator and supported by Airbus Helicopters
- Flight tests by the operator
- Aircraft released to service by the operator

www.EC225news.com

AIRBUS HELICOPTERS

Lessons Learnt - Communications

Terminology - eg “most probable root cause”:

- Used to respect AAIB constraints and the fact that the investigation was not complete or verified
- Was interpreted as hiding behind words in case we got it wrong

Forecast RTS Timeframes:

- Keen to provide good news to the market
- Resulted in some optimistic RTS forecasts
- More realistic planning communicated for redesign and retrofit

Power of the Media:

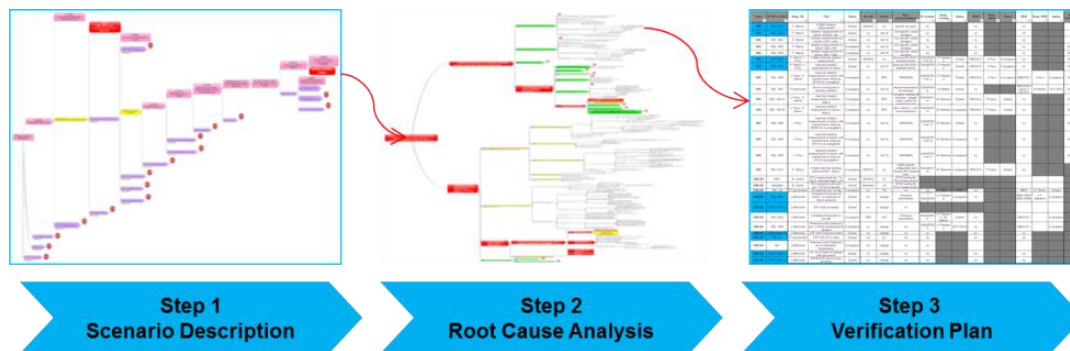
- Possibly the biggest influencer of passenger confidence



Lessons Learnt - Engineering

The Company's Highest Priority

- significant impact on other programmes
- >100 staff dedicated to finding and solving the problem
- EMLUB investigation was not complete before 2nd ditching



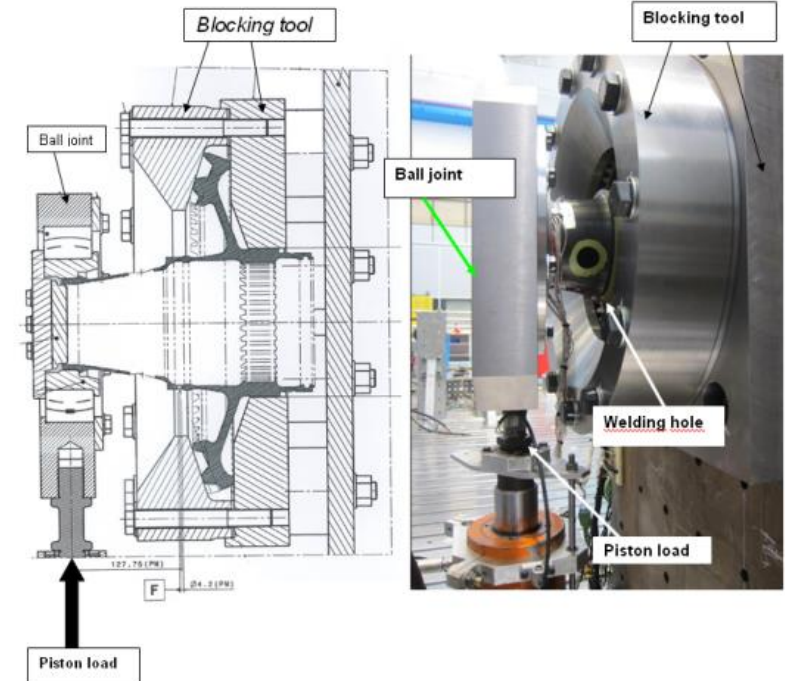
Exploitation of HUMS Capabilities:

- Both shaft failures that led to the ditchings were detectable (before failure) by HUMS
- New or revised thresholds set on all indicators
- MOD45 in-flight monitoring applied as a safety barrier

Lessons Learnt - Engineering

Robust Root Cause Analysis Methodology

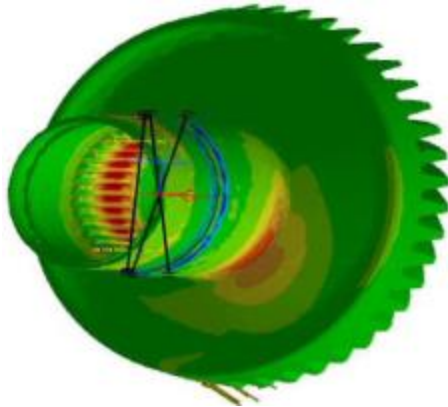
- Conditions to generate an initiating corrosion pit (outside of the weld plug hole) not imagined before the 2nd ditching
- ‘Aberdeen factor’ needed to be fully investigated
- Positive verification if potential root causes did or didn’t contribute to the failure
- Novel experiments
- Replicating the phenomena



Lessons Learnt - Engineering

Rigorous Testing Exceeding Certification Requirements


- Reliance on stress computation via analysis and not measurement in the initial design:
 - Measurements taken during investigation and redesign
 - All related gearboxes also checked and OK



– Initial MOD45 In-flight display software release:

- HUMS messages were expected by AH test pilots, but not fully documented or explained to line pilots
- Caused some MOD45 ‘false alarms’ upon RTS
- Initially corrected through training and documentation, and later via a SW update

3.2 MOD45 FAIL

Symptoms	Condition
 <p>On the instrument panel</p>	<p>MOD45 acquisition is invalid</p>
Procedure	
<p>- Limit speed to 120 kt IAS and limit to 65 % the Maximum Continuous Torque in level flight above 60 kt IAS.</p> <p>Within 15 min:</p>	
<p>HUMS + HUMS on the instrument panel.</p> <p>MFARMS control panel: MOD45 RUNNING</p> <p>CONTINUE THE FLIGHT</p> <p>AVOIDING 125 kt IAS AND APPLYING MORE THAN 65% TORQUE IF REQUIRED</p>	<p>HUMS + HUMS on the instrument panel.</p> <p>MFARMS control panel: MOD45 FAIL</p> <p>Select MOD45 menu, display the FAIL time (FAIL FOR xxxxx).</p> <p>Limit to 65 % the Maximum Continuous Torque in level flight above 60 kt IAS.</p> <p>LIMIT DURATION OF FLIGHT</p>

Lessons Learnt – Support/Logistics

Transparent World-wide Priorities and Commitments:

- AH developed a plan and then negotiated it with separate helicopter operators
- Fine adjustments made during weekly planning meetings
- 1st deliveries made concurrently to avoid priority disputes
- All Safety Measure retrofit kits delivered according to the plan
- Risks and conservative assumptions incorporated into the planning to provide a high degree of confidence
- Similar process is being followed for shaft retrofits



Lessons Learnt – Conclusion

Transparent, factual communications was the key to restoring confidence in the product and company, especially by demonstrating:

- Commitment to find and correct the problem – priority and resources
- High degree of technical expertise applied
- Transparency
- Meeting kit delivery promises



Additional Information

Additional information can be obtained from:

- 'new shaft' poster and leaflets
- Airbus Helicopters' knowledge centre
<http://www.ec225news.com>
- Step Change in Safety knowledge centre
<http://www.stepchangeinsafety.net/knowledgecentre>



Airbus Helicopters remains available to assist with briefings and briefing materials and has cut-away examples of the old and new shafts available for viewing in its facilities in Dyce.

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