

*Resolution of Premature 777 APU
Bearing Failures using VLM Simulation*

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and

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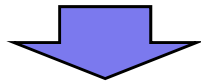
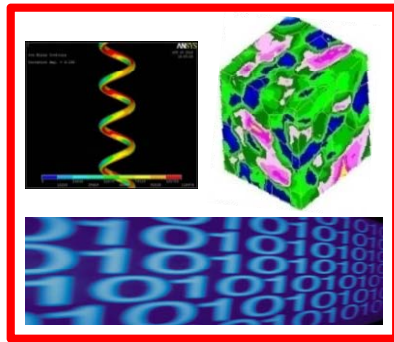
2012 Gorham PMA Parts & DER Repairs Conference

Issue

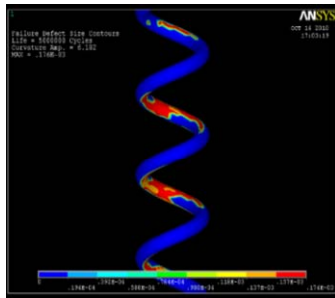
- American Airlines was experiencing high replacement on 777 APU bearings and needed to find resolution
- In March '07, the FAA mandated AA to “cold-start” the APU quarterly, each aircraft, during flight
- AA was averaging 3-4 APU removals per year
 - ❑ High replacement cost
 - ❑ Aircraft out-of-service cost
 - ❑ Typical Odor In Cabin event
- AA engineering internal study – possible causes were bearing material, bearing design, lubricant, or operating protocol
- This presentation addresses state-of-art simulation analysis conducted by VEXTEC on the APU issue

Virtual Life Management Technology: Computational Product Life Sensitivity Forecasting

**Meshing
FEA with
Virtual
Material
Simulation**



Life Cycle Sensitivity



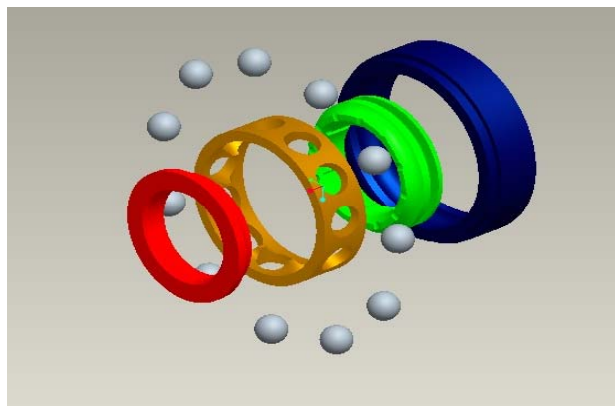
- VEXTEC is an information processing company
- VLM predicts part life probabilistically, taking into account varying conditions of material processing, design, and in-service load conditions
- Virtual Twin™ Simulator software is used to determine cause of in-service performance issues and evaluating corrective action alternatives
- AA is an early pioneer in using VLM for airline needs

Information Provided to VEXTEC

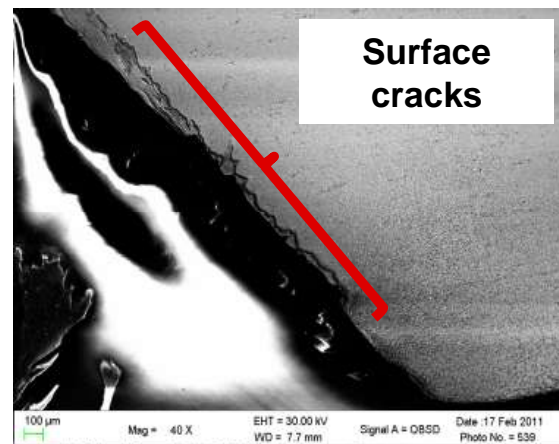


- AA had no OEM part engineering/design analysis
- AA could provide:
 - Broken parts
 - A good part (as comparison)
 - Operating history
 - General operating conditions (temperature, pressure)

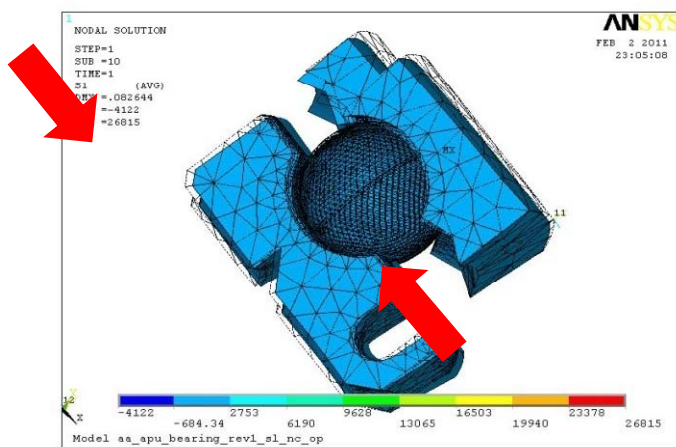
VT Simulator Set-up: 60 day Reverse Engineering Design & Material Processing



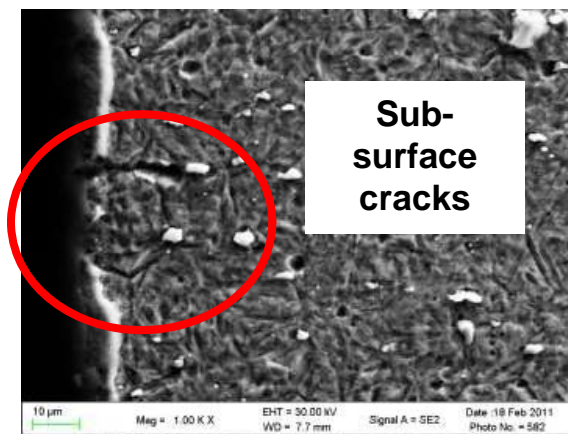
CAD from Broken Parts



Acquired Material Statistics



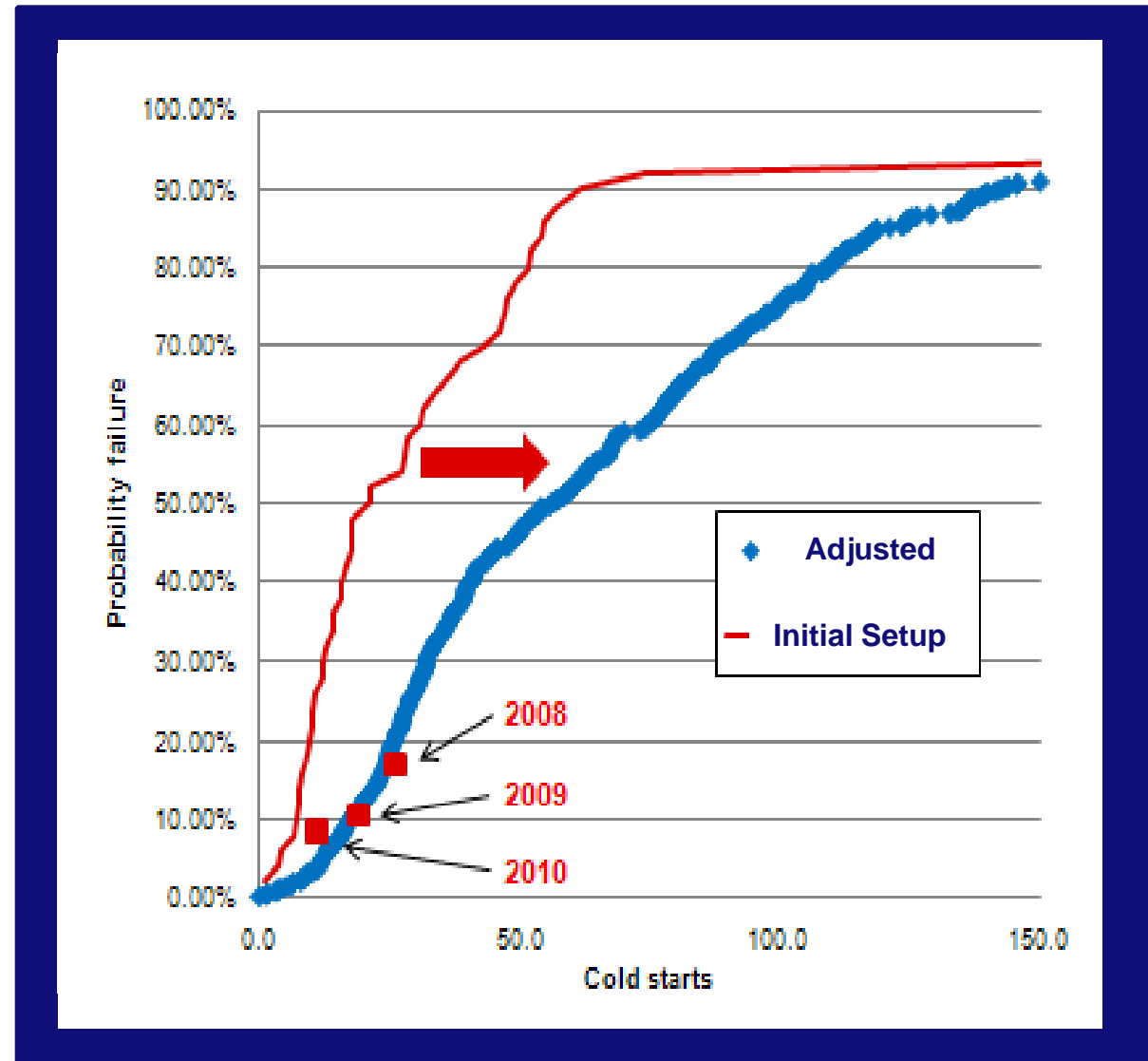
Stress Estimate from ANSYS



Evaluated Failure Mechanism

VT Simulator Checkout

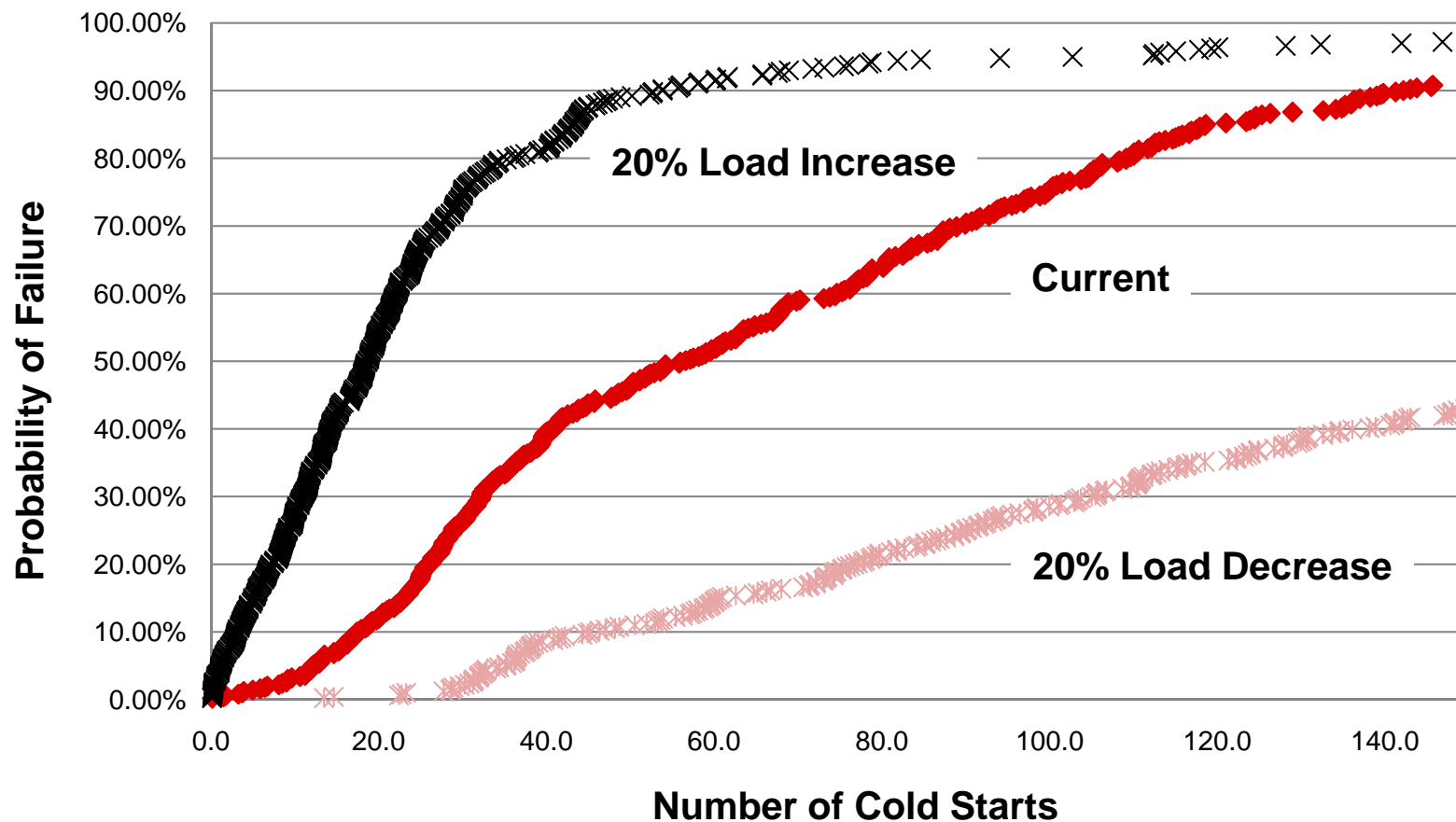
- VT Simulated AA fleet of 47 aircraft w/ 2 bearings each
- Initial simulation setup found to be in the general “ball-park”
- AA provided VEXTEC with 3 years field data to refine Simulator output



VT Simulation of 777 APU Fleet

VT Load and Design Sensitivity Study

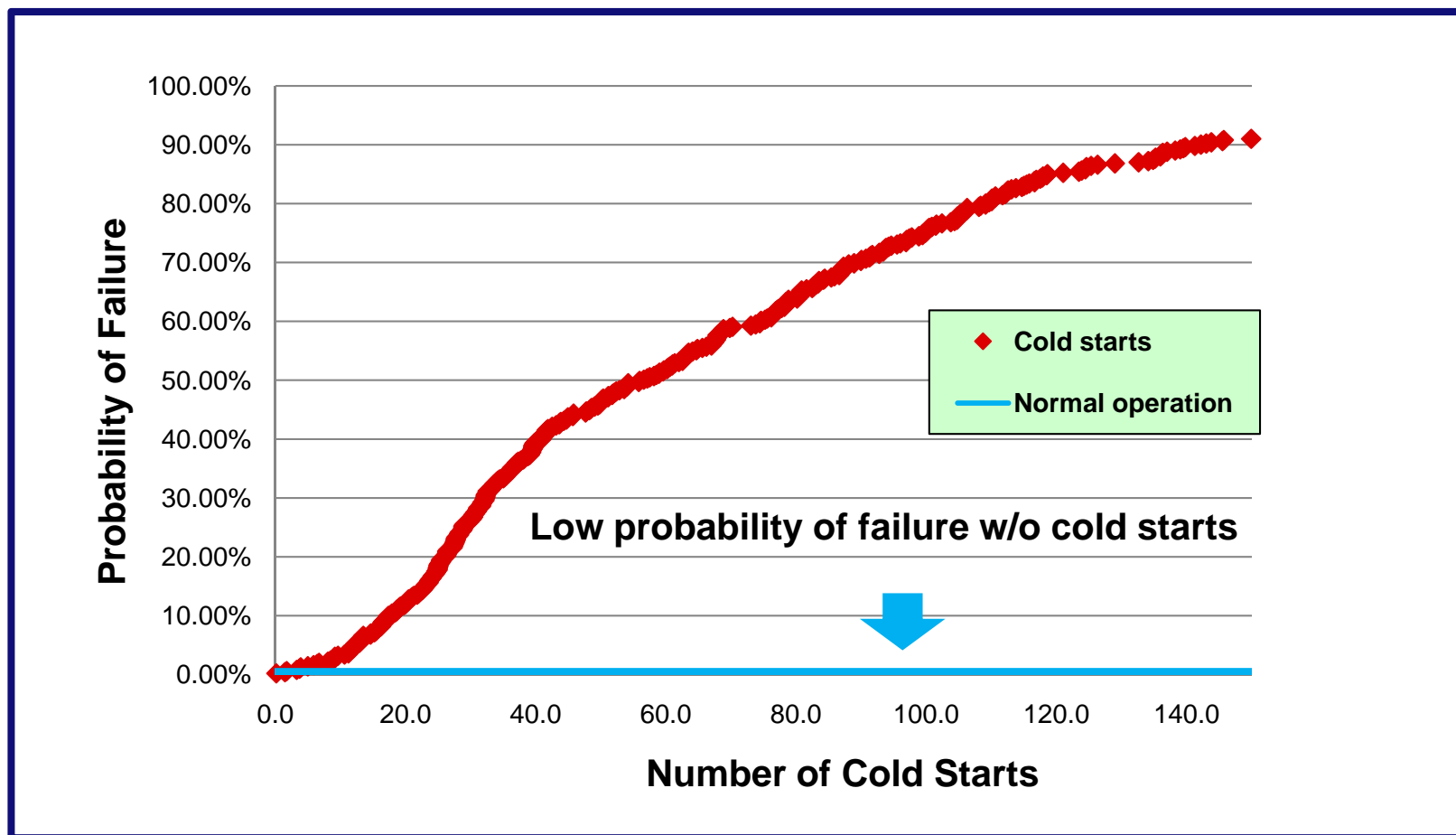
47 APU's, 94 bearings, Type II lubrication, failure is crack size of 0.032"



VT simulations did not identify any issues relative to the overall bearing design and/or manufacturing

Normal vs. Cold Start Sensitivity Study

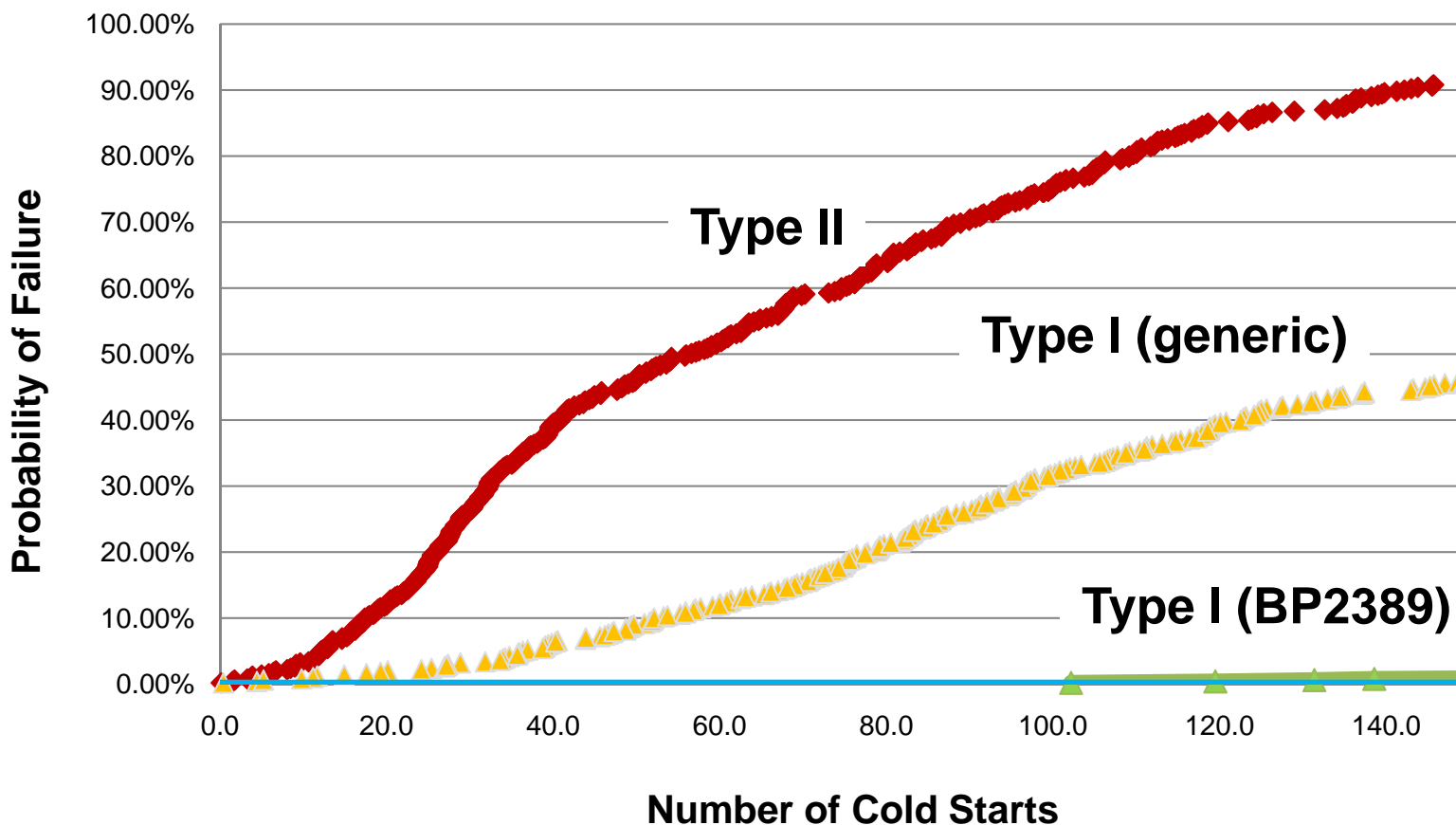
47 APU's, 94 bearings, Type II lubrication, failure is crack size of 0.032"



**Cold-start simulated as micro-seconds without lubrication.
Cold Starts found to be root cause of pre-mature APU bearing failures**

Simulated Lubrication Sensitivity Study

47 APU's, 94 bearings, Type II lubrication, failure is crack size of 0.032"



VT Simulation results provided AA with a quantified business case for changing type of lubrication being used

Summary & Comments

- **AA consolidated VEXTEC VT Simulation metrics with own internal work**
- **FAA reviewed AA documentation and approved requested changes to Cold Start protocol**
- **AA Engineering converted 777 fleet to Type 1 lubricant Aug '11**
- **Since lubricant change – no APU bearing failures have occurred (\$3-4 million annual savings)**
- **VEXTEC analysis also showed bearing redesign changes would not “FIX” problem and could increase failures**
- **VEXTEC VT Simulations helped identify and quantify sensitivity impacts in a matter of a few months**
- **AA planning more extensive use of VLM technology for other component evaluations**