

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

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**and**

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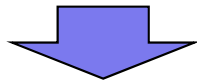
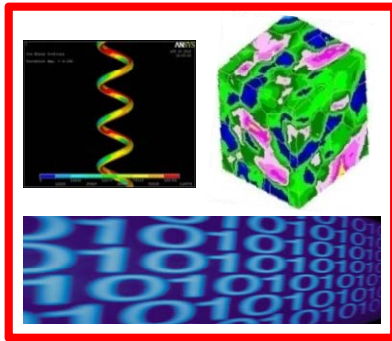
**2012 Gorham PMA Parts & DER Repairs Conference**

## *Issue*

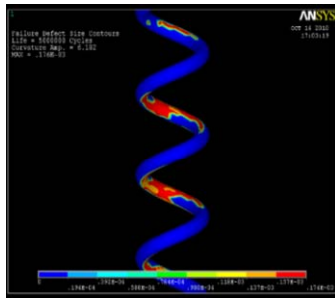
- American Airlines was experiencing high replacement on 777 APU bearings and needed to find resolution
- In March '07, the FAA mandated AA to “cold-start” the APU quarterly, each aircraft, during flight
- AA was averaging 3-4 APU removals per year
  - ❑ High replacement cost
  - ❑ Aircraft out-of-service 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**



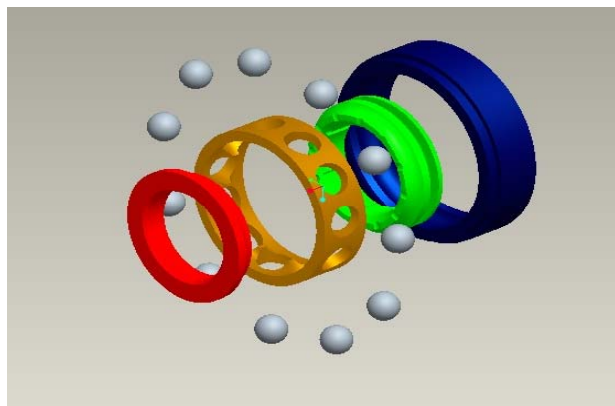
- VEXTEC is an information processing company
- VLM predicts part life probabilistically, taking into account varying conditions of material processing, design, and in-service load conditions
- Virtual Twin™ Simulator software is used to determine cause of in-service performance issues and evaluating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

*Information Provided to VEXTEC*

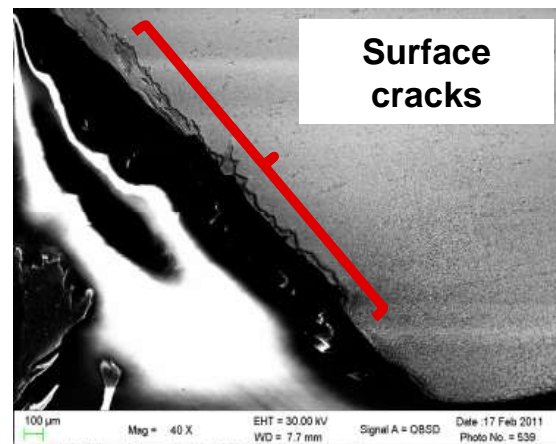


- AA had no OEM part engineering/design analysis
- AA could provide:
  - ❑ Broken parts
  - ❑ A good part (as comparison)
  - ❑ Operating history
  - ❑ General operating conditions (temperature, pressure)

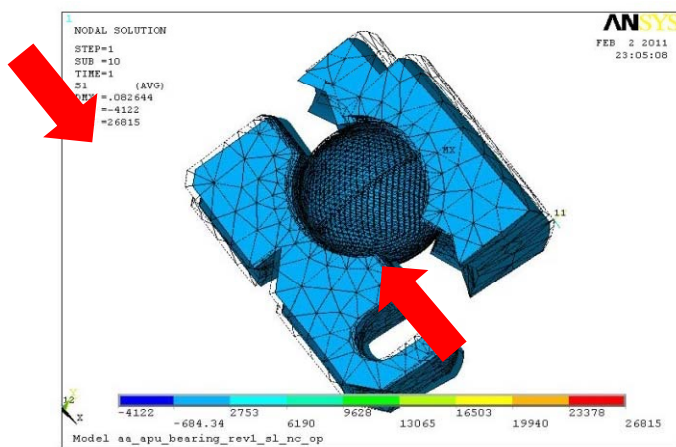
# *VT Simulator Set-up: 60 day Reverse Engineering Design & Material Processing*



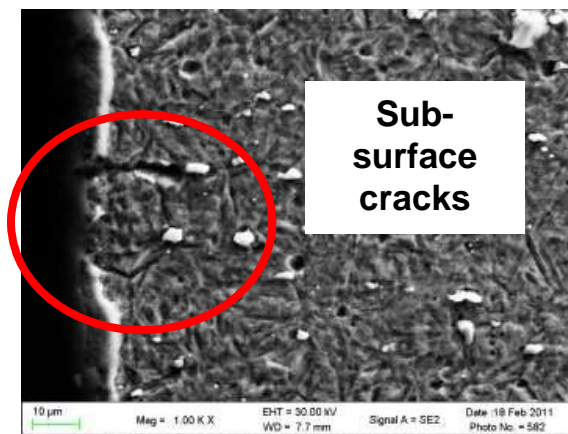
**CADD from Broken Parts**



**Acquired Material Statistics**



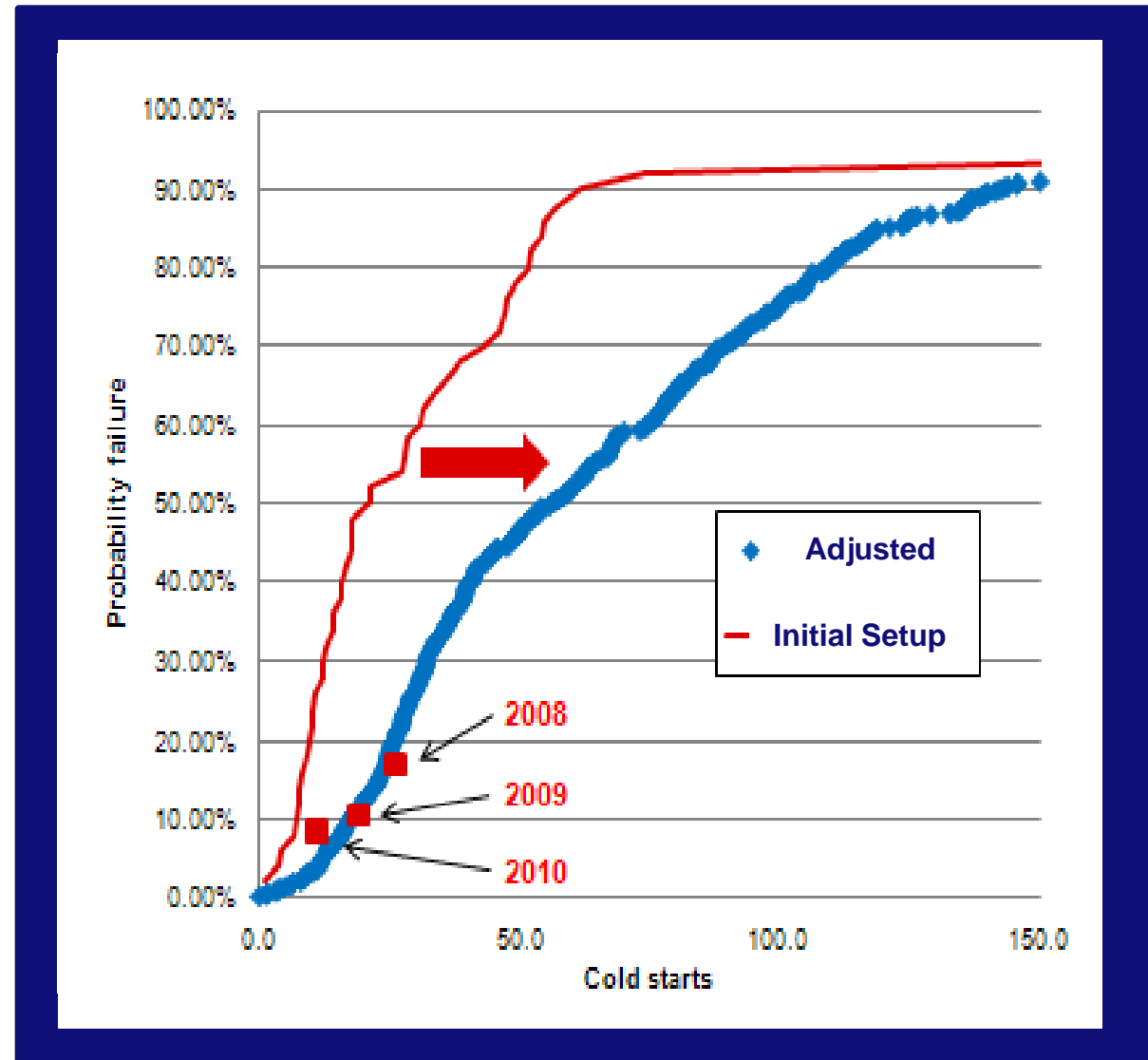
**Stress Estimate from ANSYS**



**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

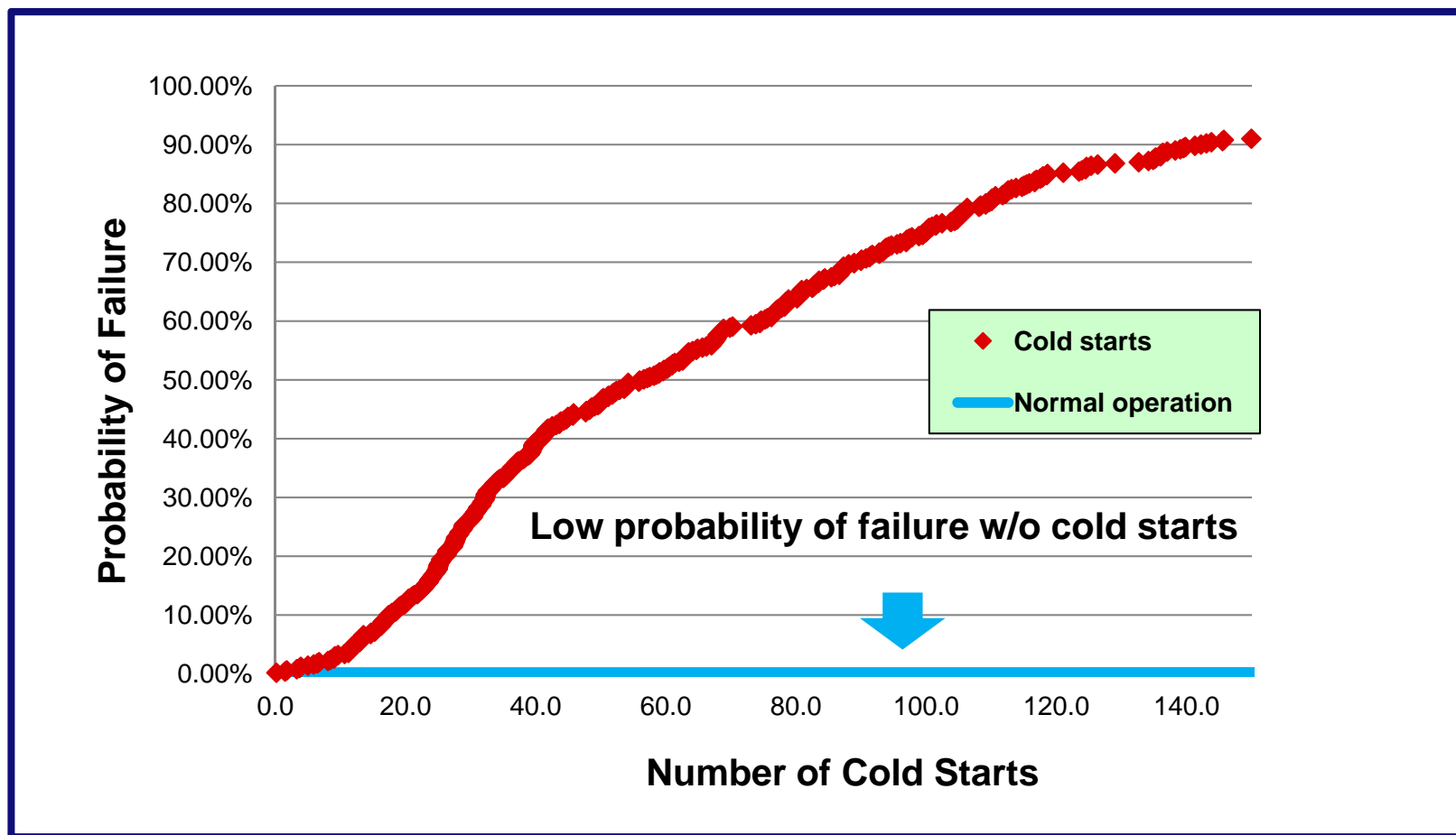




*VT Simulation of 777 APU Fleet*

## Normal vs. Cold Start Sensitivity Study

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

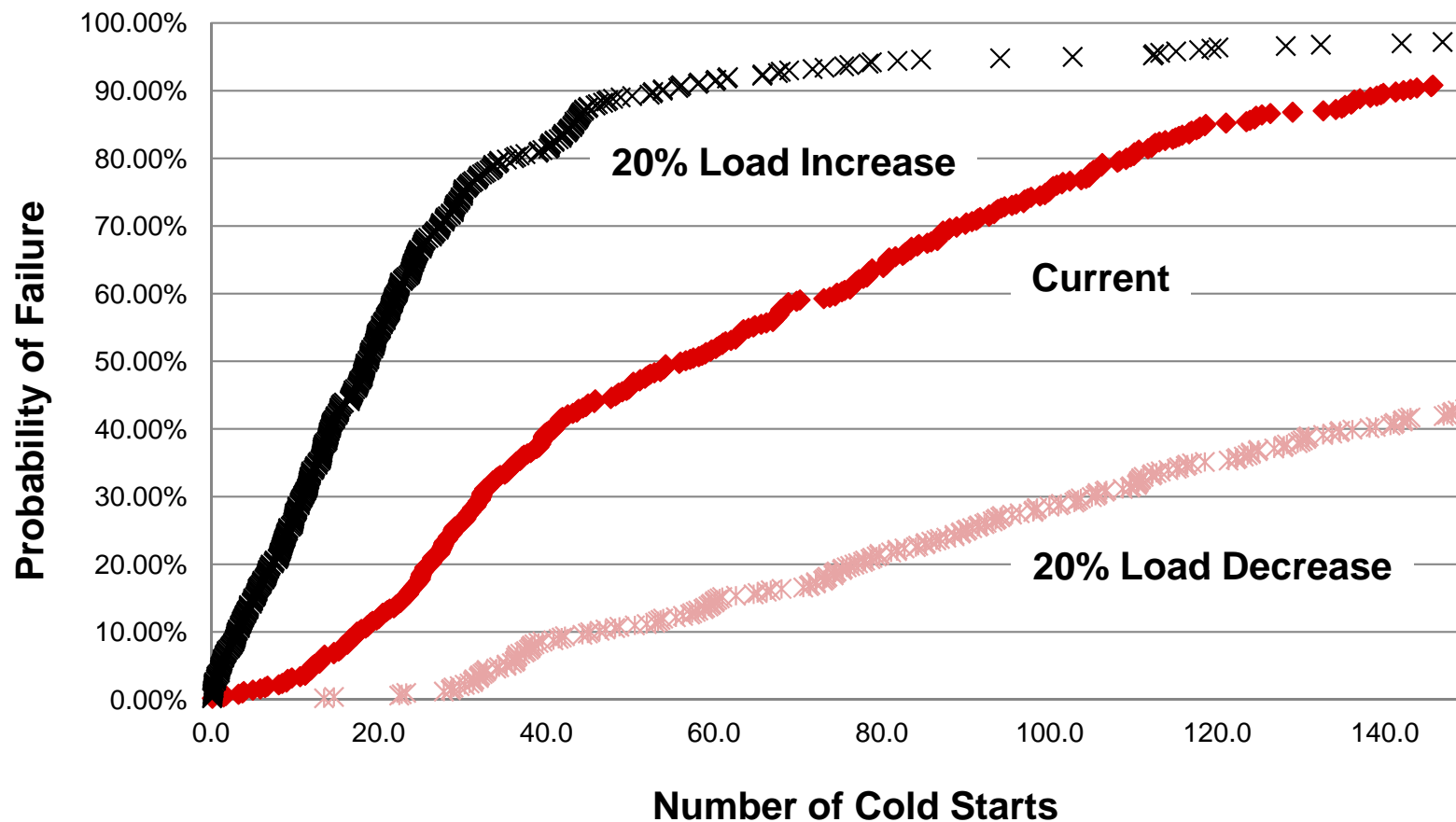


**Cold-start simulated as micro-seconds without lubrication.  
Cold Starts found to be root cause of pre-mature APU bearing failures**



# VT Load and Design Sensitivity Study

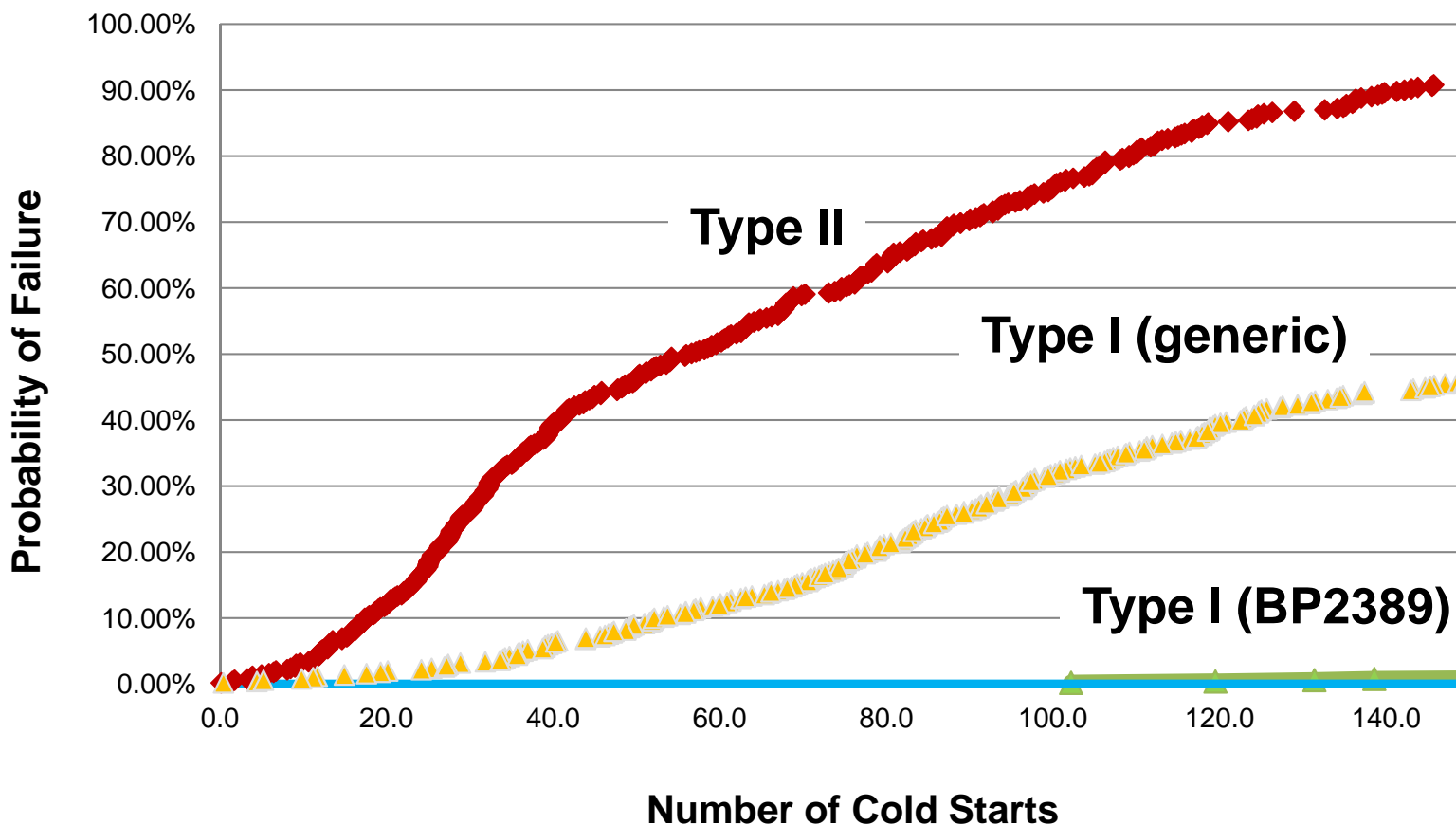
47 APU's, 94 bearings, Type II lubrication, failure is crack size of 0.032"



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

# 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 evaluations**