



Fight Warranty & TCO

Breakthrough Prediction Technology

Kevin Line

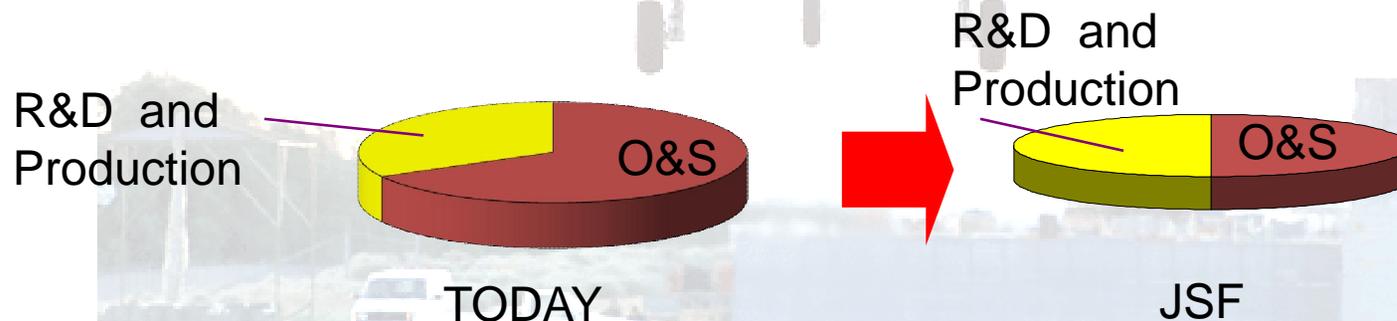


Presentation Overview

1. Reducing Total cost of ownership (TCO)
 - A key requirement of the F-35 JSF
2. Existing methods for maintenance were not sufficient
 - Macro design methods
 - Data driven maintenance methods
3. Breakthrough technology developed for reliability and maintenance
 - Simulation enable us to understand the real behavior

JSF – Revolutionize DoD to be Affordable

- Transformational Weapon System
- Highly affordable platform
- Opposing requirements for the program



DoD will reduce O&S costs

TCO - Total Cost of Owning Challenges

- Why Condition Based Maintenance failed?
 - Not deliver its full potential
 - Low market penetration (1-5%)
- Key reason: Time for Savings \$
 - Not enough advance warning to save \$
 - Planned vs. unplanned maintenance
 - Maintenance need months
- Solution? : 2001 DOD initiative F-35 JSF
 - New Technologies for long lead time CBM

JSF Engineer's Challenge

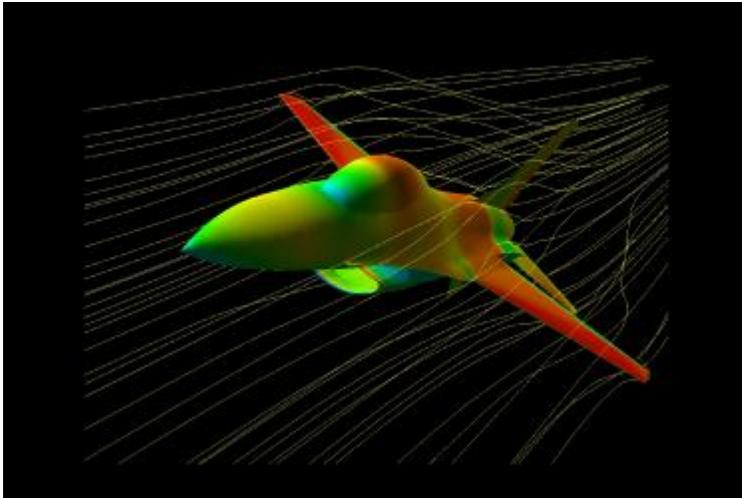
How do you make this complex machine affordable?

Predictable Design

Not Enough Data

Current macro methods are not sufficient

Understand behavior before first delivery



TCO Savings = Engineering Accountable for Field Costs

JSF Engineer's Challenge

How do you make this complex machine affordable?

Predictable Operation

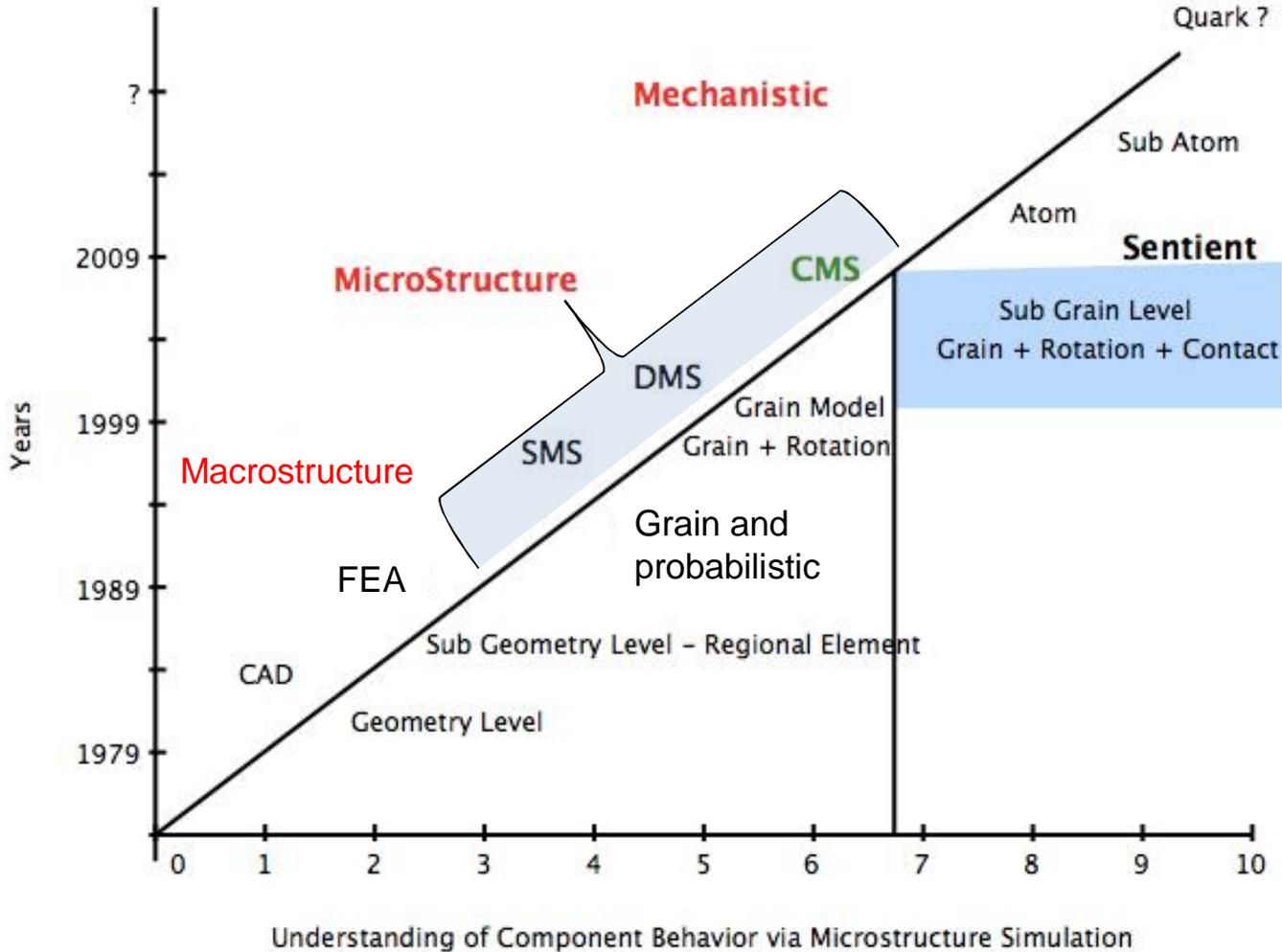
Too Much Data, don't know how to use it

Business plan to support predicted behavior



TCO Savings = Engineering Accountable for Field Costs

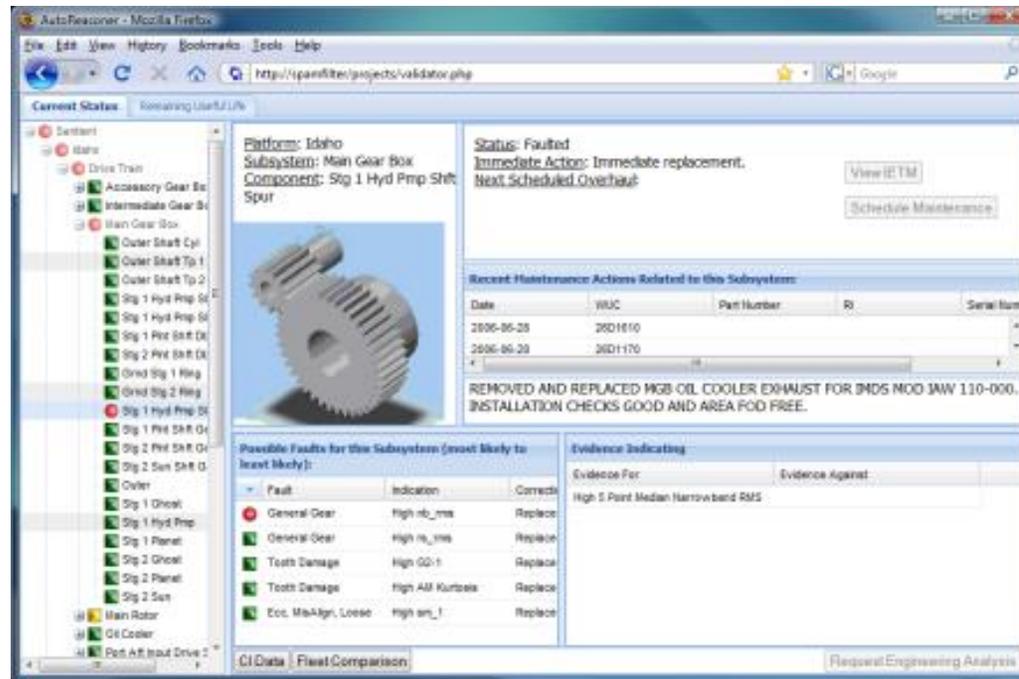
Technology Roadmap



↑
 Future Mechanistic Modeling
 High Performance Computing

The SAGE for Operators

- Integrated data picture
- Turns 50,000 voices into answers
- Only as good as your physics models



The screenshot displays the AutoReasoner web application interface. The browser window shows the URL <http://spanfile/projects/validator.php>. The interface is divided into several sections:

- Current Status:** Platform: Idaho, Subsystem: Main Gear Box, Component: Stg 1 Hyd Pmp Stk Spur. Status: Faulted. Immediate Action: Immediate replacement. Next Scheduled Overhaul: [View IETM] [Schedule Maintenance]
- Recent Maintenance Actions Related to this Subsystem:** A table with columns: Date, WUC, Part Number, R, Serial Num.

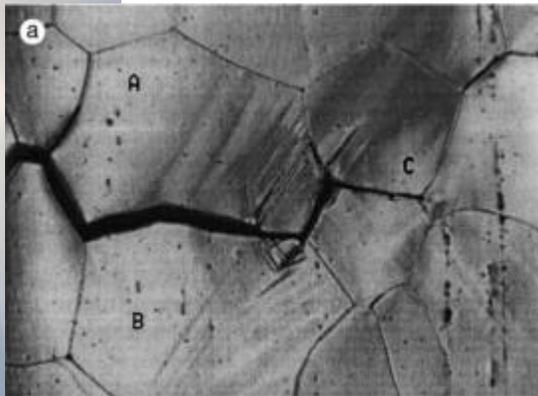
Date	WUC	Part Number	R	Serial Num
2006-06-28	28D110			
2006-06-29	28D110			
- Possible Faults for this Subsystem (most likely to least likely):**

Fault	Indication	Corrects
General Gear	High nb_rms	Replace
General Gear	High nb_rms	Replace
Tooth Damage	High GG-I	Replace
Tooth Damage	High All Kurbels	Replace
Ecc. MisAlign, Loose	High an_I	Replace
- Evidence Indicating:** Evidence For: Evidence Against: High 5 Point Median Narrowband RMS

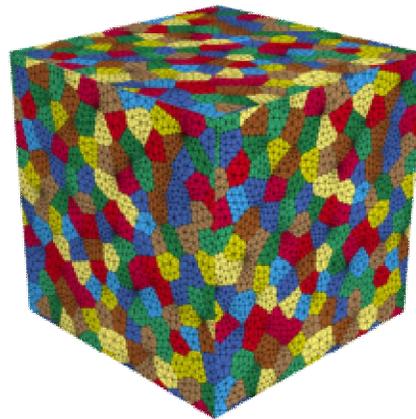
Data management and interpretation is step 1

The Micro Simulator for Engineers Component Life Prediction

- Models predict the behavior of the system
- Models the process of failure from start to finish
- Damage accumulates from the first use until final failure



Material



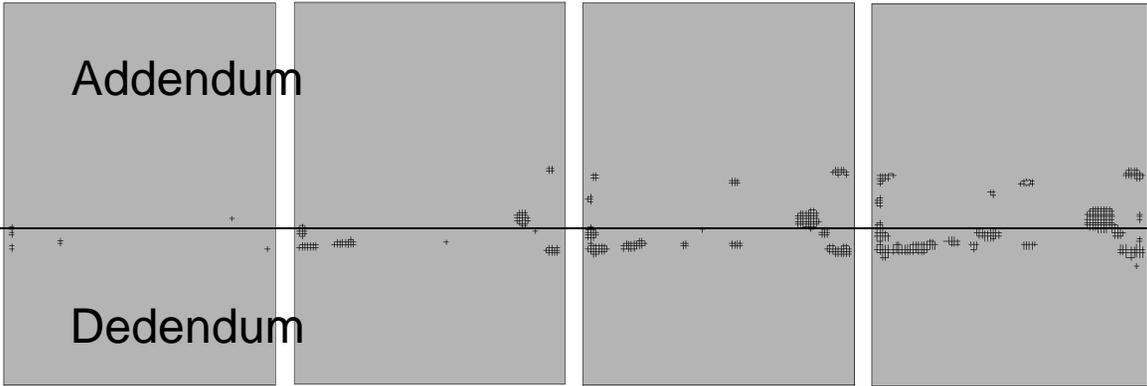
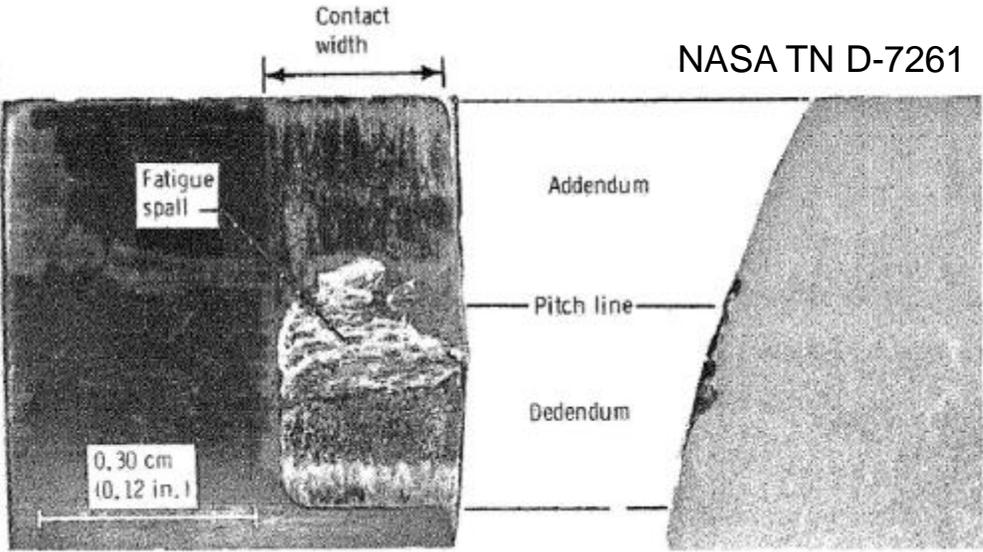
Model



Life Prediction

Physics models for failure is step 2

Gear Pitting Simulation

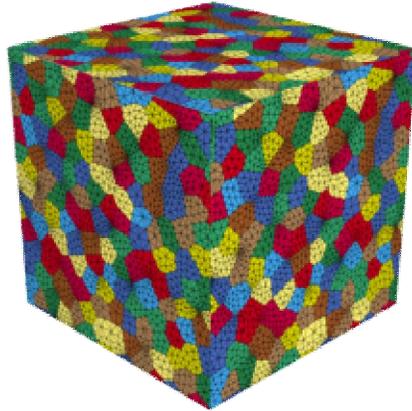


Comparison of pitting phenomena near pitch line through initiation and successive intervals

Conclusions

- How will the JSF turn out? In test now!
- What can the wind turbine industry learn from JSF and DoD operators?
 - O&S cost is largely defined in engineering
 - Data driven cannot give us the resolution and warning needed to affordably maintain equipment
 - Microstructure models are an essential element of any CBM system
 - Lead time on failure predictions is king and the only way you will significantly drive down your TCO

Sentient Solution

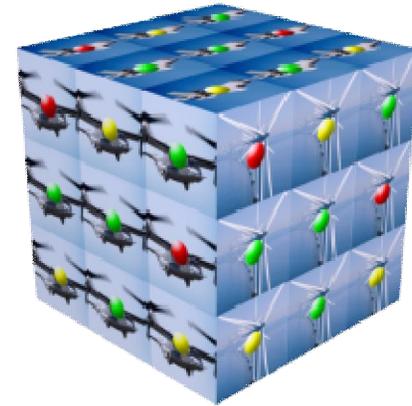


Component Life Prediction

No Data

Material Microstructure
& Variability - Behavior

Simulate & Predict vs. Testing



SAGE

Too much data

Data Driven Framework
of Models

What if Fleet Level Software

Certainty of TOC – Total Operating Costs

