CHANGING AVIATION INDUSTRY IMPACT ON STAKEHOLDERS …
An Engine Manufacturers View
Presentation to the Transportation Research Forum

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Advanced Engine Programs
United Technologies/Pratt & Whitney

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THE FIRST 100 YEARS … (1903-2003)

Bigger, Faster

50,000 commercial aircraft

Size, Number Of Passengers

1

0

Mn 0.8

Mn 2.0

Speed
THE COMMERCIAL JET AGE (1960-2003)
A Leap In Efficiency, Reliability Of Jet Engines

Reliability (On Wing Time)

Fuel Efficiency Improvement
CIVIL AVIATION FUTURE VISION

Dominant External Factors Set Challenges For . . .

- Environmental Footprint
- Digitization
- Cost Tolerance
- Available Human Resources
- Natural Resources

. . . . . Dependable Power Reinvented
## DEPENDABLE POWER REINVENTED

**Cross Enterprise Initiatives Address Challenges**

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Environmental Footprint</th>
<th>Cost Containment</th>
<th>Digitilization</th>
<th>Natural Resources Conservation</th>
<th>Human Resources</th>
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<tbody>
<tr>
<td>Green Engine Process</td>
<td>X</td>
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<td>Aircraft Diagnostics</td>
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<td>Integrated Power Module Technology</td>
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<td>Strengthened Government / Industry Partnership</td>
<td>X</td>
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<td>Total Maintenance Focus</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Environmental Concern</td>
<td>Increase/Change</td>
<td>Years</td>
<td></td>
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<tr>
<td>Electricity use per capita</td>
<td>86% increase</td>
<td>1970-2000</td>
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<tr>
<td>CO₂ concentrations</td>
<td>13% increase</td>
<td>1970-2000</td>
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<td>Waste to landfills</td>
<td>46% increase</td>
<td>1970-2000</td>
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<td>Ozone hole</td>
<td>53% deeper</td>
<td>1979-2000</td>
<td></td>
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<tr>
<td>Number of Laws (U.S.)</td>
<td>&gt;725% increase</td>
<td>1965-2000</td>
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</tbody>
</table>
GREEN ENGINE PROGRAM
P&W Company Vision/Focus For Initiatives

- Green Manufacturing
  - Lowest possible gaseous emission
- Material Efficient
- Green Materials, Low Hazmat Index
- Green Suppliers and Partners
- Green Overhaul and Repair Processes
- Design Set Human Factors
  - Smallest possible noise footprint
- Energy Efficient
- Designed Serviceability, Reusability, Recyclability
LEGACY ENGINE MONITORING MODEL

*Expert Manpower Intensive – Limited In Scope*
REINVENTED AIRCRAFT SYSTEMS DIAGNOSTICS

Data Intensive – Unlimited In Scope

Symptoms
- Pilot-Reported Anomalies
- Monitoring System-Detected Events
- Maintainer-Reported Anomalies
- Abnormal Trends in Health Data

Failure Resolution

Suspect
- Fault List
- Evidence
- Factors

Task Optimizer
- fault P: task s, 1st
- fault M: task n, 2nd
- fault K: task e, 3rd

Optimized Troubleshooting Tasks

Troubleshooting Task Results

TREND ANALYSIS
INTEGRATED POWER MODULE CONCEPT

Vehicle-Level Management Of Energy Systems

Integrated Inlet Systems

Propulsion System

Integrated Exhaust Systems

Integrated Vehicle & Power Module Control

Power Module

Thermal Management Systems
- Engine cooling
- Vehicle cooling
- Environmental control systems

Vehicle Electric Power System

Module Health Management System
INTEGRATED POWER MODULE CONCEPT

Combining Resources From All UTC Divisions

Pratt & Whitney
A United Technologies Company

Hamilton Sundstrand
A United Technologies Company

Carrier

Sikorsky
A United Technologies Company

UTC Fuel Cells
A United Technologies Company

United Technologies
Research Center

Power Module
GOVERNMENT/INDUSTRY PARTNERSHIP

Building A Bridge To The Future

1. Technology Demonstrator
2. Talon Combustor
3. Technologies
4. C17 T-1
P&W AFTERMARKET OPERATIONS

Reinvented Engine Maintenance Means ...

Timeliness …

Global reach …

Full range of …

… products … services

Serviceable Parts Part Repair

Engine Overhaul Maintenance Programs
DEPENDABLE POWER REINVENTED

Pratt & Whitney’s Commitment

Green Engine Program

Power Module Integration

Advanced Diagnostics

P&W Engine Services

Government/Industry Partnership