



PHM Experience at UTC and Pratt & Whitney: Challenges and Opportunities

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The PHM Society

1 October 2009

Focus

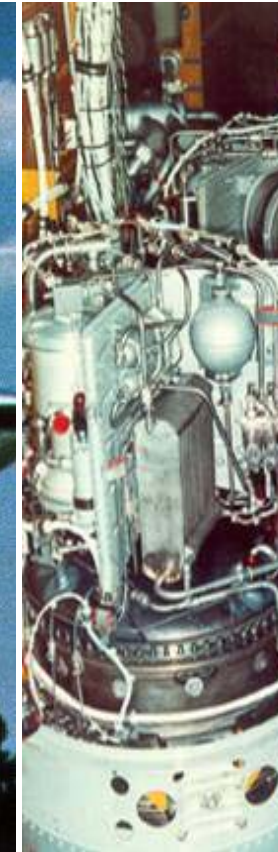
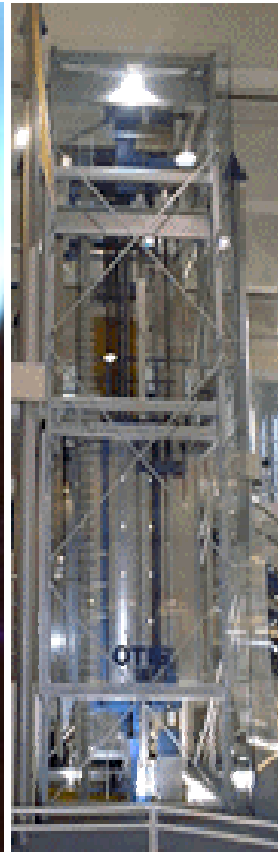
United Technologies PHM Overview

Pratt & Whitney PHM Overview

Defining Value...It's Not Easy

Lessons Learned (and some we're all still working on)

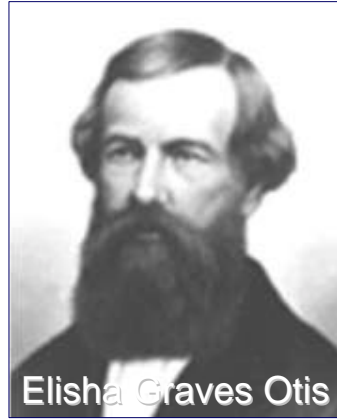
United Technologies Corporation



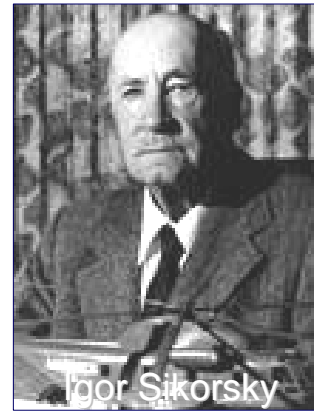
A Tradition Of Innovation



Willis Carrier



Elisha Graves Otis



Igor Sikorsky



Fred Rentschler



Thomas/Hamilton



David Sundstrand



Charles Chubb



Walter Kidde



Broad UTC PHM Experience

Remote Elevator Monitoring



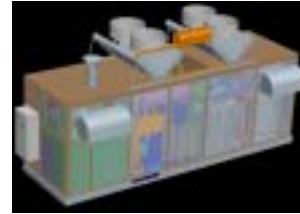
Otis

EHM, ADEM



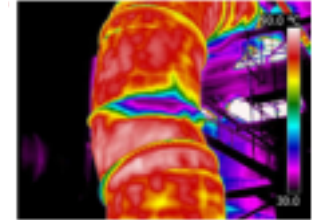
Pratt & Whitney

Fuel Cell Remote Diagnostics



UTC Power

Multi-Spectral Diagnostics



United Technologies Research Center

Health Monitoring



Hamilton Sundstrand

HUMS



Sikorsky Aircraft

Usage-Based Lifting



Sikorsky Aircraft

Health Monitoring



P&W Canada ^{PW625}

Remote Building Monitoring and Diagnostics



Carrier

Diagnostic Sensor Fusion



UTC Fire & Security

Health Monitoring



Pratt & Whitney Rocketdyne

Pratt & Whitney



Large
Commercial
Engines



Military Engines



Small Engines



Power Systems



Space



Experience and Engineering Excellence

New Engines



Engine Services



Material and Repair Services

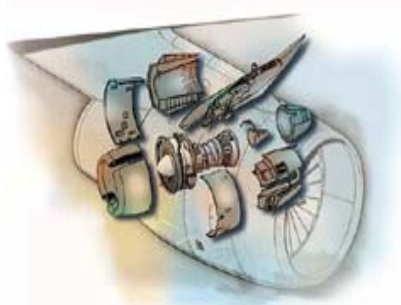


Service Solutions



Over 80 Years of Aircraft Engine Design & Maintenance

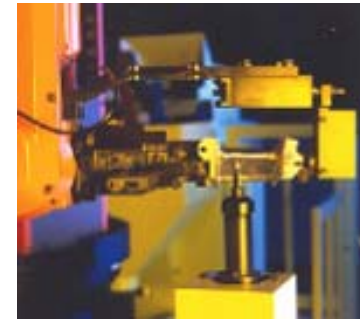
Complete MRO Services



Fleet Management
\$/FH Overhauls



Overhaul



Repair



Water Wash



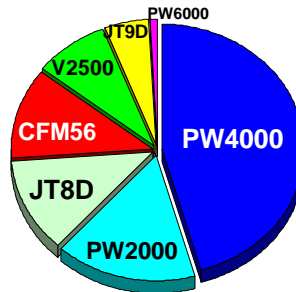
Health Management
\$/FH Monitoring



Line Maintenance



24-Hr Help Center

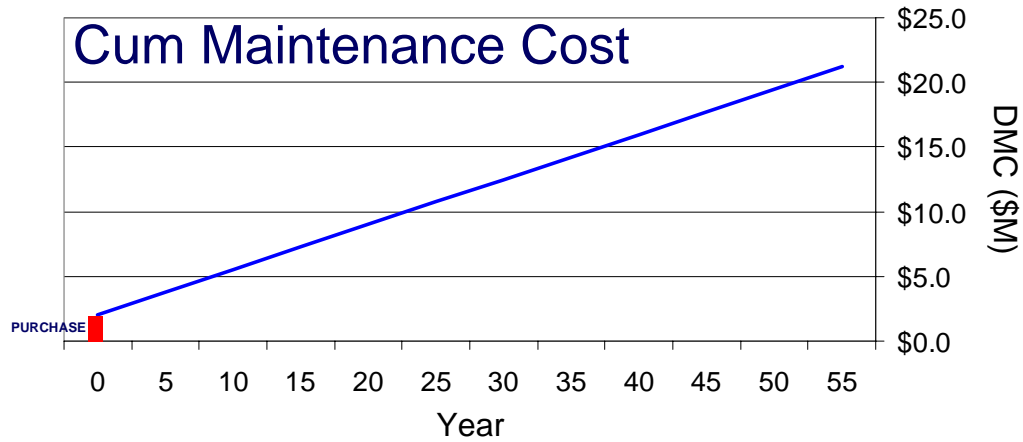


Engine Leasing

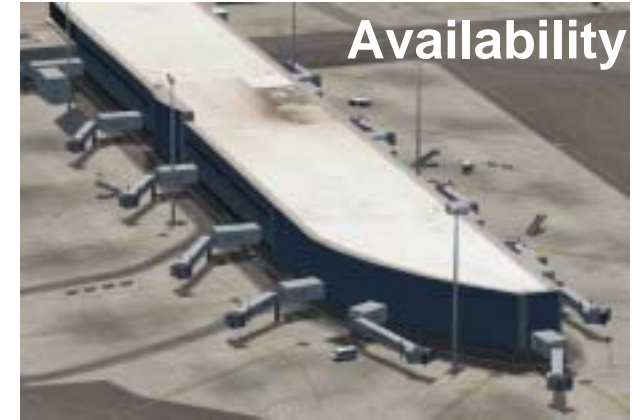


Customer Training

Customer Issues are MRO Issues



Example assumes \$2M purchase price and \$100 / EFH direct maintenance cost (DMC) at 3,500 EFH / yr



Engine Health Management

Integral to managing operations

Automatically process data

Detect issues before failures

Perform troubleshooting

Analyze

Plan maintenance

Turn aircraft

Recommend

Inspection

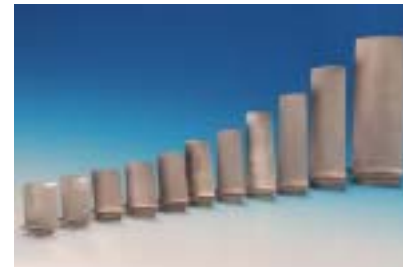
Maintenance

Manage

Life cycle costs

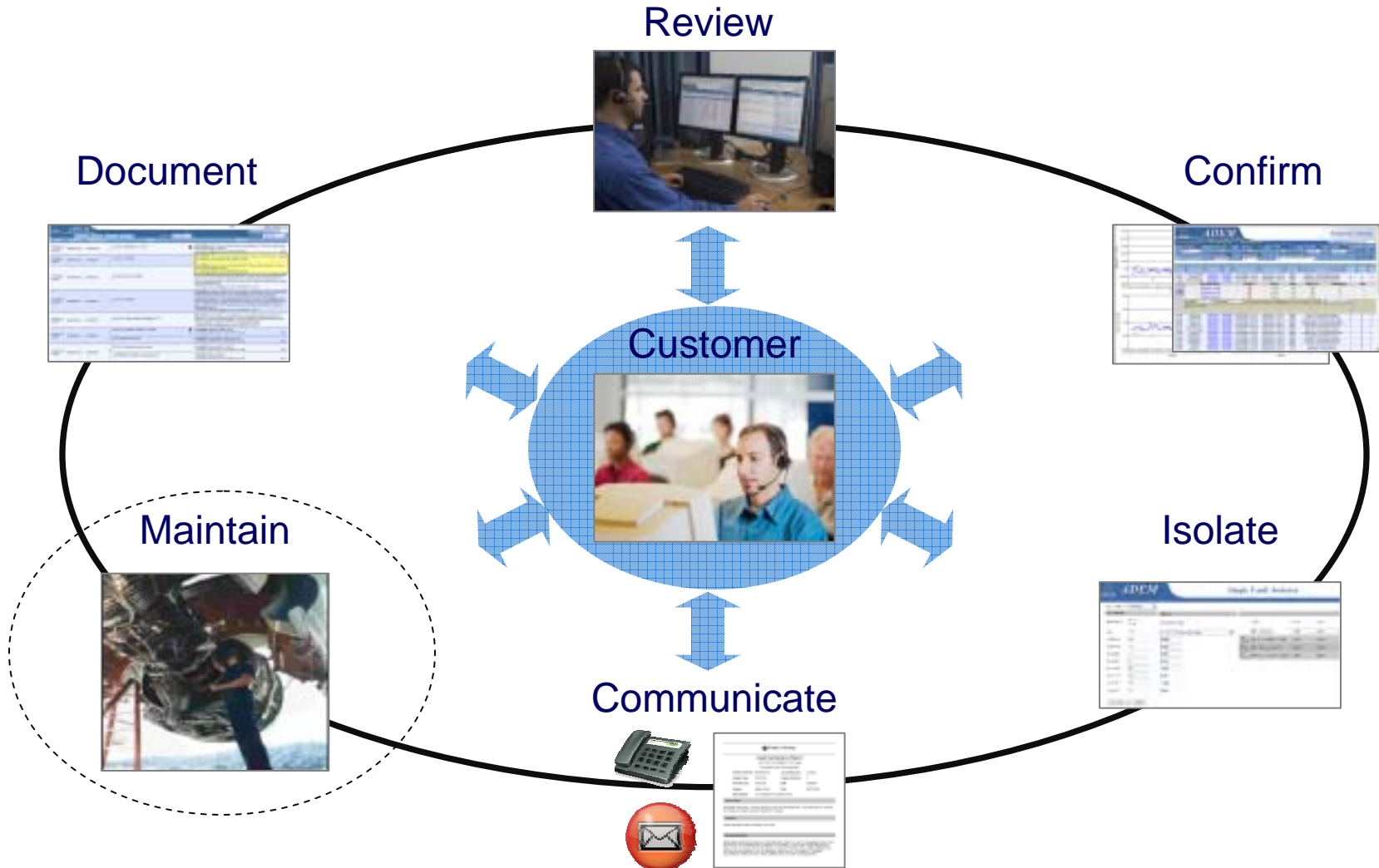
Forecasting

Supply chain



Engine Management Programs (EMPs)

Closed loop alert notification and disposition process



Key Lessons / Challenges

What's the business case?

How do we get data?

How do we support small customers, mobile customers (leasing)?

How do we solve more of our customers' problems?

A Generalized PHM Value Model

OBJECTIVE

**CREATE
VALUE**

RECIPIENT

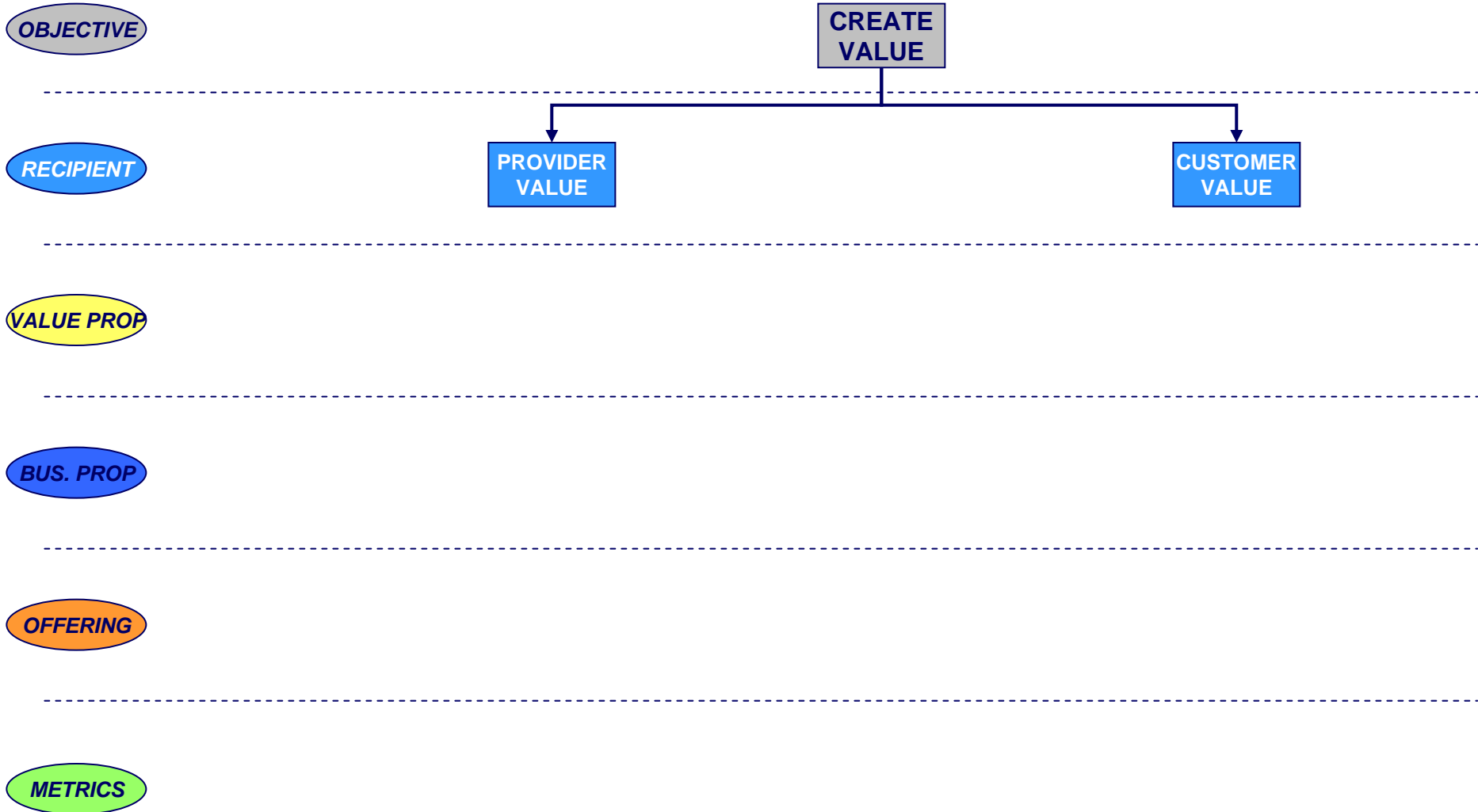
VALUE PROP

BUS. PROP

OFFERING

METRICS

A Generalized PHM Value Model



A Generalized PHM Value Model

OBJECTIVE

CREATE VALUE

RECIPIENT

PROVIDER VALUE

CUSTOMER VALUE

VALUE PROP

REDUCED MAINTENANCE COSTS

REDUCED OPERATING COSTS

INCREASED AVAILABILITY

BUS. PROP

OUTSOURCE

ADDITIONAL CAPABILITIES

GUARANTEES

OFFERING

MAINTENANCE PLANS

MONITORING PLANS

BETTER FLEET

METRICS

MAINTENANCE COSTS

OPERATING COSTS

ASSET / RESIDUAL VALUE

RELIABILITY

AVAILABILITY

A Generalized PHM Value Model

OBJECTIVE

CREATE VALUE

RECIPIENT

PROVIDER VALUE

CUSTOMER VALUE

VALUE PROP

REDUCE COSTS

GENERATE REVENUE

REDUCED MAINTENANCE COSTS

REDUCED OPERATING COSTS

INCREASED AVAILABILITY

BUS. PROP

GUARANTEED MAINTENANCE COST

WARRANTY MITIGATION

MONITORING PROGRAMS

BUNDLED / ADJACENT SERVICES

IMPROVE RELIABILITY

OUTSOURCE

ADDITIONAL CAPABILITIES

GUARANTEES

OFFERING

USAGE BY THE HOUR

MAINTENANCE COST GUARANTEES

VARIOUS MODELS

VARIOUS POSSIBILITIES

BETTER PRODUCT

MAINTENANCE PLANS

MONITORING PLANS

BETTER FLEET

METRICS

REDUCED MAINTENANCE COST

REDUCED WARRANTY COSTS

ADDITIONAL SALES

ADDITIONAL SALES

ADDITIONAL SALES

MAINTENANCE COSTS

OPERATING COSTS

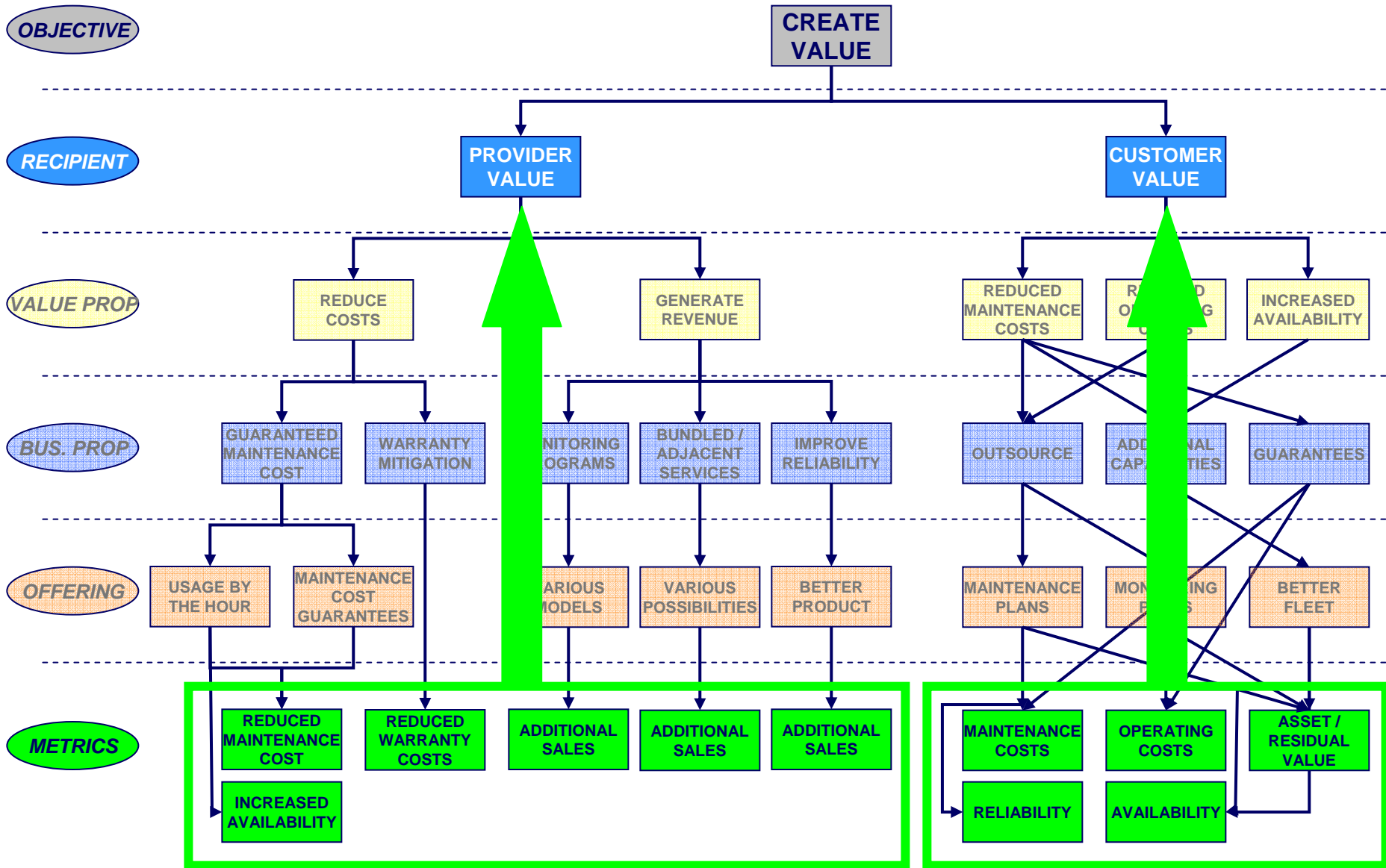
ASSET / RESIDUAL VALUE

INCREASED AVAILABILITY

RELIABILITY

AVAILABILITY

Define and Quantify the Metrics!



Diagnostics and Prognostics Mitigate Risks

Reliability typically trades with cost and weight

PHM improves reliability, reduces cost

Catch small events early before becoming big cost

Turn UERs into pre-planned removals

Forecast trends that can be managed on wing

Determine overhaul workscope on wing

Extend life – usage-based lifing

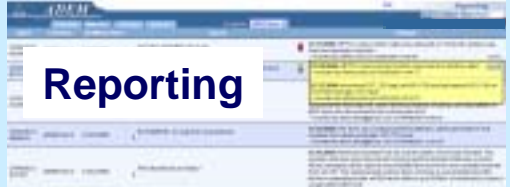

Our PHM analysis tool is **ADEM** – *Advanced Diagnostics and Engine Management*

ADEM drives hardware and systems technologies


Gas path and subsystem sensor coverage

Access to operational performance and usage data


Accurate engine simulation models



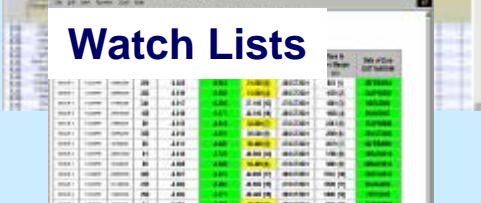
Reporting



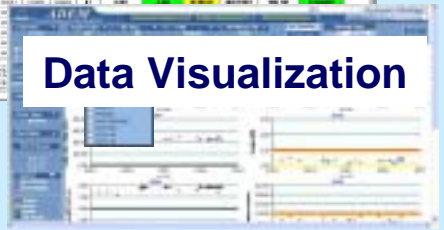
Fault Trending



Alerting



Watch Lists



Data Visualization

The image displays a vertical stack of five screenshots from the ADEM software interface. Each screenshot is labeled with a key feature: Reporting, Fault Trending, Alerting, Watch Lists, and Data Visualization. The screenshots show various data tables, charts, and dashboards used for engine performance monitoring and analysis.

Health Management Provides Quantifiable Value

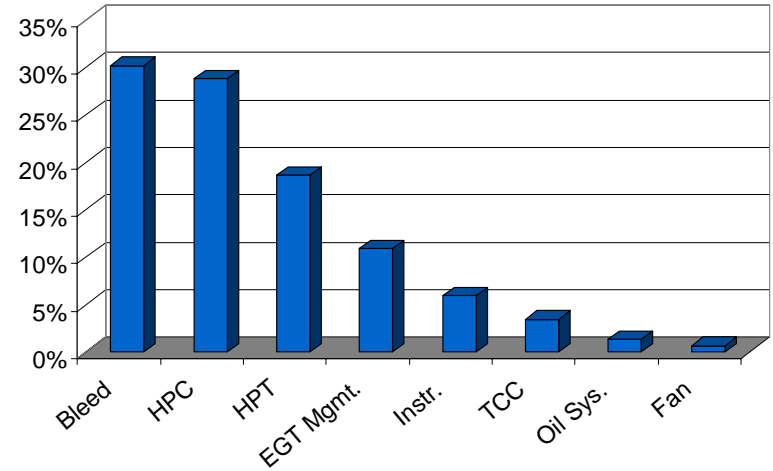
Time on wing extension

Shop visit cost reduction

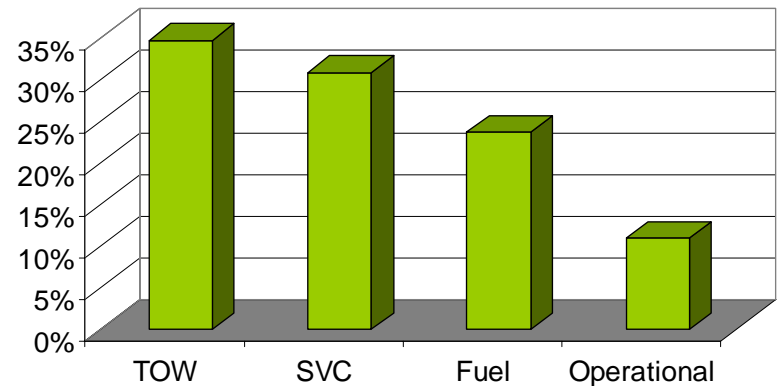
Fuel consumption reduction

Operational cost reduction

Event Value



Value Summary



Savings vary by service level, customer, fleet, etc., and do not include significant productivity improvement typically realized.

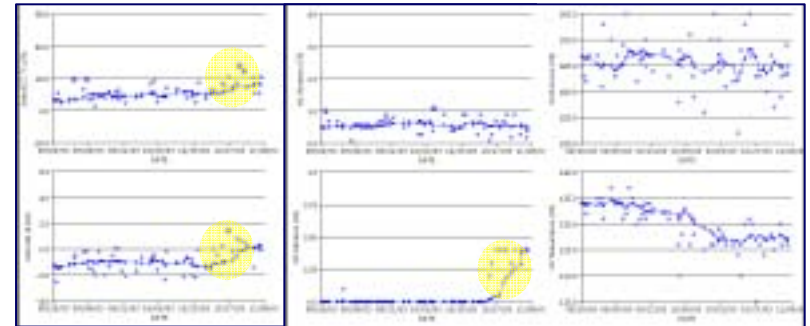
Customer Value – HPT Damage Detected

PW4000 engine removed prior to additional damage

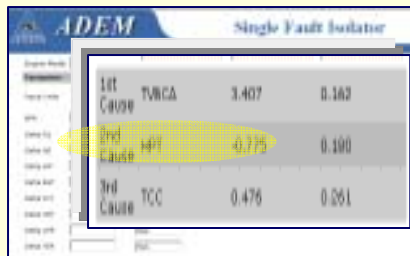
Alerts triggered



Trend plots point to HPT



Isolation indicates HPT



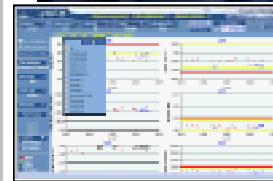
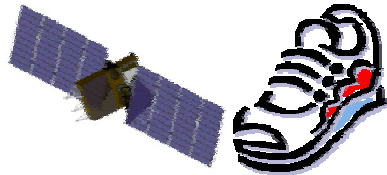
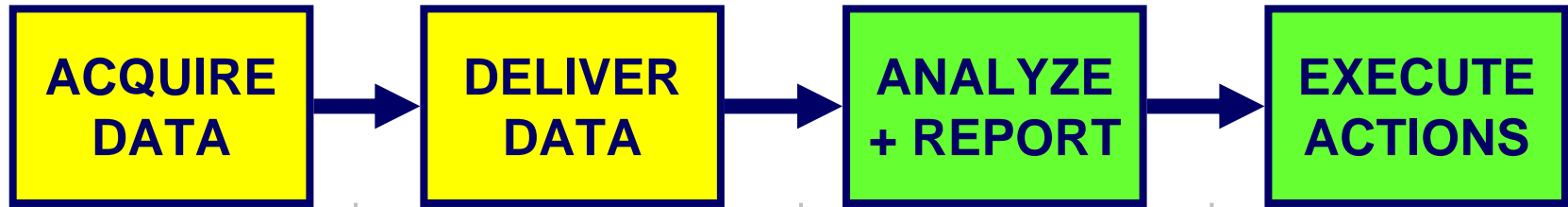
Borescope inspection revealed T1 blade damage

Engine removed prior to incurring additional damage



Estimated Savings: \$700K (UER potential – \$Million+ / Event)

Industry Health Management Value Stream



WEAK

STRONG

Improve Data Collection and Delivery Technologies

Current technologies are poor: ACARS, sneaker-net

PHM critically needs various field data for...

Warranty / guarantee mitigation

\$/FH risk mitigation

LLP usage-based life extension

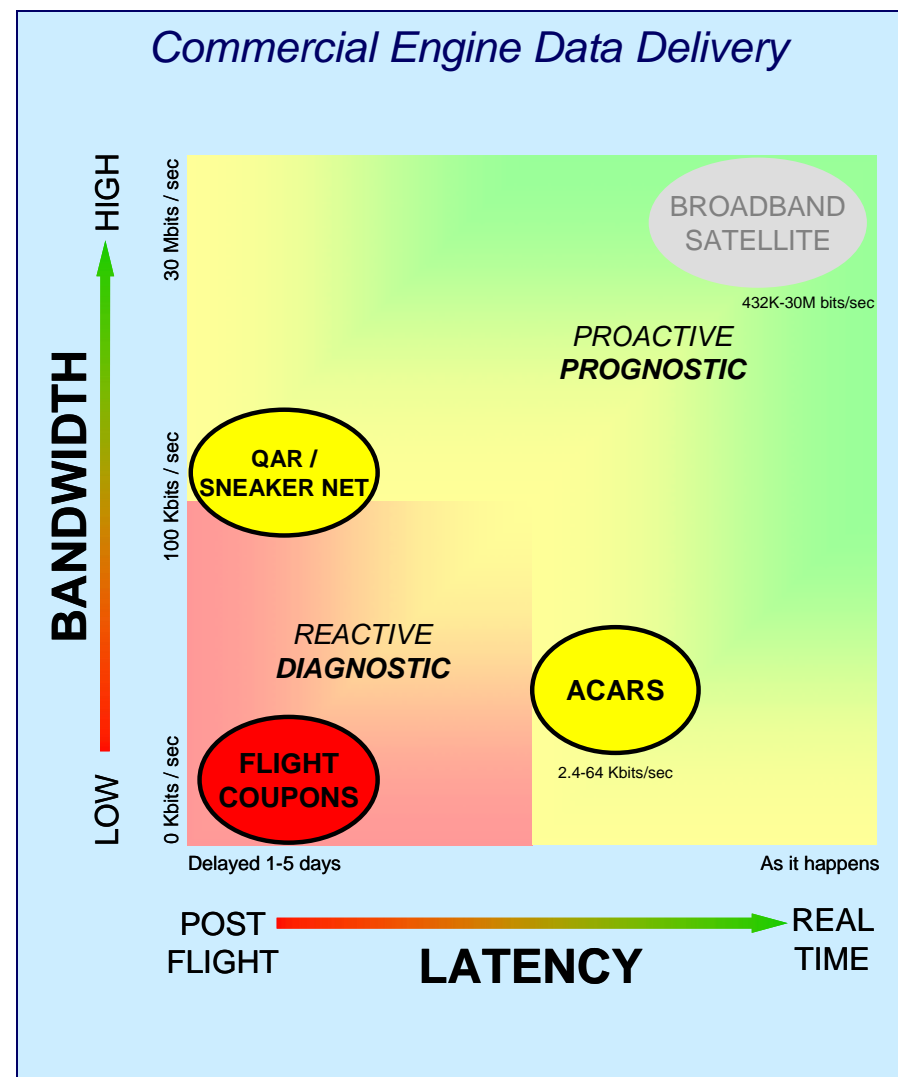
Interval and cost estimation forecasting

Revenue through health services

Emerging issue detection

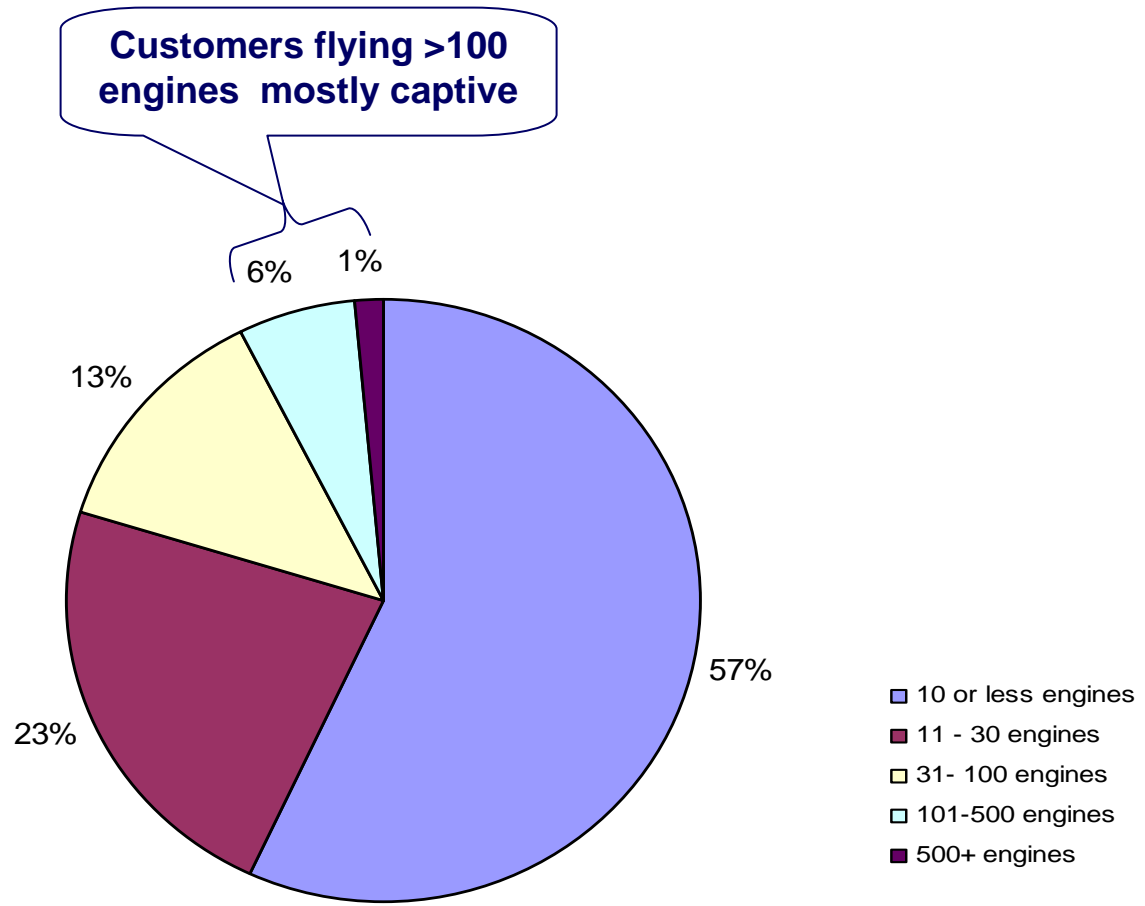
Fuel conservation services and consumption guarantees

Emissions tracking – ETS, U.S. “Cap & Trade”



How Do We Address Small / Lease Operators?

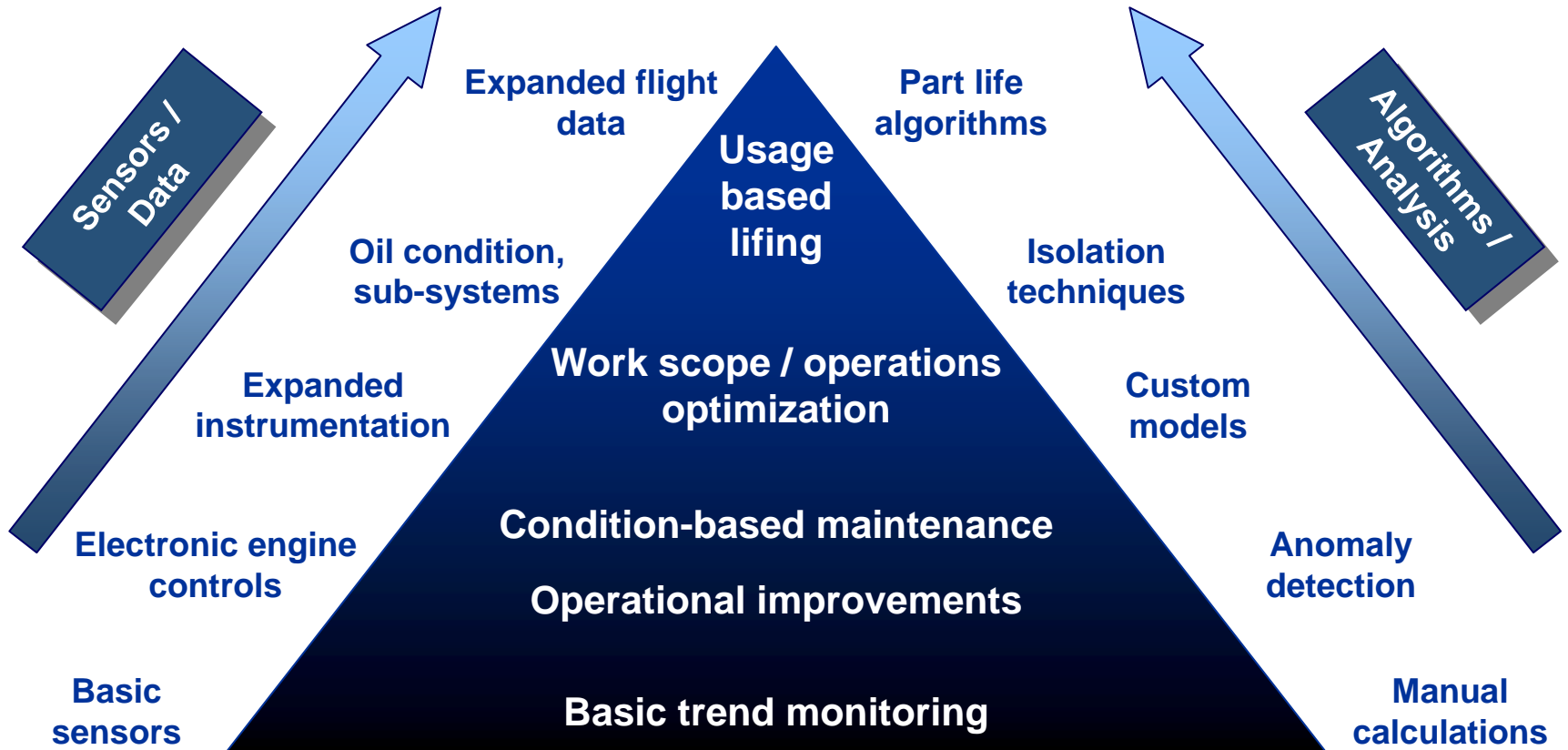
57% of world's operators fly 10 or fewer engines



Profitability?
Portability?

How Can We Address More Problems?

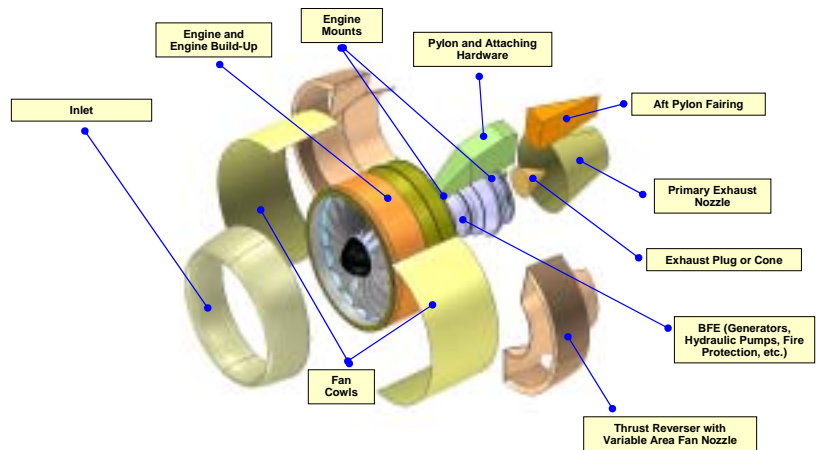
Technology advancements drive value



A Holistic Systems Approach



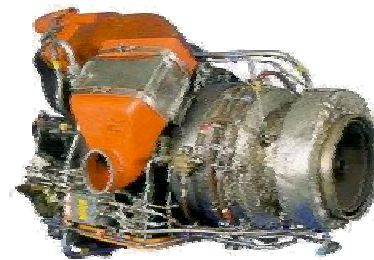
Integrated vehicle health and data management



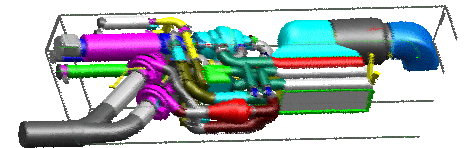
100% pylon-on-down (POD) support



Guided Troubleshooting



APU



Environmental Control System

Questions?



Thank You!