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

United Technologies

Hamilton Sundstrand Propulsion Systems

Pratt & Whitney

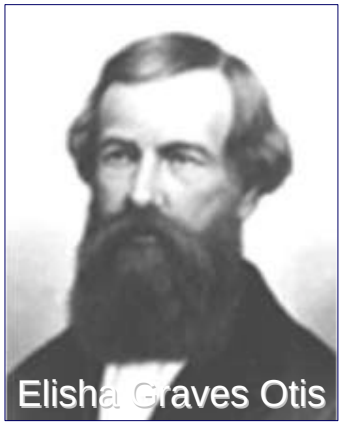
otis

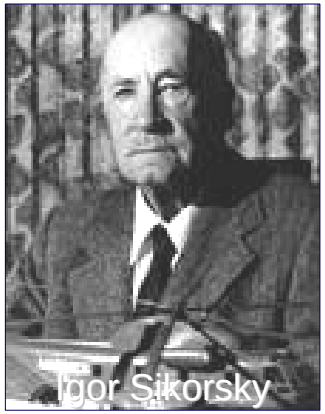
Carrier

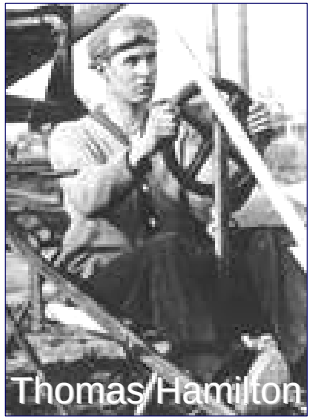
UTC Power
A United Technologies Company

UTC Fire & Security

A Tradition Of Innovation







Broad UTC PHM Experience

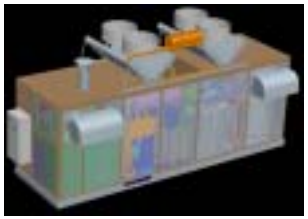
Remote Elevator Monitoring

Otis

EHM, ADEM

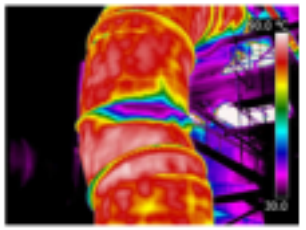
Pratt & Whitney

Fuel Cell Remote Diagnostics



UTC Power

Multi-Spectral Diagnostics



United Technologies Research Center

Health Monitoring

P&W Canada *PW625*

Health Monitoring

Hamilton Sundstrand

HUMS

Sikorsky Aircraft

Usage-Based Lifing

Sikorsky Aircraft

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

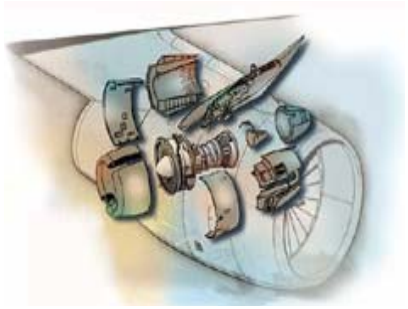
Engine Services

Material and Repair Services

Service Solutions

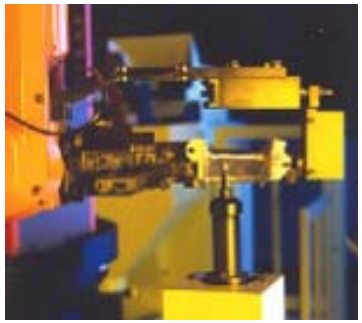
Over 80 Years of Aircraft Engine Design & Maintenance

Complete MRO Services



Fleet Management
$/FH Overhauls

Overhaul



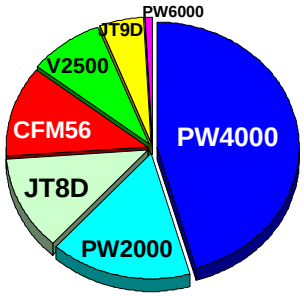
Repair

Water Wash

Health Management
$/FH Monitoring

Line Maintenance

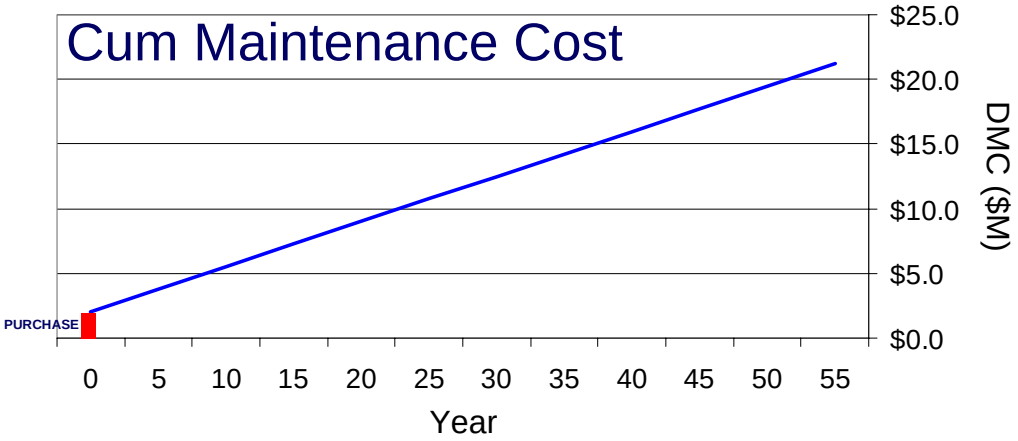
24-Hr Help Center



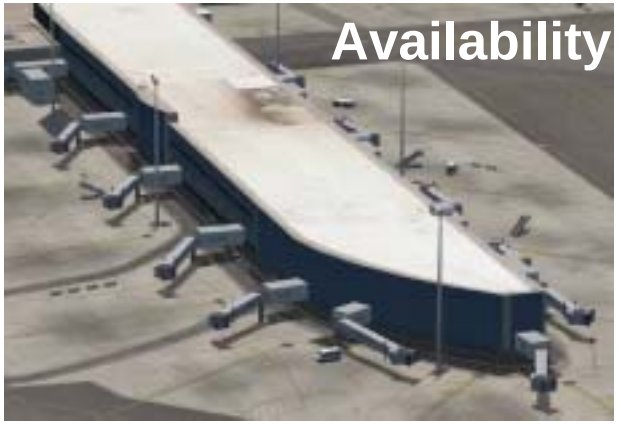
Engine Leasing

Customer Training

Customer Issues are MRO Issues



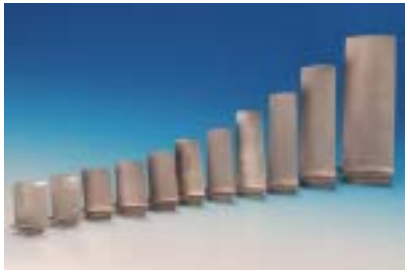
Example assumes $2M purchase price and $100 / EFH direct maintenance cost (DMC) at 3,500 EFH / yr



Engine Health Management

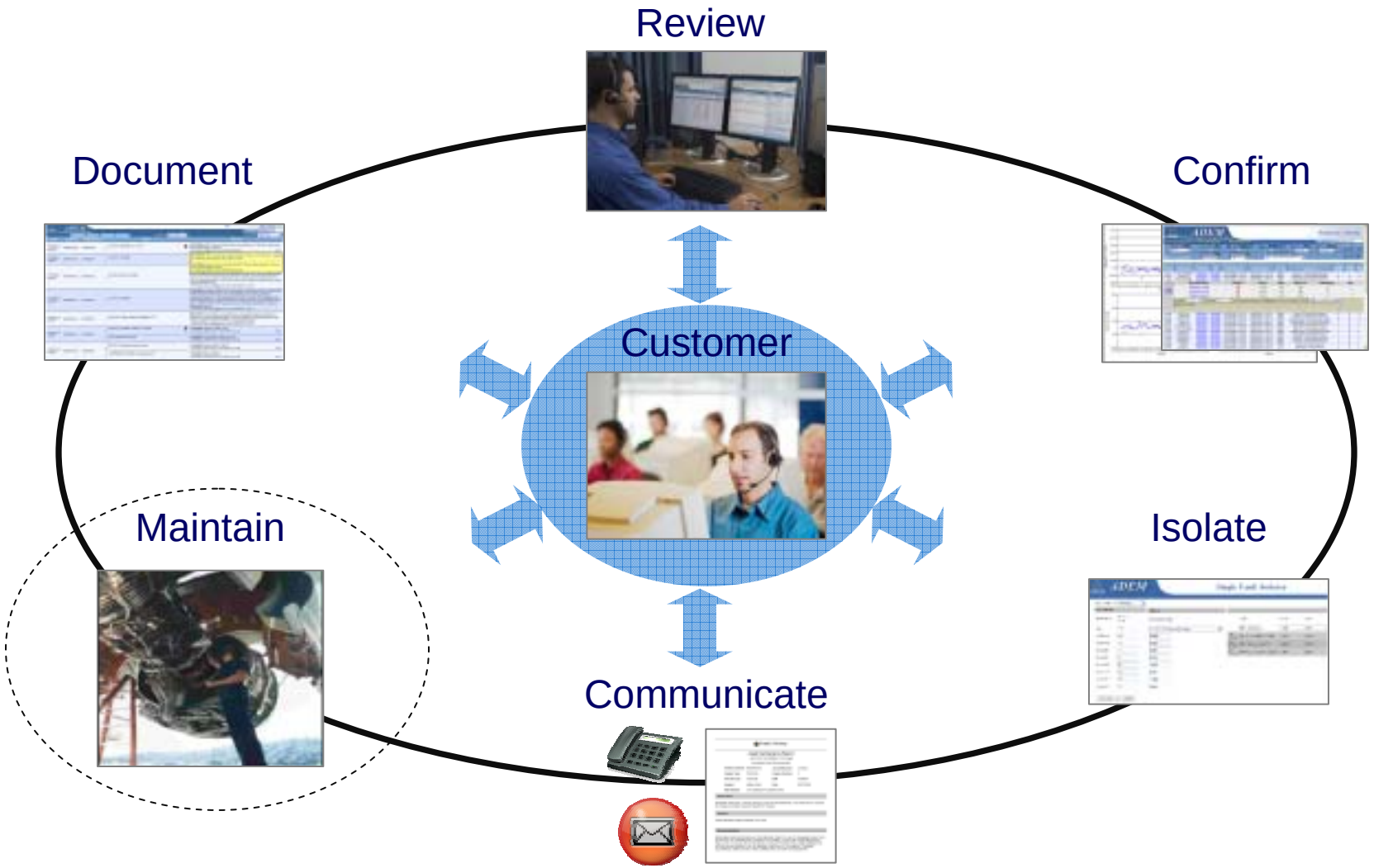
Integral to managing operations

- 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

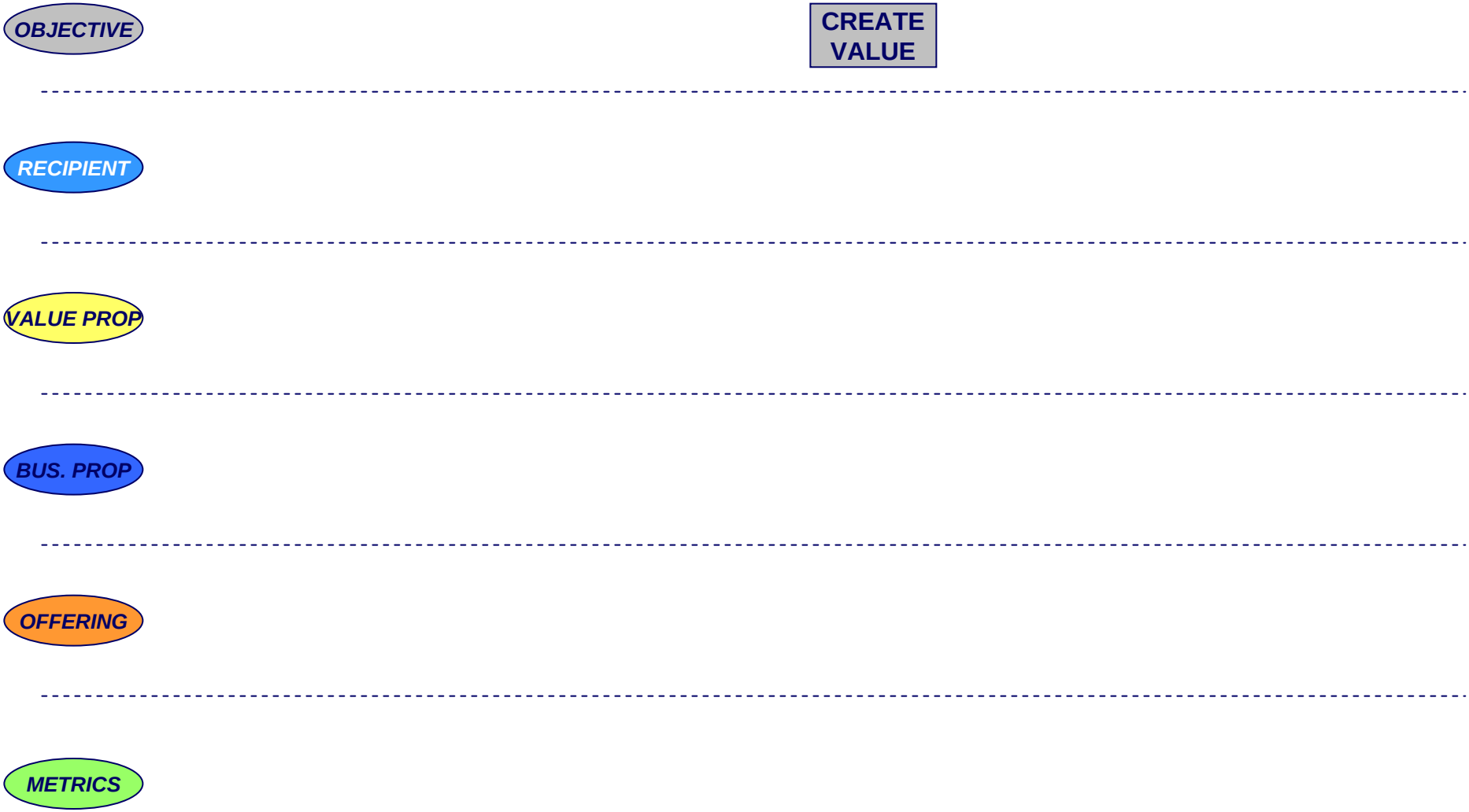
What's the business case?

How do we get data?

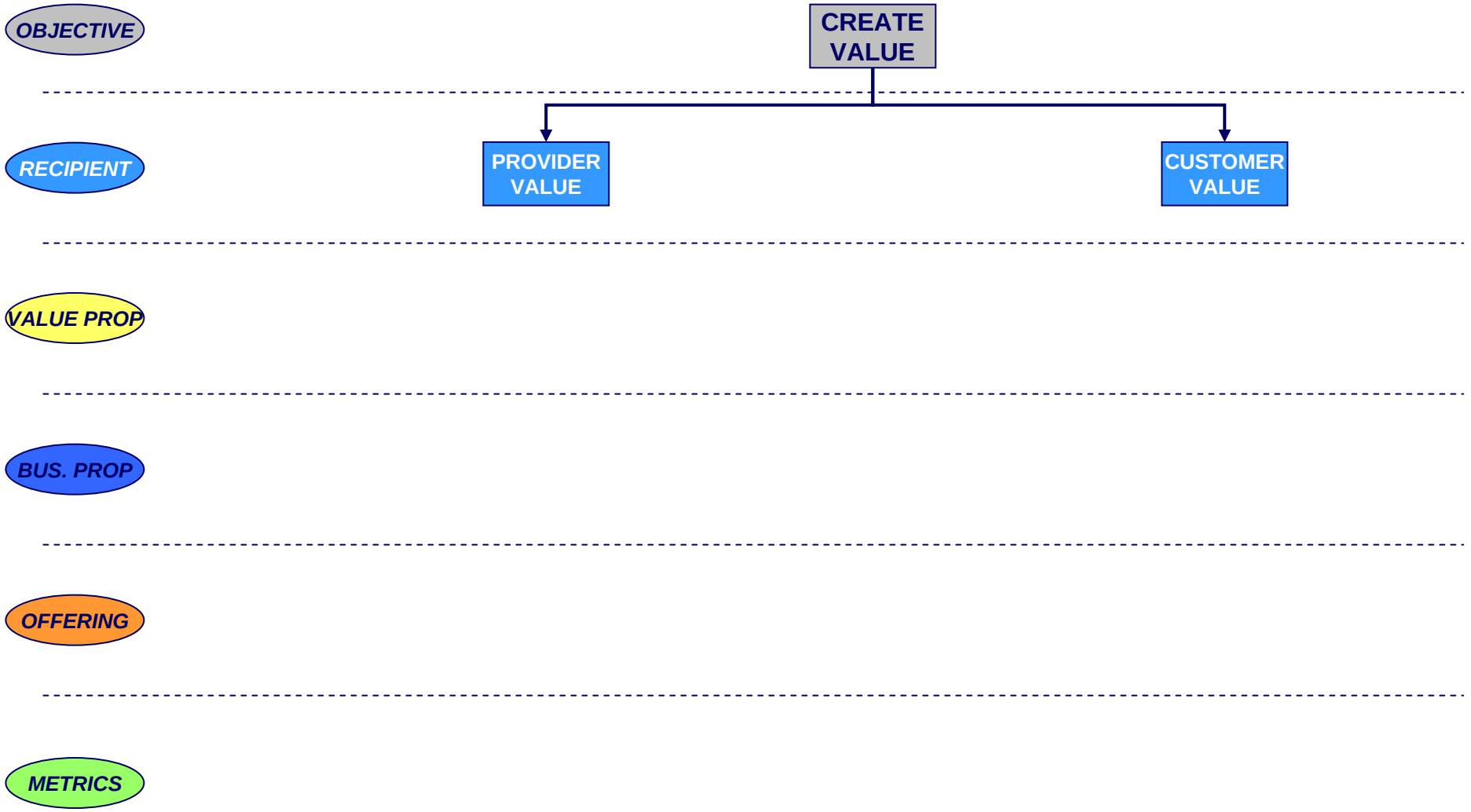
How do we support small customers, mobile customers (leasing)?

How do we solve more of our customers' problems?

A Generalized PHM Value Model



A Generalized PHM Value Model



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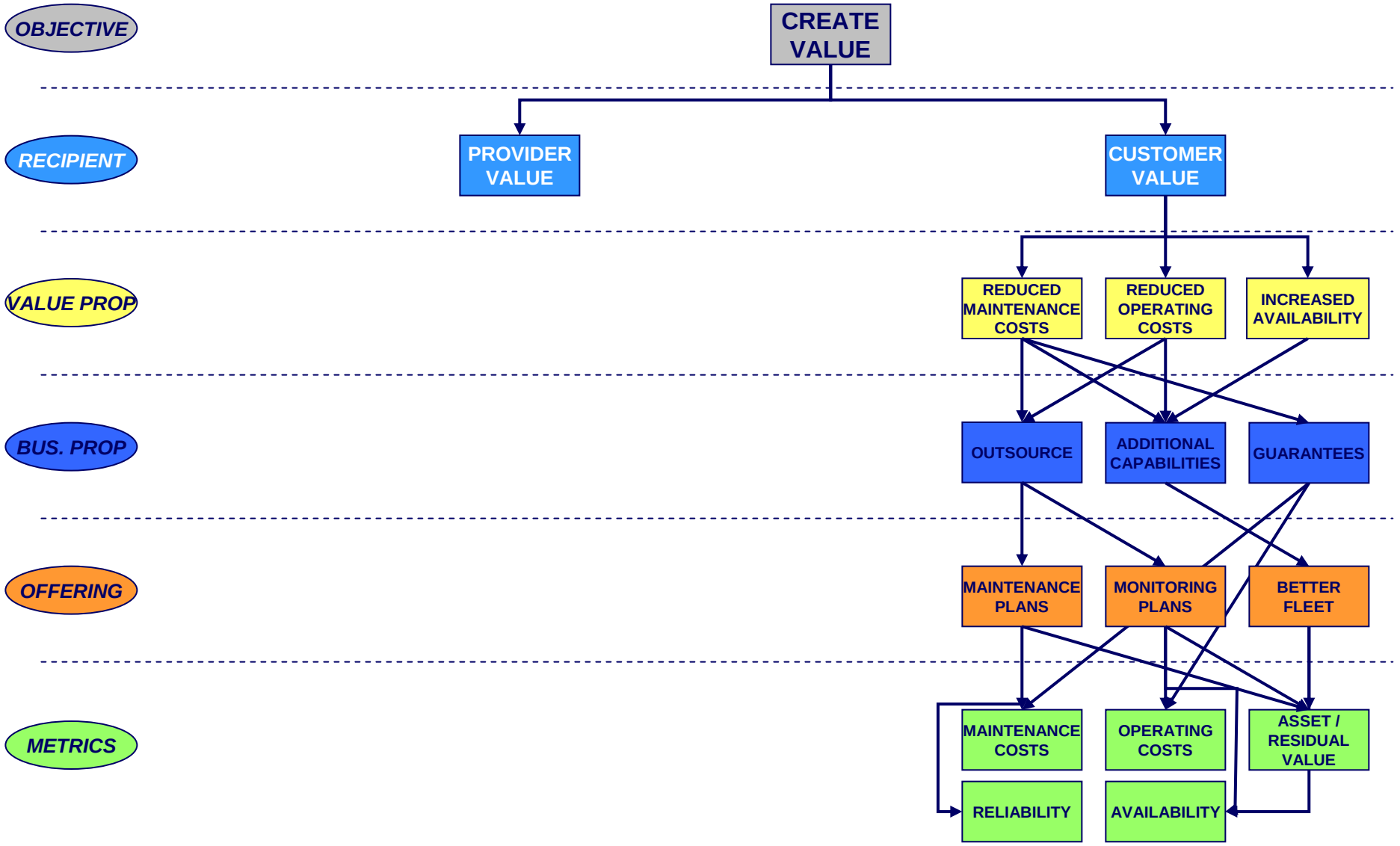

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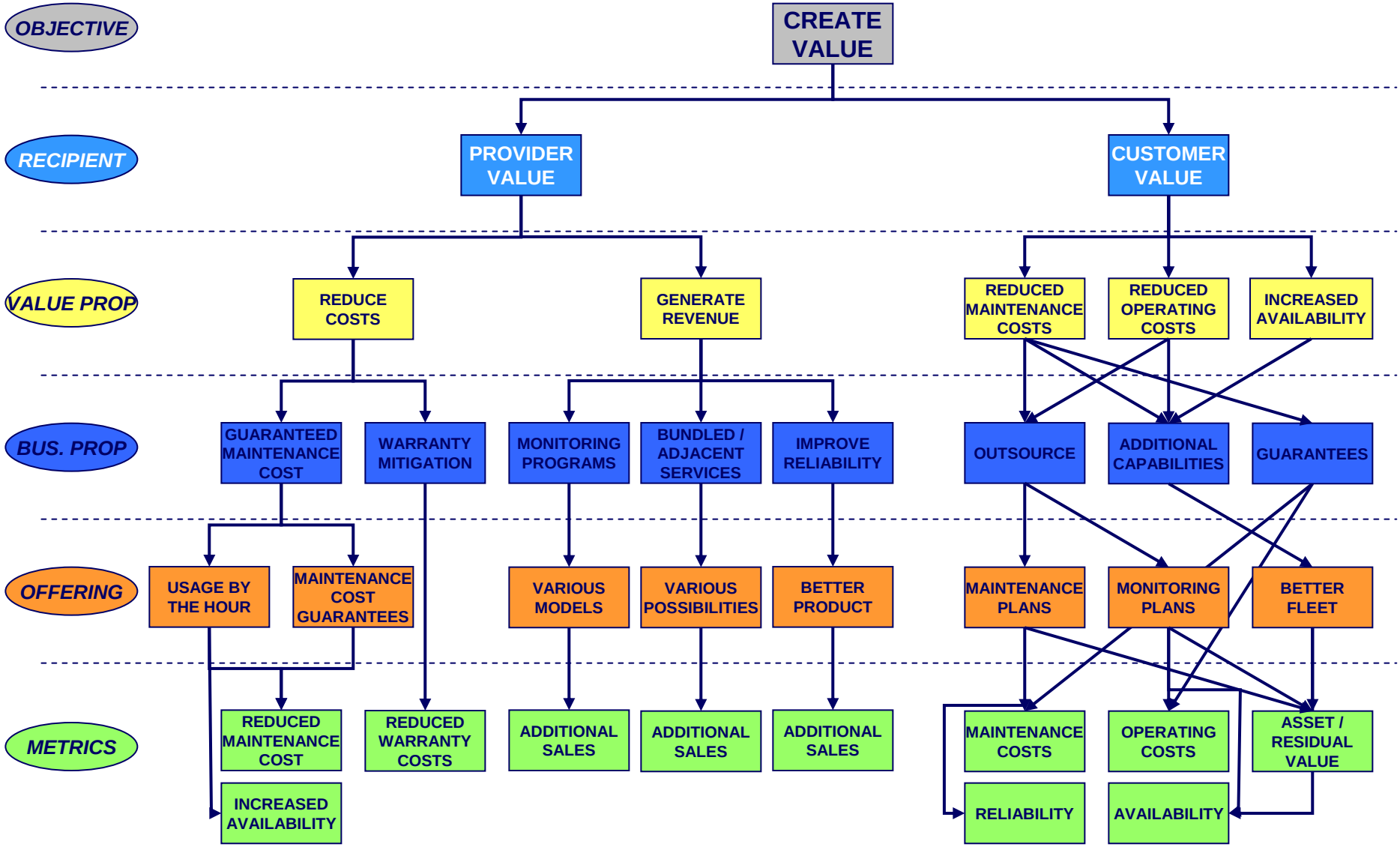
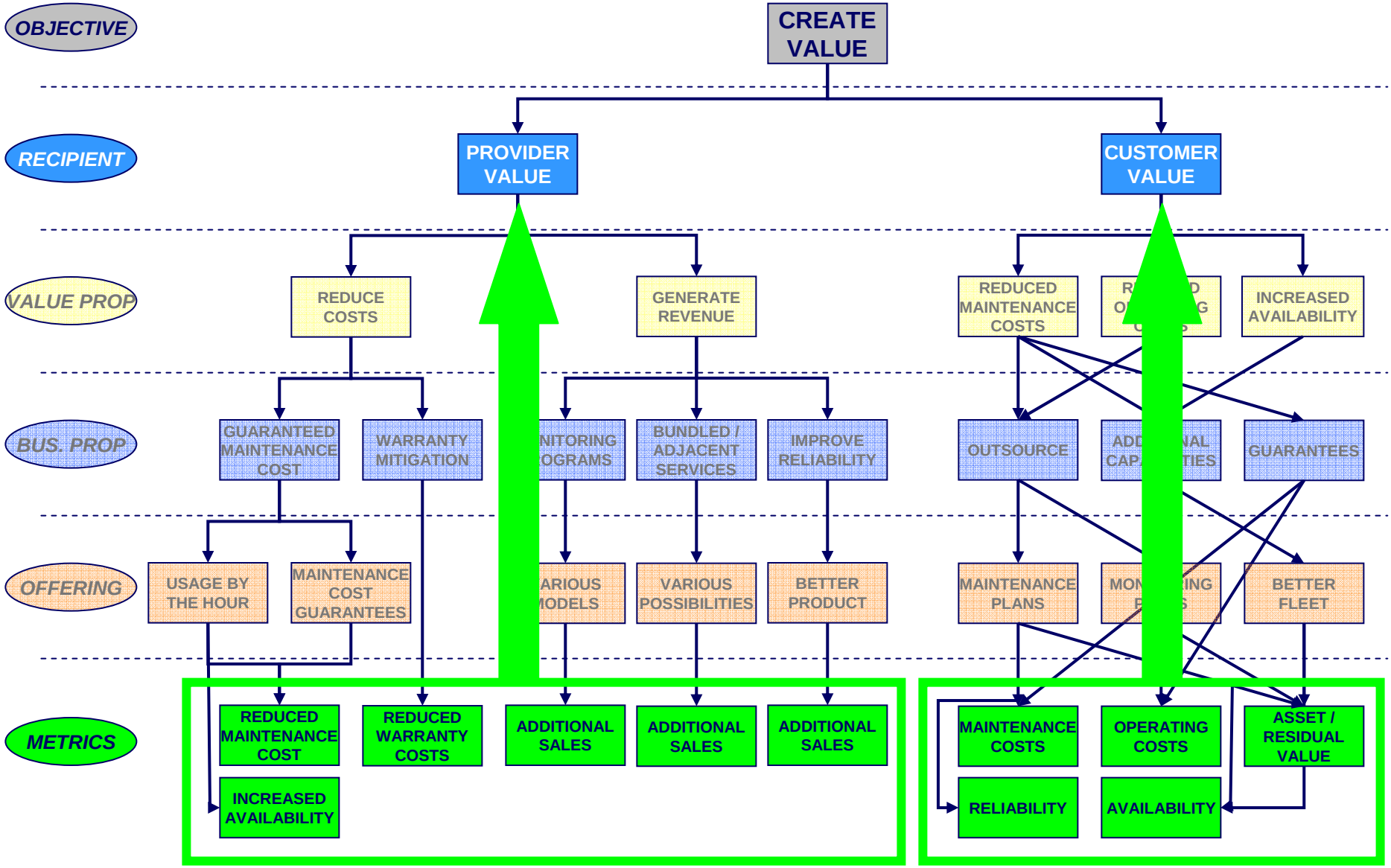


Define and Quantify the Metrics!



Diagnostics and Prognostics Mitigate Risks

Reliability typically trades with cost and weight

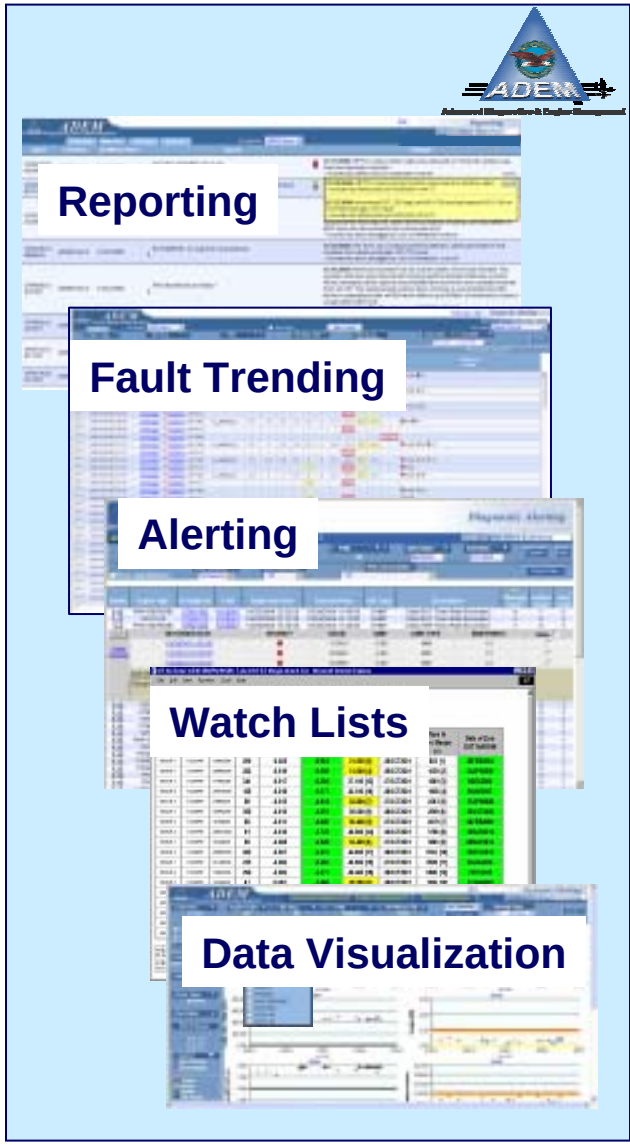
PHM improves reliability, reduces cost

- 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



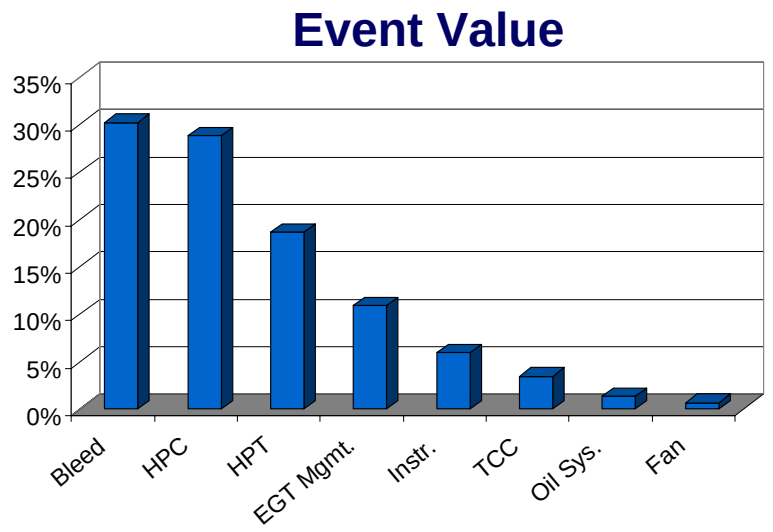
Health Management Provides Quantifiable Value

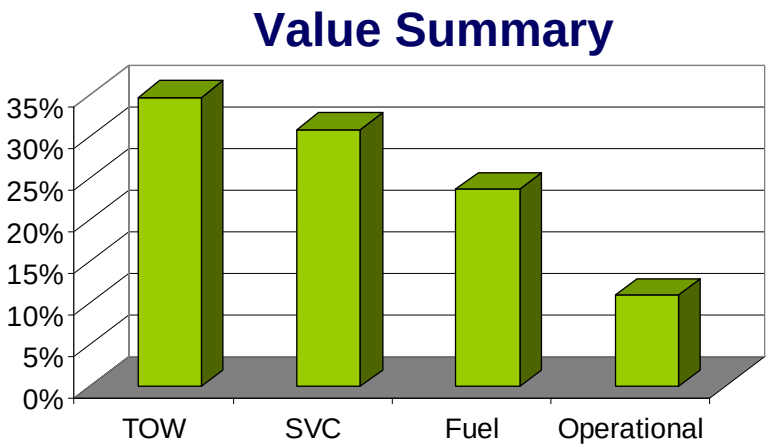
Time on wing extension

Shop visit cost reduction

Fuel consumption reduction

Operational cost reduction





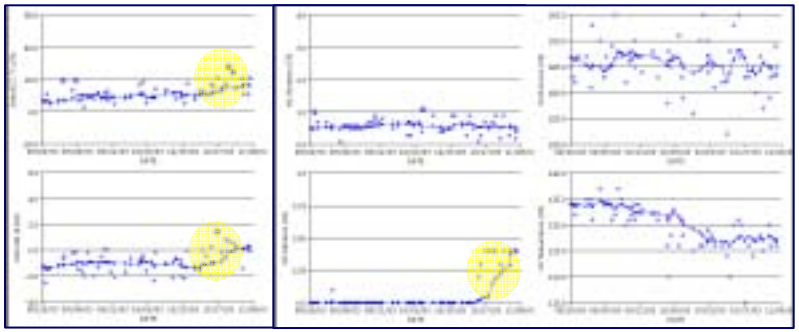
Savings vary by service level, customer, fleet, etc., and do not include significant productivity improvement typically realized.

Customer Value – HPT Damage Detected

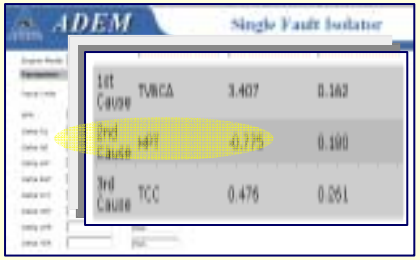
PW4000 engine removed prior to additional damage

Alerts triggered

Trend plots point to HPT



Isolation indicates HPT



Borescope inspection revealed T1 blade damage

Engine removed prior to incurring additional damage

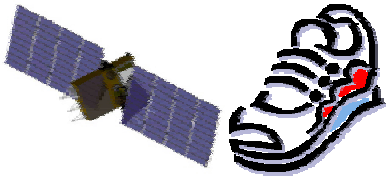
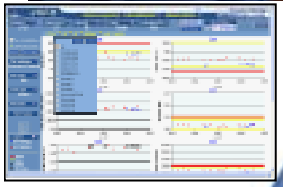
Estimated Savings: $700K (UER potential – $Million+ / Event)

Industry Health Management Value Stream

ACQUIRE DATA → **DELIVER DATA** → **ANALYZE + REPORT** → **EXECUTE ACTIONS**







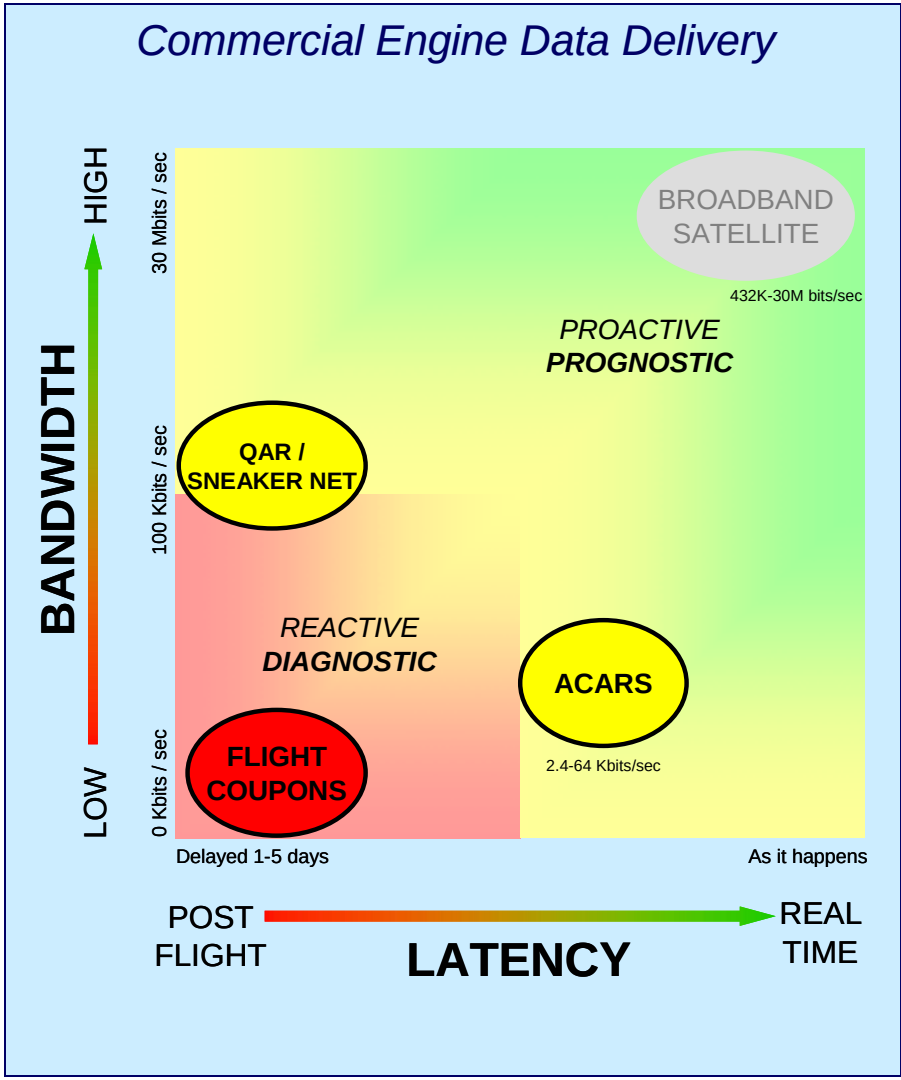
WEAK **STRONG**

Improve Data Collection and Delivery Technologies

Current technologies are poor: ACARS, sneaker-net

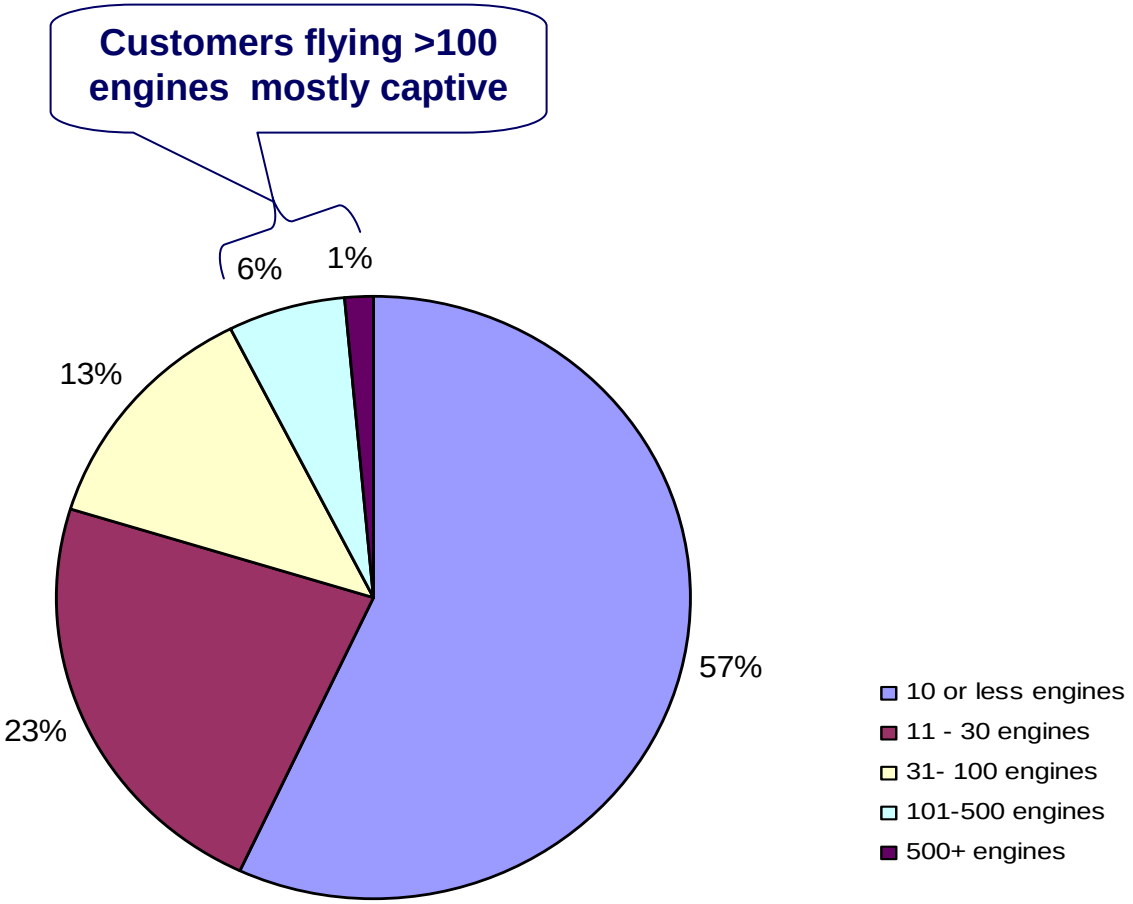
PHM critically needs various field data for…

- 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?

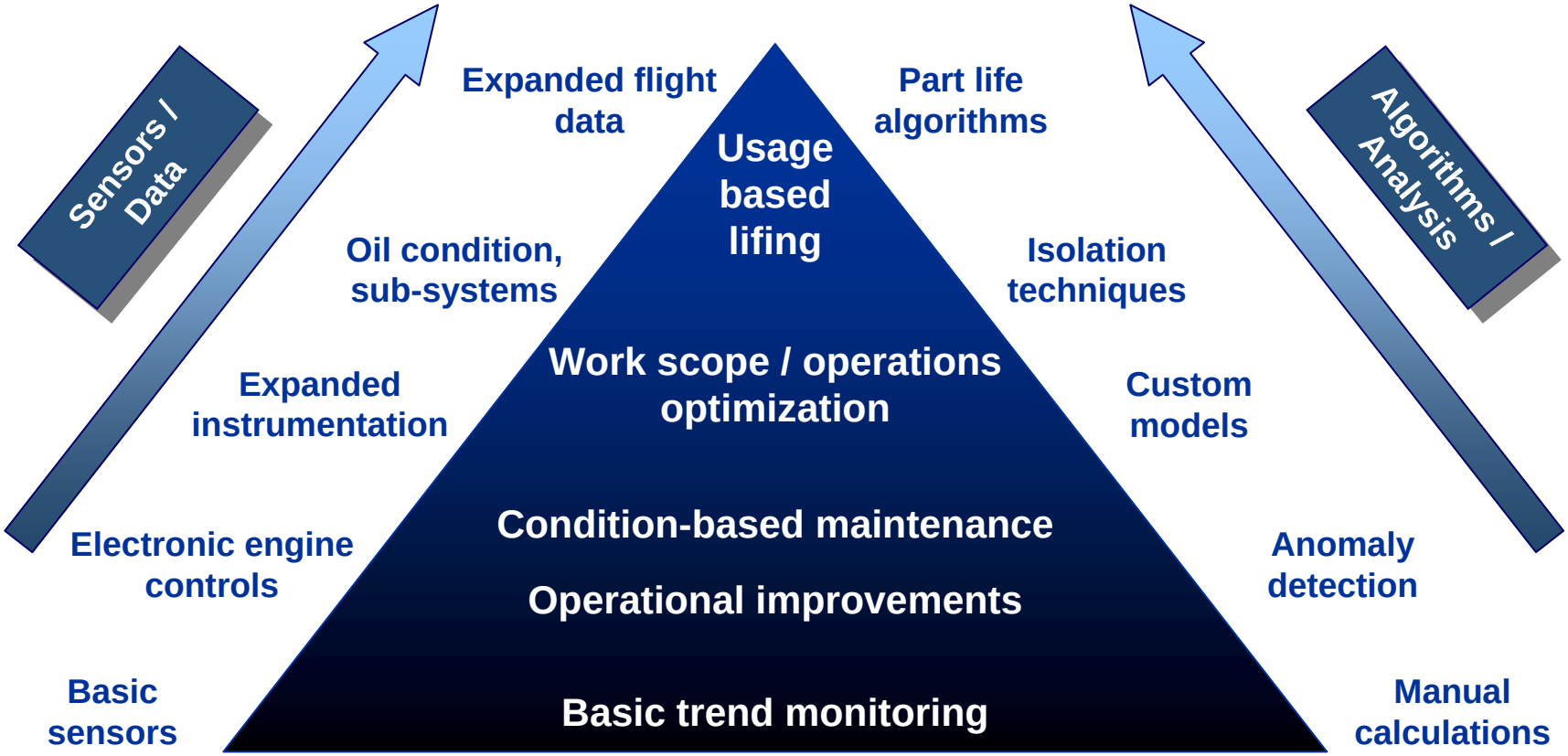
57% of world's operators fly 10 or fewer engines



Profitability?
Portability?

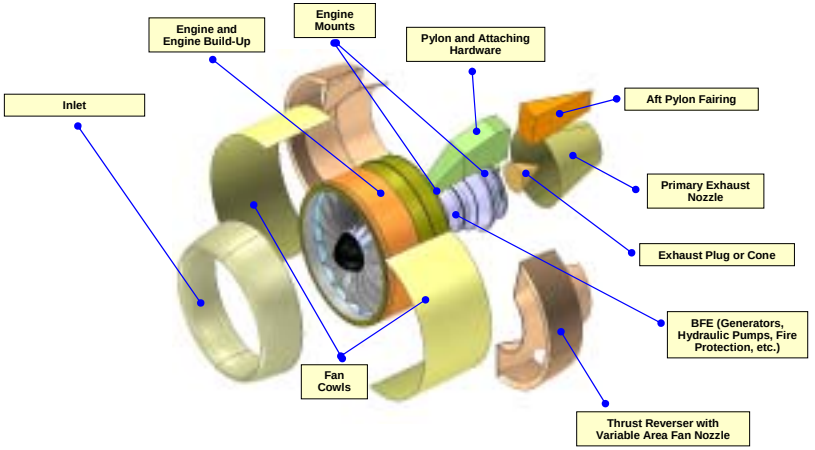
How Can We Address More Problems?

Technology advancements drive value



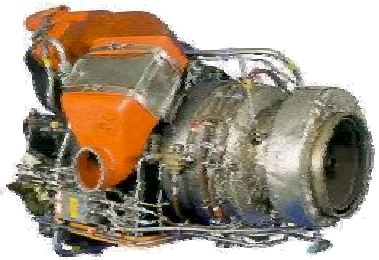
A Holistic Systems Approach

Integrated vehicle health and data management

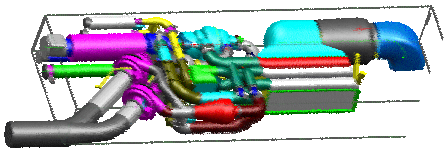


100% pylon-on-down (POD) support

Guided Troubleshooting



APU



Environmental Control System

Questions?

Thank You!