Commercial Applications for Predictive Analytics: Requirements-Driven Forecasting

ICEAA 2018 Workshop

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PRICE Systems

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Outline

1. Introduction
2. Overview
3. Case Studies
   a) Automotive
   b) Jet Engine
   c) Aircraft
   d) Software
4. Lessons Learned

Outline

Commercial Applications of Predictive Analytics: Requirements-Driven Forecasting

Our job is often to fine-tune a predictive capability, process or system by best applying knowledge to justify key drivers for forecasting.

Regardless of methodology, internally-developed or licensed, the common objective is creating valid/defensible estimates based on actual historical data as well as performance parameters.

This paper will examine four commercial case studies where unique Predictive Analytics methods were implemented to both leverage proprietary knowledgebases as well as reflect requirements metrics to create justifiable forecasts.

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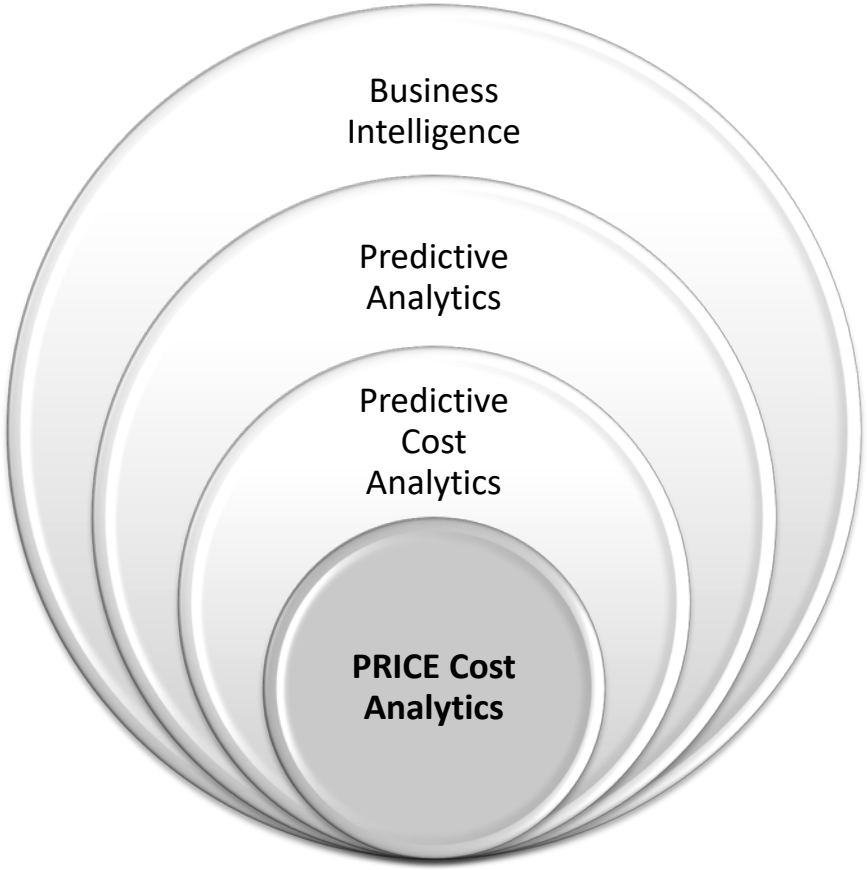
Cost Analytics Overview

- **Business intelligence (BI)** is the set of techniques and tools for the transformation of raw data into meaningful and useful information for business analysis purposes (Wikipedia 2015)
- **Predictive Analytics** encompasses a variety of statistical techniques from modeling, machine learning, and data mining that analyze current and historical facts to make predictions about future, or otherwise unknown, events (Wikipedia 2015)
- **Predictive Cost Analytics** a field of predictive analytics specifically targeting cost and schedule estimating for products, projects, on-going operations, other cost-incurring activities
- **PRICE Cost Analytics** a prescriptive, targeted implementation of predictive cost analytics encompassing a suite of proven processes, automation software, and predictive models



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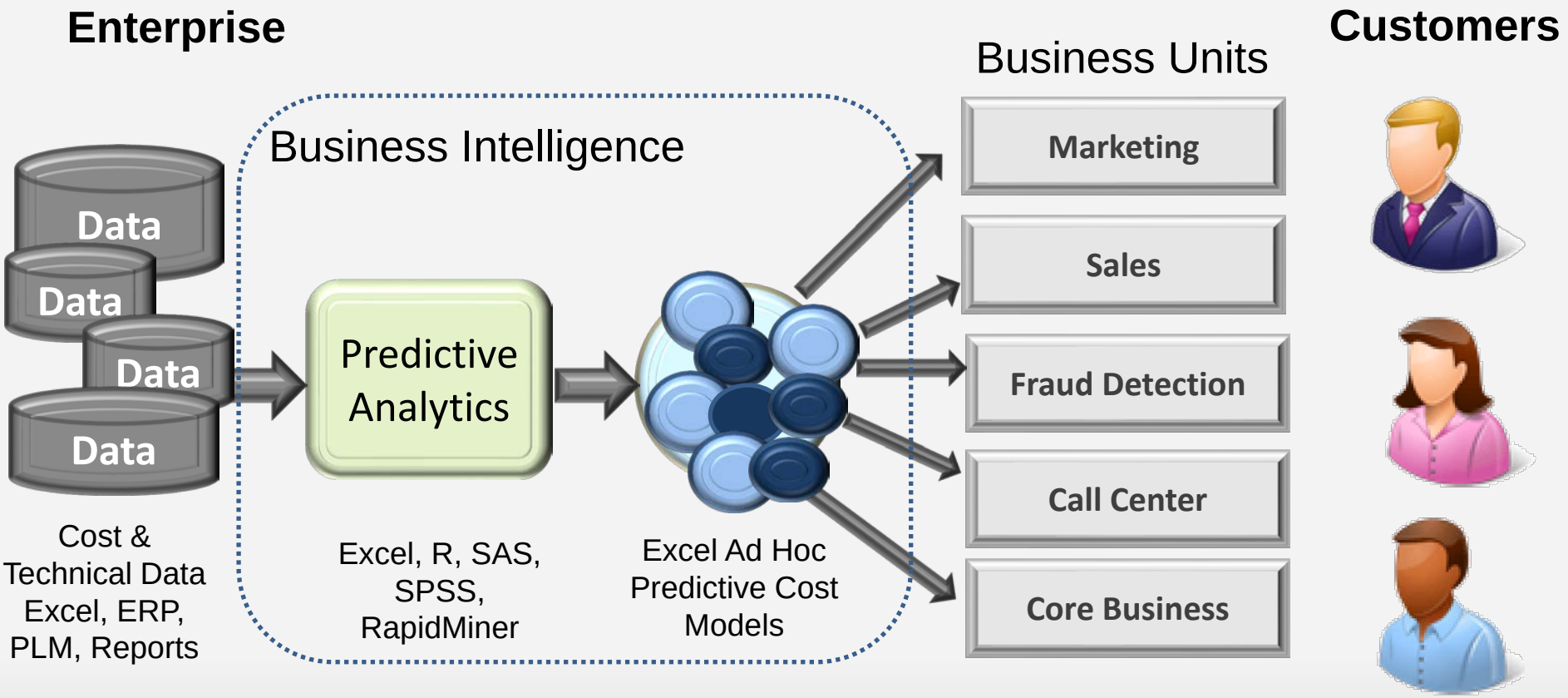
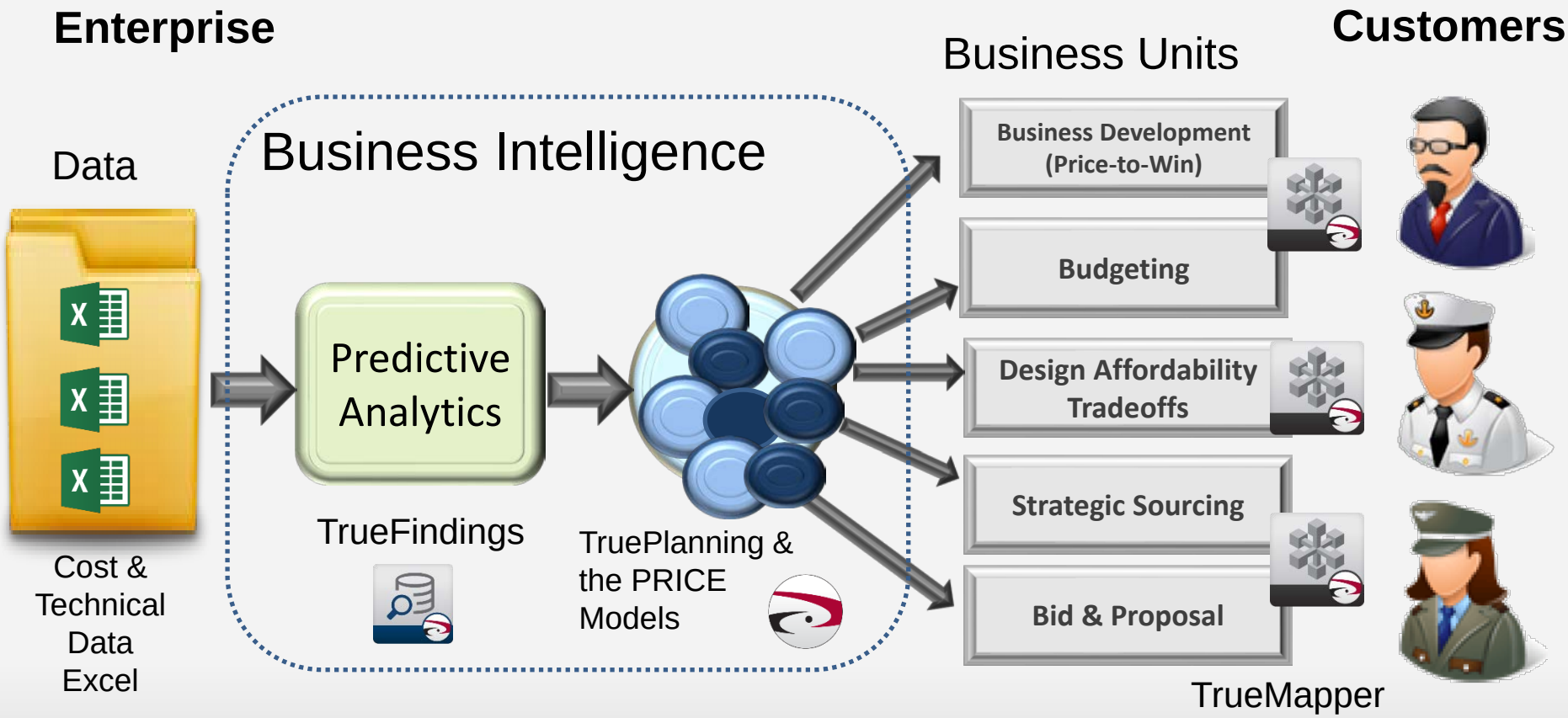
Predictive Cost Analytics



PRICE ® Cost Analytics



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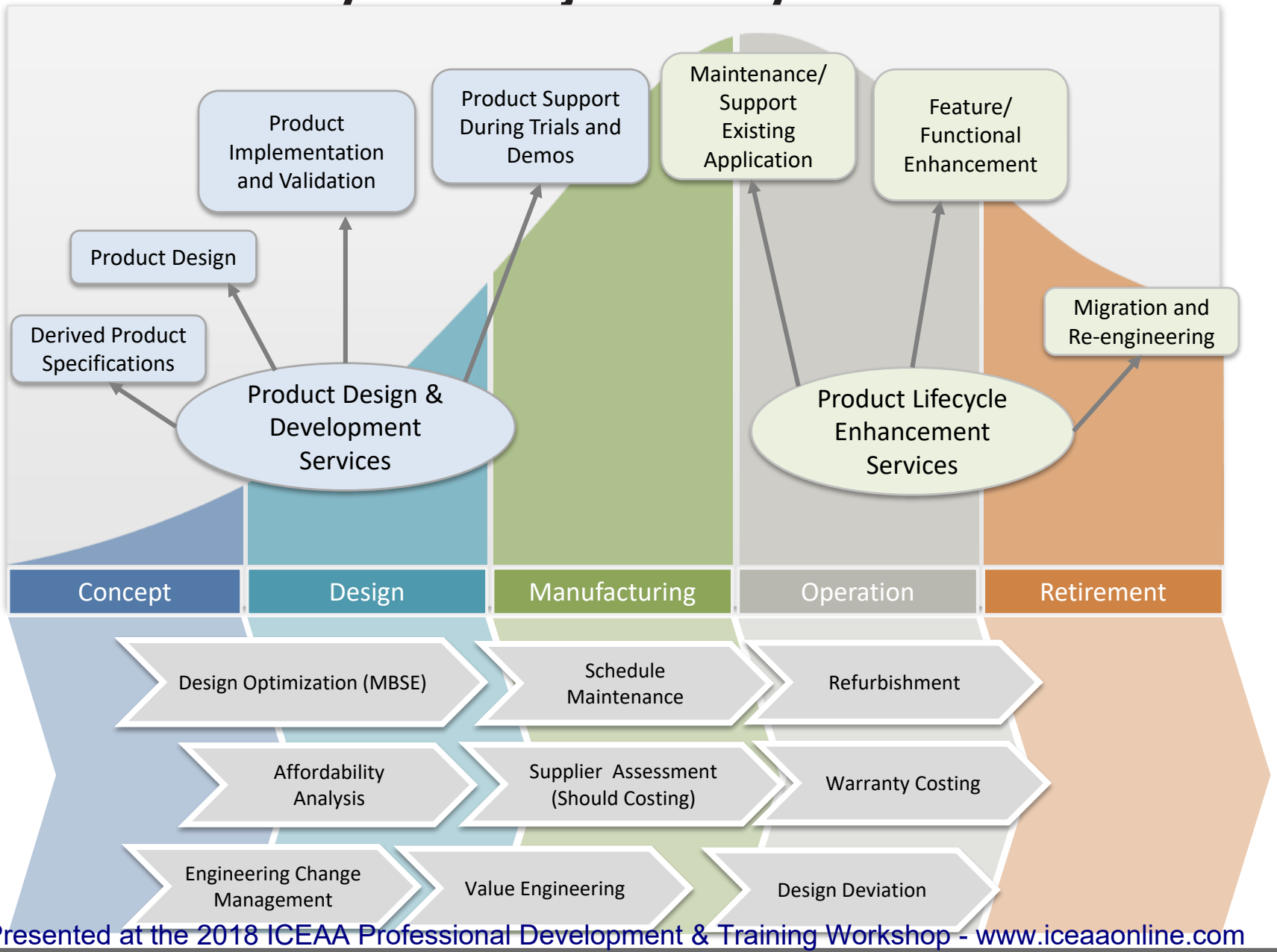
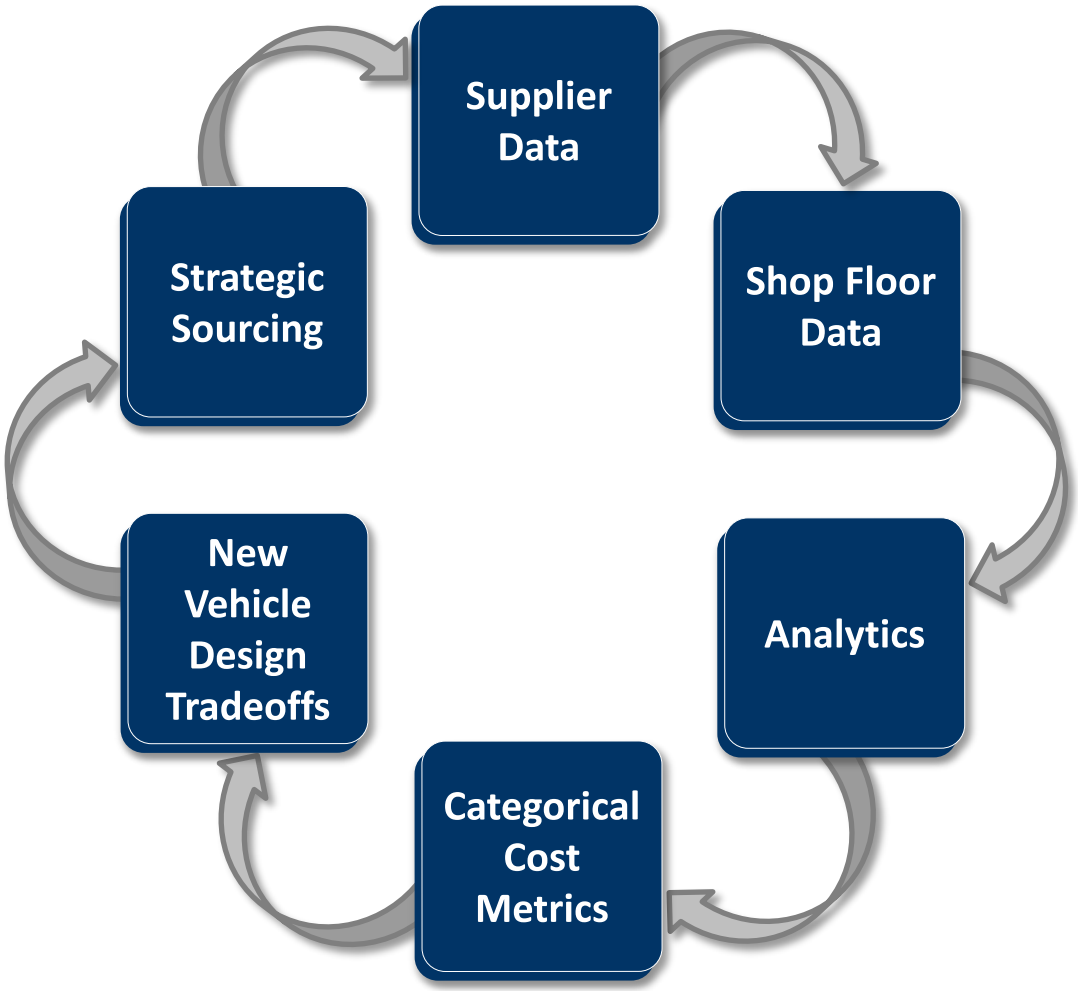
PRICE® Cost Analytics - Project Lifecycle View



AUTOMOTIVE CASE STUDY



Feature

Attribute

Feature	609
Attribute	16
Platform	5
Brand	3
Model Line	10
COC	5
CSS	32
CPSCII	340
Part	

Platform

BRAND

Model Line

COC

CSS

CPSCII

Part

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Cost Management Platform – Current State

Concept → Affordability → Design → Purchase decision → Procurement /Production

Cost Management

Cost management workbench, Workflow management & Reporting Dashboard

Product lifecycle cost management tracking

- **COST ESTIMATION FRAMEWORK**
  - PRICE® TruePlanning™
  - SmartCore™
- **CAD TO COST**
  - LeanCOST®
- **Knowledge Driven Bottoms-up Estimating**
  - CAPPe

Parametric Data management

- **INTERGRATED KNOWLEDGE MANAGEMENT**
  - PRICE® TrueAnalyst™
  - PRICE® TrueFindings ™
  - SmartCore™
- **DATA MINING & ANALYSIS**
  - PRICE® Research™
  - rapidminer
- **DATA CAPTURE**
  - Lifecycle Cost Data
  - Bottoms-up Cost Data
  - Corporate historical data

Detailed Knowledge – Goal State

Concept → Affordability → Design → Purchase decision → Procurement /Production

Cost Management

SmartCore™ — Cost management workbench, Workflow management & Reporting Dashboard

Product lifecycle cost management tracking

- COST ESTIMATION FRAMEWORK
  - PRICE® TruePlanning™
  - SmartCore™
- CAD TO COST
  - LeanCOST®
- Knowledge Driven Bottoms-up Estimating
  - CAPPe

Knowledge Management

- SmartCore™
  - QBE Questions
  - Knowledge Tree development
- LeanCOST®
  - Property import
  - Knowledge rule creation
- CAPPe
  - Property import
  - Knowledge rule creation

Properties, Capabilities and Characteristics Database

Standard Parts | Materials | Labour | Workcentre

Knowledge Database

Documented manufacturing knowledge library

KNOWLEDGE RESEARCH & ANALYSIS

PRICE® Research™

DATA CAPTURE

- Industry Data
- Bottoms-up Cost Data
- Corporate historical data

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JET ENGINE CASE STUDY

Mission-Operational Context

Value Framework (KPP- MOE)

Completed

Missions, Scenarios, & Capabilities Needed

Iterative Cycle

Inputs

Cost Analysis

Risk Analysis

Performance Analysis

Schedule Analysis

Outputs

Architecture (WBS – Tech Baseline)

Trade-Off Analysis

Best Value

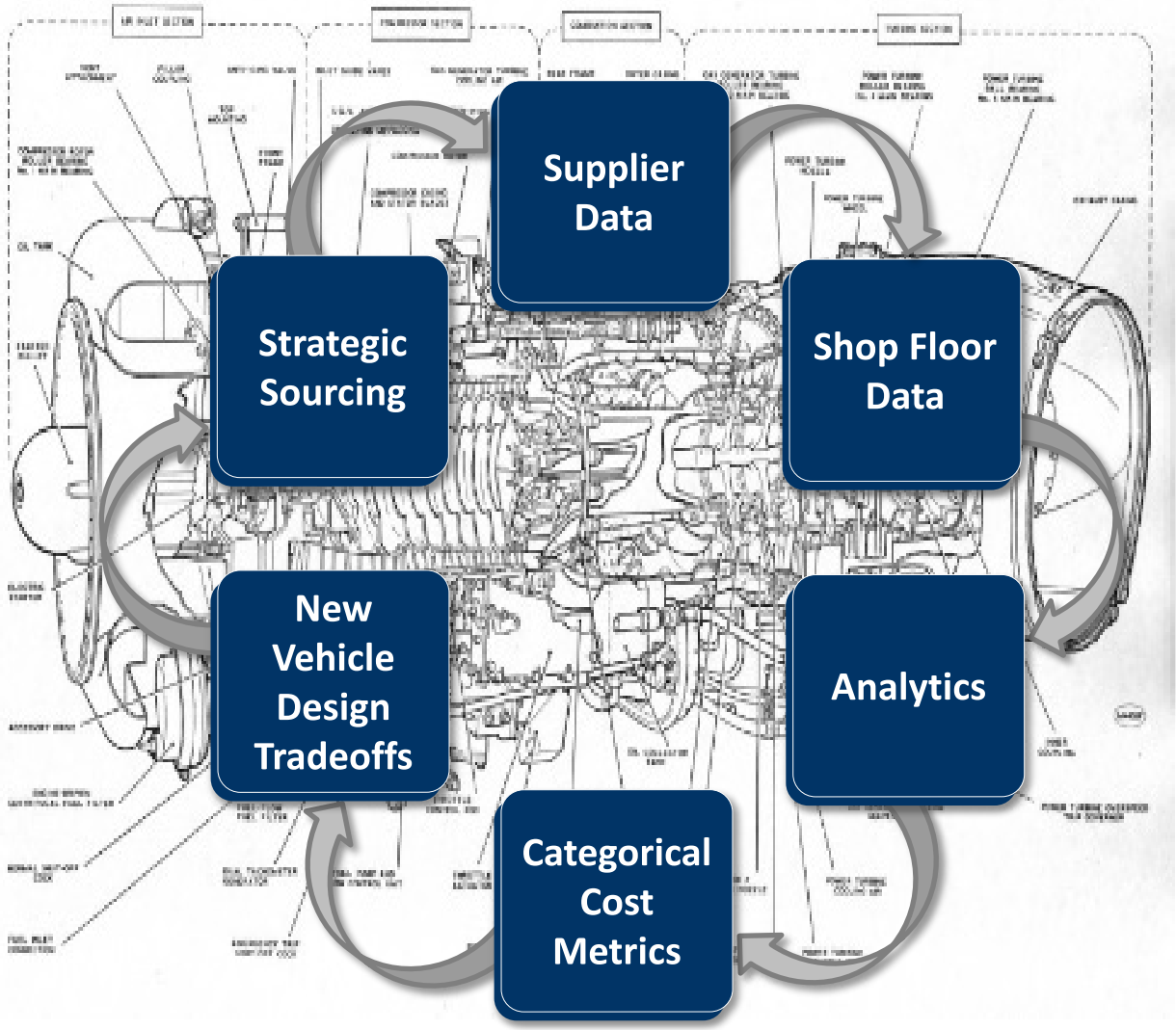
Yes

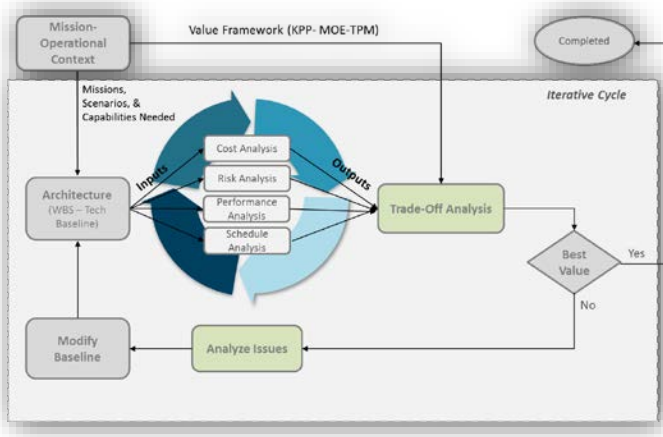
No

Modify Baseline

Analyze Issues

PRICE Cost Analytics on Engine Parts & Assemblies





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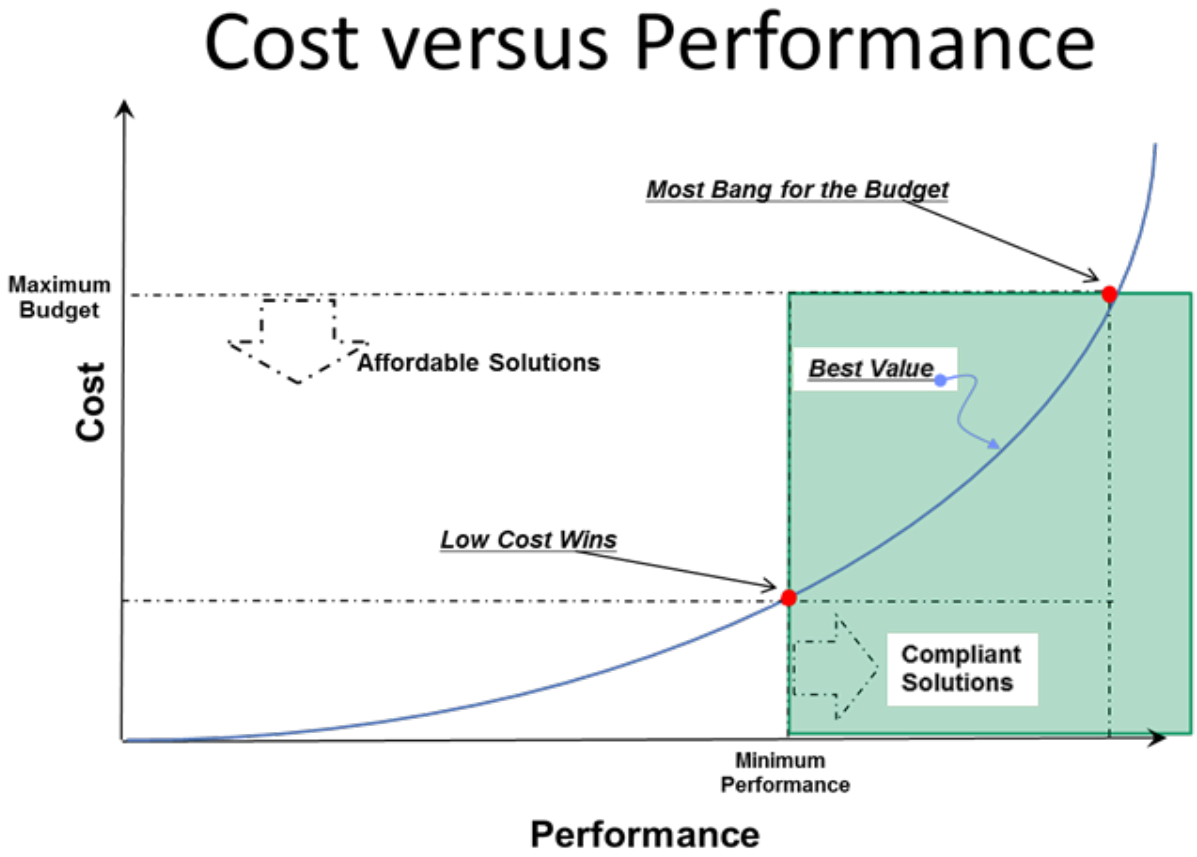
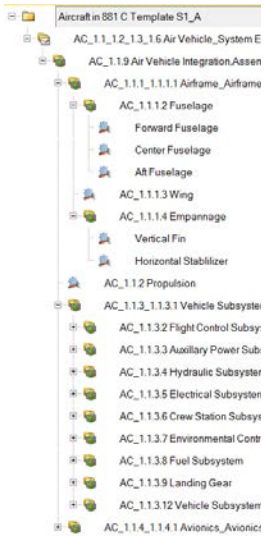
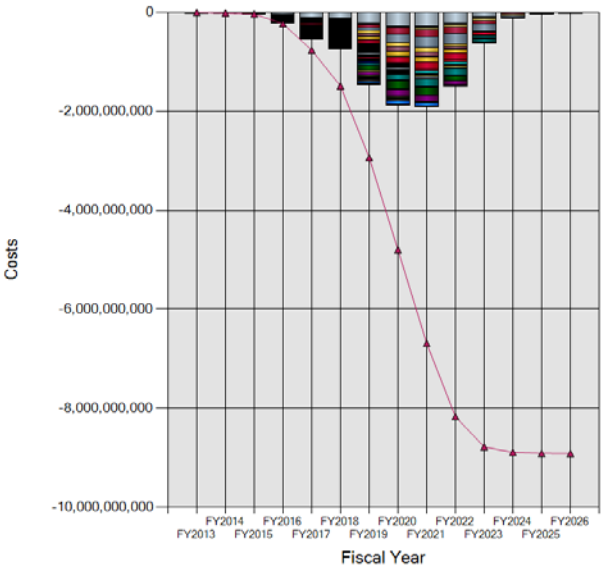
Cost Analytics and Design-Trade Benefits

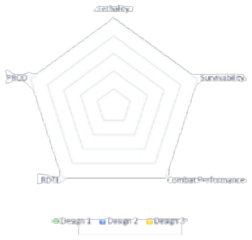


Tuttle & Bobinis (2013)
"Specifying Affordability"

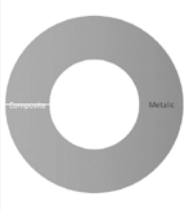
AIRCRAFT CASE STUDY:
Notional Derivative Design Process

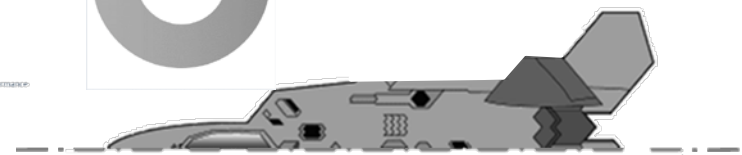


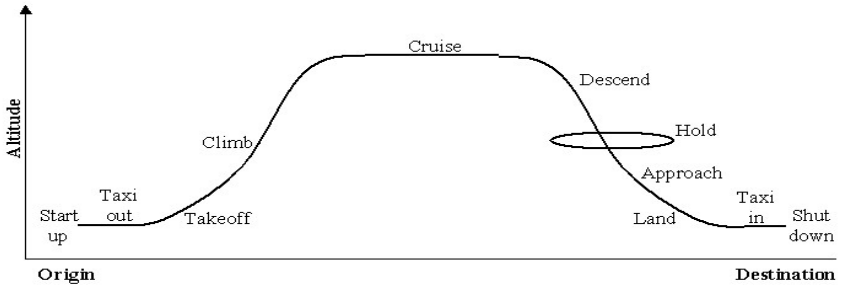


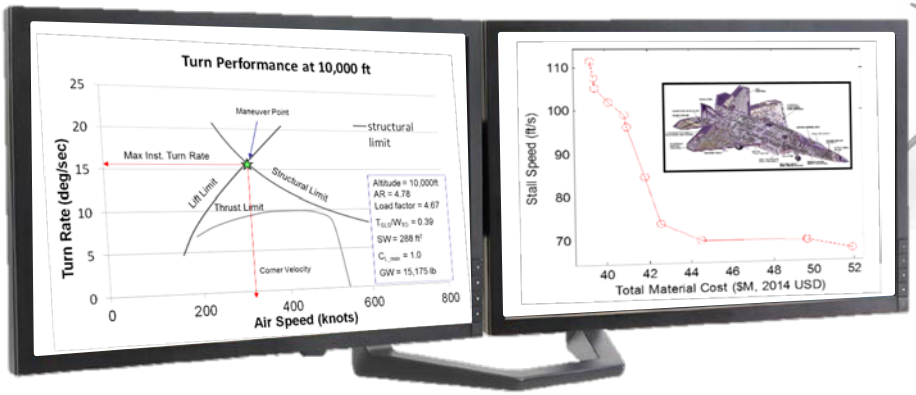


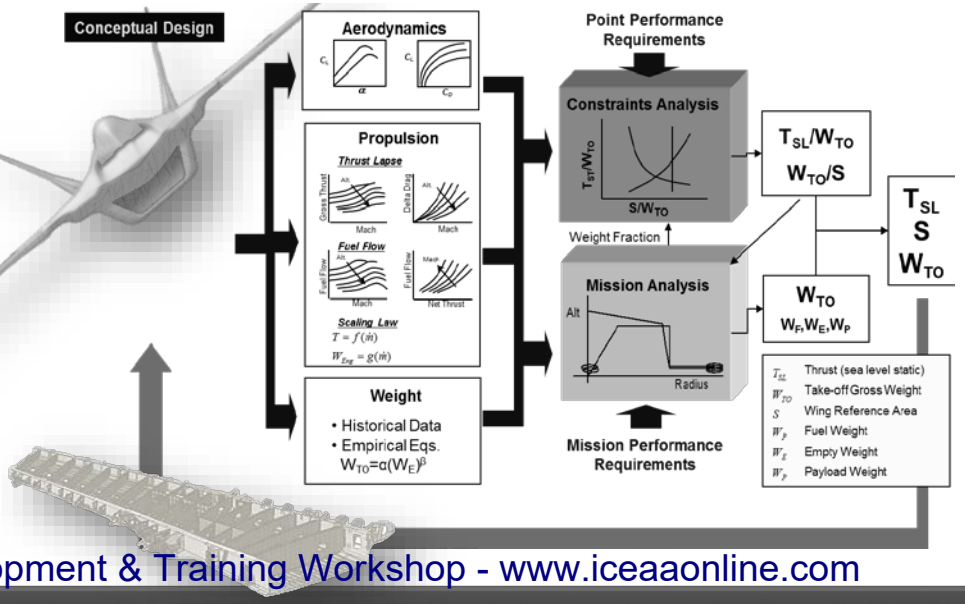
Wing Composite Fraction











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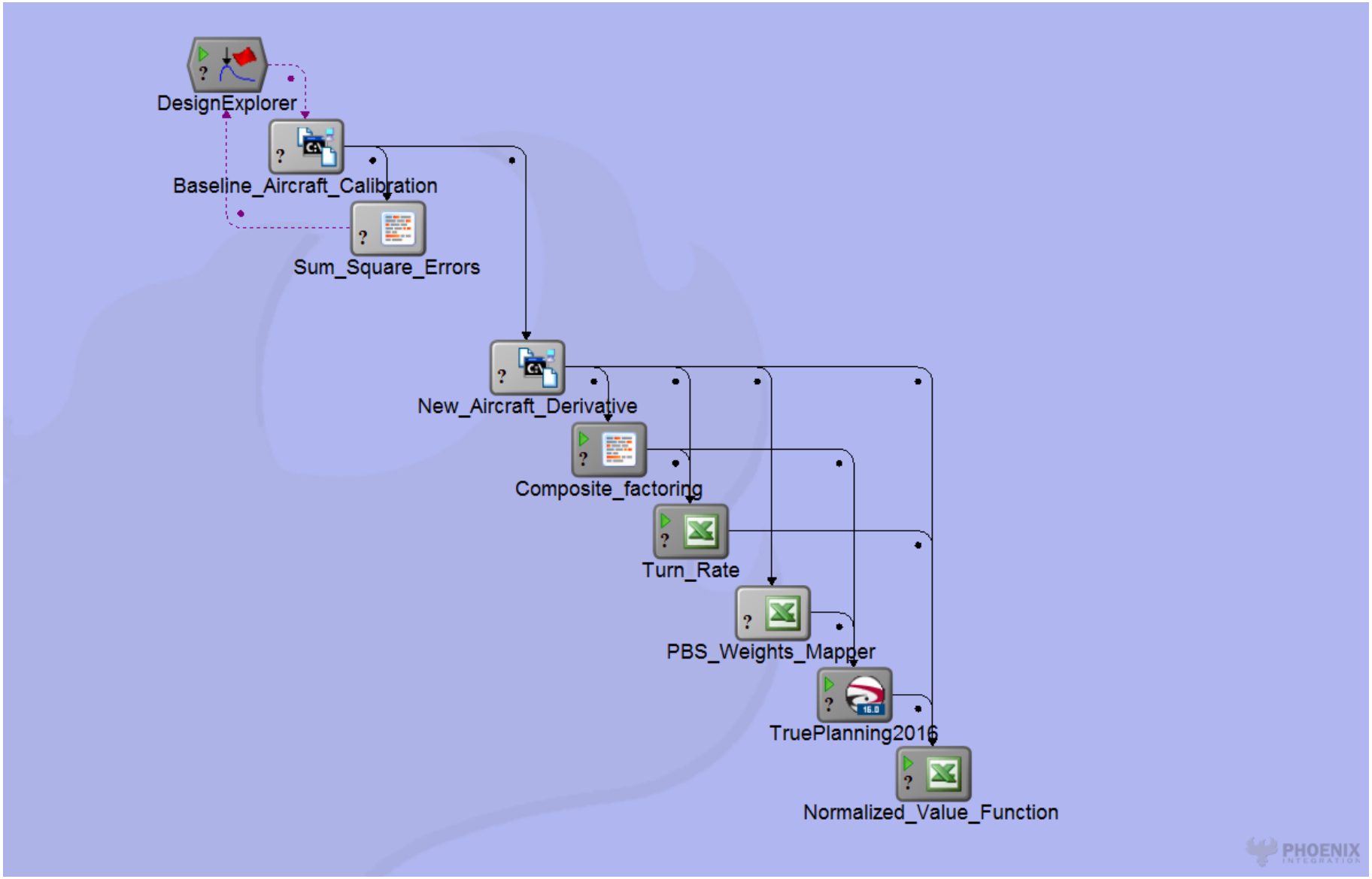
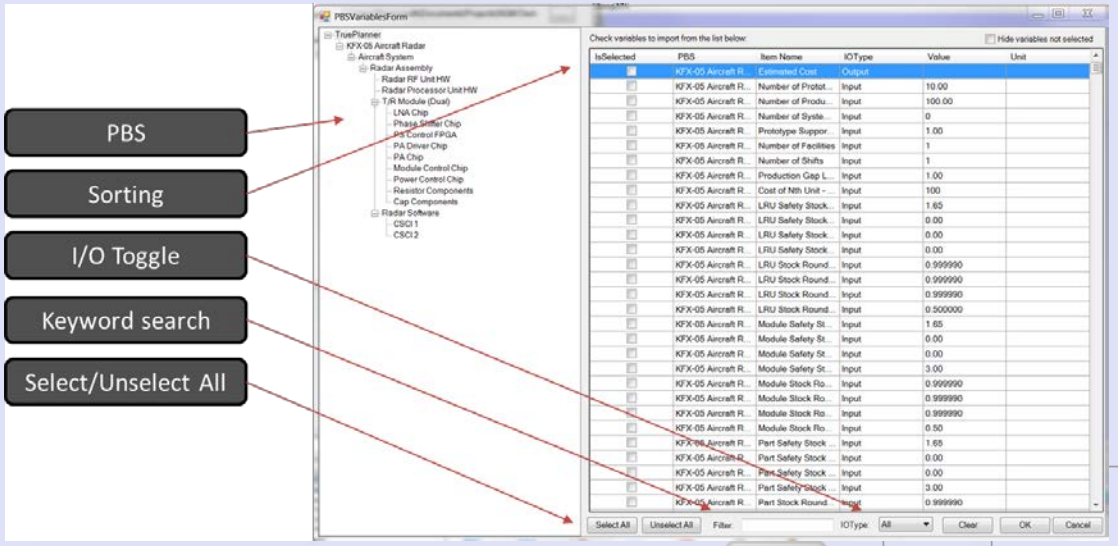
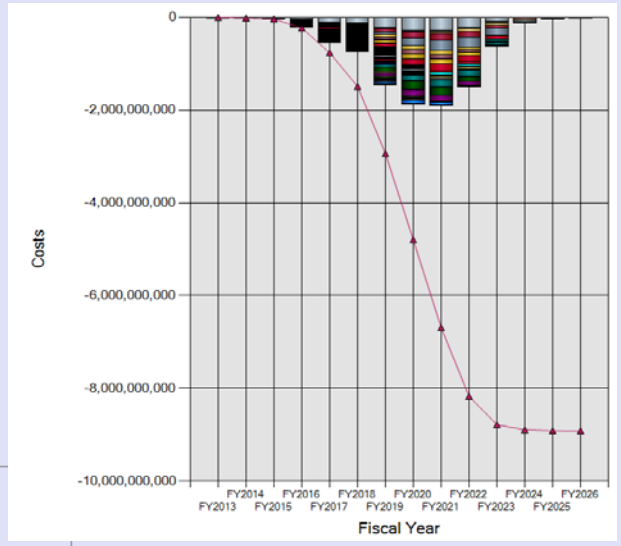
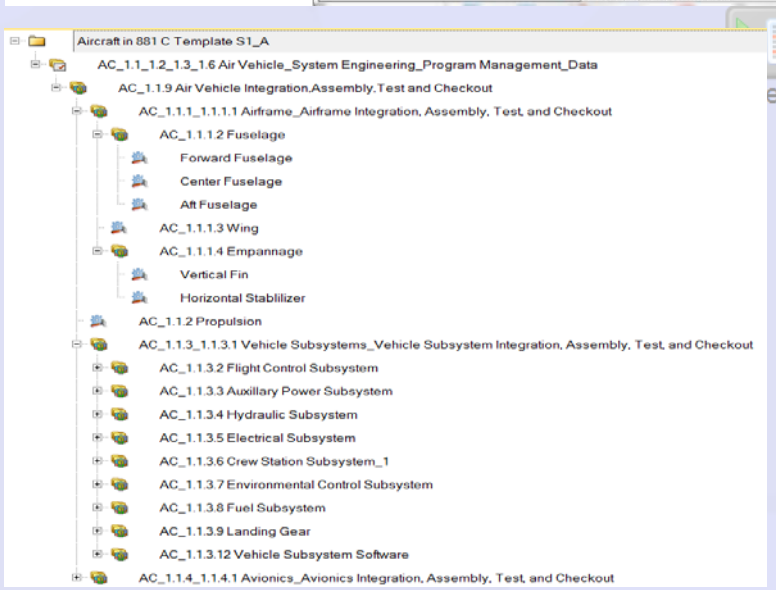
Simulation and Modeling Environment

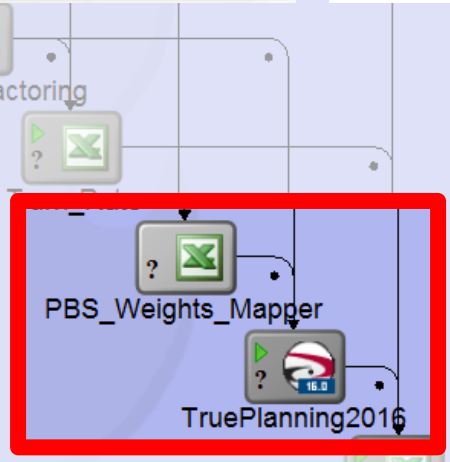


Cost Analysis









Normalized_Value_Function

Design-Driven Cost Factors

- Component Weights
- Complexities
  - Component/product
  - Process
  - Integration
- Technology Readiness Levels
- Production Units
- Learning Curves
- Etc.

SOFTWARE CASE STUDY

- Sensor-Software Development data in Excel
  - Calibrated Complexity and Productivity Drivers

	A	B	E	F	G	H	I	J	K	L	M
1	Name	Space Sensor/Detector Software Component (Text)	New Code Size - SLOC (Number)	Language (Text)	Normalized Dev. Time - Hours (Number)	Normalized Dev. Cost - 2013 $USD (Number)	KPP#1 Operational Effectiveness (Number)	KPP#2 Differentiation Effectiveness (Number)	KPP#3 Operational Availability (Number)	KPP#4 Spectral Resolution (Number)	KPP#5 Electromagnetic Intensity (Number)
2	Payload 1	Spectrometer SW	4,459	JavaScript	1,681	$ 77,871	95	96	97	95	94
3	Payload 1	Electro-Static Analyzer SW	9,875	C++	8,172	$ 254,287	95	96	95	94	95
4	Payload 1	Gamma Sensor SW	14,129	Java	12,048	$ 357,427	96	97	96	95	96
5	Payload 1	Neutron Sensor SW	14,750	Java	12,257	$ 367,696	97	97	98	98	99
6	Payload 1	Radiometer SW	153,824	Ada95	22,642	$ 746,347	98	98	99	99	99
7	Payload 2	Spectrometer SW	6,237	JavaScript	3,252	$ 133,449	95	96	95	94	95
8	Payload 2	Electro-Static Analyzer SW	8,032	C++	4,139	$ 185,747	95	95	96	96	97
9	Payload 2	Gamma Sensor SW	12,056	Java	10,214	$ 320,078	96	96	95	94	95
29	Payload 7	Gamma Sensor SW	7,495	JavaScript	3,967	$ 145,581	95	96	97	97	96
30	Payload 7	Neutron Sensor SW	12,050	C++	9,413	$ 306,413	95	96	97	95	94
31	Payload 8	Radiometer SW	6,132	Python	3,071	$ 121,318	95	95	94	93	94
32	Payload 8	Spectrometer SW	9,860	C#	7,679	$ 254,287	95	96	95	98	93
33	Payload 9	Electro-Static Analyzer SW	8,176	JavaScript	4,327	$ 185,747	95	96	97	97	97
34	Payload 9	Gamma Sensor SW	13,146	C++	11,943	$ 353,178	95	96	95	98	96
35	Payload 10	Neutron Sensor SW	5,451	Python	2,437	$ 104,469	95	95	94	97	93
36	Payload 10	Radiometer SW	8,764	C#	4,668	$ 189,816	95	96	97	95	95

Perform Predictive Analytics to determine method for fine-tuning software cost drivers as a function of KPPs

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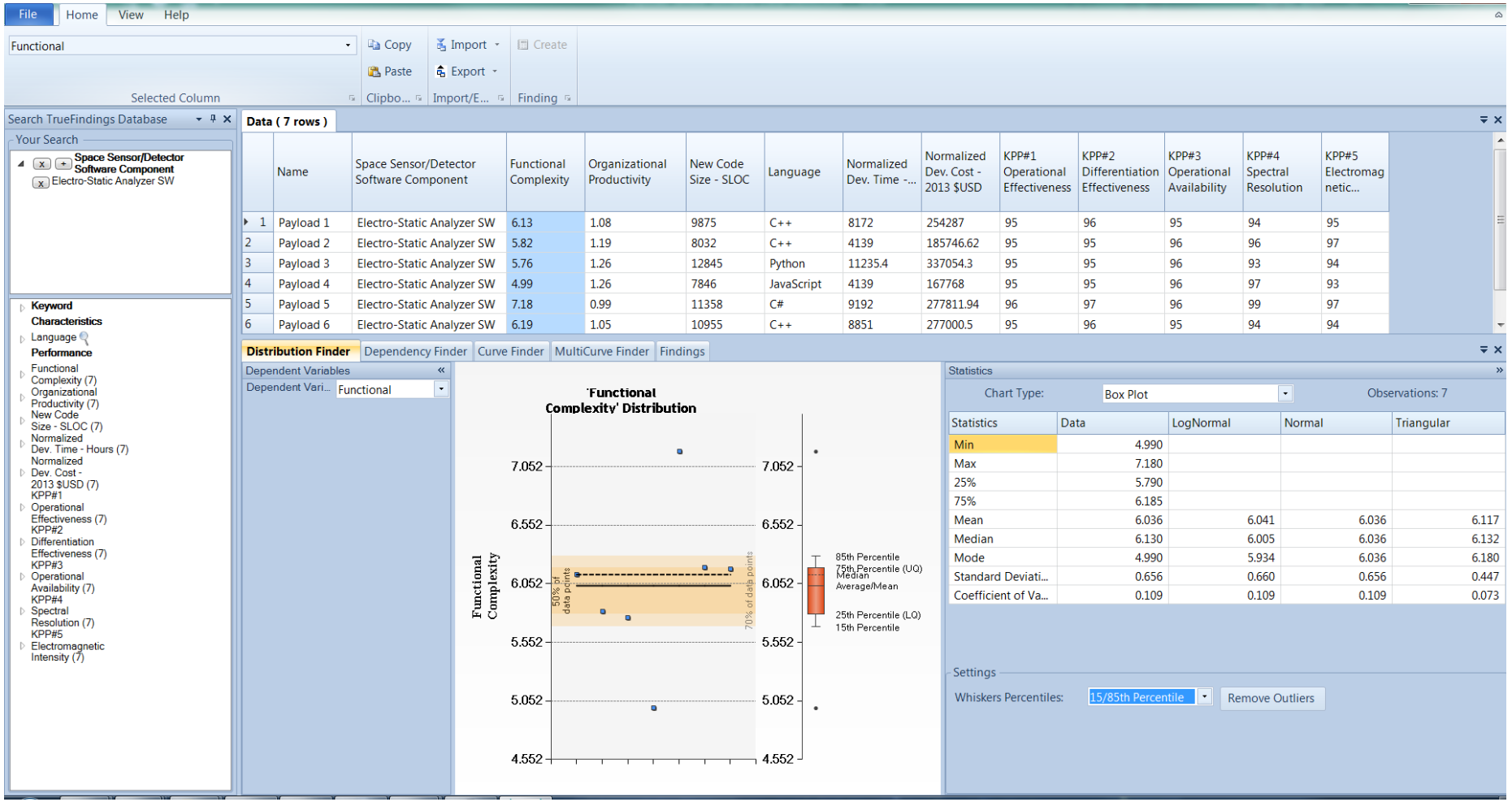
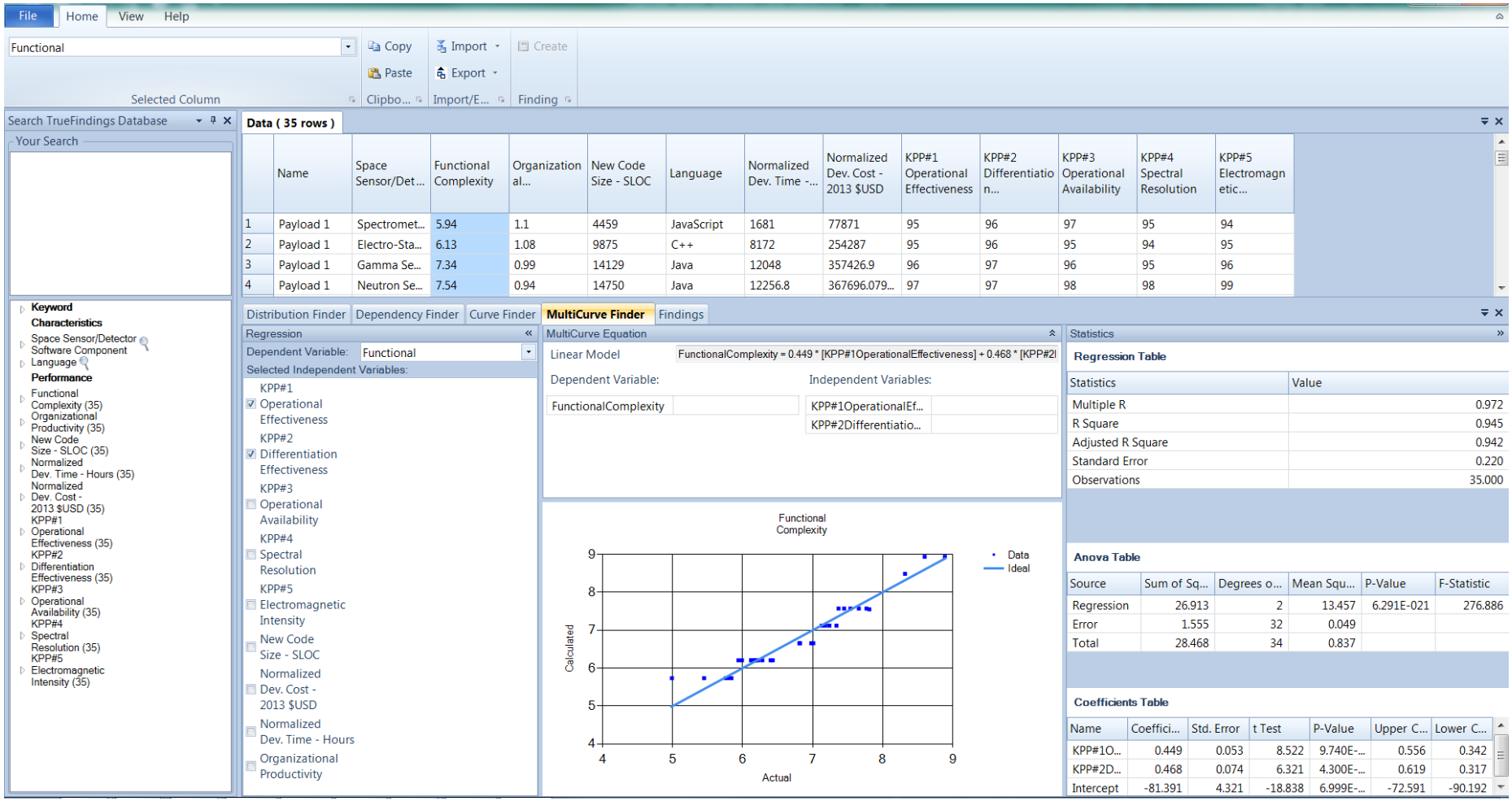
TrueFindings® Visualization



- Example Software Development data: Distribution Finder
  - Spreadsheet rows become knowledgebase fields for search/filtering
  - 1st tab-function shows descriptive statistics for all or (above) selected data

TrueFindings® Visualization



- Example Software Development data: Multicurve Finder
  - 4th tab-function shows multiple (two or more predictors) regression and tables

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Lessons Learned

Typically, predictive analytics requires painstaking processes for normalizing data and creating "one-off", multivariate models to predict outcomes. Tailoring generic predictive analytics tools to estimate costs and schedules is complicated and time consuming. It is faster and easier to "calibrate" existing, proven models that are tested and supported by experts…

PRICE Cost Analytics

- Specifically designed to predict costs and schedules
- Integrated tools combine to speed the process and lower the cost to predict costs and schedules
- Proven, reusable cost models that capture the common cost drivers of like-items to be estimated
- PRICE subject matter experts know the process, and are available to help you along the way