THE VALUE OF PERFORMANCE.

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Life-Cycle Benefits of Model-Based Integrated Health Management

eXpress Users Group Meeting

14 Sep 2012

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Life Cycle Logistics & Support

IHM Operational Elements

(for purposes of this presentation **IHM = PHM = ISHM = IVHM**)

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Vehicle IHM System

Provides:
- AV-Level Info Management
- Reliable FDIR
- Prognostics / Trends
- Supports ALE

Subsystem Control & Health Mgmt

- Propulsion
- Avionics
- Thermal Control
- Airframe

Vehicle HM

Enabling Technologies
- Diagnostics & Prognostics
- Cross-Subsystem FDIR
- Model-Based Development & Testability Analysis
- Fault Signature Detection

Fault Management, Reporting & Recording

Operator Interface / Mission Control

Safety Critical

Mission Critical

MC Displays & Controls & Control Display Unit (CDU)

Data Terminal

Diagnostic Data

In-Flight Maintenance Data Link

Portable Maintenance Device (PMD)

Maintenance Panel

Fault Codes

Flight Data Recorder

Fault / Service Info

Maintainer Vehicle Interface

IETMs
Consumables
On-Board Diagnostics

Ground IHM System

Support System
- Automated Operator / Maintainer Debrief
- Off-Board Prognostics
  - Trending
  - Life Cycle Mgmt
- Store / Distribute Diagnostic Database

DB

Objective of Model-Based Diagnostic Design Analysis - Support "Design for Maintainability" While Reducing Costs

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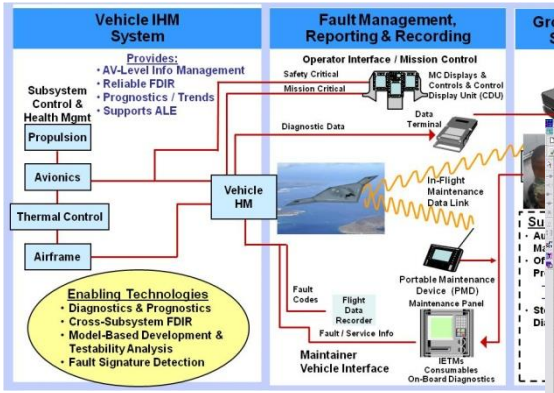
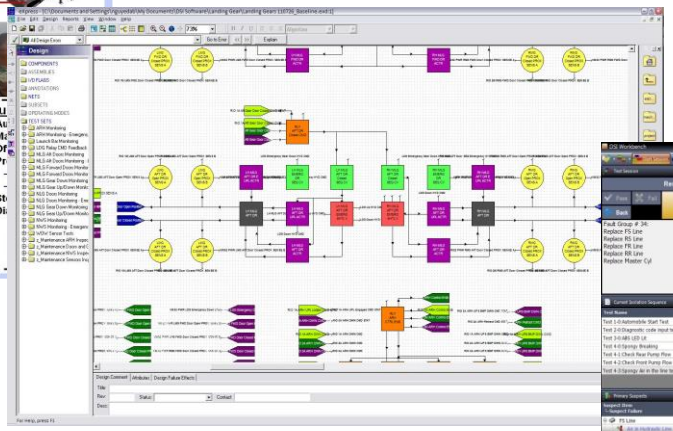
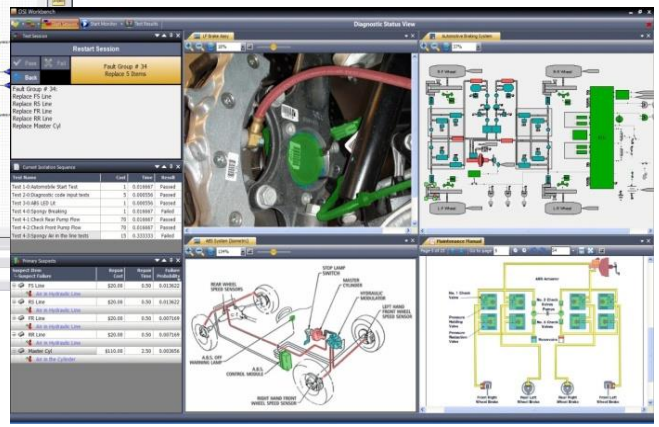
- Use Model-Based Testability Analysis Tools to Assess Fault Coverage vs. Reqmts
- Reduce Replication in Related FMECA and Testability Analysis Efforts
- Support IETM Generation and Informed Maintenance Activities
- Enable Effective Discrepancy Analysis and Design Updates During Sustainment
- Reduce Time Required to Develop Variants of Baseline Vehicle Design



Architect for Growth



Design for Supportability



Improve Maintenance & Sustainment

Model-Based System Design and Life Cycle Logistics Loop

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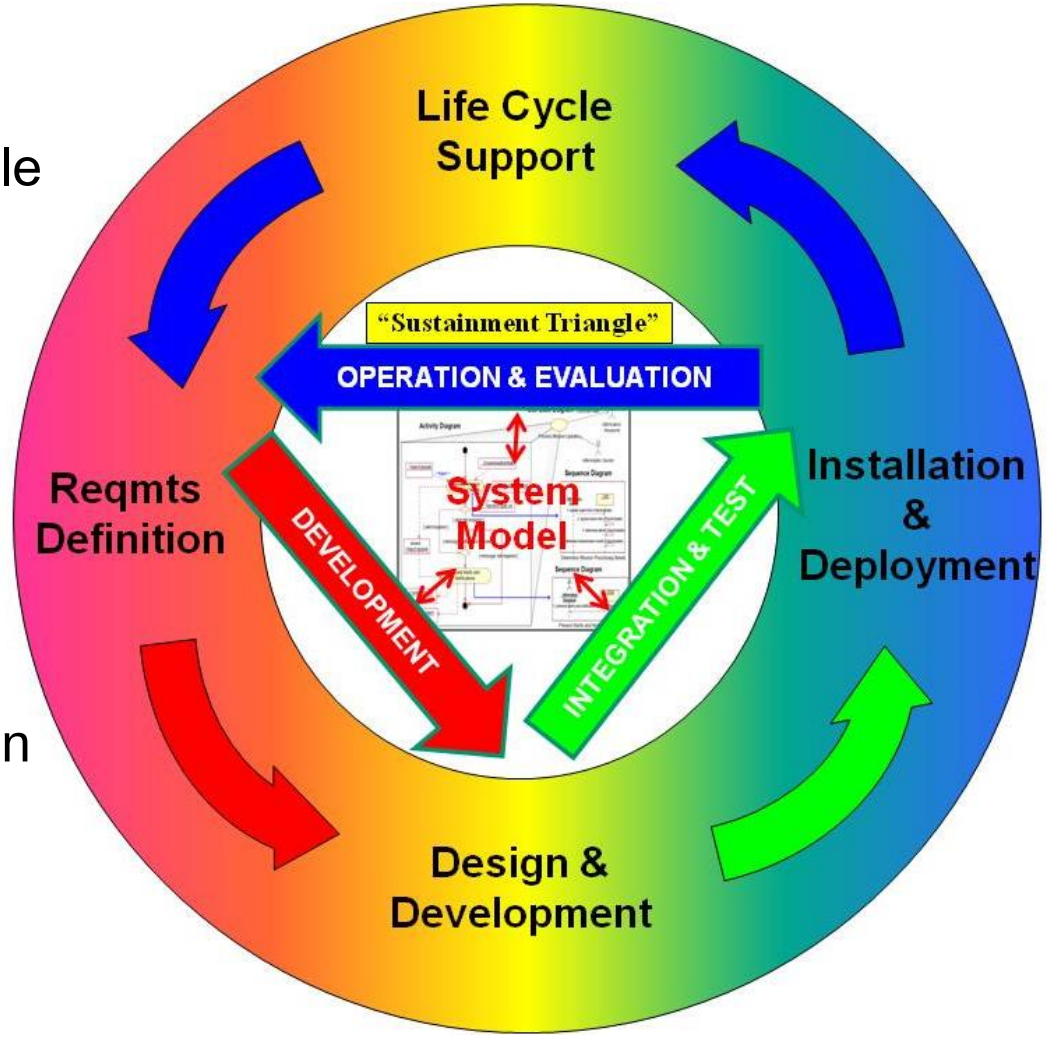
- Inner “Sustainment Triangle (Loop)” is Executed Many Times Within a Typical Product’s Life Cycle
- Shared System Model Facilitates Timely Life Cycle Support, Block Upgrades, & Configuration Management



Common Modeling Tools & Databases Facilitate Design Adaptation and Re-Use

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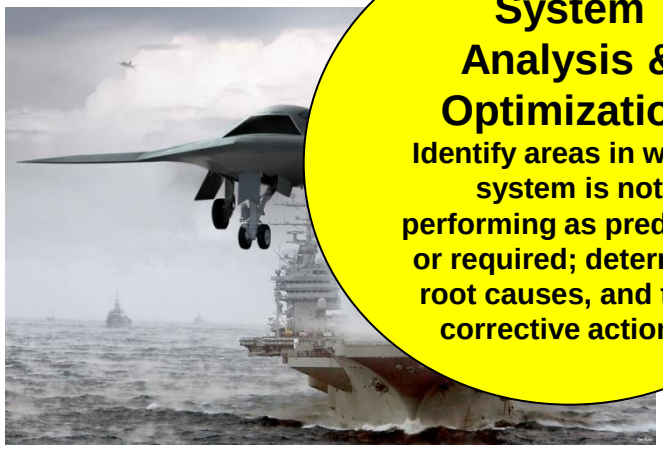
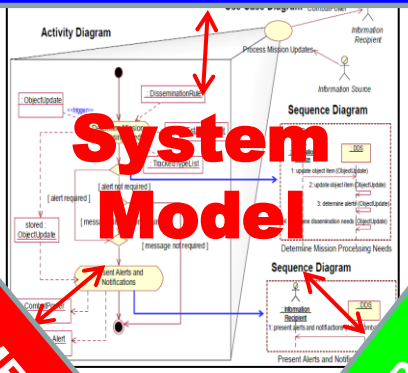


System Analysis & Optimization

Identify areas in which system is not performing as predicted or required; determine root causes, and take corrective actions.

OPERATION & EVALUATION



System Model

DEVELOPMENT

INTEGRATION & TEST

Model-Based Design and Analysis Tools

Integrated Health Management Design, Analysis, and Other Model-Based Systems Engineering Tools and Processes

Model-Based Development Tools Provide a Single, Configuration-Managed, Up-to-Date Source for Design Information – Facilitating Model Re-Use and knowledge capturing

Current Design Analysis Methods Repeat Similar Thought Processes for Related Products

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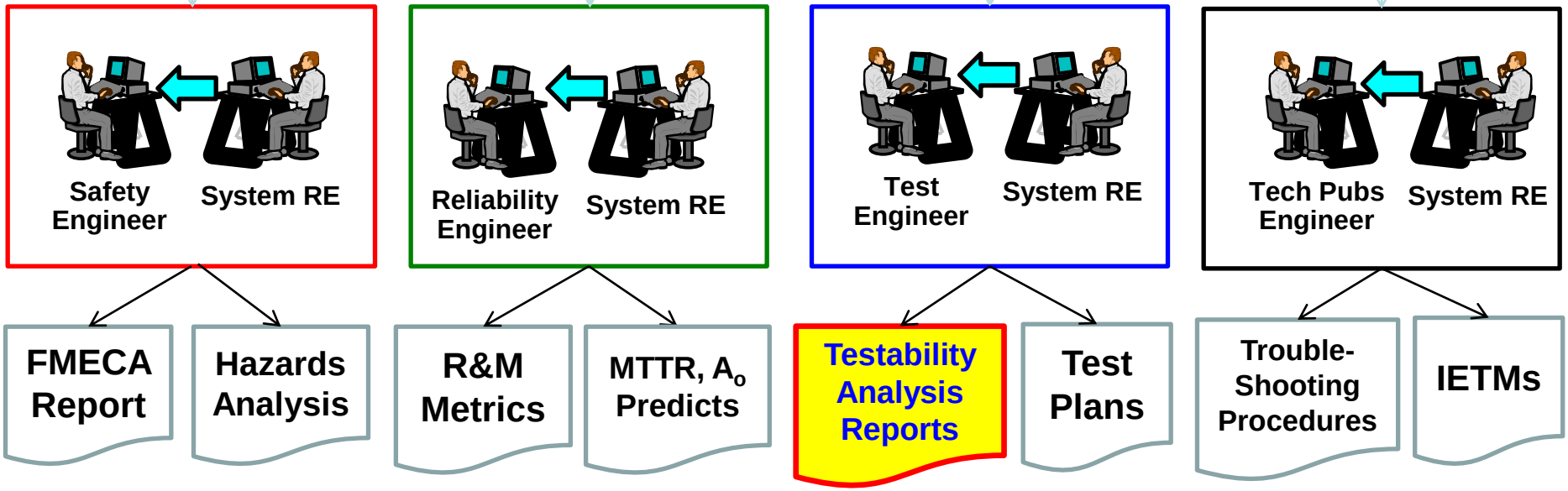
Current Process
(Simplified View)

Replicated Thought Processes and "Filtered" Information Flow



Model-Based Diagnostic Design & Analysis Provides an Opportunity to Reduce Replication of Effort When Deriving Related Products

Model-Based Process Reduces Duplication of Effort and Simplifies Analysis

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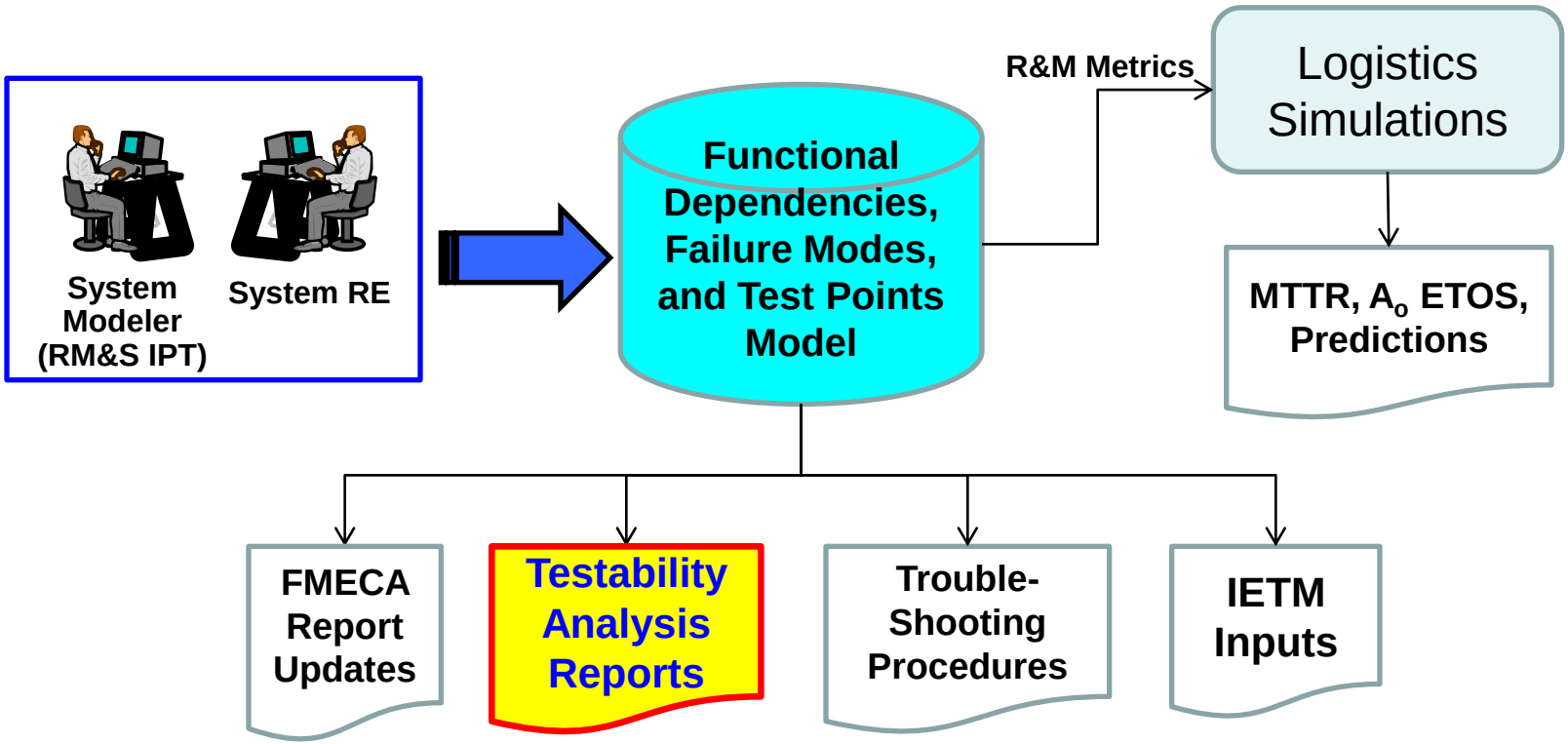
Model-Based Process



NGAS Analysis Predicts > 60% Reduction in Testability Analysis Costs Over System Life-Cycle

By Investing in the Development of Diagnostic Models for Systems, One Can Transition to a More Timely and Cost-Effective Automated Testability Analysis and Report Generation Process

Key Model Characteristics for Health Management Applications

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For our purposes a model must support the representation of:

- Physical Features or Properties of Components
  - Static/Fixed Part (e.g., the number and type of I/O ports)
- Functional, Operational, Behavioral Description of Components
  - Dynamic/Procedural/Executable Part (e.g., the function performed)
- Connectivity between Components
  - Functional Dependencies and Fault Propagation Paths
- A Graphic Depiction of the Model That Simplifies Understanding
  - Enables Efficient Model Input, Explanation, and Human Interaction

That's What I'm Talkin' About!

(DSI's **FAMOUS** Braking System)

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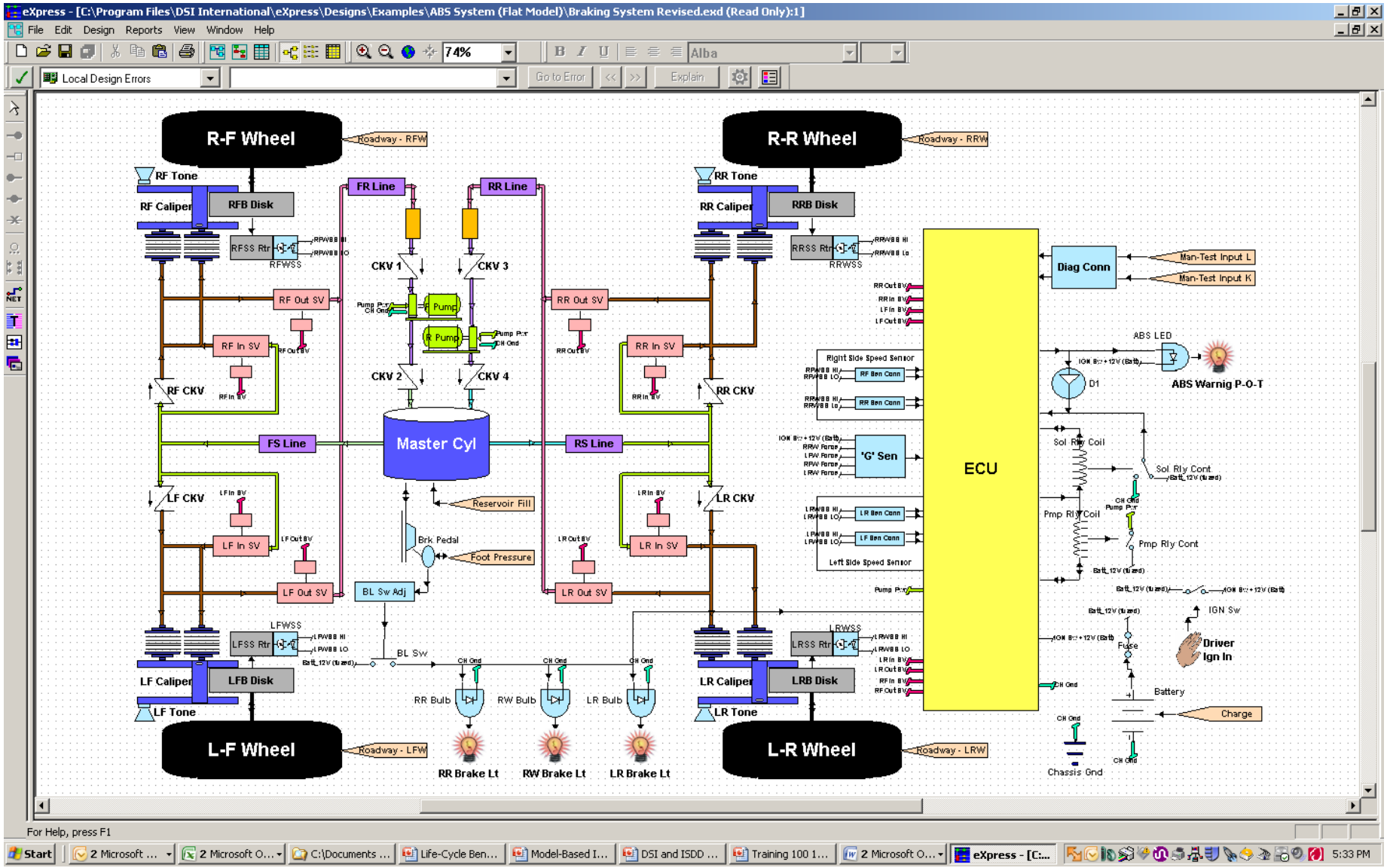

Model-Based Diagnostic & Prognostic Design & Analysis Tools Selection Criteria

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Here are some of the key tool and supplier criteria that we considered in making our decision to go with eXpress:

- **Testability Analysis / Fault Coverage Analysis**
- **FMECA (Failure Modes, Effects, & Criticality Analysis) Import/Export**
- **Design Analysis & Engineering Trade-Study Data**
- **Interoperability / Data Exchange with Other Tools**
- **User-Interface Features / Ease-of-Use**
- **Diagnostic & Prognostic Performance Simulation**
- **Software Performance Characteristics**
- **Real-Time Diagnostic Software Generation and Support**
- **Interactive Maintenance Support (for End-Users/Maintenance Personnel)**
- **Technology and Integration Readiness Levels**
- **Company Status & History**
- **Real-World Applications**
- **Software Licensing Options / Terms & Conditions**
- **Software Training, Documentation & Customer Support**

Additional Benefits of Model-Based Design and Analysis

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- Provides Design Insights for Improving Fault Coverage
  - Example: **Landing Gear Fault Isolation Improvement**
    - Fault Isolation to Single Unit: **23% Improvement** after BIT Change
    - False Removal% (STAGE): **21% Improvement** after BIT Change
- Reduces Time and Cost for FMECA Report Updates
- Accelerates Tech Pubs Fault Isolation Manual Development
- Supports Model-Based Maintenance Training and Execution
- Aids in Test Plan Development & Execution
- Provides Diagnostic Design Knowledge Capture
- Enables Model Re-Use for System Upgrades and Variants
- Facilitates Diagnostic Model Configuration Management
- Informs System Analysis & Optimization (SA&O)
- Generates Cumulative ROI over Entire Product Life-Cycle

ROI and Business Case Development for Application of Model-Based Tools and Processes to Other Life-Cycle Phases is In Progress

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Managing Complexity in Aerospace Through Model-Based Systems Engineering

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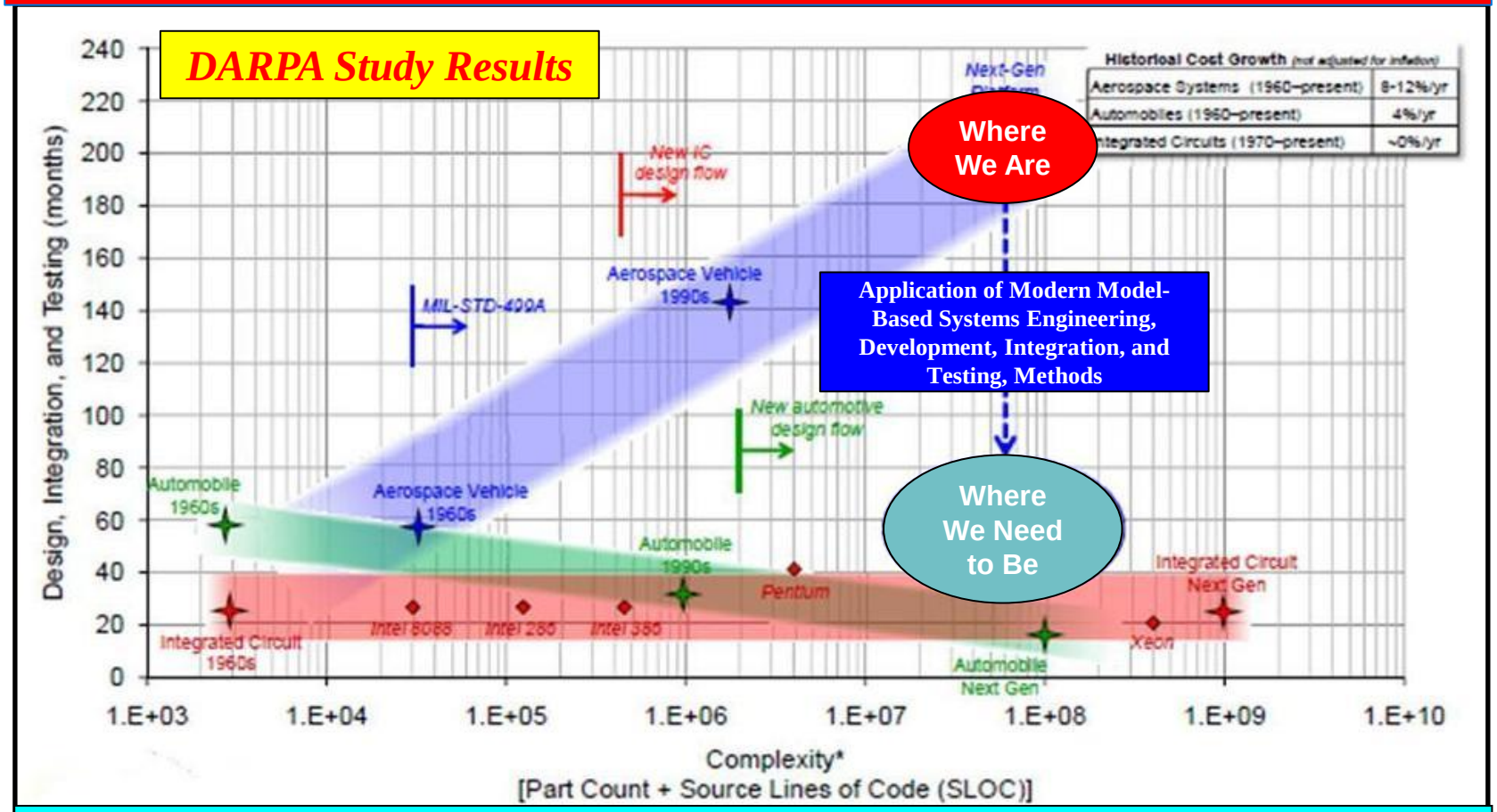
Aerospace Programs Require More Than 5 Times Longer to Perform Comparable Development & Sustainment Tasks as the Auto & Electronics Industries



Key Reasons for "The Gap":

1. Inconsistent Aerospace Application of Model-Based Systems Engineering Tools & Processes
2. Differences in Aerospace Systems Acquisition and Regulatory Environment and Time-Frame
3. Lack of Integrated Model-Based Design, Analysis, Production, and/or Operations Tools

Model-Based System Design Enables Performance-Based Logistics Improvements

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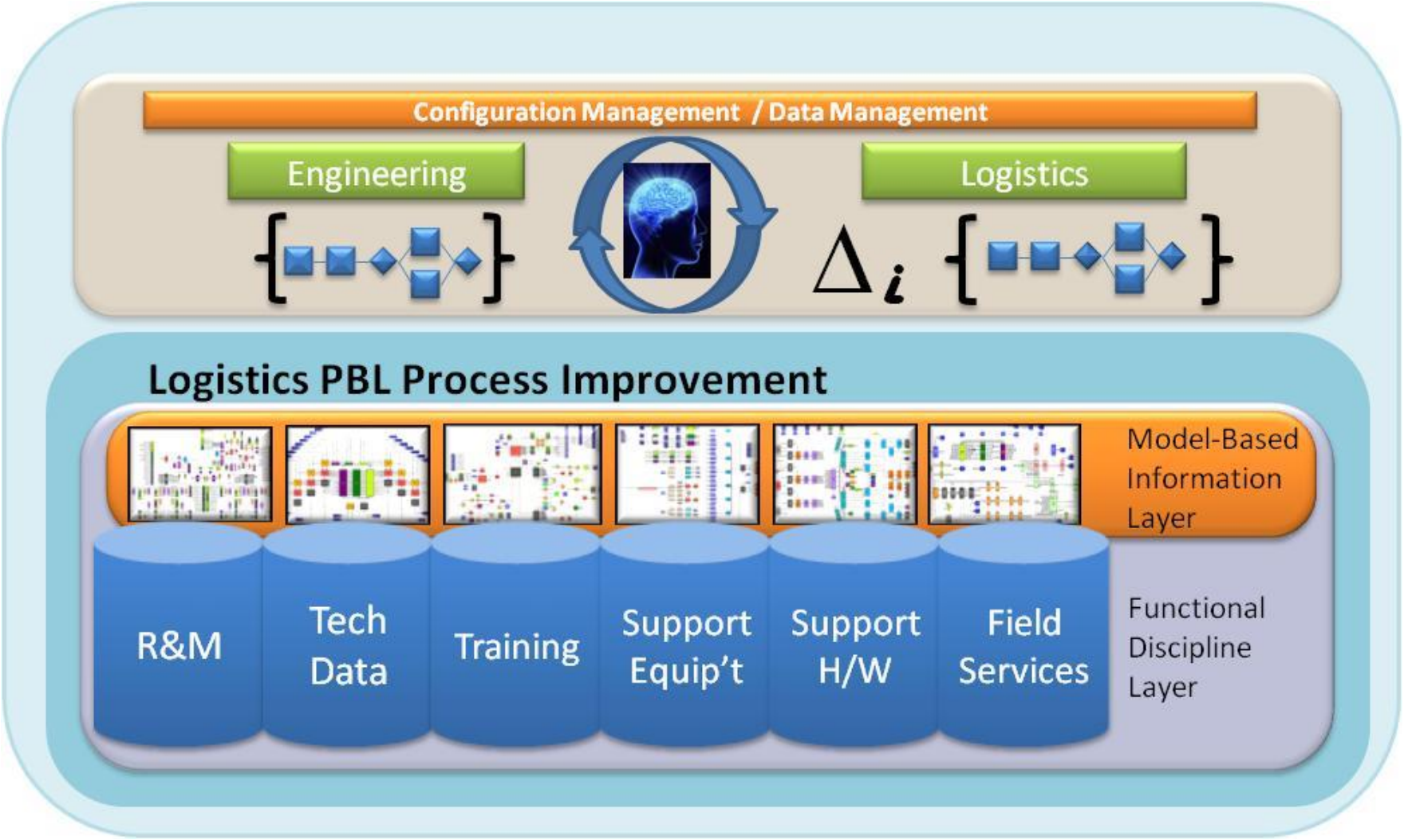

Model-Based System Development and Sustainment Loop

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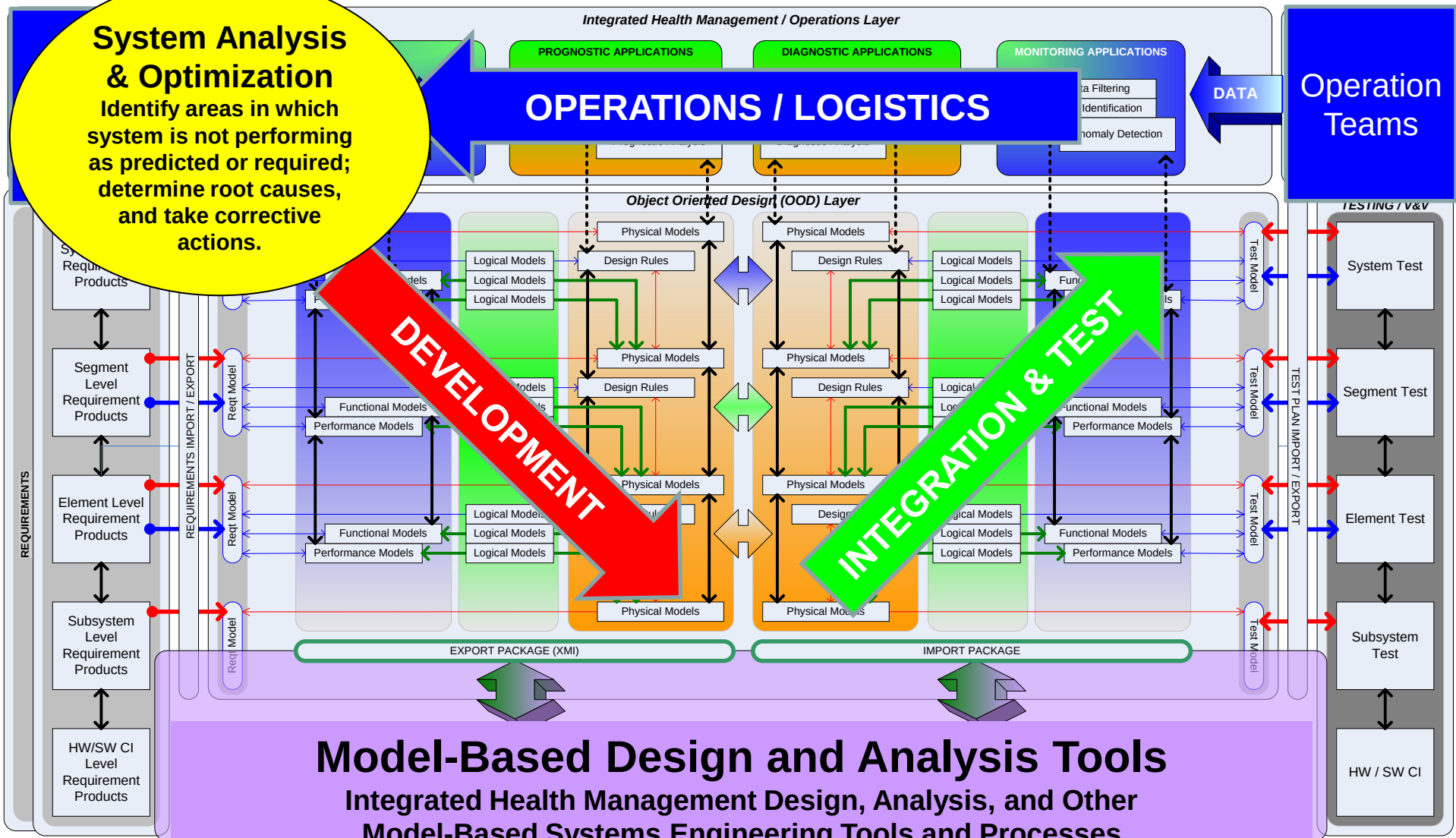

Model-Based Design and Analysis Tools

Integrated Health Management Design, Analysis, and Other Model-Based Systems Engineering Tools and Processes