

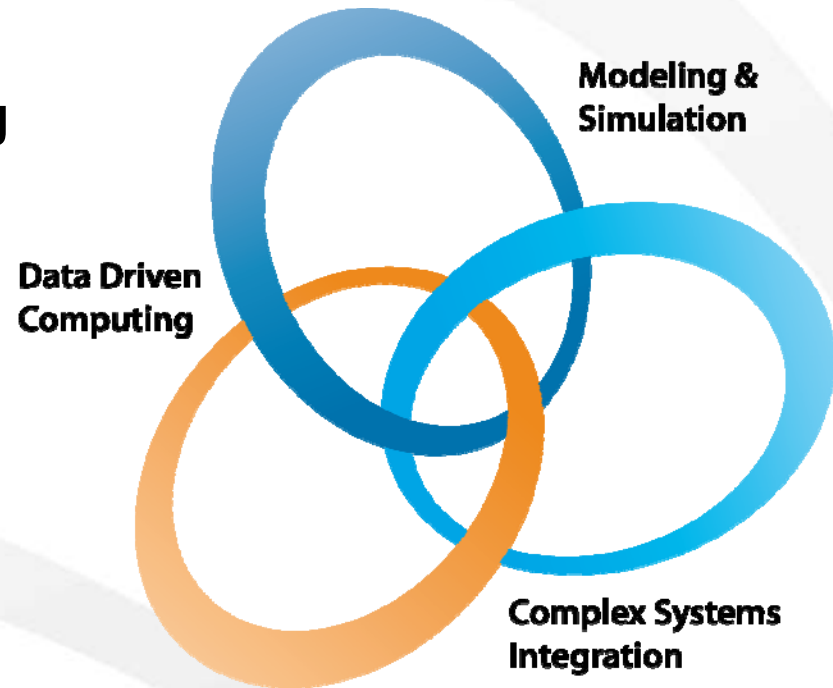


Modeling and Simulation Test Bed

**Engine Health Management System (EHMS)
Concept Demonstration
August 20, 2009**

Research

- **Key areas of research**
 - **Modeling & Simulation**
 - **Data Driven Computing**
 - **Complex Systems Integration**



EHM Diagnostics and Prognostics

From raw data to data mining pattern recognition
to analysis and information management
for decision makers

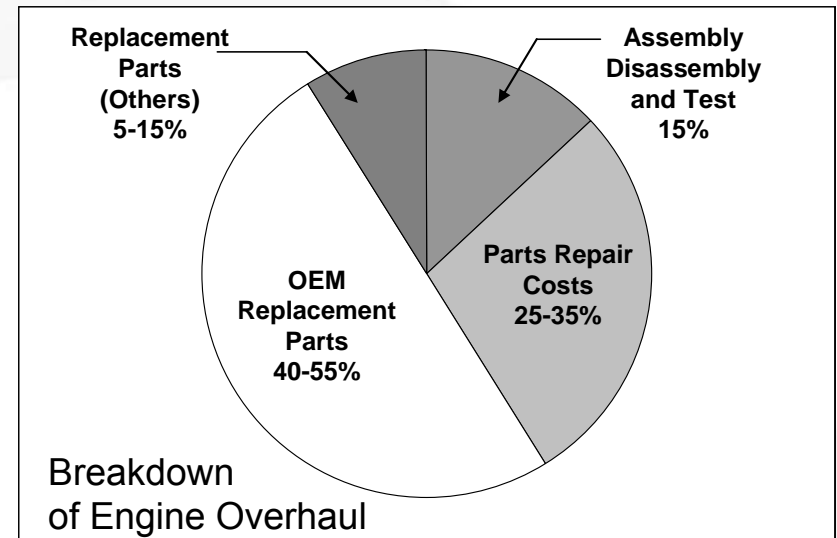


Engine Health Management (EHM)

- **What is EHM?**
- **Improved EHM System Goals**
- **Avetec's EHM System**
- **EHMS Suite**
- **EHMS Benefits**

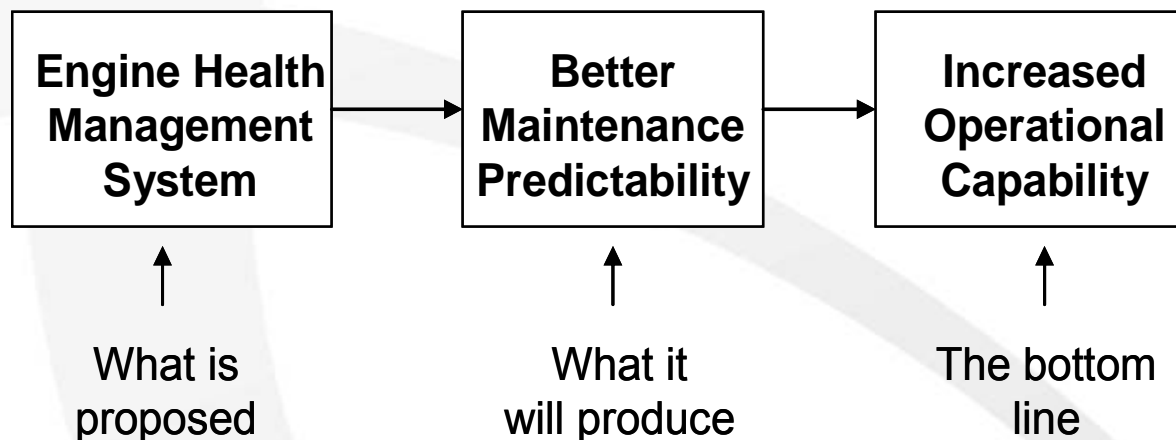
What is Engine Health Management (EHM)?

- **EHM –**
 - Process used to manage engine maintenance
 - Current EHM mostly based on fixed hours or periodic cycles
- **Commercial/military aviation under tremendous pressure to reduce maintenance costs**
 - World's airlines spend nearly \$40B/year; ~ 20% of total budget
 - For military, engine maintenance ~ 60% of maintenance budget
 - Current EHM has a high price tag in terms of direct costs, but also the indirect costs in potentially unnecessary downtimes
 - For the military this could mean the inability to meet critical mission objectives at the national security level

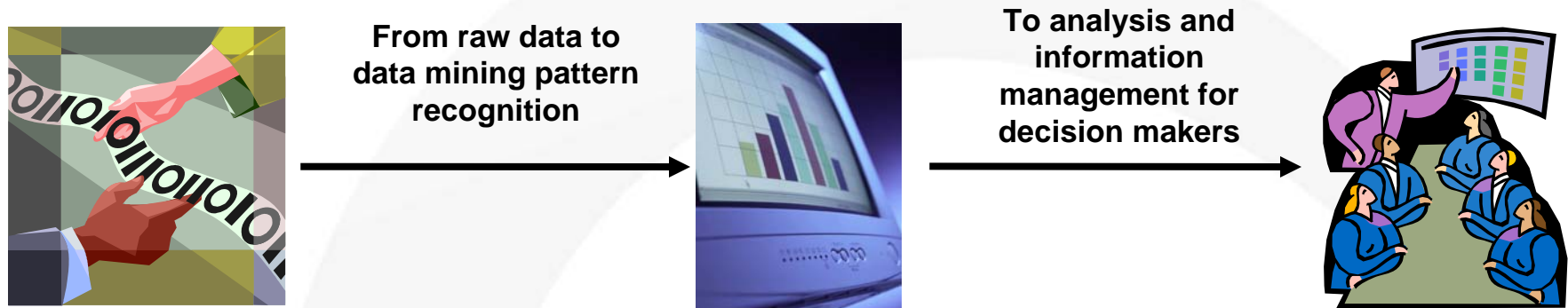


Improved EHM System Goals

- **A new EHM approach is needed using advances in HW and SW to provide better information management**
 - **Reduce costs and increase levels of maintenance predictability and productivity, customer satisfaction and mission readiness**
 - **A comprehensive EHMS program will cover the entire life cycle of the engine system or component and will feed back into the design process for the next generation system or component**



Avetec's EHM Model

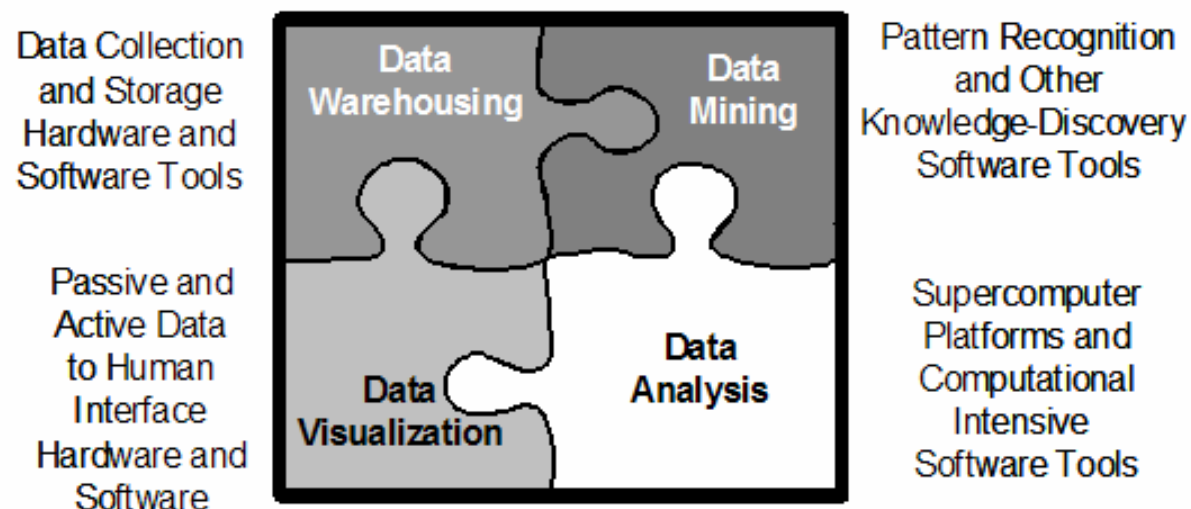


- Avetec's EHM System Suite is a comprehensive solution that will evolve as new tools and capabilities are developed
 - Some tools may be commercialized either as stand alone products or packaged to meet specific customer needs
 - Much like MS Office has evolved as a single package or as separate tools such as word processor, spreadsheet, presentation and other tools
- The EHMS Suite also represents an EHM methodology

Avetec's EHM System

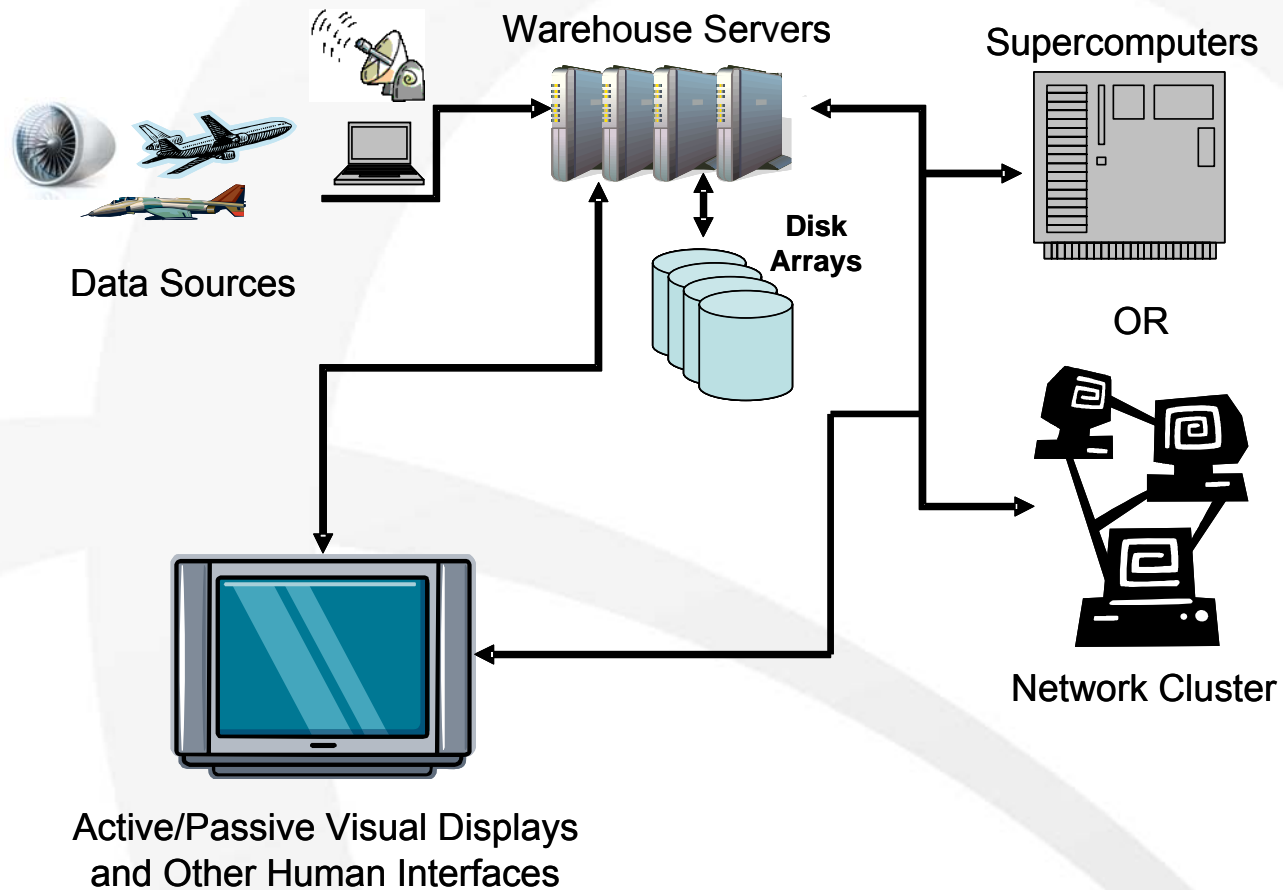
Avetec's EHM System (EHMS) is based on four primary components that together form a new comprehensive approach to EHM

Engine Health Management System

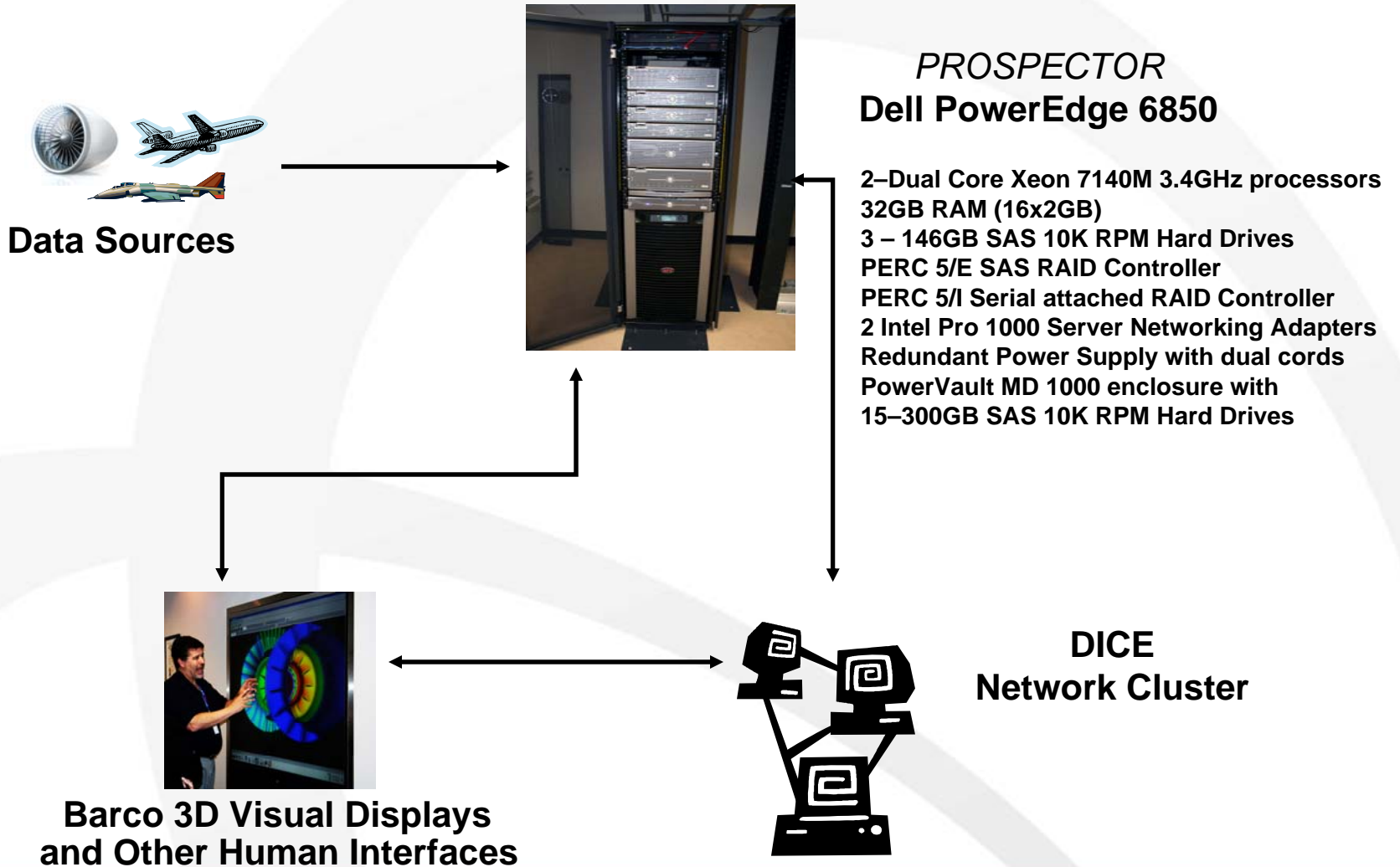


Generic EHMS Suite System

Avetec's EHM solution is a set of tools and methodologies covering entire engine life cycle and feeds back into the next generation design



Avetec's EHM System

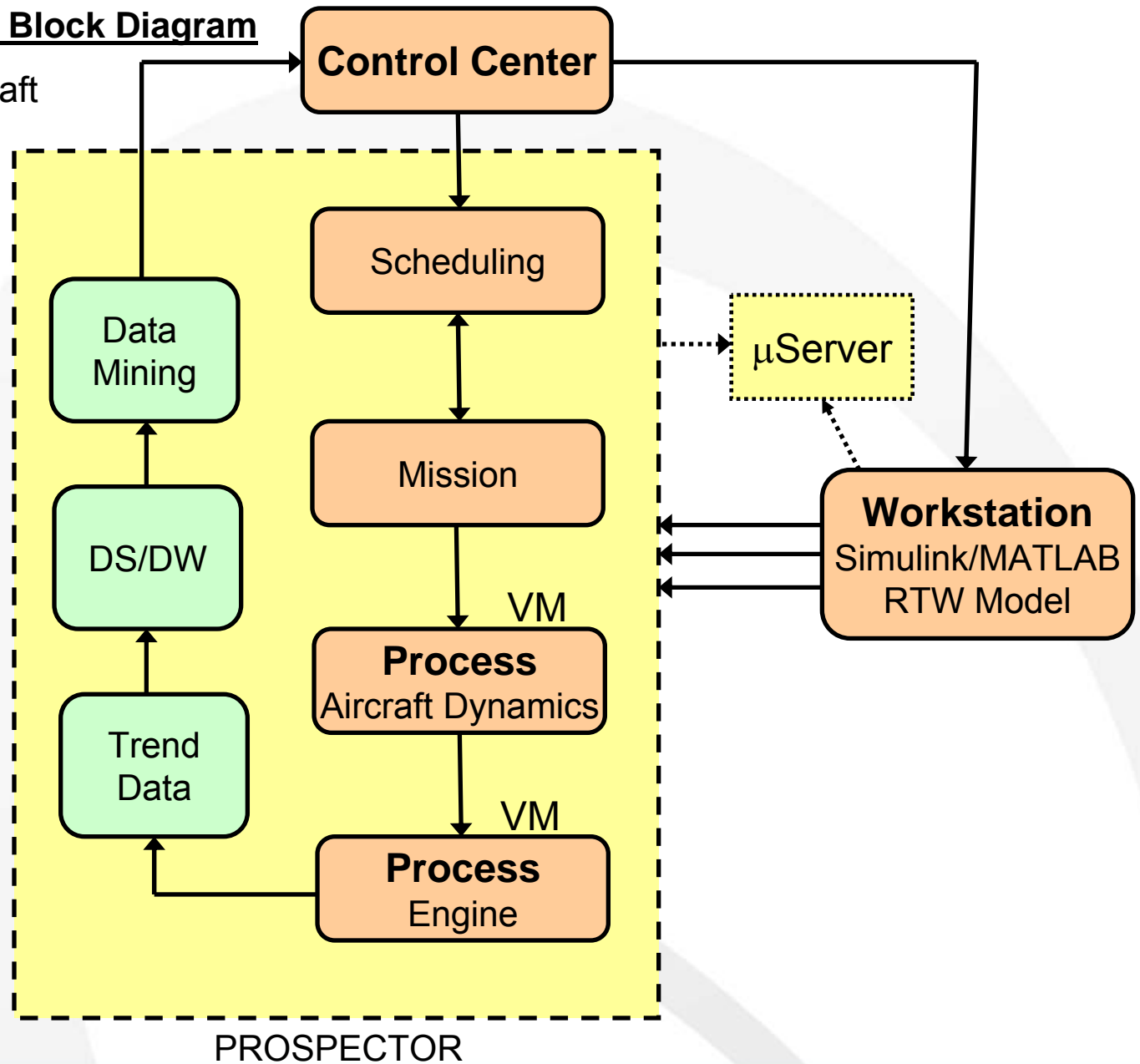


EHM Demonstration – Block Diagram

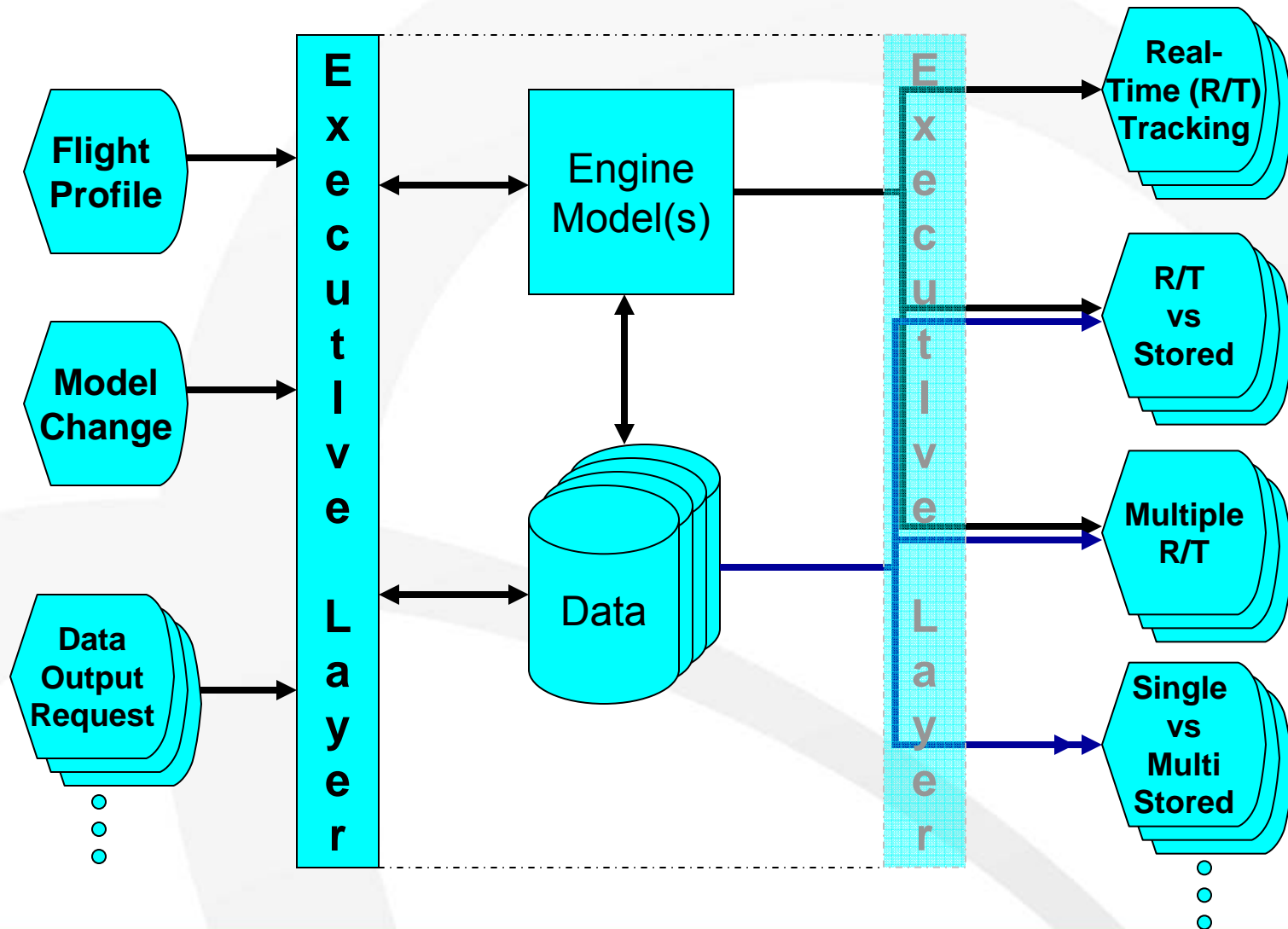
Simulated Fleet of Aircraft

1st Level:

▶ 1 aircraft – 1 flight



EHMS Concept Demonstration Architecture

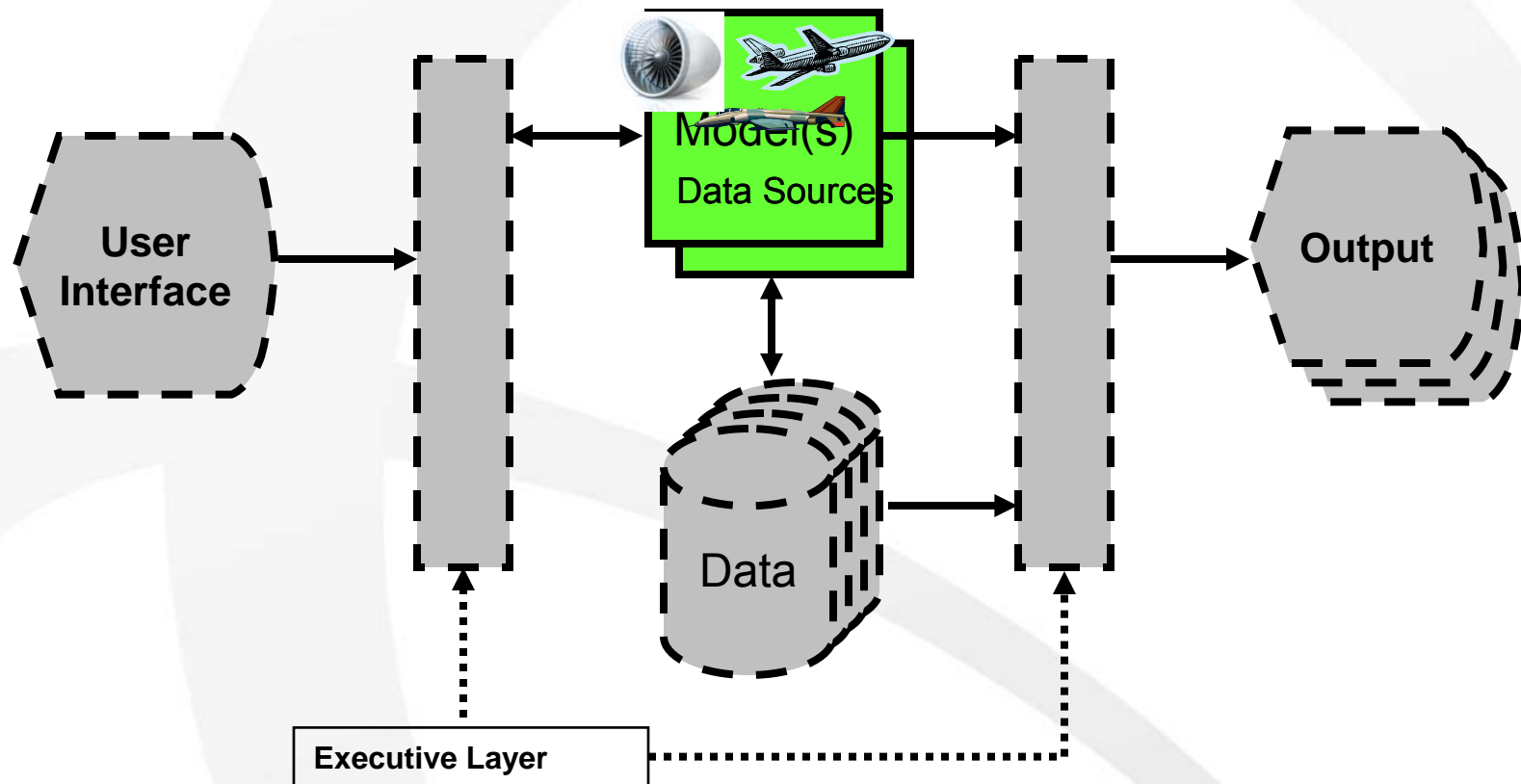


Concept Capabilities

- **Model Integration**
 - Flexibility to change model
 - Integration point for actual data
- **Systems Analysis**
 - Real-Time Analysis
 - Multi Screen
 - Multi I/O (stored and real-time)

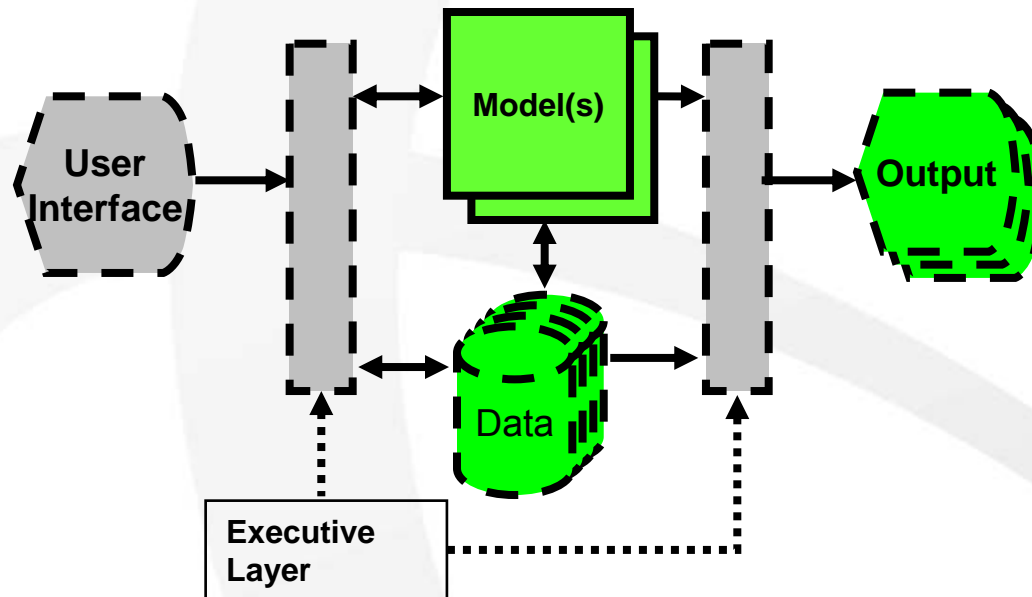
Model Integration

- Integrate Model into the architecture framework



System Analysis

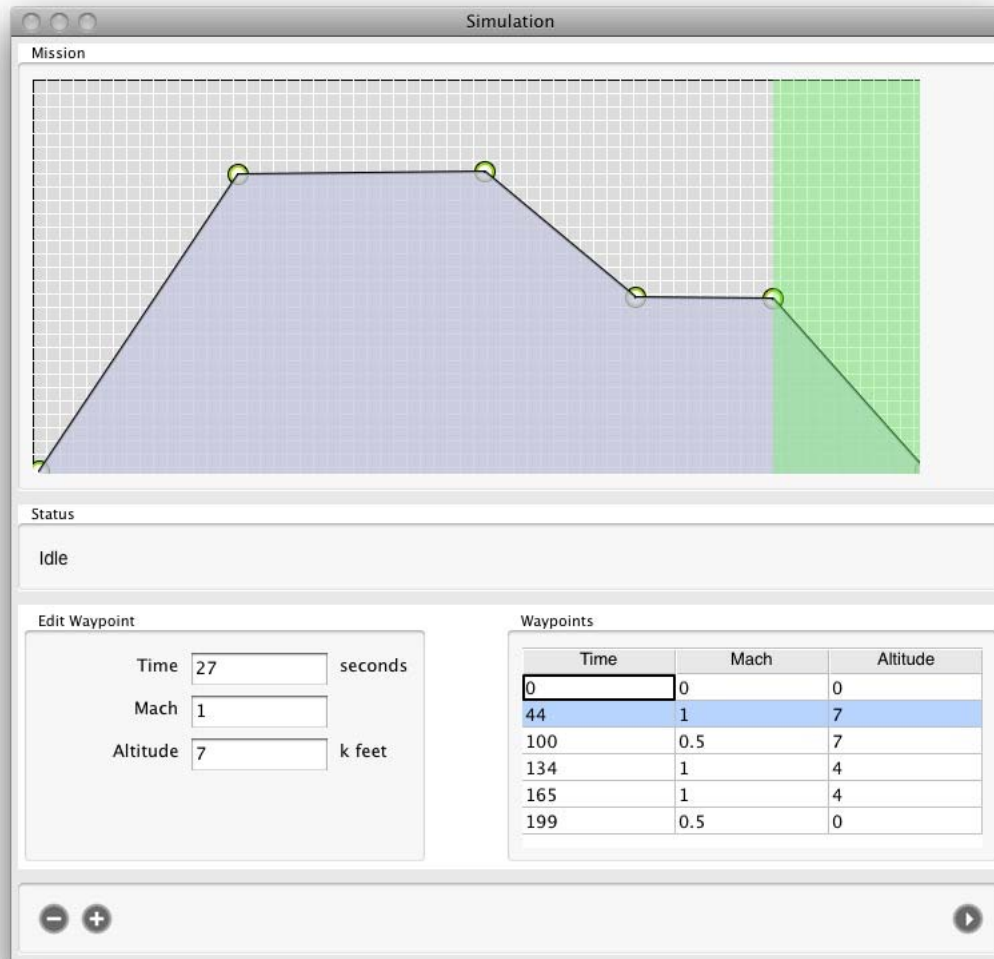
- Real-time
 - Analysis
 - Multi Screen
 - Multi I/O (stored and real-time)



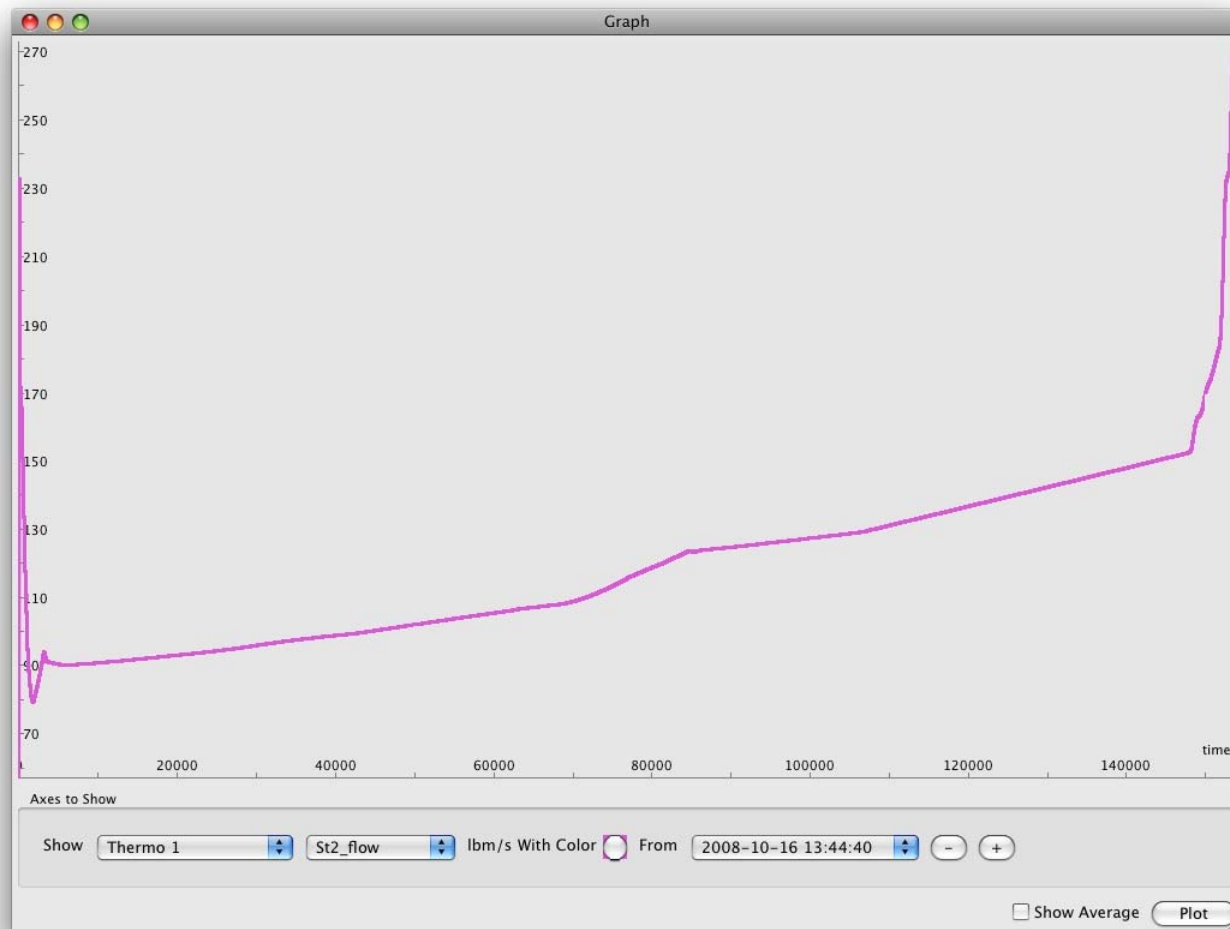
Demonstration Capabilities

- **Mx**
 - **Analysis**
 - **Multi Screen**
 - **Multi I/O**
 - ◆ **Real-time v. Stored**
 - ◆ **Stored mean v. Single Stored**
 - ◆ **Stored mean v. Multi Stored**
- **Engineering Change**
 - **Real-time v. Old Stored**
 - **New Stored v. Old Stored**
 - **New v. Old Single Profile**
- **Operations Planning**
 - **Future Schedule**
 - **Maintenance Schedule**
 - **Unplanned Mx and Reschedule**

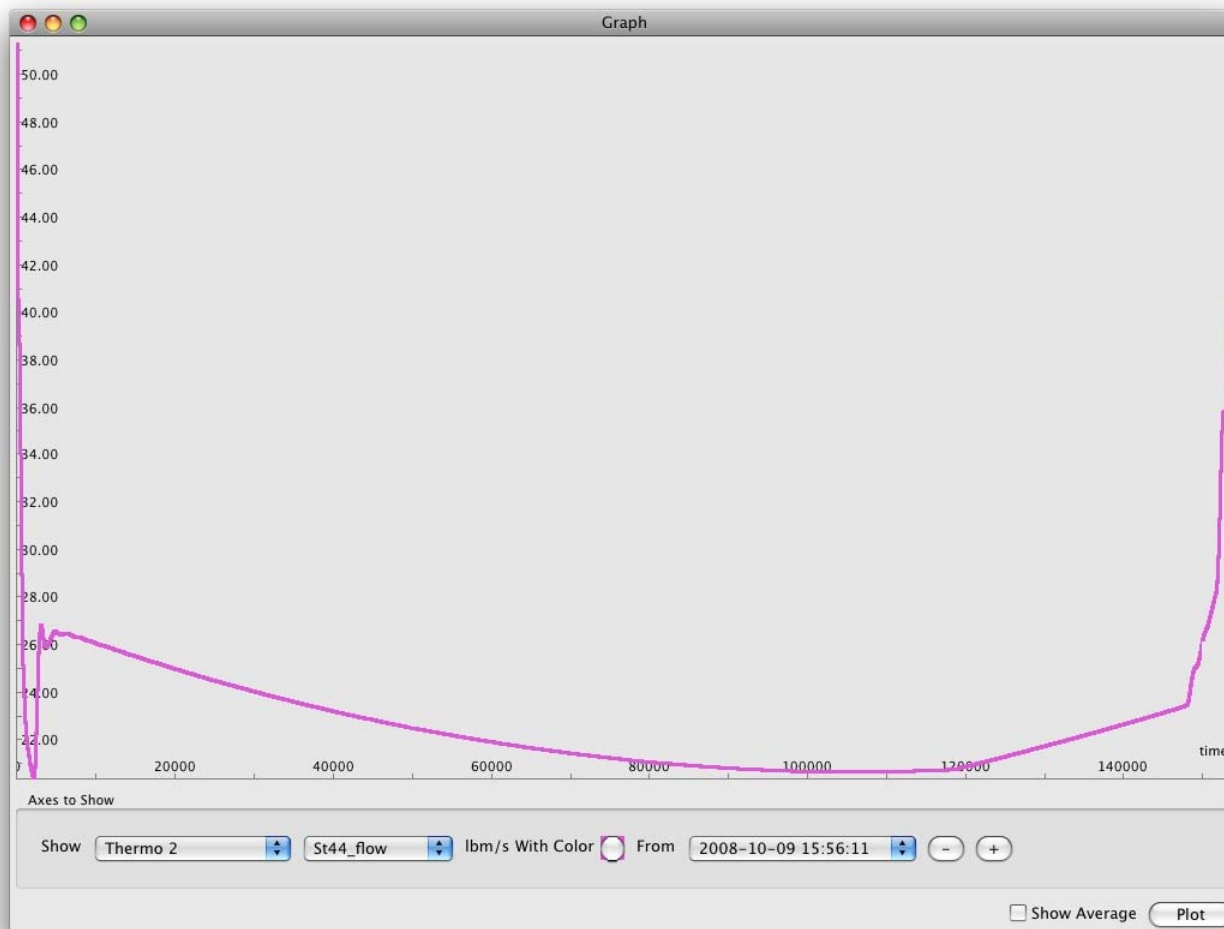
User Interface – Profile Input



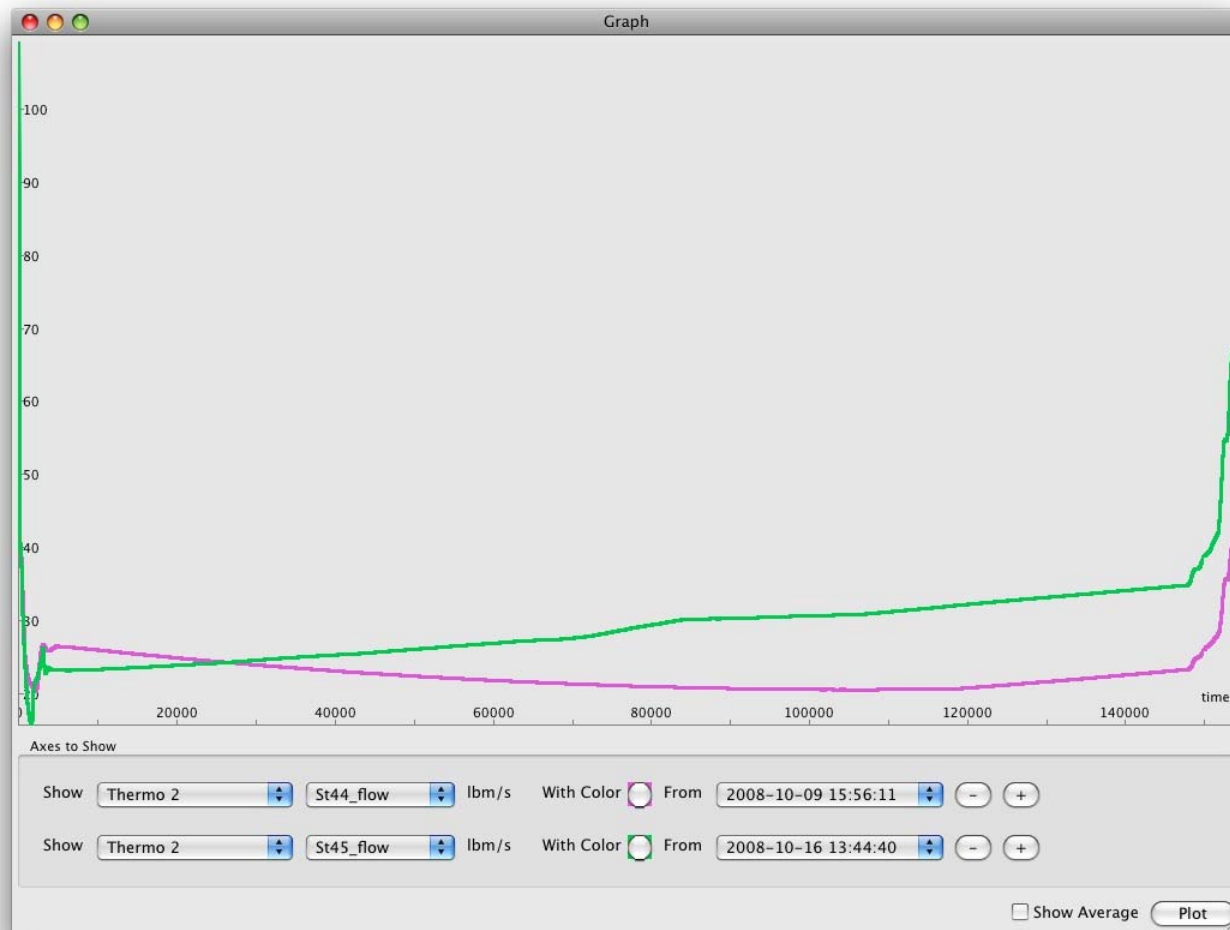
Data Presentation



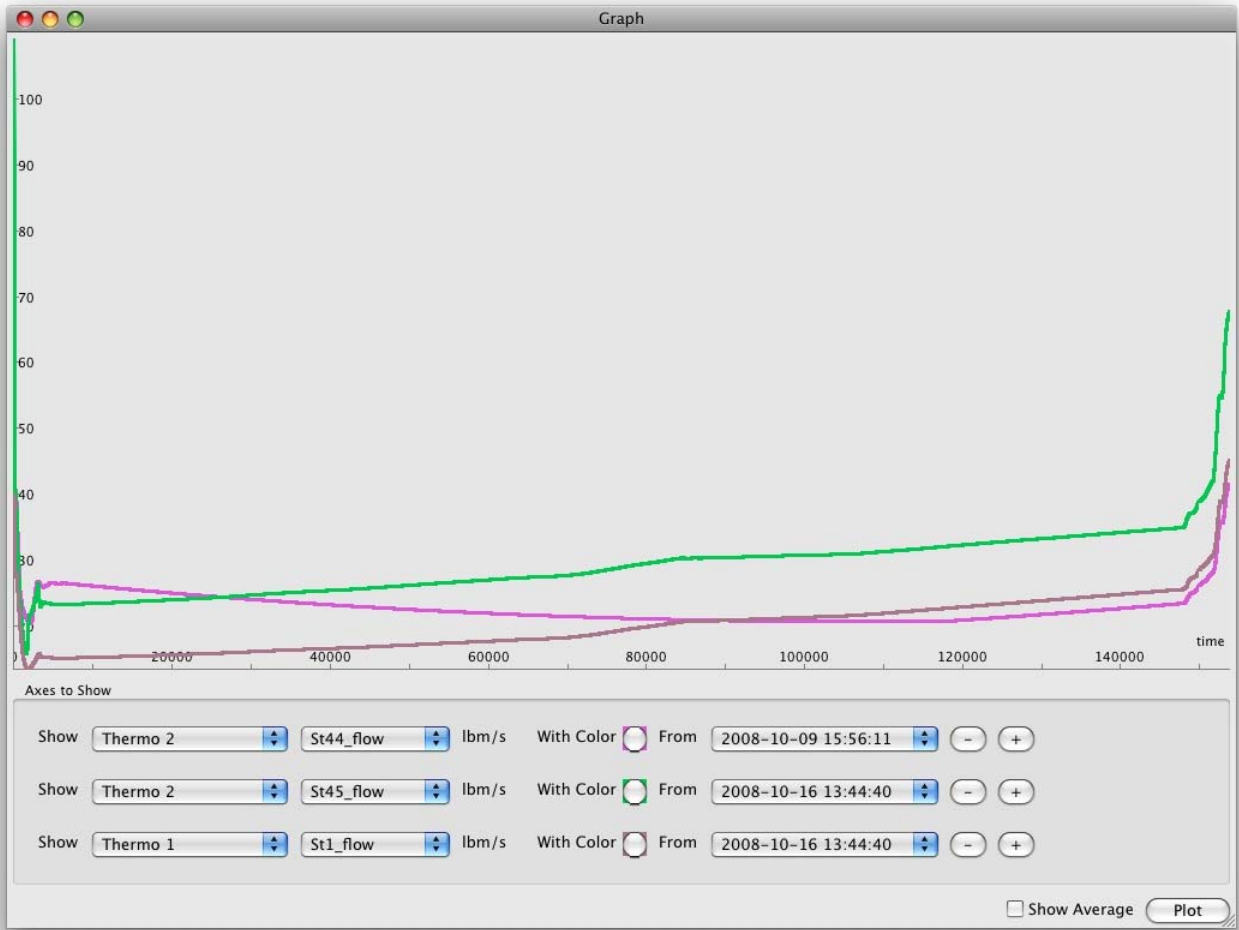
Single Presentation



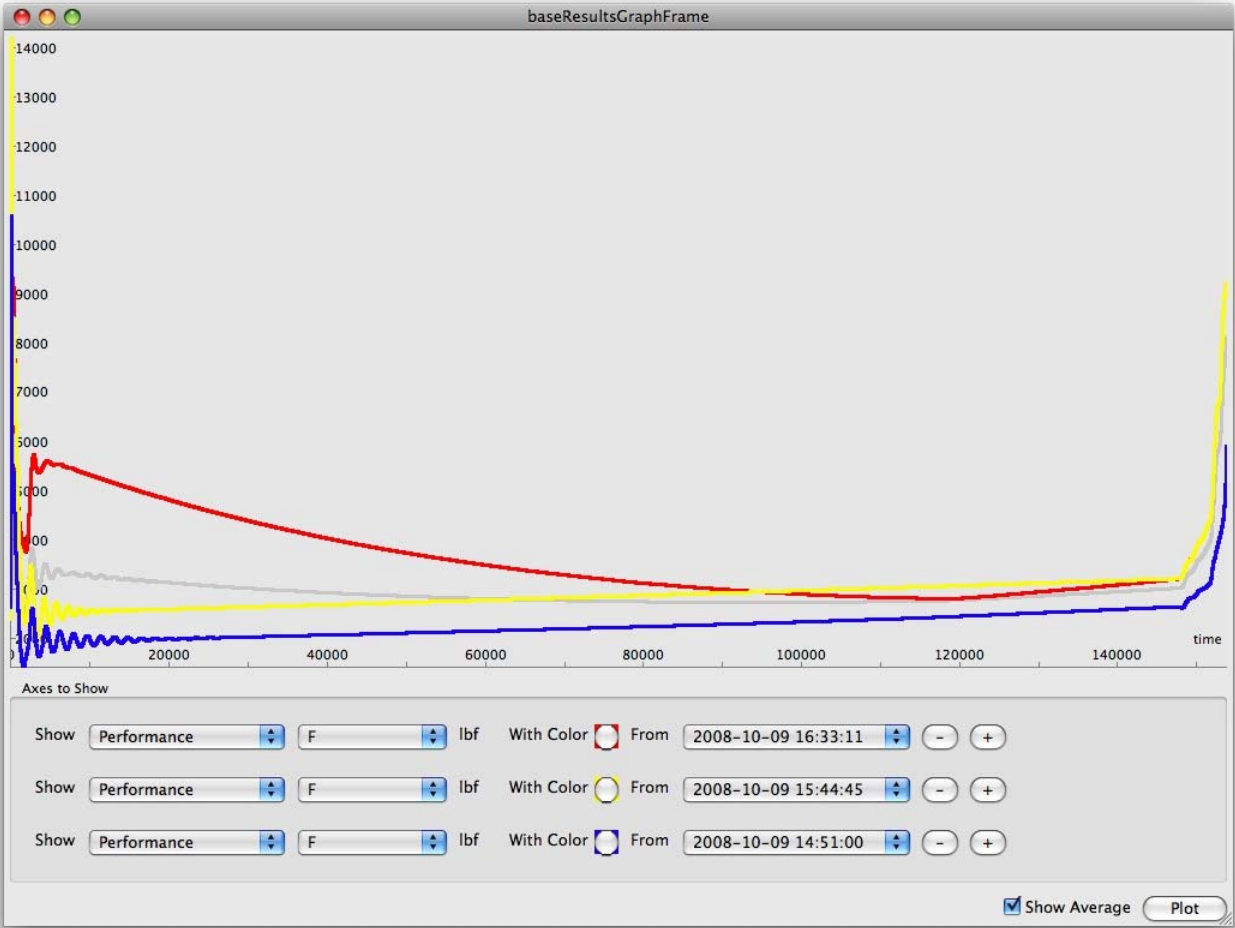
Multiple Run Comparison



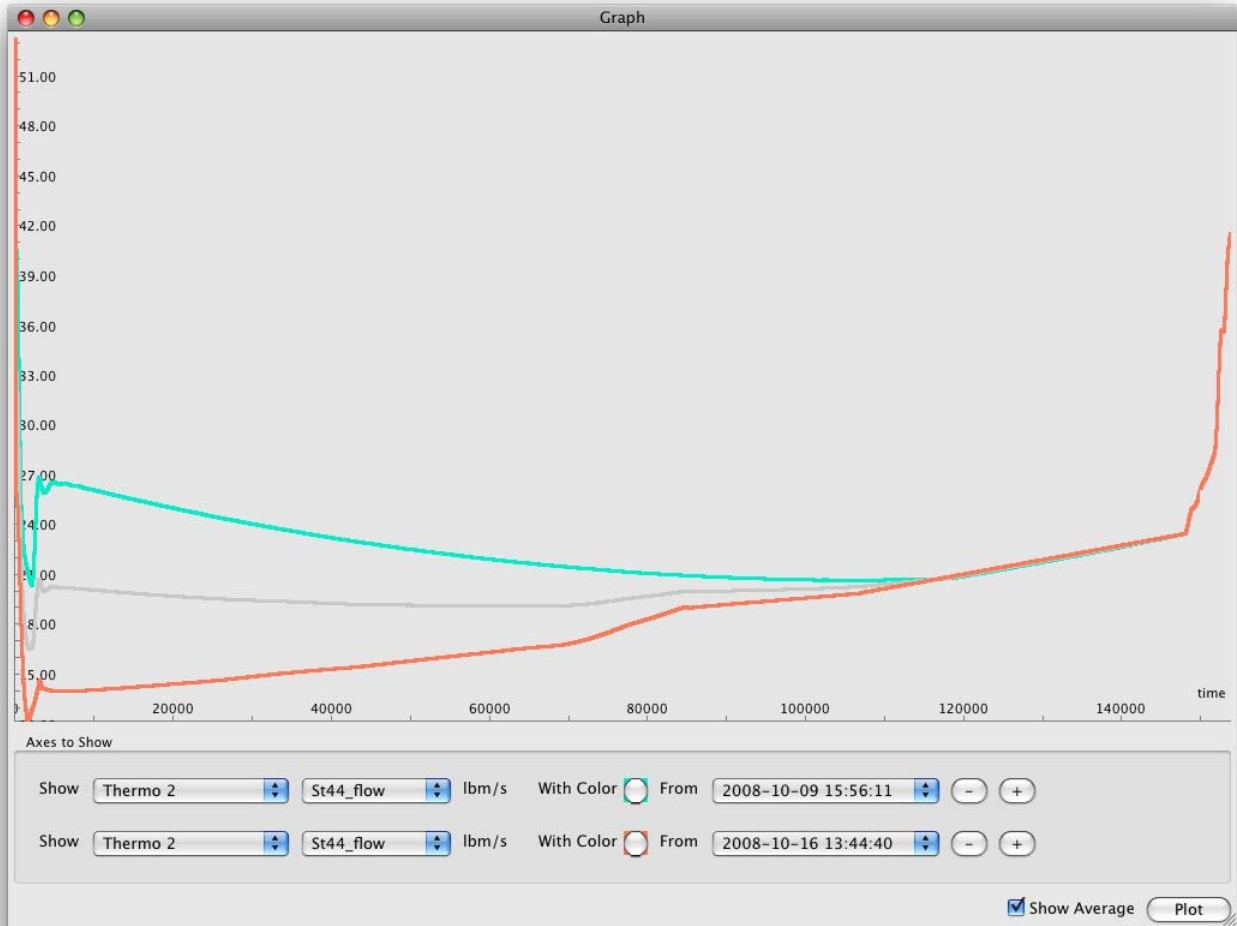
Multiple Run/Attribute Comparison



Same Parameter Multiple Runs



Multiple Runs with Averaging



EHM System

- **EHMS Suite is a comprehensive tool suite that will evolve as new tools and capabilities are developed**
 - **Flexibility**
 - ◆ Change engine model
 - ◆ Engineering change
 - ◆ Integrate real-time data from sources
 - ◆ Use stored data
 - **Analysis**
 - ◆ Custom analysis
 - ◆ Multiple parameters on same graph
 - ◆ Multiple outputs on same interface
 - **Tools**
 - ◆ Independent
 - ◆ Integration into common suite
 - ◆ Tailored to meet specific needs
- **EHMS Suite also represents an EHM methodology**

EHMS Benefits

- **Reduces aircraft maintenance budgets 10% which translates to \$4 billion in annual savings to the world commercial aviation industry**
- **Increases service life of engines**
- **Directly impacts operational capabilities: more flying time and less maintenance downtime**
- **The methodologies and tools have applications across other industries that utilize turbine engines**
- **The commercialization capacity will grow to \$42 million in revenue within six years**
- **Establishes Ohio as the center for EHM and related technologies**



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