

# Sustainment of Capital Assets

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- Context of sustainment
  - High level questions
  - Industrial base issues
  - National policy concerns
- Peculiar problem of aging defense aircraft
- A unique response: The Lean Sustainment Initiative(LSI)
- Products

History knows many more armies  
ruined by want and disorder than  
by the efforts of their enemies

*Le Testament Politique du Cardinal  
de Richelieu*

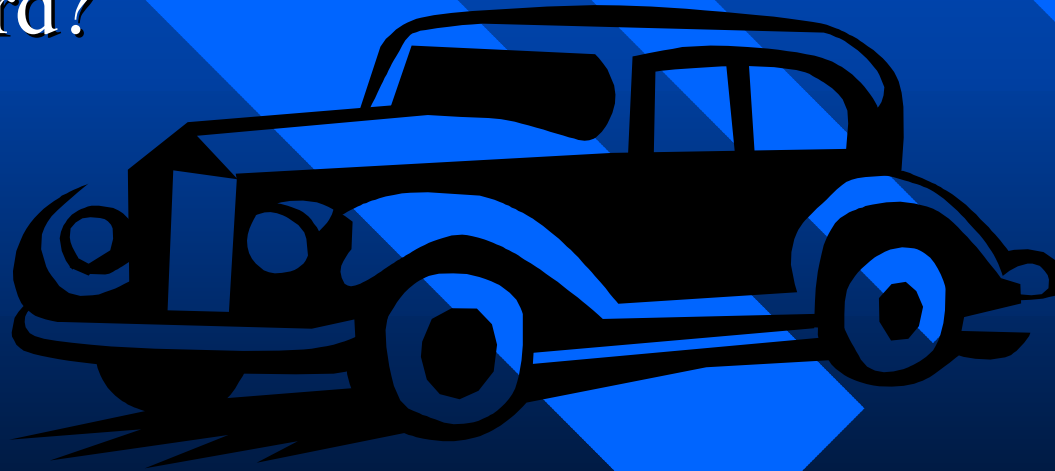
# Insufficient Sustainment

- 1812: Napoleon's retreat from Russia
- 1865: Lee's surrender at Appomattox
- 1943: von Paulus' surrender at Stalingard

# Sustainment in Aviation

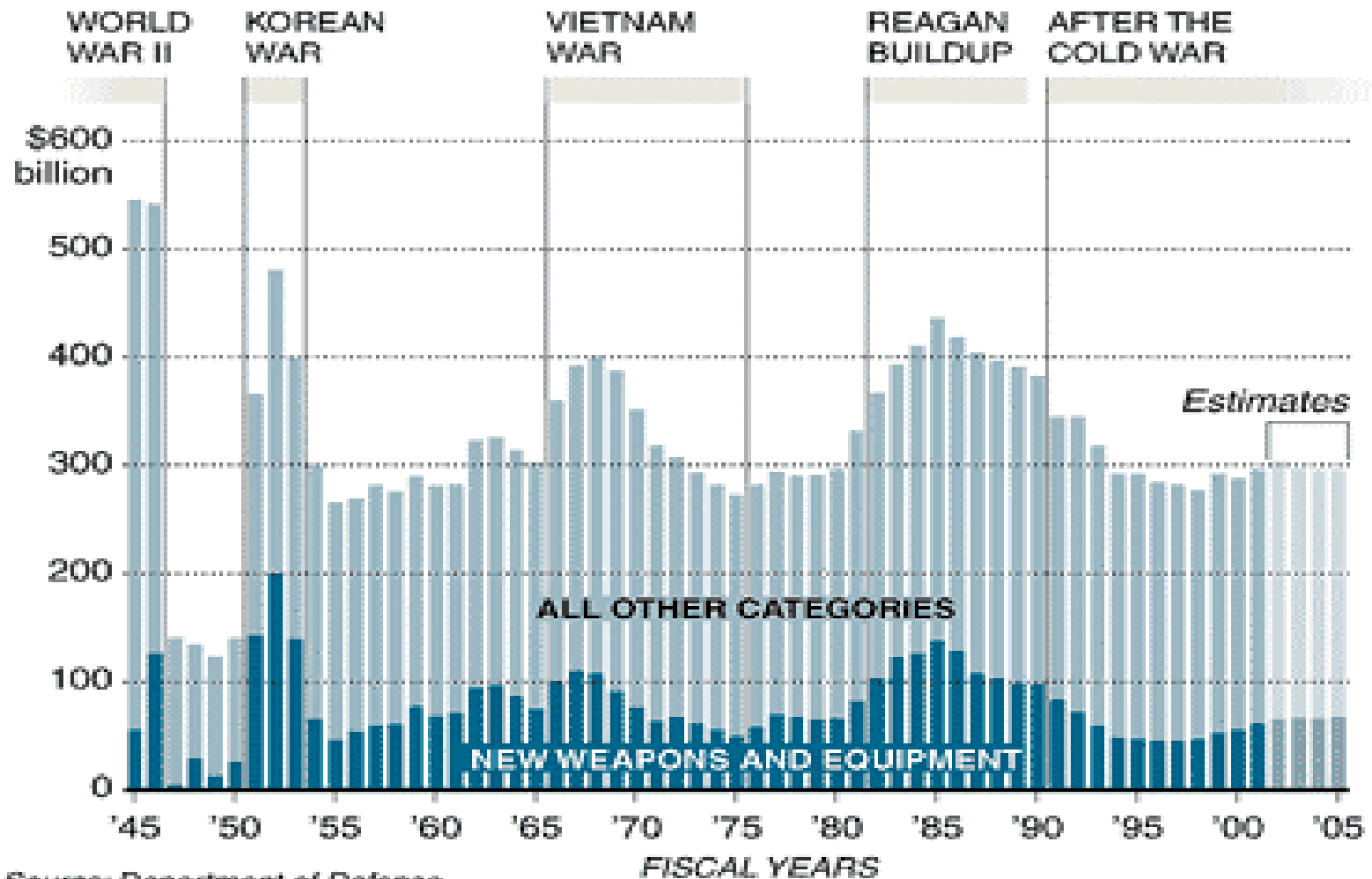
- Door Prize Question

- How does a 40 year-old taxi cab driver in Havana repair a busted clutch in a 1949 Ford?



# The Costs of Military Might

The Pentagon's annual budget since World War II, adjusted for inflation in 2001 dollars. Does not include spending by the Department of Energy on nuclear weapons.



Source: Department of Defense

## The Sustainment World

- FY 99 total federal government expenditures for sustainment of military aircraft \$14.5B.
- FY 99 total US private/commercial expenditures for sustainment of civil aircraft \$13.3B.

**\$20B - \$35B/year of potential business at stake!!**

# The Sustainment World

- Warner-Robins AFB, Georgia
  - Largest industrial complex in Georgia
  - \$4.8B replacement value of facilities
  - 14.3M square feet of facilities
  - 20,000 employees (total)
  - \$2.1B economic impact, FY 99



**The ALCs pack a big punch!!**



## High Level Key Questions

- Can the private sector guarantee sufficient support of the US defense structure in both peace and war? And at what cost?
- Can the sustainment of legacy defense systems provide opportunities to reverse the decline in the US defense industry?
- What are the essential research questions and challenges in this current conundrum? And will anyone act based on the answers?

# Can the private sector guarantee sufficient support of the US defense structure in both peace and war? And at what cost?

- Partnerships
- Incentives
- Supplier integration
- Situational awareness
- US statures
- Core competencies
- Stabilized workforce and employment

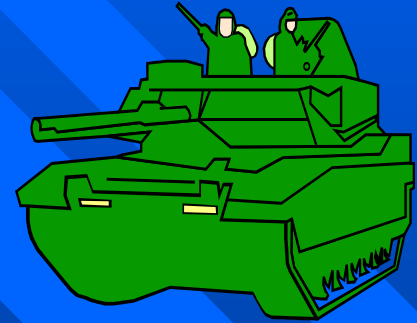
# Can the sustainment of legacy defense systems provide opportunities to reverse the decline in the US defense industry?

- Increasing cost of new weapon systems
- Lack of government and contractor reform
- Fundamental instabilities due to management of funding sources
- Unknown true costs in both government and private sectors
- Intellectual challenge driven by new designs, new platforms

# The Sustainment Arena



INDUSTRIAL  
SUPPLIERS



WAR FIGHTER



DEPOT



# What are the essential research questions and challenges in this current conundrum? And will anyone act based on the answers?

- Requirements definitions and forecasting
- Funding and contracting
- Repair-on-demand
- Resource loading and scheduling
- Information systems and communications
- Make-buy decisions
- Materials and parts
- Goals, objectives, and metrics
- System characterization and transformation
- People and organizations
- Integrated logistics databases and decision-support systems
- Policies and regulations

*A Unique Response*

The Lean Sustainment  
Initiative (LSI)



# What is LSI?

- Partnership
- Vision
- Mission
- Goals
- Stakeholders' expectations and benefits
- Research structure

PEOPLE



# Partnership



- US Air Force

- HQ Logistics, AFRL/ML, ALCs, DLA, ACC, AMC

- MRO Industry

- Boeing, Raytheon, GE, Chromalloy, Pratt & Whitney, Honeywell, Lockheed Martin

- MIT

- CTPID

- » Sloan School of Management

- » School of Engineering



## LSI Research Leads

- Tom Allen – Business Processes
- Kirk Bozdogan – Enterprise Integration
- Wes Harris – Business Processes
- John Hauser – Enterprise Integration
- Dennis Mathaisel – Sustainment Operations
- Don Rosenfield – Sustainment Operations
- Joe Sussman – Enterprise Integration
- Rich Wang – Business Processes

## LSI Vision

“To provide affordable, reliable, and responsive combat support services to the US Air Force ensuring the on-going superiority and operational capability of the nation’s air power into the twenty-first century”.

# LSI Mission

“To enable fundamental transformation of the US Air Force logistics and sustainment enterprise into a cost-effective, quality-driven, timely, and responsive combat support system”.

## LSI Goals

- Provide research-based platform for achieving fundamental transformation of the USAF sustainment system.
- Foster mutually-beneficial relationships between government and industry stakeholders.
- Deploy knowledge of lean principles and practices to pilot, implement, facilitate, and enable change.
- Address major policy, statutory, regulatory, and other barriers to change.
- Define and effectively transmit policy recommendations and strategies for overcoming barriers to change.
- Exploit the power of emerging information technologies for improving the performance of the sustainment system.

# Stakeholder Expectations (Government and Industry)

- Focus on mutually-supportive roles of government and industry stakeholders.
- Stress the development of strategies for positive change and improved system performance.
- Maintain stakeholder interest and participation through timely delivery of useful products.
- Develop a knowledge base to enable informed decision-making and risk management.
- Assist in the education and training of stakeholder future workforce.
- Develop strategies and tools which facilitate the transformation of the US Air Force sustainment system.

# Stakeholder Expectations (MIT)

- Create new and useful knowledge in an area of critical national importance and intellectual challenge.
- Export positive impact on national defense and world peace.
- Provide enriched educational experience (faculty, staff, students) in training future generations of leadership.
- Improve the performance of the US industrial base.

# Membership Benefits

- MIT-facilitated forum for dialogue, learning, and change through mutually-advantageous relationships, with MIT serving as neutral catalyst for change.
- Access to existing cumulative MIT-based knowledge on lean principles and practices on aerospace, auto, and other industries.
- Informed decision-making and risk management for significant performance improvement through knowledge-based strategies, practices, and metrics.
- Common language, reference, and guide for action.
- Education and training (workshops; short courses).
- Implementation tools and methods.
- Positive impact on policy recommendations and changes.

# Words of the Commander

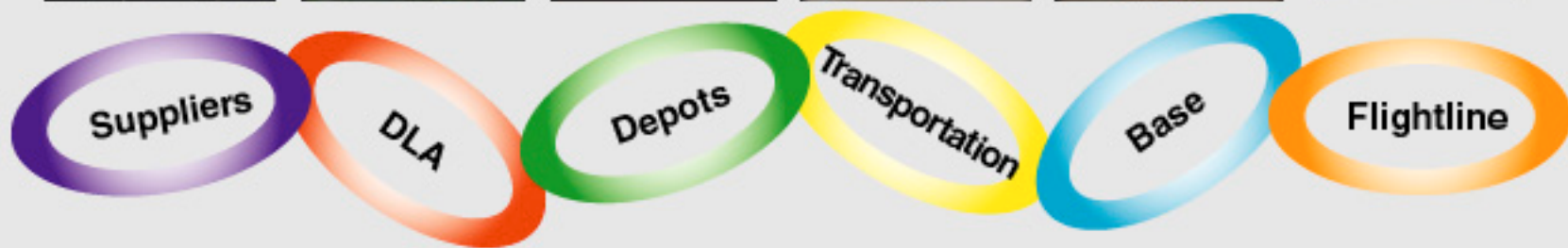
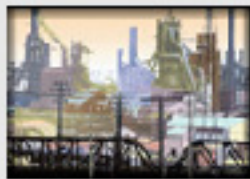
“To further explore potential government/industry partnerships, we’ve been working with government and industry representatives to establish a new and exciting undertaking, the Lean Sustainment Initiative (LSI). ... Together, government, industry, and academia can identify critical breakthroughs and change the paradigm of maintenance, repair, and overhaul support for the 21<sup>st</sup> century.

Statement of GENERAL L. L. Lyles,  
Commander, USAR Materiel Command  
Before the House Armed Services Committee

23 March 2001



# Today's Sustainment Enterprise



Inconsistent Metrics  
Unclear Relationships

# Historical Industrial Paradigms

1885	1913	1955-1990	1993-....
Craft Production	Mass Production	Toyota Production System	Lean Enterprise
Machine then harden Fit on assembly Customization	Parts inter-change-ability Moving production lines Workers don't think	Worker as problem solver Worker as process owner Eliminate waste Responsive to change	"Lean" applied to all functions in enterprise value stream Optimization of value delivered to all stakeholders and enterprises in value chain
Highly skilled workforce Low production rates High cost	Unskilled labor High production rates Low cost Quality problems	Low cost Improving productivity High quality	Low cost Improving productivity High quality Greater value

**“Lean” is the efficient delivery of customer value**

# Future Sustainment Enterprise

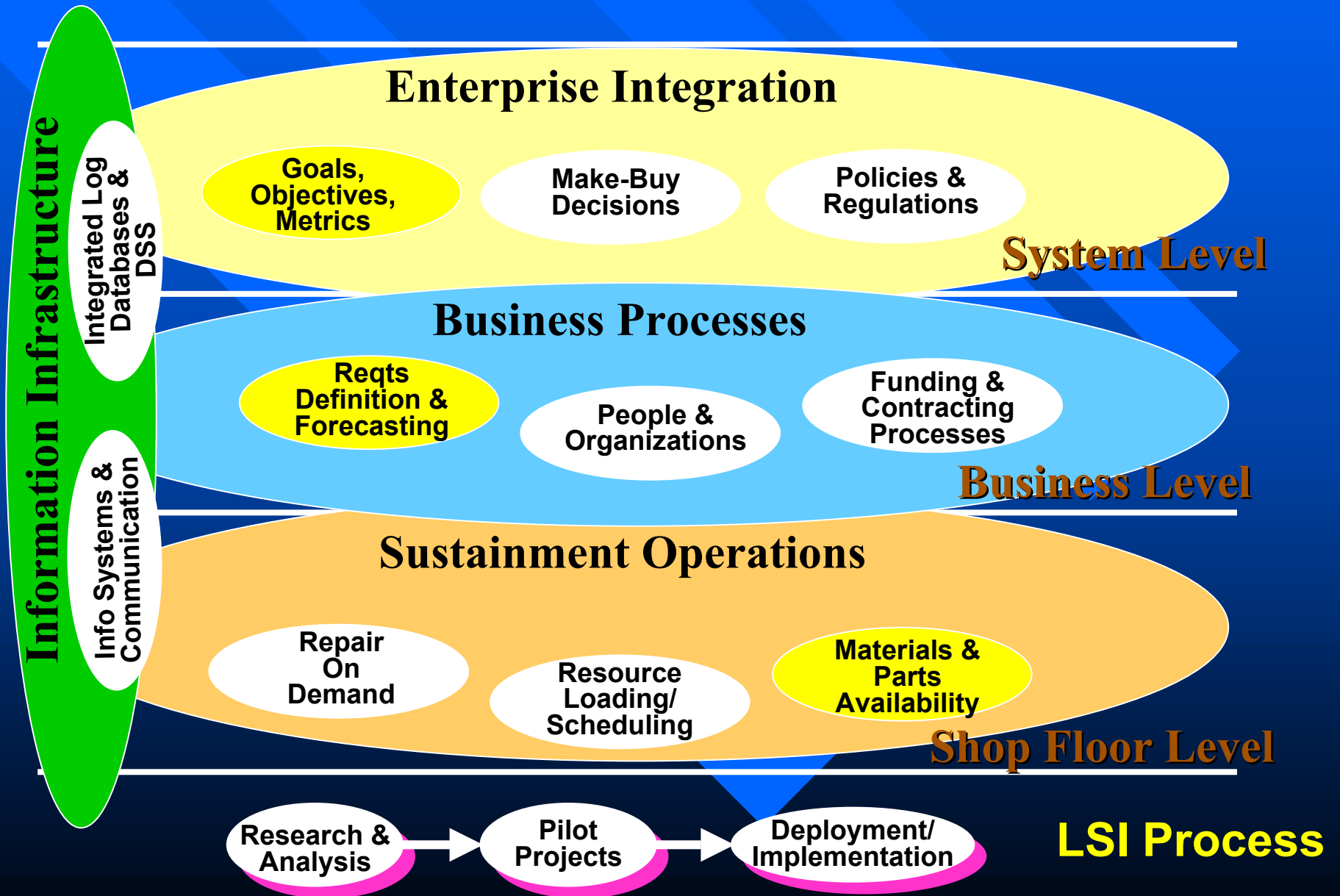


Balanced, Linked & Customer  
Focused

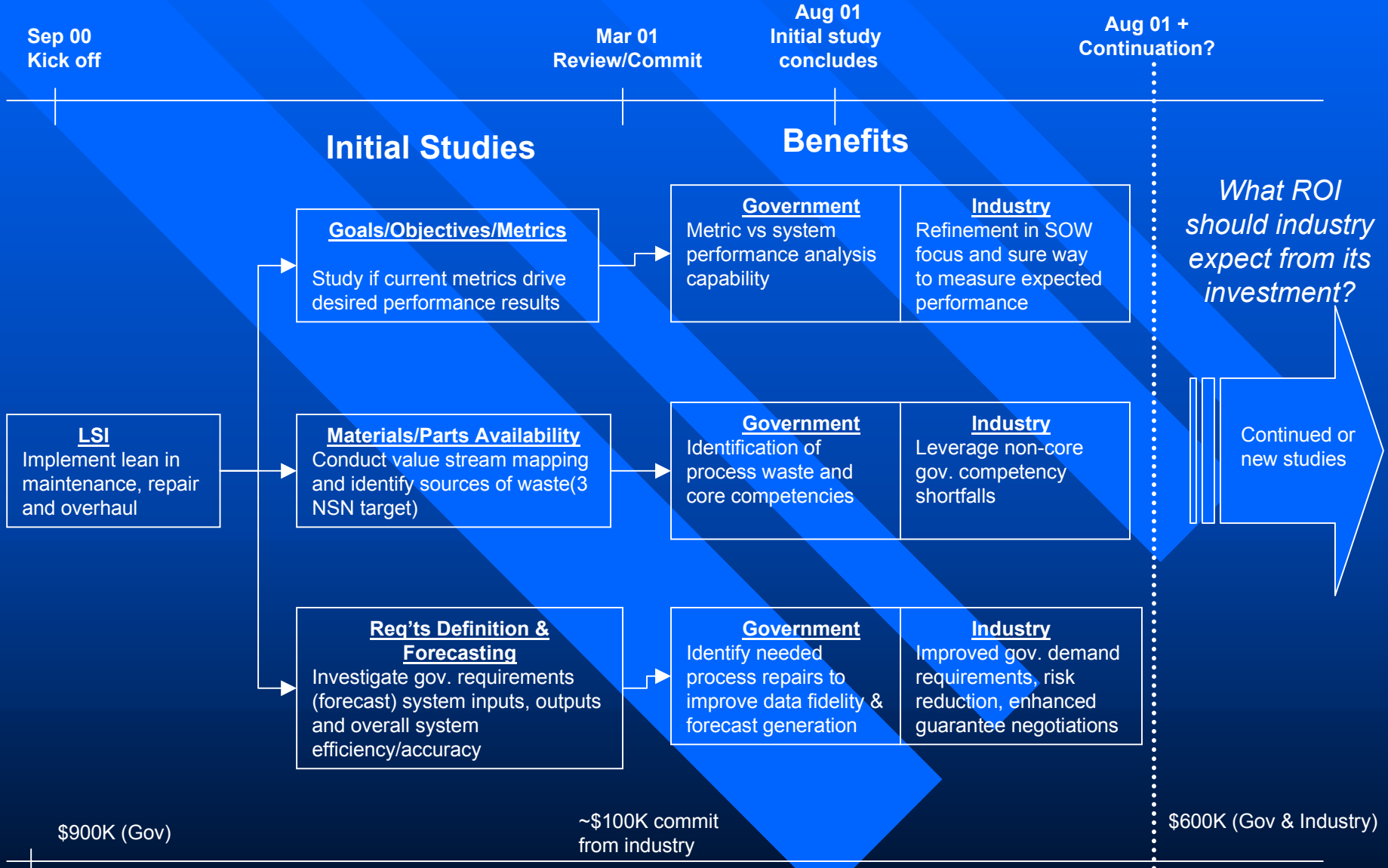
# Research Topics

- Requirements definitions and forecasting
- Funding and contracting
- Repair-on-demand
- Resource loading and scheduling
- Information systems and communications
- Make-buy decisions
- Materials and parts
- Goals, objectives, and metrics
- System characterization and transformation
- People and organizations
- Integrated logistics databases and decision-support systems
- Policies and regulations

# LSI: Program Framework



# Industry View of Benefits: Dec 00



- Boeing
- Raytheon
- GE
- Honeywell
- Pratt
- Chromalloy
- LM

# Research Focus Teams

- **Sustainment Operations:** MRO (depot, bases) government and commercial; integrated logistics support; continuous technological refreshment.
- **Business Processes:** "Above the shop-floor" support functions, processes and activities; multiple organizations and levels.
- **Information Infrastructure:** Information systems and technologies; communications; databases; decision-support systems.
- **Enterprise Integration:** System view of entire logistics and sustainment enterprise; goals-objectives-metrics; make-buy calculus; policies.

# Research Focus Team Composition

## ■ Leadership

- MIT faculty co-lead
- MIT research staff co-lead
- Government co-lead
- Industry co-lead

## ■ Membership

- MIT: faculty, staff, graduate students
- Government stakeholder representatives
- Industry stakeholder representatives

## ■ Main Responsibility

- **MIT:** Plan and perform research; identify change strategies.
- **Stakeholders:** Support research (site visits, surveys); perform implementation; provide feedback.
- **Joint:** Establish broad priorities; review progress; develop and take recommendations to point of implementation.

Effective partnership



# Research Focus Team Primary Responsibility

## ■ Sustainment Operations

- Repair-on-demand
- Resource loading and scheduling
- Materials and parts

## ■ Business Processes

- Requirements definitions and forecasting
- Funding and contracting
- People and organizations

# Research Focus Team Primary Responsibility

## ■ Information Infrastructure

- Information systems and communications
- Integrated logistics databases and decision-support systems

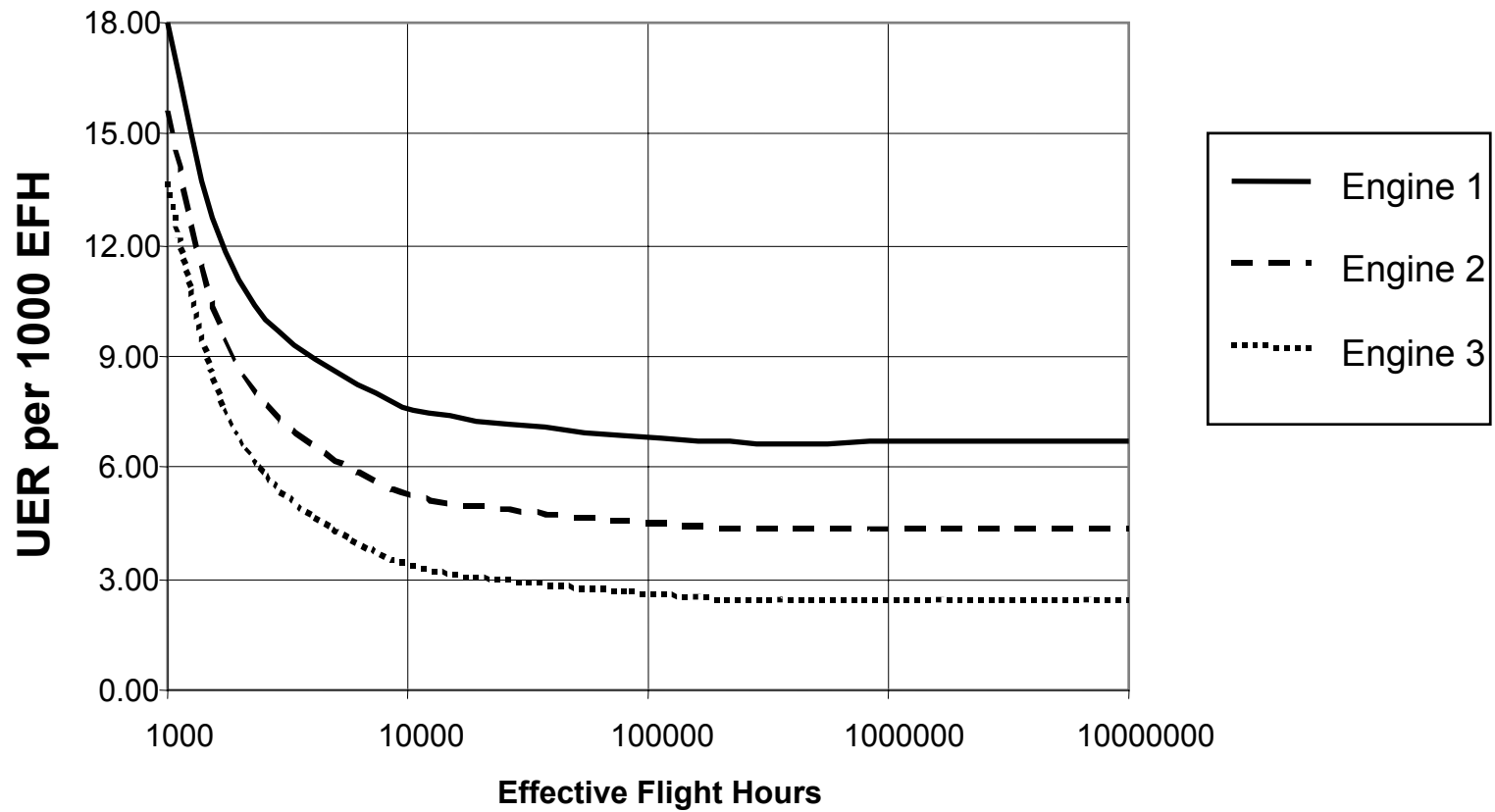
## ■ Enterprise Integration

- Make-buy decisions
- Goals, objectives, and metrics
- System characterization and transformation
- Policies and regulations

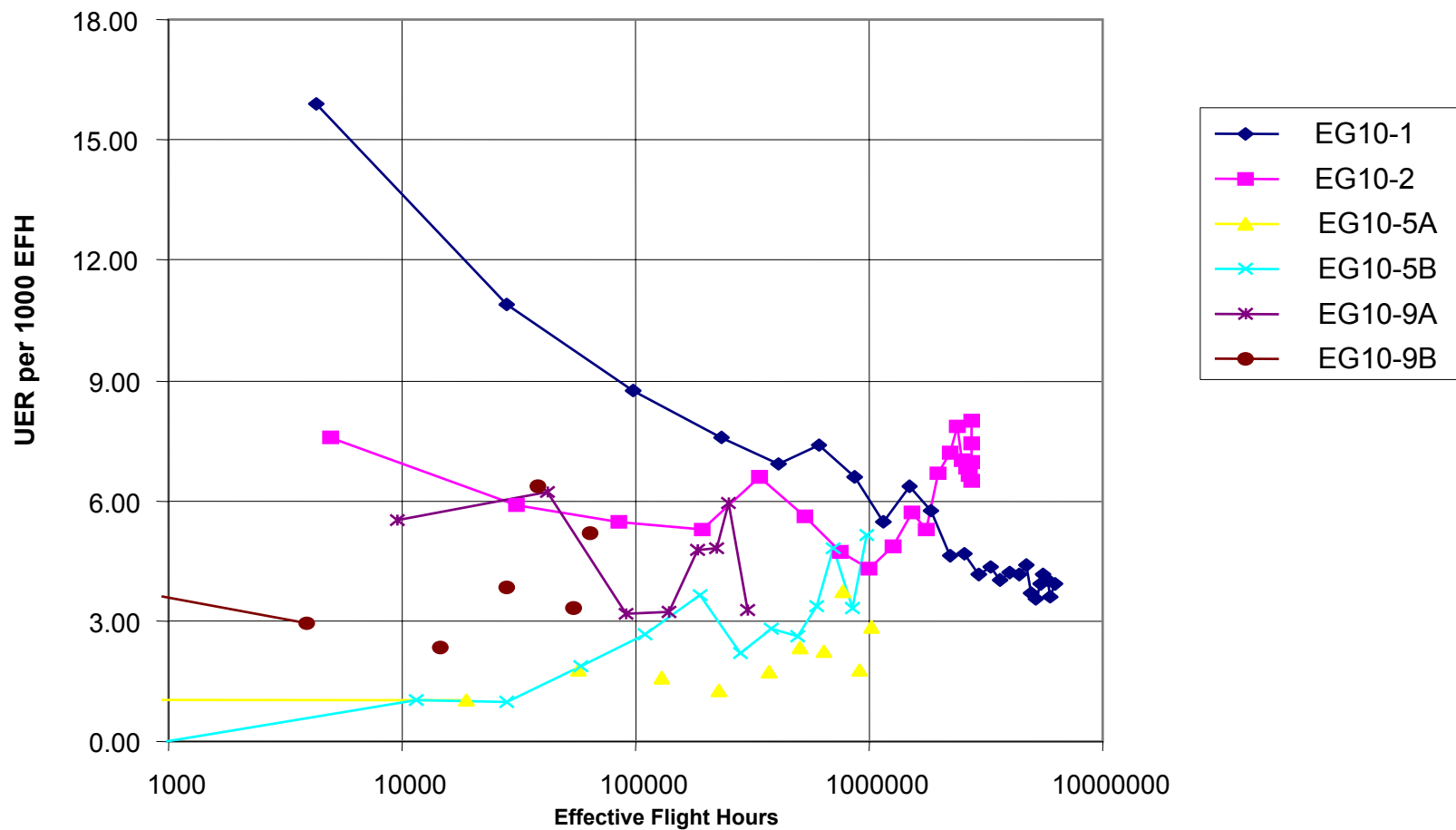
## Some Products

- **“Metrics Thermostat” tool applied to F-16 Bases (world-wide)**
- **Analysis of impact of technology, policy, and practices on design of complex sub-systems for sustainability**
- **Best sustainment practices (depot)**
- **Theses, white papers, invited lectures**
- **Recommended pilots**

# Ideal UER/1000 EFH (notional)



# EG10 UER/1000 EFH vs. Effective Flight Hours



# Lean Sustainment Initiative

## ■ *NEXT STEPS*

- Add commercial aviation stakeholders
- More industrial stakeholders
- Expand government participation
- Expand university base
- Implementation of findings, recommendations

The background features a vertical gradient from light blue at the top to dark blue at the bottom. Overlaid on this are several parallel diagonal stripes of a slightly darker blue, running from the top-left towards the bottom-right.

BACK UP

CHARTS

# Content

- Context of sustainment
  - High level questions
  - Industrial base issues
  - National policy concerns
- Peculiar problem of aging defense aircraft
- A unique response: The Lean Sustainment Initiative(LSI)
- *A Place for Aeronautics*



# Sustainment Research

- Hypothesis

- That designing early for lean sustainment results in more affordable and agile life cycle options, and a greater flexibility for technical upgrades throughout the operational lifetime of a system.

# Motivation

- The need to upgrade many aerospace systems during their life-cycles to maintain functional and cost-of-ownership competitiveness has increased sustainment costs.
- Longer inventory lifetimes of military systems and related support challenges have led to increases in sustainment costs.

## Motivation(cont.)

- Increased parts obsolescence and diminishing support resources have caused increases in sustainment costs.
- Research area is fundamental to understanding and advancing lean thinking throughout the MRO enterprise.

# Key Research Questions

- What does designing an aerospace system for sustainment entail?
- What are the key design tools, practices, and policies utilized in designing an aerospace system for sustainability?
- What impact does designing an aerospace system for sustainment have on the agents in the system's value stream?

## Key Research Questions(cont.)

- What are the enablers and barriers impacting the design of aerospace systems for sustainability?
- How does designing an aerospace system for sustainability impact the upgradeability of an aerospace system?

# Research Methodology

- Literature search
- Interviews of experts
  - Academe
  - Government
  - Industry
- Selected case studies
- Analysis
- Conclusions

# Framework Definitions

- **Policy:** guidance exerted by an agency or person that impacts sustainment decisions.
- **Technology:** the status of technical advancements that result in improvements in aerospace system maintenance capability.
- **Processes and Tools:**
  - Processes: the organizational, managerial, and material tracking techniques used to develop aerospace defense systems.
  - Tools: systems that aid in the design, manufacture, and management of aerospace defense system maintenance.
- **Results:** the sustainability performance of a system as observed by the owners of that system.

# Research Case Study

ENGINE	QUALIFIED	MAX THRUST	INVENTORY	COST/ ENGINE (\$millions)	EFH/M
EC10-1	1973	23830	1579	2.65	21
EC10-2	1973	23830	1094	2.67	25
EC10-3	1985	23770	1155	3.27	24
EC10-9	1989	29000	244	5.2	40



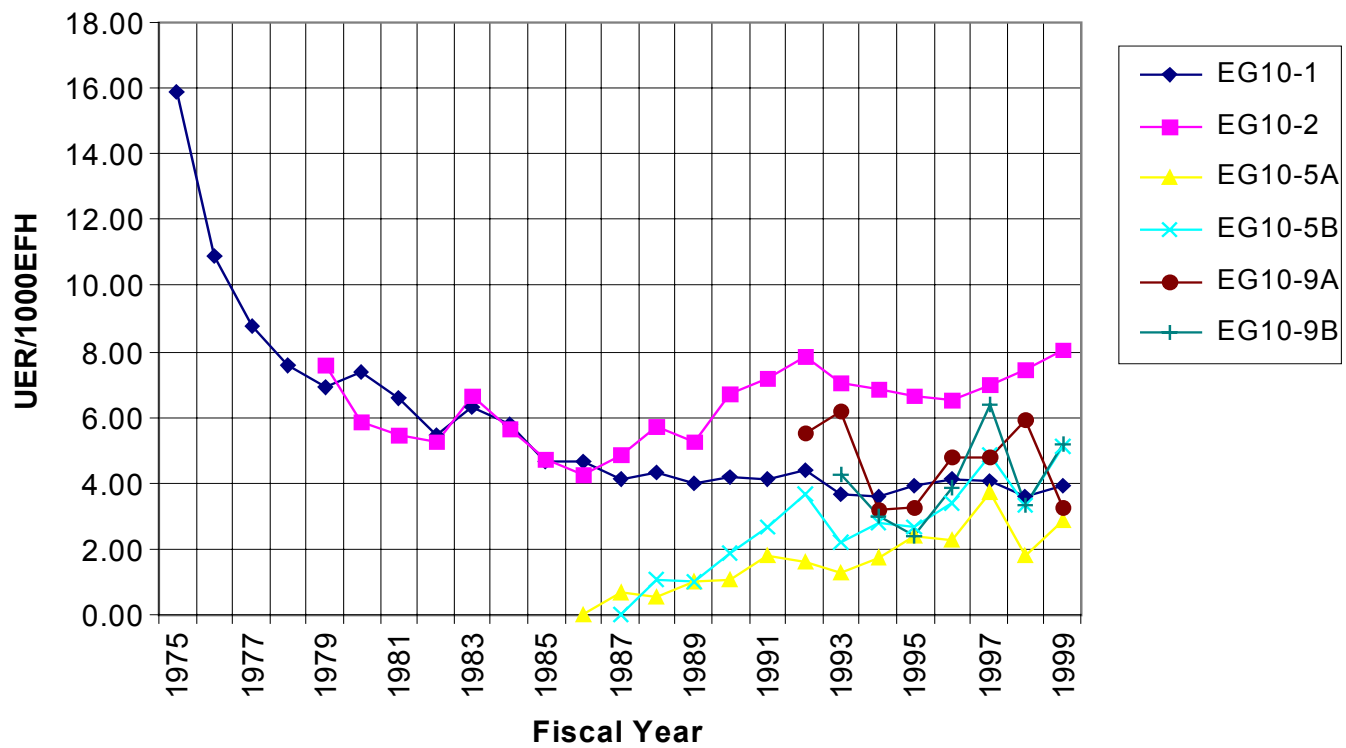
# Sustainability Metrics

- EG10 engine removal records
  - Unscheduled Engine Removals (UER)
  - Total Engine Removals (TER)
- Metric used by the DoD since mid-1970s
  - Measured in relation to both Effective Flight Hours(EFH) and fiscal year.
- UER and TER measure engine system reliability and sustainability.

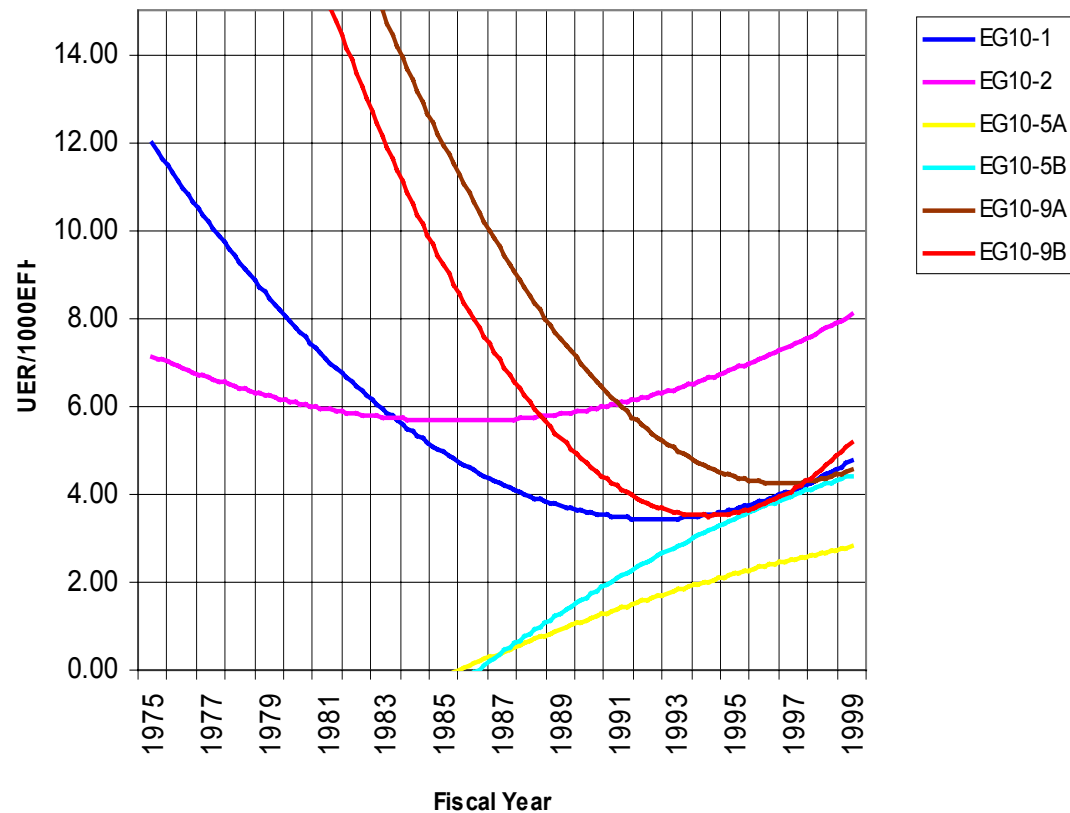


*LEAN  
SUSTAINMENT  
INITIATIVE*

# *EG10 UER/1000EFH vs. Fiscal Year*



# Polynomial Fit of E10 UER/1000EFH vs. Fiscal Year



# Conclusions

- Based on the UER metric, hypothesis is disproved.
- Balance between sustainability and performance is more critical than design philosophy.
- Design for sustainability is greatly enhanced through effective use of IPTs.
- End-use environment critical to effective design for sustainment improvement.