# Air Force Materiel Command

*Developing, Fielding, and Sustaining America's Aerospace Force*


## Modeling and Simulation in Defense Acquisition: Its Time to Put Our Foot on the Accelerator

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**AEDC/CZ**

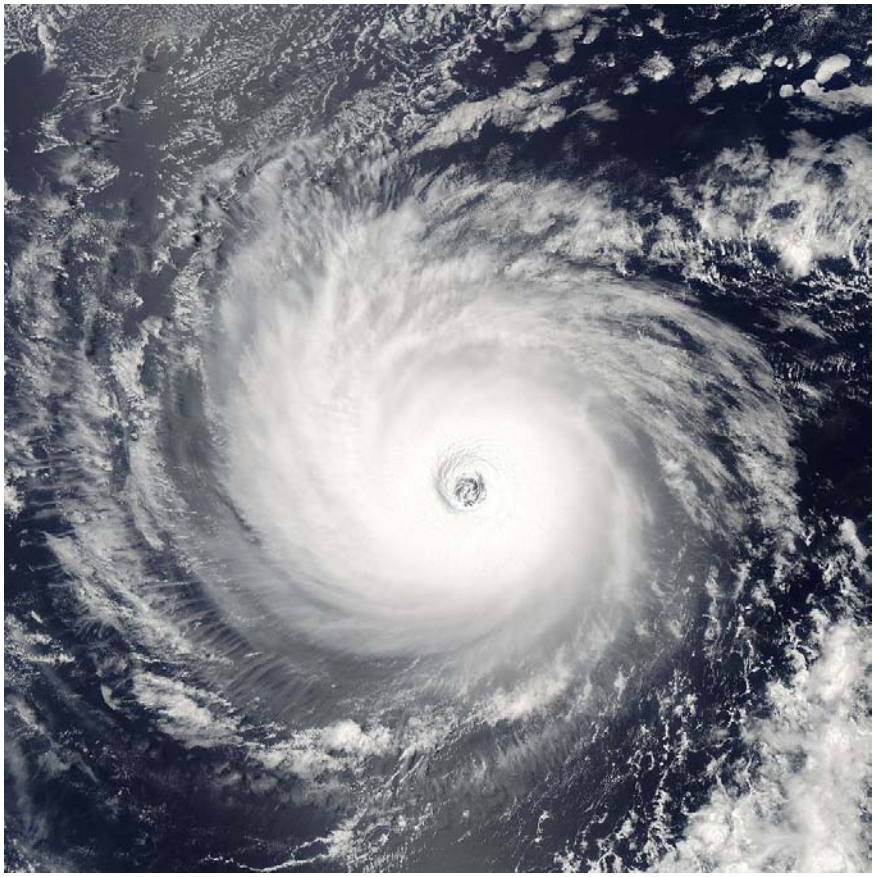
***Cleared for Public Release AEDC PA # 2012-0186***

*Integrity - Service - Excellence*

# My Challenge to the A&D Industry

- **Challenge the Aerospace and Defense Industry to move from anecdotal M&S success stories to institutionalized, effective, sustainable use of M&S to change core technical processes in acquisition**
- **Go beyond the zeros and ones to identify systemic barriers to M&S producing *desperately needed impact* on design, development, integration, testing, and fielding of A&D systems**
- **If we can't significantly improve the "So What?" budgeters and lawmakers may ask "Why M&S?"**
- **What's at stake – national economic and military security**

# Concern for Our Future



Rapidly Approaching Category 5!

- **"The scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength.**
- **"This nation must prepare with great urgency to preserve its strategic and economic security.**
- **"We are worried about the future prosperity of the United States."**

**Augustine *et al*., "Rising Above the Gathering Storm."**
**US National Academies, 2007.**

**Adapted from Loren Miller "Case study in the development and implementation of platform-based and model-based engineering with HPC to convert from prototype based to physics-based, computational product development" NDIA 15th Annual Systems Engineering Conference, San Diego, CA, October 22-25, 2012**

# Global Competition

Leaving it to our competitors…

- **"Our global competitors are well aware of the great potential of computer simulation. Throughout Europe and Asia, governments are making major investments…**
- **"We are in danger, once again, of producing world-leading science but leaving it to our competitors to harvest the technological and economic advantages."**

**Oden *et al*., "Simulation-Based Engineering Science." US National Science Foundation, May, 2006.**

**Adapted from Loren Miller "Case study in the development and implementation of platform-based and model-based engineering with HPC to convert from prototype based to physics-based, computational product development" NDIA 15th Annual Systems Engineering Conference, San Diego, CA, October 22-25, 2012**

# International Assessment

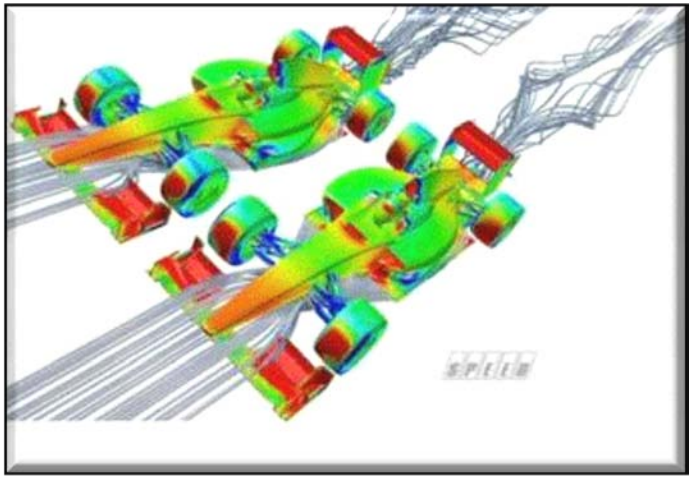

- **“Today we are at a ‘tipping point’ in computer simulation for engineering and science.**
- **“Simulation has today reached a level of predictive capability that it now firmly complements the traditional pillars of theory and experimentation/observation.**
- **“The world of computer simulation is becoming flatter every day.**
- **“Our continued capability as a nation to lead in simulation-based discovery and innovation is key to our ability to compete in the 21st century.”**

**Glotzer *et al*., “International Assessment of Research and Development in Simulation-Based Engineering and Science.” WTEC, 2009.**

**Adapted from Loren Miller “Case study in the development and implementation of platform-based and model-based engineering with HPC to convert from prototype based to physics-based, computational product development” NDIA 15th Annual Systems Engineering Conference, San Diego, CA, October 22-25, 2012**

# Race Car Axioms

- Races are won in the curves
- The corollary is that races are also lost in the curves
- You can't set up to win in the curve after you are already in the curve
- You have to have confidence in your vehicle to accelerate in the curves

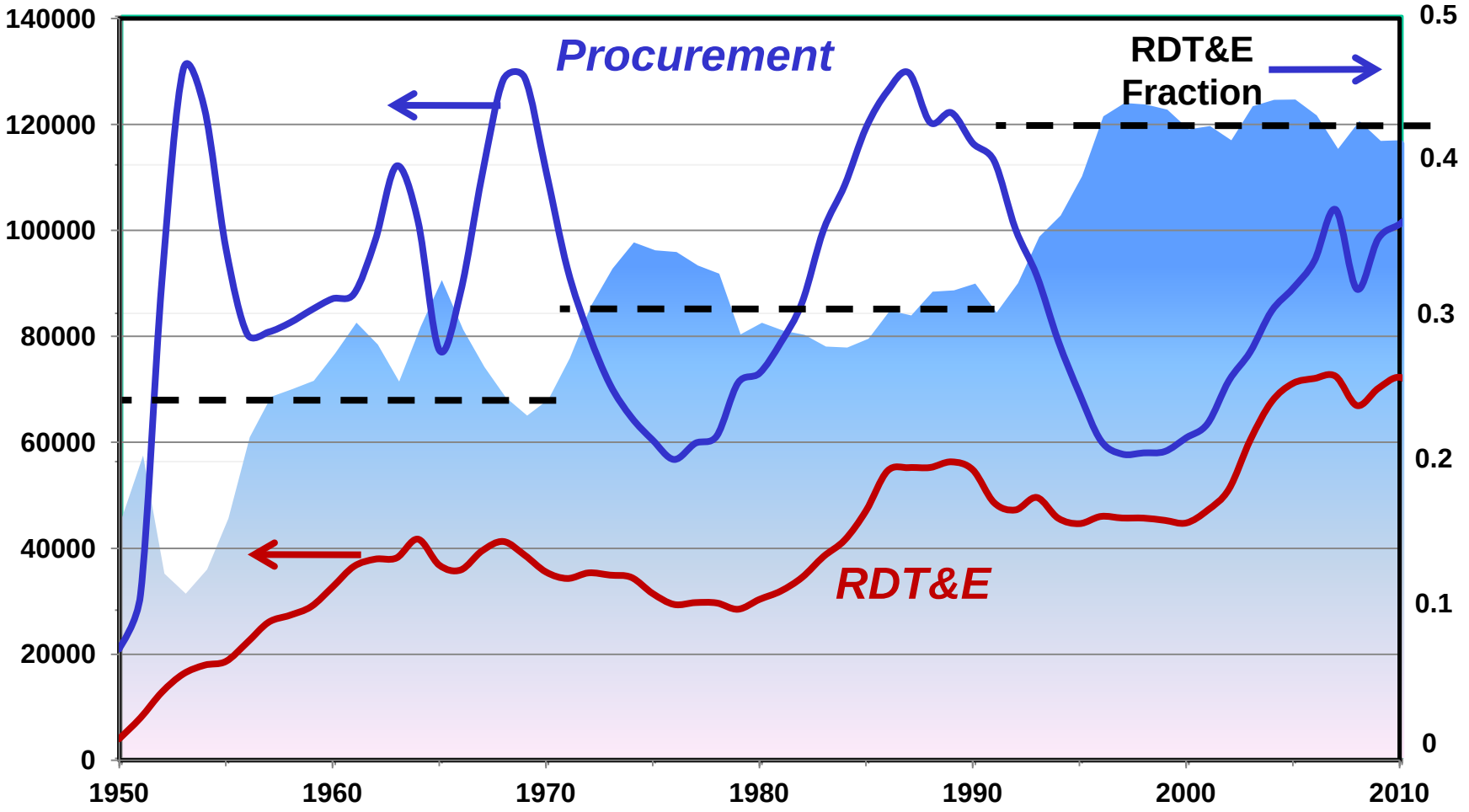


# Premise

- **The US A&D Industry is losing speed in every curve (of the defense budgeting process)**
- **After years of technological dominance on the track, we are losing our competitive edge**
- **Competitors have narrowed the gap and are improving their capabilities to accelerate through the curves**
- **Unless we get better at accelerating through the curves we could lose some races**
- **The roadway ahead is still under construction – we definitely need to be responsive to sudden turns**

# This is the Track We Drive on – Right Hand and Left Hand Turns Slow Us Up

## DoD Total Outlay for Improvements (FY08 $, Millions)



# Our Generic Dynamic Driving Pattern

*We put our foot on the brake here*

*More cars enter the race here*

*We put our foot on the brake and accelerator here*

*Total Outlay for Improvements*

Reduction of
- Capability
- Capacity
- Competence

Reduction of
- Capability
- Capacity
- Competence

- Increase in Acquisition Programs
- Partial Rebuild of Competence

*Procurement*

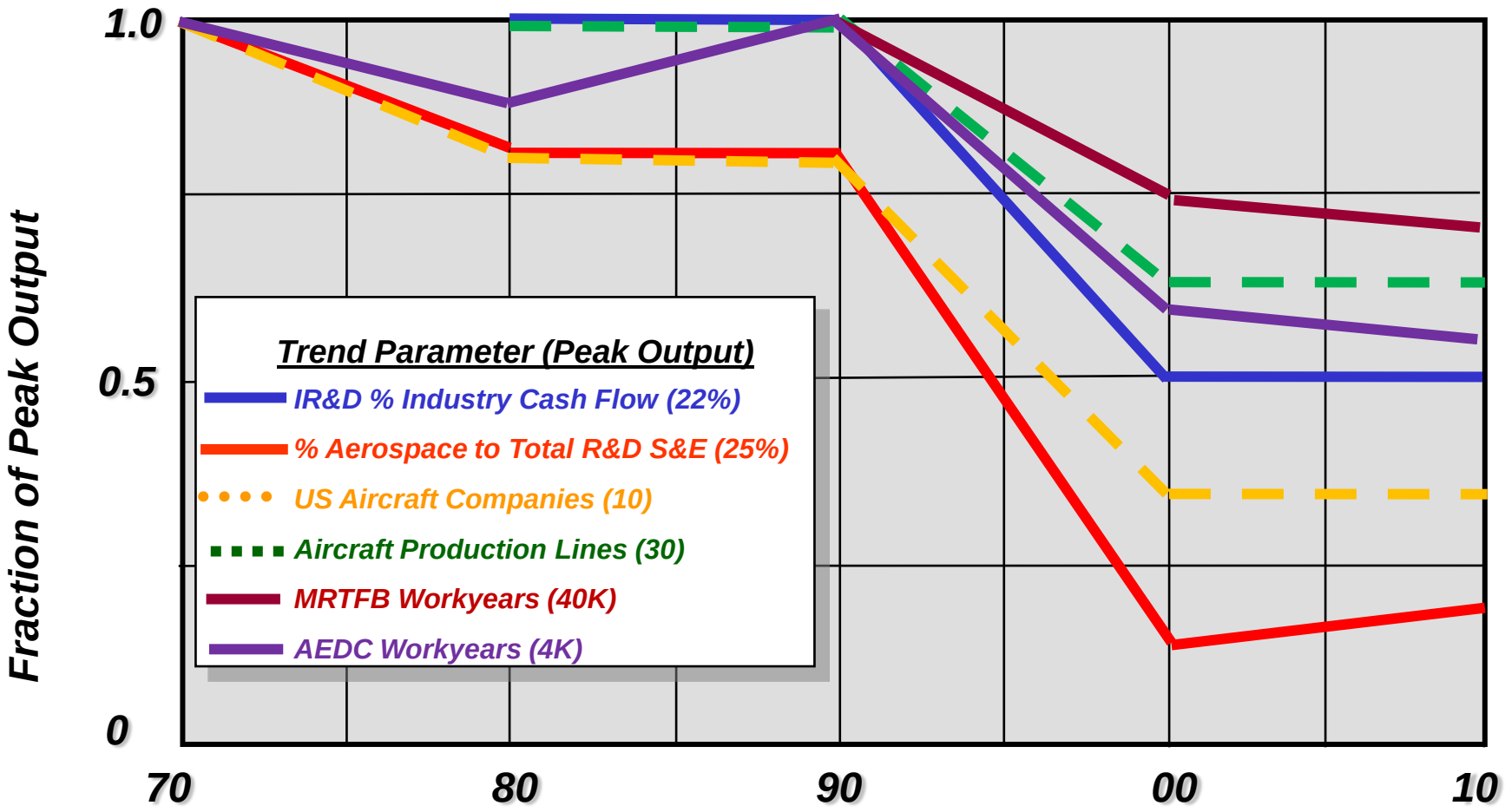
- Stretched Development Phase at Reduced Capacity
- Continuation of Acquisition Programs from Previous Buildup Cycle

- Rapid Increase in RDT&E Backlog
- Compounded by Previous Stretched Programs in Firefighting Mode
- Further Budget Stretching

*RDT&E*

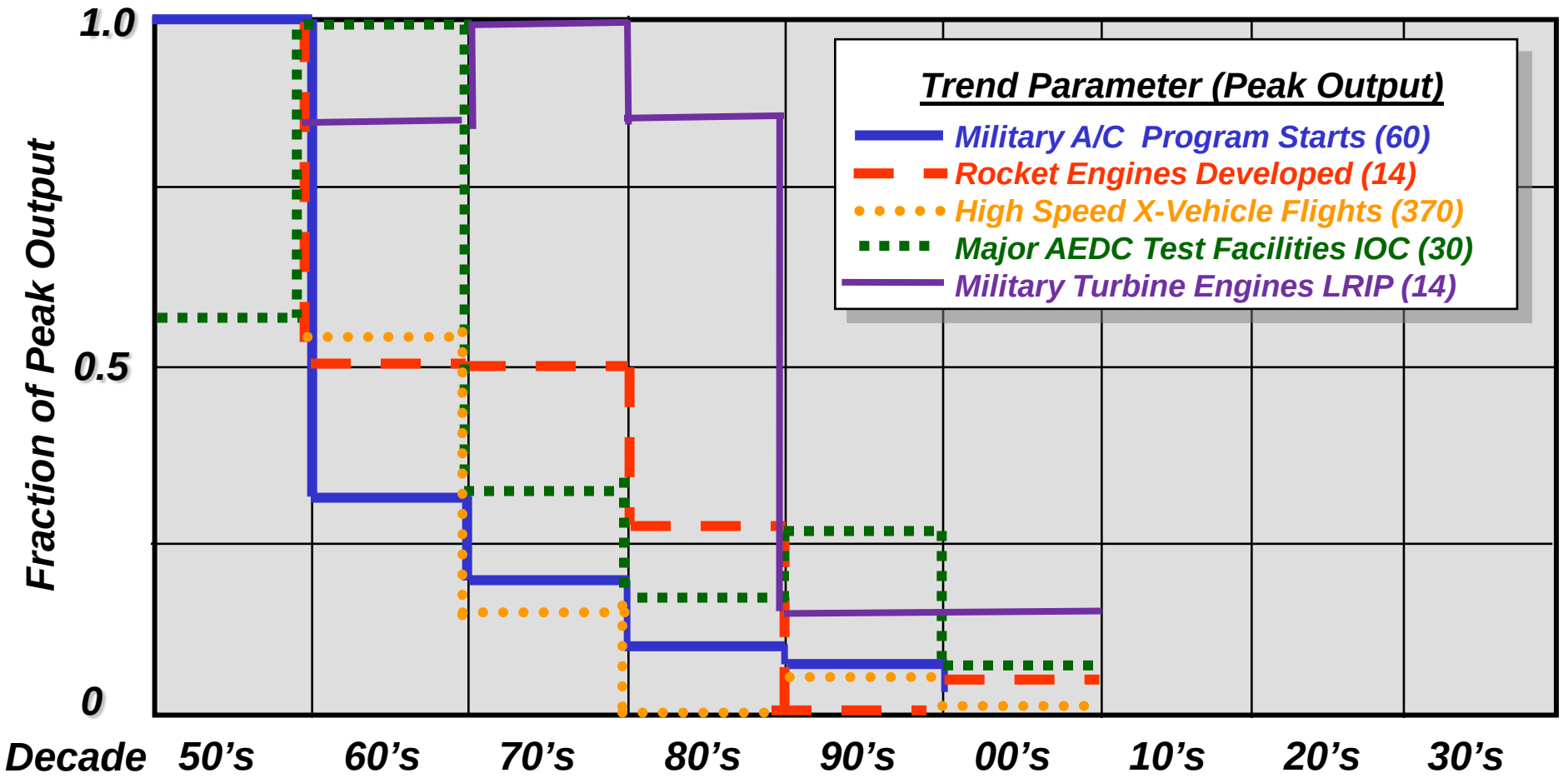
# Applying the Brakes in the Curves Reduced Aerospace Capacity

***Capacity Trend Data from Multiple Elements of the Aerospace Industry Supportive of RDT&E***

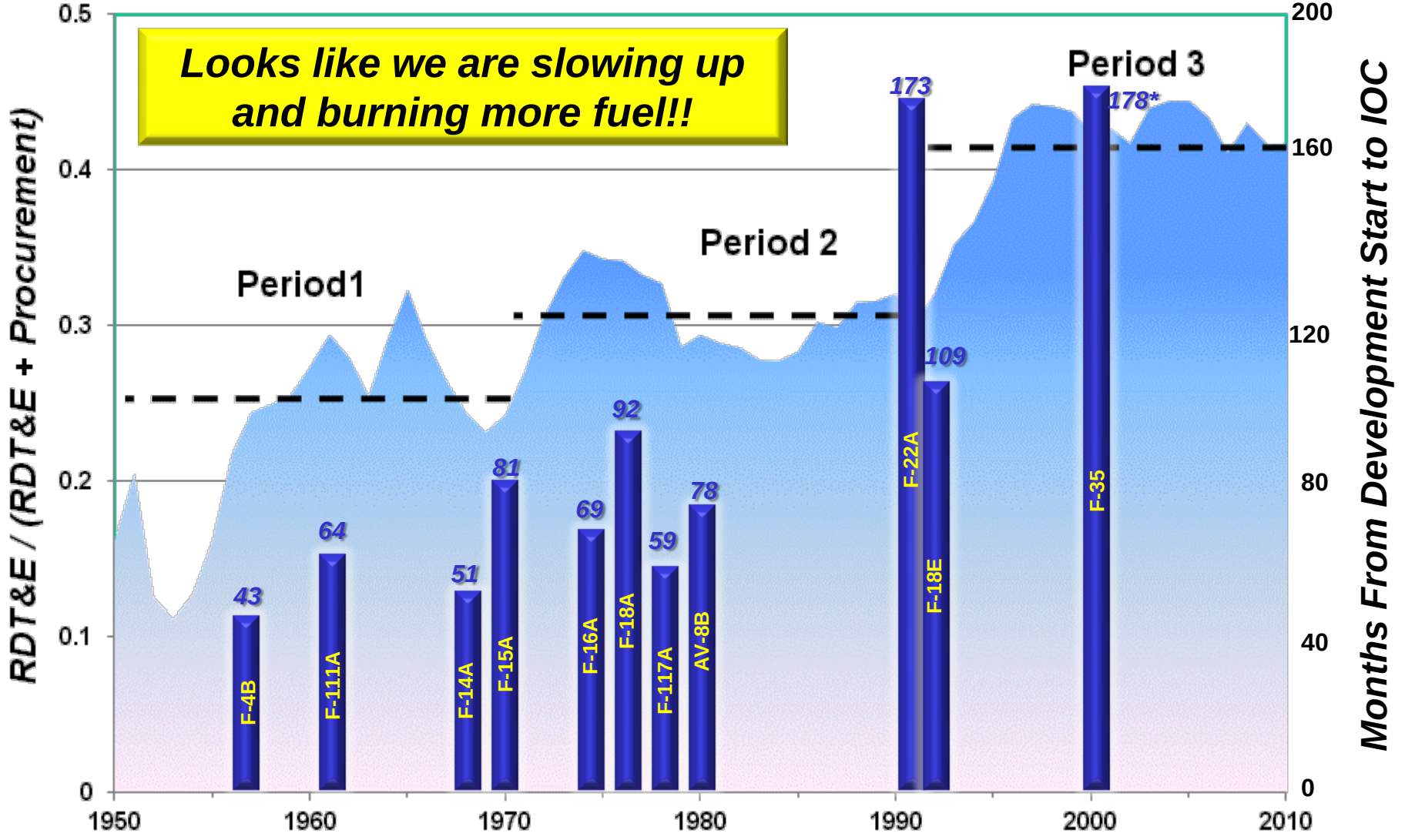


# Aerospace Engineering Trends

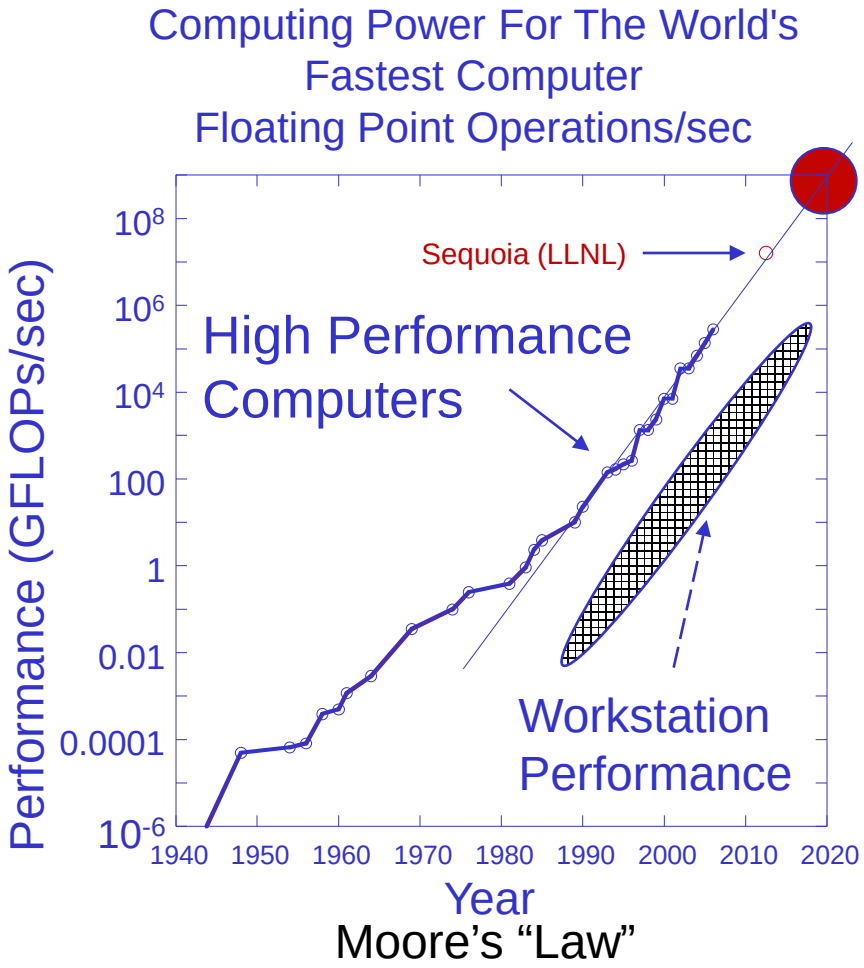
## Our "Drivers" Have Far Fewer Racing Opportunities



# So How is Aerospace And Defense Doing in the Curves?

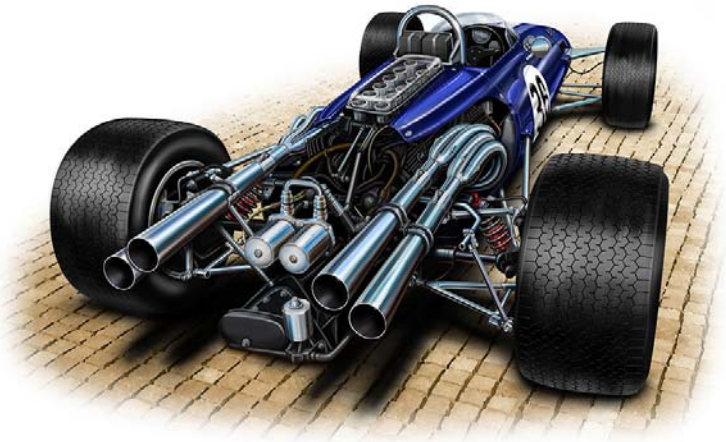


# We Have Increased the Power Under the Hood…



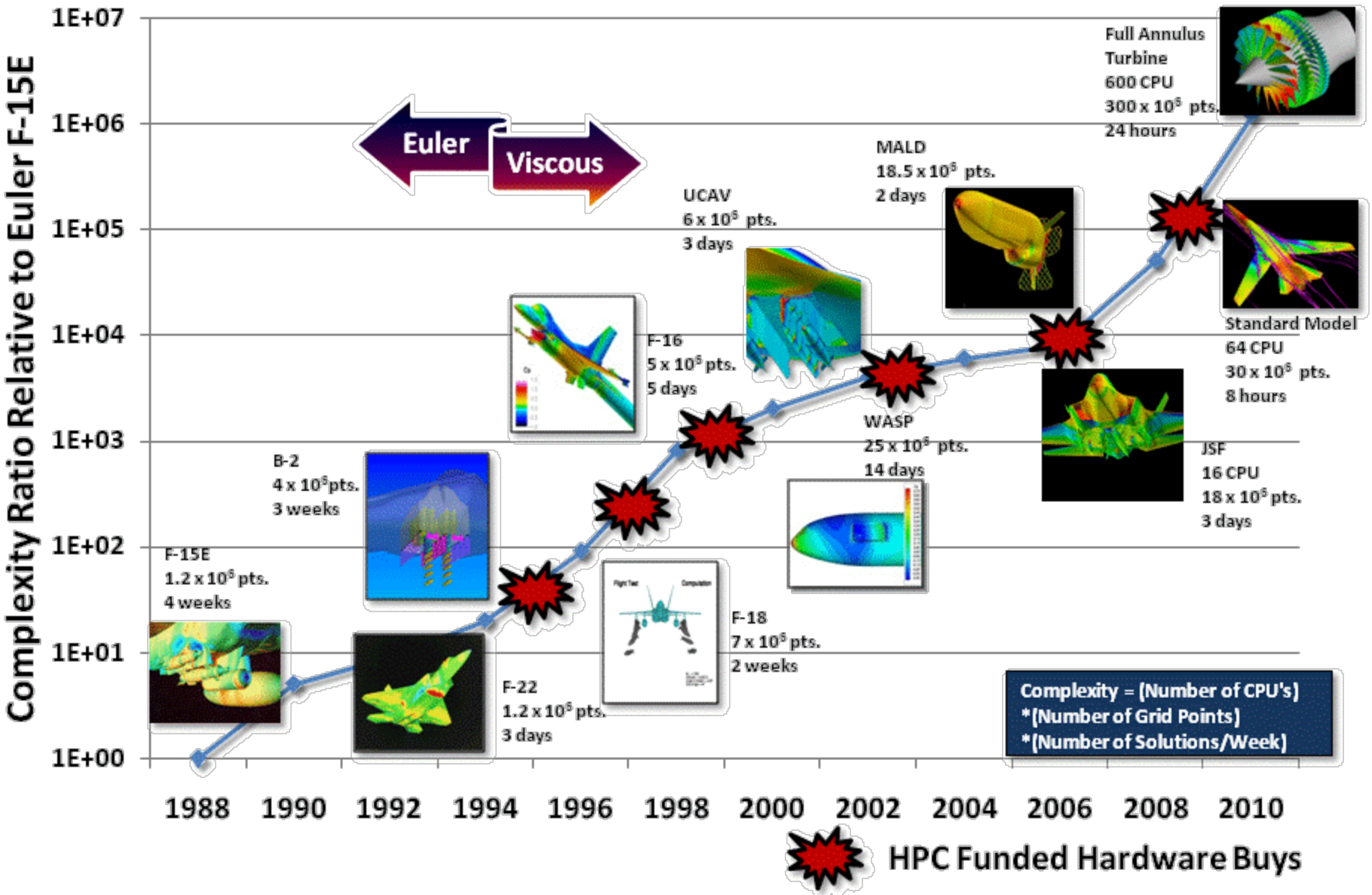

Moore's "Law"

Cores



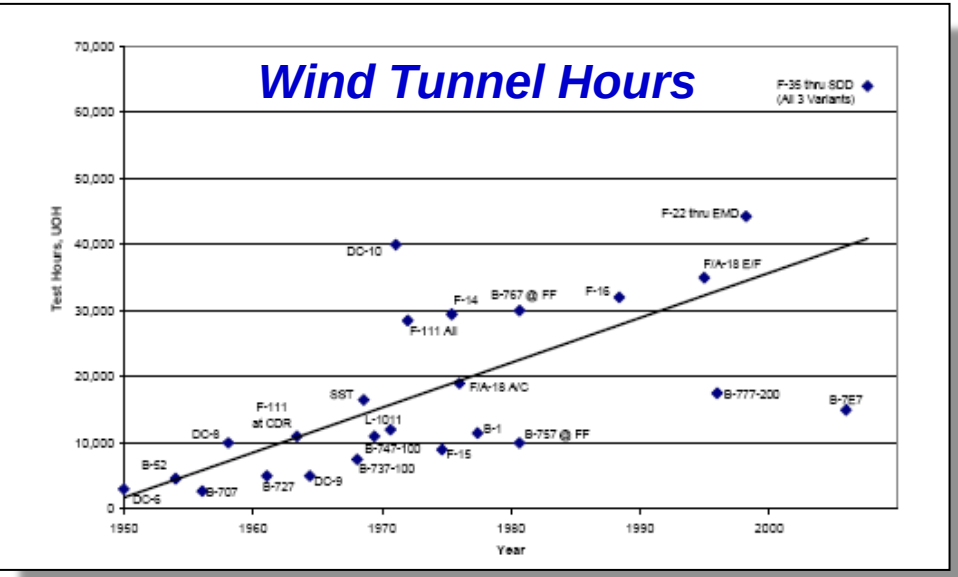
**… But we are not getting the necessary output from the added horsepower**

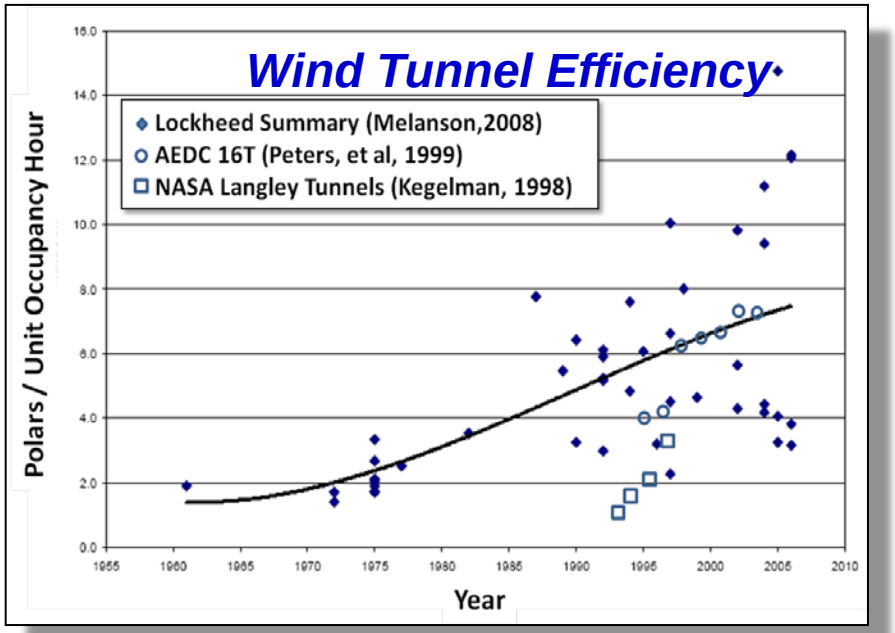
# The Added Horsepower is Really Adding RPM's to Our Motor…



# … But We Are Not Getting Around The Track Faster

- We have increased the throughput of our wind tunnels and increased the use of modeling …
- But have not decreased the total hours or cycle time spent in developing systems




**We have not changed our fundamental approach to the acquisition of aeronautical data – we are not accelerating through the curves !!**

Melanson, Mark R. "An Assessment of the Increase in Wind Tunnel Testing Requirements for Air Vehicles Over the Last Fifty Years," AIAA Paper 2008-830, January 2008

# Taking the Next Curve

- **The road ahead is under construction – expect many potholes**
- **Looking at our performance in the last several curves we will go even slower (e.g. development costs over 50%, time to IOC for a tactical aircraft > 200 months) unless we learn to accelerate**

# What is Slowing Us Up in the Adoption of M&S as an Accelerator?

- Technological Impediments
  - Software scalability
  - Complexity
  - Validation & Verification
- Experience and Intellectual Capital
- Processes
  - Cultural acceptance
  - Concept of Operations – inertia of traditional processes for design, integration, and testing
  - Lack of Incentives

# Cycle Time
# Key Effectiveness Parameter

$$\text{Cycle Time} \sim \frac{\text{Workload}}{q \cdot \text{Capacity}}$$

- ***Workload*** **– Process driven, currently ~22,000 of wind tunnel testing and 13,000 of propulsion cell testing**
- ***q (inverse of rework)*** **– Process driven, typically have 10 structural failures found in flight**
- ***Capacity*** **– Budget and process driven, availability x staffing x throughput**

***50% reduction in wind tunnel costs equates to just a few tenths of a percent reduction in program costs – Reducing acquisition cycle time by a month could save more than the cost of the entire wind tunnel campaign***

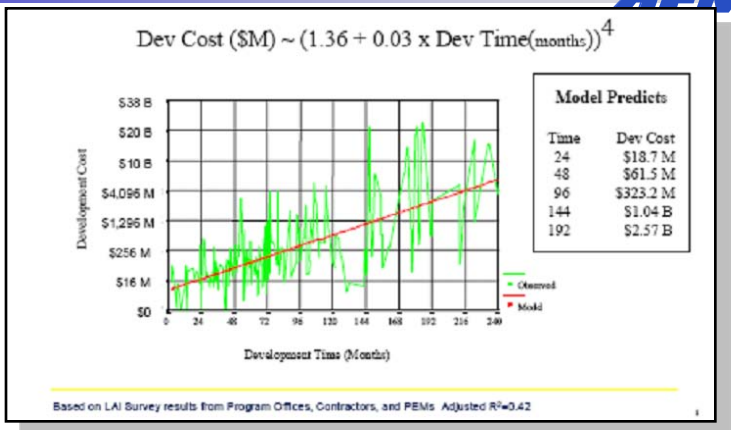
# To Accelerate Through The Curves Need to Focus On Cycle Time

Faster

Better

Cheaper

- Minimizing total cycle time by improving the velocity or clock speed of enterprise processes is most important measure
- Resilient, robust designs with minimal late defects
- Development costs scale with development time to fourth power




*"The ability to compete based on time can also be used as a weapon."*

*—Andrew F. Krepinevich, Executive Director, Center for Strategic and Budgetary Assessments*

***Using cycle time enables coupling between capacity, throughput, and rework on acquisition output***

# How Can M&S Be The Accelerator?

- More technically feasible and affordable requirements setting pre-Milestone A
- More robust, resilient designs
- Reduced cycle time through
  - Reduced work through streamline processes
  - Closed designs at CDR, reduced late defects after first flight

… but it will take

  - Strong collaboration between government and industry
  - Sustainable focus on deployment of M&S to fundamental acquisition processes independent of specific programs

# CREATE-AV

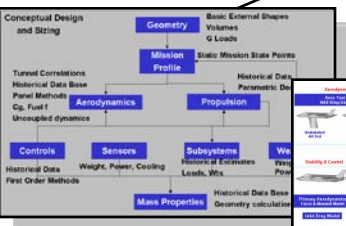
## *Inserting HPC Into Key Acquisition and Sustainment Processes*

AFMC

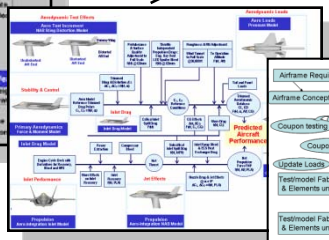
### *Acquisition Process*


*CREATE-AV – Technology Enabler to Affect Process*

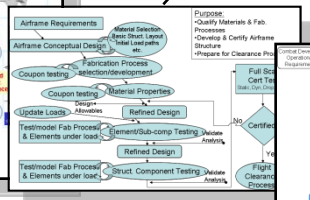
| Labs, COCOMS | Labs, Industry, COCOMS | Labs, Industry, DT | Industry, Programs, DT | Industry, Programs, OT | COCOMS SEEK Eagle Tiger Teams - Labs - T&E |
|---|---|---|---|---|---|



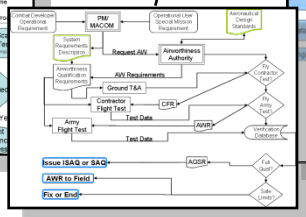

Quantified Technology Assessment



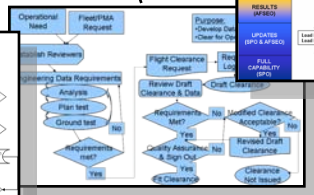
Ground Test Force Accounting



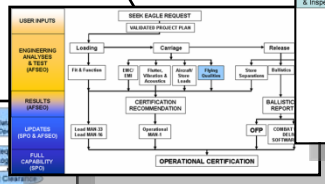

Airframe Certification



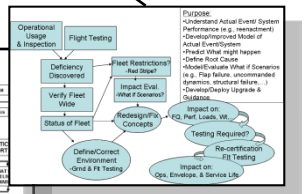

Airworthiness Qualification




Flight Clearance




SEEK EAGLE Certification




Mishap Investigation

# Moving Ahead

- Forums?
  - NDIA – process workshops
  - CREATE Sustainment and Deployment government /industry consortium
  - Engineering Resilient Systems
- WIFM?
  - Taxpayer – strong defense in declining budget
  - Warfighter – capability on time and cost
  - Acquisition Community – revitalized, effective processes producing more outcome per dollar
  - Industry – More program opportunities for fixed top line DoD budgets, shorter time to market
  - M&S and T&E Communities – Quantifiable value proposition, sustainability

# Parting Thought

**“It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than a new system. For the initiator has the enmity of all who would profit by the preservation of the old institution and merely lukewarm defenders in those who gain by the new ones. ”**

***Prince Niccolo Machiavelli***