Economics of Human Systems Integration:
The Pratt & Whitney F119 Engine

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March 18th, 2009

Annapolis, MD

Research Advisors: **R. Valerdi and D.H. Rhodes**

HSI in the Air Force

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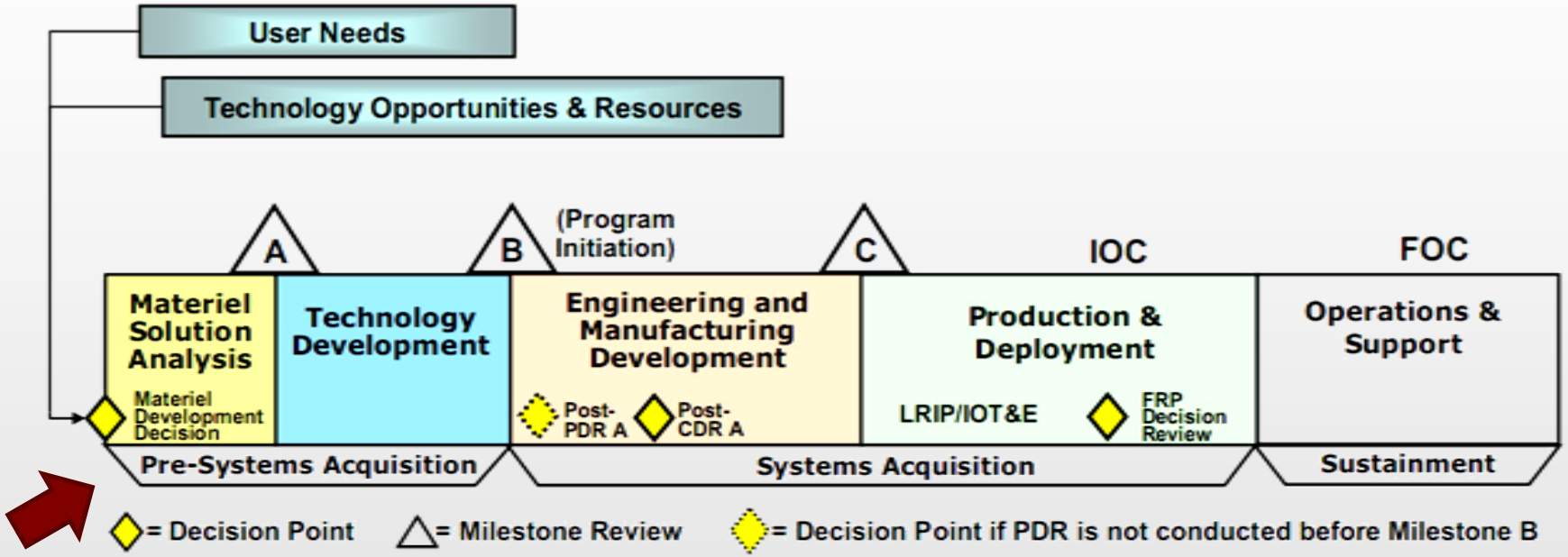
Economics of HSI



DoDI 5000.02, *Operation of the Defense Acquisition System*

(Begins)

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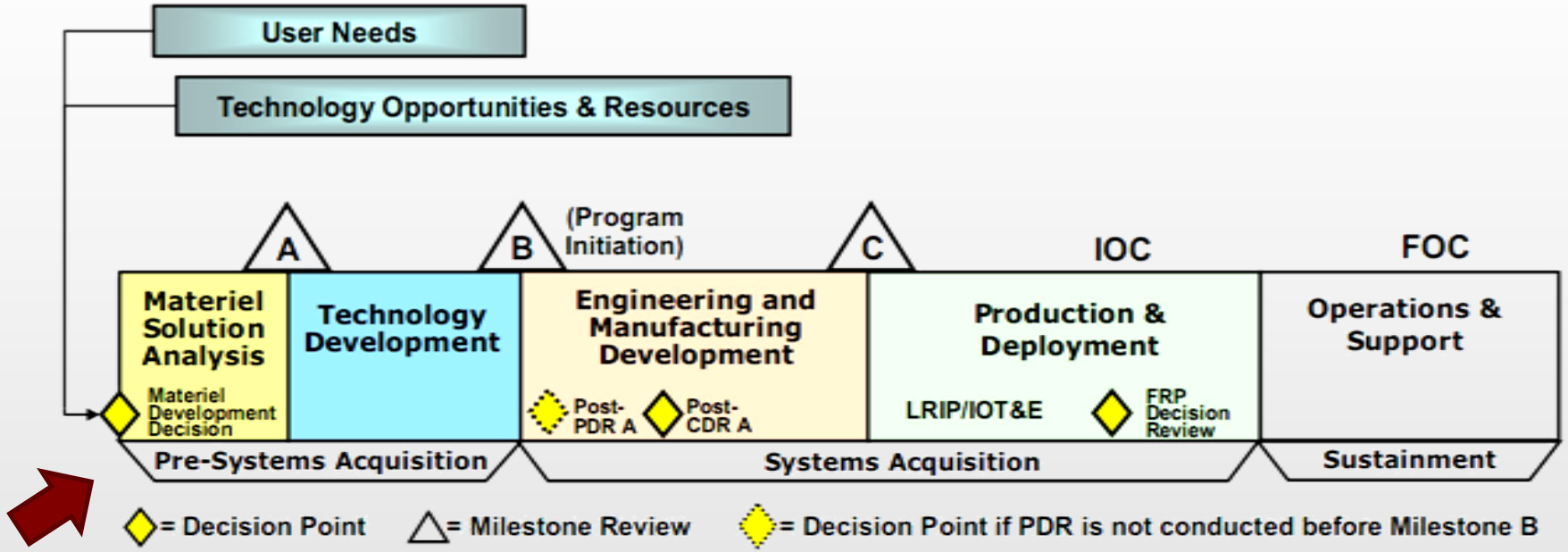
Economics of HSI



Cost Drivers

Size Drivers

Leading Indicators

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Research Questions

- How did Pratt & Whitney predict how much HSI effort would be needed?
- How much did HSI effort eventually cost?
- How did HSI fit into the larger systems engineering picture?

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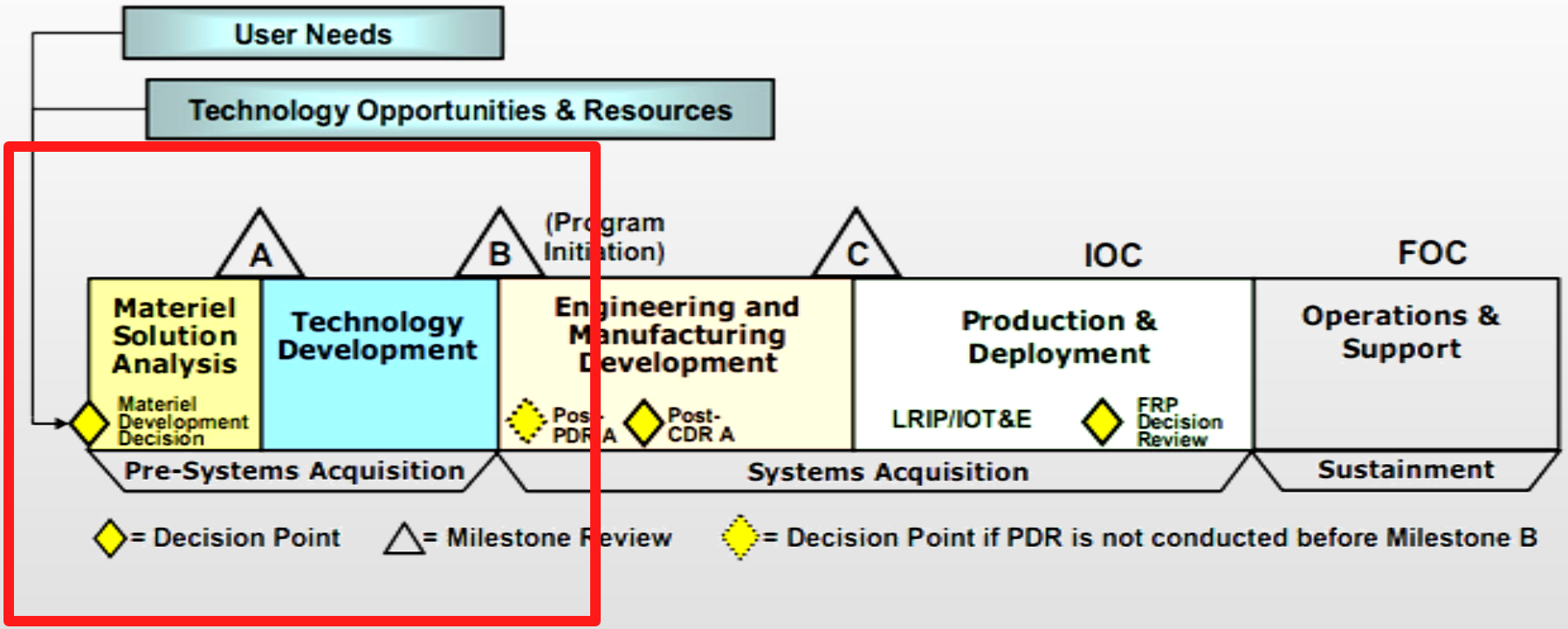
Methodology



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The F-22 Raptor
Air Superiority Fighter

Replaces F-15

Air dominance, multi-role fighter

Dominance through *stealth, speed, agility, versatility, supportability*

First Look – First Shot – First Kill

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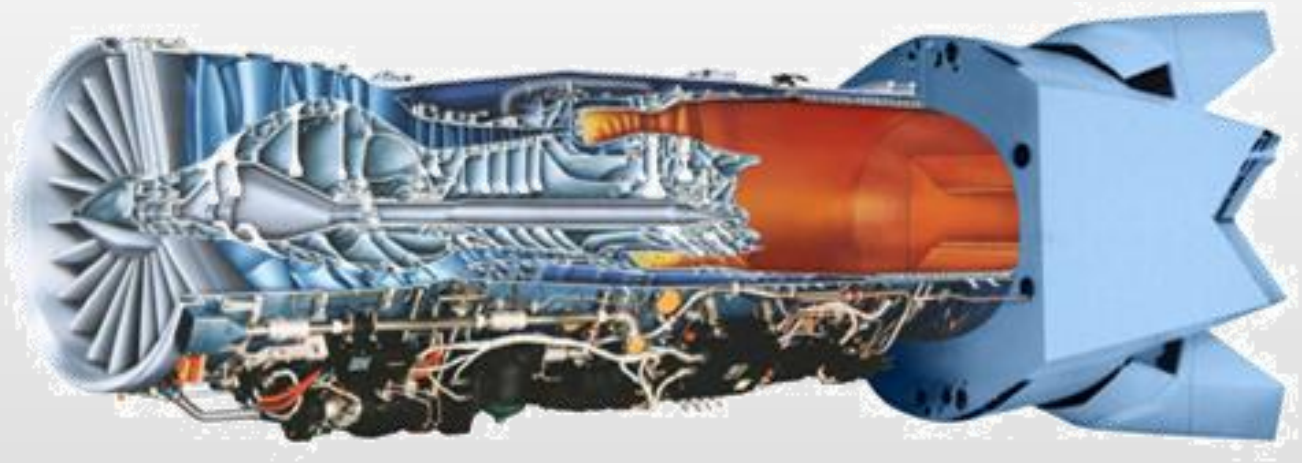
The Pratt & Whitney F119 Engine

1981 & 1985 – GAO reports recommend integrating MPT

1983 – Memorandums emphasizing readiness, availability, cutting costs

1983 – F-22 supportability goals established

1984 – AF Reliability, Maintainability & Supportability (RM&S) Program



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Early Air Force Emphasis on Reliability and Maintainability

Types of studies
- Technology assessment
- Engine size and cycle
- Design life optimization
- Stage count, configuration, rotor speeds
- Evolution from demonstrator to prototype

Tradeoff alternatives
Design and programmatic alternatives based on cost, schedule, and performance requirements

Evaluation criteria
- Safety
- Weapon system life cycle cost
- Supportability
- Reliability/maintainability
- Weight
- Operability/stability
- Manpower, personnel, and training

Planned trade studies
- Affordability
- Design refinement
- Pre-planned product improvement
- Materials and manufacturing technology

Balanced design

- Low-risk
- Affordable
- Achieves all ATF / NATF requirements

Yankel, J., & Deskin, W. (2002). "Development of the F-22 propulsion system."

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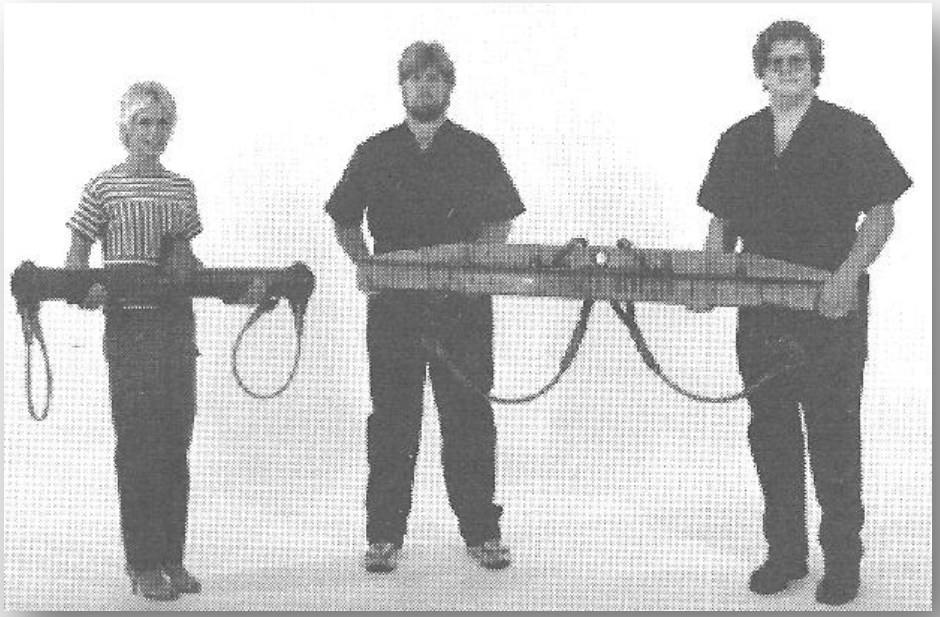
Leadership and IPD



…advances were intended to ***reduce operational level and intermediate level maintenance items by 75% and depot level tools by 60%, with a 40% reduction in average tool weight****,"* (Aronstein, et al. 1998).

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HSI Efforts Lead to Competition Success

1991 – Engineering & Manufacturing Development

400 distinct demonstrations

110,000 hrs component tests

3,000 hrs full-up engine tests

50% more test hrs than GE

$2M mock-ups

$1.375B contract awarded 02 Aug1991

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Observations

- ***How did Pratt & Whitney predict how much HSI effort would be needed?***
  - **USAF Requirements-driven**
  - **Competition, Business need**
- ***How much did HSI effort eventually cost?***
  - **Estimation by analogy**
  - **"HSI Slice" unclear**
- ***How did HSI fit into the larger systems engineering picture?***
  - **IPD, CICR, CCB, IPT, CIPT, etc.**
  - **Emphasis in requirements, pre-milestone A/B**

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Next Steps

- *How did Pratt & Whitney predict how much HSI effort would be needed?*
- *How much did HSI effort eventually cost?*
- *How did HSI fit into the larger systems engineering picture?*

- **USAF F119 SPO**
  - **"HSI Requirements"**
- **INCOSE IW09**
  - **Expert Opinion**
- **Tinker AFB Maintenance Costs**
- **Parametric Cost Model**

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Acknowledgments

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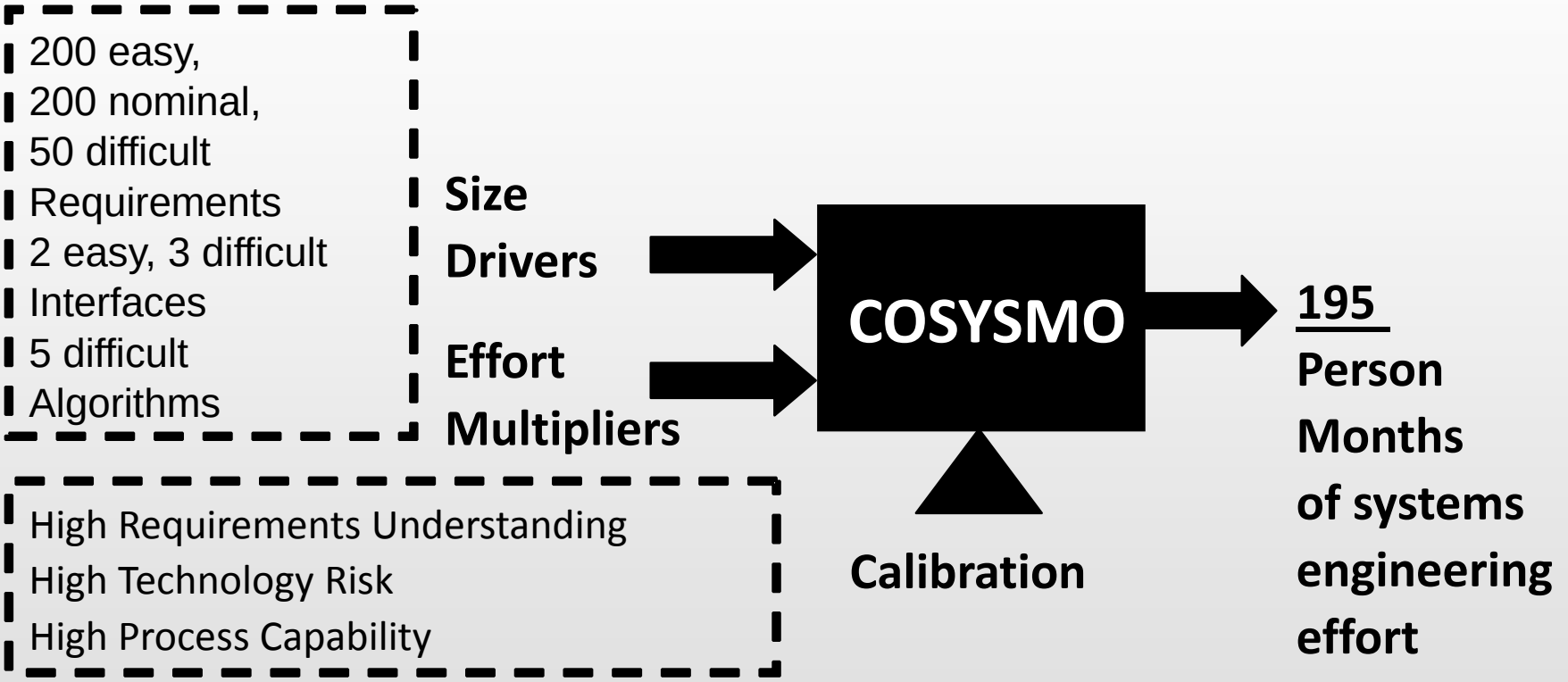

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