

# Life Cycle Costing and Its Relationship to T&E

W. C. (Dev) Devers  
Institute for Defense Analyses  
Cost Analysis and Research Division  
November 4, 1999

# Overview

- DoD Acquisition Process: DoD 5000 Series
- Role of Cost Analysis in supporting the acquisition process and programs Life Cycle
- Where T&E and Cost Analysis Are Linked in the Acquisition Process and life cycle analysis
- Estimating T&E Costs
- Assessing the Effects of T&E Results on LCC
- Data Sources

# DoD Acquisition Policy

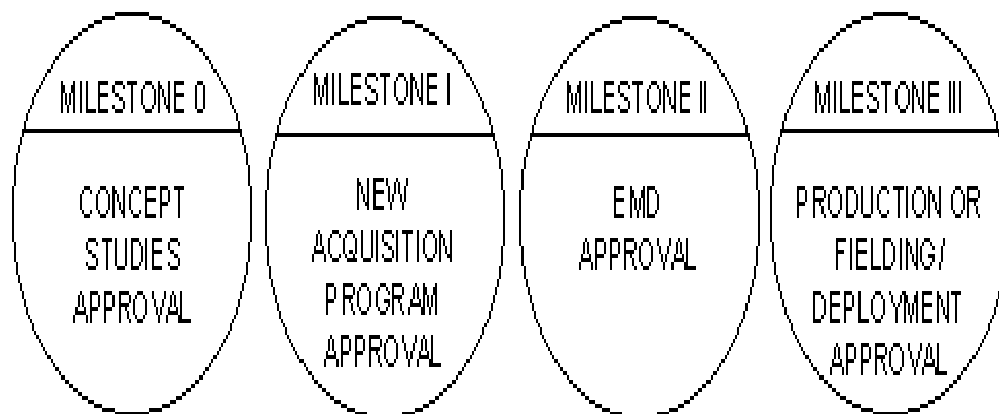
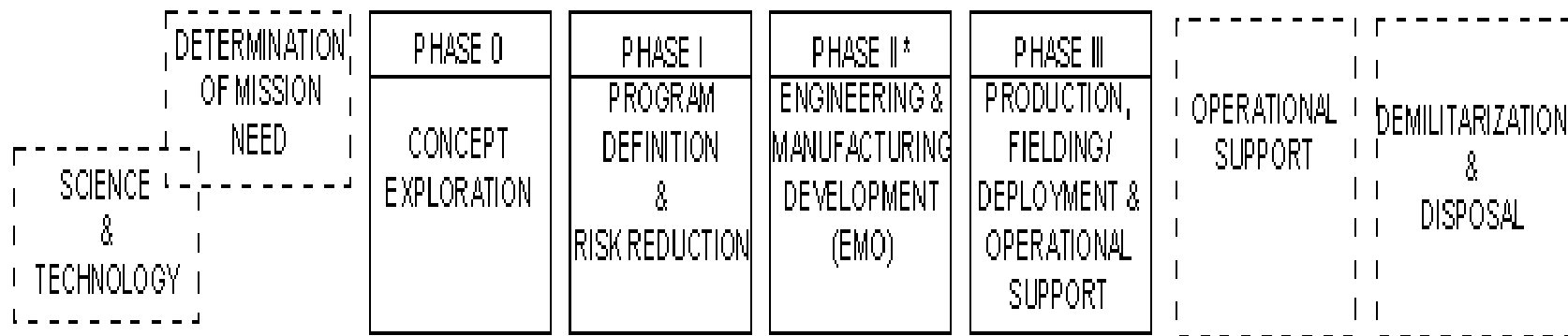
- Primary objective:
  - Acquire quality products that satisfy the needs of the operational user with measurable improvements to mission accomplishment, in a timely manner, at a fair and reasonable price.
- Policies and principles are divided into three major categories:
  - (1) Translating Operational Needs into Stable, Affordable Programs,
  - (2) Acquiring Quality Products, and
  - (3) Organizing for Efficiency and Effectiveness.

# DoD Acquisition Phases and Milestones

## Phases and milestone decision points

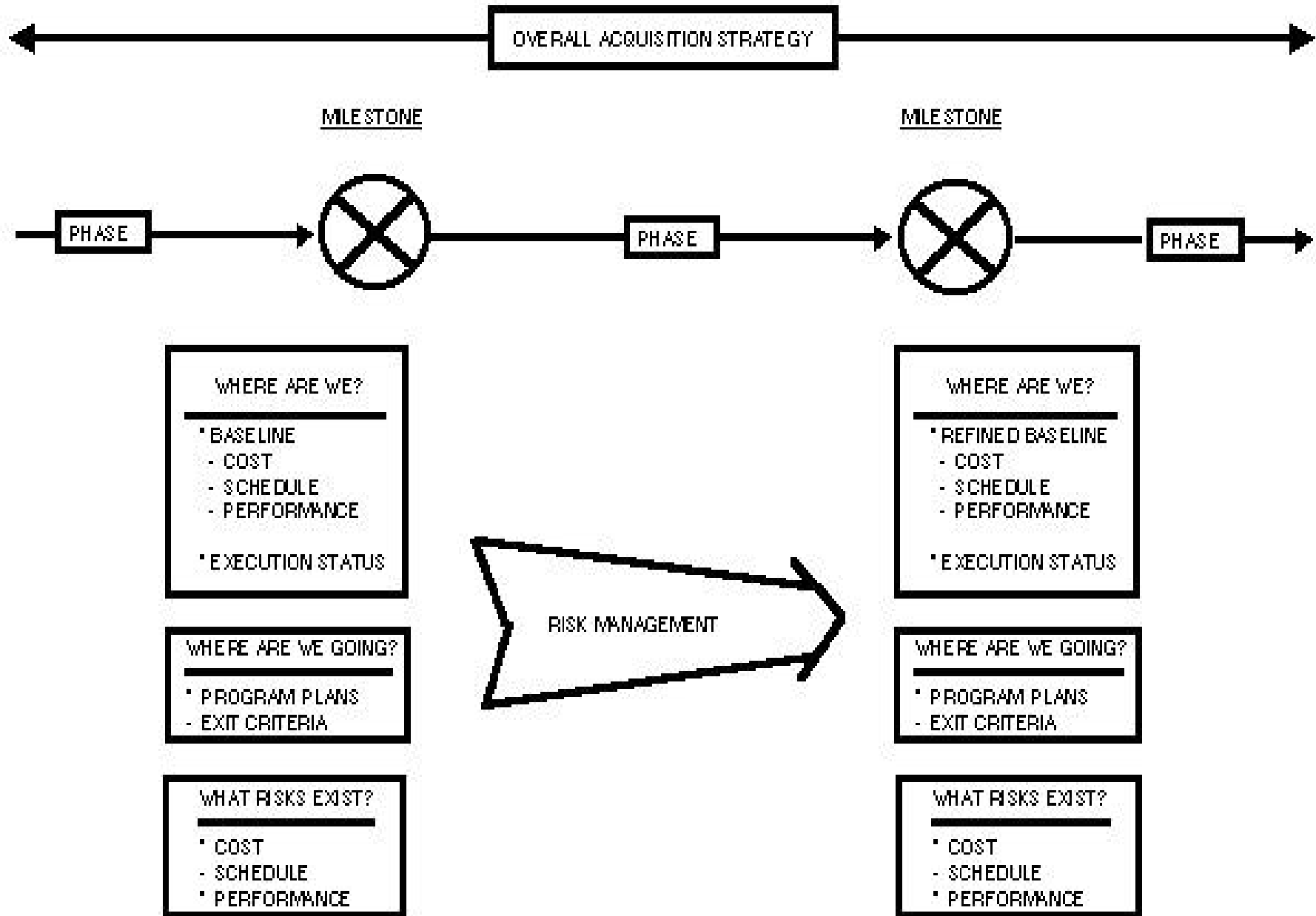
- Facilitate the orderly translation of broadly stated mission needs into system-specific performance requirements and a stable design that can be produced efficiently.
- Low Rate Initial Production (LRIP) may occur during Phase II if so decided at Milestone II (see DoD 5000.2R part 1.4.4.1)

# Four Major Milestone Decision Points and Four Phases of the DoD Acquisition Process



\* MAY INCLUDE LOW RATE INITIAL PRODUCTION (LRIP)

# ACQUISITION PHASES AND MILESTONE DECISION POINTS



# Role of the Program Manager in the DoD Acquisition Process

- Establish key cost, schedule, and performance parameters;
- Document key parameters in an Acquisition Program Baseline;
- Develop an acquisition strategy, which addresses
  - potential sources,
  - risk management,
  - Cost as an Independent Variable (CAIV), contract approach, and
  - management approach.
- Develop a test and evaluation strategy that describes the salient elements of the test program and complies with all statutory requirements regarding testing.
- Develop a life-cycle cost estimate for the program.

# Cost As an Independent Variable

- Objectives
  - Provide the customer/warfighter with highly capable systems that are affordable over the life cycle and
  - establish balance between cost, schedule and performance early in the acquisition process and to manage to the cost objective.
- Potential Metrics
  - Unit Recurring Production Cost (dominate)
  - Unit Life Cycle Cost



# Test and Evaluation (T&E)

- Process by which a system or components are compared against requirements and specifications through testing.
- Results are evaluated to assess progress of design, performance, supportability, etc.
  - Developmental test and evaluation is an engineering tool used to reduce risk throughout the defense acquisition cycle
  - Operational test and evaluation is the actual or simulated employment, by typical users, of a system under realistic operational conditions.

# Purpose of T&E

- Fundamental purpose - identify the areas of risk to be reduced or eliminated.
- Roles during phases of development,
  - Early Phases (DT&E)
    - concerned chiefly with attainment of engineering design goals
    - demonstrate the feasibility of conceptual approaches,
    - evaluate design risk,
    - identify design alternatives,
    - compare and analyze trade-offs, and
    - estimate satisfaction of operational requirements.
  - Later Phases (OT&E), focuses on questions of
    - operational effectiveness,
    - suitability and
    - supportability.
  - DT&E and OT&E are not necessarily serial phases in the evolution of a system.

# Cost Communities Role in Program Life Cycle

- Prior to Milestones 0 & I:
  - Provides estimates to support design trades
- Prior to Milestone II:
  - Provides LCC estimates to support Analysis of Alternatives
  - Assists in defining CAIV
  - Develops Program Office LCC estimate
  - Develops independent LCC assessments: OSD CAIG and service cost organizations
- Prior to Milestone III:
  - Provides PO estimate for procurement
  - Develops independent LCC assessments: OSD CAIG and service cost organizations
- During EMD and production
  - Tracks actual EMD and procurement costs: Contractor Cost Performance Reports (CPRs) and Contract Cost Data Reports (CCDRs) and government costs
- During deployment and operations
  - Tracks actual O&S costs: VAMOSOC Systems (Navy VAMOSOC, Air Force Total Ownership Cost, and Army OSCMIS)

# Role of the OSD Cost Analysis Improvement Group (CAIG)

Implement 10 U.S.C.2434 (Reference (h)) and DoD  
Instruction 5000.2 (Reference (f))

- For Milestone II and III Reviews. Prepare report on their independent estimate of program life-cycle costs of each Category ID program
- For a Category IC program, provide a similar report at either Milestone II or III

# Scope of the CAIG Independent LCC Estimate

Cover all elements of the total life-cycle costs of the program including the following:

- Cost of all research and development efforts,
- Cost of the prime hardware and its major subcomponents to include:
  - support costs (including training, peculiar support equipment, and data),
  - initial spares,
  - military construction costs, and
  - the cost of all related procurements (including, where applicable, modifications to existing aircraft or ship platforms)
- Operating and support costs

# Bases for the CAIG Estimate

- Based on cost analysis requirements description (CARD) provided by Service,
- Examine the mutual consistency of the CARD with
  - current threat,
  - operational requirements, and technical requirements documents;
  - and with contractual documents, including requests for proposals.
- Report any instances of significant inconsistencies and provide an assessment of their potential implications for cost
- Review each of the program and estimating assumptions, and provide its opinion of their validity in its report.

# OSD CAIG Risk Assessment.

- Include quantitative assessments of the risk in the estimate of life-cycle costs.
  - Consider the validity of such programmatic assumptions of the CARs as
    - EMD schedules,
    - rates of utilization of test assets,
    - production ramp rates, and
    - buy rates
- Consider uncertainties in inputs to
  - any cost estimating relationships (CERs) used in its estimates,
  - as well as the uncertainties inherent in the calibration of the CERs, and
  - uncertainties in the factors used in making any estimates by analogy.
- Consider cost and schedule risk implications of the program's technical risks

# Where T&E and LCC Analysis Are Linked

- Both directly address risks in programs
  - T&E helps reduce risks and assess progress toward meeting program requirements
  - LCC analyses assess the cost and schedule risks to help determine if a program is affordable
- LCCs include estimates of T&E resources
- LCC analysis uses data from T&E experience as a basis for critical elements O&S estimates as programs moves from EMD to Procurement



# Elements in Estimating the Cost of T&E

## (Aircraft used as example)

- Contractor T&E
  - System Test and Evaluation
    - Ground tests including subsystem costs
      - subsystem qualification and R&M
      - wind tunnel
      - T&E support
      - static, fatigue, and drop
      - facilities
    - Other costs
      - Mockups
      - T&E support to government DT&E, OT&E, and operational evaluations
      - facilities
  - Contractor flight testing
- Government Tests
  - DT&E and combined DT/OT Flight tests
  - Live fire

# Methods Used to Estimate T&E Costs

- Separate estimates for contractor and government test costs
- Contractor T&E costs
  - Cost Estimating Relationships are developed using historical CCDR and CPR data
  - Examples:
    - Contractor subsystem tests:  $\text{labor hours} = \text{labor hours/lb} \times \text{total of subsystems aircraft unit weight}$
    - Contractor flight tests:  $\text{labor hours} = \text{labor hours/flying hours} \times \text{projected total test flight hours}$
- Government T&E costs
  - System specific staffing costs at test ranges are estimated based on staffing requirements

# Average Fighter Aircraft Contractor T&E Costs Compared to Contractor Total EMD Costs FY 1999 Dollars Millions

| Total Test<br>labor hours  | Total Test<br>\$M | Total EMD<br>labor hours | Total EMD<br>\$M | % total<br>labor hours | % \$<br>\$M |
|--|-------------------|--------------------------|------------------|------------------------|-------------|
| 13616833   | \$1,201           | 30480500                 | \$3,509          | 43.9                   | 33.9        |
| Approximately 19% of the total T&E labor hours are estimated to be hardware related leaving 25% for direct support |                   |                          |                  |                        |             |
| Includes Contractor Sytem Test & Evaluation, Flight Tests, and Avionics Integration Tests                          |                   |                          |                  |                        |             |

# Life Cycle Cost Element Structure

- RDT&E
- EMD
- Procurement
  - Non-recurring system costs
  - Recurring system costs
  - Support costs (including training, **peculiar support equipment**, and data),
  - **Initial spares,**
  - Military construction costs, and
  - All related procurements (system modifications)
- O&S
- Disposal

# Aircraft EMD Cost Elements & Work Breakdown Structure

- Level 1: Program
- Level 2: Program Elements
  - Air Vehicle
  - System Test & Evaluation
  - System Engineering/Program Management
  - Integrated Logistics Support
  - Other
- Level 3: Air Vehicle Elements
  - Airframe
  - Propulsion
  - Avionics
  - Armament
  - Other
- Level 4: Functions
  - Engineering
  - Tooling
  - Manufacturing
  - Quality Control

# O&S Cost Element Structure

- Mission Personnel
  - Operations
  - **Maintenance**
  - Other
- Unit-Level Consumption
  - **POL**
  - **Consumables**
  - **Depot-Level Reparables**
  - Other
- Depot Maintenance
  - **Airframe Overhaul**
  - **Engine Overhaul**
  - Other
- **Contractor Support**
- Sustaining Support
  - Support Equipment Replacement
  - **Modification Kit Procurement/Installation**
  - Sustaining Engineering
  - **Post Deployment Software Support**
  - Simulator Operations
- Indirect Support
  - Personnel Support
  - Installation Support

**Bold = areas where T&E plays a role in O&S costs estimates**

# O&S Cost Estimating Linkage to T&E

- Critical O&S cost elements are driven by the system's reliability and maintainability characteristics
  - R&M characteristics are used to determine
    - maintenance staffing - Logistics Cost of Ownership Model (discrete event simulation of maintenance networks)
    - consumable and depot level reparable spare parts
    - Airframe and engine overhaul/rework requirements
    - Interim contractor support requirements
  - During EMD T&E results including reliability growth maintenance repair time experience are used to estimate R&M characteristics of a mature system

# O&S Cost Estimating Linkage to T&E (Continued)

- T&E costs are estimated for major modifications after deployment of the weapon system
- T&E costs are estimate for major software block updates



# Data Sources

- Contractor T&E costs:
  - Cost data and models developed by DoD
  - Earned Value Management System
    - Managed by OSD(A&T)
    - Cost Performance Report
    - Cost/Schedule Status Report
  - Contract Cost Data Reports (Proprietary Data)
    - Managed by OSD(CAIG)
    - Provides actual costs during EMD and production by Contract Work Breakdown Structure
- Government T&E costs: Service Cost Agencies

# Current Experience and Capability to Estimate Fixed-Wing Aircraft LCCs

| <b>Fixed-Wing Aircraft</b>        |                        |            |              |                         |
|-----------------------------------|------------------------|------------|--------------|-------------------------|
| <i>Then-Year \$ through FYDP:</i> | <b>RDT&amp;E (20%)</b> |            |              | <b>Production (39%)</b> |
|                                   | <b>PDRR</b>            | <b>EMD</b> |              |                         |
|                                   | <i>\$26B</i>           |            | <i>\$70B</i> |                         |
| Airframe                          |                        | 30%        |              | 24%                     |
| Propulsion                        |                        | 5%         |              | 9%                      |
| Avionics                          |                        | 32%        |              | 23%                     |
| Integration, Assembly and Test    |                        | 5%         |              | 10%                     |
| Software (in Avionics and IA&T)   |                        | 0%         |              | 0%                      |
| Armament                          |                        | 1%         |              | 4%                      |
| Test and Evaluation               |                        | 10%        |              | 0%                      |
| SE/PM                             |                        | 12%        |              | 12%                     |
| Data                              |                        | 1%         |              | 3%                      |
| Training                          |                        | 2%         |              | 2%                      |
| Support Equipment                 |                        | 3%         |              | 8%                      |
| Spares                            |                        | 0%         |              | 6%                      |

- The colors indicate capability to estimate costs in that cost element
- Dollars shown under the phase represent the FYDP years FY 1999 to 2005,
- Percentages next to the phase indicate the typical percentage of total life-cycle cost.
- Individual WBS percentages reflect their portion of the phase in total. Percentages for RDT&E are shown in whole because PDRR and EMD could not be broken out.

Source: Status of DoD's Capability to Estimate the Costs of Weapon Systems 1999 update, April 1999, IDA Document D-2300

# Current Experience and Capability to Estimate Fixed-Wing Aircraft LCCs (cont.)

## Fixed-Wing Aircraft (cont.)

|                          | O&S (41%) |     |
|--------------------------|-----------|-----|
| Mission Personnel        |           | 22% |
| Unit-Level Consumption   |           | 15% |
| Intermediate Maintenance |           | 8%  |
| Depot Maintenance        |           | 13% |
| Contractor Support       |           | 8%  |
| Sustaining Support       |           | 26% |
| Indirect Support         |           | 8%  |

O&S costs for new systems represent about 41% of LCC; however, this may tend to underestimate actual % because we tend to underestimate O&S costs during system development and early procurement and systems lives are longer

# FYDP Representation

---

## **RDT&E**

ATIRCM/CMWS  
Joint Strike Fighter (JSF)  
E-2C Reproduction  
F/A-18 E/F  
CEC  
C-17A  
Airborne Laser (ABL)  
B-1B CMUP/DSUP/JDAM/COMP UP  
F-22  
JSTARS  
JPATS

## **Procurement**

Black Hawk (UH-60L)  
ATIRCM/CMWS  
Longbow Apache  
T-45TS  
E-2C Reproduction  
AV-8B Remanufacture  
F/A-18 E/F  
CEC  
C-17A  
C-130J  
B-1B CMUP/DSUP/JDAM/COMP UP  
F-22  
JSTARS  
AWACS RSIP (E-3)  
JPATS

# Fixed-Wing Test & Evaluation Aircraft Estimating Source List

- *MACDAR Fighter Aircraft Database, Tecolote, 1998*
- *Advanced Fighter Aircraft Cost Model, AFCAA, 1998*
- *Development Eng. and BTL Development Cost Models, Technomics, Aug 1990*
- *Kanter's Factors, Cost Factors and Estimating Relationships, Electronic Sys. Division, April 1990*
- *Assessing Acquisition Schedules for Tactical Aircraft, IDA 1989*
- *Aircraft Airframe CERs, RAND, 1987 (Total Level)*

# Research Efforts Recently Completed

---

- Defense Contractor Overhead Rate Analysis, NAVAIR, 1998 (follow-on)
- MACDAR Fighter Aircraft Database, Tecolote, 1998 (follow-on)
- Advanced Fighter Aircraft Cost Model (JSF), AFCAA, 1998
- Air Force Total Ownership Cost (AFTOC) MIS, MCR, 1998 (follow-on)
- Maintenance Trade Decision Support System, Bionetics Corp., 1998
- NAVAIR O&S Cost Model, Brennan & Associates, Inc., 1998
- Life Cycle Cost Model Development, Brennan & Associates, Inc., 1998

# Areas Most in Need of Further Research

---

- Avionics
- Modifications (structural and avionics)
- Software
- Test and Evaluation

# Summary

- Both T&E and LCC analysis address program risks
- LCC estimates include estimates of T&E costs
- T&E results are used to
  - estimate the O&S costs of a mature system
  - estimate the interim contractor logistics costs while in transition to the mature system