Integrating Systems Engineering, Risk and Earned Value Management

CPM Spring Conference 2001

San Diego, CA

24 May 2001

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Topics

- **Threats to Program Success**

- **Systems Engineering (SE)**
  - **Develop a Product per Operational Needs**
  - **Requirements Management**
  - **Technical Performance Metrics (TPM)**
  - **Performance-Based Earned Value (PBEV)**
  - **Risk Management**

- **Government Requirements, Industry and Professional Standards**

- **Integrated Processes**

- **Best Practices**

Threats to Program Success

- **Inadequate Early Warning**

- **Schedules, Metrics Overstate True Progress**

- **Remaining Work Underestimated**

- **Product Will Not Meet User Needs**
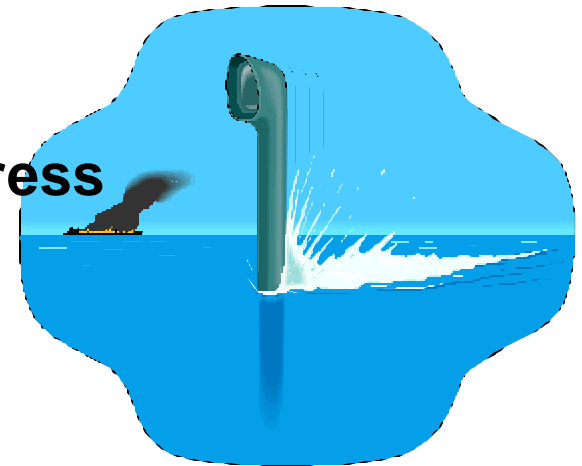
CAN BE PREVENTED BY INTEGRATING:
- SYSTEMS ENGINEERING (SE)
- RISK MANAGEMENT (RM)
- EARNED VALUE MANAGEMENT (EVM)
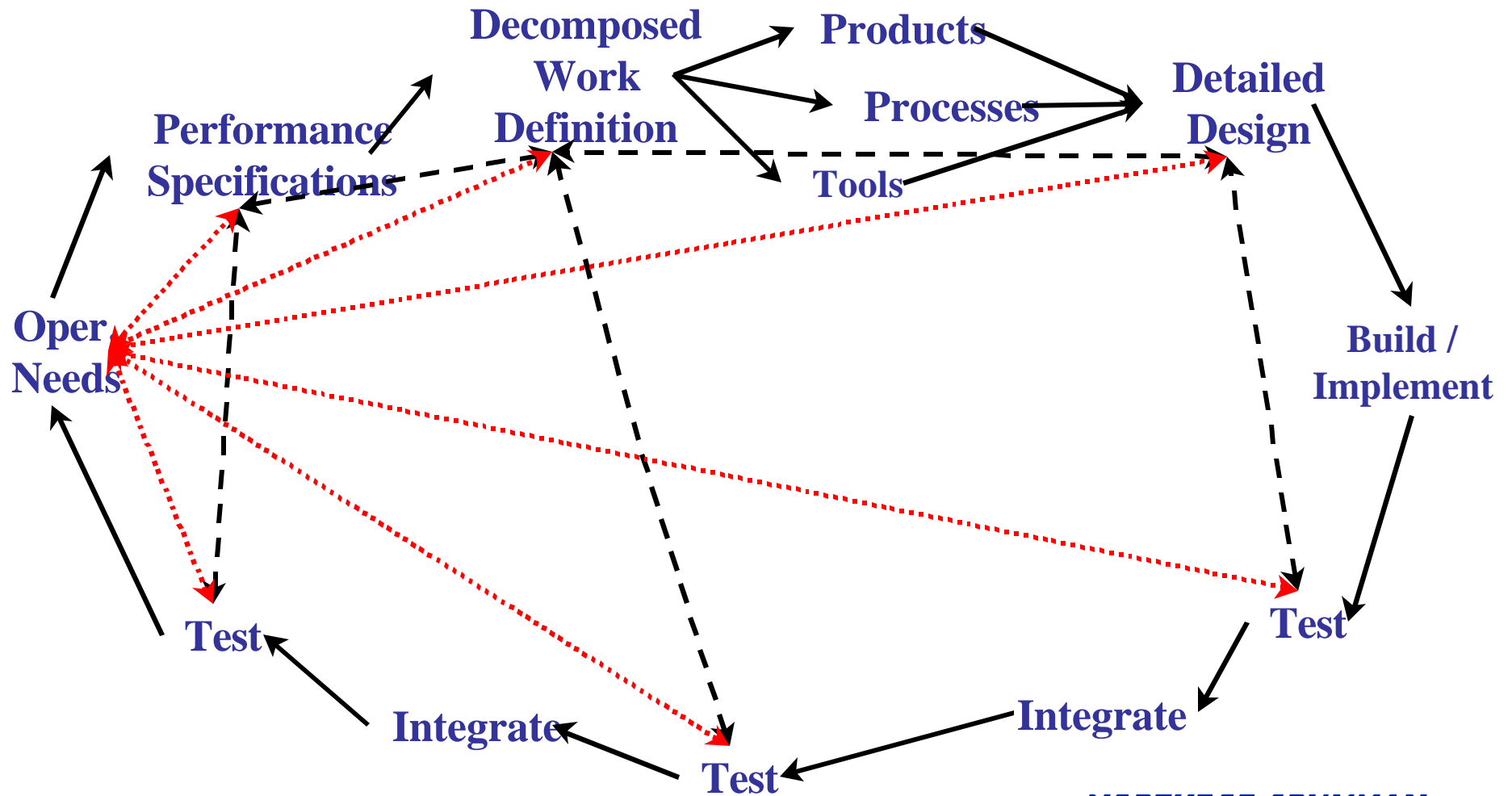
SE / What Is It?

- **SE Processes Transform Operational Needs and Requirements into Systems**

- **Solution Includes**
  - **Design**
  - **Manufacturing**
  - **Test and Evaluation**
  - **Support of Product**

- **Balance Between Performance, Risk, Cost and Schedule**

- **Top-down, Iterative Process**

  As defined in Interim Reg. DoD 5000.2-R, Part 5.2

SE Process

- **Requirements analysis**

- **Functional analysis and allocation**

- **Design synthesis and verification**
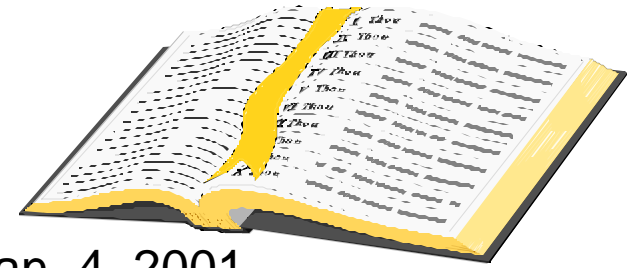
- **System analysis and control**

SE Model

Decomposed Work Definition

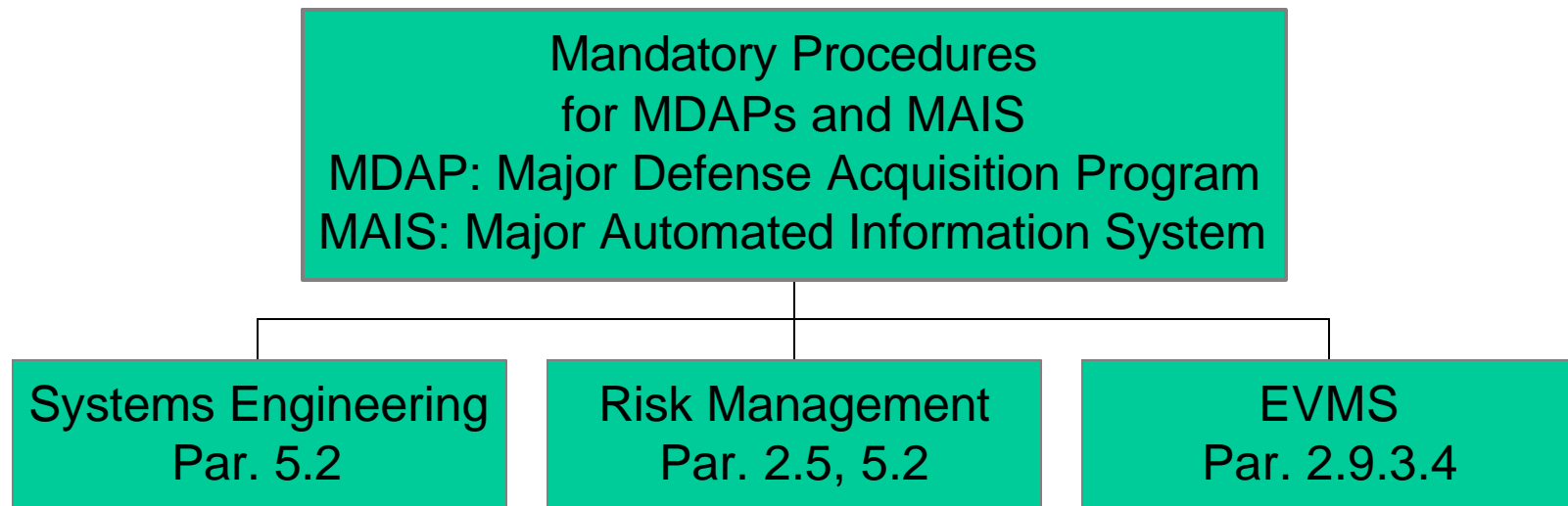**Products**

Processes

Detailed Design

Performance Specifications

Tools

Oper Needs

Build / Implement

Test

Test

Integrate

Integrate

Test

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DoD Requirements

Interim Regulation, DoD 5000.2, Jan. 4, 2001

Mandatory Procedures
for MDAPs and MAIS
MDAP: Major Defense Acquisition Program
MAIS: Major Automated Information System

Systems Engineering
Par. 5.2

Risk Management
Par. 2.5, 5.2

EVMS
Par. 2.9.3.4

SE Procedures

Government / Industry/ Professional Standards

Northrop Grumman, Integrated Systems Sector, Air Combat System (ACS) SE Procedures

Int. Reg. DoD 5000.2

EIA/IS-731 Std.

CMMI-SE/SW V1.0

ANSI/EIA-748-98 (EVMS)

PMBOK® Guide (1)

- SE Technical Process

- SE Management Process

- Organization Process

- Configuration and Data Management Process
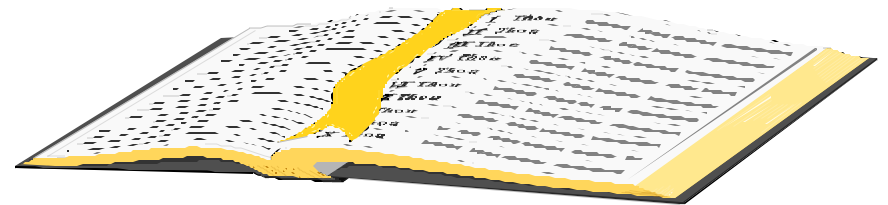
(1) Project Management Institute, A Guide to the Project Management Body of Knowledge, December 2000

Requirements Management Products

- **Concept of Operations**

- **System Integration Requirements Document (SIRD)**

- **Design Constraints / Key Drivers**

- **System Description Document (SDD)**

- **System Requirements Review (SRR) Documentation**

- **Functional Description Document (FDD)**

- **Specification / Document Tree**

- **Technical Performance Metrics (TPM) and Plan**

- **Trade Study Documentation**

- **Requirements Traceability Database (RTD)**

- **Configuration Baseline**
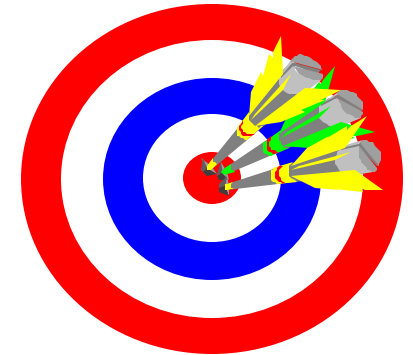
REQUIREMENTS TRACEABILITY

- **Verify that All Requirements are Addressed and Tested**

- **Traces Requirements From the Input to a Phase to the Product of that Phase**

- **Reassure Team that are:**
  - **Building the <u>right product</u> (Validation)**
  - **Building the <u>product right</u> (Verification)**

- **Defined by Requirements Traceability Database (RTD)**
  - **To <u>Documentation</u> and <u>Components</u>**
  - **To <u>Test Plan</u> and <u>Test Results</u>**
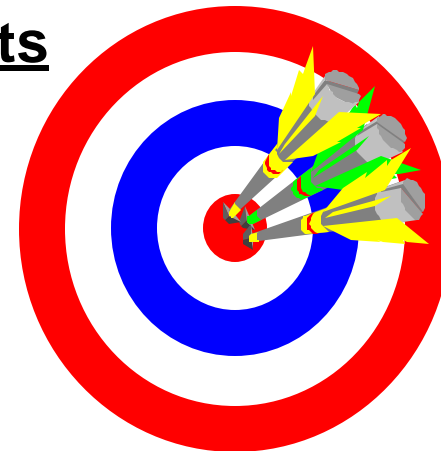
REQUIREMENTS TRACEABILITY MATRIX
Through Documentation and Components

DOCU MENT:

SYS. SPEC.	SRS	SYS.DES CSC	IGN DOC. CSU	TEST CSCI	PLAN: CSC
2.2.1	2.2.4	2.5.1	2.5.1.2	2.7.1	2.7.1.4
	2.2.5	2.5.3	2.5.3.3	2.7.4	2.7.4.1

COMP ONENT:

SYS- TEM	CSCI	CSC	CSU	CSCI	CSC
	1.0	1.1.0	1.1.0.1	1.0	1.1.0

Requirements Traceability / SLATE

Rating: GREEN
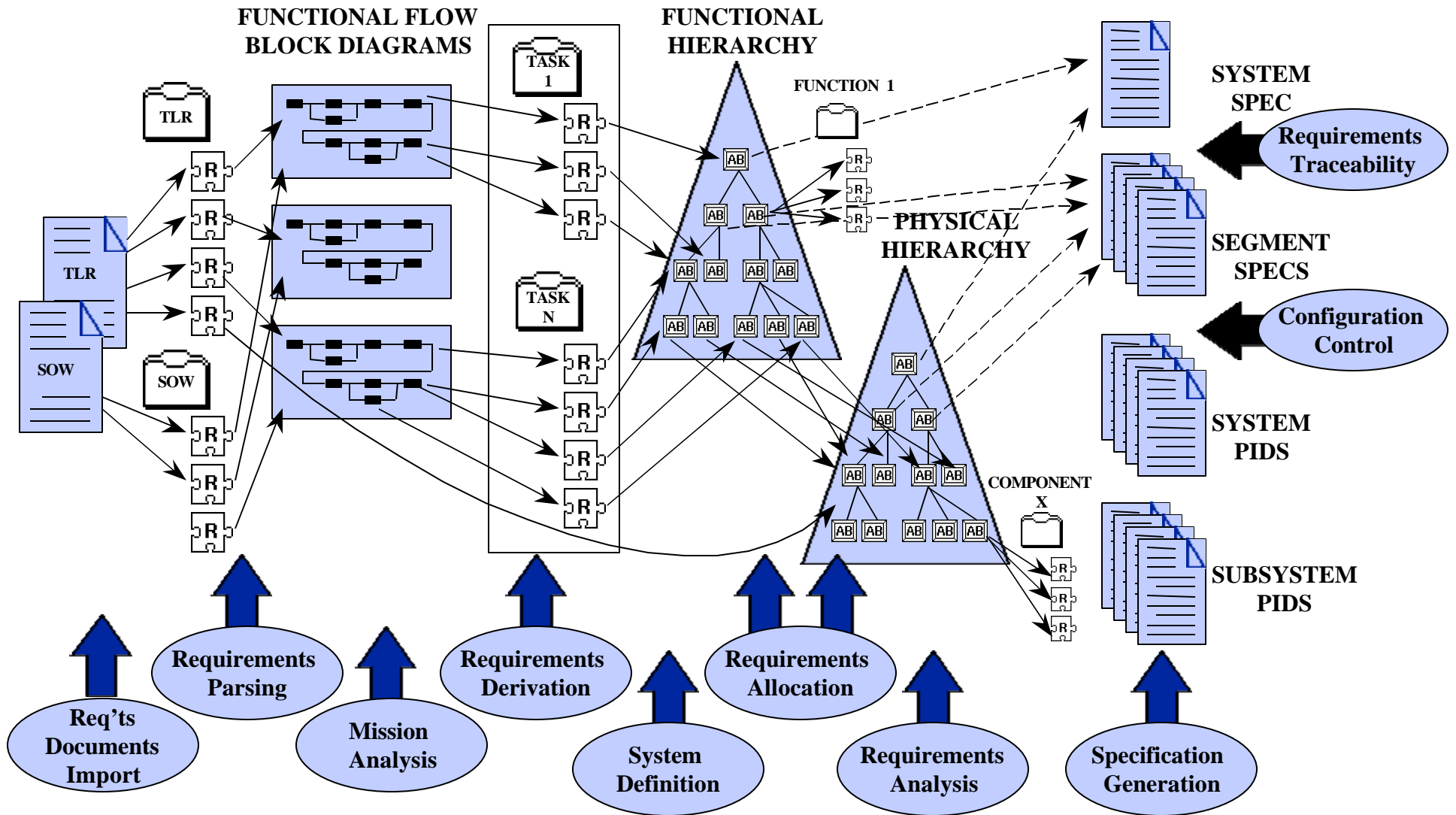
Program X Requirements Management Matrix

Defined Requirements ——————

Validated* ----------

Operations Code (7)
- ■ Test Report #
- Verification Method
- Verification ECD
- ■ Status
- ■ Assigned
- ■ Linked
- ■ Entered

18 Sept. Time Now

Test 1; DTR/TP's (46 SDD Req'ts)
Test 2; DTR/TP's (8 SDD Req'ts)
Test 3; DTR/TP's (17 SDD Req'ts)
Test 4; DTR/TP's (35 SDD Req'ts)
Test 5; DTR/TP's (1 SDD Req't)
Flight Test ETR's (? Req'ts)

Requirements ("Shalls")

SIRD (65) 7/9/99
SDD (97)

KPP's (3)

GREEN   **YELLOW**   **RED**

300
200
100
0

Operations (7 per Req't)
2037
1500
1000
500
0

Time (months)

| ATP 5/26/99 | SRR 8/25/99 | Y2K | SIR 4/26/00 | FRR 12/22/00 | F/T Complete 8/15/01 |

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Requirements Traceability Database (RTD)
SE Work Package EVM Technique

- 7 RTD Operations per Requirement

- Monthly Milestones with % Complete
  - Requirements Tool Calculates Metrics
  - % = # RTD Operations Complete / Total RTD Operations

- Closely Monitor Verification Activity

Performance Metrics

- **SE System Analysis and Control activities include (1):**
  - **Performance metrics to measure**
    - **Technical development and design, actual vs. planned**
    - **Meeting system requirements:**
      - **Performance (TPM)**
      - **Progress in implementing risk handling plans**
      - **Producibility**
      - **Cost and schedule**
  - **Performance metrics traceable to performance parameters identified by operational user**
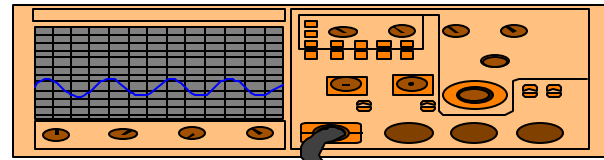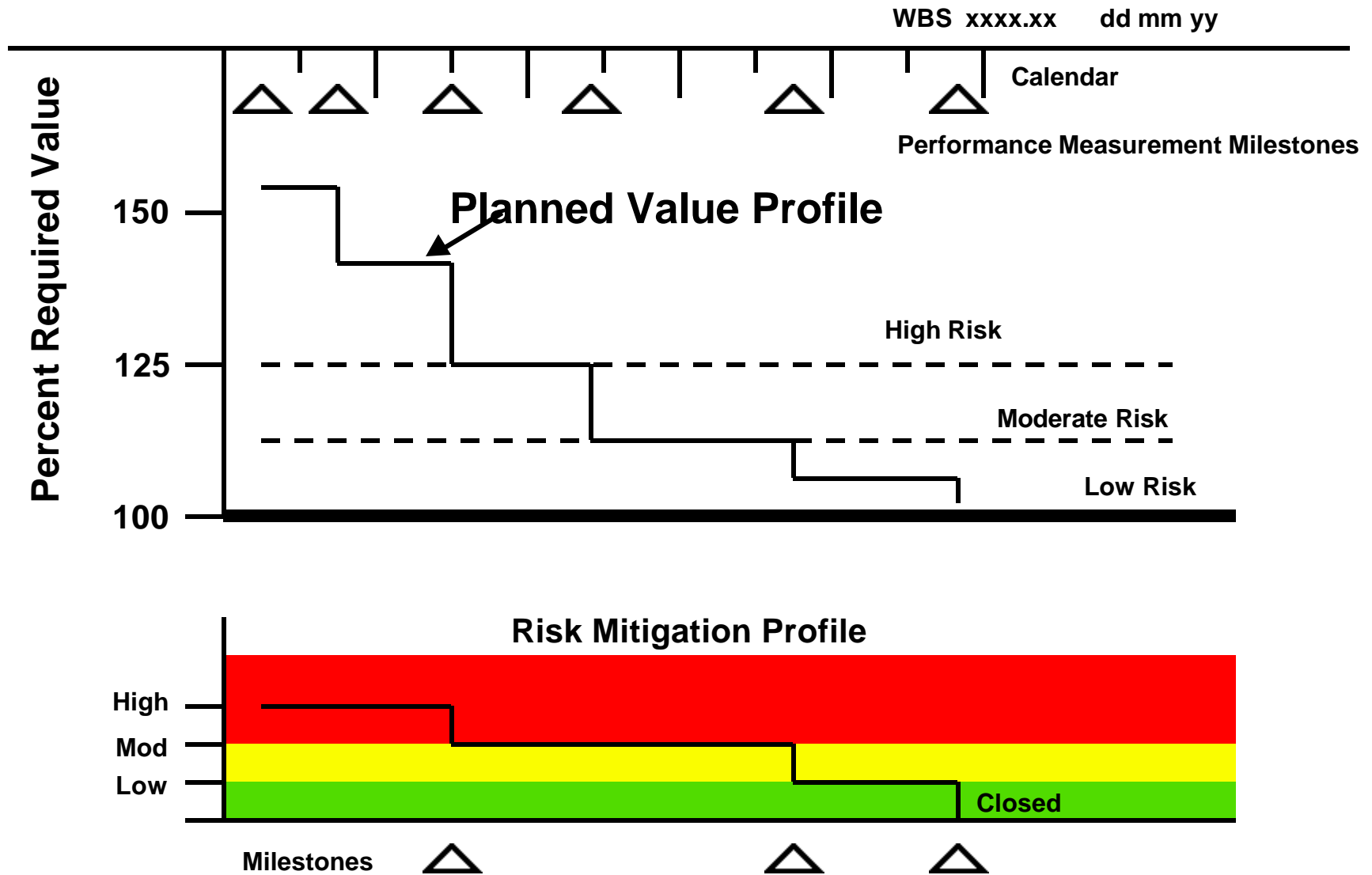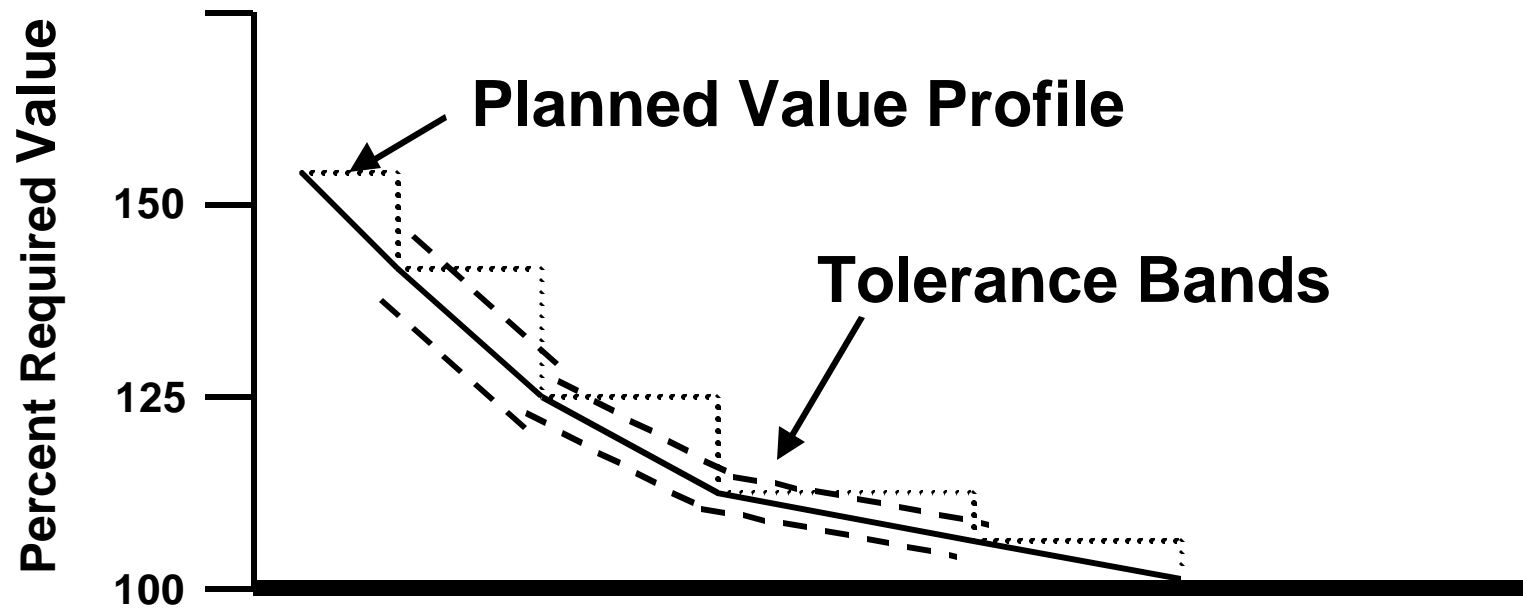
(1) Interim Reg. DoD 5000.2-R, para. 5.2

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ANTENNA TPMs - Gain and Radar Cross Section Achievement (notional)

QTR/YEAR		4/98	1Q99	2Q99	3Q99	4Q99	1Q00	2Q00	3Q00
RISK	TECHNICAL								
	COST								
	SCHEDULE								

EVENTS △

SRR

IDR 3/15 ⇧ FDR 6/15 ⇧

Qual Start ⇧   Qual Complete ⇧   Flight Units ⇧

LAB TESTS ⇧ ⇧

1/30   2/30

GAIN
DELTA FROM SPEC
+3 dB
0 db
-3 dB
Notes:

RCS
DELTA FROM SPEC
max
SPEC
min

REQUIREMENTS REFERENCE:	RESPONSIBLE ENG.. Dew
SOURCE CONTROL DRAWING 3391P020	EXTENSION: 888-552-5820

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Technical Performance Plan / TPM

WBS xxxx.xx   dd mm yy

Calendar

Performance Measurement Milestones

Percent Required Value

Planned Value Profile

150

High Risk

125

Moderate Risk

Low Risk

100

Risk Mitigation Profile

High

Mod

Low

Closed

Milestones

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Technical Performance Plan with Tolerance Bands

Planned Value Profile

Tolerance Bands

Percent Required Value

150

125

100

Earned Value and TPMs

- **Acceptable Deviation Should Decrease Over Time**

- **Parametric Data or Expert Judgement Available**

- **<u>Maximum</u> EV if <u>No</u> Deviation**

- **<u>Less</u> EV if <u>within</u> Tolerance Bands**

- **<u>No</u> EV if <u>outside</u> Tolerance Bands**

PERFORMANCE-BASED EARNED VALUE

- **Lean Goal: Reduce EV costs; Measure what's important**

- **Emphasize SE Performance Metrics**
  - **<u>Progress</u> of Technical Development, Design, Test**
  - **TPM**
  - **Risk drivers/critical path**

- **Measure Key Technical Performance Indicators**
  - **<u>Products</u>; not tasks, inchstones, reviews**
  - **<u>Verification</u> of TPMs (Successful test and documentation)**

- **<u>Integrate</u> Schedule, TPM, PBEV**

SCHEDULE/TPM

EV
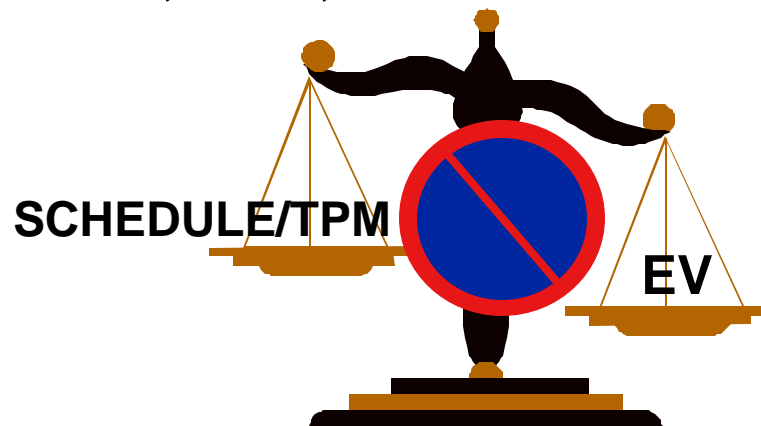
Best Practices to Monitor Program Technical Progress with SE Tasks

- **SE products, milestones on IMS**

- **Discrete SE work packages and EV measures**
  - Track progress of key SE products
  - Track progress of completing RTD

- **Monitor SE schedule variances**
  - <u>Mirrors</u> program's overall technical progress
  - Small absolute value; high impact

- **Use TPMs as a basis of PBEV for technical tasks**

- **Compare SE schedule variances with technical PBEV**

What Is Risk Management?

- **Risk: Uncertain event or condition that, if it occurs, has a negative (or positive) effect on a project objective**

- **Systematic process of identifying, analyzing and responding to project risk**

- **Part of the SE Process**

- **Proactively Working to Prevent an Unfavorable Event from Occurring which Threatens Objectives**
 - **Cost, Schedule, Technical**
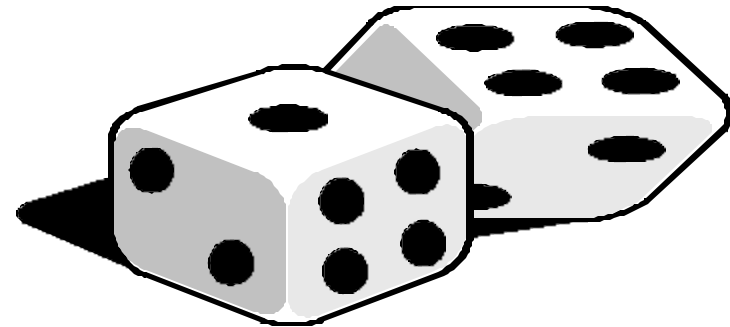
Potential Sources of Technical Risk
Partial List

- **Technology Maturity**

- **Lack of Applicable Historical Data**

- **Design Complexity**

- **Challenging Requirements**

- **Dependency Factors**

- **Estimating Bias**

- **Supplier Expertise and Performance**

- **Customer Uncertainty**

- **Design and Configuration Changes**

- **Complex Interfaces**

- **Safety**

- **Lack of Experience/Expertise**

- **Complex Manufacturing Processes**

- **Complex Software**

- **Performance Based on Analysis Only**

Why Do We Manage Risk?
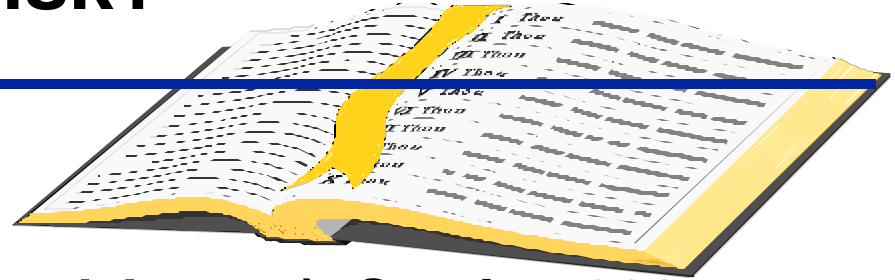
- **Government Requirements:**
  - Interim Reg. DoD 5000.2
  - OMB Circular No. A-11 (Fixed Assets), Section 300.7
    - Analysis of goals (cost, schedule, performance) includes risk assessment

- **Professional: PMBOK ®**
  - 5.5.1.3: Implement a contingency plan or workaround plans to respond to a risk
  - 7.4.3.4: EAC, forecast of most likely costs based on project performance and risk quantification

- **CMMI-SE/SW v1.02**
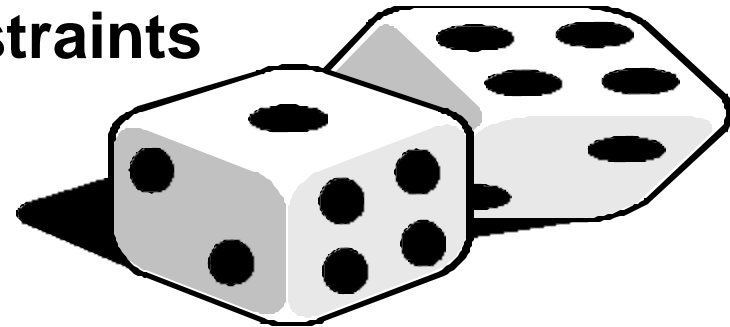 - Maturity Level 3 Process Area: Risk Management

EVM GUIDES SILENT ON RISK

- **Industry Standard**

- **EVM Implementation Guide (EVMIG)**

- **Company EVMS**
  - Most EVM System <u>Descriptions silent on risk</u>
  - Risk mitigation plans <u>not</u> always <u>budgeted</u> or <u>scheduled</u>
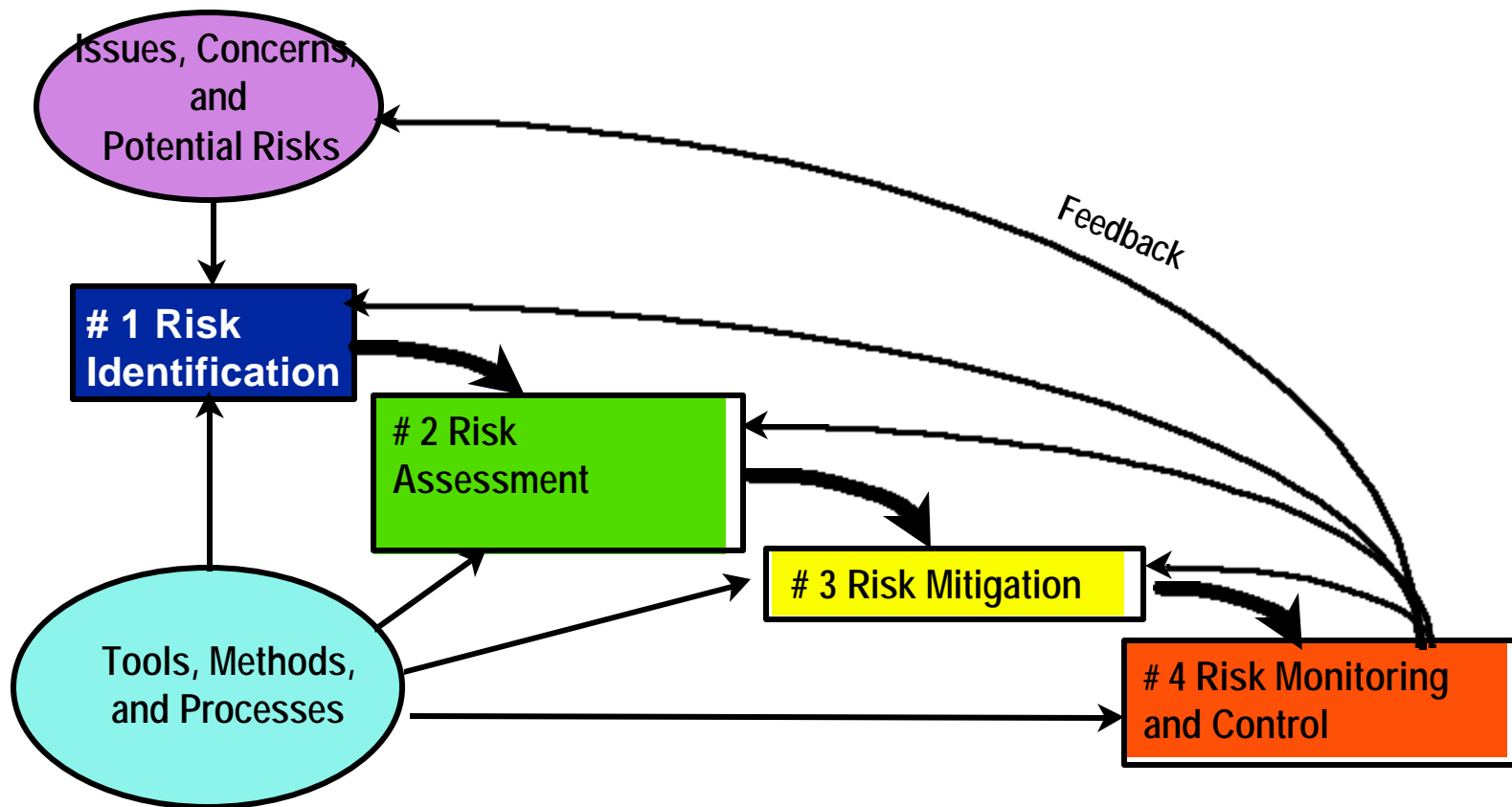 - Program projections <u>inconsistent</u> with risk assessments and risk mitigation plans
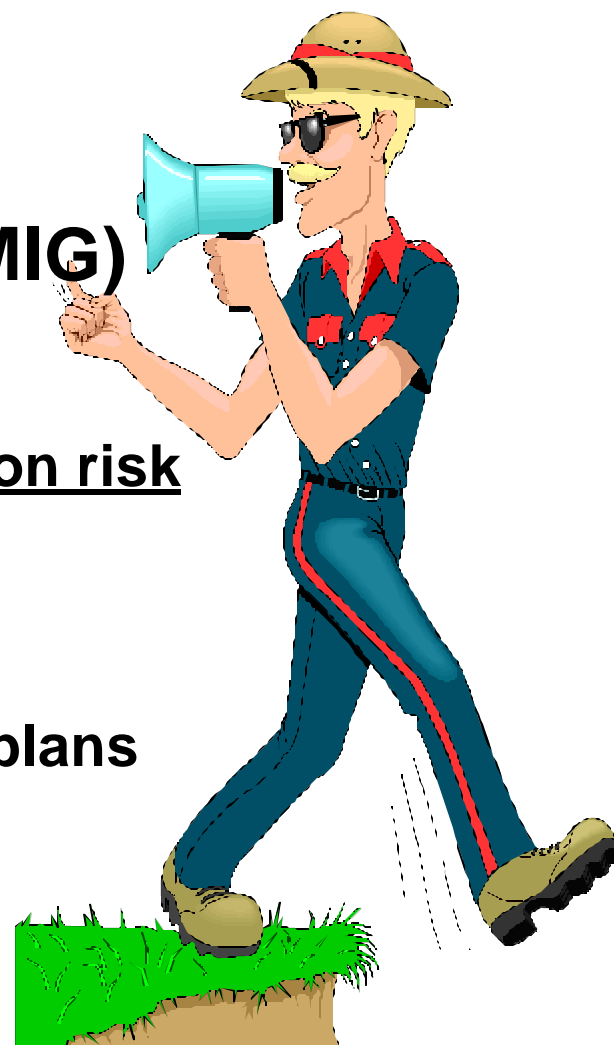
Risk Inherent in Contractors' Practices

- **Integrated Master Plan and Schedule**

- **Performance Measurement Baseline (PMB)**

- **Management Reserve**

- **Integrated Baseline Review**

- **Establish and monitor TPMs**

- **Develop EAC**

- **Trade offs to meet cost constraints**

Risk Management Process

Issues, Concerns, and Potential Risks

1 Risk Identification

2 Risk Assessment

3 Risk Mitigation

4 Risk Monitoring and Control

Tools, Methods, and Processes

Feedback

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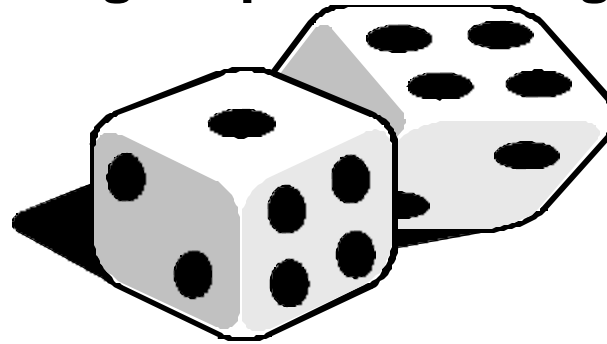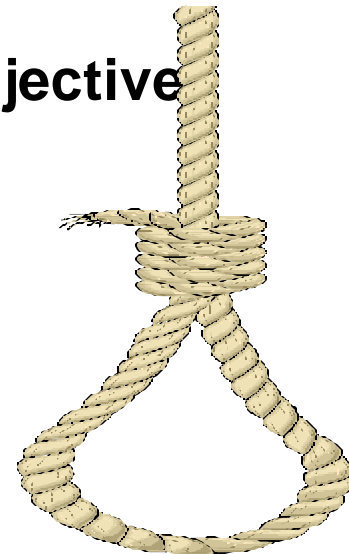
Risk Assessment

- **Two Parameters:**
  - **Probability of Not Achieving a Specified Program or System Objective**

  - **Consequences of Not Achieving the Objective**
    - **Impacts:**
      - **Cost**
      - **Schedule**
      - **Technical Requirements**
      - **Customer Satisfaction**

Risk Component   Aircrew Requirements   IPT: Project X
Area of Impact   Cost / Schedule

Risk Description:

- **Aircrew Requirements Not Fully Defined May Drive Cost Increases and Schedule Slips**

Key Points:

- **Requirements Creep Adversely Impacts Cost and Schedule**

Mitigation Activity: ECD

- **Establish Customer Aircrew Working Group to Prioritize Requirements.**
  (A) 06/16/00

- **Develop Draft ConOps to Identify Real Needs.**   **10/31/00**

- **Identifying Minimum Capabilities**
  04/30/01

- **Define Trade-offs with Customer Aircrew**
  05/31/01

Probability 5 → 1

S C

Impact 1 → 5

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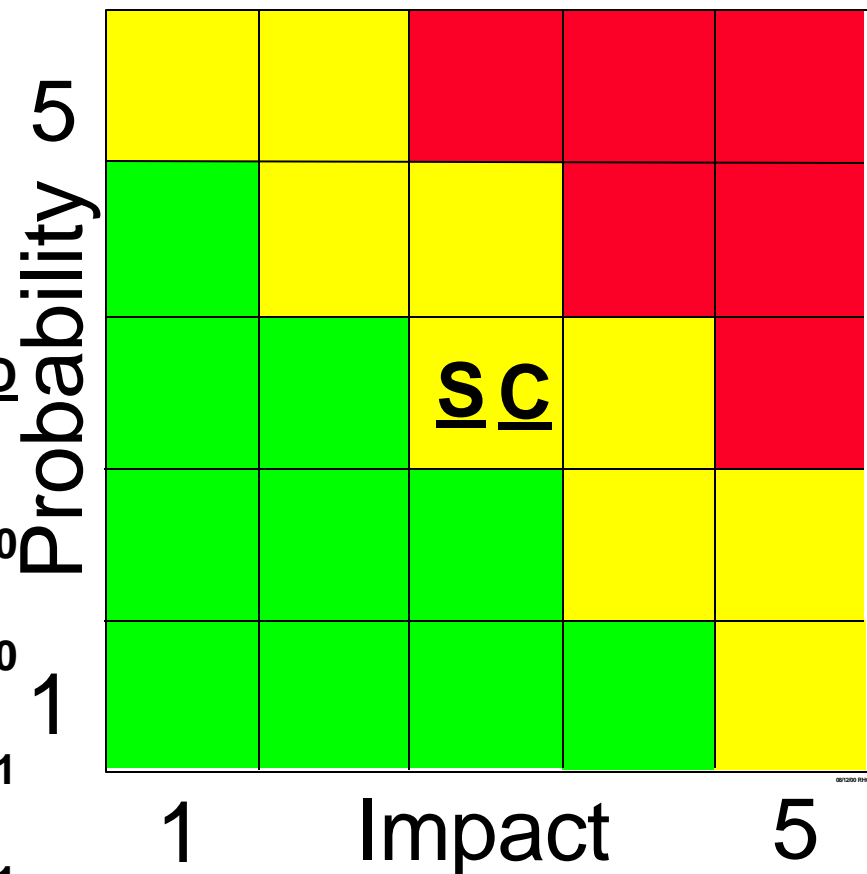
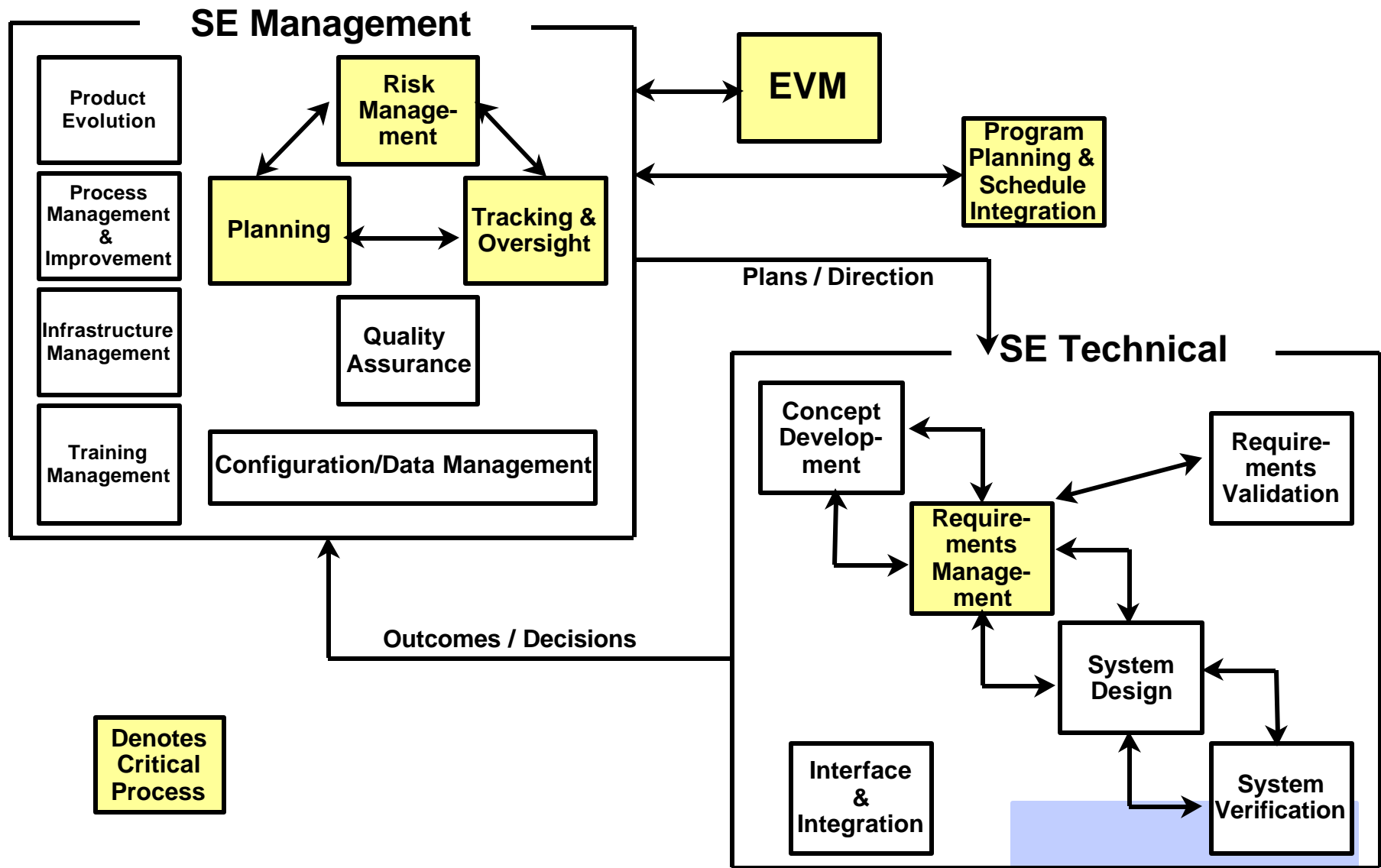# Best Practices to Integrate RM with EV

- **Include RM Activities on the Baseline Schedule**
  - **Define Exit Criteria for RM Decision Points**
  - **Establish Dependencies**

- **Budget the RM Effort, Track with EV**

- **Address RM in Performance Analysis**

- **Incorporate RM in EAC Development**
  - **If probability and impact are high (Most Likely)**

Northrop Grumman ACS Process Integration

SE Management

Product Evolution

Process Management & Improvement

Infrastructure Management

Training Management

Risk Management

Planning

Tracking & Oversight

Quality Assurance

Configuration/Data Management

EVM

Program Planning & Schedule Integration

Plans / Direction

Outcomes / Decisions

SE Technical

Concept Development

Requirements Validation

Requirements Management

System Design

Interface & Integration

System Verification

Denotes Critical Process

ACS EVM System Description (1)
Linked to SE and Risk Procedures

- **CAM Responsibilities**
  - **Integrate budget and schedule with technical SOW**
  - **Identify technical metrics**
  - **Use *TPMs* as a basis for *EV***
  - **Incorporate *risk* assessment and corrective actions into EVMS**

- **Program Manager Responsibilities**
  - **Assess *EAC* based on pressures, *risks*, opportunities**

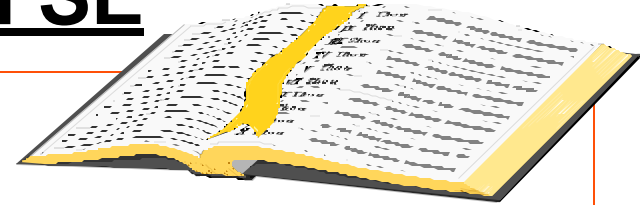**1) Air Combat Systems Procedure DTM F208**

ACS SE Procedure
Links TPMs to EV

- **SE Tracking and Oversight (E1-0401.9)**
  - *TPMs* track key technical parameters
  - *EV* should be based on *TPMs* which best indicate progress towards meeting technical requirements

ACS Risk Procedure
Links to EVMS and SE

- **Risk Management** (D1-5002)
  - **Sources** of risk identification:
    - Projected or actual adverse performance
      - Technical performance based on *TPMs*
      - Cost or schedule performance per *EVMS*
  - Significant *risk* management activities are *planned, budgeted and tracked in the EVM and scheduling* systems
  - If the *risk* cannot be fully mitigated, immediately:
    - Revise the *EAC*
    - Report *schedule* impacts on affected schedules

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Linked Controls and Procedures

	Controls			
Procedure	Req. Trace.	TPMs	EV Measures	Risk Items
Req. Mgt.	X	X	X	X
System Design	X	X	X	
System Verific.	X	X	X	
Planning	X		X	X
EVM	X	X	X	X
Risk Mgt.		X	X	X

SUMMARY FOR SUCCESS

- **Operational Needs: Define, Decompose, Validate, Verify**

- **Requirements Management Traceability**

- **Plan SE Tasks in PMB**

- **Use TPMs and Performance-Based Earned Value**

- **Correlate Progress of SE Tasks with Technical Progress**

- **Include Risk Management Activities in PMB**

- **Integrated, Documented Processes**

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