DD(X)
Software Measurement

... how the PSM process and data models were used to design, implement, and grow a measurement program

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Outline

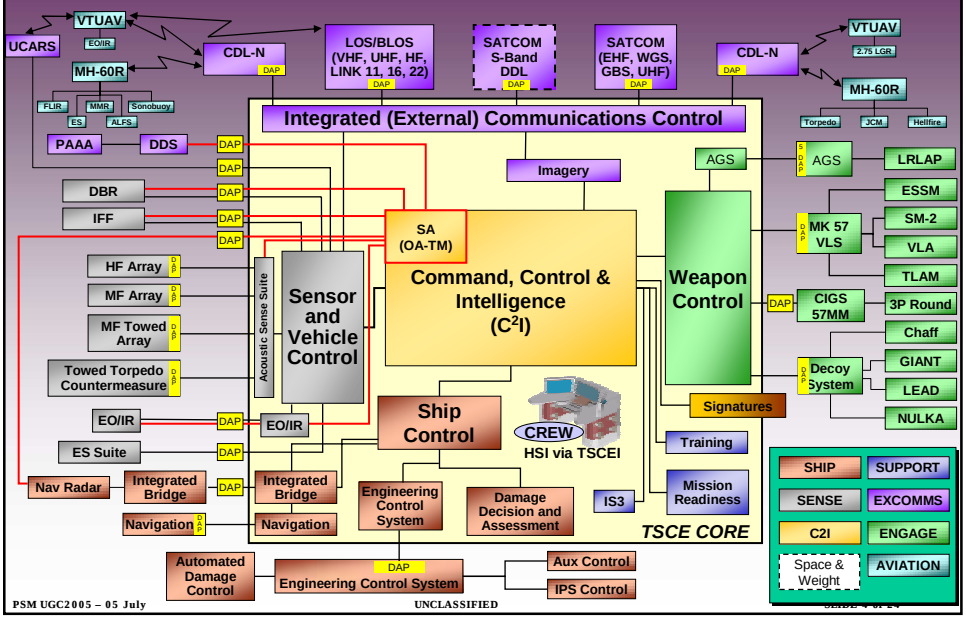
- DD(X) – A true 'system of systems'
- SW Engineering – A term not used lightly
- SW Measurement – A STANDARD Definition
- SW Measurement and an Acquisition Program Office
- DD(X) Measurement Process Model

DD(X) System Characteristics

- A Large, Mission-Critical, Software-Intensive System
  - ✓ Release 4 – 6 ~ 4,180,000 ELOC
  - ✓ Flight 1 TOTAL ~ 5,904,000 ELOC
- DD(X) is a Multi-Sensor/Multi-Weapon Platform
  - ✓ Sensor System (9+)
  - ✓ Command & Control System
  - ✓ Communications Systems (12+)
  - ✓ Multiple Weapon Systems (4+)
  - ✓ Ship Control System (3+)
  - ✓ Logistics / Support System (3+)
- Total Ship System Integration vice traditional stove-piped systems

DD(X) Mission Systems Context Diagram

Note: This is not a "Design Diagram". It filters many of the logical interfaces in order to convey a high-level view of DD(X) Mission Systems.



DD(X) Software Characteristics

- SW Budget ~ $ 1+ Billion
- 500+ SW Configuration Items
- ~ 25 Million delivered SLOC
- ~ 26 Organizations developing / integrating software

What is SW Engineering

- "Engineering" means something
  - ✓ Process Based, Results Oriented
  - ✓ Discipline & Rigor
  - ✓ Quantifiable Methods & Results
- IEEE Computer Society Definition of SWE
  - ✓ "The application of a
    - systematic,
    - disciplined,
    - quantifiable

    approach to the development, operation, and maintenance of software;"

IEEE Standard Glossary of Software Engineering Terminology

SW Measurement STANDARD DEFINITION

- For DD(X), Software Measurement is defined as:
  - ✓ "The Systematic Application of Formal Methods, Processes, and Procedures to Quantify Attributes of the Software Process and the associated Software Work Products"
- Sources for the DD(X) Approach to Software Measurement include:
  - ✓ Practical Software & Systems Measurement
  - ✓ Capability Maturity Model – Integrated
    - Measurement and Analysis Process Area
    - Quantitative Project Management Process Area
  - ✓ ISO 15939

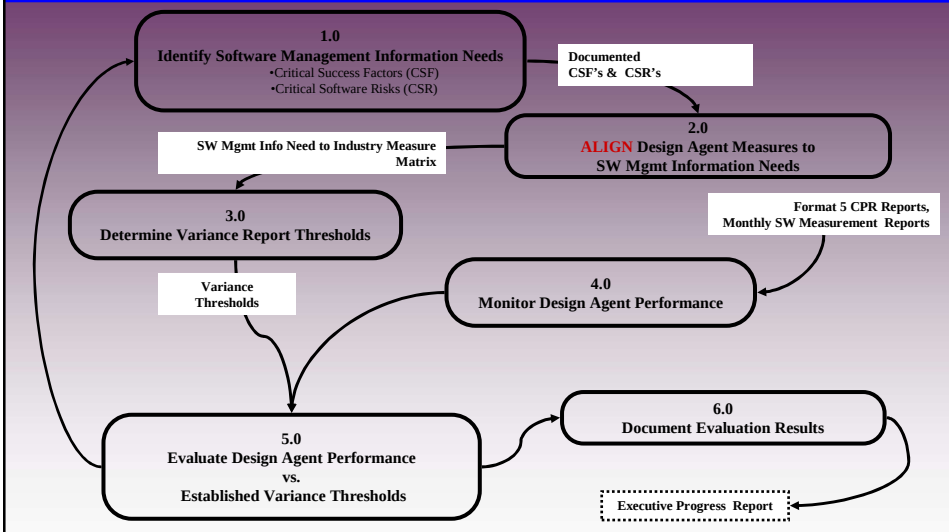
Software Measurement & DD(X) APO

- PMS500 SW Engineering is responsible for four (4) things:
  - ✓ Encourage, Facilitate, and Promote Engineering Behavior ***
  - ✓ Track and evaluate industry performance against known practices that reduce risk ***
  - ✓ Report evaluation results to PMS500 Leadership
  - ✓ Identify any emerging technologies, methods, etc. that may benefit the program

DD(X) Software Measurement System Drivers

- **Adhere to Measurement System Design Constraints**
  - ✓ **Encourage, Facilitate, and Promote Engineering Behavior**
    - **What you measure will affect the behavior of those who execute the processes or develop the work products being measured**
  - ✓ **Measurement Program Must Support Leadership Decision Making**
    - **Before we add or modify a measure, we discuss the impact to the associated leadership decisions**

DD(X) SW Measurement Activity / Data Flow Diagram



1.0 DD(X) Software Management Information Needs

- **Stated Program Goals**
  - ✓ Zero Cost Growth
  - ✓ On-Time Development
  - ✓ 100% Contracted Functionality
  - ✓ Zero Priority 1/2 Defects
- **Identified Program Risks**
  - ✓ Concurrent Engineering
  - ✓ Distributed Development
  - ✓ Classified / Unclassified Work Environments
  - ✓ …

DD(X) Software Measurement System Drivers

- **Critical Engineering Success Factors**
  - ✓ People
    - Sufficient and Capable Staff
  - ✓ Process
    - Adherence to Capable Processes
  - ✓ Product
    - Complete, Concise, & Quality Work Products
    - Fully Functional, High Quality Software
- **Critical Software Risks**
  - ✓ Distributed Development
  - ✓ Engineering Environment

People Indicators

- **Sufficient**
  - ✓ Is there enough people to get the job done?
    - Staffing Profiles
      - Planned (BCWS) vs. Actual (ACWP)
- **Capable**
  - ✓ Are the people capable of performing the work required?
    - % Trained

Process Indicators

- **Capability**
  - ✓ Are the processes capable of delivering quality and performance within cost / schedule constraints?
    - Adherence to Best Practices
      - IEEE 12207, IEEE 1012, ISO 15939, etc.
    - Performance Results
      - Cost Variance, Schedule Variance
- **Compliance**
  - ✓ Are the capable processes being following?
    - Process Appraisal Results
    - Quality Assurance Audit Reports

Product Indicators

- Defect Containment Matrix
  - ✓ Identifies Phase Injected and Phase Removed
  - ✓ Design Agent historical performance used as initial quality thresholds
  - ✓ DD(X) exceeded historical performance
  - ✓ One for each release
  - ✓ Data across DCM's allow for trend analysis
    - Prediction of latent defects in shipboard software

Distributed Development Indicators

- Distributed Development
  - ✓ Process Maturity
    - SW-CMM migration to CMM-I
  - ✓ Common Tools
    - Requirements (DOORS)
    - Design (ROSE-RT)
    - Configuration Management (Multi-site Clearcase)
    - Engineering Change Control (WSTR)
- Engineering Environment
  - ✓ Classified Work Environment
  - ✓ Network Connectivity

2.0 Map Mgmt Info Needs to Design Agent Proposed Measures

- Current acquisition climate places emphasis on industry expertise
- Most DD(X) Software Suppliers have mature processes, including measurement
- Alignment was achieved through an iterative process of understanding and education
  - ✓ Measure vs Metric
  - ✓ Base / Derived Measure, Indicator, Model
- Design Agent was very open to improved methods and measures for monitoring developmental progress
- The PSM Issue/Category/Measure (ICM) table was very helpful to bound the discussion and reduce semantic misunderstandings

3.0 Determine Variance Thresholds

- For multi-billion dollar software development efforts, thresholds are an interesting issue
- Typical guidance suggests thresholds of 5 to 10%
- For all practical purposes, we report ALL variances and each one requires an explanation with a recovery plan

4.0 Monitor Design Agent Performance

- DD(X) Design Agent prepares a 'Composite Measurement Report' each month
  - ✓ Content was negotiated between the Design Agent and PMS500
  - ✓ Includes Indicators, Derived, AND Base Measures
- DA also prepares a monthly earned value report that includes risk progress
- SWEng analyzes measurement data (including Base Measures) for variances and trends

Lessons Learned regarding Gov't monitoring of progress

- Include measures for monitoring progress in milestone entry/exit criteria
  - ✓ Software Requirements Review
- In a large, system of systems effort, it is vital that the WBS system have discrete numbers for software
  - ✓ The third level of WBS reporting for large ACAT1 programs does not begin to separate HW / SW / Systems efforts
  - ✓ Sometimes the 4th level is sufficient.
  - ✓ Often it requires the 5th level to distinguish SW from systems / HW.
- Create a software CLIN for consolidation of software WBSs

Lessons Learned regarding Gov't monitoring of progress

- Software development can pay for the sins of systems engineering
- Large accounting systems can affect the timeliness of data analysis
  - ✓ It's not unusual for data collection, aggregation, verification, analysis, and report preparation to take 4+ weeks
- Creating information models from related indicators is an art, not a science
- Cost / Schedule pressure and thorough root cause analysis are in direct conflict
  - ✓ Synthesizing staffing, cost/schedule performance, defect containment, and release size, etc. in order to estimate the likelihood of maintaining schedule is no small task an can take considerable time.

6.0 Document Evaluation Results

- A Composite Executive Software Status Report is prepared by SWEng for Navy SW leadership (PMS500 / PEO-IWS)
  - ✓ PMS500 SWEng extracts measures (base / derived) from DA reports
- Report covers 5 PSM 'issue areas'
  - ✓ Schedule & Progress
  - ✓ Resources & Cost
  - ✓ Product Size / Stability
  - ✓ Product Quality
  - ✓ Process Performance
- PMS500 SWEng works closely with DA Software Process Engineering Lead to understand cause and resolution of 'anomalies'
  - ✓ DA is aware of, and generally concurs with, the Executive Software Status Brief
    - The data is agreed to.
    - The analysis and resulting estimates may diverge

Closed Loop Process

- Executive Software Status Report provides Navy SW Leadership with quick-look at developmental progress
- SWEng anticipates leadership questions and provides analysis / recovery plan with the initial report
- SWEng responds to any leadership questions
  - ✓ Short term response to address the issue
  - ✓ Review the issue with DA to determine if additional measures or analysis is required in future reports
- Issues are thoroughly vetted at bi-monthly software reviews

Conclusion

- The Process and Data Models from PSM have been tremendously valuable in developing the DD(X) Measurement Program
- Guidance from PSM, CMMI, and ISO15939 continues to be useful tools as DD(X) enhances it's approach to software measurement
- DD(X) is proceeding forward. The quantitative foundation that has been established is bringing great benefits to DD(X) leadership in making mid-course corrections