DD(X) Software Measurement
Setting the Foundation for Objective Program Oversight and Informed Decision Making

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Outline

- DD(X) SW Engineering (SWE) - What does that mean?
- SW Measurement – A STANDARD Definition
- SW Measurement in the context of a US DoD Acquisition Program Office (DDx-APO)
- DD(X) SW Measurement Data Model
- DD(X) Software Tracking & Oversight Process (STOP)
DD(X) System Characteristics

- ~ $3,000,000,000 contract through CDR
- ~ 70,000 Lines in IMS
- DD(X) is a Weapons Platform
  - Sensor System
  - C4ISR System
  - Multiple Weapon Systems
  - Ship Control System
  - Logistics / Support System
- ~ 30 Organizations supporting DD(X) development
DD(X) Software Characteristics

- 26 Organizations developing / integrating software
- ~ 25 Million SLOC (not including MIS)
- Total Ship System Integration vice traditional stove-piped ship systems
- ~ $400,000,000 SW budget through CDR
- SW Budget could approach $ 1B through 5th Ship
- DD(X) Software MUST BE ENGINEERED not developed or crafted.
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
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
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) SW Measurement Process Model

1.0 Identify Software Management Information Needs
   • Critical Success Factors (CSF)
   • Critical Software Risks (CSR)

2.0 Map Industry Measures to SW Management Information Needs

3.0 Determine Variance Report Thresholds

4.0 Monitor Industry Performance
   CDRL Reports, IPT / CPT Reports

5.0 Document Evaluation Results
   Monthly Performance Report
   Variance Report

6.0 Evaluate Industry Performance vs. Established Variance Thresholds

7.0 Document Evaluation Results

SW Mgmt Info Need to Industry Measure Matrix

Figure 1: Software Tracking & Oversight Process
Stated Program Goals

✓ Zero Cost Growth
✓ On-Time Development
✓ 100% Contracted Functionality
✓ Zero Priority 1/2 Defects

Identified Program Risks

✓ Concurrent Engineering
✓ Distributed Development
✓ ...

DD(X) Software Management
Information Needs
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
Track Critical Engineering Success Factors

✓ People
  ● Sufficient, Capable, and Stable Staff

✓ Process
  ● Adherence to Capable Processes

✓ Technology
  ● Balance Innovation & Risk

✓ Product
  ● Complete, Concise, & Quality Technical Work Products
  ● Complete, Concise, & Quality Management Work Products
  ● Fully Functional, High Quality Software
People Indicators

- Sufficient
  - Is there enough people to get the job done?
    - Staffing Profiles (Planned vs. Actual)

- Stable
  - Is the work environment sufficiently stable so people can work to their potential?
    - Turnover (Technical, Management)

- Capable
  - Are the people capable of performing the work required?
    - % Qualified
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.
      - CMMI, SPMN
    - Performance Results
      - Cost Variance, Schedule Variance, Defect Escapes

- **Compliance**
  - Are the capable processes being following?
    - Process Evaluation Results
    - Work Product Evaluation
Technology Indicators

- **Maturity**
  - Does the selected technologies balance innovation with risk?
    - Bleeding Edge vs. Leading Edge

- **Change Tolerance**
  - Will the selected technologies provide the best long term value to the Navy and provide for system enhancements over time?
    - Proprietary vs. Open Source
Work Product Indicators

➢ Quality

✓ Are the software work products of requisite quality?
  • Management Products (Adhere to standards?)
    – SDP, Risk Plan, CM Plan, Q-Mgmt Plan
  • Technical Products (Clear, Concise, Complete?)
    – Requirements Specifications, Design Documentation
    – SW Code, Test Cases

➢ Performance

✓ Does the software perform in accordance with our expectations?
  • Measures of Performance (MOP)
  • Technical Performance Measures (TPM)
  • Critical Technical Parameters (CTP’s)
<table>
<thead>
<tr>
<th>Critical Success Factor</th>
<th>Indicator</th>
<th>TD Threshold</th>
<th>PM Threshold</th>
<th>Periodic Reports During...</th>
</tr>
</thead>
<tbody>
<tr>
<td>People</td>
<td>• Staff Sufficiency</td>
<td></td>
<td></td>
<td>S Q Q Q Q Q Q Q Q Q</td>
</tr>
<tr>
<td></td>
<td>• Staff Capability</td>
<td>85%</td>
<td>75%</td>
<td>S Q Q Q Q Q Q Q Q Q</td>
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<tr>
<td></td>
<td>• Staff Stability</td>
<td>85%</td>
<td>75%</td>
<td>S Q Q Q Q Q Q Q Q Q</td>
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<tr>
<td>Process</td>
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<td>na</td>
<td>Q Q Q Q Q Q Q Q Q Q Q Q</td>
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<tr>
<td></td>
<td>• Compliance</td>
<td>na</td>
<td>na</td>
<td>Q Q Q Q Q Q Q Q Q Q Q Q</td>
</tr>
<tr>
<td></td>
<td>• Cost Performance</td>
<td>5%</td>
<td>10%</td>
<td>M M M M M M M M</td>
</tr>
<tr>
<td></td>
<td>• Schedule Performance</td>
<td>5%</td>
<td>10%</td>
<td>M M M M M M M M</td>
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<tr>
<td></td>
<td>• Quality Performance</td>
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<td>M M M M M M M M</td>
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<tr>
<td>Technology</td>
<td>Maturity (Leading-Bleeding Edge)</td>
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<td>na</td>
<td>As Introduced</td>
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<tr>
<td></td>
<td>Longevity</td>
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<td>As Introduced</td>
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<td></td>
<td>Sustainability (Open – Proprietary)</td>
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<td>na</td>
<td>As Introduced</td>
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## Measurement Data Table

<table>
<thead>
<tr>
<th>Critical Success Factor</th>
<th>Indicator</th>
<th>TD Threshold</th>
<th>PM Threshold</th>
<th>Periodic Reports During …</th>
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<td><strong>Product – Mgmt</strong></td>
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<td></td>
<td>Plan</td>
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<td></td>
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<td>na</td>
<td>Q  Q  Q  Q  Q  Q  Q  Q  Q</td>
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<tr>
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<td>Plan</td>
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<td>Traceability: R 2 D</td>
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<td>75%</td>
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<tr>
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<td>Stability</td>
<td>95%</td>
<td>85%</td>
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<td>Clarity</td>
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<tr>
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<td>Testability</td>
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<td>Q  Q  Q  Q  Q  Q  Q  Q  Q</td>
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<td><strong>Product – Tech – Design</strong></td>
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<td>75%</td>
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<tr>
<td></td>
<td>Stability</td>
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<td>85%</td>
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<tr>
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<td>Clarity</td>
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<td>M  M  M  M  M  M  M  M  M</td>
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<td>Testability</td>
<td>na</td>
<td>na</td>
<td>Q  Q  Q  Q  Q  Q  Q  Q  Q</td>
</tr>
</tbody>
</table>
Collect & Analyze Industry Measurement Reports

- DD(X) Design Agent prepares a ‘Composite Measurement Report’ each month
  - Content was negotiated between the DA and PMS500
  - Includes Indicators, Derived, AND Base Measures

- PMS500 SW Engineering (SWEng) extracts pre-selected data (base / derived measures) from the CMR

- SWEng analyzes measurement data for variances and trends.

- A Composite SW Measurement Brief is prepared by SWEng for PMS500 leadership
Process - Cost / Schedule Variance

<table>
<thead>
<tr>
<th>Month</th>
<th>CV %</th>
<th>SV %</th>
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<tbody>
<tr>
<td>Jul-01</td>
<td></td>
<td></td>
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<td>Aug-01</td>
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<tr>
<td>Dec-01</td>
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</table>

The graph shows the cost and schedule variance from July to December, with CV and SV indicating the cost variance and schedule variance respectively. The CV values range from $-3.0% to 18.0%, while the SV values range from $-3.0% to $(8,000).
Process - Escapes by Activity & Phase

Defects Found out of Phase

<table>
<thead>
<tr>
<th>Increment 1</th>
<th>Increment 2</th>
<th>Increment 3</th>
<th>Increment 4</th>
<th>Increment 5</th>
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<tbody>
<tr>
<td>Requirements</td>
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<td>117</td>
<td>101</td>
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<tr>
<td>Design</td>
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<td>48</td>
<td>39</td>
<td>43</td>
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<tr>
<td>Code &amp; Unit Test</td>
<td>128</td>
<td>115</td>
<td>97</td>
<td>109</td>
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<tr>
<td>Integration Test</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>16</td>
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<tr>
<td>Acceptance Test</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>TOTAL</td>
<td>368</td>
<td>302</td>
<td>256</td>
<td>309</td>
</tr>
</tbody>
</table>
**Technology - Maturity**

**Summary Evaluation**
- Rationale ROSE
- Rationale ClearQuest
- PVCS
- Object Orientation for Sys Development
- Object Orientation for SW Development
- Formal Requirements Quality Checklists
- Formal Design Quality Checklists
- Formal Code Inspection Checklists
- DOORS
- Simulation / Modeling
- Interactive / Evolutionary Requirements
- Incremental SW Delivery
- Code Modularization

**State of the Art** = .80 - 1.0
**Leading Edge** = .40 - .70
**State of Practice** = .10 - .30
**Bleeding Edge** = -.20 - 0.0
SUMMARY EVALUATION

- **Rationale ROSE**
- **Rationale ClearQuest**
- **PVCS**
- **Object Orientation for Sys Development**
- **Object Orientation for SW Development**
- **Formal Requirements Quality Checklists**
- **Formal Design Quality Checklists**
- **Formal Code Inspection Checklists**
- **DOORS**
- **Simulation / Modeling**
- **Interactive / Evolutionary Requirements**
- **Incremental SW Delivery**
- **Code Modularization**

**Very Effective** = .08 - 1.0
**Effective** = .40 - .70
**Nominal** = .10 - .30
**Counter Effective** = -.20 - 0.0
### CPM’s - SW Size (KSLOC)

<table>
<thead>
<tr>
<th>Release</th>
<th>Planned SLOC</th>
<th>Delivered SLOC</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>130</td>
<td>143</td>
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<tr>
<td>2</td>
<td>155</td>
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<td>3</td>
<td>145</td>
<td>181</td>
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<tr>
<td>4</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>98</td>
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</table>
Conclusion

- The Process and Data Models from PSM have been tremendously valuable in developing the DD(X) Software Tracking & Oversight Program.

- Guidance from PSM, CMMI, and ISO15939 continues to be useful tools as DD(X) refines its approach to software measurement.

- As DD(X) proceeds forward, the quantitative foundation that has been established will bring great benefits to DD(X) leadership in making mid-course corrections.