

Practical Software and Systems Measurement

Objective Information for Decision Makers



***Impact of Digital Engineering
on Measurement***

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Impact of Digital Engineering on Measurement

- ***DoD has released a Digital Engineering (DE) Strategy***
- ***DoD Services are developing DE Implementation Plans***
- ***PSM has developed an Information Category-Measurable Concept Measurement (ICM) table which reflects measurement best practices***

What impact does the move towards Digital Engineering have on measurement?



Digital Engineering Overview

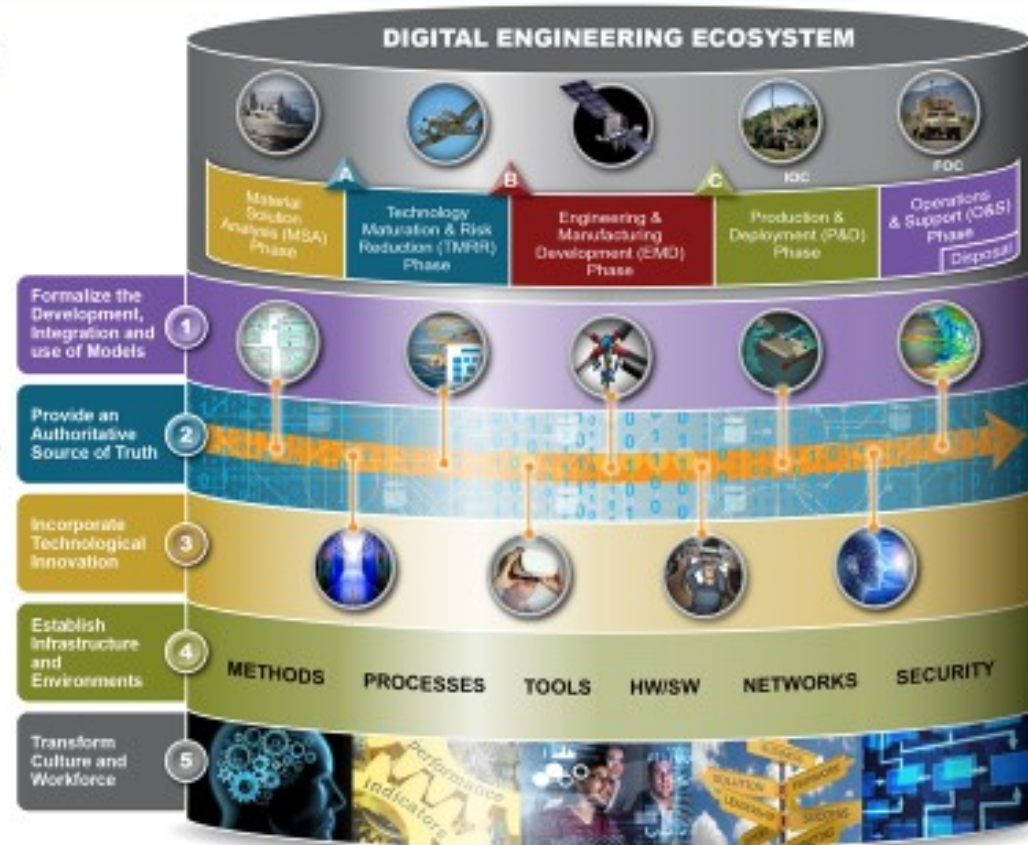


- **What is Digital Engineering?**

- Combines model-based techniques, digital practices, and computing infrastructure
- Enables Delivery of high pay off solutions to the warfighter at the speed of relevance

- **Reforms Business Practices**

- Digital enterprise connects people, processes, data, and capabilities
- Improves technical, contract, and business practices through an authoritative source of truth and digital artifacts



Modernizes how we design, operate, and sustain capabilities to outpace our adversaries



Digital Engineering Strategy



- **Digital Engineering Strategy**
 - Basic capabilities needed by Services and Agencies to begin use of digital engineering practices
- **Objective**
 - Guide the planning, development, and implementation of digital engineering across the services and agencies
- **Expected Impact**
 - Increase technical cohesion and awareness of system in lifecycle activities
 - Reform the Department's business practices for greater performance and agility
- **Coordination**
 - Approved by USD(R&E), DASD(SE), and each Service

<https://www.acq.osd.mil/se/docs/2018-DES.pdf>



Digital Engineering Strategy: Five Goals



Modernizes how we design, operate, and sustain capabilities to outpace our adversaries

Objectives of the Workshop

- ***Assess the impact digital engineering may have on measurement***
- ***In particular, review the ICM table to assess how does measurement change as projects implement digital engineering approaches***

Workshop Format

1:30 Introductions, Review of Objectives, Agenda, and Review of DE Strategy

2:00 Review of each information category in ICM to identify any areas which may be affected by DE

- ***Schedule & Progress***
- ***Resources & Cost***
- ***Size & Stability***
- ***Product Quality***
- ***Process Performance***
- ***Technology Effectiveness***
- ***Customer Satisfaction***

4:00 Review of impacts and implications

Project – Schedule and Progress

Information Categories	Measurable Concepts	Questions Addressed	Measures		Notes
			Prospective Indicators	Sample Base Measures	
Schedule and Progress	Milestone Completion	Is the project or service meeting scheduled milestones? Are critical tasks or delivery dates	- Milestone Progress	- Number of milestones started and completed versus plan	- Completion should be based on achieving specific quantifiable milestone completion criteria - Include updates as schedules change - Milestones may include inch stones, or
	Work Unit Progress	Are specific activities and products completed as scheduled?	- Requirements Progress - Problem Reports Progress - Reviews Progress - Change Requests Progress - System Elements (Units) Progress - Test Cases Progress - Action Items Progress	- Requirements defined, traced, verified, validated - Problem reports discovered, closed - Reviews completed - Change requests opened, resolved - System elements designed, implemented, integrated, approved, qualified, accepted - Test cases developed, attempted, passed - Action items opened, completed	- Other work unit progress measures may be defined based on the work in progress - Other schedule performance indicators are included with financial performance indicators (e.g. earned value measures)
	Work Backlog	Is the backlog of work units growing? Has the backlog of work units been adequately addressed?	- Work Unit Backlog Trends - Burndown Rates	- Work units in backlog, work units in backlog resolved	- Measure/categorize by priority level and age - Work units may be: -- actions, assignments -- service requests
	Incremental Capability	Is capability being delivered as scheduled in incremental builds, releases, or service provisions?	- System Elements Integrated - Functionality Integrated	- Systems elements integrated (planned versus actual) - Functions integrated (planned versus actual)	

Project – Resources and Cost

Information Categories	Measurable Concepts	Questions Addressed	Measures		Notes
			Prospective Indicators	Sample Base Measures	
Resources and Cost	Financial Performance	Is the project or service meeting budget and schedule objectives? Is the project or service at risk of exceeding established cost and schedule objectives?	<ul style="list-style-type: none">- CPI, SPI Trends- Earned Value Cost and Schedule Variance- Budget Adequacy and Trends- Cost Trends- Cost and Schedule Impact Risk Trends	Earned Value: <ul style="list-style-type: none">- Budgeted Cost of Work Scheduled (BCWS)- Budgeted Cost of Work Performed (BCWP)- Actual Cost of Work Performed (ACWP)- Budget at Completion (BAC)- Latest Revised Estimate (LRE)- Estimate at Completion (EAC)- Budget, planned, and actual costs- Cost and schedule risk	<ul style="list-style-type: none">- For deployed systems, costs include those to operate, maintain (resolve problems), and enhance system- Include updates as funding changes- For risks, develop a range of cost values with associated probabilities, not just a single "cost" value, to facilitate improved awareness of potential cost exposure. Note that this should be related to both cost and schedule risk.
	Personnel Effort	Is effort being expended according to plan? Is there enough staff with the required skills?	<ul style="list-style-type: none">- Staff Level Sufficiency- Effort Distribution and Trends- Skill Profiles- Staff Turnover Rates	<ul style="list-style-type: none">- Number of staff on project and projected- Number of staff by skill level- Number of staff by activity- Staff added, removed, quit	<ul style="list-style-type: none">- Can also focus on key staff- Effort distribution and trends by activity provides a more detailed profile- Look at these measures for the current state and future projection- Skills include expertise, experience, training, education, and domain knowledge
	Facilities and Support Resources	Are needed facilities, equipment, tools, and materials available as needed to meet milestones?	<ul style="list-style-type: none">- Resource availability- Resource utilization	<ul style="list-style-type: none">- Quantity needed, available- Time required, available, used	

Project – Size and Stability

Information Categories	Measurable Concepts	Questions Addressed	Measures		Notes
			Prospective Indicators	Sample Base Measures	
Size and Stability	Physical Size and Stability	How big is and how much change is occurring with the product's physical size, physical characteristics, or interfaces?	<ul style="list-style-type: none">- System Element Trends- Interface Complexity- Interface Compatibility- Lines of Code Trends	<ul style="list-style-type: none">- System elements added, modified, deleted- Interface number (unique), complexity, growth, approval rates, changes, TBD/TBR closure per plan- Lines of code added, modified, deleted	<ul style="list-style-type: none">- Consider both internal and external interfaces- System elements can include software or hardware elements
	Functional Size and Stability	How big is and how much change is occurring with the product's functional size, content, or logical characteristics?	<ul style="list-style-type: none">- Requirements Trends- Architecture Element Trends- Functional Element Trends- Work Unit Backlog Size Trends- Function Points Trends- Call Center Request Trends- TBD/TBRs Trends	<ul style="list-style-type: none">- Number added, modified, deleted	<ul style="list-style-type: none">- This can be applied at any part or level of the system definition- Functional architecture changes can be at the level of architecture description, model, or elements- Call center requests can be categorized as problems or enhancements

Project – Product Quality

Information Categories	Measurable Concepts	Questions Addressed	Measures		Notes
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Product Quality	Functional Correctness	Is the product good enough for delivery to the user? Are identified problems being resolved?	- Defect Profiles - Defect Density - Technical Measurement Trends - System Elements Accepted	- Defects by status, severity, priority, distribution, age, etc. - Technical measurement requirement, target, threshold, budget, and actual - System elements verified	Technical measurement includes Measures of Effectiveness, Measures of Performance, and Technical Performance Measures
	Supportability - Maintainability	How much support does the system require? How difficult is it to support?	- Time to Restore - Mean-Time-to-Repair - Cyclomatic Complexity	- Hours to restore - Calendar hours and labor hours to repair - Number of paths through system	Support includes maintenance, training, provision of supplies, etc.
	Efficiency	Does the target system make efficient use of system resources?	- Utilization - Throughput - Response Time	- System element capacity available, used - Time for function (budget, actual)	It is important to capture benchmark times for key system functions. These can be reviewed as the system is maintained or altered, to ensure that no degradation occurs.
	Portability	To what extent can the functionality be re-hosted on different platforms?	- Interface Compliance	- Interfaces verified	Use of portability can also include reusability and adaptability
	Usability	Is the user interface adequate and appropriate for operations? Are operator errors within	- User Interface Acceptability - Operator Error Trends	- Actions from user interface reviews - Operator errors	
	Dependability - Reliability	How often is service to users interrupted? Are failure rates within acceptable bounds?	- Mean-Time-to-Failure - Availability	- System element failures by severity, priority - System element start, end times	Instead of availability, might measure downtime (outages)
	Security - Safety	How many vulnerabilities are identified and remediated by life cycle phase? How many relevant attack patterns have been covered by test cases?	- Profile of vulnerabilities - Cost to fix vulnerabilities - Attack Pattern Test Coverage Profile	- Vulnerabilities discovered, remediated - Cost to fix vulnerabilities - Test cases developed, verified per attack pattern	

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Project – Process Performance

Information Categories	Measurable Concepts	Questions Addressed	Measures		Notes
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Process Performance	Process Compliance	How consistently does the project implement the defined project	<ul style="list-style-type: none"> - Process Reference Maturity/Capability Rating - Process Audit Findings 	<ul style="list-style-type: none"> - Maturity/Capability Rating Goal, Assessed - Number of audit findings by process area 	
	Process Efficiency	Are the processes efficient enough to meet current commitments and	<ul style="list-style-type: none"> - Productivity Performance Trends - Cycle Time Performance Trends - Service Level Agreement (SLA) 	<ul style="list-style-type: none"> - Work unit size - Effort expended - Elapsed calendar and time expended 	For agile developments, team velocity is a measure of productivity
	Process Effectiveness	Are the processes generating the results expected? How much rework is occurring?	<ul style="list-style-type: none"> - Defect Containment - Test Effectiveness - Test Coverage - Defect-prone system elements distribution - Operational and Maintenance Effectiveness - Rework Effort Distribution - Rework System Elements Trends - Risk Handling Trends 	<ul style="list-style-type: none"> - Defects by phase injected, discovered, and resolved (defect propagation) - Defects discovered per test case and test type - Defects discovered per system element - Schedule and effort expended - total and rework - System elements requiring rework - Number of identified risks treated per plan 	<ul style="list-style-type: none"> - Defect containment is also called "Defect Escapes" - Defects per system element is particularly important for key elements of the architecture, or if safety/security related - For services, schedule and effort expended might include those related to service calls - Rework in production might measure waste of production units - Could also measure benefits of processes (e.g. cost prevention) - Risk trends may include overdue actions, age of open risk actions by severity or state

Project – Technology Effectiveness

Information Categories	Measurable Concepts	Questions Addressed	Measures		Notes
			Prospective Indicators	Sample Base Measures	
Technology Effectiveness	Technology Suitability	Can technology meet all allocated requirements, or will additional technology be needed?	- Requirements Coverage	- Requirements met by technology	
	Technology Maturity	Is the technology ready to be used in this project? Does the technology risk impact the achievement of planned objectives?	- Technology Maturity Trends - Risk Exposure Trends	- Technology Readiness Level (TRL) - Number risks identified, treated, closed by probability and consequence	- Might also consider technology obsolescence - is the technology about to become obsolete? - Technology risk may also be seen in technology volatility - Risk identification may be by priority - Risk handling may include analysis, approval, implementation, verification, and closure
	Technology Volatility	Does new technology pose a risk due to too many changes?	- Technology Baseline Changes Trends	- Number of requirements impacted by changed technology	

Project – Customer Satisfaction

Information Categories	Measurable Concepts	Questions Addressed	Measures		Notes
			Prospective Indicators	Sample Base Measures	
Customer Satisfaction	Customer Feedback	How do our customers perceive our performance for individual projects	- Satisfaction Ratings Trends - Award Fee Distributions	- Satisfaction ratings - Award fees received	Contractor Performance Assessment or other survey
	Customer Support	How quickly are customer support	- Support Request Distributions - Support Time Trends	- Number of support requests - Calendar time to address requests	

Workshop Background

- ***PSM has provided a effective forum for addressing best practices in measurement***
- ***With the advent of digital engineering, approaches to systems engineering are changing***
- ***The question is whether these changes will effect the measurement approaches***

Intended Output

- ***Review of the current ICM table with identification of areas impacted by DE, with possible recommended updates***