Measures for Maintenance

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Briefing Agenda

- Introduce study
- Summarize study findings
- Discuss current data collection activities
- Focus in on metrics for maintenance
- Acknowledge participants
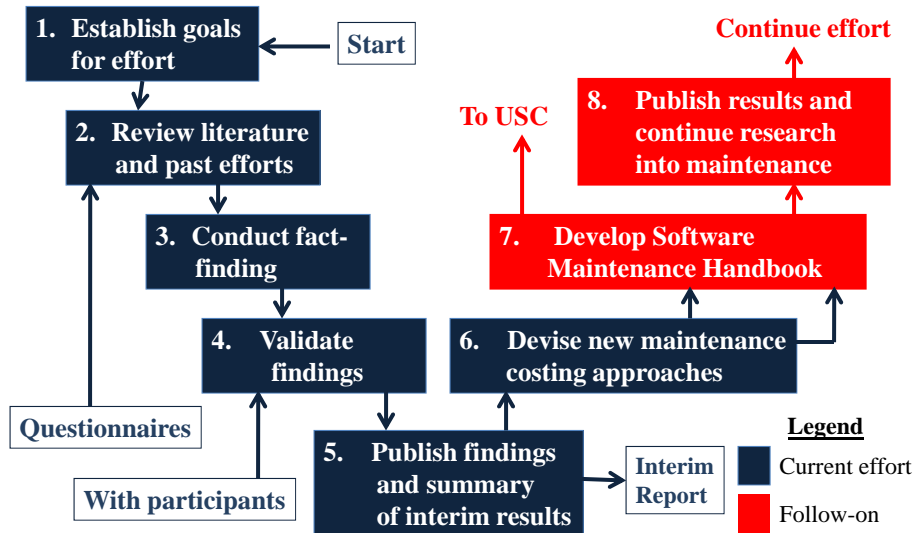- Summarize and conclude

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Goals of Study

- Investigate maintenance
  - What are the tasks
  - Who does them
  - What are the costs
  - How they are estimated
  - How do we manage them
  - What measures do we use
- Understand
  - Current budgeting, estimating and measurement practices
- Recommend
  - Improvements in the way we address maintenance

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Plan of Attack

1. Establish goals for effort

Start

Continue effort

To USC

8. Publish results and continue research into maintenance

2. Review literature and past efforts

7. Develop Software Maintenance Handbook

3. Conduct fact-finding

4. Validate findings

6. Devise new maintenance costing approaches

Questionnaires

5. Publish findings and summary of interim results

Interim Report

With participants

Legend

Current effort

Follow-on

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Army Projects Interviewed

- In progress
- Visited:
  - Ft. Monmouth, NJ
  - Picatinny Arsenal, NJ
  - Redstone Arsenal, AL
- Projects Interviewed
  - Adams Cell
  - Aerial Targets
  - America's Army
  - Apache AH-64A
  - Blackhawk UH-60
  - Bradley
  - Hellfire

- Kiowa
- JAMS
- JLENS
- Longbow
- MFCS
- MLRS
- NLOS
- NSITE
- Paladin
- Patriot
- SBX
- Shadow and Hunter UAS
- TACMS MCTD
- Others

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Air Force Projects Polled

- In progress
- Visited:
  - Hanscom AFB, MA
  - Robins AFB, GA
- Coordinated with major defense firms to verify findings

Findings to date in AF and defense industry investigations are similar to those that we found in Army life cycle support centers

- Projects interviewed:
  - AWACS
  - C130J
  - MPS   - SOF Aircraft
  - MMP-U   - JMPS
  - TACP-M   - Joint STARS
  - FAB-T   - JTIDS
  - JSS   - F-15
  - CITS   - MRT
  - DASR   - MMRT
  - Elec. Warfare

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What is Software Maintenance?

- Software maintenance is **<u>defined</u>** as the modification of the software product after delivery to correct faults, to improve performance or other attributes, or to adapt the product to work in a new environment (ISO/IEC 14764).
- Effort involved in modifications perceived to focus mostly on adaptive changes (80%) vs. corrective and perfective actions (20%)
  - Perception is that maintenance modifies releases to address new requirements and makes needed fixes
  - The reality of what really goes on during maintenance often differs from perceptions in that they do more work than this
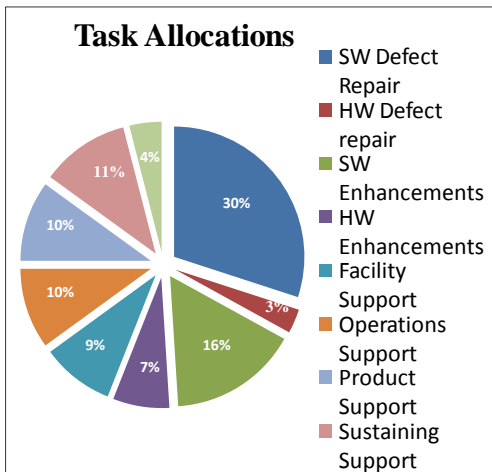
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Who Does Maintenance, Why Where, When and How?

Question	Perception	Reality
Who	Developers	Separate teams - Commercial: primarily out-sourced - Government: mainly in-sourced
Why	To fix bugs, improve performance and incorporate changes in current releases	To add functionality and reduce current defect backlog by addressing open change requests/trouble reports in priority order
Where	Development site	Both at operational and central maintenance sites and in the field - Use operational equipment when possible
When	After delivery	During first year of operation and thereafter on periodic basis
How	Using a well-disciplined subset of software development processes	Often done on a catch as catch can basis with little planning and haphazard testing; some shops though are CMMI Level 5

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Findings – Groups Do More Than Just Maintenance

Task Allocations

- SW Defect Repair — 30%
- HW Defect repair — 3%
- SW Enhancements — 16%
- HW Enhancements — 7%
- Facility Support — 9%
- Operations Support — 10%
- Product Support — 10%
- Sustaining Support — 11%
- (4%)

- About fifty percent of their work involves:
  - Software & hardware repairs
  - Product enhancements (both software and hardware)
- The other fifty percent is devoted to other tasks:
  - Sustaining engineering
  - Operations, product and facility support
- Maintenance staff includes both government and in-house contractor personnel

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Work Done by Maintenance Organizations

1. Operations, maintenance & support
   - 1.1 Maintenance
   - 1.2 Sustaining engineering
   - 1.3 Independent test and verification
   - 1.4 Product support
   - 1.5 Information assurance
   - 1.6 Acquisition support
   - 1.7 Operations support
   - 1.8 Facility support
   - 1.9 Field support
   - 1.10 Management
   - 1.11 Parts
   - 1.12 Spares
   - 1.13 Licenses
   - 1.14 Cost item general

1.1.1 Release requirements
1.1.2 Release planning
1.1.3 Architecture analysis
1.1.4 Hardware defect repair
1.1.5 Software defect repair
1.1.6 Hardware enhancements
1.1.7 Software enhancements
1.1.8 Release integration & test
1.1.9 Release qualification & delivery

1.5.1 Protective services
1.5.2 DIACAP

1.10.1 Release management
1.10.2 Sustaining engineering management
1.10.3 Risk management
1.10.4 Metrics analysis

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Maintenance Versus Sustaining Engineering

Maintenance Releases

- Modify software to correct, perfect or adapt content based on change requests and software trouble reports
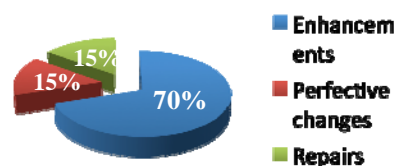- Focus is to periodically update and release new versions

Sustaining Engineering Releases and Support

- Sustain infrastructure including test and integration facilities
- Administer networks and security
- Install patches/make repairs
- Manage changes/ensure quality
- Provide help desk and market watch
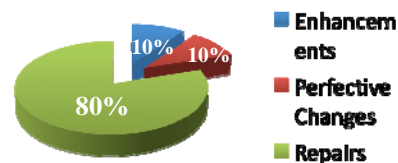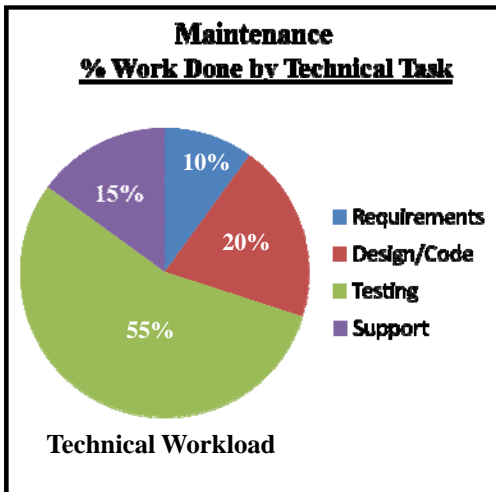- Provide user training and support

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Typical Release Contents

LEGEND

- **Enhancements** – incorporating new functions and features into the release based on approved change requests
- **Perfective changes** – making the software run more quicker or more efficiently.
- **Repairs** – fixes incorporated to address outstanding software trouble reports.
- **Patch Releases** – software releases sent to field to correct minor problems.
- **Major Releases** – software versions each released with different functionality.
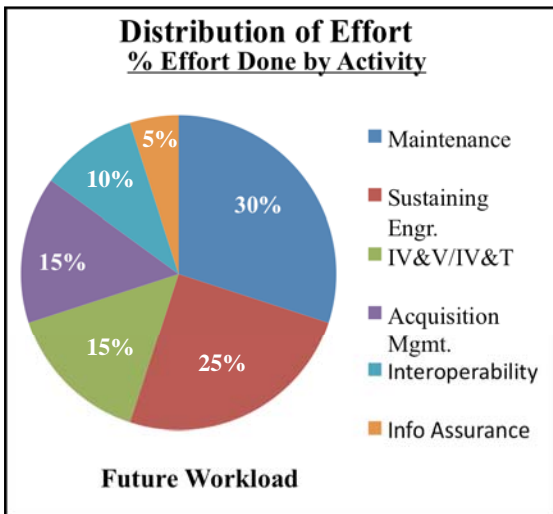
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Findings - Testing Is The Primary Maintenance Activity

Maintenance
% Work Done by Technical Task

- Requirements — 10%
- Design/Code — 20%
- Testing — 55%
- Support — 15%

Technical Workload

- As much as 60-70% of the technical work done during maintenance supports the retesting and qualifying the system
- Testing is made harder when developers fail to transition and turnover the needed set of regression tests for use in revalidating the software once changes have been made
- Support tasks are performed to maintain system integrity and support field operations

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Forecast Future Maintenance Effort Distributions

Distribution of Effort
% Effort Done by Activity

- Maintenance — 30%
- Sustaining Engr. — 25%
- IV&V/IV&T — 15%
- Acquisition Mgmt. — 15%
- Interoperability — 10%
- Info Assurance — 5%

Future Workload

- Workload will rise as more and more systems are retrofit to support net-centric warfare concepts
- Total effort will not change, however, its distribution will
- Information Assurance work will continue to grow as more nets added
- Net result will be that the backlog of priority changes/trouble reports will take longer to handle

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Ten Maintenance Myths

- **<u>Myth 1</u>** – PDSS workload is aimed at satisfying requirements
  - Goal is getting rid of high priority ECPs/STRs (backlog reduction)
- **<u>Myth 2</u>** – PDSS is funded based on requirements
  - Mostly funded LOE using whatever funds are available
- **<u>Myth 3</u>** – In general, maintenance schedules are based on user need dates
  - Actually, based on periodic calendar release dates

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Ten Maintenance Myths

- **<u>Myth 4</u>** – Sustaining engineering effort is separately estimated and managed
  - Most of funding for this effort is taken out of hide
- **<u>Myth 5</u>** – IV&V uses separate processes, people and tools to assess capability of the code to perform
  - Often projects must share people and tools because of lack of funds
  - Tactical equipment and resource availability often constrain options

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Ten Maintenance Myths

- **Myth 6** – Maintenance personnel are junior
  - Actually senior people with skills not readily available on active marketplace (Ada, VAX, etc.)
- **Myth 7** – Motivating maintenance personnel is hard
  - Interesting work, educational opportunities, etc. do the job
- **Myth 8** – Current process improvement efforts address maintenance
  - Address only a subset of the work involved

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Ten Maintenance Myths

- **Myth 9** – All maintenance groups do is maintenance
  - The Center has the flexibility to enter the software business
  - It also has the ability to use new paradigms and embrace commercial best practices
- **Myth 10** –The maintenance Group's focus is software
  - They also fix hardware and work lots of contract issues

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Different Risk Factors Drive Maintenance Activities

- Platform upgrades/machine replacements
  - Major changes occur on average every 3 to 5 years
- Personnel turnover
  - Turnover rate in maintenance of 10 to12% versus 3 to 5% for development personnel (some reassigned, not lost)
- COTS package updates (both OS and applications)
  - New releases issued every year to justify license renewals
- Database conversions and updates
  - Someone has to populate databases and validate data
- Maintenance cultures makes change difficult
  - When things aren't broken, it is hard to change them
- Unfunded mandates make getting the job done harder

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Different Insights are Needed

Insight Desired	Development Measures	Maintenance Measures
Schedule performance	Milestone progress	Rate of progress
Budget performance	Financial performance	Financial performance
Resource utilization	Personnel assignment/ramp-up	Personnel utilization/turnover
Risk	Programmatic risk	Technical risk
Size and stability	Requirements growth	Requirements backlog
	SLOC growth	Repair backlog
Product quality	Design and code defects	Defect backlog/introduction
Process performance	Maturity capability	Maturity capability
Technology effectiveness	Technology readiness	Technology risk
Customer satisfaction	Award fee	Operational capability
Test effectiveness	Law of exhaustive testing	Degree of automation
Unfunded mandates	Get well plan – ECPs	Law of diminishing returns

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Maintenance Measurements

Information Categories	Measurable Concepts	Measures Indicators	Description
Project (by release)	Cost	Estimated/actual cost	Estimated and actual cost in $ by release separated by year into the following categories: (1) labor costs ($), (2) license costs ($), (3) travel costs ($), (4) Other Other Direct Costs ($), (5) indirect costs ($), and (6) profit ($), as applicable.
	Effort	Estimated/actual hours	Estimated and actual number of labor hours separated by year into the following categories: (1) requirements changes, (2) defect repairs, (3) sustaining engineering including user, help desk, training and facility support, (4) test preparation, (5) test dry runs, (6) regression test conduct, (7) FQT conduct, (8) interoperability test conduct, (9) Quality Assurance (QA), (10) Configuration Management (CM), (11) systems administration, and (12) information assurance.
	Schedule	Planned/actual schedule	Schedule including planned and actual start and delivery date for the release.
	Product size	Planned/actual size	Planned/actual size in ESLOC by release separated into the following categories: (1) new lines (added), (2) reused lines (old), (3) modified lines (changed), (4) deleted lines, and (5) auto-generated lines.
	Team size	Planned/actual team size	Planned/actual average and peak size in numbers of Full Time Equivalents (FTEs).

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Maintenance Measurement - II

Information Categories	Measurable Concepts	Measures Indicators	Description
	Contractors used	Percent utilization	Planned/actual contractor usage by percent of total effort measured in terms of labor-hours expended separated into (1) government % and (2) contractor %.
	Languages used	Percent utilization	Language usage by percent of total usage.
Volume of enhancements	No. requirements changes	Requirements (total)	Number of requirements by release separated into the following categories: (1) requirements added, (2) requirements deleted, (3) requirements deferred, and (4) total number of requirements including existing.
	Effort	Effort/requirements change	Directly chargeable labor hours expended total and per requirements change request to implement changes.
	Requirements backlog	Number of changes deferred	Number of requirements changes at start and end of release separated into the following categories: (1) requirements deferred and (2) requirements dropped.
	Test effort	Number of tests planned/actual	Number of tests planned and actual for the release for qualifying changes made separated into the following categories: (1) regression tests, (2) FQT's, and (3) interoperability tests.
	Test effectiveness	Percentage automation	Planned/actual percentage of the tests automated separated into (1) regression test %, (2) FQT % and (3) interoperability test %.

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Maintenance Workshop

- Refine information needs and initial set of measures/metrics that could be used for them
  - Must relate needs to the work performed
  - Must relate needs to the data that is being captured so that they can be quantified
- To set the stage, we have posted a WBS and metrics paper on the PSM web site
  - We have also sent data definitions and a draft ICM Table to participants

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Status of Other Study Efforts

- Maintenance WBS
  - Developed aligned activity & task structure
  - Validated it with several defense contractors
  - Looking to pilot its use on active programs
- Estimation models
  - Assessed capabilities of COCOMO II, SLIM, SEER and True S
  - Validated findings with developers
  - Developing cost database to calibrate the models

- Metrics
  - Developed recommended set at both the enterprise and project levels
  - Need data to gain insight into trends and feasibility
  - Want to run pilot project to validate metrics
- Load Balancing Model
  - Developed cost model to balance maintenance labor load across maintenance phases
  - Running pilot project at AF/ESC to validate model

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Maintenance Model Assessment

- **COCOMO II**
  - Drives estimate using code fragment change
  - COPLIMO extends model to take into account life cycle impact of investments
- **SEER-SEM**
  - Drives estimate using size and years to be covered
  - Estimate allocated to four types of changes
  - SEER-IT used to estimate sustaining activities

- **SLIM**
  - Derives maintenance prediction from base estimate using SLIM MasterPlan
  - Views estimate in terms of:
    - Major & minor enhancements
    - Baseline support
- **True S**
  - Maintenance determined by the number of latent defects in a release
  - Assumes maintenance can involve more than just a release

Tomorrow, we will present a paper providing more details on this assessment

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Summary and Conclusions

- Summary
  - Communicated study findings to PSM community
  - Looking for feedback
  - Looking for pilot projects
  - Looking for maintenance data
- Conclusions
  - Lots of interest in topic and lots more to learn
  - Study is debunking the myths of maintenance

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