

DoD's Software Sustainment Ecosystem: Needed Skill Sets and Gap Analysis

Michael H. McLendon
Dr. Forrest Shull
Dr. Christopher Miller

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

Copyright 2018 Carnegie Mellon University. All Rights Reserved.

This material is based upon work funded and supported by the Department of Defense under Contract No. FA8702-15-D-0002 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

NO WARRANTY. THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

[DISTRIBUTION STATEMENT A] This material has been approved for public release and unlimited distribution. Please see Copyright notice for non-US Government use and distribution.

This material may be reproduced in its entirety, without modification, and freely distributed in written or electronic form without requesting formal permission. Permission is required for any other use. Requests for permission should be directed to the Software Engineering Institute at permission@sei.cmu.edu.

DM18-0600

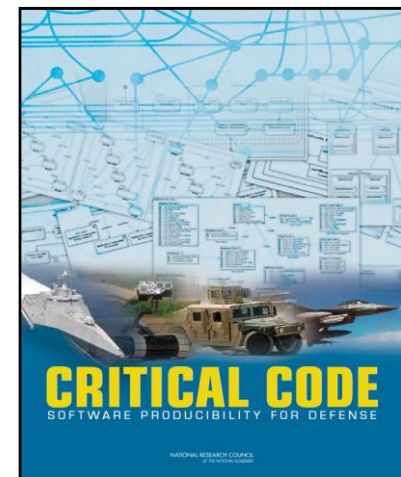
Session Objectives



- Provide an overview of software sustainment
- Introduce the Software Sustainment Ecosystem
- Discuss Software Sustainment Workforce implications
- Provide overview of Software Sustainment Workforce Gap Analysis & Skill Sets Model

Software and DoD

- Warfighter capability embodied in **software**... a unique source of strategic, military advantage
- DoD's ability to produce and evolve **software** is at core of achieving and sustaining mission superiority, agility, more timely and better decisions
- **Software**... essential to vast range of military system capabilities, operations... deepening and broadening role [NRC Critical Code, 2010]
- Many aspects of **cyber security (defensive and offensive)** closely linked with software capability
- Creates challenges for leading and managing software-intensive systems



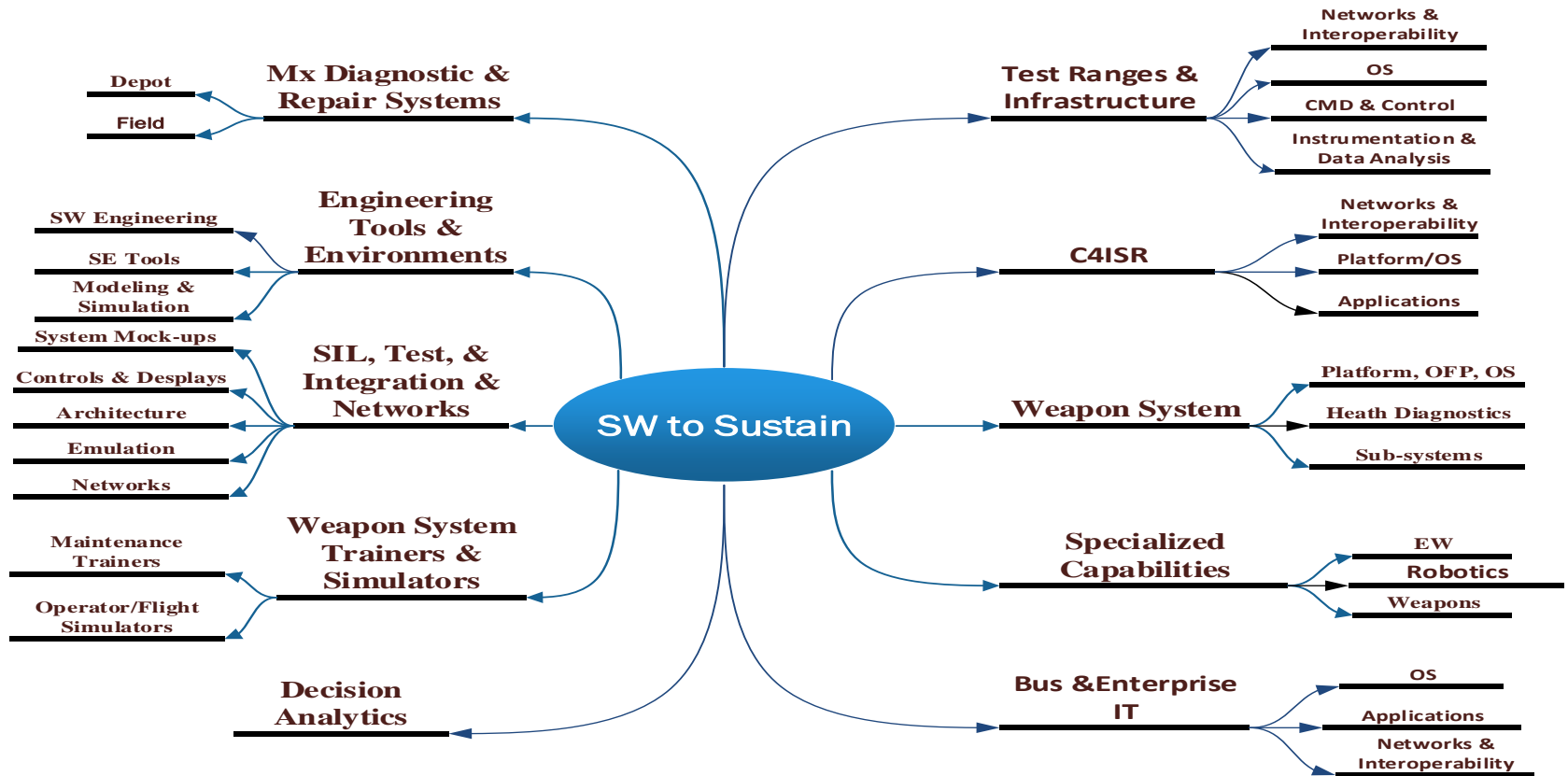
Sustainment – An Evolving Perspective

Typically, defined as O&M, modernization (upgrades) of capability involve:

- Ensure safety, availability, and effectiveness of aging aircraft/systems
- Identify technology needs and approaches
 - Extend service life; ease maintenance burden
 - Facilitate future adaptations and performance enhancements
- Shift to SW digital systems functionality was “game changer”
 - Large increase in SW size/complexity
 - Software-enabled capabilities replacing HW
 - Software use/complexity, rapid technology refresh growing faster than DoD’s ability to address it across the lifecycle



DoD's SW* to Sustain Is Large... with Limited Enterprise Visibility



*Includes COTS, GOTS, and Custom Code

This is a notional topology; there is no DoD inventory of SW and on-going analysis of its demographics to inform decisions

Demand Drivers

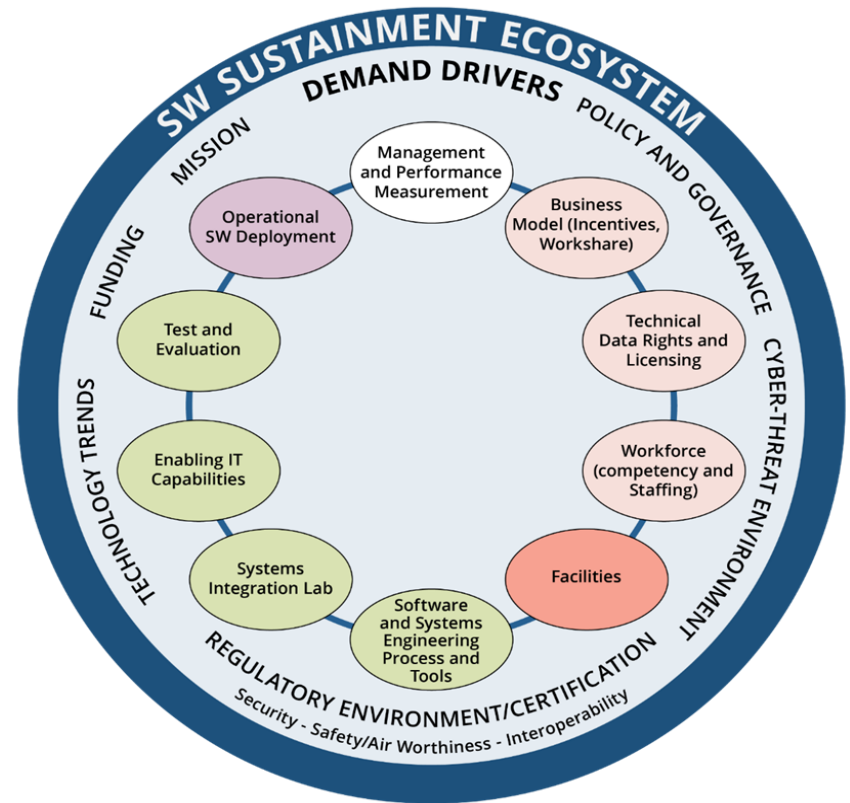
- DoD environment: Highly dynamic, constantly changing:
 - Threats
 - Mission needs
 - Policy & governance
 - Regulatory / certification requirements
- For many of these changes, software is the most cost-effective means of implementation
- Software adds its own challenge due to continual innovation / technology refresh

At the heart of software sustainment:

- The planning and execution of a disciplined engineering process required to keep the system operational in the face of a changing environment and evolving requirements

SW Sustainment Ecosystem Overview

- Four **infrastructure** elements:
Basic, fundamental resources necessary for the sustainment activities
- Three **knowledge and expertise** elements: Skill sets, the government organic workforce, access to necessary technical information needed to deliver and deploy the capabilities for the warfighter
- Three ungrouped elements:
 - Facilities
 - Operational SW Deployment
 - Management / Performance Measurement



"DoD Software Sustainment Study Phase I: DoD's Software Sustainment Ecosystem." Special Report CMU/SEI-2016-SR-035.

Ecosystem Elements

Infrastructure

Systems and Software Engineering Process and Tools – The engineering practices to be applied to plan and execute the work.

Enabling IT Infrastructure – The information technology environment and assets upon which the work must be conducted.

Test and Evaluation (T&E) – The mechanisms by which changes made during software sustainment are verified as ready to be rolled out to users. For DoD weapons systems, significant investments in program-specific hardware may be required.

Systems Integration Laboratory (SIL) – The SIL is a specific type of T&E equipment, providing accurate analysis of the impact of changes, and is increasingly important to DoD sustainment practice.

Knowledge and expertise

Workforce (Competency and Staffing) – The means of accessing a sufficient organic workforce with appropriate skill sets.

Business Model (Incentives, Workshare) – The strategic decision regarding which parts of the work will be done by the organic workforce and which by contractors, and how the overall work is managed both technically and contractually.

Technical Data Rights and Licensing – The tactical decisions governing what technical information is necessary to be accessed by the organic workforce, and the mechanisms by which they have access.

Enabling resources / activities

Facilities – The physical location that meets the needs of the work (providing sufficient space, security levels, etc.).

Operational Software Deployment – The mechanisms and strategy by which new versions of the software under sustainment are delivered to users.

Management and Performance Measurement – The management function necessary to organize and monitor the work being conducted to ensure that it is executing as planned, and to identify any problems that need to be resolved.

Workforce / Human Capital

- Software sustainment is NOT about restoring form, fit, and function – but rather an engineering activity that requires specialized competencies performed by a dedicated workforce
- The Services use different approaches to satisfy staffing needs, reflecting different doctrines and business models
 - **DoD has not comprehensively analyzed its organic software human capital needs to address the size, composition, and competency needs for the workforce over the life cycle**
- DoD studies dating back to 1982 have raised concerns about the technical competencies and size of DoD's software workforce
 - Specific challenges in today's environment relate to **recruiting & retaining talent**

Software engineering is not currently designated by a standalone occupational career code, nor managed as a unique (set of) career field(s)

Technical Data Rights and Licensing

- FAR Section 27 and DFARS Subpart 227.72 set out basic rights of both the contractor and the DoD for IP, including computer software
- Software sustainment is an engineering activity which requires access to the technical data showing the design and implementation details for almost any change
- Program Managers have the responsibility to secure appropriate data rights to sustain the system
 - Without the source code it is next to impossible to cost-effectively enhance the capabilities of the software or improve its internal quality as needed to respond to sustainment drivers
 - PM-level focus inhibits enterprise-level visibility

Acquisition PMs are not consistently acquiring the software technical data needed to plan and execute organic software sustainment... No enterprise-level view of what data has been acquired and how gaps are affecting ability to sustain... problem exacerbated by lack of early acquisition involvement of SW sustainment organizations

Systems and Software Engineering Environment (Process, Practice, and Tools)

- Software sustainment demands the same engineering capabilities used in the development phase of a program
 - Common misperception that software sustainment is just about “coding”
 - In reality, only 29-37% of the effort across the software development life cycle is expended in coding [e.g. Yang08]
- The capacity of the engineering function is determined by and tailored to meet the projected workload
- Systems and software engineering processes, practices, and tools are not static and continue to evolve
 - Technological innovations create churn that has benefits, but also creates risk

Establishing and continually refreshing engineering capabilities are critical to the performance of software sustainment.

Workforce Implications

Looking at **critical engineering competencies** as determinant of effective software sustainment:

- National security dictates that certain skills need to be **government responsibilities**, without which the government cannot understand the technical baseline and make appropriate decisions with engineering implications
- **Model of engineering capabilities** to perform sustainment and maintain the technical baseline (organically owned and operated)
- Skill set does **not remain static** over time

Each Service sustainment site recognizes the necessity to explicitly identify competency needs

Gap Analysis

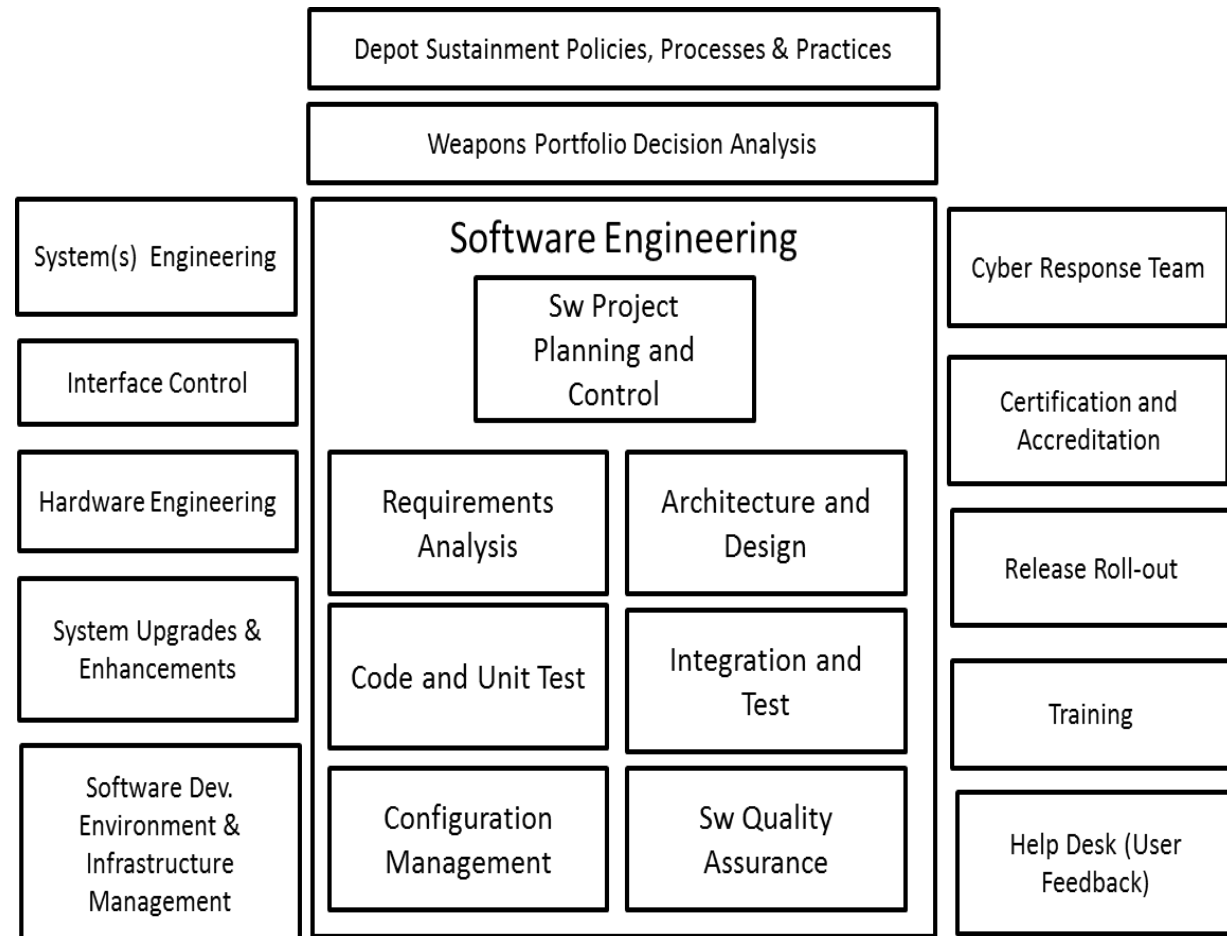
DoD has limited visibility into its software engineering workforce.

We have recommended a comprehensive enterprise assessment of the organic software sustainment workforce, considering:

- Current and future demands for the engineering and associated technical workforce, in terms of size and composition
- Competency needs
- Continuing education requirements
- Hiring and retention
- Approaches to providing visibility of this critical asset at the DoD level to enable on-going analysis, evaluation, and actions. This includes addressing cyber and security system engineering workforce needs as a priority

SW Skillsets Model

- Provides a framework to identify critical software sustainment competencies
- Many of these competencies have domain-specific and commodity versions
- Our study has revealed programs actively managing their critical software competencies



Implementing the Skillsets Model example

	PM	Deputy PM	Chief Eng	SW Arch	SWE 1	SWE 2	SWE 3	SWE 4	Tester 1	Test 2	CM / Sys Admin
Sw Proj Planning &Control	O	O									
Requirements Analysis	O	O	O	O							
Architecture & Design		O	O	O							
Code & Unit Test				O	O	O	S	S	O	S	
Integration and Test											S
Configuration Mgmt											S
Sw Quality Assurance											S
Cyber Response Team											
Certification & Accredit'n											S
Release Roll-out	O	O									S
Training											S
Help Desk(User Feedback)											S
System(s) Engineering											
Interface Control											
Hardware Engineering											
System Upgrades/ Enhancements											S
Software Development Environment / Infra Mgmt											S
Depot Sustainment Policies, Processes, & Practices		O	O								S
Weapons Portfolio Decision Analysis	O	O	O	O							

Software Sustainment group staffed based on ensuring there was at least one organic (O) staff position for each Software Sustainment function and secondary positions are staffed with a Supplemental (S) workforce

Technical Baseline drives Workforce Knowledge & Capability decisions

Balancing national security and best value, including:

- Technical Data Package / Technical Data Rights
- COTS Licenses
- Original Equipment Manufacturer (OEM)
 - Organic versus Contractor



“access to and knowledge of the technical baseline”

Takeaways

- Software sustainment is not like Hardware Sustainment – it involves continuous engineering
- The Software Sustainment Ecosystem conveys the complexity of sustaining software in today's environment
- Software Sustainment Workforce Gap Analysis highlights the issues (competencies, retention, etc)
- Skill Sets Model provides a structure to identify which software sustainment skills/capabilities need to be organic; and how to balance an organic and supplemental workforce



Backup Slides

Software Sustainment – SEI Definition

Software sustainment:

Orchestrating the processes, practices, technical resources, information, and workforce competencies for systems and software engineering...

.....to enable systems to continue mission operations and also to be enhanced to meet evolving threat and capability needs.