



An Assessment of the National Security Software Industrial Base

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**Center for Strategic and International Studies
Defense-Industrial Initiatives Group**

Executive Summary

- Size of software projects within the DoD and the national security community has grown exponentially and complexity has increased
- The issue is not the supply of programmers at the macro level. The overall ability to deliver code appears to be in line with demand, however in certain areas (Java software developers for example) the market is tight. There are, however, choke point issues with the upper tiers of the software developer cadres.
- The choke-point is in the pool of top-tier program management/software architect/senior technical talent, a cadre that is necessary given the low threshold where software projects become strained (\$10+ million of software content)
- Industry is trying to grow this cadre with “high potential” employee training/career development strategies; coordinating government HR strategies with industry is critical
- Current policies regarding when individuals can start security clearance process also creates issues when initially “ramping-up” software projects.

Key Observations/Conclusions (1)

- **The lack of comprehensive, accurate, timely and comparable data about software projects within DoD limits the ability to undertake any bottom-up analysis or enterprise-wide assessments about the demand for software.**
 - **If you cannot measure it, you cannot manage it**
 - **Bottom-up analysis not possible without better data**
 - **Potential to amend and leverage the DD2360**
- **The overall pool of software developers appears to be adequate**
 - **DoD business systems access this broader, global software industrial base, therefore with the use of COTS, supply-demand is not the issue, information assurance becomes the key issue.**
- **A supply-demand imbalance exists in the upper echelons of the software developer/ management cadres, exacerbated by the fact that this talent is not fungible outside their domains of expertise**
 - **No database exists to identify these key individuals, the demographics of this group or critical vulnerabilities by domain**
 - **This senior cadre can be grown but it takes time (10 years plus) and a concerted HR/career strategy**
 - **Worthwhile investigating management/architecture/systems engineering tools to improve the effectiveness of this senior cadre**



Key Observations/Conclusions (2)

- **If COTS software used in defense business systems requires modification to apply to particular domains, then the issues of limited pools of key technical/management talent identified begin to apply to defense business systems as well.**
- **“Desire” versus Supply as opposed to Demand versus Supply worth further investigation**
 - **What were expectations when first launching major systems**
 - **What is the total demand for software maintenance versus the funded portion, what is being deferred? What is the true cost and/or risk of deferral?**

Exponential growth in size of software projects driven by multiple factors:

- Users demanding more functionality of systems/platforms
- Exponential increase in computing and processing capacity provides opportunity for exponential growth in software content per system
- Software has inherent advantages for some functions such as control systems and signal processing (including lower production cost and higher reliability)
- Rapid growth over last decade of large-scale systems and Systems-of-Systems, which need software to “glue them together”
- Doctrinal drive to leverage and extend US battlefield information superiority

Platform	Year	% of Functions Controlled by SW
F-4	1960	8%
A-7	1964	10%
F-111	1970	20%
F-15	1975	35%
F-16	1982	45%
B-2	1990	65%
F-22	2000	80%

Growth in software a function of technology and capability needs, no let-up in demand foreseen

Source: DSB
quoting PM
Magazine

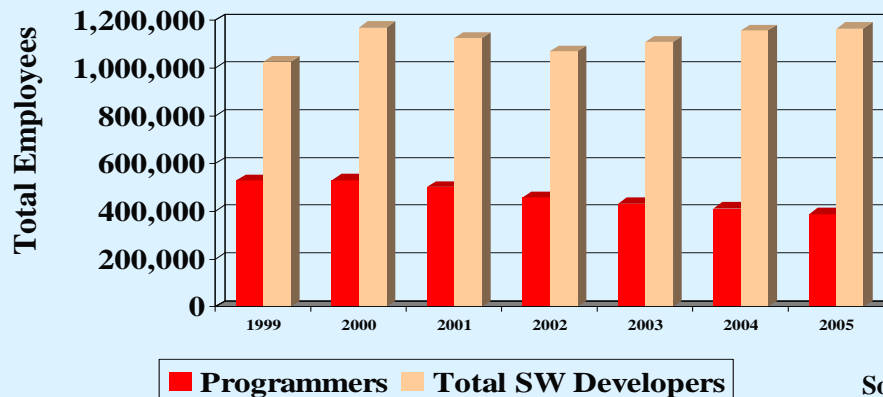
Begs the question: If size of software per system is growing exponentially, does DoD have enough capacity to satisfy this level of growth and activity?

- Three approaches to the problem:
 - An assessment of the supply-demand for critical software personnel
 - Bottom-up assessment based on the amount of software being requested (lines of code) and the potential supply
 - An assessment of the demand for software based on original baseline plan versus actual delivery – “desire” versus supply (this assessment was outside of the Phase I study scope)

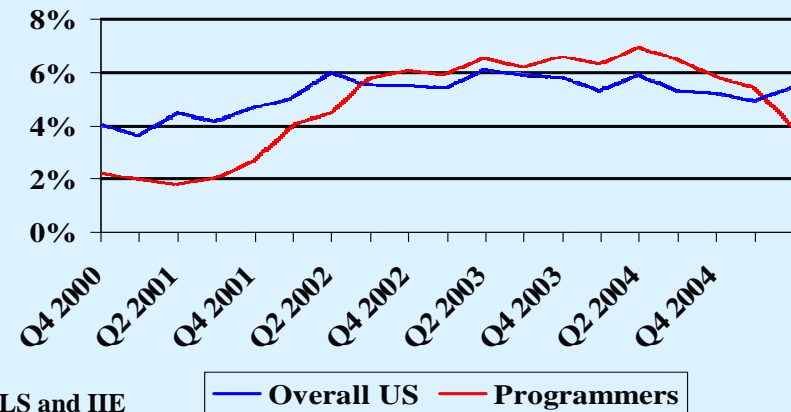
- **Key Observation: No comprehensive database of major software projects exists within DoD, either at the OSD or Service level.**
- **The lack of comprehensive, accurate, timely and comparable data about software projects within DoD limits the ability to undertake any bottom-up analysis or enterprise-wide assessments about the demand for software**

At the national level, supply of software programmers appears adequate

National Software Developer Employment



Software Developer Unemployment



Source: BLS and IIE

- National demand for programmers is declining, and projected to remain flat by the BLS (1.9% increase in programmer population from 2004-2014)
- Programmer unemployment levels equal or higher than the national average

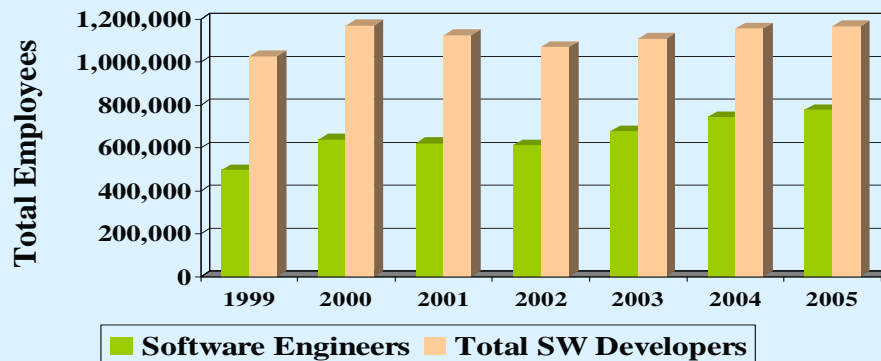
Observations:

- Demand flat due to tools and newer languages enabling higher productivity, and offshoring. Entry level moving up from “programmer”

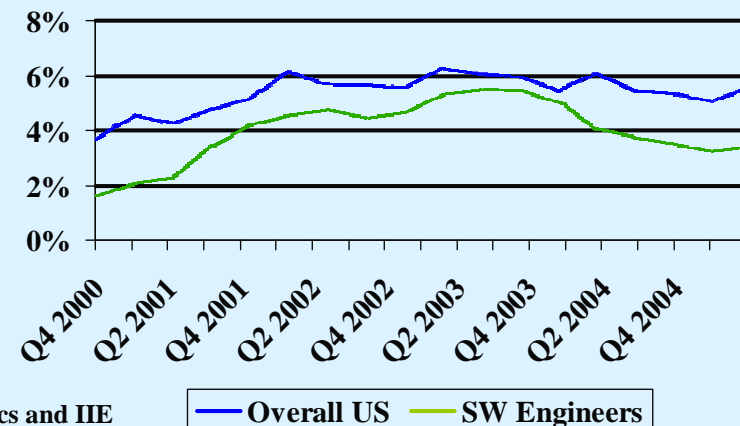
**No apparent problem with national supply of programmers
What about software engineers?**

At the national level, some issues with supply of software engineers (application and system)

National Software Developer Employment



Software Developer Unemployment



Source: Bureau of Labor Statistics and IIE

- National demand for software engineers rising, and projected to increase over 40% by BLS (48% growth in application software engineer population forecast 2004-2014, and 43% growth in system software engineers from 2004-2014)

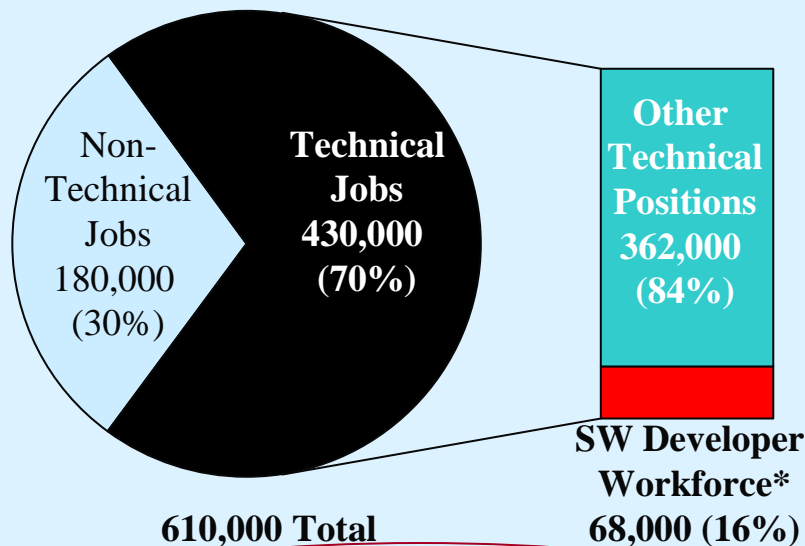
Observations:

- Schools awarding an estimated 60,000 computer/information sciences degrees a year to U.S. citizens and commercial industry able to access foreign talent

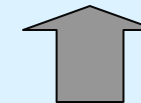
**If there are issues, it's at the upper end of the developer cadre
What about software development professionals with clearances?**

The pool of potential clearable software developers is large; however, ability to “ramp up” programs and attract new workers are key issues

Current Cleared National Security Contractor Workforce



**Total “Cleared” SW Developers*
68,000 (7% of US citizen SW workforce)**



Market demand
Self-selection (don't want to work in national security field)

**Total “Clearable” SW Workforce
Est. 690,000 (67% of US)**

Criminal Conduct
Drugs
Emotional/Mental Disorders
Dishonorable Military Discharge



**Total US Citizen SW Developer Workforce
1,030,000**

**CSIS Industry Survey indicates = 65K – 80K
In Nat'l Security SW Developer Workforce**

* Software developer workforce defined as Software Engineers (systems and applications) and Programmers supporting National Security

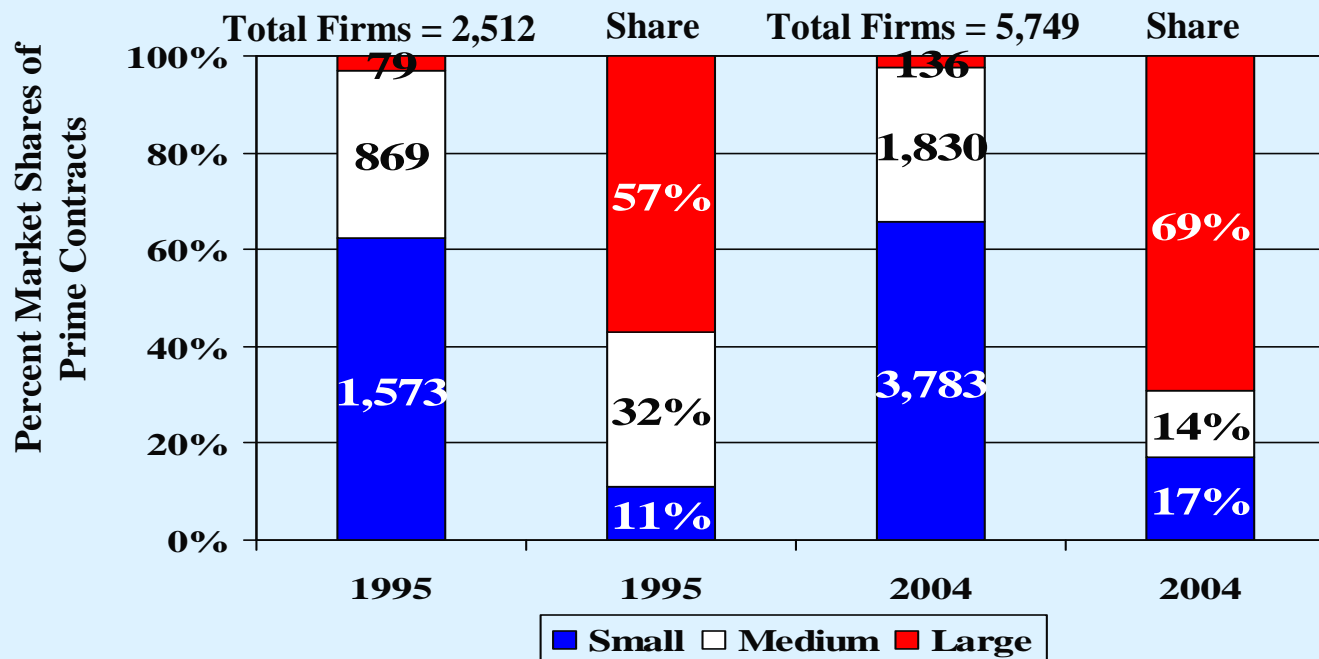
Industry's ability to “ramp up” individual programs constrained by clearance policies

- A “chicken and egg” situation has developed
 - Individuals need a security clearance to work on a project or be hired
 - Individuals cannot begin security clearance process unless they have a job/contract
- Larger firms may have the financial resources to hire new talent and wait until security clearances are issued (and then even large firms try to minimize idle capacity). Much harder for smaller firms.
- Need to ramp up once contracts awarded and lack of surge capacity encourages poaching among firms for pool of cleared people
- Another strategy involves subcontracting segments of the software (mitigating need for large software staffs and future risk of idle capacity), however coordination and management challenges increase
- Anecdotal evidence that programs are being classified at higher levels, further complicating search for cleared talent

Key Observation: Can “ramp up” problem be solved with a pre-cleared cadre of software professionals and/or review of policies regarding when security clearance process can begin?

Search for pools of cleared professionals has been one driver of consolidation in the defense IT/software industry

DoD Software/IT Industrial base by Number of Competitors and Market Share of Prime Contracts (by \$ value) to Large, Medium and Small Firms

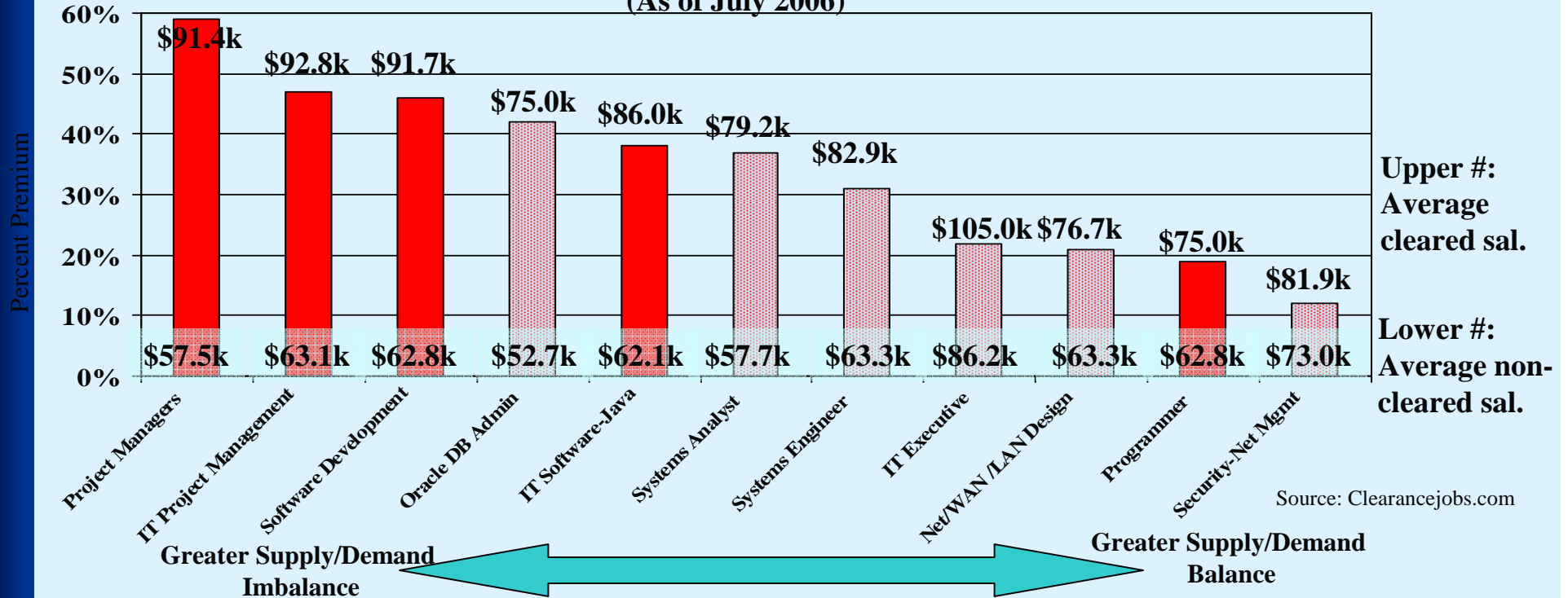


- “Critical mass” has increased
- Large scale projects also driving consolidation (big companies needed to take on big projects)
- Consolidation and size of projects has squeezed mid-tier
- Small business set asides improved small firms’ share

Category definitions: **Large Companies:** Have total sales from all sources of \$1B +
Medium Sized Companies: Have sales of under \$1B but in excess of US Federal Small Business limits
Small Businesses: Are designated by the US Federal Government as a Small Business

Premiums in software salaries for cleared professionals send important signals about the supply/demand

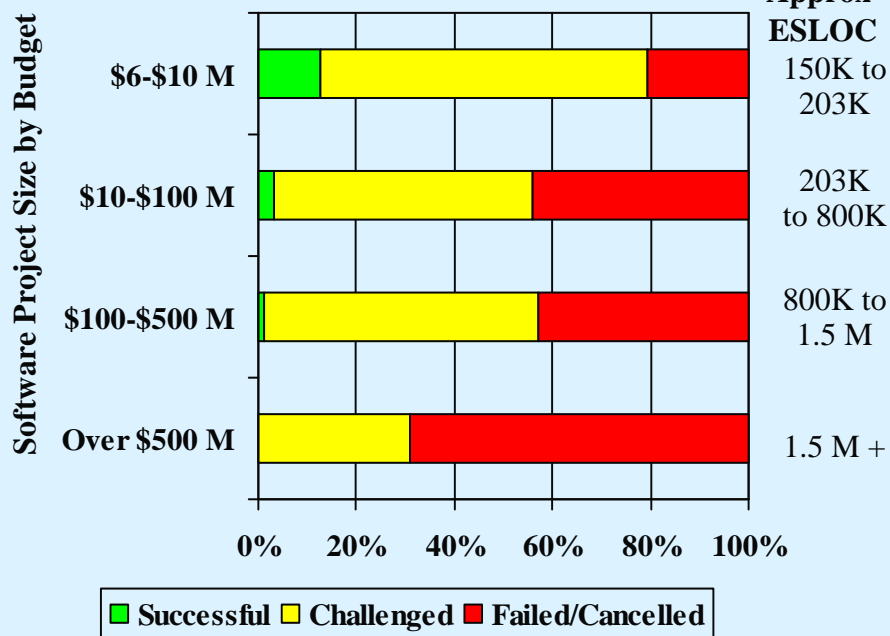
**Comparison of Average Starting Salaries for Cleared & Non-Cleared Positions
(As of July 2006)**



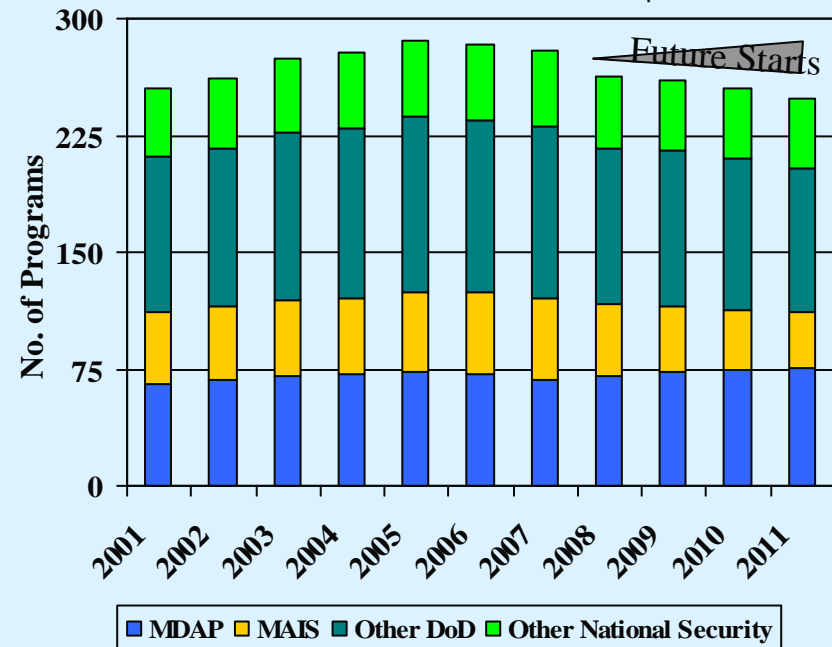
**Smaller premiums for cleared programmers signals limited issues (ex-Java)
Large premiums for senior management/development talent indicates issue**

Given the low threshold before software projects face problems ('Software Sound Barrier' is \$10 million), the need for experienced senior talent is critical for DoD

Results from Commercial & Government Software Development Programs, 1994 – 2004



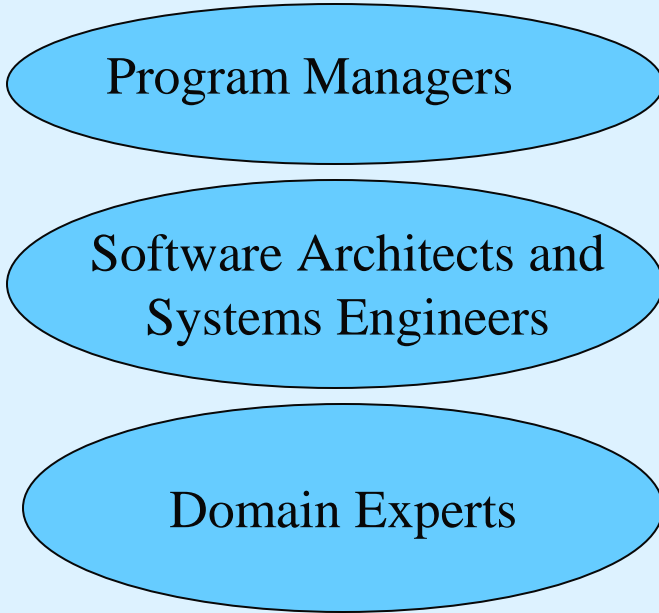
Est. No. of New Defense Development Programs With Software Content of \$10M +



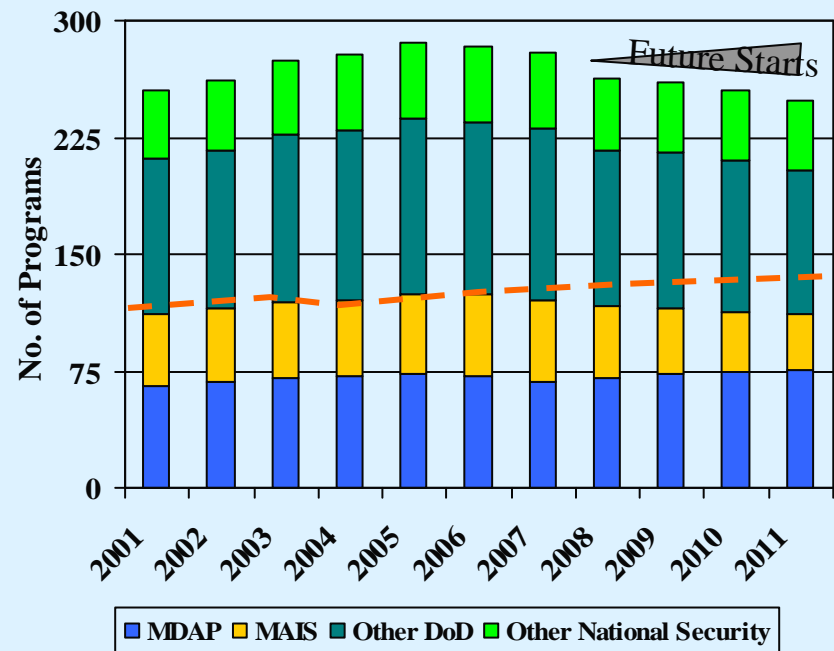
DoD has significant demand for experienced, senior program and software technical talent to usher high risk programs

From an industry survey, there are 500-600 individuals in this group considered to be the “elite”/”A-team”

Composition of the Elite/A-Teams



No. of Defense Development Programs Covered By Top-Tier Management Cadre (at 5 per)



Implies that national security community can cover about 100+/- national security projects with top-tier management teams



Fungibility of key talent also an issue, particularly with the domain experts

Program Managers	Fungible
Software Architects and Systems Engineers	Moderately fungible
Domain Experts	Not very fungible (outside of domain, can move from air traffic mgmt to air defense for example)

**Key issue is software expertise by domain
Industry attempting to create next generation
Note: No database exists to identify these key individuals, the demographics of this group or critical vulnerabilities by domain**

Observations Regarding Mitigation Strategies

- Reducing the number of programs over the “software sound barrier” is not realistic given DoD needs, however there are software program management techniques which break-up programs into smaller software build packages
 - More, smaller programs increase the need for overall management/coordination talent
- Continue to explore software development tools and techniques that can aid in the architecture/design of projects
- Grow/expand the top-tier/A-class cadre
 - Research indicates this can be done

Research indicates the top-tier cadre are born and then honed (part nature, part nurture)

Key personal attributes for systems engineers/program managers:

- Curious, questioning, open-minded
- Broad and/or out-of-the-box thinkers
- Good communicators
- Tolerance for uncertainty

Key attributes of the domain experts centered on deep technical depth and ability to translate complex user requirements into a system design

The Domain Experts, Systems Engineers, Program Managers honed via:

- 10-15 years of experience
- Education must be paired with practical experience (solving real problems)
- Holding jobs in multiple disciplines / work on a variety of tasks (after first getting grounding in a particular field)
- Must have technical depth

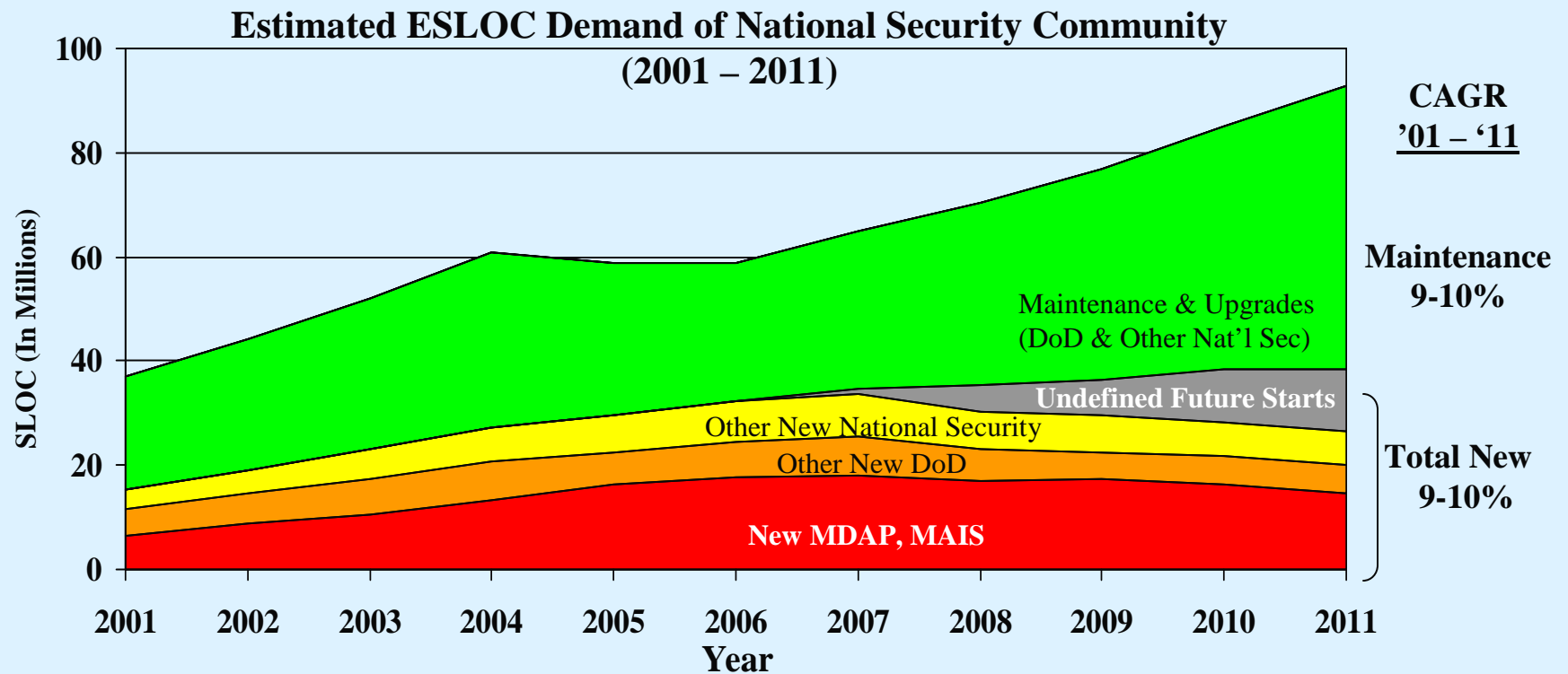
Problems in growing this cadre are often organizational boundaries and too narrow experiences

Observation: Key industry players implementing “high potential” employee training/career development strategies in attempt to grow this cadre, coordinating government HR strategies with industry critical



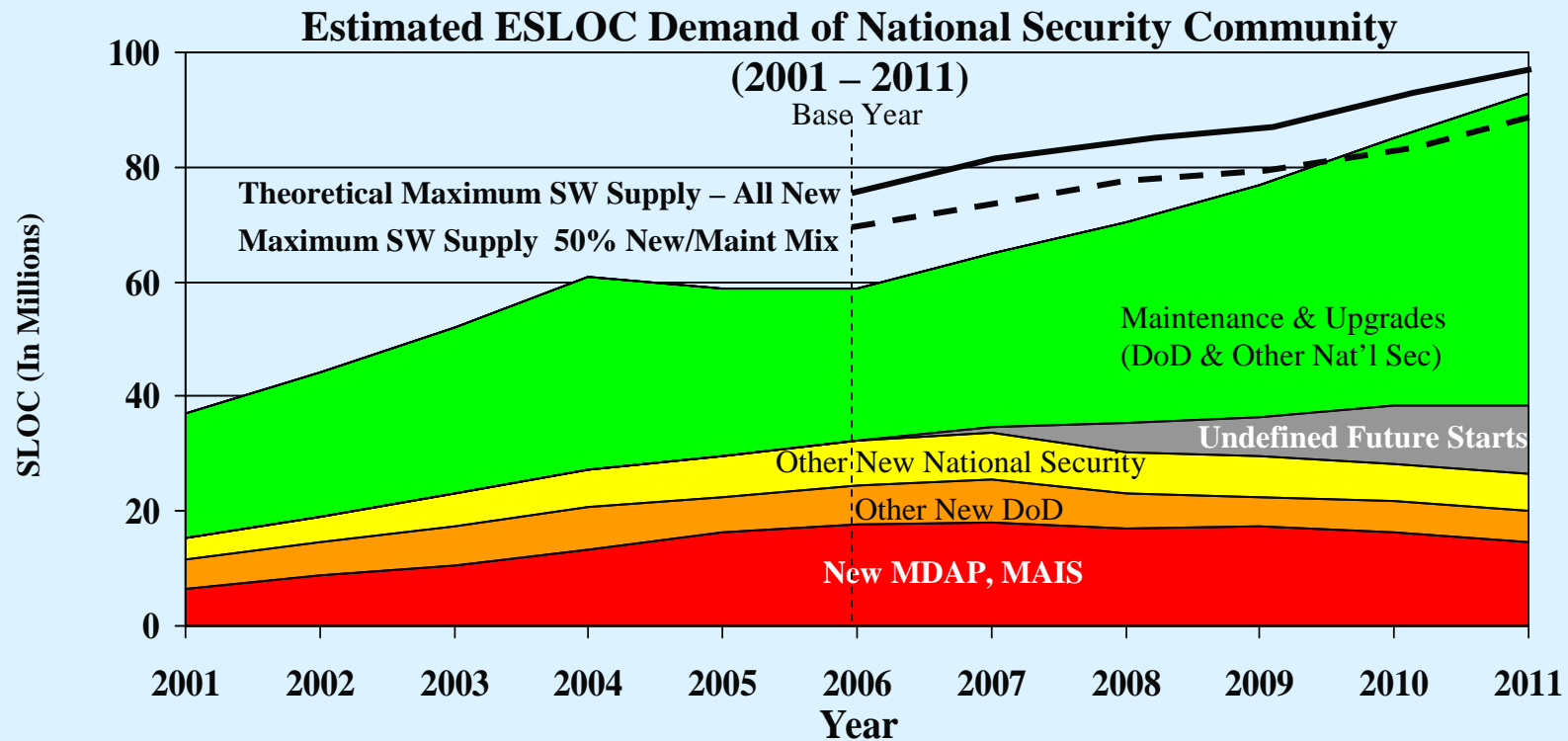
Parametric Analysis – A Second View

Estimated Demand for New and Maintenance Software: Maintenance Effort Growing as Fast as New Development



Note: No central or easily comparable sources of software maintenance and upgrade data found – even within Services. Need common software data collection process and repository to manage effectively.

Estimated overall software supply exceeds software demand for now: potential issues in mid-term



Note: Focused on weapon systems and major C4ISR, overall software productivity rates held constant over FYDP



Full Demand Analysis – A Third Approach

Potential Desire versus Supply

- Because demand = supply over the long haul
- May be worthwhile assessing “desire” versus demand
 - Assess the baseline demand for software at initial conception of a program
 - Compare to actual production of software and schedule
 - Would produce a “desire – supply” curve
 - Permits testing of thesis that “desire” is growing exponentially and “supply” is growing linearly
- Additionally, true software maintenance demand should be examined as if meeting 100% of requirements was planned
 - Maintenance and upgrade projects largely on-time/budget but
 - Services now meeting only 45% – 70% of SW maintenance and upgrade requirements
 - Demand should be examined at full requirements level versus funded level
 - what is being deferred?
 - what is true cost/risk of maintaining old language/code?



Appendix



Software Developers is the group of concern

Occupation	2005 Pop(000)	Post-Secondary-Education	Job Functions
Software Developers (Total)	1,166		
Computer programmers	389	Bachelor's degree	Develop and write computer programs to store, locate, and retrieve specific documents, data, and information. May program web sites."
Computer software engineers, applications	456	Master's/ Bachelor's degree	"Develop, create, and modify general computer applications software or specialized utility programs. Analyze user needs and develop software solutions. Design software or customize software for client use with the aim of optimizing operational efficiency.
Computer software engineers, systems software	321	Master's/ Bachelor's degree	"Research, design, develop, and test operating systems-level software, compilers, and network distribution software for medical, industrial, military, communications, aerospace, business, scientific, and general computing applications. Set operational specifications and formulate and analyze software requirements."
Computer and Information Scientists, Research	26	Doctorate	Conduct research into fundamental computer and information science as theorists, designers, or inventors. Solve or develop solutions to problems in the field of computer hardware and software
Database administrators	99	Bachelor's degree	Coordinate changes to computer databases, test and implement the database systems including planning and implementing security measures
Network and computer systems administrators	270	Bachelor's degree	Install, configure, and support an organization's local area network (LAN), wide area network (WAN), and Internet system. Maintain network hardware and software.
Computer support specialists	500	Associate's degree	Provide technical assistance to computer system users including hardware and software, systems.
Computer systems analysts	677	Bachelor's degree	Research/recommend solutions for science, engineering, business, and all other data processing problems for application to electronic data processing systems.
Network systems and communications analysts	185	Bachelor's degree	Research/recommend network and communications hardware & software.
Computer Specialists, All Other	117	Bachelor's degree	All computer specialists not listed separately.



Data sources

Non-DoD

- Reports Utilized by Category & No.
 - Workforce/Economic - 22
 - Software Demand - 16
 - College IT Graduates - 11
 - Programmer Productivity – 10
 - Misc. – 10
- Software Consultants
 - Standish Group (CHAOS studies)
 - QSM, Inc.
 - Reifer
- Industry Interviews

– Defense Industry	13
– Other Industry	<u>1</u>
Total	14

DoD

- CAIG Software Cost Data Samples
28 MDAPS/MAIS Programs
- NII: Selected Program Software Parameters
- Department Interviews

– OSD/AT&L Defense Sysms Mgmt:	6
– Current and Fmr AT&L leadership:	2
– Other OSD Mgmt :	2
– Service Chief Engineers:	3
– Program Exec Officers (PEOs):	4
– Program Offices:	16
– Software Sustainment Centers	<u>6</u>
Total	39



Research Resources

AIIM
Air Force Research Laboratory
Army Research Office
Assistant Secretary of Defense for NII
Boeing
Booz, Allen & Hamilton
Bureau of Labor Statistics
CACI
CATO Institute
Center for Defense Information
Center for National Software Studies
Center for Software Engineering, USC
Center for Technology and National Security Policy, NDU
Computer Sciences Corporation
Computing Research Association
Congressional Research Service
Council on Competitiveness
Defense Acquisition University
DARPA
Defense Information Systems Agency
Defense Science Board
Defense Technical Information Center
Department of Defense Enterprise Software Initiative
Director for Defense Research and Engineering
Director for Program Analysis and Evaluation
Electronic Industries Alliance
Escher Institute
Federal Sources, Inc.
Gartner, Inc.
General Accounting Office
Government Electronics and Information Association
IBM
Information Technology Association of America
Inforum, University of Maryland
Institute for Defense Analysis
Institute for Software Research, University of California at Irvine
Institute of Electrical and Electronics Engineers
Kestrel Institute
Library of Congress
Lockheed Martin
Microsoft
MIT Lincoln Laboratory
Mitre
National Academy of Engineering
National Coordination Office for Computing, Information, and Comm.
National Defense Industrial Association
National Research Council
National Science Foundation
National Software Alliance



Research Resources (Cont)

National Technical Information Service
Naval Research Laboratory
Northrop Grumman
Quantitative Software Management
Rand
Raytheon
SAIC
Sandia National Laboratories
Software Engineering Institute, Carnegie Mellon University
Software Engineering Research Center
Software Technology Support Center
SRI International
Standish Group
Systems and Software Consortium
The Data and Analysis Center for Software
The Northern Virginia Technology Council
Under Secretary of Defense for Acquisition, Technology & Logistics
Washington Technology