

# A Human Capital Crisis in Cybersecurity

## Technical Proficiency Matters

A Report of the  
CSIS Commission on Cybersecurity for the 44th Presidency

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# CONTENTS

Executive Summary	v
Vision for the Future Cybersecurity Workforce	5
Current Efforts	6
Other Efforts that Could Make a Big Difference	9
Next Steps: Recommendations	13
Recommended Action Plan	14
Long-term Recommendations	16
Governance	16
Analysis of Alternatives	16
Summary Assessment	19
Conclusion	19
Appendix A. Federal CIO Documents	20
1. Federal Information Security Workforce Development Matrix: Roles Identification, Definition, and Prioritization	20
2. Information Security Workforce Development Matrix: Systems Operations and Maintenance Professional	22
3. Information Security Workforce Development Matrix : Chief Information Security Officer	23
4. U.S. Cyber Command: Memorandum for Secretaries of the Military Departments	24
Appendix B. Taxonomy of Cybersecurity Roles	27
Appendix C. Draft Definition for Potential Legislation	32
Appendix D. Cybersecurity Workforce Action Plan	33
Appendix E. Acknowledgments	34
About the Authors	35



## EXECUTIVE SUMMARY

### Crisis in Cybersecurity

“The cyber threat to the United States affects all aspects of society, business, and government, but there is neither a broad cadre of cyber experts nor an established cyber career field to build upon, particularly within the Federal government.”<sup>1</sup>

Evidence continues to build showing that our information infrastructure is vulnerable to threats not just from nation states but also from individuals and small groups who seek to do us harm or who wish to exploit our weaknesses for personal gain.

### Where We Are

The nation and the world are now critically dependent on the cyber infrastructure that is vulnerable to threats and often under attack in the most real sense of the word. Military and nuclear energy systems are under continuous attack, experiencing large losses. For at least the past six years the U.S. Department of Defense, nuclear laboratory sites and other sensitive U.S. civilian government sites have been deeply penetrated, multiple times, by other nation-states. As stated by Gen. William Lord, Chief of Warfighting Integration and Chief Information Officer in the Office of the Secretary of the U.S. Air Force, “China has downloaded 10 to 20 terabytes of data from the NIPRNet (the sensitive, but unclassified U.S. military network). There is a nation-state threat by the Chinese.”<sup>2</sup>

Terrorists and organized crime groups are actively exploiting weak U.S. security and extorting money used for criminal purposes and to buy terrorist bombs. In October 2008, for example, Express Scripts, one of the nation’s largest processors of pharmacy prescriptions, reported that extortionists had threatened to disclose personal and medical information on millions of Americans if the company failed to meet payment demands.

A critical element of a robust cybersecurity strategy is having the right people at every level to identify, build and staff the defenses and responses. And that is, by many accounts, the area where we are the weakest. According to interviews conducted with Jim Gosler, NSA Visiting Scientist and founding director of the CIA’s Clandestine Information Technology Office, there are only about 1,000 security specialists in the United States who have the specialized skills to operate effectively in cyberspace; however, the United States needs about 10,000 to 30,000 such individuals.<sup>3</sup>

The problem is both of quantity and quality, especially when it comes to highly skilled “red teaming” professionals. We not only have a shortage of the highly technically skilled people required to operate

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<sup>1</sup> Center for Strategic and International Studies, “Securing Cyberspace for the 44th Presidency,” December 2008, p. 72, [http://csis.org/files/media/csis/pubs/081208\\_securingcyberspace\\_44.pdf](http://csis.org/files/media/csis/pubs/081208_securingcyberspace_44.pdf).

<sup>2</sup> Dawn S. Onley and Patience Wait, “Red storm rising,” *Government Computer News*, August 17, 2006, <http://gcn.com/articles/2006/08/17/red-storm-rising.aspx>.

<sup>3</sup> Jim Gosler, “Cyberwarrior Shortage Threatens U.S. Security,” *NPR Morning Edition*, July 19, 2010, <http://www.npr.mobi/templates/transcript/transcript.php?storyId=128574055>.

and support systems already deployed, but also an even more desperate shortage of people who can design secure systems, write safe computer code, and create the ever more sophisticated tools needed to prevent, detect, mitigate and reconstitute from damage due to system failures and malicious acts.

The cybersecurity workforce to which we speak in this report consists of those who self-identify as cybersecurity specialists as well as those who build and operate our systems and networks. That workforce includes not only workers on government payrolls, but also those contractors who operate as part of the extended government workforce. It also includes those who build and maintain the critical infrastructure on which the public and private sectors have come to rely.

## Where We Need to Go

Having the right number of people with the requisite technical skills matters and there are four elements of any strategy to deal with this challenge:

- Promote and fund the development of more rigorous curriculums in our schools.
- Support the development and adoption of technically rigorous professional certifications that include tough educational and monitored practical components.
- Use a combination of the hiring process, the acquisition process, and training resources to raise the level of technical competence of those who build, operate, and defend governmental systems.
- Ensure there is a career path, as with other disciplines like civil engineering or medicine, to reward and retain those with high-level technical skills.

It is the consensus of the Commission that the current professional certification regime is not merely inadequate; it creates a dangerously false sense of security for the following reasons:

- Individuals and employers are spending scarce resources on credentials that do not demonstrably improve their ability to address security-related risks; and
- Credentials, as currently available, are focused on demonstrating expertise in documenting compliance with policy and statutes rather than expertise in mitigating risks and preventing and responding to attacks.

In many ways, cybersecurity is similar to 19<sup>th</sup> century medicine – a growing field dealing with real threats with lots of self-taught practitioners, only some of whom know what they are doing. The evolution of the practice of medicine mandated different skills and specialties coupled with qualifications and assessments. In medicine, we now have accreditation standards and professional certifications by specialty. We can afford nothing less in the world of cybersecurity. We need to develop a culture of professionalism -- and set the right goals -- for the cybersecurity workforce. Doing so will help prevent, detect, and/or respond to intentional or unintentional compromises involving both federal and other critical infrastructure systems.

## What Is Being Done

Skills and experience matter. They must be taught, and then demonstrated on the job. The Commission's work has been focused on those currently in the workforce, and those who are, or will shortly be, in the labor pool.

We do not start with a blank slate. There are several initiatives attempting to address the issues of career paths and training of the cybersecurity workforce. Organizations and initiatives that can be leveraged going forward include the Department of Homeland Security (DHS), International Information Systems Security Certification Consortium, Information Systems Audit and Control Association, the Institute of Electrical and Electronics Engineers, Department of Justice (DOJ), Federal Bureau of Investigation (FBI), National Security Agency (NSA), Department of Defense (DOD), Federal Chief Information Officers Council, Office of Personnel Management (OPM), Department of State (DOS), U.S. Cyber Command (USCYBERCOM), and U.S. Cyber Challenge.

## How We Get from Where We Are to Where We Need to Be

With all these activities underway, it is the Commission's intention to give impetus to and leverage the existing efforts and initiatives to move forward in a comprehensive and coherent manner. This report focuses on those actions that the federal government can take in the short to medium term to develop and hire a more cybersecurity capable workforce. By using its instruments of direct control – hiring and procurement – and by serving as a model, the federal government can significantly influence the quantity and quality of the cybersecurity workforce.

***Expand cyber education.*** The current Administration is addressing the education of cyber professionals as part of the Comprehensive National Cybersecurity Initiative, an unclassified description of which was released on March 2, 2010. The topic is included as Initiative 8:

While billions of dollars are being spent on new technologies to secure the U.S. Government in cyberspace, it is the people with the right knowledge, skills, and abilities to implement those technologies who will determine success. However there are not enough cybersecurity experts within the federal Government or private sector to implement the CNCI, nor is there an adequately established federal cybersecurity career field. Existing cybersecurity training and personnel development programs, while good, are limited in focus and lack unity of effort. In order to effectively ensure our continued technical advantage and future cybersecurity, we must develop a technologically skilled and cyber-savvy workforce and an effective pipeline of future employees. It will take a national strategy, similar to the effort to upgrade science and mathematics education in the 1950's, to meet this challenge.<sup>4</sup>

The Commission makes recommendations to build on the current activities of both the Executive Branch and the Legislative Branch. Additionally, there is an Action Plan, including a time line, in order to address those recommendations. Long-term recommendations for sustainability and governance are also included.

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<sup>4</sup> "The Comprehensive National Cybersecurity Initiative," U.S. National Security Council, [www.whitehouse.gov/cybersecurity/comprehensive-national-cybersecurity-initiative](http://www.whitehouse.gov/cybersecurity/comprehensive-national-cybersecurity-initiative).



***Build a rigorous certification system in two or three specialty areas.*** On the basis of our analysis, the Commission is recommending the creation of a governance body, which would develop and administer certifications in two or three specialty areas, where rigorous certifications do not exist. The governance body should also develop criteria for evaluating other certification programs so that, using a federated model, other existing or future certification programs that meet its standards can also be accredited. The organization could be created initially as not-for-profit and there should be an oversight board that would include representatives of each of the following:

- Major private sector organizations that employ cybersecurity professionals;
- Universities with major cyber education and research programs; and
- Key federal government agencies.

The role of the oversight board would be to direct and evaluate a two-year pilot test and, at the end of the first year, offer recommendations on whether/how the body should continue.

## **Conclusion**

We are unified by a shared objective to help protect our critical infrastructure by detecting, responding to, and ultimately, preventing cyber attacks and accidents. Technology alone can't solve the problem. We need good people. The Commission found that, while a number of initiatives and efforts are underway, much remains to be done. The recommendations in this paper are designed to accelerate reaching two goals: (1) expanding the number and quality of highly skilled cybersecurity professionals and (2) giving those who hire those workers or who buy their services even better indicators of the skill levels of those whom they are engaging.

While much is being done, our adversaries are growing in number and capability. We must redouble our efforts.

# A HUMAN CAPITAL CRISIS IN CYBERSECURITY

## TECHNICAL PROFICIENCY MATTERS

“The cyber threat to the United States affects all aspects of society, business, and government, but there is neither a broad cadre of cyber experts nor an established cyber career field to build upon, particularly within the federal government. [Using an] airplane analogy, we have a shortage of ‘pilots’ (and ‘ground crews’ to support them) for cyberspace.”<sup>1</sup>

That the nation and the world are now critically dependent on the cyber infrastructure is no longer a matter of debate. Evidence continues to build showing that our systems for power (nuclear and conventional), water, banking, and credit, as well as our national security and public safety systems rely on complex and sophisticated computer and telecommunications technology. That information infrastructure is vulnerable to threats not just from nation states but also from individuals and small groups who seek to do us harm or who wish to exploit our weaknesses for personal gain. As stated by Gen. William Lord, Chief of Warfighting Integration and Chief Information Officer in the Office of the Secretary of the U.S. Air Force, “China has downloaded 10 to 20 terabytes of data from the NIPRNet (the sensitive, but unclassified U.S. military network). There is a nation-state threat by the Chinese.”<sup>2</sup>

Terrorists and organized crime groups are actively exploiting weak U.S. security and extorting money used for criminal purposes and to buy terrorist bombs. In October 2008, for example, Express Scripts, one of the nation’s largest processors of pharmacy prescriptions, reported extortionists had threatened to disclose personal and medical information on millions of Americans if the company failed to meet payment demands.

A critical element of a robust cybersecurity strategy is having the right people at every level to identify, build and staff the defenses and responses. And that is, by many accounts, the area where we are weakest. For instance, when asked about the most critical problem facing the military as it responds to the growing cyber challenge, Lt. Gen. Charles Croom, Commander of the Joint Task Force-Global Network Operations, stated, “I cannot get the technical security people I need.”<sup>3</sup> These views are supported by other government officials. According to Jim Gosler, NSA Visiting Scientist and founding director of the CIA’s Clandestine Information Technology Office, “There are about 1,000 security people in the U.S. who have the specialized security skills to operate effectively in cyberspace. We need 10,000 to 30,000.”<sup>4</sup>

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<sup>1</sup> CSIS, “Securing Cyberspace,” p. 72.

<sup>2</sup> “Red storm,” <http://gcen.com/articles/2006/08/17/red-storm-rising.aspx>.

<sup>3</sup> Response to a question from a member of the CSIS Commission on Cybersecurity, May 28, 2008.

<sup>4</sup> “Cyberwarrior Shortage,” <http://www.npr.mobi/templates/transcript/transcript.php?storyId=128574055>.

The problem is both of quantity and quality, especially when it comes to highly skilled “red teaming” professionals. The December 2008 CSIS report in some ways understates the problem. We not only have a shortage of the highly technically skilled people required to operate and support systems we have already deployed, we also face an even more desperate shortage of people who can design secure systems, write safe computer code, and create the ever more sophisticated tools needed to prevent, detect, mitigate, and reconstitute systems after an attack.

The reality of the staffing problem was illuminated on April 19, 2007, in a hearing of the U.S. House of Representatives Homeland Security Committee, Subcommittee on Emerging Threats, Cybersecurity and Science and Technology. Witnesses from the Department of State (DOS) and the Department of Commerce (DOC) both testified their systems were penetrated with zero-day attacks (attacks using exploits for which no patch exists). The Commerce Department witness testified he did not know when the attack had first occurred. He said the attack had spread to at least 32 systems, all of which were contacting servers in China. These DOC systems were in the Bureau of Industry and Security (BIS), the division that determines which U.S. technologies are too sensitive to be exported. He further said he did not know how many other BIS systems were infected or whether the infections had been eliminated from DOC networks. The DOS witness, on the other hand, testified that his people found the attack within moments after it had occurred, cleaned the infected system, and stopped the infection’s spread. The DOC witness said his organization had met the compliance requirements of the Federal Information Security Management Act (FISMA) but the attack got through because it used a zero-day vulnerability. By contrast, the DOS witness, who also met FISMA compliance requirements, had built a team of network forensics investigators, deep-packet-analysis experts and security programmers who could find and eliminate problems.

Richard Hale, Chief Information Assurance Executive at the Defense Information Systems Agency (DISA), told a small gathering at the March 2010 RSA Conference in San Francisco that the Department of State experience directly mirrors what DISA finds when it evaluates DOD facilities. Those units that are overly dependent on security tools rarely find the Advanced Persistent Threat (APT) while those that have deep and broad technical security skills and constantly adapt the tools to changing threat patterns are the ones that find and eliminate the APT.

In January 2010, after Google and other commercial companies reported that their systems had been hacked by a foreign government, representatives from these companies met with U.S. government officials and asked why the government was not doing a better job of protecting such systems. The answer was that today’s tools are ineffective in stopping advanced persistent threats; and that the companies themselves needed to upgrade the skills of their security hunters. Hunters are the people who can dig deeply into the workings of computers and networks to track the attackers who get through the organization’s defenses. Although commercial companies have long sought such people, they are in fact in very short supply and the competition for these people is fierce. Simply put, there are not enough to go around.

Having the right number of people with the requisite technical skills matters. That’s what the comparison of the DOC and DOS experiences illustrates. There are four elements of any strategy to deal with this challenge, all of which can be accelerated by governmental action:

- *Promoting and funding the development of more rigorous curricula in our schools.* The National Science Foundation and the National Security Agency, among others, have begun to move in this direction. While there are understandable concerns about infringement on academic discretion, there is a connection between the skill level of those who build systems and the safety and security of those systems. Several U.S. colleges, funded under the Scholarship for Service program, have been graduating security experts with advanced technical skills, but the total number of new graduates with very deep technical skills is well under 200 per year.
- *Supporting the development and adoption of technically rigorous professional certifications that include a tough educational component and a monitored practical component.* Unfortunately, there is already a plethora of certifications, some of which require little more than passing a written examination and being able to describe one's job experience creatively. And all but a few focus on terms and principles, not on the hard technical skills and knowledge that are in such short supply.
- *Using a combination of the hiring process, the acquisition process, and training resources to raise the level of technical competence of those who build, operate, and defend governmental systems.* We need to be sure those whom we hire, whether as federal employees or contractors, have the requisite skills. As more rigorous professional certifications based upon a common body of knowledge become available, we have a duty to those currently in the workforce to help them obtain this knowledge and earn such credentials.
- *Assuring there is a career path as with other disciplines, like engineering or medicine, and rewarding and retaining those with high-level technical skills, both in the civilian workforce and in the uniformed services.*

It is the consensus of the Commission that the current professional certification regime is not merely inadequate; it creates a dangerously false sense of security for the following reasons:

- Individuals and employers are spending scarce resources on credentials that do not demonstrably improve their ability to address security-related risks; and
- Credentials, as currently available, are all too often focused on demonstrating expertise in documenting compliance with policy and statutes rather than expertise in actually mitigating risks and preventing and responding to attacks.

Any efforts to mandate certifying and licensing requirements based on the current regime of professional certifications would be premature. The issues of certification and licensing of computer professionals, especially software engineers, has been quite controversial. The Association for Computing Machinery (ACM), among others, has strongly opposed licensing software engineers. There seems to be little controversy, however, about the need for greater professionalization, defined as demonstrated competence in a defined body of knowledge and commitment to ethical standards.

We would also draw a distinction between certification and licensing. Professional certification is the process by which individuals show that they know and can apply a specific body of knowledge. Licensing, as we use the term, is a state function that is based on a finding that the public interest requires that the right to practice in a field be regulated in some fashion; this right is presumably based, at least in part, on the possession of a professional certification.

It is our view that certification and, ultimately, licensing regimes are essential elements for informing and protecting those who buy complex professional services that the buyers are often unable to evaluate. Any such regime must be based on an individual's ability to understand and apply a body of knowledge that represents the complete set of concepts, terms and activities that make up a professional domain. Further, certifying organizations carry the burden of proof; namely, that those who can earn the credential that these organizations offer are demonstrably more competent than those who cannot. Absent such a body of knowledge and demonstration there is little basis for supporting a certification program. Indeed such certifications would be dangerous and misleading. For the moment, the emphasis needs to be on building on what has already been done to increase the number and rigor of professional certifications. The marketplace and political system will ultimately decide whether those certifications become licenses, *de facto* or *de jure*.

A complete body of knowledge covering the entire field of software engineering may be years away. However, the body of knowledge needed by professionals to create software free of common and critical security flaws has been developed, vetted widely, and kept up to date. That is the foundation for a certification program in software assurance that can gain wide adoption. This body of knowledge was created in late 2008 by a consortium of national experts, sponsored by DHS and NSA, and was updated in late 2009. It contains ranked lists of the most common errors, explanations of why the errors are dangerous, examples of those errors in multiple languages, and ways of eliminating those errors.<sup>5</sup>

Any programmer who writes code without being aware of those problems and is not capable of writing code free of those errors is a threat to his or her employers and to others who use computers connected to systems running his or her software.

Just as a body of knowledge exists for creating software free of common and critical security flaws, the development of other certifications will depend on the development of similar bodies of knowledge. The path to meaningful certification should also be one that is structured. For example, educational institutions should teach the “theory” of good coding, provide specialized instruction on the “hands-on practice” of good coding, and examinations.

In many ways, cybersecurity is a lot like 19<sup>th</sup> century medicine – a growing field dealing with real threats with lots of often self-taught practitioners, only some of whom know what they are doing. What has evolved in medicine over the last century is a system that recognizes that different kinds of skills and specialties are required. And, since most of us are not able to assess the qualifications of a practitioner when a need arises, we now have an education system with accreditation standards and professional certifications by specialty. We can afford no less in the world of cyber.

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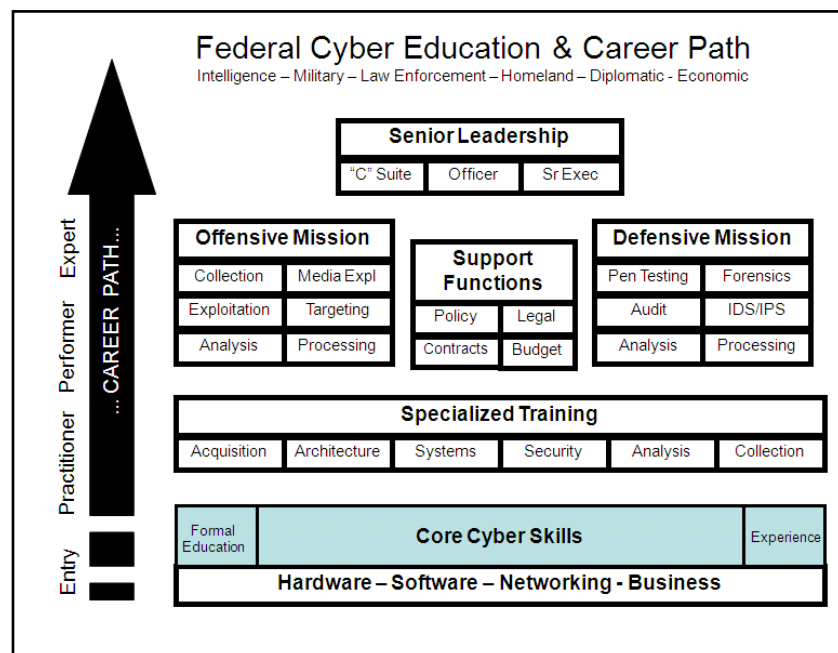
<sup>5</sup> More information about the certification program can be found at <http://cwe.mitre.org/top25>.

We need to be clear why human capability is so important. Tools and techniques, like automated configuration and patch management, help greatly, but we will continue to need capable personnel to create such tools, and to handle those issues not subject to automated detection and response. If we have learned nothing else, we now know that those who seek to exploit our weaknesses for gain, to do us harm, or even just for mischief, are every bit as smart as we are. We seek to change the mindset of the current workforce and to 1) develop a workforce of true cybersecurity professionals and 2) “security-enable” the broader workforce. We need both a cadre of cybersecurity professionals and a “cyber-enhanced” workforce that is security aware. For example, those who design, build, code and maintain systems need to be security aware in order address the challenge facing the nation.

## Vision for the Future Cybersecurity Workforce

The Commission envisions a technically proficient cybersecurity workforce to prevent, detect, recover, and/or respond to intentional or unintentional compromises both on federal and critical infrastructure systems.

The following diagram illustrates an agreed upon vision for the learning disciplines associated with the cybersecurity workforce development:



**Assumption:** This paper is based on a simple assumption: **Skills matter and must be demonstrated on the job.**

This report suggests those actions that the federal government can take in the short to medium term to develop and hire a more cybersecurity capable workforce. By using its instruments of direct control – hiring and procurement – and by serving as a model, the federal government can significantly influence the quantity and quality of the cybersecurity workforce.

Our proposals recognize the work in progress and attempt to build upon existing efforts, some of which are described below.

**Background:** The workforce challenge is being addressed in several ways:

(1) encouraging more young people, starting in elementary school, to pursue education and training in the more quantitative fields of science, technology, engineering, and math to prepare them to be cybersecurity workers, (2) developing more rigorous curricula in computer-related disciplines; and (3) automating daily operational tasks in cybersecurity, like configuration and patch management. While these approaches offer promise for addressing part if not the entire problem in the longer term, we cannot afford to wait. Hence, the Commission's work has been focused on those currently in the workforce and those who are, or will shortly be, in the labor pool.

### ***Current Efforts***

We do not start with a blank slate. The following is a short description of several organizations and initiatives that attempt to address the issues related to career paths and the training of the cybersecurity workforce. This listing is by no means exhaustive, but it does attempt to highlight some initiatives that can be leveraged going forward.

#### **Department of Homeland Security (DHS)**

**IT Security Essential Body of Knowledge (EBK): A Competency and Functional Framework.** The EBK is a framework to map Information Technology (IT) security competencies. DHS has included fourteen areas ranging from incident management through digital forensics. The EBK was developed as complimentary framework to existing efforts of the National Institute of Standards and Technology (NIST) and the Committee on National Security Systems (CNSS) guidance on IT security training. DHS built upon established work resources and best practices from the public and private sectors. The EBK is intended to be a resource tool for the public and private sectors, as well as higher education in its development of curriculum and training.<sup>6</sup>

#### **International Information System Security Certification Consortium (ISC)<sup>2</sup> (<http://www.isc2.org>)**

**Certified Information Systems Security Professional (CISSP)** is an information security credential accredited by ANSI ISO/IEC Standard 17024:2003 accreditation and leads the industry in acceptance. This certification is included in the DOD Information Assurance Workforce Improvement Program. The CISSP curriculum includes ten Common Body of Knowledge (CBK) information security topics. According to the (ISC)<sup>2</sup>, "the CISSP CBK is a taxonomy – a collection of topics relevant to information security professionals around the world. The CISSP CBK establishes a common framework of information security terms and principles that allow information security professionals worldwide to discuss, debate, and resolve matters pertaining to the profession with a common understanding."<sup>7</sup>

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<sup>6</sup> See <http://www.us-cert.gov/ITSecurityEBK>.

<sup>7</sup> Harold F. Tipton, *Official (ISC)<sup>2</sup> Guide to the CISSP CBK*, 2nd ed. (New York: Auerbach Publications, 2009).

## ISACA

ISACA,<sup>8</sup> originally known as the Information Systems Audit and Control Association, has established the Control Objectives for Information and related Technology (CoBIT) auditing and control standards, which are widely recognized and used. ISACA offers the following:

- Certified Information Systems Auditor (CISA);
- Certified Information Security Manager (CISM);
- Certified in Governance of Enterprise (CGIT); and
- Certified in Risk and Information Systems Control (CRISC).

## The SANS Institute

SANS is a graduate degree-granting education and research institution that also provides advanced security training and certifications. Its 120,000 alumni are the computer network defenders, penetration testers, security-savvy system operators, forensics experts, secure programmers, and managers in more than 20,000 organizations including the NSA, the Defense Industrial Base, the FBI, banks, hospitals, and universities.<sup>9</sup>

## CREST

The United Kingdom has developed a model for hands-on certification in the form of its Council of Registered Security Testers (CREST)<sup>10</sup> test for security penetration testers. The UK government is also building a network of independent certifiers. CREST was created in response to the need for regulated and professional security testers to serve the global information security marketplace. CREST is a not-for-profit organization with the goal of representing the information security testing industry and offering a demonstrable level of assurance as to the competency of organizations and individuals within approved companies.

## The Institute of Electrical and Electronics Engineers (IEEE)

The IEEE is an international, non-profit, professional organization, which provides learning opportunities within the engineering, research, and technology fields. The goal of the IEEE education programs is to ensure the growth of skill and knowledge in the electricity-related technical professions and to foster individual commitment to continuing education among IEEE members, the engineering and scientific communities, and the general public. The IEEE offers certification and training for software professionals. The organization recognizes there is a gap between education and work requirements and attempts to verify the students' understanding of the fundamentals of software development practices.<sup>11</sup>

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<sup>8</sup> See <http://www.isaca.org>.

<sup>9</sup> See <http://www.sans.org>.

<sup>10</sup> See <http://www.crest-approved.org>.

<sup>11</sup> See <http://www.computer.org/portal/web/guest/home>.



IEEE certifications include:

- Certified Software Development Associate (CSDA); and
- Certified Software Development Professional (CSDP).

### **Department of Justice: Federal Bureau of Investigation (FBI)**

The FBI Academy at Quantico provides a cyber education training program for domestic law enforcement and counterintelligence agencies. The Academy trains approximately 3,000 federal agents in cyber skills, with many receiving advanced training. Currently, the Office of Justice Program's (OJP's) Bureau of Justice Assistance (BJA) provides federal assistance for training for law enforcement officials. The Counter-Terrorism Training and Resources for Law Enforcement group, an interagency working group convened by the Department of Justice, provides training for cybersecurity and privacy.<sup>12</sup>

### **National Security Agency (NSA)**

The NSA and the DHS have jointly sponsored the National Centers of Academic Excellence in Information Assurance (IA) Education (CAE/IAE) and CAE-Research (CAE-R) programs. The goal of the programs is to reduce vulnerabilities in our national information infrastructure by promoting higher education and research in IA. The programs also attempt to address the growing need for professionals with IA expertise in various disciplines. The designation of an institution as a CAE/IAE or CAE-R is valid for five academic years, after which the school must reapply. Students who attend designated schools are eligible for scholarships and grants through DOD and DHS.<sup>13</sup>

Additionally, the NSA has an initiative underway that is working to qualifying cyberwarriors. Aspects of this initiative include defining the cybersecurity workforce and moving forward with education and training.

### **Department of Defense (DOD): DOD 8570.01-M, Information Assurance Workforce Improvement Program**

This initiative implements DOD Directive 8570.1, Information Assurance Training, Certification, and Workforce Management, dated August 15, 2004. It provides guidance for the identification and categorization of positions and certification of personnel conducting Information Assurance (IA) functions within the DOD workforce supporting the DOD Global Information Grid (GIG). The DOD IA workforce includes, but is not limited to, all individuals performing any of the IA functions described in the Manual. Additional chapters focusing on personnel performing specialized IA functions including certification and accreditation (C&A) and vulnerability assessment will be published as changes to the Manual. This program also establishes IA workforce oversight and management reporting requirements to support DOD Directive 8570.1. DOD 8570.01-M establishes the following goals:

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<sup>12</sup> See <http://www.counterterrorismtraining.gov>.

<sup>13</sup> See [http://www.nsa.gov/ia/academic\\_outreach/nat\\_cae/index.shtml](http://www.nsa.gov/ia/academic_outreach/nat_cae/index.shtml).

- Develop a DOD IA workforce with a common understanding of the concepts, principles, and applications of IA for each category, specialty, level, and function to enhance protection and availability of DOD information, information systems, and networks;
- Establish baseline technical and management IA skills among personnel performing IA functions across the DOD enterprise;
- Provide warfighters qualified IA personnel in each category, specialty and level;
- Implement a formal IA workforce skill development and sustainment process, comprised of resident courses, distributive training, blended training, supervised on the job training (OJT), exercises, and certification/recertification;
- Verify IA workforce knowledge and skills through standard certification testing; and
- Augment and expand on a continuous basis the knowledge and skills obtained through experience or formal education.

#### **Federal Chief Information Officers (CIO) Council and the Office of Personnel Management (OPM)**

The E-Government Act of 2002 (Section 209)<sup>14</sup> and Clinger-Cohen Act of 1996 (Division E)<sup>15</sup> include requirements for assessing the competencies and skills of the federal IT workforce. The purpose of these requirements is to analyze the needs of the federal government related to IT and information resources management. Currently, the CIO Council's IT Workforce Committee, in conjunction with the OPM, is working on the new workforce survey instrument. Additionally, they have identified eleven information security roles and have assigned priorities to the roles.<sup>16</sup> They are working on developing a matrix similar to their efforts for project management. To date, there are two draft documents available: "Systems Operations and Maintenance Professional" and "Chief Information Security Officer."<sup>17</sup>

#### ***Other Efforts that Could Make a Big Difference***

As previously stated, there are several initiatives underway that can be leveraged to address workforce issues. The following initiatives identified by the Commission should be studied, as they initially appear to be addressing short and medium term cybersecurity workforce issues such as training.

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<sup>14</sup> See <http://www.gpo.gov/fdsys/pkg/PLAW-107publ347/pdf/PLAW-107publ347.pdf>.

<sup>15</sup> See <http://www.gpo.gov/fdsys/pkg/PLAW-104publ106/pdf/PLAW-104publ106.pdf>.

<sup>16</sup> See Appendix A1: Federal Information Security Workforce Development Matrix: Roles Identification, Definition, and Prioritization.

<sup>17</sup> See Appendix A2: Information Security Workforce Development Matrix (DRAFT): Systems Operations and Maintenance Professional; and Appendix A3: Information Security Workforce Development Matrix (DRAFT): Chief Information Security Officer.

## **Department of State (DOS)**

As discussed above, the DOS team is clearly demonstrating that skills do matter. It has instituted a training program for all new team members covering multiple levels of competency with extensive, hands-on training in the DOS environment.

## **U.S. Cyber Command**

The U.S. Cyber Command (USCYBERCOM) is a subordinate unified command under the United States Strategic Command created by the Secretary of Defense on June 23, 2009.<sup>18</sup> USCYBERCOM includes responsibility for several organizations including: the Joint Task Force for Global Network Operations (JFT-GNO); Joint Functional Component Command for Network Warfare (JFCC-NW); and the Defense Information Systems Agency (DISA), which will provide technical assistance for network and information assurance. They are to coordinate computer-network defense and direct U.S. cyber-attack operations.

## **DOD 8570.01-M Change 2 (released Spring 2010)**

This release reflects the DOD's commitment to continuous improvement in the IA Workforce Improvement Program. Change 2 emphasizes the Department's intent that the IA Workforce Improvement Program rely on skills-based training aligned with operational needs. DOD components will be encouraged to construct training and certification regimes that develop and assess the skills necessary to provide effective IA capabilities. This emphasis, coupled with improved compliance metrics, will move the Department away from reliance on stand alone, prescriptive certifications as the primary compliance metric for IA workforce training and certification.

## **U.S. Cyber Challenge**

The Center for Strategic and International Studies (CSIS) brought together executives from high tech companies, academics, and government officials to launch a project known as the U.S. Cyber Challenge, which enables Americans to demonstrate their cybersecurity knowledge, skills, and passion.<sup>19</sup>

As part of this effort, candidates who prove their skills are being invited to attend regional "cyber camps" which will be held at local colleges, where these individuals will continue to develop their skills more fully and participate in additional competitions. The best of the candidates will be introduced to key federal agencies and corporations where the most advanced cybersecurity work is being done. Several examples of Cyber Challenge competitions are shown in the following table.

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<sup>18</sup> See Appendix A4: U.S. Cyber Command: Memorandum for Secretaries of the Military Departments.

<sup>19</sup> See <http://www.uscyberchallenge.org>.

Competition	Target audience	What it does	Impact/Participant Comment
Cyber Security Treasure Hunt	Adults and college students (and very talented high school students) who want to prove they have basic mastery of vulnerabilities and other areas of security	Like a scavenger hunt, the game delivers an online quiz that sends candidates to a simulated environment where they can safely explore, find answers, and return to the quiz.	This is the primary qualification for students wishing to earn a place in the 2010 cyber camps. Comment: "Even if the contestant cannot complete all the challenges, it creates a powerful interest to learn and explore more of these ideas."
CyberPatriot	High school students	Students must harden systems to block attacks and are scored on their success in keeping the attackers out.	An Air Force official: "All the contestants I met are interested in pursuing degrees, scholarships, USAF appointments, etc., to have a role in cyberspace in some form in the future!"
NetWars	Adults and college students (and very talented high school students) who have very high levels of skills and want to prove they should win internships and scholarships at important organizations.	Students work in a real-world, online laboratory where contestants must capture and hold cyber territory as hundreds of others try to do the same.	According to a December 2009 CNN report, NetWars seeks out young adults with exceptional computer skills and provides them with job opportunities in government or the private sector. <sup>20</sup>
DC3 Digital Forensics Challenge	Separate competitions for high school students, college students, and adults to show they have forensics skills	Provides a disk image of data taken from actual cases investigated by the DOD Cyber Crime Center and asks four levels of questions. The fourth level includes questions even DC3 does not know how to answer.	Motivates young people to further develop their forensics skills.
On-site cyber tournaments	College students	Teams come together to attack and defend systems over a period of one-to-two days.	The winning team of a tournament held at Cal Poly Pomona California State University was offered cybersecurity positions by Boeing.

<sup>20</sup> Jeanne Meserve and Mike H. Ahlers, "Cyber Challenge tests nation's top hackers," CNN, December 21, 2009, <http://www.cnn.com/2009/TECH/12/21/cyber.challenge.hackers/index.html?iref=allsearch>.

### **University of Maryland and University College (UMUC)**

The University of Maryland University College (UMUC) has three new degree programs starting in Fall 2010. They are a Bachelor and Master of Science in Cybersecurity and Master of Science in Cybersecurity Policy. The UMUC is the largest U.S. public university with approximately 94,000 enrolled students, which includes 50,000 active duty military, reservists, dependents, and veterans.<sup>21</sup>

### **National Collegiate Cybersecurity Competition**

The mission of the Collegiate Cyber Defense Competition (CCDC) system serves institutions with information assurance or computer security curriculums.<sup>22</sup> It provides those schools with a controlled, competitive environment to assess their students' depth of understanding and operational competency in managing the challenges inherent in protecting a corporate network infrastructure and business information systems. Competition has grown from 5 schools in 2005 to 63 schools across 8 regions in 2009.

CCDC events are designed to:

- Build a meaningful mechanism by which institutions of higher education can evaluate their programs.
- Provide an educational venue in which students are able to apply the theory and practical skills they have learned in their course work.
- Foster a spirit of teamwork, ethical behavior, and effective communication both within and across teams.
- Create interest and awareness among participating institutions and students.

### **Defense Advanced Research Projects Agency (DARPA)**

The Defense Advanced Research Projects Agency's (DARPA's) mission is to facilitate research and development including the development of new technology and techniques for use by the military.<sup>23</sup> One example is the recently completed program entitled, "The Cyber Trust Program" which was to create the technology and techniques to enable trustworthy information systems by:

1. Developing hardware, firmware, and microkernel architectures as necessary to provide foundational security for operating systems and applications.
2. Developing tools to find vulnerabilities in complex open source software.
3. Developing scalable formal methods to verify complex hardware/software.

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<sup>21</sup> See <http://www.umuc.edu>.

<sup>22</sup> See <http://www.nationalccdc.org>.

<sup>23</sup> See <http://www.darpa.gov>.

## Next Steps: Recommendations

With all these activities underway, it is the Commission's intention to give impetus to and leverage existing efforts and initiatives to move forward in a comprehensive manner. The current Administration is addressing the education of cyber professionals as part of the Comprehensive National Cybersecurity Initiative, an unclassified description of which was released on March 2, 2010. The topic is included as Initiative 8:

**Expand cyber education.** While billions of dollars are being spent on new technologies to secure the U.S. Government in cyberspace, it is the people with the right knowledge, skills, and abilities to implement those technologies who will determine success. However there are not enough cybersecurity experts within the federal Government or private sector to implement the CNCI, nor is there an adequately established federal cybersecurity career field. Existing cybersecurity training and personnel development programs, while good, are limited in focus and lack unity of effort. In order to effectively ensure our continued technical advantage and future cybersecurity, we must develop a technologically skilled and cyber-savvy workforce and an effective pipeline of future employees. It will take a national strategy, similar to the effort to upgrade science and mathematics education in the 1950's, to meet this challenge.<sup>24</sup>

Building on many of the activities underway, the Commission is recommending the following for both the executive branch and legislative branch of the federal government:

1. The President's cybersecurity coordinator should sponsor an effort to create an initial taxonomy of cyber roles and skills (See Appendix B, Taxonomy of Roles, v5 Draft) that can be the basis for recruiting and training and provide a more specific target for the education and training community to drive curriculum development and a regime of professional certifications grounded in practical reality;
2. The Office of Management and Budget (under the leadership of the Chief Information Officer and the Administrator of federal Procurement Policy), in conjunction with the National Institute Standards and Technology, should ensure the skills matrix along with future certification and eventually licensing requirements, if appropriate, be included as "standards" in their <http://checklists.nist.gov> and develop any additional procurement language, if necessary for:

### PART 39-ACQUISITION OF INFORMATION TECHNOLOGY

1. The authority citation for 48 CFR part 39 continues to read as follows:  
Authority: 40 U.S.C. 121(c); 10U.S.C. chapter 137; and 42 U.S.C. 2473(c).
2. Amend section 39.101 by revising paragraph (d) to read as follows:  
39.101 Policy.

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<sup>24</sup> Comprehensive National Security Initiative, <http://www.whitehouse.gov/cybersecurity/comprehensive-national-cybersecurity-initiative>.

(d) In acquiring information technology, agencies shall include the appropriate IT security policies and requirements, including use of common security configurations available from the NIST's website at <http://checklists.nist.gov>. Agency contracting officers should consult with the requiring official to ensure the appropriate standards are incorporated.  
(<http://www.whitehouse.gov/omb/assets/omb/memoranda/fy2008/m08-22.pdf>)

3. The Chief Information Officers Council should modify its biennial survey of the federal information technology workforce to elicit more granular information on the cybersecurity skill profile of that workforce and to identify gaps;
4. The Office of Personnel Management should draft an action plan to address “career path issues” in the federal workforce including developing a separate job series similar to the existing professional services (e.g., legal, medical, chaplain, and mental health). In addition, OPM should adjust the law enforcement classification (agents with the power to carry weapons and make arrests) to include special hiring authority where there is evidence of shortages. OPM should also consider mandatory continuous training and establish an extensive probationary period for skills to be demonstrated on-the-job;
5. The Department of Homeland Security, in conjunction with the Federal CIO Council, should create the Cyber Corps Alumni group which would include the top 10 percent of the students who complete the program and high-achieving graduates of other similar government-sponsored programs. As part of this initiative, the program for the alumni group would include a specific set of benefits such as training on how to be a Chief Information Security Officer, how to network with top cybersecurity professionals; how to develop leadership skills, and other related topics;
6. Congress should develop model legislative language to address potential workforce gaps (See Appendix C, Definition for Legislative Branch); and
7. The Department of Labor’s Bureau of Labor Statistics (BLS) should lead an interagency committee to develop Standard Occupational Classification (SOC) for the cybersecurity workforce.<sup>25</sup> This work would build upon the taxonomy recommended in Item 1.

### ***Recommended Action Plan***

The following actions could be taken in order to address the recommendations.

The actions are intended to be a starting place, and are not necessarily inclusive of all actions which must be taken to address all workforce issues:

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<sup>25</sup> See <http://www.bls.gov/soc/socmanu.htm>.

*3 to 6 Months:*

- Harmonize the existing efforts with the Office of National Director, Office of Personnel Management, and the Federal Chief Information Officers (CIO) Council to address potential for a new federal personnel classification series (e.g., address the need for forensic analysts);
- Develop and expand the workforce survey initiative of the Federal CIO Council to address cybersecurity throughout the federal workforce;
- Create the Cyber Corps Alumni Group;
- Begin development of the program for the Cyber Corps Alumni Group;
- Expand on the initial taxonomy of cybersecurity roles and skills;<sup>26</sup>
- Finalize the definitions for cybersecurity services;<sup>27</sup>
- Develop model procurement language for inclusion in federal contracts; and
- Finalize model legislative language to address cybersecurity workforce issues for the executive branch to share with Congress.

*6 to 9 Months:*

- Publish the classification standards for any new designations for cybersecurity positions;
- Recruit a workforce on the basis of the agreed upon classification standards;
- Finalize the taxonomy and train agency personnel on its use. The Office of Personnel Management, in conjunction with the Federal CIO Council, should take the lead for this effort;
- Include model legislative language for the cybersecurity workforce for inclusion in any appropriate cyber-related legislation;
- Develop curriculums for inclusion of federal programs such as Scholarship for Service;
- Establish and invite membership to the Cyber Corps Alumni Group;
- Finalize the model procurement language for inclusion in contracts along with appropriate policy documents if necessary;
- Establish the SOC Committee to address the outcome of the finalized taxonomy; and
- Conduct the workforce survey.

*9 to 12 Months:*

- Analyze and finalize the workforce survey to include recommendations;
- Finalize initial curriculums to address future needs on the basis of the recommendations identified from the final workforce survey;
- Identify and develop activities to be automated for the cybersecurity workforce including, but not limited to, configuration management and patch management;

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<sup>26</sup> See Appendix B: Taxonomy of Cybersecurity Roles.

<sup>27</sup> See Appendix C: Draft Definition for Potential Legislation.



- Review and update the job role taxonomy on the basis of the recommendations identified from the workforce survey;
- Continue the Cyber Corps Alumni Group initiative;
- Finalize the SOC and Update the SOC Manual; and
- Review and ensure contracts are being updated with the approved procurement language.

#### *12 Months and beyond:*

- Develop and deploy training programs addressing the existing federal workforce;
- Continue to recruit and train the cybersecurity workforce;
- Develop and deploy automated tools for lower level daily cybersecurity tasks;
- Continue with the development and enhancement of the Cyber Corps Alumni Group initiative;
- Update and modify curriculums for federally funded cybersecurity programs; and
- Continue to address workforce issues to ensure a clearly defined career path.

### ***Long-term Recommendations***

The following recommendations will sustain and maintain the professional cybersecurity workforce for both the public and private sectors:

1. The creation of an ongoing U.S. Cyber Challenge by leveraging the existing efforts and initiative launched by CSIS; and
2. The establishment of an independent Board of Information Security Examiners to develop and administer a process for certifying cybersecurity professionals in each area of specialization as developed from the action plan above. The areas of specialization should include not only so-called cybersecurity roles, such as intrusion detection and forensics, but also areas such as software development and network operations, which are critical to cybersecurity.

### **Governance**

The creation of an ongoing U.S. Cyber Challenge and an independent Board of Information Security Examiners recommended in this report raises the issue of how those efforts should be governed. These two initiatives are intended to create a pipeline of technically proficient cybersecurity practitioners and to provide employers and purchasers of cybersecurity services some level of assurance as to the competence of those whom they engage. The following outlines the potential alternatives for the independent Board of Information Security Examiners, which is envisioned to set the standards for all related activities for certification.

### **Analysis of Alternatives**

Other professions, most notably the medical profession, have built a structure of independent certifying bodies linked to state licensing requirements. To practice in most jurisdictions, physicians are required to meet certain educational requirements and demonstrate certain practical experience at

independently accredited institutions and then pass an examination that typically includes tests of both cognitive knowledge and practical skills.<sup>28</sup> Other medical-related professions – nurses, physician assistants, etc – are subject to similar requirements. And the education sector has responded by developing curricula that support certification and licensing and, we are convinced, will do so if the roles and skills required in the cybersecurity workforce are clearly defined.

Medicine has addressed the need for more specialized professional certifications under a regime overseen by the American Board of Medical Specialties.<sup>29</sup> Board certifications, rigorously administered and overseen, provide important information about the skills and knowledge of practitioners to the purchaser of medical services. While no test or credential can guarantee an outcome, taken together with information about performance, it increases the quality of care and patient's level of assurance. Similarly, it is essential to assure that those who buy cybersecurity services have tools to evaluate the competence of those whom they engage. Facing medical problems, few of us have the knowledge to evaluate the competence of those to whom we turn for assistance. Instead, we rely on a combination of independently administered professional certifications, state licensing authorities, and reputational information to tell us whether the provider has the needed training and has demonstrated the skills that we need.

With these examples in mind, there are several options for overseeing this initiative:

1. **Status quo:** A variety of professional societies and for-profit entities developing and issuing certifications along with separate entities operating what is currently the U.S. Cyber Challenge.
2. **Federated model:** A central body that establishes standards for and accredits professional certifications. This process includes the development of model certifications. Testing is conducted by accredited professional organizations.
3. **Unified model:** Independent Board of Information Security Examiners is established in which a single body administers all professional certifications.

In our view, the criteria for evaluating governance options are:

- *Relevance to the current and future labor market.* Cybersecurity is a diverse and dynamic field that requires a broad range of ever-evolving sets of skills. Most importantly, training and certifications need to be connected to real jobs in the current marketplace AND new challenges. This criterion also recognizes it will take time to implement the model.
- *Independence and integrity.* Potential employers and purchasers of cybersecurity services need to be assured that certification processes have intellectual rigor and are not unduly biased by the economic interests of particular providers.

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<sup>28</sup> See <http://www.amaassn.org/aps/physcred.html>.

<sup>29</sup> See <http://www.abms.org>.

- *Sustainability.* There needs to be a viable business model.

### *The status quo*

A number of certification programs have evolved, some are even ISO 17024 certified. A few address specific equipment or technologies while others are more general. While the existence of such programs has spurred investments in training, the consensus of the CSIS Commission was that, all too often, there was little if any connection to the specific technical cybersecurity skills that are needed in the workplace.

In the absence of an alternative, several organizations that have built robust and highly profitable lines of business are understandably anxious to evolve the work that they have done to meet changing needs.

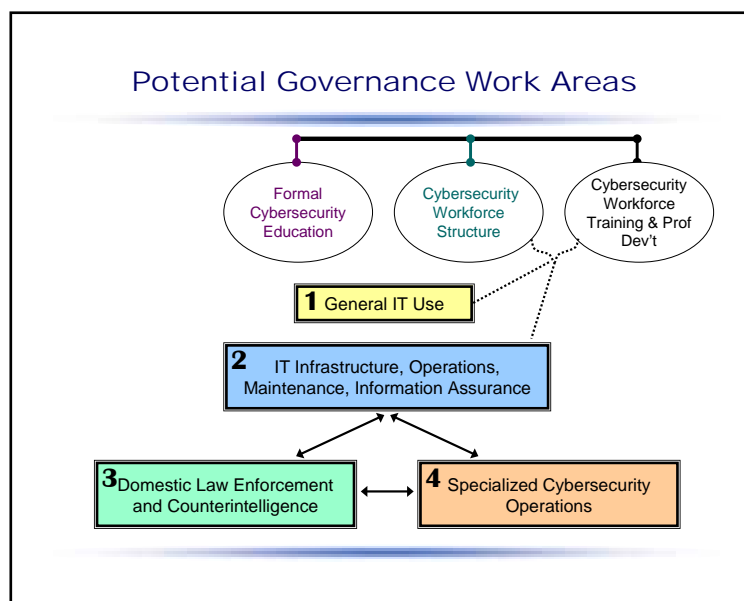
### *The federated model*

There are a number of certification programs already underway some of which are described in this report. Under the Federated Model, a separate entity would be created to develop rigorous certifications for high-level cybersecurity specialties for which none now exist and criteria for accrediting other, existing certification programs.

### *The unified model*

The Unified Model, used in a number of other professions; e.g., the law and accounting, entails a single body that administers all certifications. The challenges of developing and implementing a reliable regime for certifying and licensing the range of skills and subspecialties under the rubric of “cybersecurity professional” would make this model difficult to apply.

The following shows the potential functional areas, which could be governed by the Independent Board of Examiners:



The following table includes our assessment using the criteria defined with a low to high ranking of the criteria for each alternative:

### ***Summary Assessment***

	Status Quo	Federated	Unified
Relevance	Low-medium	High	High
Rigor and Independence	Low-medium	High	High
Sustainability	High	Medium	High

On the basis of our analysis, the Commission is recommending the creation of a governance body initially based on a federated model, which would develop and administer certifications in two or three specialty areas and evaluate whether some/any existing certification programs meet its standards. The organization could be created initially as a not-for-profit in order to conduct the pilots. The effort would be under the direction of a Board that would include representatives from:

- Major private sector organizations that employ high-end cybersecurity professionals;
- Universities with major cyber education and research programs; and
- Key federal government agencies and congressional committees.<sup>30</sup>

The role of the oversight board would be to direct and evaluate a two-year pilot test and, at the end of the first year, offer recommendations on whether/how the body should continue.

## **Conclusion**

We are unified by a shared objective to help protect our critical infrastructure by detecting, responding to, and ultimately preventing cyber attacks and accidents. Technology alone can't solve the problem. We need good people. The Commission found that, while a number of initiatives and efforts are underway, much remains to be done. The recommendations in this paper are designed to accelerate reaching two goals: (1) expanding the number and quality of highly skilled cybersecurity professionals and (2) giving those who hire those workers or who buy their services even better indicators of the skill levels of those whom they are engaging.

While much is being done, our adversaries are growing in number and capability. We must redouble our efforts.

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<sup>30</sup> Since this would be an oversight/advisory group, not a board of directors with fiduciary responsibilities, we presume that it will be possible for government officials to participate.

## APPENDIX A. FEDERAL CIO DOCUMENTS

### 1. FEDERAL INFORMATION SECURITY WORKFORCE DEVELOPMENT MATRIX: ROLES IDENTIFICATION, DEFINITION, AND PRIORITIZATION

#### INFORMATION SECURITY DRAFT ROLES\* (Last updated 4/21/2009)

*\*The following listed roles are specific to the information security, information assurance, and information technology security function and environment.*

##### High Priority

**1. Chief Information Security Officer-** The Chief Information Security Officer (CISO) is responsible for the information security strategy within an organization. The CISO establishes, implements, and monitors the development and subsequent enforcement of the organization's information security program (i.e., policies, procedures, security architecture standards, security awareness and training program, IT contingency plans, IT security compliance issues). The CISO leads the evaluation and assessment of the security program to ensure that all aspects are in compliance with security requirements, while understanding security threats and vulnerabilities to operations and the organization's environment. The CISO is responsible for information security risk management (e.g., determines risk impact, establishes risk mitigation plans and programs, works with business owners to devise processes for risk assessment) within the organization. The CISO manages the incidents response program (e.g., identifies, reports, and remediates incidents).

**2. Systems Operations & Maintenance Professional-** The Systems Operations and Maintenance Professional supports and implements the security of information and information systems during the operations, maintenance, and enhancements phases of the systems development life cycle. The Systems Operations and Maintenance Professional is also responsible for implementing server configurations, operating systems, database systems, firewalls, patch management, and account management to protect the systems against threats and vulnerabilities.

**3. Network Security Specialist-** The Network Security Specialist is responsible for examining malicious software, suspicious network activities, and non-authorized presence in the network to analyze the nature of the threat, and secure and monitor firewall configurations. The Network Security Specialist needs to understand the specimen's attack capabilities, its propagation characteristics, and define signatures for detecting malware presence.

**4. Digital Forensics & Incident Response Analyst-** The Digital Forensics and Incident Response Analyst performs a variety of highly technical analyses and procedures dealing with the collection, processing, preservation, analysis, and presentation of computer-related evidence, and is responsible for disseminating and reporting cyber-related activities, conducting vulnerability analyses and risk management of computer systems and all applications during all phases of the systems development lifecycle. The Digital Forensics and Incident Response Analyst provides oversight of incident data flow and response, content, and remediation, and partners with other incident response centers in maintaining an understanding of threats, vulnerabilities, and exploits that could impact networks and assets.

**5. Information Security Assessor-** The Information Security Assessor is responsible for overseeing, evaluating, and supporting compliance issues pertinent to the organization. Individuals in this role perform a variety of activities that encompass compliance from internal and external perspectives. These include leading and conducting internal investigations, helping employees to comply with internal policies and procedures, and serving as a resource for external compliance officers during independent assessments. The Information Security Assessor provides guidance and autonomous evaluation of the organization to management. This individual is responsible for planning and executing information systems operational assessment by obtaining, analyzing, and appraising competent evidential data for forming an objective opinion on the adequacy of information systems, procedures, and documentation. This individual also prepares, tests, and utilizes generalized computer audit software, programs, and questionnaires for accomplishing audit objectives and procedures.

##### Medium Priority

**6. Information Systems Security Officer-** The Information Systems Security Officer (ISSO) specializes in the information and security strategy within a system and is engaged throughout the systems development life cycle. The ISSO is charged with the development and subsequent enforcement of the company's security policies and procedures, security awareness programs, business continuity and disaster recovery plans, and all industry and governmental compliance issues. The ISSO communicates with the business at the system level and understands security threats and vulnerabilities to the operations and the system's environment.

**7. Security Architect-** The Security Architect is responsible for implementing business needs. The Security Architect supports the business function as well as technology and environmental conditions (e.g., law and regulation), and translates them into security designs that support the organization to efficiently carry out its activities while minimizing risks from security threats and vulnerabilities.

**8. Vulnerability Analyst-** The Vulnerability Analyst is responsible for detecting threats and vulnerabilities in target systems, networks, and applications by conducting systems, network, and web penetration testing. The Vulnerability Analyst identifies flaws that can be exploited to cause business risk, and provides crucial insights into the most pressing issues, suggesting how to prioritize security resources.

**9. Information Security Systems & Software Development Specialist\*\***-The Information Security Systems and Software Development Specialist is responsible for secure design, development, testing, integration, implementation, maintenance, and/or documentation of software applications (web based and non-web) following formal secure systems development lifecycle processes and using security engineering principles.

#### **Low Priority**

**10. Chief Information Officer-** The Chief Information Officer (CIO) focuses on information security strategy within an organization and is responsible for the strategic use and management of information, information systems, and IT. The CIO establishes and oversees IT security metrics programs, including evaluation of compliance with corporate policies and the effectiveness of policy implementation. The CIO also leads the evaluation of new and emerging IT security technologies.

**11. Information Security Risk Analyst-** The Risk Analyst is responsible for facilitating and developing data-gathering methods to control and minimize risks by understanding external threats and vulnerabilities to the operation and environment. The Risk Analyst analyzes vulnerabilities identified and implements best practices in their mitigation. This individual communicates compliance regulations and policies, monitors audit preparation practices, and implements risk management policies and procedures.

*\*\* The Information Security Systems & Software Development Specialist is an emerging role that was not rated on importance in the February focus group exercise. This role is classified under medium priority until further data and feedback can be obtained and analyzed.*

## 2. INFORMATION SECURITY WORKFORCE DEVELOPMENT MATRIX\*

Systems Operations and Maintenance Professional**				The Systems Operations and Maintenance Professional supports and implements the security of information and information systems during the operations, maintenance, and enhancements phases of the systems development life cycle. The Systems Operations and Maintenance Professional is also responsible for implementing server configurations, operating systems, database systems, firewalls, patch management, and account management to protect the systems against threats and vulnerabilities.			
Performance Level	Description/Complexity	Competencies/Skills	Suggested Credentials	Suggested Learning & Development Sources			
<b>I: Entry</b>	Has a basic understanding of computer systems and related information security software and hardware components Ability to perform basic security system administration duties including software and hardware installation, troubleshooting, system backup, network component maintenance Basic understanding of tools and methods for identifying anomalies in system behavior; develops ability to recognize anomalies Applies skills and abilities with supervision on projects, programs, and initiatives with low threat and scope (e.g., inter-office)	Performance levels are associated with recommended proficiency descriptors applicable to each of the relevant competency/skill models listed below. <b>Competency/Skill Proficiency Descriptors</b> I-Entry: Basic understanding of concepts addressed in relevant competency/skill models II-Intermediate: Working knowledge and application of relevant competency/skill models in work activities III-Advanced: Advanced application and mastery of relevant competency/skill models <b>Relevant Competency/Skills Sources:</b> ▶ OPM GS-2200 Job Family Standard Competencies ▶ Clinger-Cohen Core Competencies with an emphasis on Technical, Desktop Technology Tools, and IT Security/Information Assurance competency areas ( <a href="http://www.cio.gov">www.cio.gov</a> ) ▶ DHS EBK Competencies ▶ FISMA Guidance ▶ OPM's IT Workforce Roadmap ▶ NIST SP 800-16, Revision 1 ▶ ODNI Cyber Subdirectory Competencies ▶ DoD Directive 8570 ▶ CNSS Policies, Directives, and Reports	0-3 years experience involving work directly related to systems operations and maintenance (e.g., help desk). OR a Bachelors Degree (suggested areas of study include Computer Science, Information Technology, Information Engineering, Business/Management) ▶ Participation in Scholarship for Service program through a designated Center of Academic Excellence in Information Assurance Education (CAEIAE)	1. Development Resources: ▶ IT Workforce Roadmap ( <a href="http://IT.Roadmap.gov">IT.Roadmap.gov</a> ) ▶ Graduate Programs, USDA IT Programs ▶ GoLearn Courses ( <a href="http://www.golearn.gov">www.golearn.gov</a> ) ▶ CIO Council ( <a href="http://www.cio.gov">www.cio.gov</a> ) ▶ DoD DISA Training ▶ GSA's CIO university Program 2. University Information Security Programs: ▶ National Defense University- IRM College ▶ IS/IA Degree Programs- CAEIAE ▶ Private University Programs (e.g., GMU, MIT) 3. OPM Development Center: The Federal Executive Institute and the Management Development Centers 4. Participation in coaching/mentoring/job shadowing programs 5. Agency Requirements: organization and business area training identified as required 6. Clinger-Cohen Core Competency-based training sources and Capital Planning and Investment Control (CPI) mandate 7. Current and emerging legislation, policy, and regulations (e.g., FISMA, NIST SP-800 series, FIPS, OMB directives, CNSSI No. 4012) 8. Training by external vendors for security configuration (e.g., Oracle, Computer Associates, IBM, and HP Tools, Sans Institute)			
<b>II: Intermediate</b>	Applies an understanding of the information security operational characteristics of a variety of computer platforms, networks, software applications, and operating systems Ability to explain to others the methods and techniques used in installation, testing, network debugging, troubleshooting, and maintenance of PCs, servers, printers, and related equipment Automates repetitive processes (e.g., log reviews, configuration testing) to facilitate information security operations Evaluates and assesses operating practices to determine adequate risk management and compliance standards, with on-going systems monitoring Is responsible for contributing, with limited supervision, to projects, programs, and initiatives with medium-threat and moderate scope (e.g., sub-organization wide)		<ul style="list-style-type: none"> <li>Bachelors Degree and 2+ years experience (suggested areas of study include Computer Science, Information Technology, Information Engineering, Business/Management, or degrees from a designated CAEIAE); OR 3-5 years experience involving work directly related to security control evaluation and implementation on information technology, systems, and programs</li> <li>Possession and demonstrated application of relevant certifications               <ul style="list-style-type: none"> <li>Core: MCSE, CCNA, CCNP, ISC<sup>2</sup> CAP</li> <li>Related: CISSP, CISM, ISC<sup>2</sup> ISSMP, CompTIA, SANS GIAC, PMP</li> </ul> </li> </ul>				
<b>III: Advanced</b>	Effectively communicates technical information to non-technical audiences; influences others to comply with policies and conform to standards and best practices Designs the organization's working information security systems operations and maintenance strategy and methodology to comply with the organization's standards and mission Understands the needs of the organization and establishes appropriate vendor relationships to manage the proposal and purchasing process Attends and participates in professional conferences to stay abreast of new trends and innovations in the field of information systems Independently manages, plans, evaluates, and advocates for information security compliance systems, plans, and functions, and is responsible for the management of complex projects, programs, and initiatives with high threat and large scope (e.g., agency-wide or inter-governmental), with on-going systems monitoring		<ul style="list-style-type: none"> <li>Bachelors Degree and 3+ years experience (preferred areas of study include Computer Science, Information Technology, Information Assurance/Security, Engineering, Business/Management, or degrees from a designated CAEIAE); OR 5+ years of experience involving work directly related to security control evaluation and implementation on information technology, systems, and programs</li> <li>Demonstrated experience in managing/supervising a systems operations and maintenance group</li> <li>Possession and demonstrated application of relevant certifications               <ul style="list-style-type: none"> <li>Core: MCSE, CCNA, CCNP, ISC<sup>2</sup> CAP</li> <li>Related: CISSP, CISM, ISC<sup>2</sup> ISSMP, CompTIA, SANS GIAC, PMP</li> </ul> </li> </ul>				

\* Criteria included in the above matrix are provided as **guidance only**. These criteria are not a replacement for OPM basic qualifications as outlined in the relevant occupational qualification standards. The intention of the qualifications matrix is to assist departments/agencies in defining the qualifications criteria that are most relevant and applicable to their IT Security workforce. No singular qualification component on its own (i.e., education) should be the sole determinant in classifying an individual's proficiency level. Rather, all aspects of experience, competencies, education, and training/certifications should be considered when making performance level evaluations.

\*\*The role description is specific to the information security, information assurance, and information technology security function and environment.

### 3. INFORMATION SECURITY WORKFORCE DEVELOPMENT MATRIX\*

Performance Level	Description/Complexity	Competencies/Skills	Suggested Credential	Suggested Learning & Development Sources
III: Advanced	<p>Demonstrates an in depth understanding of enterprise-wide, multi-platform operating systems security, network security, application security, database security, regulatory compliance, incident and risk management</p> <p>Identifies, understands, manages, and interprets information security risks and threats as it affects the business and aligns the information security strategy to achieve organizational mission</p> <p>Designs the organization's information security governance framework to facilitate the implementation of the organization's information security strategy</p> <p>Set expectations, determines appropriate security measures to be used across the department/agency, and maintains governance over the standards and methodologies for information security risk management and compliance reviews</p> <p>Independently manages, plans, evaluates, and advocates for information security solutions, plans, and functions, and is responsible for the management of complex projects, program, and initiatives with high threat and large scope (e.g., organization-wide or inter-governmental)</p> <p>Leads, enables, and is accountable for the implementation and integration of solutions to ensure information security within the organization</p> <p>Understands mechanisms for securing new technologies; understands the impact of new and emerging technologies on the information security environment, as well as tools and methods for mitigating risks</p>	<p>Performance levels are associated with recommended proficiency descriptors applicable to each of the relevant competency/skill models listed below</p> <p><b>Competency/Skill Proficiency Descriptors</b></p> <p>III-Advanced: Advanced application and mastery of relevant competency/skill models</p> <p><b>Relevant Competency/Skill Sources:</b></p> <ul style="list-style-type: none"><li>▶ NIST SP 800-100 Information Security Handbook: A Guide for Managers</li><li>▶ OPM GS-2200 Job Family Standard Competencies</li><li>▶ Clinger-Cohen Core Competencies with an emphasis on <i>Technical, Desktop Technology Tools, and IT Security/Information Assurance</i> competency areas</li><li>▶ DHS EBK Competencies</li><li>▶ FISMA Guidance</li><li>▶ OPM's IT Workforce Roadmap</li><li>▶ NIST SP 800-16, Revision 1</li><li>▶ ODNI Cyber Subdirectory Competencies</li><li>▶ DoD Directive 8570</li><li>▶ CNSS Policies, Directives, and Reports</li><li>▶ OPM's Executive Core Qualifications (ECQs) (for SES positions)</li><li>▶ Additional Key Competencies identified for this role (for senior management positions):<ul style="list-style-type: none"><li>• Leadership &amp; People Management</li><li>• Written &amp; Oral Communication</li><li>• Creative Problem Solving</li><li>• Budget Formation &amp; Allocation</li><li>• Project/Program Management</li></ul></li></ul>	<ul style="list-style-type: none"><li>▶ Graduate Degree with 5+ years experience (suggested areas of study include Computer Science, Information Technology, Information Assurance/Security, Engineering, Business/Management, or degrees from a designated CAEIAE); OR 8+ years of experience involving work with transferable skills related to information security, incident and risk management</li><li>▶ Demonstrated experience in leading an Information Security/IA compliance group</li><li>▶ Possession and demonstrated application of relevant certifications<ul style="list-style-type: none"><li>▶ Core: CISSP, CISM, CISA, GSLC</li><li>▶ Related: ISSMP, CIW-Security, CAP, COMPTIA</li></ul></li><li>▶ Security clearance commensurate with organizational requirements</li></ul>	<ol style="list-style-type: none"><li>1. University Information Security Programs:<ul style="list-style-type: none"><li>▶ National Defense University-IRM College</li><li>▶ IS/IA Degree Programs- CAEIAE</li><li>▶ Private University Programs (e.g., GMU, MIT)</li></ul></li><li>2. OPM Development Center: The Federal Executive Institute and the Management Development Centers</li><li>3. Attendance at industry conferences, work groups, and briefings (i.e. DHS- GFrist, FIA; Black Hat, RSA; ISACA; SANS FIRE; CAISSWG; AFCEA)</li><li>4. Development Resources:<ul style="list-style-type: none"><li>▶ IT Workforce Roadmap (IT Roadmap)</li><li>▶ Graduate Programs, USDA IT Programs</li><li>▶ GoLearn Courses (<a href="http://www.golearn.gov">www.golearn.gov</a>)</li><li>▶ CIO Council (<a href="http://www.cio.gov">www.cio.gov</a>)</li><li>▶ DoD DISA Training</li><li>▶ AFCEA (<a href="http://www.afcea.org">www.afcea.org</a>)</li><li>▶ CAISSWG</li><li>▶ GSA's CIO University Program</li></ul></li><li>5. Participation in coaching/mentoring/job shadowing programs</li><li>6. Agency Requirements: organization and business area training identified as required</li><li>7. Current and emerging legislation, policy, and regulations (e.g., FISMA, NIST SP-800 series, FIPS, OMB directives, CNSSI No. 4011 &amp; 4012 )</li><li>8. Training by external vendors (e.g., Sans Institute , ISC², ISACA, MIS)</li></ol>

\* Criteria included in the above matrix are provided as **guidance only**. These criteria are not a replacement for OPM basic qualifications as outlined in the relevant occupational qualification standards. The intention of the qualifications matrix is to assist departments/agencies in defining the qualifications criteria that are most relevant and applicable to their IT Security workforce. No singular qualification component on its own (i.e., education) should be the sole determinant in classifying an individual's proficiency level. Rather, all aspects of experience, competencies, education, and training/certifications should be considered when making performance level evaluations.

\*\*The role description is specific to the information security, information assurance, and information technology security function and environment.



#### 4. U.S. CYBER COMMAND: MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS



THE SECRETARY OF DEFENSE  
1000 DEFENSE PENTAGON  
WASHINGTON, DC 20301-1000

JUN 23 2009

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS  
CHAIRMAN OF THE JOINT CHIEFS OF STAFF  
UNDER SECRETARIES OF DEFENSE  
DEPUTY CHIEF MANAGEMENT OFFICER  
COMMANDERS OF THE COMBATANT COMMANDS  
ASSISTANT SECRETARIES OF DEFENSE  
GENERAL COUNSEL OF THE DEPARTMENT OF  
DEFENSE  
DIRECTOR, OPERATIONAL TEST AND EVALUATION  
DIRECTOR, COST ASSESSMENT AND PROGRAM  
EVALUATION  
INSPECTOR GENERAL OF THE DEPARTMENT OF  
DEFENSE  
ASSISTANTS TO THE SECRETARY OF DEFENSE  
DIRECTOR, ADMINISTRATION AND MANAGEMENT  
DIRECTOR, NET ASSESSMENT  
DIRECTORS OF THE DEFENSE AGENCIES  
DIRECTORS OF THE DOD FIELD ACTIVITIES

SUBJECT: Establishment of a Subordinate Unified U.S. Cyber Command Under U.S.  
Strategic Command for Military Cyberspace Operations

Cyberspace and its associated technologies offer unprecedented opportunities to the United States and are vital to our Nation's security and, by extension, to all aspects of military operations. Yet our increasing dependency on cyberspace, alongside a growing array of cyber threats and vulnerabilities, adds a new element of risk to our national security. To address this risk effectively and to secure freedom of action in cyberspace, the Department of Defense requires a command that possesses the required technical capability and remains focused on the integration of cyberspace operations. Further, this command must be capable of synchronizing warfighting effects across the global security environment as well as providing support to civil authorities and international partners.

Effective immediately, Commander, U.S. Strategic Command (CDRUSSTRATCOM) is directed to establish a subordinate unified command designated as U.S. Cyber Command (USCYBERCOM). In conjunction with the establishment of USCYBERCOM and the development of a new national strategy for cybersecurity, the Under Secretary of Defense for Policy will lead a review of policy and strategy to develop a comprehensive approach to DoD cyberspace operations.



OSD 05914-09



I intend to recommend that the President redesignate the position of Director, National Security Agency (DIRNSA) as the Director, National Security Agency and Commander, U.S. Cyber Command as a position of importance and responsibility under the provisions of title 10, United States Code, Section 601 and authorize it to carry the grade of General or Admiral. I also intend to recommend that the President designate the position of Deputy Commander, U.S. Cyber Command as a position of importance and responsibility under the provisions of title 10, United States Code, Section 601 and authorize it to carry the grade of Lieutenant General or Vice Admiral. Should the DIRNSA position become vacant, the Deputy Commander, USCYBERCOM assumes duties as Commander, USCYBERCOM and the Deputy Director, National Security Agency assumes duties as DIRNSA until an active duty general or flag officer fills the DIRNSA position.

This command will reach initial operating capability (IOC) not later than October 2009 and full operating capability (FOC) not later than October 2010. While the preferred location for the command headquarters is Fort Meade, Maryland, CDRUSSTRATCOM will ensure that all phases of establishing this command and selecting the final command headquarters location are implemented in accordance with existing laws and regulations.

CDRUSSTRATCOM shall disestablish the Joint Task Force-Global Network Operations (JTF-GNO) and Joint Functional Component Command- Network Warfare (JFCC-NW) prior to FOC. The Military Departments shall identify and provide, for my approval, appropriate component support to USCYBERCOM to be in place and functioning prior to FOC. Upon disestablishment of JTF-GNO, the officer formerly serving as both Director, Defense Information Systems Agency (DIRDISA) and Commander, JTF-GNO will retain the position and duties as DIRDISA, relinquishing all duties as Commander, JTF-GNO, and continue to provide network and information assurance technical assistance to USCYBERCOM as required. Upon disestablishment of JTF-GNO, I also intend to recommend that the President redesignate the position of DIRDISA and Commander, JTF-GNO as DIRDISA, a position of importance and responsibility under the provisions of title 10, United States Code, Section 601, and authorize it to carry the grade of Lieutenant General or Vice Admiral.

The Chairman of the Joint Chiefs of Staff shall issue a planning order directing CDRUSSTRATCOM to develop an implementation plan for USCYBERCOM, to be submitted for my approval by 1 September 2009. The implementation plan must delineate USCYBERCOM's mission, roles and responsibilities; command and control, reporting and support relationships with combatant commands, Services, and U.S. Government departments and agencies; minimum requirements to achieve IOC and FOC; and accountability measures with Service and DISA network operating centers. CDRUSSTRATCOM shall delegate authority to conduct the specified cyberspace operations detailed in Section 18.d.(3) of the Unified Command Plan (UCP) to the

Commander, USCYBERCOM. The implementation plan will contain a phased approach for this delegation, to include those authorities required at IOC, by FOC, and a recommendation for the authorities that will be retained by CDRUSSTRATCOM. CDRUSSTRATCOM shall submit this implementation plan to the Joint Staff and the Office of the Under Secretary of Defense (Policy) for coordination with combatant commands, Services, and appropriate DoD agencies.

This memorandum reinforces, but does not expand, USSTRATCOM authorities and responsibilities for military cyberspace operations. In exercising CDRUSSTRATCOM's UCP assigned responsibilities, USCYBERCOM shall establish and maintain direct liaison with combatant commands, Services, and DoD agencies according to the approved implementation plan. Further, combatant commanders, Services, and DoD agencies shall remain responsible for compliance with USSTRATCOM's direction, as stipulated by USCYBERCOM, for operation and defense of the Global Information Grid.

A handwritten signature in black ink, appearing to read "R. M. Gates". The signature is fluid and cursive, with the first name "Robert" and last name "Gates" clearly distinguishable.

## APPENDIX B. TAXONOMY OF CYBERSECURITY ROLES

This appendix is predicated on two premises: (1) that in protecting the cyber infrastructure, skills matters; and (2) that cybersecurity is a complex field embracing a range of roles and therefore, the skills required to perform them and, thus, a robust strategy must reflect the diversity of roles and skills sets each role requires.<sup>1</sup>

The purpose of this paper is to identify the key roles in cybersecurity, the functions they perform, and then, the specific skills (including requisite training and education) required to perform those roles.

The good news is a great deal of work is already under way in various quarters and a number of organizations already have models on which we can draw; this is a journey of discovery, not invention. The taxonomy is intended to be illustrative as a basis for a more robust conversation about key cybersecurity roles and skills and training and certifications required to fulfill those roles. Our objective is to synthesize what we know, disseminate it so that others can use and perfect it, and accelerate the development of a more robust model.

If we can come to consensus on the roles and requisite skill sets, then:

- the Training and Education sectors will have a much clearer understanding of the labor market into which their graduate will be going;
- the purchasers of cybersecurity services, whether they are hiring staff or buying contractual support, can specify more clearly the qualifications they seek; and
- the current, sometimes confusing regime of professional certification programs can reflect the needs of potential employers.

To begin the conversation, we have identified nine key roles. As the suggested taxonomy demonstrates, many of the key roles in cybersecurity, like writing safe programs, are performed by persons not identified as cybersecurity specialists. They are as follows:

- System administration – client systems and servers;
- Network administration and network security operations;
- Security assessment, security auditing and information assurance;
- Threat analysis, intrusion and data analysis, intelligence and counter intelligence;
- Forensics investigation;
- Programming;
- Technical writing;
- Security architecture and engineering; and
- Information security and incident management.<sup>2</sup>

At least for the moment, we have not included executive and leadership roles or specialized functions unique to national security, intelligence or law enforcement. We have also omitted the basic awareness and survival skills that everyone in an organization needs to possess; the cyber equivalent of good hygiene.

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<sup>1</sup> An apt metaphor may be modern medicine, which relies on very specific roles and skill sets from the board-certified neurosurgeon to the licensed technician who operates the sophisticated imaging equipment. And, in challenging problems even within a specialty, different skills and aptitudes differentiate the practitioners adept at diagnosis from those highly accomplished at treating a condition.

<sup>2</sup> Based on "Enhancing and Expanding the National Cybersecurity Work Force: Manpower Requirements and an Action Plan to Meet Those Requirements" Version 0.6, April 15, 2009 [unpublished].

Role	Duties	Illustrative Duties	Skills
<b>System administration – Servers and Client Systems</b>	System administrators ensure software and hardware are installed and running effectively, both upon initial implementation and as changes are made for updates and patches and reconfigurations. They also manage user accounts and may manage access privileges. In small sites they also manage security devices and software like firewalls and intrusion detection systems. According to NSA reports to military CIOs, errors and omissions in configuration have accounted for more than 80% of all exploitable problems found by the NSA Red Teams (groups that test the defenses of computer networks and systems by doing what adversaries would do to find and exploit weaknesses). Thus, system administrators are the keys to ensuring systems are implemented and maintained securely. System administrators also have another critical security role – serving as the human early warning sensors. Because they know their systems and the way those systems should be operating, they are often the first people to see evidence that an adversary has penetrated their systems and taken control. Rapid identification and response helps lessen the damage from break-ins and can help reduce the spread of infections introduced during those break-ins.	<ol style="list-style-type: none"> <li>1. Use command line functions to identify potentially malicious processes and behaviors such as anonymous administrative logins via the network.</li> <li>2. Use scripts to eliminate normal events so that abnormal events will stand out when logs are reviewed.</li> <li>3. Use standard testing tools to verify that standard secure configurations have not been disabled or corrupted by software installation scripts or malicious actors.</li> <li>4. Ensure all default passwords have been changed, administrative passwords are regularly changed, screen locking is active on all client systems and that user passwords are of appropriate strength to meet organizational standards.</li> <li>5. Apply strong and appropriate access controls to shared file systems and applications.</li> <li>6. Place each user in the appropriate group and (for Windows systems) ensure group policy is administered effectively.</li> <li>7. Verify backup files have not been corrupted.</li> <li>8. Use Wireshark or other tool to baseline network traffic so abnormal traffic can be seen. (advanced).</li> <li>9. Develop scripts to automate monitoring activities (advanced)</li> </ol>	
<b>Secure Network Administration and Network Security Operations – Sometimes called Network Engineering or Network Security Engineering</b>	Network administrators install, configure, operate, and troubleshoot route and switched networks. They implement and verify connections to remote sites in a wide area network. They work with Internet Protocol (IP), frame relay, VLANs, Ethernet, gateway routing protocols, and access control lists. Their principal responsibility is to maintain the reliability and performance of the network, with security being an increasing element of reliability. Network administrators may manage wireless networks and voice networks as well as data networks. Years ago the network administrators worked in network operations centers while people responsible for monitoring security worked in security operations centers. Separation of those functions, however, led to cracks in network defenses that were deeply exploited by adversaries. As a result, today many security-aware organizations are breaking down the barriers and integrating their network and security operations staff and centers so that the career paths are merging. The combined centers manage and monitor email and spam control systems, firewalls, intrusion detection and prevention and other network and gateway security services.	<ol style="list-style-type: none"> <li>1. Configure firewall to perform a route lookup based on source address to protect from IP spoofing using ingress and egress filtering.</li> <li>2. Prevent ICMP DOS attacks without blocking ICMP packets.</li> <li>3. Configure a firewall for static network address translation (NAT).</li> <li>4. Set routes to black hole unwanted traffic.</li> <li>5. Use tools to test firewall configurations to ensure they are in compliance with policy.</li> <li>6. Identify security weaknesses in network architectures.</li> <li>7. Use network monitoring tools to establish expected network behavior.</li> </ol>	

<b>Security assessment, security auditing and information assurance</b>	<p>These are the people who verify that security controls have been implemented effectively and identify areas that need improvement. They also implement advanced security procedures to deal with highly targeted and sophisticated threats. They work in many different groups, from operations, to information security, to internal audit, to investigations. They may be called penetration testers, blue teamers, security assessors, auditors, or simply information assurance professionals. Regardless of their location and job title, their most important roles are to verify that the important controls are in place, to identify the controls that have not been implemented correctly or fully, and to assist the site in making the corrections. The best of the assessors and information assurance staff not only find problems; but also assist organizations in solving the problems they find by making recommendations that are feasible and that they can back up with models of where those controls are in place. They see themselves as successful only when the organization's controls are effectively in place.</p>	<ol style="list-style-type: none"> <li>1. Perform penetration test.</li> <li>2. Verify inventory of hardware and software is complete using active network inventory technology.</li> <li>3. Verify perimeter protections are in place by verifying firewall and other gateway settings correspond with enterprise policy, and by deploying packet sniffers to verify that http traffic does not bypass http proxies.</li> <li>4. Verify that log analysis is tuned to identify and respond to anomalies from site-specific baselines.</li> <li>5. Verify administrative passwords are not shared and that two factor authentication is used on all critical systems.</li> <li>6. Assess the time that divisions require to correct critical vulnerabilities and monitor and compare trends in that metric.</li> <li>7. Verify that dormant accounts and accounts of employees that have left are disabled regularly and in a timely fashion.</li> <li>8. Verify malware defenses are effectively implemented and that systems without o date malware defenses are found and corrected on a regular basis.</li> <li>9. Test configurations of the operating systems and ensure such tests are done regularly for all systems – or that group policy is effectively in place for all systems.</li> <li>10. Scan for wireless connections.</li> <li>11. Measure the effectiveness of incident response in actual or simulated incidents.</li> </ol>	
<b>Threat analysis, intrusion and data analysis, intelligence and counter intelligence</b>	<p>Intrusion analysts, working closely with threat and intelligence analysts, are the watchers who look at network traffic and logs (and increasingly at large amounts of data) trying to pick the signal out of the noise. They are supported by increasingly sophisticated tools, but in the end it is their deep understanding of how attacks are formed and how they hide along with their pattern recognition skills and instincts that enable the identification of many of the newest and most challenging attacks.</p>	<ol style="list-style-type: none"> <li>1. Monitoring current attack and threat information to identify those that are relevant to the enterprise.</li> <li>2. Identifying elements of the organization that are subject to targeted attacks and identifying traffic patterns that define potential attacks.</li> <li>3. Differentiating between anomalous traffic patterns caused by misbehaving hardware and that caused by malicious actors using deep understanding of networking, TCP/IP, and logs.</li> <li>4. Finding evidence of low and slow attacks (stealthy attacks that might send a few packets only every three or four days).</li> <li>5. Setting up and monitoring honey pots.</li> <li>6. Establishing expected traffic patterns and log patterns to enable the discovery of anomalous traffic.</li> <li>7. Developing scripts and short programs for automating analysis of logs and network traffic.</li> <li>8. Reverse engineering malware to identify behaviors and to point to other systems that may have been attacked.</li> <li>9.</li> </ol>	

<b>Forensics investigation</b>	<p>When a system has been compromised or when an employee or contractor is suspected of using a computer in an illegal manner, or when a computer is captured in a terrorist hideout, forensics experts are called in to find evidence of a crime, to follow the trail of the intruder to determine what damage was done, to isolate the methods used in penetrating networks and in spreading through computer systems, or to find other information that can assist in identifying and convicting hackers and other criminals. Forensics analysts capture digital data from media and network devices and mobile devices, capture volatile data from computers; conduct incident analysis on standalone computers or networks; analyze digital media and network devices to find the data of value to the investigation. And they do all that with an understanding of legal issues and techniques that will allow their work to be accepted as evidence in courts of law.</p>	<ol style="list-style-type: none"> <li>1. Image volatile memory on a computer without corrupting the data.</li> <li>2. Image a disk including all hidden sectors.</li> <li>3. Use dirty string searches to find information of interest.</li> <li>4. Create a timeline of intruder activity.</li> </ol>	
<b>Software Development</b>	<p>Computers have no business value without software – and software is written by programmers. At the same time, programmers are the source of nearly every vulnerability that allows attackers to penetrate systems. Security people spend a great deal of time cleaning up after attacks that exploited software errors. Proactive security depends heavily on ensuring programmers write code that is as free as possible from the errors that commonly create vulnerabilities.</p> <p>Early in 2009 a task force of federal and private software security experts reached consensus on the twenty-five most dangerous errors programmers make.</p> <p>The one security task for programmers, then, is to develop code that is free of those Top 25 errors. In assessing skills in this area, it is useful to differentiate between general security knowledge and language-specific, hands-on secure coding skills. Generalized security training for programmers, although easier to administer, fails to answer the key questions that the programmers have – how do I write secure code and what errors must I avoid. Those questions can be answered only in specific programming languages.</p>	<ol style="list-style-type: none"> <li>1. Software/applications are developed using enhanced security controls such as two factor authentication; encryption; passwords.</li> <li>2. Software/applications are tested by a security team prior to deployment into the production environment.</li> <li>3. Software/applications are developed with audit trails to ensure to track data access and authorizations.</li> </ol>	



<b>Security architecture (sometimes called Security Engineering): Baking Security In</b>	<p>When a new technology, system or application is being designed or upgraded, the planners and designers focus on selecting the hardware and shaping the software that is needed to deliver the system's proposed functions effectively and reliably. They rarely consider security threats as part of that process, even though security problems can be a huge threat to reliability. Baking security into the design, early in the process, can make the system much easier to secure when it is deployed.</p> <p>The key skills needed to be effective in designing security into the architecture of new systems, are (1) applying knowledge of applicable attack vectors to virtual testing of the design of the system and (2) applying knowledge of network architecture, system and network capabilities, and their interactions. These are VERY RARE skills -- much like building and bridge engineering skills before the requisite knowledge became codified and taught in engineering schools.</p>		
<b>Information security and incident management</b>	<p>The most difficult position for which to define tasks is the security manager. Security managers do everything from budgeting and selling ideas to reviewing security plans to assessing actual security controls, to selecting, purchasing, and deploying security tools, preparing and submitting and defending compliance reports, negotiating with auditors, helping operations people bake security in, managing security awareness programs, and much, much more.</p> <p>We include the job here with the hope that others – perhaps the team working with the US Office of Personnel management.</p> <p>The one area of security management that is often most critical, at least when it happens, is incident response. When systems have been penetrated, when data has been lost, when systems need to be shut down, the security manager must rise to the occasion.</p>		

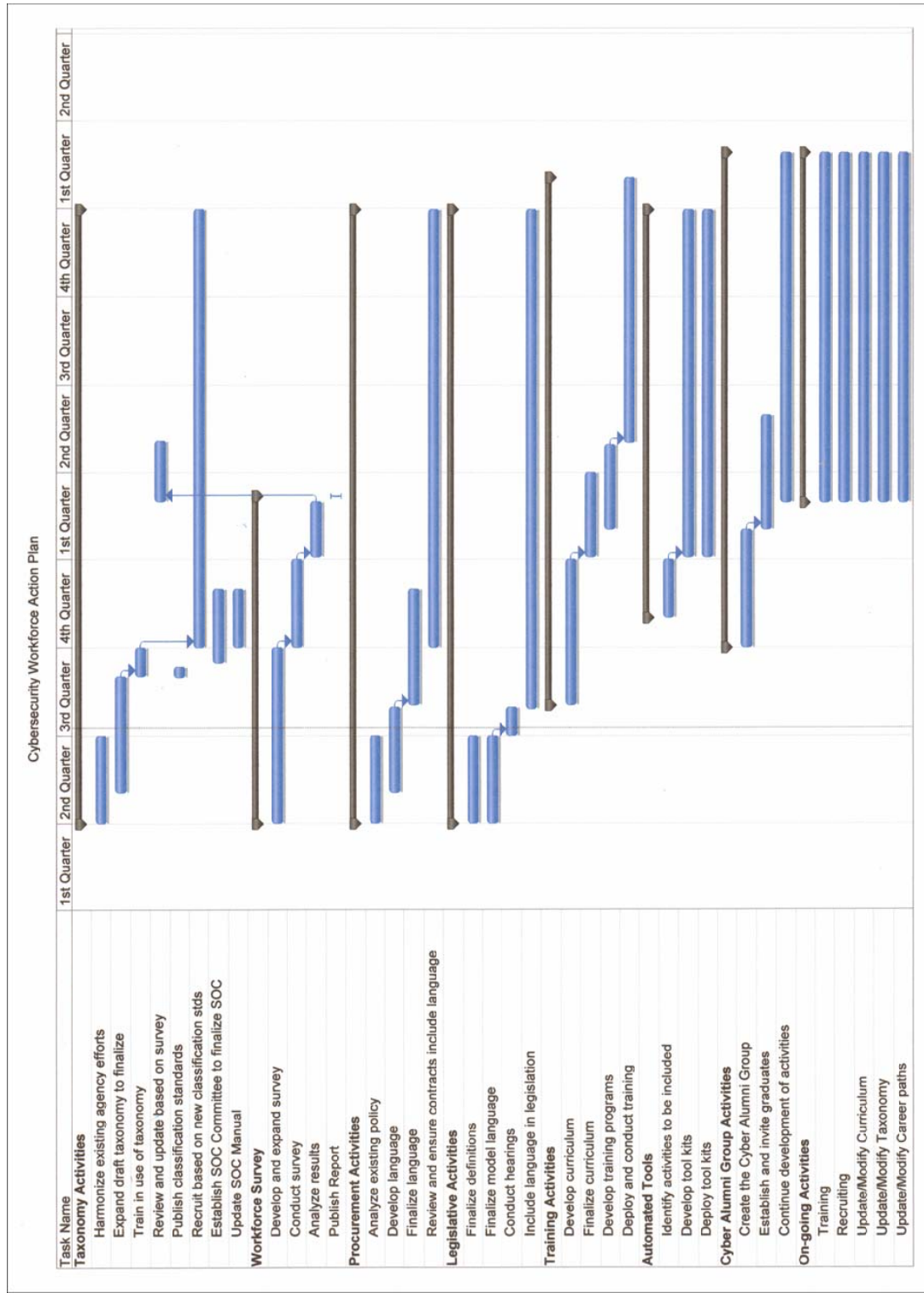


## **APPENDIX C. DRAFT DEFINITION FOR POTENTIAL LEGISLATION**

The term “cyber security services” means the development, implementation, operation and administration of measures and/or activities intended to prevent, detect, recover from and/or respond to intentional or inadvertent compromises of the confidentiality, integrity and availability of information technology including but not limited to intrusion detection, computer forensics, configuration management, and system development.

- (a) **CERTIFICATION** — Beginning 3 years after the date of enactment of this Act for it shall be unlawful for an individual to be employed as a provider of cybersecurity services to any Federal agency who is not a cybersecurity professional unless such individual is operating under the direct supervision of a cybersecurity professional.
- (b) **CERTIFIED SERVICE PROVIDER REQUIREMENT** — Notwithstanding any other provision of law, the head of a Federal agency may not use, or permit the use of, cybersecurity services for that agency that are not directly supervised by a cybersecurity professional.

## APPENDIX D. CYBERSECURITY WORKFORCE ACTION PLAN



## APPENDIX E. ACKNOWLEDGMENTS

With apologies to those whom we have omitted, members of the Commission would like to thank the staff members of the following Executive Branch Departments and Agencies; Congressional committees; and associations for their time and the insights they offered:

- Office of Management and Budget
- Federal Chief Information Officers Council
- Office of Personnel Management
- Office of the Director for National Intelligence
- Department of Defense
  - Department of the Army
  - Department of the Air Force
  - Department of the Navy
  - Joint Chiefs of Staff
  - National Security Agency
  - National Defense University
- Department of Homeland Security
- Department of Justice
  - Federal Bureau of Investigation
- Department of State
- Department of Commerce
  - Information Security Program Advisory Board

### **U.S. House of Representatives:**

- Armed Services
- Homeland Security
- Oversight and Government Reform
- Science and Technology

### **U.S. Senate:**

- Commerce, Science and Transportation
- Homeland Security and Government Affairs
- Select Committee on Intelligence

### **Associations:**

- International Information Systems Security Certification Consortium (ISC)<sup>2</sup>
- ISACA

## ABOUT THE AUTHORS

**Karen Evans** is an independent consultant in the areas of leadership, management, and the strategic use of information technology. She recently retired after nearly 28 years of federal government service with responsibilities ranging from a GS-2 to presidential appointee as the administrator for e-government and information technology (IT) at the Office of Management and Budget (OMB) in the Executive Office of the President. She oversaw the federal IT budget of nearly \$71 billion, which included implementation of IT throughout the federal government. This included advising the director of OMB on the performance of IT investments, overseeing the development of enterprise architectures within and across the agencies, directing the activities of the Chief Information Officers Council, and overseeing the usage of the E-Government Fund to support interagency partnerships and innovation. Ms. Evans also had responsibilities in the areas of capital planning and investment control; information security; privacy and accessibility of IT for persons with disabilities; and access to, dissemination of, and preservation of government information.

**Franklin Reeder** is chairman of the National Board of Information Security Examiners. He served at the Office of Management and Budget (OMB) from 1970 to 1995, where he was chief of information policy, deputy associate director for veterans affairs and personnel, and assistant director for general management. From 1977 to 1980, he was deputy director of House Information Systems, the computers and telecommunications support arm of the U.S. House of Representatives, and from 1995 to 1997, he served as director of the Office of Administration in the Executive Office of the President. He was a member of the Obama-Biden Presidential Transition Team serving on the OMB and White House agency review teams and the technology, innovation, and government reform team. Mr. Reeder was cofounder and chairman of the Center for Internet Security, a nonprofit established to help organizations manage the organizational risks related to information security. From 2000 to 2006, he chaired the Information Security and Privacy Advisory Board of the National Institute of Standards and Technology, a federal advisory committee.





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