



Defense Acquisition Research Journal

A Publication of the Defense Acquisition University



STRENGTHENING Cost Consciousness, Professionalism, and Technical Excellence

2016

Edward Hirsch Research Paper Competition

Presented on behalf of DAU by:



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*The High Flying Leadership
Qualities: What Matters the Most?*
Col Robert L. Tremaine, USAF (Ret.)



*Metrics-based Risk Assessment and
Management of Digital Forensics*
**Mehmet Sahinoglu,
MSgt Stephen Stockton, USAF (Ret.),
Capt Robert M. Barclay, USAF (Ret.),
and Scott Morton**

*Catalysts of Military Innovation: A Case Study
of Defense Biometrics*
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*#eVALUate: Monetizing Service Acquisition
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Lt Col Timothy G. Hawkins, USAF (Ret.)**

The Defense Acquisition Professional Reading List
*The American Warfare State: The Domestic
Politics of Military Spending*
Written by Rebecca Thorpe
Reviewed by Trevor Taylor

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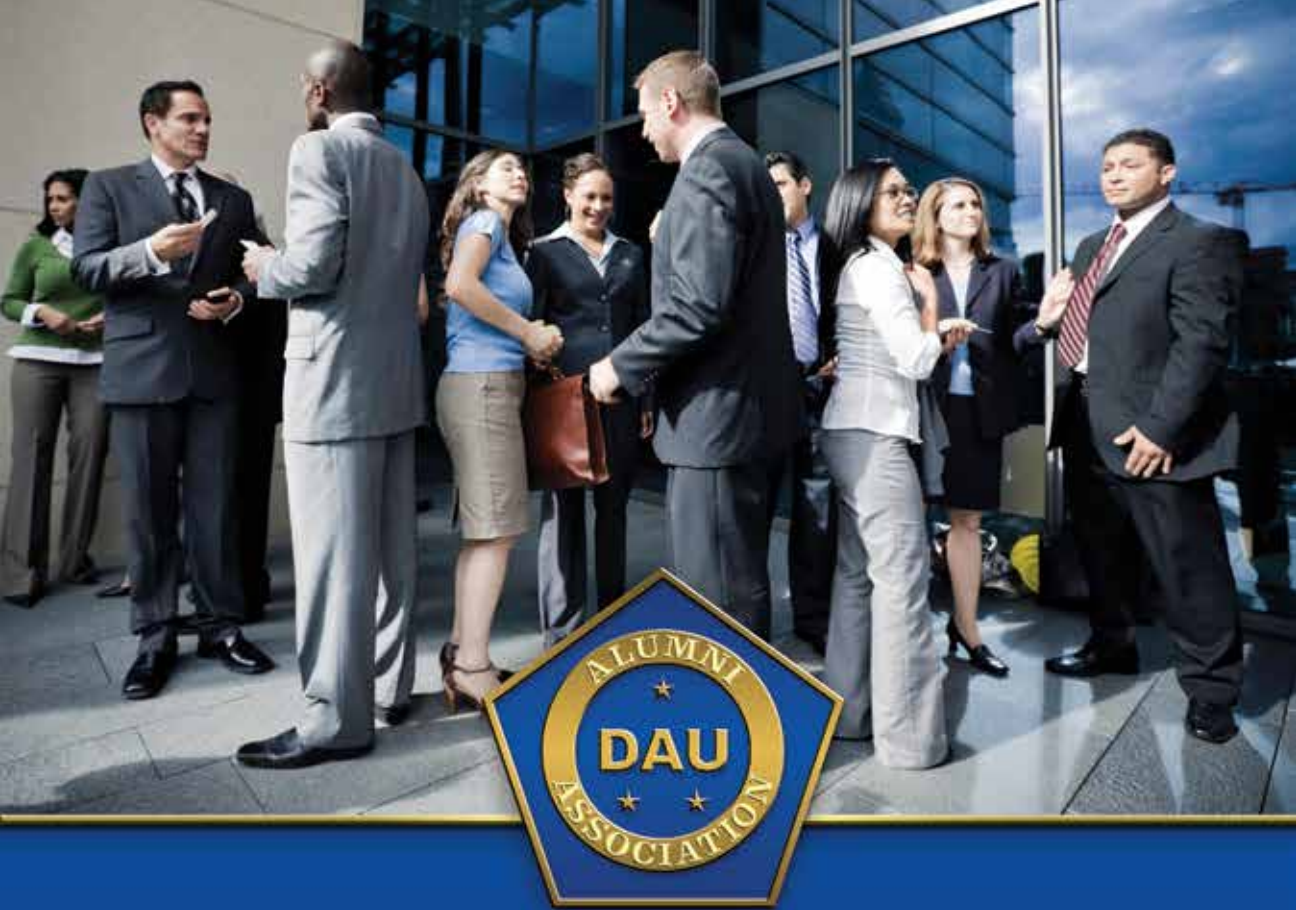
Call for Authors

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or e-mail dauaa2@aol.com.**



FROM THE CHAIRMAN AND EXECUTIVE EDITOR

Dr. Larrie D. Ferreiro



The theme for this edition of *Defense Acquisition Research Journal* is “Strengthening Cost Consciousness, Professionalism, and Technical Excellence,” which is the iron triangle of a robust defense acquisition system. It is also the theme of this year’s annual research paper competition sponsored by our partner organization, the Defense Acquisition University Alumni Association.

The first-place winner is Col Robert L. Tremaine’s, USAF (Ret.) “The High Flying Leadership Qualities: What Matters the Most?” In it, he evaluates the factors of leadership, such as leading by example and communicating effectively, which mark effective organizations and form the basis for thoughtful and effective development programs that combine training, practice, and cultivation.

The second-place winner is “Metrics-based Risk Assessment and Management of Digital Forensics,” by Mehmet Sahinoglu; MSgt Stephen Stockton, USAF (Ret.); Capt Robert M. Barclay, USAF (Ret.); and Scott Morton. The authors contend that digital forensics, a relatively new field for assessing evidence for a variety of purposes, can be quantified by using a novel method that calculates the risk index for the digital forensics process.

The other two papers in this edition are “Catalysts of Military Innovation: A Case Study of Defense Biometrics” by COL Glenn Voelz, USA, which examines doctrinal innovation and warfighting strategies as catalysts of military technology innovation using a case study of defense biometrics; and “#eVALUate: Monetizing Service Acquisition Trade-offs Using the Quality-Infused Price® Methodology” by Capt Daniel J. Finkenstadt, USAF, and Lt Col Timothy G. Hawkins, USAF (Ret.), which proposes a method to leverage the use of subjective service quality in both selecting contractors and managing their performance.

The featured book in this issue’s Defense Acquisition Professional Reading List is Rebecca Thorpe’s *The American Warfare State: The Domestic Politics of Military Spending*, reviewed by Professor Trevor Taylor of Cranfield University at the Defence Academy of the United Kingdom.



DAU CENTER FOR DEFENSE ACQUISITION

RESEARCH AGENDA 2016–2017

This Research Agenda is intended to make researchers aware of the topics that are, or should be, of particular concern to the broader defense acquisition community within the federal government, academia, and defense industrial sectors. The center compiles the agenda annually, using inputs from subject matter experts across those sectors. Topics are periodically vetted and updated by the DAU Center's Research Advisory Board to ensure they address current areas of strategic interest.

The purpose of conducting research in these areas is to provide solid, empirically based findings to create a broad body of knowledge that can inform the development of policies, procedures, and processes in defense acquisition, and to help shape the thought leadership for the acquisition community. Most of these research topics were selected to support the DoD's Better Buying Power Initiative (see <http://bbp.dau.mil>). Some questions may cross topics and thus appear in multiple research areas.

Potential researchers are encouraged to contact the DAU Director of Research (research@dau.mil) to suggest additional research questions and topics. They are also encouraged to contact the listed Points of Contact (POC), who may be able to provide general guidance as to current areas of interest, potential sources of information, etc.

Competition POCs

- John Cannaday, DAU: john.cannaday@dau.mil
- Salvatore Cianci, DAU: salvatore.cianci@dau.mil
- Frank Kenlon (global market outreach), DAU: frank.kenlon@dau.mil

Measuring the Effects of Competition

- What means are there (or can be developed) to measure the effect on defense acquisition costs of maintaining the defense industrial base in various sectors?
- What means are there (or can be developed) of measuring the effect of utilizing defense industrial infrastructure for commercial manufacture, and in particular, in growth industries? In other words, can we measure the effect of using defense manufacturing to expand the buyer base?
- What means are there (or can be developed) to determine the degree of openness that exists in competitive awards?
- What are the different effects of the two best value source selection processes (trade-off vs. lowest price technically acceptable) on program cost, schedule, and performance?

Strategic Competition

- Is there evidence that competition between system portfolios is an effective means of controlling price and costs?
- Does lack of competition automatically mean higher prices? For example, is there evidence that sole source can result in lower overall administrative costs at both the government and industry levels, to the effect of lowering total costs?
- What are the long-term historical trends for competition guidance and practice in defense acquisition policies and practices?

- To what extent are contracts being awarded non-competitively by congressional mandate for policy interest reasons? What is the effect on contract price and performance?
- What means are there (or can be developed) to determine the degree to which competitive program costs are negatively affected by laws and regulations such as the Berry Amendment, Buy America Act, etc.?
- The DoD should have enormous buying power and the ability to influence supplier prices. Is this the case? Examine the potential change in cost performance due to greater centralization of buying organizations or strategies.

Effects of Industrial Base

- What are the effects on program cost, schedule, and performance of having more or fewer competitors? What measures are there to determine these effects?
- What means are there (or can be developed) to measure the breadth and depth of the industrial base in various sectors that go beyond simple head-count of providers?
- Has change in the defense industrial base resulted in actual change in output? How is that measured?

Competitive Contracting

- Commercial industry often cultivates long-term, exclusive (noncompetitive) supply chain relationships. Does this model have any application to defense acquisition? Under what conditions/circumstances?
- What is the effect on program cost, schedule, and performance of awards based on varying levels of competition: (a) “Effective” competition (two or more offers); (b) “Ineffective” competition (only one offer received in response to competitive solicitation); (c) split awards vs. winner take all; and (d) sole source.

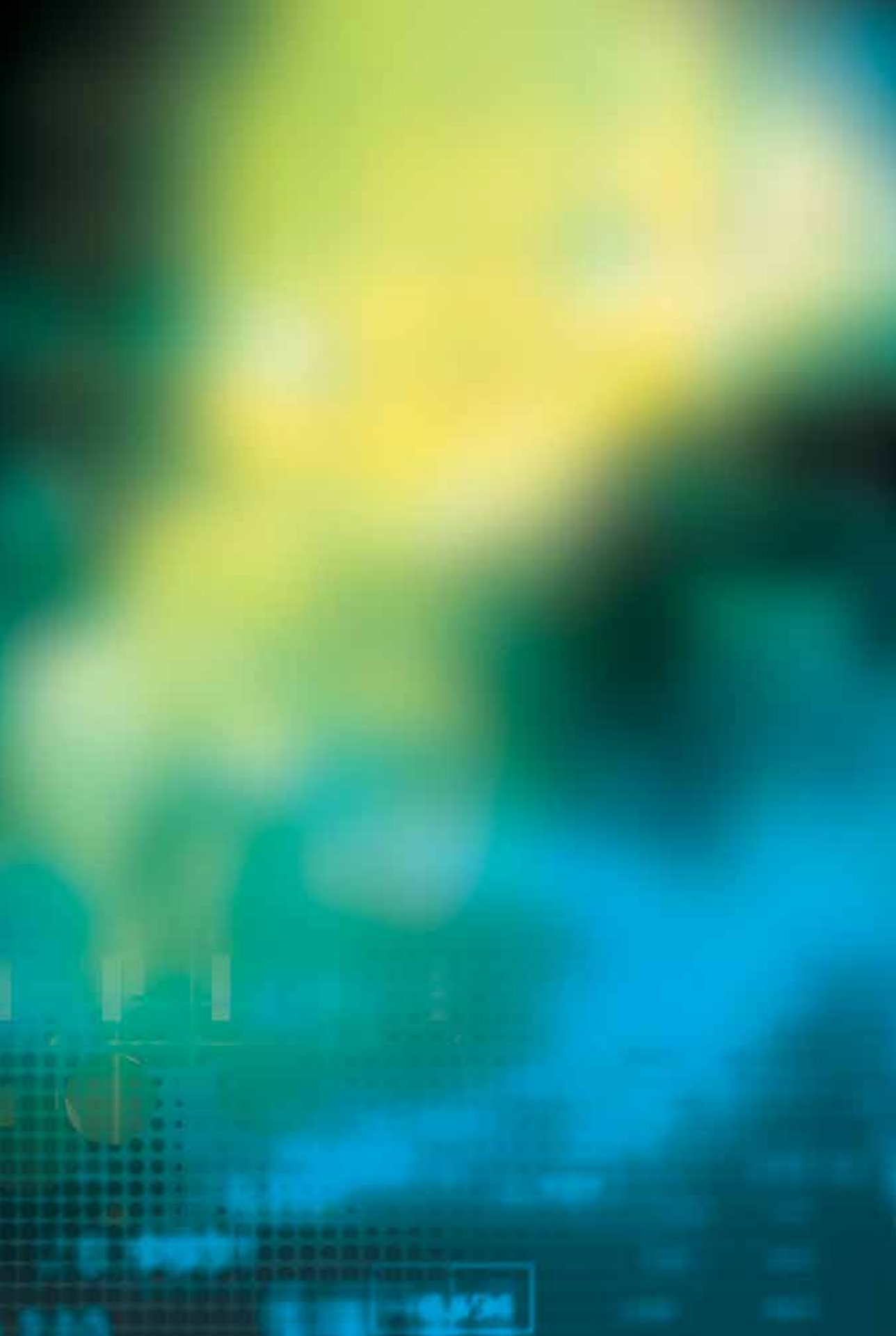
Improve DoD Outreach for Technology and Products from Global Markets

- How have militaries in the past benefitted from global technology development?
- How/why have militaries missed the largest technological advances?
- What are the key areas that require the DoD's focus and attention in the coming years to maintain or enhance the technological advantage of its weapon systems and equipment?
- What types of efforts should the DoD consider pursuing to increase the breadth and depth of technology push efforts in DoD acquisition programs?
- How effectively are the DoD's global science and technology investments transitioned into DoD acquisition programs?
- Are the DoD's applied research and development (i.e., acquisition program) investments effectively pursuing and using sources of global technology to affordably meet current and future DoD acquisition program requirements? If not, what steps could the DoD take to improve its performance in these two areas?
- What are the strengths and weaknesses of the DoD's global defense technology investment approach as compared to the approaches used by other nations?
- What are the strengths and weaknesses of the DoD's global defense technology investment approach as compared to the approaches used by the private sector—both domestic and foreign entities (companies, universities, private-public partnerships, think tanks, etc.)?
- How does the DoD currently assess the relative benefits and risks associated with global versus U.S. sourcing of key technologies used in DoD acquisition programs? How could the DoD improve its policies and procedures in this area to enhance the benefits of global technology sourcing while minimizing potential risks?

- How could current DoD/U.S. Technology Security and Foreign Disclosure (TSFD) decision-making policies and processes be improved to help the DoD better balance the benefits and risks associated with potential global sourcing of key technologies used in current and future DoD acquisition programs?
- How do DoD primes and key subcontractors currently assess the relative benefits and risks associated with global versus U.S. sourcing of key technologies used in DoD acquisition programs? How could they improve their contractor policies and procedures in this area to enhance the benefits of global technology sourcing while minimizing potential risks?
- How could current U.S. Export Control System decision-making policies and processes be improved to help the DoD better balance the benefits and risks associated with potential global sourcing of key technologies used in current and future DoD acquisition programs?

Comparative Studies

- Compare the industrial policies of military acquisition in different nations and the policy impacts on acquisition outcomes.
- Compare the cost and contract performance of highly regulated public utilities with nonregulated “natural monopolies,” e.g., military satellites, warship building, etc.
- Compare contracting/competition practices between the DoD and complex, custom-built commercial products (e.g., offshore oil platforms).
- Compare program cost performance in various market sectors: highly competitive (multiple offerors), limited (two or three offerors), monopoly?
- Compare the cost and contract performance of military acquisition programs in nations having single “purple” acquisition organizations with those having Service-level acquisition agencies.



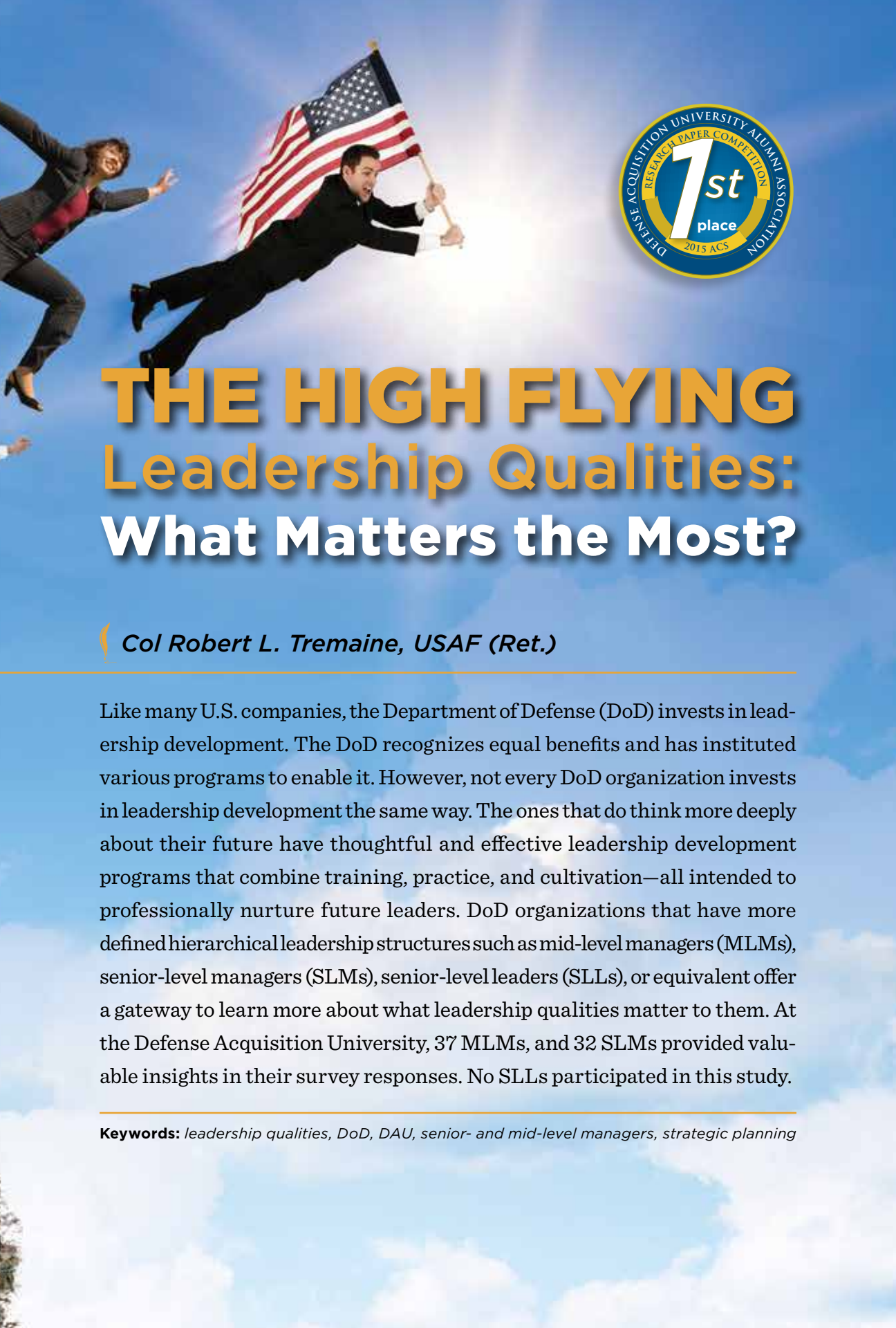


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We're on the Web at:
<http://www.dau.mil/pubscats/Pages/ARJ.aspx>
and
<http://dau.dodlive.mil>



A background image showing a man and a woman in business attire flying through the air against a blue sky with clouds. The man is holding a large American flag. The woman is also flying, looking towards the camera.

THE HIGH FLYING Leadership Qualities: What Matters the Most?

Col Robert L. Tremaine, USAF (Ret.)

Like many U.S. companies, the Department of Defense (DoD) invests in leadership development. The DoD recognizes equal benefits and has instituted various programs to enable it. However, not every DoD organization invests in leadership development the same way. The ones that do think more deeply about their future have thoughtful and effective leadership development programs that combine training, practice, and cultivation—all intended to professionally nurture future leaders. DoD organizations that have more defined hierarchical leadership structures such as mid-level managers (MLMs), senior-level managers (SLMs), senior-level leaders (SLLs), or equivalent offer a gateway to learn more about what leadership qualities matter to them. At the Defense Acquisition University, 37 MLMs, and 32 SLMs provided valuable insights in their survey responses. No SLLs participated in this study.

Keywords: *leadership qualities, DoD, DAU, senior- and mid-level managers, strategic planning*

If institutions like DAU treat learning as a lifetime pursuit, then what do its mid-level managers (MLMs) and senior-level managers (SLMs) have to say about the leadership qualities that matter most during their own continuing professional development journey? Aside from growing more capable leaders along with the ability to create greater influence inside and outside their learning spheres, are there any leadership quality outliers in particular that deserve a more intensive review based on responses from a representative sample population? The DAU workforce is in a powerful position to address this question given the inherent diversity and capability among its ranks, as well as the previous operational and functional background of its personnel steeped in both DoD and industry experience.

Research Methodology

Based on their experiences, survey respondents were asked to identify the five leadership qualities that mattered most to them, from a list of 14 representative ones drawn from multiple sources. The respondents had to make hard choices. What specific factors influenced their leadership quotient and why? Did their position, generational affiliation, supervisory experience, and number of years in their current position at DAU create any noticeable flux? What about the qualities that fell outside their top five? Were they still important, and to what degree? The remainder of this article addresses answers to these questions in aggregate, as well as in the context of various demographic slices among both MLMs and SLMs to understand better the causes, and whether or not there is a cause for concern for other institutions similar to DAU throughout the DoD. The more granular results are reported through frequency tables and augmented by qualitative comments.

The order of the 14 leadership qualities (Table 1) in this particular survey was intentionally randomized.

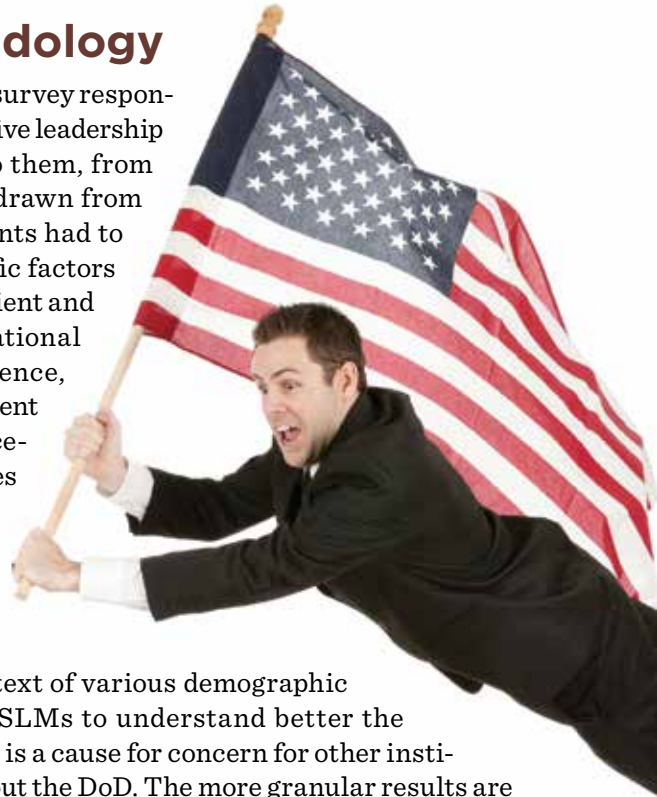


TABLE 1. 14 LEADERSHIP QUALITIES

Leads by Example	Develops Self & Others
Effective Communicator	Builds & Nurtures Trust Relationships
Competent	Credible
Displays Respect & Support for Others	Behavior Aligns with DAU Values
Critical Thinking	Exercises Authority & Decision Making
Promotes Collaboration	Maintains DAU Enterprise Perspective
Change Agent	Innovator

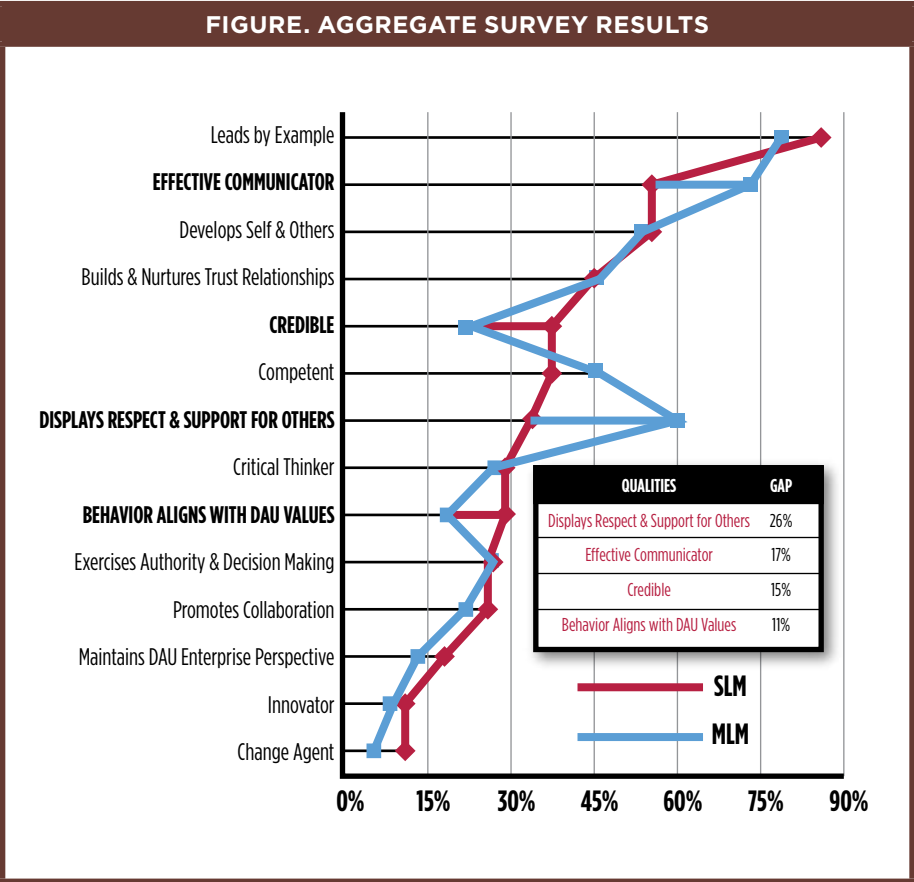
Results and Findings (Aggregate)

The Figure displays Aggregate Survey Results. Among all the respondents, **Leads by Example** and **Effective Communicator** rose as the top two choices. Research underscores similar findings. Both characteristics seem to embody the importance of the expected qualities found “in” and “of” leaders; they also tend to be inextricably linked in practice. RBC Financial Group, Canada’s largest financial corporation, recognized the value and combined the two by instituting a communication process called “Leadership Dialogues” where “established leaders relate their career experiences to developing leaders” (Beslin & Reddin, 2004). As part of Effective Communicator, listening is also an especially important component. Listening takes time and generally requires us to think more about our thinking (i.e., metacognition). Without it, decision missteps can potentially result. In their book, *Leadership by Example: The Ten Key Principles of All Great Leaders*, Dr. Sanjiv Chopra and David Fisher remind us that as

Abraham Lincoln said, “It is better to be silent and be thought a fool than to speak up and dispel all doubt” (Chopra & Fisher, 2012) by speaking up too soon. Surprisingly, research shows the average person listens at around 25 percent efficiency levels (Husman, Lahiff, & Penrose, 1988), even though listening is so closely tied to effective leadership (Johnson & Bechler, 1998). An ample supply of programs teaches us to be better communicators; few programs exist that teach us to be



better listeners (Janusik, Fullenkamp, & Partese, n.d.) or the important role that culture plays in communication through the motivation, knowledge, and skills of the interactants involved (Spitzberg, 1994).



For **Develops Self and Others**, instruments like an organization’s Strategic Plan (SP) or other similar means generally characterize some aspect of its leadership development programs as part of its mission heading. The Department of Homeland Security (DHS, 2014) addresses leadership development in its SP under Goal 6: Strengthen Service Delivery and Manage DHS Resources, with a specific objective that focuses on “building an effective, mission-focused, diverse, and inspiring cadre of leaders” (p. 45). Whatever the manifestation, these programs can also pay huge dividends by lowering costly turnover rates, growing more capable leaders, and creating greater opportunities for professional gains as well as concomitant organizational successes inside and outside their domains.

In the respondents' selection of their top five, the author discerned a noticeable variance between how DAU SLMs and MLMs viewed Effective Communication, **Credible**, and **Displays Respect for Others**. MLMs more often selected Effective Communication and Displays Respect for Others in their top five, and provided quite a few supporting comments to reinforce their importance:

Effective Communication: "A leader must be able to communicate vision/purpose to the organization for it to understand goals and why they are important to the mission Basis for leadership Can't lead if you can't communicate It's not WHAT you say, but HOW you say it Effective leaders must be able to share knowledge and ideas as well as transmit urgency and enthusiasm to others."

Displays Respect for Others (Critical for a Leader): "Treat others the way you would expect to be treated A leader needs to respect not only the people that work for them, but also everyone in the enterprise; otherwise, trust breaks down A successful organization demonstrates respect for all levels of the organization Without respect, others will not listen or follow. An effective leader must be willing to consider others' opinions and be open to feedback, even if it's not favorable."

SLMs placed a greater emphasis than MLMs on Credible. For some MLMs, Credible may have dropped out of their top five based on their supporting comments (found under Leads by Example and Competent) where they responded:

Credible: "Basis of credibility ... A subordinate should only have to look one place for the standard that needs to be met—the supervisor Do as I do works much better than do as I say Time honored leadership quality ... It's one of the key things I look for in my leaders You get from others what you model for them You must be an expert in your chosen field—it ties to credibility."

Involving more MLMs as "leads" on strategic initiatives that cut across the enterprise, where they can demonstrate how their dependability and expertise converge, might help close the gap between the SLMs and MLMs top five.



Findings (By Demographic)

Does a leader’s role (either faculty or staff) influence the importance of certain leadership qualities?

For each role grouping, the following leadership qualities rose one standard deviation *above* the mean ($\bar{x} + 1\sigma$) as shown in Table 2.

TABLE 2. RESPONSES TO 14 LEADERSHIP QUALITIES BASED ON “ROLE”													
Leadership Qualities	Aggregate				By Role				$\bar{X}$		Standard Deviation (σ)		$\bar{X} \pm 1\sigma$
	SLM AGG	MLM AGG	SLM AD	SLM Faculty	SLM Faculty	MLM Faculty	SLM Staff	MLM Staff	MLM Staff	Avg of Avgs	ALL	SLM	MLM
Leads by Example	85%	79%	75%	100%	40%	82%	90%	60%	82%	9%	8%	7%	90%
Develops Self & Others	56%	55%	67%	40%	55%	50%	50%	60%	52%	14%	17%	6%	66%
Effective Communicator	56%	71%	67%	40%	70%	50%	50%	80%	63%	13%	7%	7%	75%
Builds & Nurtures Trust Relationships	44%	47%	58%	20%	42%	40%	40%	80%	43%	19%	20%	14%	63%
Competent	37%	45%	25%	60%	42%	40%	40%	60%	44%	13%	16%	8%	57%
Credible	37%	21%	58%	0%	24%	30%	30%	0%	24%	17%	16%	12%	41%
Displays Respect & Support for Others	33%	58%	17%	40%	61%	50%	50%	40%	49%	18%	20%	10%	67%
Behavior Aligns with DAU Values	30%	21%	17%	60%	21%	30%	30%	20%	26%	13%	16%	7%	39%
Critical Thinking	30%	26%	42%	20%	30%	20%	20%	0%	27%	11%	10%	10%	38%
Exercises Authority & Decision Making	26%	26%	17%	40%	27%	30%	30%	20%	31%	18%	21%	10%	48%
Promotes Collaboration	26%	21%	8%	40%	21%	20%	40%	20%	24%	8%	9%	4%	33%
Maintains DAU Enterprise Perspective	19%	13%	17%	40%	9%	10%	10%	40%	17%	10%	10%	9%	27%
Change Agent	11%	8%	8%	0%	9%	20%	0%	0%	11%	9%	10%	7%	20%
Innovator	11%	8%	25%	0%	6%	0%	0%	20%	8%	7%	8%	5%	16%

- Associate deans: Develops Self and Others, Credible, **Critical Thinking**, and **Innovator**
- SLM faculty: Leads by Example, **Competent**, **Behavior Aligns with DAU Values**, **Promotes Collaboration**, and **Maintains DAU Enterprise Perspective**
- MLM staff: Effective Communicator, **Builds and Nurtures Trust Relationships**, Competent, Maintains DAU Enterprise Perspective, and Innovator
- SLM staff: Leads by Example, Promotes Collaboration, and **Change Agent**

For the same grouping, the following leadership qualities fell one standard deviation *below* the mean ($\bar{x} - 1\sigma$) as shown in Table 2.

- Associate deans: Competent and Promotes Collaboration
- MLM staff: Leads by Example, Credible, Critical Thinking, and Change Agent
- SLM faculty: Effective Communicator, Builds and Nurtures Trust Relationships, Credible, Change Agent, and Innovator
- SLM staff: Effective Communicator and Innovator

For Credible, the foundation of building trust, according to Stephen Covey (2009), MLM faculty who raised its importance responded:

“Can’t lead without it ... Captures a number of the other qualities that matter and would be foolish to leave it out ... implies knowledgeable and proactive ... Similar to **Competent**—means we bring experience to the situation ... When subordinates come to believe that a senior is not credible or sufficiently informed, not honest, forthright, or responsive, they’ll likely no longer be listening by the time the leader finally recognizes his/her isolation.”

For Change Agent, where leaders work to alter employee attitudes and behaviors because it’s important for long-term success and sustainability (Abbas & Asghar, 2010, p. 26), SLM staff who raised its importance responded:

“Change is the constant Need Change Agent to overcome natural resistance to change ... DAU can’t continue to do things the way they have always been done Our leadership needs to be able to recognize positive change and be willing to accomplish that change.”

Some of the greatest differences in the top five selections occurred among the associate deans, SLM faculty, and MLM staff in their selections of Competent, Credible, Promotes Collaboration, and Innovator. Of all the demographic groups, the associate deans were the only one to score Develops Self and Others one standard deviation above the mean. As the saying goes, “What you see depends on where you sit.” Associate deans might be more strategically positioned to witness the greater impacts that a more capable and “developed” workforce can make. SLM faculty were the only group to raise Behavior Aligns with DAU Values one standard deviation above the mean. This might stem from their frequent interaction with diversified and sometimes larger groups, combined with the recognition that “the greater the linkage between behavior and values, the greater an organization’s success” (Rubino, 1998). SLM faculty also generally witness firsthand the prevailing professionalism, enthusiasm, and resulting impacts of more cross-cutting enterprise projects (or the absence thereof), firsthand.

Do generational affiliations indicate any predispositions?

For the generational slice, the following leadership qualities rose one standard deviation *above* the mean ($\bar{x} + 1\sigma$) as shown in Table 3.

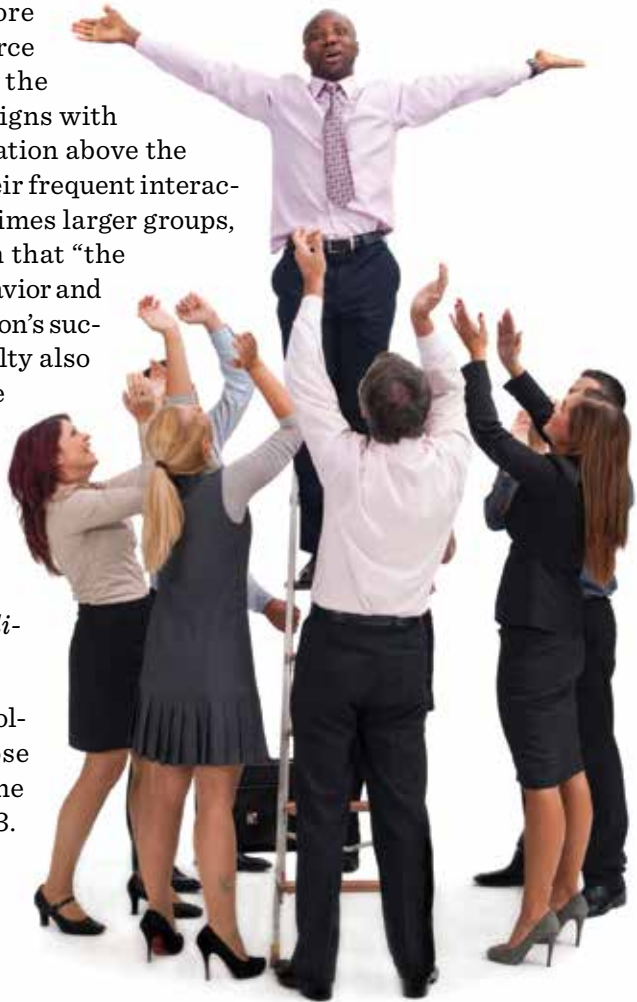


TABLE 3. RESPONSES TO 14 LEADERSHIP QUALITIES BASED ON “GENERATION”														
Leadership Qualities	Aggregate		By Generation				X̄		Standard Deviation (σ)				X̄ ± 1σ	
	SLM AGG	MLM AGG	SLM Boomr	MLM Boomr	SLM Gen X	MLM Gen X	Avg of X	Avg of X	ALL	SLM	MLM	MLM	X̄ + 1σ	X̄ - 1σ
Leads by Example	85%	79%	87%	77%	75%	88%	82%	82%	9%	8%	7%	90%	73%	
Develops Self & Others	56%	55%	61%	57%	25%	50%	52%	52%	14%	17%	6%	66%	38%	
Effective Communicator	56%	71%	57%	67%	50%	88%	63%	63%	13%	7%	7%	75%	50%	
Builds & Nurtures Trust Relationships	44%	47%	52%	43%	0%	63%	43%	43%	19%	20%	14%	63%	24%	
Competent	37%	45%	30%	47%	75%	38%	44%	44%	13%	16%	8%	57%	31%	
Credible	37%	21%	39%	27%	25%	0%	24%	24%	17%	16%	12%	41%	7%	
Displays Respect & Support for Others	33%	58%	26%	60%	75%	50%	49%	49%	18%	20%	10%	67%	30%	
Behavior Aligns with DAU Values	30%	21%	35%	17%	0%	38%	26%	26%	13%	16%	7%	39%	13%	
Critical Thinking	30%	26%	26%	27%	50%	25%	27%	27%	11%	10%	10%	38%	16%	
Exercises Authority & Decision Making	26%	26%	17%	30%	75%	13%	31%	31%	18%	21%	10%	48%	13%	
Promotes Collaboration	26%	21%	26%	20%	25%	25%	24%	24%	8%	9%	4%	33%	16%	
Maintains DAU Enterprise Perspective	19%	13%	22%	13%	0%	13%	17%	17%	10%	10%	9%	27%	7%	
Change Agent	11%	8%	9%	10%	25%	0%	11%	11%	9%	10%	7%	20%	1%	
Innovator	11%	8%	13%	7%	0%	13%	8%	8%	7%	8%	5%	16%	1%	

- GEN X SLMs: Competent, Critical Thinking, **Exercises Authority and Decision Making**, and Change Agent
- GEN X MLMs: Effective Communicator and Builds and Nurtures Trust Relationships

In this same category, the following leadership qualities fell one standard deviation *below* the mean ($\bar{x} - 1\sigma$) as shown in Table 3.

- Boomer SLMs: Competent
- GEN X SLMs: Develops Self and Others, Effective Communicator, Builds and Nurtures Trust Relationships, Displays Respect for Others, Behavior Aligns with DAU Values, Maintains DAU Enterprise Perspective, and Innovator
- GEN X MLMs: Credible, Exercises Authority and Decision Making, and Change Agent

By juxtaposing SLMs and MLMs along the lines of their generational affiliation, more dramatic variances surfaced for GEN X in particular. While the Boomers were generally consistent in the selection of their top five, GEN X SLMs' selections were more dispersed for 11 of the 14 qualities, while GEN X MLMs were less distributed in their selections. No Boomer left any of the 14 qualities out of their top five leadership qualities. GEN X SLMs and GEN X MLMs left out four and two, respectively. There can be several explanations for the GEN X fluctuations.

GEN X SLMs apparently placed significantly more stock in Competent, Critical Thinking, Exercises Authority and Decision Making, and Change Agent in what appears to be at the expense of three of the top five.

For Competent, they may have learned and want what Kolditz (2007) theorized: "Leaders need to take the time and effort to show followers what they're good at and why followers should be confident in the leader's ability" (p. 41). In their supporting comments, the respondents said:

Competent: "A leader needs to be competent for several reasons. Subordinates will have respect for a leader that has technical and leadership competence A competent leader automatically sets high standards for his/her employees because subordinates will naturally follow leadership's example A leader should be competent in their role; if not, then that is a weakness to those you wish to lead."

For Critical Thinking, they could have learned very early the value of questioning more, challenging the status quo, and reaping the benefits of creative tension and divergent thinking. They may have even learned how to “dispute their beliefs,” according to Dr. Albert Ellis, and promote more rational thinking about their own beliefs (Epstein, 2001); as well as recognize what other scholars have reported—that thinking controls feelings and volition (Elder, 1996), which can easily cloud rational and sound thinking. Two of the respondents pointed out that:

Critical Thinking: “Critical thinking skills are required for an individual to be successful at nearly all of the qualities identified It strengthens individual capabilities and encourages professionalism of others through an intellectually disciplined process by conceptualizing, applying, evaluating, and formulating a reasoning of beliefs.”

For Exercises Authority and Decision Making, the other groups gave a substantially higher number of reasons for keeping them out of the top five. Two respondents characterized it simply by saying:

Exercises Authority and Decision Making: “I feel this trait is important, but not as valuable as others listed in my opinion I considered it less important [and] because I have to trust my people to execute, I delegate.”

For Change Agent to rise in the ranking, especially in the top five, something had to occur with some of the GEN X MLMs in their past where they probably experienced the necessity for change. More often than not, many individuals generally question the need. Why the change? How will I/we be affected? Am I/we at risk as a result of the change? Harvard Professor John Kotter (1996) established an eight-step process if the case for change can be made.

1. Establishing a Sense of Urgency
2. Creating the Guiding Coalition
3. Developing a Vision and Strategy
4. Communicating the Change Vision
5. Empowering Employees for Broad-based Action
6. Generating Short-term Wins

7. Consolidating Gains and Producing More Change

8. Anchoring New Approaches in the Culture

Kotter's construct is still very popular. However, GEN X MLMs might not yet fully appreciate the extent of the value proposition of change due to inexperience and/or limited exposure to certain situations, the reason for change, or perhaps merely more inconsistency among the MLMs in their top five selections. Timing could also be a factor. For example, DAU underwent a major transformation at the turn of the past century. DAU's relevancy as an institution came under scrutiny. It was about to be absorbed by another institution. DAU clearly had a "Sense of Urgency" (i.e., Kotter's Step 1) and even incorporated the word "Transformation" to promulgate it as one of DAU's five top goals. DAU had to change—and many of the Boomers and some GEN X SLMs took part in the transformation. GEN X MLMs who joined DAU later didn't, and missed the revolution. "Transformation" is no longer a DAU Strategic Goal, which could later create greater resistance to change.

The reason GEN X MLMs ranked Credible so low is only speculative. Instead of devaluing Credible, they may have made tighter connections to other leadership qualities. One of the respondents said, "Credible is similar to competent—it means we bring experience to the situation." Additionally, GEN X MLMs may not fully appreciate the trust tax (Covey, 2009)—imposed by certain leaders (and organizations) and so closely coupled with credibility—that costs organizations time and money by instituting (or inadvertently maintaining) various decision barriers (e.g., lengthy coordination cycles, bureaucratic red tape, extensive time spent in meetings, etc.).

Does supervisory experience influence the perceived importance of certain leadership qualities?

For SLMs with 15 years or more of supervisory experience, the following leadership qualities rose one standard deviation *above* the mean ($\bar{x} + 1\sigma$) as shown in Table 4, with the following supporting comments:

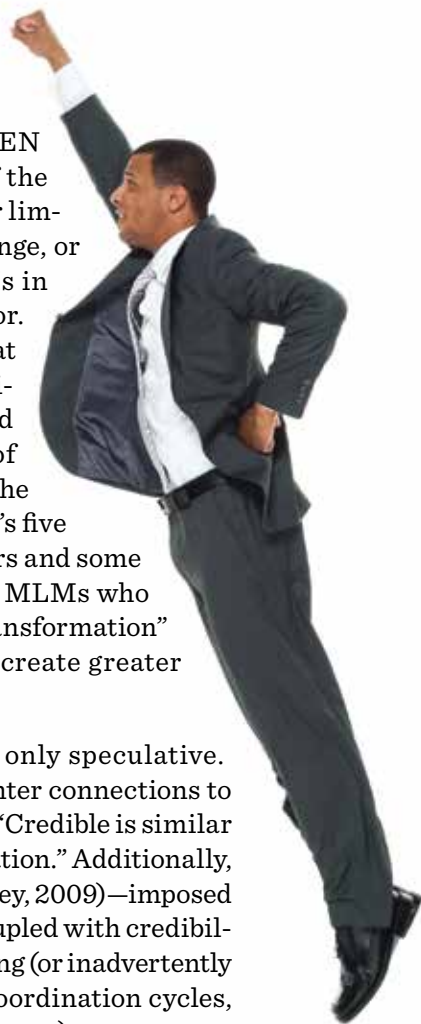


TABLE 4. RESPONSES TO 14 LEADERSHIP QUALITIES BASED ON “SUPERVISOR EXPERIENCE”												
Leadership Qualities	Aggregate				By Supervisory Experience				$\bar{X}$	Standard Deviation (σ)		
	SLM AGG	MLM AGG	SLM 15 +	MLM 15 +	SLM < 15	MLM < 15	ALL	SLM	MLM	$\bar{X} \pm 1\sigma$		
Leads by Example	85%	79%	86%	80%	83%	78%	9%	8%	7%	90%	73%	
Develops Self & Others	56%	55%	67%	60%	17%	50%	14%	17%	6%	66%	38%	
Effective Communicator	56%	71%	57%	65%	50%	78%	13%	7%	7%	75%	50%	
Builds & Nurtures Trust Relationships	44%	47%	52%	35%	17%	61%	19%	20%	14%	63%	24%	
Competent	37%	45%	33%	40%	50%	50%	13%	16%	8%	57%	31%	
Credible	37%	21%	43%	25%	17%	17%	17%	16%	12%	41%	7%	
Displays Respect & Support for Others	33%	58%	24%	55%	67%	61%	18%	20%	10%	67%	30%	
Behavior Aligns with DAU Values	30%	21%	33%	15%	17%	28%	13%	16%	7%	39%	13%	
Critical Thinking	30%	26%	29%	35%	33%	17%	11%	10%	10%	38%	16%	
Exercises Authority & Decision Making	26%	26%	14%	35%	67%	17%	18%	21%	10%	48%	13%	
Promotes Collaboration	26%	21%	24%	20%	33%	22%	8%	9%	4%	33%	16%	
Maintains DAU Enterprise Perspective	19%	13%	19%	15%	17%	11%	10%	10%	9%	27%	7%	
Change Agent	11%	8%	5%	10%	33%	6%	9%	10%	7%	20%	1%	
Innovator	11%	8%	14%	10%	0%	6%	7%	8%	5%	16%	1%	

Develops Self and Others: “[A] Leader’s job is to train him/herself out of their jobs by preparing the next wave of leaders and prepare themselves for their next job Learning is a never-ending process. Everyone can always improve, learn something new, and expand their minds, thoughts, and ideas. This will lead to better critical thinking and open up peoples’ ‘apertures’ as they view the world One of the most important functions of a leader is to facilitate development of his or her subordinates, providing mentorship and development opportunities so they can accomplish success in their own careers and positively contribute to the mission We have to stay current and relevant, and we have to do succession. That means developing our people, and also giving them [the] best chance to succeed also outside of DAU Enabling opportunities for growth in capability and improvement in themselves by supporting learning engagements and new experiences demonstrates direct interest and investment in the individual that coincides with objectives of the organization.”

Credible: “A credible leader possesses character (ethical, honest, loyal, respects others) and is recognized as competent (accountable and gets results) Credibility is the foundation for effectiveness and working with others as senior, peer, or subordinate; credibility includes competency A lack of respect and support for others severely degrades the organizational climate Most important quality. Goes with integrity. Without it, there will be no trust.”

For SLMs with less than 15 years of supervisory experience, the following leadership qualities rose one standard deviation *above* the mean ($\bar{x} + 1\sigma$), with the following supporting comments:

Displays Respect and Support for Others: “This is a simple rule, but often forgotten. Simple respect for everyone, regardless of rank or position. It is just as important to treat the janitorial staff with respect as it is senior leadership—everyone deserves respect. The truth is we all just have different jobs. This rolls into leading by example—people watch the way you treat others and it makes a difference on how they see you as leadership material.”

Exercises Authority and Decision Making: None given.

Promotes Collaboration: “This piggy-backs on DAU Values—we are customer-focused, team-oriented, strive for excellence, and are agile and responsive to customer requirements We must promote collaboration with our faculty peers, stakeholders, acquisition workforce, etc., to ensure that we develop the most qualified acquisition workforce.”

Change Agent: None given.

For MLMs with less than 15 years of supervisory experience, the following leadership quality rose one standard deviation *above* the mean ($\bar{x} + 1\sigma$) as shown in Table 4, with the following supporting comments:

Effective Communicator: “A leader needs to be able to communicate ideas, policy, etc., up and down the chain for his unit to be effective and feel that they are valued enough to be kept in the loop on decisions impacting them As a leader, you need to issue clear instructions for your subordinates to follow, as well as easy-to-understand interpretations of policy to enable your people to follow them We gain a lot by lessons learned by following the policies and procedures we have in place, and in order to ensure folks know that they exist or have changed, we need to have leaders and managers that communicate clearly and deliberately.”

Considering that the importance of professional development, communication, relationships, and even innovation tend to become more compelling over time, the dichotomy reinforced the importance of experience. With more experience, supervisors could be learning later that all four leadership qualities are essential to their success.

For SLMs with 15 years or more, the following leadership qualities fell one standard deviation *below* the mean ($\bar{x} - 1\sigma$), without any supporting comments:

Displays Respect and Support for Others: None given.

For SLMs with less than 15 years, the following leadership qualities fell one standard deviation *below* the mean ($\bar{x} - 1\sigma$), without any supporting comments:



Develops Self and Others, Effective Communicator, Builds and Nurtures Trust Relationships, Displays Respect and Support for Others, and Innovator: None given.

Do the number of years at an organization like DAU influence the perceived importance of certain leadership qualities?

For SLMs at DAU with 3 to 10 years, the following leadership quality rose one standard deviation *above* the mean ($\bar{x} + 1\sigma$), with the following supporting comments:

Critical Thinking: “Problem solving is vital will find the best path focused on outcomes and reality ... separates perceptions and agendas from needs and goals.”

For SLMs at DAU more than 10 years, the following leadership qualities rose one standard deviation *above* the mean ($\bar{x} + 1\sigma$) as shown in Table 5, with the following supporting comments:

TABLE 5. RESPONSES TO 14 LEADERSHIP QUALITIES BASED ON “YEARS AT DAU”												
Leadership Qualities	Aggregate			By Years at DAU			Standard Deviation (σ)			X̄ ± 1σ		
	SLM AGG	MLM AGG	SLM 3-10	MLM 3-10	SLM > 10	MLM > 10	Avg of Avgs	ALL	SLM	MLM	X̄ + 1σ	X̄ - 1σ
Leads by Example	85%	79%	77%	79%	93%	78%	82%	9%	8%	7%	90%	73%
Develops Self & Others	56%	55%	46%	50%	64%	67%	52%	14%	17%	6%	66%	38%
Effective Communicator	56%	71%	62%	71%	50%	67%	63%	13%	7%	7%	75%	50%
Builds & Nurtures Trust Relationships	44%	47%	31%	42%	57%	44%	43%	19%	20%	14%	63%	24%
Competent	37%	45%	46%	54%	29%	33%	44%	13%	16%	8%	57%	31%
Credible	37%	21%	31%	29%	43%	0%	24%	17%	16%	12%	41%	7%
Displays Respect & Support for Others	33%	58%	46%	54%	21%	78%	49%	18%	20%	10%	67%	30%
Behavior Aligns with DAU Values	30%	21%	23%	25%	36%	22%	26%	13%	16%	7%	39%	13%
Critical Thinking	30%	26%	38%	25%	21%	22%	27%	11%	10%	10%	38%	16%
Exercises Authority & Decision Making	26%	26%	31%	21%	21%	44%	31%	18%	21%	10%	48%	13%
Promotes Collaboration	26%	21%	31%	25%	21%	11%	24%	8%	9%	4%	33%	16%
Maintains DAU Enterprise Perspective	19%	13%	23%	13%	14%	11%	17%	10%	10%	9%	27%	7%
Change Agent	11%	8%	8%	4%	14%	22%	11%	9%	10%	7%	20%	1%
Innovator	11%	8%	8%	8%	14%	0%	8%	7%	8%	5%	16%	1%

Leads by Example: “Cannot expect people to follow if you are not walking [the] talk! ... People are more willing to follow someone that’s personally committed You have to show integrity, show what you expect of others, no less than what they can expect of you Every action a leader takes is closely examined by those he works with. As a leader, you broadcast your values, ethics, competence, commitment, and knowledge. These actions are infectious throughout the organization and set the standards for behavior.”

Credible: “A must if you are going to be recognized as [an] SME in a functional area within the [Defense Acquisition Management] process ... This gets to trust and respect without which a leader is inept ... If you aren’t credible, you could also be regarded as insincere, which doesn’t aid trust or the internal organizational climate, nor the confidence of external customers who count on DAU to help develop a professional acquisition workforce Most important quality. Goes with integrity. Without it, there will be no trust.”

For MLMs at DAU more than 10 years, the following leadership qualities fell one standard deviation *below* the mean ($\bar{x} + 1\sigma$) as shown in Table 5, with the following supporting comments:

Develops Self and Others: “A really good manager seeks to develop subordinates to the extent that they can be given ‘mission orders’ to execute without being given every little detail of how to do it Demonstrates selflessness, which is an important leadership quality ... If it’s important to the supervisor to develop skills and education in both themselves and employees, it shows that you care not only about the job, but about making all better at what we do You need to encourage growth in your people to fight against stagnation of thought (this includes yourself).”

Displays Respect and Support for Others: “Critical for a leader. Treat others the way you would expect to be treated Respect is a two-way street. You get what you give Without respect both ways, you have nothing. People will only do what they have to in order to get by; support and respect by the supervisor displays a trusting work environment.”

Change Agent: “Having trust in leaders instills confidence in them The leader’s credibility reflects the organization’s capabilities.”

For SLMs at DAU more than 10 years, the following leadership qualities fell one standard deviation *below* the mean ($\bar{x} - 1\sigma$), with the following supporting comments:

Effective Communicator: “These are all great traits of a good leader. Cannot ‘justify’ why they are at the bottom.”

Competent: “I think it’s a component of credibility You don’t have to be the smartest guy or gal to lead, but you have to be smart enough to surround yourself with the smart folks and then listen to them Competent is a minimum threshold to rise to a leadership position. Other attributes become the delta between an average leader and a good leader.”

Displays Respect and Support for Others: “As a leader, it is important for you to display respect and support for others. When your followers recognize that you care and respect them, they will work harder to accomplish the mission.”

For MLMs at DAU more than 10 years, the following leadership quality fell one standard deviation *below* the mean ($\bar{x} - 1\sigma$), without any supporting comments:

Credible, Promotes Collaboration and Innovation:
None given.

Various studies have shown that 20 percent to 67 percent of the variance that measures the climate for creativity in organizations is directly attributable to leadership behavior.

Various studies have shown that 20 percent to 67 percent of the variance that measures the climate for creativity in organizations is directly attributable to leadership behavior. This suggests that leaders must act in ways that promote and support organizational innovation (Horth & Buchner, 2014). Over 80 percent of executive leaders surveyed in 2007 felt innovation was a success indicator, although less than 30 percent were satisfied with their present innovation levels (Legrand & Weiss, 2011). Coincidentally, many of the 10 traits of innovative leaders described by Jack Zenger and Joseph Folkman (2014) in the text that follows are embodied in the top 14 leadership qualities outlined in this study:

- Display excellent strategic vision. The most effective innovation leaders could *vividly describe their vision* of the future, and as one respondent noted about his boss: “She excelled at *painting a clear picture* of the destination, while we worked to figure out how to get there” (Effective Communication).
- Have a strong customer focus. What was merely interesting to the customer became fascinating to these individuals. They sought to get inside the customer’s mind. They *networked with clients and asked incessant questions* about their needs and wants (Critical Thinking).
- Create a climate of reciprocal trust. Innovation often requires some level of risk. Not all innovative ideas are successful. These highly innovative leaders initiated warm, *collaborative relationships* with the innovators who worked for them. They made themselves highly accessible. Colleagues knew that their leader would cover their backs and not throw them under the bus if something went wrong. People were never punished for honest mistakes (Promotes Collaboration).
- Display fearless loyalty to doing what’s right for the organization and customer. Pleasing the boss or some other higher level executive always took a back seat to doing the right thing for the project or the company (Behavior Aligns with Values).
- Put their faith in a culture that *magnifies upward communication*. These leaders believed that the best and most innovative ideas bubbled up from underneath. They strived to create a culture that uncorked good ideas from the first level of the organization.

They were often described as projecting optimism, full of energy, and always receptive to new ideas. Grimness was replaced with kidding and laughter (Effective Communication).

- Are persuasive. These individuals were highly effective in getting others to accept good ideas. They *did not push or force their ideas* onto their teams. Instead, they presented ideas with enthusiasm and conviction, and the team willingly followed (Displays Respect and Support for Others).
- Excel at setting stretch goals. These goals required people to go far beyond just working harder. These goals required that they find new ways to achieve a high goal (Critical Thinking).
- Emphasize speed. These leaders believed that speed scraped the barnacles off the hull of the boat. Experiments and rapid prototypes were preferred to lengthy studies by large committees.
- Are *candid in their communication*. These leaders were described as providing honest, and at times even blunt, feedback. Subordinates felt they could always count on straight answers from their leader (Effective Communication).
- Inspire and motivate through action. One respondent said, “For innovation to exist, you have to feel inspired.” This comes from a clear sense of purpose and meaning in the work (Builds and Nurtures Trust Relationships).

Other Leadership Qualities

At the end of the survey, the respondents were also asked what other qualities they thought were important in a DAU leader and why. Here’s a sampling of what they had to say:

Ability to manage personnel issues effectively. Problems can quickly get out of hand if not handled in a quick and fair manner. It will not only impact the person, but the perception among others that either you are not handling it well or not handling it; thus, it may affect morale amongst the other members.



Be forward thinking. In today's world where things change constantly, it is important to look ahead and try to lead your workers towards the more productive path; this is part of being competent; we want to lead folks towards what we believe is the future and not down a dead end.

A leader should be a good teacher and committed to teaching those who work for him. Humility is also an important characteristic.

Patience and persistence. Bureaucratic organizations are slow to change, so leaders in DAU need to be prepared for the long haul.

Curiosity. It is the best antidote to complacency.

Cross-region collaboration.

DAU's leaders should know their way around the inside of a classroom.

Conclusions

What does all this mean? As Table 6 shows, when it comes to leadership, demographic factors can easily influence how individuals judge certain leadership qualities through their personal experiences and exposure to various situations. The DAU respondents who participated in this particular study highlighted how they fluctuate. Is it a cause for concern? It invariably depends on a given scenario and what vital leadership qualities have either been highly effective or perhaps marginalized in their view. Historically, if leaders are undervaluing a particular set of leadership imperatives that needs more thrust, it could cost the organization they lead—profoundly. Polaroid, Eastman Kodak, Blockbuster, Eastern Airlines, Arthur Andersen, DeLorean Motors, Levitz Furniture, Enron, and many other corporations like these learned what happens when key leadership qualities lose all lift. These companies are now either resting in peace, have been cannibalized by another company, or are operating as a mere fraction of their original size. Their leaders underestimated, ignored, and/or prematurely dismissed how their culture, product lines, processes, corporate structure, competition, customer base, outside forces, politics, etc., combined in some way to create a consequential nexus with negative returns. Their leaders had to make hard choices, or tried to make them and subsequently succumbed to insurmountable organizational resistance.

When it comes to leadership, demographic factors can easily influence how individuals judge certain leadership qualities through their personal experiences and exposure to various situations.

On the other hand, what leadership qualities did they discount too quickly that would have resulted in more favorable outcomes? According to research, leadership shortcomings generally center on the failure to recognize (or believe in) the warning signs and respond in kind with a confluence of these same 14 leadership qualities.

In this study, the respondents had to reflect on their experiences and decide what still predominates today. The leadership qualities that rose to their top five were generally very consistent in the aggregate until the slicing began. The most significant fluctuations occurred among four of the top five. Leading by Example saw much less variation. The respondents did not undervalue any particular leadership quality. Instead, they seemed to make connections among several below their top five to reclaim their relative importance.

It's difficult to attribute any one factor that promotes the predominance or lessens some of the leadership qualities that typically find their way over others in the top five. This author was particularly surprised to see where Innovator fell, however. Lately, the Defense Acquisition Executive and his senior leaders have reinforced both its importance and connection to persistence (Kendall, 2015). Inarguably, DAU is not a technology company and is not necessarily subject to the same consequences of disruptive technology that affect technology companies. However, since Innovator fell so markedly outside the respondents' top five, will it eventually result in a negative "performance trajectory" and hasten DAU's decline as it did for other companies with the same fatal flight path (Christensen, 2015, pp. 9-21)? Even though DAU is fulfilling congressional direction (in accordance with the Defense Acquisition Workforce Improvement Act, 1991) to train DoD's acquisition workforce, many companies are hot on its heels, vying to deliver the same training and other services that DAU provides. Because DAU aligns its workforce with annually updated Strategic Goals and measurable performance targets, this "development-of-the-fittest" approach knowingly positions SLMs and MLMs to recognize better, during their development, the early warning signs that leaders sometimes miss—and sometimes miss too late (McCall, 1998, p. 17). At DAU, the fluctuations among the 14 leadership qualities is no cause for concern in this author's opinion. This is so as long as SLMs and MLMs who eventually take the helm learn that both the emphasis and relative importance of the 14 leadership qualities *will* change, depending on the nexus of all the factors and conditions that could produce real organizational peril if they do not. And, that's what matters the most.

TABLE 6. RESPONSES TO 14 LEADERSHIP QUALITIES BASED ON “AGGREGATE”

DAU Leadership Qualities	Aggregate		By Role					By Generation				By Supervisory Exp				By Years at DAU				$\bar{x}$	Standard Deviations (σ)			Average $\bar{x} \pm 1\sigma$	
	SLM AGG	MLM AGG	SLM AD	SLM Faculty	MLM Faculty	SLM Staff	MLM Staff	SLM Boomr	MLM Boomr	SLM Gen X	MLM Gen X	SLM 15 +	MLM 15 +	SLM < 15	MLM < 15	SLM 3-10	MLM 3-10	SLM > 10	MLM > 10	AVG of avgs	ALL	SLM	MLM	$\bar{x} + 1\sigma$	$\bar{x} - 1\sigma$
Leads by Example	85%	79%	75%	100%	82%	90%	60%	87%	77%	75%	88%	86%	80%	83%	78%	77%	79%	93%	78%	82%	9%	8%	7%	90%	73%
Develops Self & Others	56%	55%	67%	40%	55%	50%	60%	61%	57%	25%	50%	67%	60%	17%	50%	46%	50%	64%	67%	52%	14%	17%	6%	66%	38%
Effective Communicator	56%	71%	67%	40%	70%	50%	80%	57%	67%	50%	88%	57%	65%	50%	78%	62%	71%	50%	67%	63%	13%	7%	7%	75%	50%
Builds & Nurtures Trust Relationships	44%	47%	58%	20%	42%	40%	80%	52%	43%	0%	63%	52%	35%	17%	61%	31%	42%	57%	44%	43%	19%	20%	14%	63%	24%
Competent	37%	45%	25%	60%	42%	40%	60%	30%	47%	75%	38%	33%	40%	50%	50%	46%	54%	29%	33%	44%	13%	16%	8%	57%	31%
Credible	37%	21%	58%	0%	24%	30%	0%	39%	27%	25%	0%	43%	25%	17%	17%	31%	29%	43%	0%	24%	17%	16%	12%	41%	7%
Displays Respect & Support for Others	33%	58%	17%	40%	61%	50%	40%	26%	60%	75%	50%	24%	55%	67%	61%	46%	54%	21%	78%	48%	18%	20%	10%	67%	30%
Behavior Aligns with DAU Values	30%	21%	17%	60%	21%	30%	20%	35%	17%	0%	38%	33%	15%	17%	28%	23%	25%	36%	22%	26%	13%	16%	7%	39%	13%
Critical Thinking	30%	26%	42%	20%	30%	20%	0%	26%	27%	50%	25%	29%	35%	33%	17%	38%	25%	21%	22%	27%	11%	10%	10%	38%	16%
Exercises Authority & Decision Making	26%	26%	17%	40%	27%	30%	20%	17%	30%	75%	13%	14%	35%	67%	17%	31%	21%	21%	44%	31%	18%	21%	10%	48%	13%
Promotes Collaboration	26%	21%	8%	40%	21%	40%	20%	26%	20%	25%	25%	24%	20%	33%	22%	31%	25%	21%	11%	24%	8%	9%	4%	33%	16%
Maintains DAU Enterprise Perspective	19%	13%	17%	40%	9%	10%	40%	22%	13%	0%	13%	19%	15%	17%	11%	23%	13%	14%	11%	17%	10%	10%	9%	27%	7%
Change Agent	11%	8%	8%	0%	9%	20%	0%	9%	10%	25%	0%	5%	10%	33%	6%	8%	4%	14%	22%	11%	9%	10%	7%	20%	1%
Innovator	11%	8%	25%	0%	6%	0%	20%	13%	7%	0%	13%	14%	10%	0%	6%	8%	8%	14%	0%	8%	7%	8%	5%	16%	1%

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Biography



Col Robert L. Tremaine, USAF (Ret.), is the associate dean for Outreach and Mission Assistance at the Defense Acquisition University West Region. He has over 30 years of experience in air, missile, and space weapon systems acquisition. Col Tremaine holds a BS from the U.S. Air Force Academy and an MS from the Air Force Institute of Technology. He is Level III Defense Acquisition Workforce Improvement Act certified in both Program Management and Systems Planning, Research, Development, and Engineering. Col Tremaine is a graduate of the Canadian Force Command and Staff College in Toronto, Ontario, Canada; and the U.S. Army War College in Carlisle Barracks, Pennsylvania. He also completed a military research fellowship in association with the Harvard Business School.

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METRICS-BASED **Risk Assessment** and **Management** of **DIGITAL FORENSICS**

 *Mehmet Sahinoglu, MSgt Stephen Stockton, USAF (Ret.),
Capt Robert M. Barclay, USAF (Ret.), and Scott Morton*

Driven by the ubiquity of computers in modern life and the subsequent rise of cybercriminality and cyberterrorism in the government and defense industry, digital forensics is an increasingly salient component of the defense acquisition process. Though primarily located in the law enforcement community, digital forensics is increasingly practiced within the corporate world for legal and regulatory requirements. Digital forensics risk involves the assessment, acquisition, and examination of digital evidence in a manner that meets legal standards of proof and admissibility. The authors adopt a model of digital forensics risk assessment that quantifies an investigator's experience with

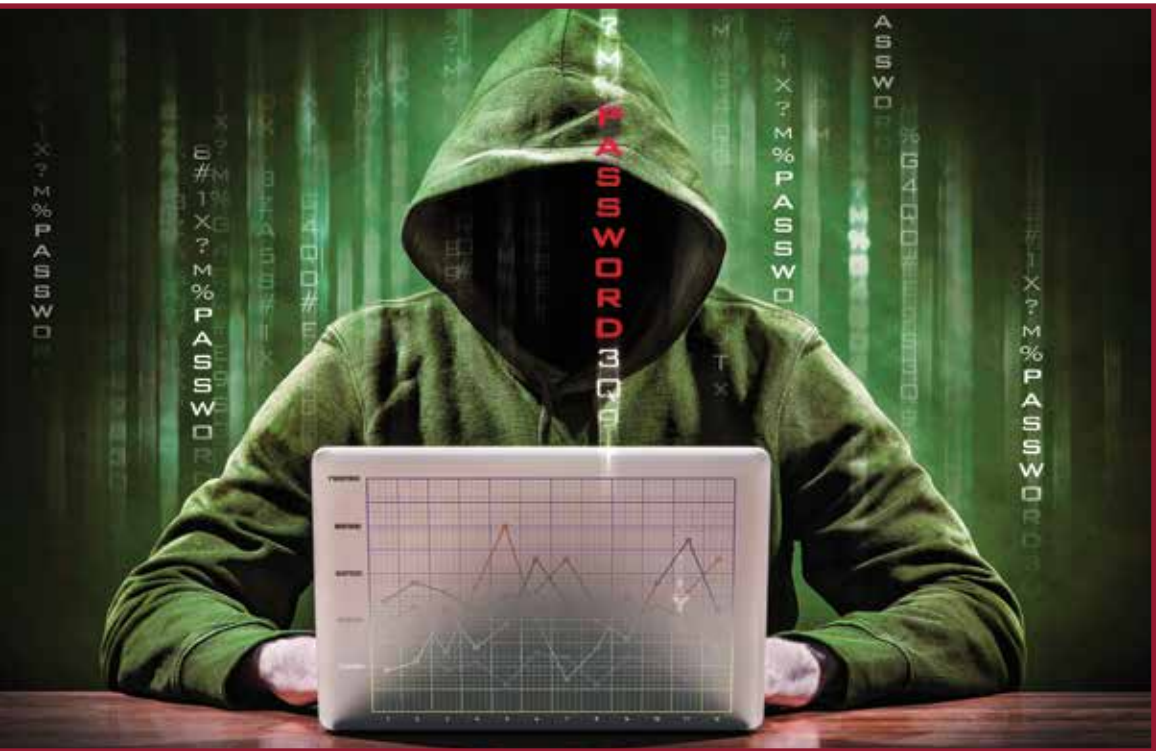


eight crucial aspects of the digital forensics process. This research adds the concept of quantifying through a designed risk meter algorithm to calculate digital forensics risk indices. Numerical and/or cognitive data were painstakingly collected to supply input parameters to calculate the quantitative risk index for the digital forensics process. Much needed risk management procedures and metrics are also appended.

Keywords: Cyberterrorism, cybercriminality, risk meter

Digital forensics is a topic that has been popularized by television programs such as *CSI*. Crime-solving glamour and drama aside, the reality is that the digital forensics process is a highly technical field that depends on the proper implementation of specific, well-accepted protocols and procedures. Inadequate forensic tools and technical examination, as well as lack of adherence to appropriate protocols and procedures, can result in evidence that does not meet legal standards of proof and admissibility. Digital forensics risk arises, for example, when personnel lack the proper tools to conduct investigations, fail to process evidentiary data properly, or do not follow accepted protocols and procedures.

Assessing and quantifying digital forensics risk is the goal of this article. To do so, the authors utilize a digital forensics risk meter, based on a series of questions designed to assess respondents' perceptions of digital forensics risk. Based on the responses, a digital forensics risk index will be calculated. Where this approach differs is that other approaches typically provide general guidance in the form of best practices, classification schemes or, at best, a checklist for digital forensics procedures, and do not provide quantitative tools (based on game theory) for risk management and mitigation. Examples of other such approaches follow:



- U.S. Department of Justice, *Forensic Examination of Digital Evidence: A Guide for Law Enforcement* (general guidelines and worksheets) (U.S. Department of Justice, 2004)
- *Error, Uncertainty, and Loss in Digital Evidence* (certainty levels) (Casey, 2002)
- *Cyber Criminal Activity Analysis Models using Markov Chain for Digital Forensics* (suspicion levels) (Kim & In, 2008)
- *Two-Dimensional Evidence Reliability Amplification Process Model for Digital Forensics* (evidence reliability) (Khatir, Hejazi, & Sneiders, 2008)
- *Building a Digital Forensic Laboratory: Establishing and Managing a Successful Facility* (checklist) (Jones & Valli, 2011)

One approach that does employ quantification, *Metrics for Network Forensics Conviction Evidence*, is confined to network forensics—mostly measuring severity impact—and does not provide mitigation advice (Amran, Phan, & Parish, 2009). In that research article, the authors show “how security metrics can be used to sustain a sense of credibility to network evidence gathered as an elaboration and extension to an embedded feature of Network Forensics Readiness (NFR).” They then propose “a procedure of evidence acquisition in network forensics ... then analyze a sample of a packet data in order to extract useful information as evidence through a formalized intuitive model, based on capturing adversarial behavior and layer analysis, ... apply the Common Vulnerability Scoring System—or CVSS metrics to show the severity of network attacks committed...” (p. 1).

The digital forensics risk meter presented in this article will provide objective, automated, dollar-based risk mitigation advice for interested parties such as investigators, administrators, and officers of the court to minimize digital forensics risk. Figure 1 represents a decision tree diagram to assess risk; Figure 2 (with the Advice column on the right extracted from Figure B-1, Appendix B) represents sample mitigation advice generated from the respondents’ inputs. This article will not only present a quantitative model, but will generate a prototype numerical index that facilitates appropriate protocols and procedures to ensure that legal standards of proof and admissibility are met.

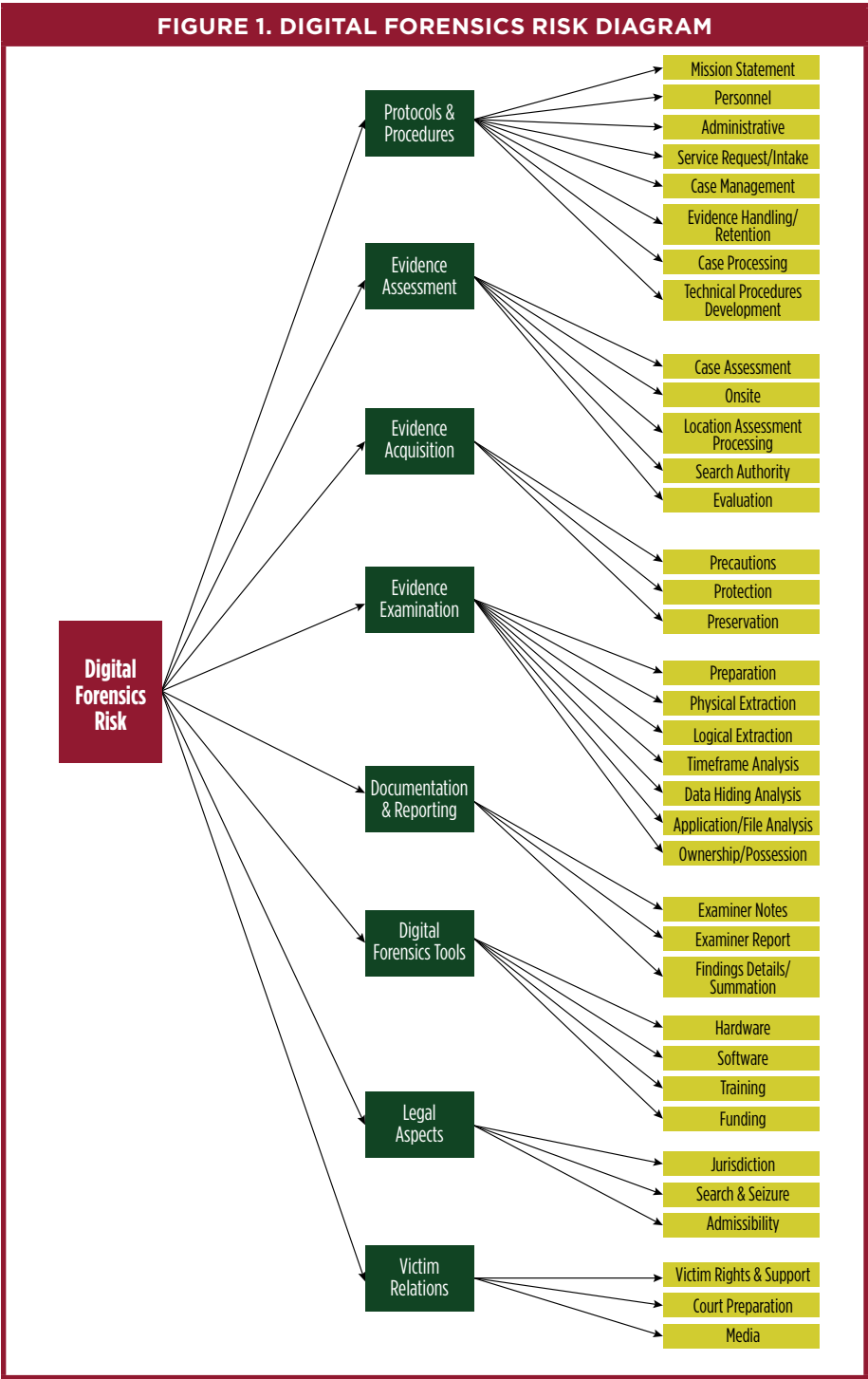


FIGURE 2. MEDIAN DIGITAL FORENSICS RISK METER RESULTS MITIGATED TO 35.83%										
Vulnerab.	Threat	CM & LCM	Res. Risk	CM & LCM	Res. Risk	Change	Opt Cost	Unit Cost	Final Cost	Advice
0.220042	0.415771	0.325000		0.325000						
		0.675000	0.061754	0.675000	0.061754					
	0.237754	0.375000		0.375000						
		0.625000	0.032697	0.625000	0.032697					
	0.346476	0.550000		0.550000						
		0.450000	0.034308	0.450000	0.034308					
0.317111	0.559259	0.450000		0.721705		0.271705	\$49.77			Increase the CM capacity for threat "Examiner Notes" for the vulnerability of "Documentation & Reporting" from 45.00% to 72.17% for an improvement of 27.17%
		0.550000	0.097541	0.278295	0.049355					
	0.440741	0.375000		0.375000						
		0.625000	0.087352	0.625000	0.087352					

FIGURE 2. MEDIAN DIGITAL FORENSICS RISK METER RESULTS MITIGATED TO 35.83%, CONTINUED										
Vulnerab.	Threat	CM & LCM	Res. Risk	CM & LCM	Res. Risk	Change	Opt Cost	Unit Cost	Final Cost	Advice
0.462847	0.408269	0.725000		0.999195		0.274195	\$50.23			Increase the CM capacity for threat "Victim Rights & Support" for the vulnerability of "Victim Relations" from 72.50% to 99.92% for an improvement of 27.42%
		0.275000	0.051966	0.000805	0.000152					
0.250646		0.575000		0.575000						
		0.425000	0.049305	0.425000	0.049305					
0.341085		0.725000		0.725000						
0.275000	0.043414	0.275000	0.275000	0.43414						
						Total Change	Total Cost	Break Even Cost	Total Final Cost	
						54.59%	\$100.00	\$1.83		

FIGURE 2. MEDIAN DIGITAL FORENSICS RISK METER RESULTS MITIGATED TO 35.83%, CONTINUED					
Criticality	1.00	Total Risk	0.458337	Total Risk	0.358337
Capital Cost	\$1,000.00	Percentage	45.833670	Percentage	35.833698
Total Threat Costs	N/A	Final Risk	0.458337	Final Risk	0.358337
		ECL	\$458.34	ECL	\$358.34
		Change Cost		ECL Delta	\$100.00
		Show where you are in Security Meter		Print Single Threat/CM Selection	
		Optimize		Print Advice Threat/CM Selections	
				Print All Threat/CM Selections	
				Update Survey Questions	

Note. CM = Countermeasure; ECL = Expected Cost of Loss; LCM = Lack of Countermeasure; Opt = Optimize to; Res. Risk = Residual Risk; Vulnerab. = Vulnerability.

Vulnerabilities, Threats, and Countermeasures

Based on industry best practices guidelines, such as the U.S. Department of Justice (2004) *Forensic Examination of Digital Evidence: A Guide for Law Enforcement*, eight specific vulnerabilities are assessed:

1. Protocols and Procedures
2. Evidence Assessment
3. Evidence Acquisition
4. Evidence Examination
5. Documentation and Reporting
6. Digital Forensics Tools
7. Legal Aspects
8. Victim Relations

Within each vulnerability category, questions pertain to specific threats and countermeasures. For example, within the Evidence Acquisition vulnerability, respondents are asked questions regarding precautions, protection, and preservation threats and countermeasures. Within the Evidence Examination vulnerability, respondents are asked questions regarding preparation, physical extraction, logical extraction, timeframe analysis, data hiding analysis, application/file analysis, and ownership/possession threats and countermeasures. Within the digital forensics Tools vulnerability, respondents are asked questions regarding hardware, software, training, and funding threats and countermeasures. Figure 1 details these vulnerabilities and threats. The responses are then used to generate a quantitative Digital Forensics risk index.

Assessment Questions

Questions are designed to elicit responses regarding the perceived risk to proper Digital Forensics procedures, evidence handling/examination, admissibility, and other associated issues from particular threats, as well as the countermeasures the respondents may employ to counteract those

threats. For example, in the Evidence Examination vulnerability, questions regarding the data hiding analysis threat include both threat and countermeasure questions. Threat questions would include:

- Do file headers not correspond to file extensions?
- Did the suspect encrypt or password-protect data?
- Are hidden messages present?
- Are host-protected areas (HPA) present?



Countermeasure questions would include:

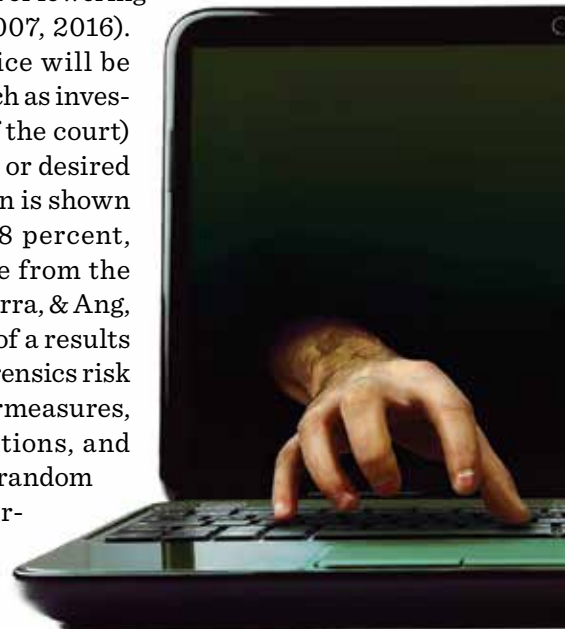
- Did the examiner correlate file headers to the corresponding file extensions to identify any mismatches that may indicate the user intentionally hid data?

- Did the examiner gain access to all password-protected, encrypted, and compressed files, which may indicate an attempt to conceal the data from unauthorized users?
- Did the examiner conduct a thorough stenographic analysis?
- Did the examiner gain access to HPAs that may indicate an attempt to conceal data?

Sample vulnerability (Evidence Acquisition) assessment questions employed in the digital forensics risk meter are found in Appendix A. Appendix A also clarifies and precludes confusion between Evidence Acquisition and materiel acquisition. The first proactive step in any digital forensic investigation is acquisition. The inherent problem with digital media is that it is readily modified just by accessing files. Working from a copy is one of the fundamental steps to making a forensic investigation auditable and acceptable to a court (Acquisition, n.d.).

Risk Calculation and Risk Management through Surveys

Based on their experience, the respondents answer yes or no to the survey questions. These responses are then used to calculate residual risk. Employing a game-theoretical mathematical approach, the calculated risk index is used to generate an optimization or lowering of risk to desired levels (Sahinoglu, 2007, 2016). A more detailed set of mitigation advice will be generated to show interested parties (such as investigators, administrators, and officers of the court) where risk can be reduced to optimized or desired levels. An example of such risk reduction is shown in Figure 2, from 45.8 percent to 35.8 percent, which represents the median response from the study participants (Sahinoglu, Cueva-Parra, & Ang, 2012). Figure 2 is an actual screenshot of a results table, representing the median digital forensics risk meter results displaying threat, countermeasures, residual risk indices, optimization options, and risk mitigation advice. For this study, a random sample of responses from 27 survey participants was analyzed; their residual



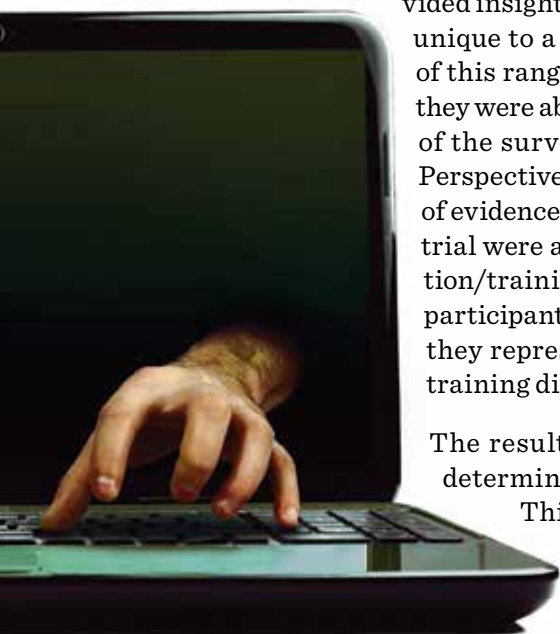
risk results are tabulated and presented in Appendix B. The survey portfolio used in this assessment and upon which this research article is based showed the complexity of the digital forensics field, encompassing tools, procedures, specific training, budget, and trial.

Digital forensics has two crucial phases (Appendix A). The first phase included all the forensics involved with the collection of data, while the second phase concerns defending the data collected, the means by which the data were collected, and chain of custody applied from the original collection until court (Sahinoglu, Stockton, Morton, Barclay, & Eryilmaz, 2014). The initial goal was to obtain survey input from local city leaders in Montgomery, Alabama. Although individuals from the Governor's Office, Montgomery Police Department, and District Attorney's office were willing to assist, our short timeframe and their busy schedules prevented their offices from providing input to the digital forensics survey. Fortunately, the authors had contacts at other law enforcement offices, which agreed to make personnel available for the survey and eventual follow-up. Eventually, three law enforcement offices and one special investigation/training organization participated and provided valuable input.

Our first objective was to explain the purpose of the survey and the potential value the combined results could offer each of the offices. At each location, participants included investigators, initial responders, digital forensics specialists, and legal experts (i.e., District Attorney Office personnel). The range of expertise of the participants was invaluable, as each provided insight into an aspect of the survey that is often

unique to a position within a department. Because of this range of expertise, the authors are confident they were able to capture the three main components of the survey portion of the Risk-o-Meter (RoM). Perspectives from collection of evidence, packaging of evidence for trial, and presentation of evidence at trial were all given. Although the special investigation/training organization had many fewer survey participants, they did offer a unique perspective, as they represented an organization that focuses on training digital forensics experts for the military.

The results were then run for each participant, determining the Initial Repair Cost to Mitigate. This was determined by using a Criticality of 1.0, Equipment Cost of \$0.0, and a



Production Cost of \$1,000. The median of all results was determined and then optimized through the RoM to determine the best “bang for the buck” that would reduce the participant’s Total Residual Risk by 10 percent. The initial Total Residual Risk for the median participant was 45.8 percent, with an Expected Cost of Loss (ECL) of \$458.34. Once optimized, the Total Risk was reduced to 35.8 percent, and the ECL was reduced by \$100 to a total ECL of \$358.34 (Figure 2). The first optimized solution was to increase the countermeasure (CM) capacity for the “Examiner Notes” threat for the Documentation and Reporting vulnerability from 45.0 percent to 72.17 percent, for an improvement of 27.17 percent. The second optimized solution was to increase the CM capacity for the “Victim Rights and Support” threat for the Victim Relations vulnerability from 72.50 percent to 99.92 percent, for an improvement of 27.42 percent.



Table B-2 in Appendix B depicts a set of constrained linear equations used within the body of the risk meter’s innovative second-stage software for the game-theoretic optimization necessary to create the Advice column (shown on the right in Figure 2). The Advice column’s original survey calculations are depicted in Figure B-1, which displays company ECSO8: 14th Ranked Overall Median Survey. This is followed by Figure B-2, which displays company OPD1’s Group Median Survey Taker’s

Original Survey Outcome; while Figure B-3 displays company AUPD5’s Group Median Survey Taker’s Original Survey Outcome. In each case, the company representative seemed impressed with the results and noted the results for possible future implementation. One organization actually commented that they had already begun looking into increases in at least one CM that was identified by the optimization. Clearly, this episode validated the tool and its usefulness in their eyes.

Discussion and Conclusions

The advantages of conducting business on the Internet have been well documented. Conducting business online is frequently faster and cheaper than utilizing traditional methods. However, this comes with the digital forensics-related vulnerabilities and pertinent threats that tend to convert the positive advantages to clear disadvantages as a result of fraud and wrongdoing. With the advent of the Internet and burgeoning information systems, digital forensics has gained worldwide momentum. In every environment, the content of digital information relative to criminal undertakings and investigations alike has vastly increased, growing disproportionately to the capacities of state and local governments, as well as federal agencies and military components. The risk assessment, risk mitigation, or general risk management that involve planned investment policy in order of priority, with a sound and auditable, cost-effective approach, are missing links. The proposed digital forensics risk meter is an innovative initiative that provides a quantitative assessment of risk to the user as well as recommendations for mitigating that risk. This approach will be a highly useful tool to interested parties such as investigators, company or system administrators, and officers of the court seeking to minimize and thereby mitigate digital forensics risk by leveraging and introducing early, preventive CMs identified as an outcome of this dynamic closed-end survey.

This approach will be a highly useful tool to interested parties such as investigators, company or system administrators, and officers of the court seeking to minimize and thereby mitigate digital forensics risk by leveraging and introducing early, preventive CMs identified as an outcome of this dynamic closed-end survey.

Additional future research by the principal author will involve the addition of cloud computing concerns such as service provider cooperation and data accessibility, as well as the incorporation of new questions so as to better refine user responses and subsequent calculation of risk and mitigation recommendations. Minimization or mitigation of digital forensics risk will greatly facilitate the success of digital forensics investigations, ensuring that legal standards of proof and admissibility are ultimately met. The digital forensics risk meter tool provides the means to identify areas where risk can

be minimized, as well as giving the objective, dollar-based mitigation advice to do just that. This aspect of objective quantifiable risk assessment and management will add to the trustworthiness of acquisition practices in terms of dependable Internet communications involving great quantities of materiel and their budgetary repercussions.

Limitations and Future Research

The limitations are obvious due to input data deficiency, but methods such as the one proposed in this article are a good way to start due to the objective, hands-off, automated, cost-effective treatment of the problem at hand. Sound assessment of digital forensics risk can result when information entered, from learned respondents, is as close to the truth as feasibly possible. The discussion that follows clarifies how this proposed work is directly relevant to acquisition risk mitigation if applied appropriately within a system.

This research article is not focused on the usual law enforcement or digital-policing procedures, but is directed towards greater awareness for the in-house (e.g., acquisition community) workforce as they manage already existing risk assessment and risk management algorithms. By leveraging the countermeasures outlined in this article (in particular, the Advice column in Figure 2, which employs probability-estimation and game-theoretic risk computing), the authors anticipate that acquisition practitioners can better preclude future digital forensics breaches by taking timely CMs.

Law enforcement, in cooperation with the defense acquisition community, is increasingly becoming an important player in digital forensics, thereby lending increased scrutiny in this vital area. Law enforcement is more aware of evidence such as drug cartel activity and money laundering through all avenues such as export, import, and domestic acquisition activities. Even in homicide cases, much useful evidence can be deduced by using digital forensics information. In addition, digital forensics sciences not only can break a difficult case, but can do so quickly and inexpensively compared to police detectives' usual time-tested, but tedious practices. The proposed risk meter software and its algorithm can successfully lead the way toward navigating the stages of cost-effective risk assessment and management.

In conclusion, the best “bang for the buck” derives from simple usability and scientific objectivity.

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Appendix A

Sample Vulnerability (Evidence Acquisition, Documentation and Reporting, and Victim Relations) Assessment Questions (in XML format) and Survey Template

```

<survey>
<vulnerability title= "Evidence Acquisition" level= "0">
<vQuestion> Are special precautions not taken to preserve digital evidence?
</vQuestion>
<vQuestion> Was write protection not utilized to preserve and protect
original evidence? </vQuestion>
<vQuestion> Was digital evidence not secured in accordance with
departmental guidelines? </vQuestion>
<vQuestion> Was speed the primary concern when it came to acquiring
digital evidence? </vQuestion>

<threat title = "Precautions">
<tQuestion> Was evidence on storage devices destroyed or altered?
</tQuestion>
<tQuestion> Was equipment damaged by static electricity and magnetic
fields? </tQuestion>
<tQuestion> Was the original internal configuration of storage devices and
hardware unnoted? </tQuestion>
<tQuestion> Were investigators unable to provide drive attributes?
</tQuestion>

<threat title = "Protection">
<tQuestion> Was CMOS/BIOS information not captured? </tQuestion>
<tQuestion> Was the computer's functionality and the forensic boot disk
not tested? </tQuestion>
<tQuestion> Did the forensic boot disk not boot? </tQuestion>
<tQuestion> Did the investigators not collect drive configuration information
from the CMOS/BIOS? </tQuestion>

```

```

<threat title = "Preservation">
<tQuestion> Did the investigators not perform the acquisition using the
examiner's system? </tQuestion>
<tQuestion> Was a RAID present in the subject system? </tQuestion>
<tQuestion> Was host-specific data not captured? </tQuestion>
<tQuestion> Was successful acquisition not verified? </tQuestion>

```

```

</threat>
</vulnerability>
</survey>

```

DIGITAL FORENSICS RISK SURVEY

This survey has 8 main categories of vulnerabilities. Please identify the areas below where you have observed vulnerabilities while involved with digital forensics activities within your organization.

** A minimum of 2 categories must be chosen:*

Vulnerability Area	Reference Page
☐ Protocols & Procedures	Pages 1 & 2
☐ Evidence Assessment	Pages 3 & 4
☐ Evidence Acquisition	Page 5
☐ Evidence Examination	Pages 6 & 7
☐ Documentation & Reporting	Page 8
☐ Digital Forensics Tools	Page 9
☐ Legal Aspects	Page 10
☐ Victim Relations	Page 11

DIRECTIONS:

This Page:

- Select all vulnerability areas that apply
- Proceed to appropriate pages to complete survey for each vulnerability area

Survey Page(s):

Vulnerability

- Rate **Vulnerability** (0.1-10) with 10 being *most* vulnerable and 0.1 being *least* vulnerable
- Select all vulnerability statements that apply (*must choose at least one*)

Threat

- Rate **Threat** (0.1-10) with 10 being *greatest* threat and 0.1 being the *least* threat
- Using square check box, select all threat statements that apply to each threat category chosen (*must choose at least one*)

Countermeasure

- Rate associated **Countermeasure** for each threat category chosen above (0.1-10) with 0.1 being *least* effective and 10 being the *most* effective countermeasure
- Using square check box, select all countermeasure statements that apply (*must choose at least one*)

Rate (01.-10) if vulnerability applies

Vulnerability: Legal Aspects

☐ Legal authority for forensic examinations is unclear

☐ The extent of the authority to search is unstated

☐ Courtroom admissibility is not a prime consideration

Must select one (minimum) for each Vulnerability selected

Rate (0.1-10) for all Threats that apply

Threat: Jurisdiction

☐ There is conflicting jurisdiction

☐ Multiple jurisdictions are often involved

☐ Potential evidentiary data are stored on the cloud or some other distant network resource

☐ Cases often cross international borders

Countermeasures

☐ Jurisdiction is established among agencies prior to investigations

☐ Investigators and other officials from different areas coordinate and cooperate on cases

☐ Court orders are obtained when requiring distant service providers to provide potentially evidentiary data

☐ There are bilateral or multilateral agreements that facilitate cooperation with foreign law enforcement agencies

Threat: Search & Seizure

☐ Cases are often challenged for lack of probable cause

☐ On-site investigators often proceed without knowledge of a warrant

☐ Investigators go beyond warrants originally used to assert search authority

☐ The evidentiary chain of custody is often challenged

Countermeasures

☐ Forensic investigators unequivocally identify and articulate a probable cause necessary to obtain search warrants

☐ Search warrants are obtained prior to investigation on site

☐ New search warrants are obtained as new evidence is uncovered to avoid charges of "stale" warrants

☐ Full documentation of the evidentiary chain of custody is maintained throughout the investigation

Threat: Admissibility

☐ Digital evidence is sometimes changed by seizure

☐ Individuals besides forensic investigators access original digital evidence

☐ Does activity related to cases come under legal/judicial review

☐ The state of evidence is often unknown prior to opening files

Countermeasures

☐ Strict measures are taken to ensure that when seizing digital evidence, the action does not change that evidence

☐ Only forensically competent persons are allowed access to original digital evidence

☐ All activities related to seizures, access, storage, or transfer of digital evidence are fully documented, preserved, and available for legal/judicial review

☐ Evidence is "frozen" prior to opening the files

Must select one (minimum) Threat for each vulnerability selected

Appendix B

Respondent Results Tabulations

**TABLE B-1. COMPANIES'/RESPONDENTS' (AFIT, AUPD, ECSO, OPD)
SURVEY RESULTS FOR DIGITAL FORENSICS RISK METER STUDY**

Survey Taker	Residual Risk %	Ranked Overall (Out of 27)	Remarks
AFIT1	52.47	6th	2nd out of 4 within AFIT
AFIT2	49.90	9th	3rd out of 4 within AFIT
AFIT3	52.71	5th	1st out of 4 within AFIT
AFIT4	47.64	10th	4th out of 4 within AFIT
AUPD1	31.15	26th	7th out of 7 within AUPD
AUPD2	39.67	20th	5th out of 7 within AUPD
AUPD3	50.02	8th	1st out of 7 within AUPD
AUPD4	36.98	21st	6th out of 7 within AUPD
AUPD5	44.59	16th - <i>Overall Average</i>	4th out of 7 within AUPD
AUPD6	46.06	13th	3rd out of 7 within AUPD
AUPD7	47.06	11th	2nd out of 7 within AUPD
ECSO1	51.80	7th	5th out of 9 within ECSO
ECSO2	46.66	12th	6th out of 9 within ECSO
ECSO3	56.94	2nd	2nd out of 9 within ECSO
ECSO4	57.67	1st	1st out of 9 within ECSO
ECSO5	54.87	3rd	3rd out of 9 within ECSO
ECSO6	41.36	19th	9th out of 9 within ECSO
ECSO7	54.84	4th	4th out of 9 within ECSO
ECSO8	45.83	14th <i>Overall Average</i>	7th out of 9 within ECSO
ECSO9	45.01	15th	8th out of 9 within ECSO
OPD1	35.00	23rd	4th out of 7 within OPD
OPD2	42.56	18th	2nd out of 7 within OPD
OPD3	44.35	17th	1st out of 7 within OPD
OPD4	33.39	25th	6th out of 7 within OPD
OPD5	28.23	27th	7th out of 7 within OPD
OPD6	34.39	24th	5th out of 7 within OPD
OPD7	36.41	22nd	3rd out of 7 within OPD

Note. Respondents are ranked within and overall, where Median is 45.83% (ECSO8) and Average is 44.73% (AUPD5: 44.49% is the closest respondent to 44.7%).

**TABLE B-2. SET OF CONSTRAINED LINEAR EQUATIONS
FOR TABLE B-1'S MEDIAN**

Min COLLOSS (Column loss), s. t. (subject to):
 $CM_{11} < 1$ **(1)**, $CM_{12} < 1$ **(2)**, $CM_{13} < 1$ **(3)**, $CM_{21} < 1$ **(4)**, $CM_{22} < 1$ **(5)**, $CM_{31} < 1$ **(6)**,
 $CM_{32} < 1$ **(7)**, $CM_{33} < 1$ **(8)**, COLLOSS < 1 **(9)**

$CM_{11} > 0.675$ **(10)**, $CM_{12} > 0.475$ **(11)**, $CM_{13} > 0.725$ **(12)**,
 $CM_{21} > 0.725$ **(13)**, $CM_{22} > 0.725$ **(14)**,
 $CM_{31} > 0.675$ **(15)**, $CM_{32} > 0.675$ **(16)**, $CM_{33} > 0.675$ **(17)**,

$0.09148 CM_{11} - 1COLLOSS < 0$ **(18)**, $0.05231 CM_{12} - 1COLLOSS < 0$ **(19)**,
 $0.07629 CM_{13} - 1COLLOSS < 0$ **(20)**, $0.17734 CM_{21} - 1COLLOSS < 0$ **(21)**,
 $0.13966 CM_{22} - 1COLLOSS < 0$ **(22)**, $0.18896 CM_{31} - 1COLLOSS < 0$ **(23)**,
 $0.11601 CM_{32} - 1COLLOSS < 0$ **(24)**, $0.15787 CM_{33} - 1COLLOSS < 0$ **(25)**,

$0.09148 CM_{11} + 0.05231 CM_{12} + 0.07629 CM_{13} + 0.17734 CM_{21} + 0.13966 CM_{22} +$
 $0.18896 CM_{31} + 0.11601 CM_{32} + 0.15787 CM_{33} > 1 - 0.3583 = 1 - 0.3583 = 0.6417$ **(26)**

Note. Used to attain a risk mitigated to 35.83% from an undesirable 45.83% inspired by Figure 2; where Total # Constraints = 3 * #Selected Threats + 2 = 3 * 8 + 2 = 24 + 2 = 26 along with Objective(Min).

FIGURE B-1. EC SO8: 14TH RANKED OVERALL MEDIAN SURVEY TAKER'S ORIGINAL SURVEY OUTCOME						
VB	vb	Threat	threat	LCM	Risk	Post % Post vb >
Protocols and Procedures	0.220042	Personnel	0.415771	0.675000	0.061754	0.13
		Administrative	0.237754	0.625000	0.032697	0.07
		Service Request/Intake	0.346476	0.450000	0.034308	0.07 0.280926 !
Documentation and Reporting	0.317111	Examiner Notes	0.559259	0.550000	0.097541	0.21
		Examiner Report	0.440741	0.625000	0.087352	0.19 0.403401 !
Victim Relations	0.462847	Victim Rights and Support	0.408269	0.275000	0.051966	0.11
		Court Preparation	0.250646	0.425000	0.049305	0.11
		Media	0.341085	0.275000	0.043414	0.09 0.315673
Criticality		1.00				
Capital Cost		\$1,000.00				
Total Threat Costs		N/A				
Res-Risk* Criticality		0.458337				
Total Res-Risk		0.458337				
Expected Cost of Loss		\$458.34				
Cust. Guess Res-Risk		0.50				

FIGURE B-2. OPD1: GROUP MEDIAN SURVEY TAKER'S ORIGINAL SURVEY OUTCOME						
VB	vb	Threat	threat	LCM	Risk	Post % Post vb >
Evidence Assessment	0.309524	Onsite	0.585714	0.450000	0.081582	0.23
Digital Forensics Tools	0.247253	Evaluation	0.414286	0.450000	0.057704	0.16
		Software	0.422222	0.550000	0.057418	0.16
Victim Relations	0.443223	Training	0.577778	0.325000	0.046429	0.13
		Victim Rights and Support	0.438889	0.250000	0.048631	0.14
		Court Preparation	0.258333	0.450000	0.051525	0.15
		Media	0.302778	0.050000	0.006710	0.02
Criticality		1.00				0.305333
Capital Cost		\$1,000.00				
Total Threat Costs		N/A				
Res-Risk* Criticality		0.349998				
Total Res-Risk		0.349998				
Expected Cost of Loss		\$350.00				
Cust. Guess Res-Risk		0.50				

FIGURE B-3. AUPD5: GROUP MEDIAN SURVEY TAKER'S ORIGINAL SURVEY OUTCOME							
VB	vb	Threat	threat	LCM	Risk	Post %	Post vb >
Protocols and Procedures	0.162121	Administrative	0.225000	0.650000	0.23710	0.05	
		Service Request/Intake	0.285417	0.500000	0.023136	0.05	
		Case Management	0.214583	0.675000	0.023482	0.05	
		Case Processing	0.275000	0.675000	0.030094	0.07	0.225211 !
Evidence Examination	0.203030	Physical Extraction	0.500000	0.650000	0.065985	0.15	
		Data Hiding Analysis	0.500000	0.450000	0.045682	0.10	0.250428 !
Documentation and Reporting	0.219192	Examiner Notes	0.500000	0.450000	0.049318	0.11	
		Examiner Report	0.500000	0.625000	0.068497	0.15	0.264218 !
Legal Aspects	0.132323	Search and Seizure	1.000000	0.325000	0.043005	0.10	0.096445
Victim Relations	0.283333	Victim Rights and Support	0.310096	0.275000	0.024162	0.05	
		Court Preparation	0.347556	0.225000	0.022157	0.05	
		Media	0.342348	0.275000	0.026675	0.06	0.163697
Criticality							
1.00							
Capital Cost							
\$1,000.00							
Total Threat Costs							
N/A							
Res-Risk* Criticality							
0.445903							
Total Res-Risk							
0.445903							
Expected Cost of Loss							
\$445.90							
Cust. Guess Res-Risk							
0.50							

Biographies



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Catalysts of Military Innovation: A Case Study of Defense **BIOMETRICS**

 **COL Glenn Voelz, USA**

Military innovation is a central component of U.S. strategic advantage; however, the precise conditions that enable such innovation remain a matter of debate. The recent introduction of biometrics onto the battlefield offers a useful case study for examining catalysts of military innovation and specific factors that enabled the Department of Defense to rapidly field new technologies in response to urgent operational requirements. This article considers how doctrinal design and warfighting strategies became important catalysts, and how challenges associated with rapid fielding, interoperability, and training limited U.S. forces from realizing the full potential of these new technologies. This case study proposes that military innovation can occur only by using an integrated approach that encompasses the interdependent elements of technology, acquisition, doctrinal design, and warfighting strategies. It offers general conclusions on conditions that create fertile environments for military innovation and identifies lessons learned for future efforts at introducing new technologies into the field.

Keywords: *Doctrine, acquisition strategy, Department of Defense Automated Biometric Identification System*





Military innovation has reemerged as a topic of interest among national security professionals. This has been spurred by a growing concern that the United States has ceded the military-technological advantage it enjoyed for most of the post-World War II era. The push to regain this edge has led to a number of new initiatives such as Better Buying Power 3.0, aimed at accelerating acquisition reform and incentivizing innovation within government. Similarly, the Department of Defense (DoD) recently announced the Defense Innovation Initiative, a set of long-range research and development programs intended to identify advanced capabilities as the basis of a “Third Offset Strategy.” These efforts focus on achieving high-payoff breakthroughs in areas such as artificial intelligence, robotics, additive manufacturing, and nanotechnology, among others. Last year, Secretary of Defense Ashton Carter opened the Defense Innovation Unit Experimental in Silicon Valley to “scout, connect, and support the innovation of disruptive technology” with potential military value. The common theme among these initiatives is to create U.S. strategic advantage by improving the process of military innovation; however, the precise conditions that enable this to occur remain a matter of some debate.

One source of insight comes from analyzing recent examples of military innovation that emerged during the conflicts in Iraq and Afghanistan. Among these, biometrics offers a useful case study of a technology that was virtually unknown on the battlefield prior to 9/11, yet by the end of the decade had become a ubiquitous feature of U.S. military operations. This particular example is instructive because it involved the rapid and relatively successful integration of a new technology that substantively changed the way U.S. forces conducted operations on the ground. This outcome was due to several factors. As an untested military technology, biometrics evolved concurrently with new doctrinal concepts describing how the tools would be used on the battlefield to create desired effects. These capabilities were then applied as part of a coherent warfighting strategy focused on specific operational challenges encountered in Iraq and Afghanistan. Within this context, biometrics became a key enabling technology of population-centric counterinsurgency, applied across a range of use cases such as detainee management, high-value targeting, and



support to Rule of Law operations. However, despite the success in rapidly moving these new technologies into the field, in some cases the operational impact was limited due to challenges with interoperability, informational sharing, and training. The case study of biometrics demonstrates that effective military innovation can only occur through an integrated approach that takes into account the interdependent elements of technology development, acquisition planning, doctrinal design, and warfighting strategy.

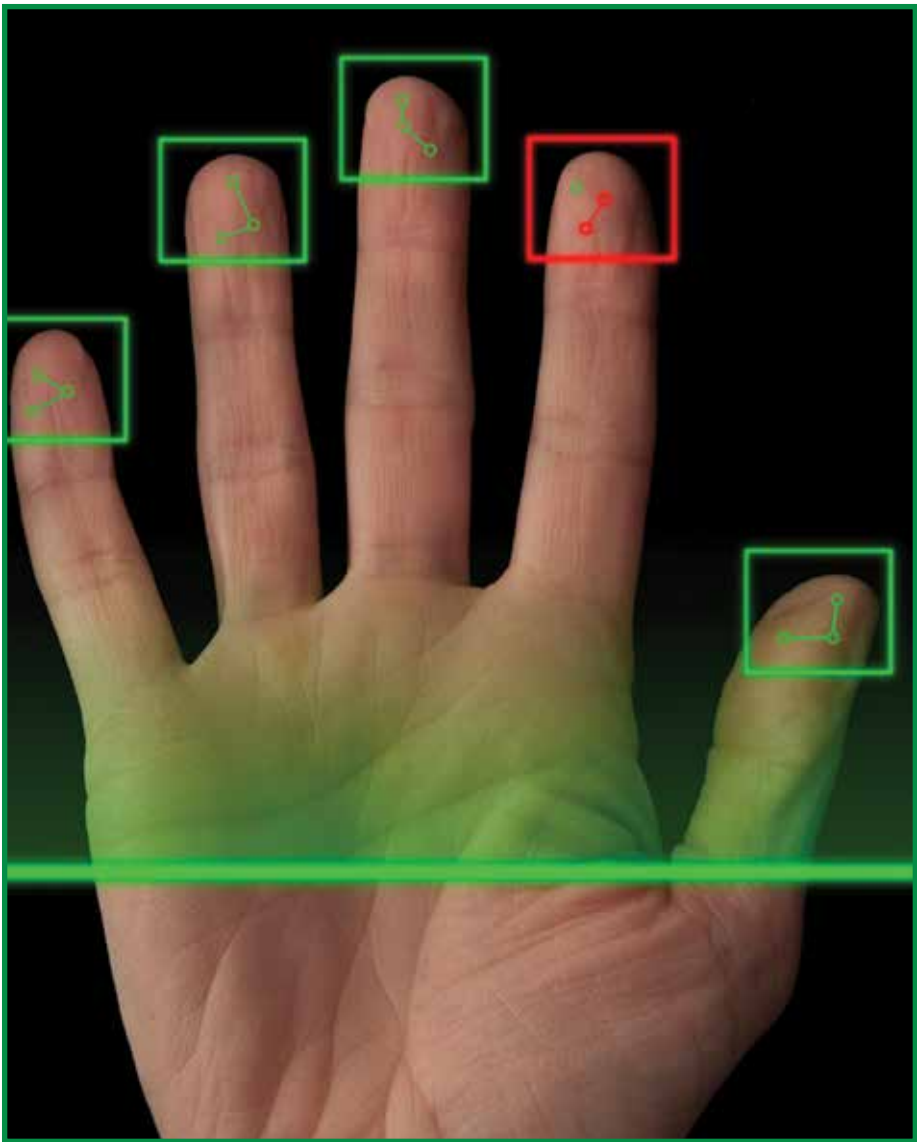
Defining Military Innovation

Innovation describes the process by which a new idea, technology, or method provides an improved capability for addressing an existing need. Generally, it follows a process of discovery, application, and exploitation where basic research is transformed from a concept into a tool or process that delivers some kind of operational advantage. Scholars of military innovation look to several characteristics for evidence of meaningful change. The first is whether the process of innovation substantively alters the manner in which military formations function in the field. A second factor is whether these changes are significant in terms of scope and organizational impact. A third component takes into account whether these changes ultimately produce greater military effectiveness (Grissom, 2006).

There exists a relatively deep body of academic literature on military innovation, examining the technological, cultural, and bureaucratic aspects of change. Much of this research focuses on “innovation inhibitors” that undermine the successful adoption of new technologies and methods (Jungdahl & Macdonald, 2014). Many of these studies apply the lens of organizational theory with emphasis on institutional factors such as bureaucratic culture and leadership dynamics as key variables in the process of innovation (Avant, 1994; Posen, 1984). Williamson Murray’s influential study, *Military Adaptation in War*, notes how modern bureaucratic and military cultures have become antithetical to adaptation, often for reasons relating to parochial interests or avoidance of negative consequences resulting from incorrect decisions (Murray, 2009).



Some experts consider wartime innovation a phenomenon that must be examined separately from that of peacetime change (Rosen, 1991). Indeed, with many examples of wartime innovation, the causal pathways of change tend to be somewhat less complex and highly responsive to the exigent demands of the battlefield. In such instances, the act of warfighting becomes a laboratory for conducting “natural experiments” in which technology requirements are explicitly articulated in response to challenges posed by an actual adversary rather than a hypothetical one. This situation provides



immediate tactical feedback and creates a powerful dynamic for iterative design and process improvement. These factors inevitably sharpen how operational needs are defined, while at the same time accelerating the bureaucratic process of research, development, prototyping, and fielding.

Yet, even in cases where explicit tactical demands drive the adoption of a new military technology, these tools do not exist in isolation. Successful diffusion of new technologies or methods still requires a conceptual driver to guide the course of innovation. This provides the context for how a given technology will be employed on the battlefield, thereby creating meaningful military effects. Importantly, Williamson Murray observes that technological sophistication is not necessarily the most critical factor of successful innovation. Rather, it is how well a new technology is incorporated into an effective concept for fighting that matters. This emerges from evolutionary problem solving focused on specific operational challenges. However, effective implementation also requires a coherent framework of employment grounded in doctrine, operational concepts, and an overarching strategic vision for how the technology will be used.

In the case of biometrics, the key conceptual driver was the realization that counterinsurgency and counterterrorism operations against irregular adversaries required different doctrinal approaches and technical tools than those optimized for conventional military conflict. In particular, the intelligence, surveillance, and reconnaissance technologies needed for identifying and targeting individual combatants and their networks were not the same as those designed for detecting and destroying motorized rifle battalions. This new mode of warfare turned combatant identity into a critical technical signature of the battlefield. In this complex human terrain, biometric technologies helped put a uniform on the nation's enemies and reduced their ability to leverage anonymity for military advantage. This paradigm shift in thinking about identity and military targeting established a clear operational role for biometrics. It firmly placed the new technology within an explicit doctrinal framework and described how it would be used to support the overarching warfighting strategy. In the case of biometrics, several specific factors were instrumental as catalysts for innovation:

1. **Clear Operational Use Case.** Military innovation is most effective when it addresses a well-defined operational challenge. As a largely untested battlefield technology, biometrics evolved rapidly for the simple reason that it provided a practical solution to help identify, track, and target irregular combatants fighting without uniforms or conventional formations. Within the context of waging

counterinsurgency, biometrics technologies offered a powerful tool with a wide variety of use cases such as detainee management, high-value targeting, and support to Rule of Law operations.

- 2. Value Proposition Linked to Doctrinal and Strategic Concepts.** New military technologies require a coherent concept of employment that clearly demonstrates their value within a larger doctrinal and strategic framework. Biometrics succeeded in part because it was introduced within the context of new doctrinal and strategic approaches focused on population-centric counterinsurgency and identity-based targeting. These priorities emerged within the broader context of Iraq and Afghanistan, where biometrics became an increasingly important technical tool for navigating complex human terrain and assisting U.S. forces in waging war against the enemy.
- 3. Effective Bureaucratic Constituencies.** Military innovation ultimately occurs within an organizational context; therefore, it requires strong bureaucratic advocates with the institutional capacity to manage the development and integration of new technologies. Biometrics had a distinct advantage of being a multiuse technology with a broad range of operational applications. Just as biometrics appeared on the battlefield, the value of the technology was also recognized by law enforcement, Homeland Security, and the Intelligence Community, thereby creating a critical mass of interest groups—all pushing for new investments. However, numerous constituencies pursuing parallel development programs also created challenges for interoperability and data sharing as the new technologies evolved.
- 4. Development Partners in a Competitive Marketplace.** Military innovation works best when government works collaboratively with a diverse range of development partners in a dynamic and competitive marketplace. As biometrics technologies appeared on the battlefield, a growing demand also emerged for new commercial applications that drove a period of rapid innovations in the nondefense sector. This enabled DoD to benefit from significant private investment in research, development, and prototyping. While DoD was not the only market driver of this innovation, it was in a unique position to exploit the latest developments for the commercial sector and adapt these tools directly to military needs.

Biometrics Fundamentals

As a general term, biometrics describes the measure of biological and/or behavioral characteristics that can be used for automated recognition or identity verification. A biometric modality refers to a type or class of biometric samples such as those derived from a facial image, fingerprint, iris, or voice pattern. Biometric matching describes the capability and/or process of comparing biometric data in order to link previously obtained biometrics and related contextual data to a particular identity or for the verification of identity (Defense Forensics and Biometrics Agency, 2013). Biometric data can be combined with biographical and other contextual information to build a “pattern of life” profile for individual subjects. When analyzed together with other biometric records and all-source intelligence, this information can reveal connections among individuals, correlate their activities, and expose the structure of their networks.

Biometrics as Military Innovation

One of the early lessons learned from the conflicts in Iraq and Afghanistan was that many of the legacy intelligence technologies developed for conventional warfare against state-based adversaries did not provide the kind of information needed to effectively support counterinsurgency operations and, in particular, identity-based, high-value targeting (Defense Science Board, 2011). As the United States shifted towards a counterinsurgency strategy, it required population-centric information and refined targeting intelligence for identifying, isolating, and eliminating insurgents from the battlefield. These operational challenges demanded new technologies to enable U.S. forces to detect and identify individual actors, characterize and geo-locate their activities, and understand the structure and function of their networks. This presented an enormous tactical dilemma for soldiers fighting on an irregular battlefield against adversaries who did not wear uniforms and could not easily be distinguished from the local population. As such, identity verification emerged as one of the major technical challenges of the campaigns in Iraq and Afghanistan. Although relatively untested as a military technology, biometrics rapidly emerged as an important tool for differentiating actors within a complex and often ambiguous operational environment.

Prior to 2001, the U.S. military had no significant operational experience in the use of biometrics. DoD’s original vision for biometrics was relatively limited in scope and focused principally on tasks such as information assurance

for automation systems and physical access control (Defense Science Board, 2007; National Science and Technology Council, 2008, p. 21). However, new Homeland Security concerns following 9/11 and the subsequent conflicts in Iraq and Afghanistan became the initial catalysts that transformed biometrics into an operationally focused technology. Although the Army's biometric development program had been operating since 1999, it was not until 2001 that the Battle Command Battle Laboratory produced the first Biometric Automated Toolset (BAT) prototype, a multimodal (fingerprint, iris, and face) system for collecting, matching, and storing personally identifying information. This technology was initially field-tested in the Balkans where it was primarily used for identifying local national workers accessing U.S. installations. As these technologies matured from prototype design into a functional capability, a number of new uses evolved that greatly expanded the value of these tools across the range of military operations.

Biometrics Use Case: Detainee Management

Almost immediately at the start of operations in Iraq and Afghanistan, U.S. forces faced an unprecedented challenge of managing the large numbers of detainees on the battlefield. One report from early in the conflicts noted how the "handling of detainees, appropriately documenting their capture, and identifying and accounting for them, were all dysfunctional processes, using little or no automation tools" (Jones, 2004, p. 21). New biometrics technologies offered one solution for this dilemma. In early 2002, a BAT prototype was fielded to Joint Special Operations Command in Afghanistan and first used for enrolling persons of interest detained on the battlefield. By 2003, similar systems were deployed at detention facilities in Iraq for detainee management and later as a tool for generating biometrically enhanced interrogation reporting (Iasso, 2013). By 2004, DoD directed that all U.S. military units worldwide would collect biometric data from detainees (DoD, 2004). One vivid demonstration of the value of this data came in 2011 when 500 Taliban prisoners escaped from Kandahar's Sarposa prison. All detainees had previously undergone biometric enrollment, and within 1 month 30 individuals were recaptured in the local area as a result of random biometric checks (The Eyes Have It: Biometrics in Afghanistan, 2012). Since then, biometric data gathered by DoD and other government agencies have been used to identify and prevent tens of thousands of potentially threatening individuals from entering the United States (Partnership for Public Service, 2013, pp. 12-13).

The first major operational employment of the BAT system was by Marine Corps units during the resettlement of Fallujah following major combat operations in 2004. Handheld biometric devices and databases were used to monitor the flow of residents into and out of the city as a means of identifying insurgents moving among the population (McWilliams & Schlosser, 2014, p. 62; Shanker, 2011). The use of this technology on the battlefield expanded rapidly as the United States shifted towards a population-centric counterinsurgency strategy in Iraq and became a critical tool during the “surge” period for identifying and segregating insurgents from the larger population. By that time, thousands of BAT toolsets and the newer Handheld Interagency Identity Detection Equipment (HIIDE) systems had been fielded to tactical units. Multimodal or 13-point biometric collection (10 fingers, two irises, and one face) became a standard feature of combat patrols and documenting encounters with persons of interest. By the end of combat operations in Iraq, U.S. forces had compiled a biometric database containing some three million individual files (Ackerman, 2011).

Biometric technologies proved equally important in Afghanistan where few inhabitants possessed verifiable identity documentation and combatants could not easily be distinguished from the surrounding population. Over 7,000 biometric collection devices were fielded and used for functions such as detainee management, execution of high-risk warrants, and targeted raids against named insurgents. During the conflict, U.S. forces collected over 2.5 million biometrics records and placed some 33,000 individual identities on biometrically enabled watch lists (The Eyes Have It, 2012; U.S. Government Accountability Office [GAO], 2012).

Biometrics as Doctrinal Innovation

The basic act of fielding a new technology by itself does not represent true military innovation. Tools are not inherently valuable without a viable concept of employment that describes how a given technology will contribute towards achieving an organization’s core functions. This requires a concurrent process of doctrinal innovation that exploits the potential of a new technology by providing a theoretical framework and methods for how it will be used to achieve military objectives. To be successful, doctrinal innovation must occur on a sufficiently large scale to overturn old ways of doing business, thereby institutionalizing the new tools and methods (Cote, 1996). This is no small task and sometimes requires a wholesale reconceptualization of how an organization perceives its central warfighting tasks.

The catalysts for such change may come from a variety of sources. Some theories focus on endogenous factors such as organizational culture, civil-military relations, or Service rivalries as central dynamics in this process (Posen, 1984; Rosen, 1991). Other theories weigh more heavily on the influence of exogenous factors such as the rise of unanticipated threats or emergence of novel technologies that disrupt the fundamental balance of military advantage on the battlefield. In the case of biometrics, several external factors played a role in driving how these technologies evolved on the battlefield.

The U.S. military's adoption of biometrics emerged within the context of a larger paradigm shift that moved identity to the center of a new warfighting paradigm. Counterinsurgency and counterterrorism operations required the U.S. military to undertake a major doctrinal reorientation focused on targeting *networks* and *individual combatants* rather than formations and weapons platforms. In his counterinsurgency guidance to multinational forces in Iraq, Army Gen. David Petraeus directed commanders to “defeat the network, not just the attack” by focusing intelligence assets on the nodes and links of



the insurgency—identifying its leaders, financiers, suppliers, and operators (Petraeus, 2008, p. 2). This required technologies to support a new targeting paradigm by enabling U.S. forces to “identify and separate the reconcilables from the irreconcilables” on an irregular battlefield. Biometrics became a central technical component of this new strategic approach.

Biometrics Use Case: High-Value Targeting

An important aspect of U.S. counterinsurgency and counterterrorism strategies involved identity-based targeting of individual combatants. Biometric technologies and Biometrically Enabled Intelligence (BEI) became important elements of the shift to this new targeting paradigm. This process for targeting high-value individuals was doctrinally formalized within the find, fix, finish, exploit, analyze, and disseminate (F3EAD) methodology. Biometric databases and watchlist information played an important role in identifying, tracking, and targeting these individuals. For example Biometric Identification Analysis Reports (BIAR) provided U.S. forces with biographical information, encounter history, and disposition instructions for persons of interest. During the “surge” period in Iraq, these data were used to remove an average of two high-value individuals from the battlefield each day. When combined with forensic data, this biometric information was a powerful tool for penetrating cells employing Improvised Explosive Devices against coalition forces and matching specific individuals to these activities. For example, from 2007 to 2008, more than 1,700 adversary combatants were biometrically linked to forensic evidence directly associating them with the manufacture and use of these devices on the battlefield (Kieffer & Trissell, 2010).

As biometric technologies evolved within this new warfighting paradigm, DoD directed combatant commanders to integrate these capabilities into mission planning across the six-phase joint planning model (DoD, 2008). The Army formalized the doctrinal role for biometrics technologies as part of its concept for Biometrically Enabled Intelligence (BEI), or the intelligence resulting from the combination of biometric data with other intelligence information to identify potential threat actors. The Navy and Marine Corps adopted a similar concept known as Identity Operations (IdOps) into their respective Service doctrine. This approach encompasses the synchronized application of biometric technologies, forensics, and identity management capabilities in support of maritime and expeditionary operations (Department of the Navy, 2012).

More recently, the DoD Intelligence Community introduced into joint doctrine an overarching concept for Identity Intelligence (I2), or the collection, analysis exploitation and management of identity attributes and associated technologies and processes (Joint Chiefs of Staff, 2013). I2 integrates several distinct technical-functional areas combining BEI with other all-source data to connect individual actors to other persons, places, activities, or materials. This doctrine defines a specific role for biometric technologies across a range of mission functions including raids, checkpoint operations, border control and maritime interdiction, force protection, support to host-nation Rule of Law, and detailed human terrain mapping. These examples all illustrate the degree to which biometric technologies have been integrated within a doctrinal framework supported by specific use cases and tactical applications.

Biometrics Use Case: Support to Rule of Law and Stability Operations

U.S. counterinsurgency strategy presented enormous procedural challenges regarding legal adjudication of “unprivileged enemy belligerents” detained on the battlefield as well as monitoring released individuals for recidivism. Biometric technologies played a critical role in supporting such “evidence-based” operations, particularly during the stability and support phase when formal criminal proceedings became the only means of effectively removing insurgents from the battlefield (Voetelink, 2013). Biometric and forensic data provided much of the evidentiary basis for prosecution support packages used by detainee review boards and host-nation criminal proceedings against suspected insurgents. These packages provided detailed biological and biographical information linking suspect individuals to insurgent activities.

Counterinsurgency strategy also called for U.S. forces to help reestablish rule of law and support local governance. This included the transfer of biometric information and technologies to local partners and training on how to use these tools as part of legal proceedings. As one example, the Afghan government now maintains its own biometric database and uses this information in support of warrant-based targeting and prosecutions. Of recent cases tried in the Afghan National Security Court, there have been convictions in a majority of instances where biometric data have been linked to forensic evidence presented in the case (Pendall & Sieg, 2014).

Acquisition and Technology Integration as Factors in Military Innovation

The nature of bureaucratic culture and the dynamics of the acquisition process also play an important role in the process of military innovation. As a general rule, bureaucracies tend towards a status quo bias; therefore, they are not necessarily designed to accommodate adaptation (Samuelson & Zeckhauser, 1988). This means that organizations cannot always exploit the full potential of an emerging technology even when there are clear advantages over previous methods (Murray, 2009). In the case of biometrics, challenges relating to the acquisition process and integration of the new technologies produced mixed results in terms of creating the conditions for successful innovation.

In the initial aftermath of 9/11, government officials immediately recognized the need for improved border control and automated systems for identifying individuals trying to enter the country. New biometrics technologies offered one means of verifying identities and comparing these records against watchlists of potential threats gathered by DoD and other government agencies. Effective use of these data required an unprecedented effort to overcome deep institutional barriers between the Department of Defense, the Intelligence Community, Homeland Security, and domestic law enforcement so that threat identity information could be shared across the entire enterprise. However, the U.S. government had only two major operational biometric systems on 9/11—one at the Federal Bureau of Investigation (FBI) and another with U.S. Immigration and Naturalization—as well as a handful of smaller research projects and pilot studies (National Science and Technology Council, 2008).

As U.S. forces began collecting large amounts of biometric data on the battlefield, a critical need emerged for an authoritative database to process, store, and match these biometric records. This required an information management system designed for sharing identity information among widely dispersed military forces in the field, as well as with domestic law enforcement and the Intelligence Community. Within DoD, this led to the initial prototype design for what became the Department of Defense Automated Biometric Identification System (DoD ABIS), the military's centralized multimodal biometric data repository. This system later included a Biometrically Enabled Watchlist feature enabling analysts to highlight person-of-interest records, and provide disposition instructions and other relevant information. As DoD was deploying its prototype system, the FBI had already fielded its own automated fingerprint database system known as

the Integrated Automated Fingerprint Identification System. Concurrently, the Department of Homeland Security was conducting an upgrade of its own biometric identity system used for managing immigration, visa, border control, and law enforcement requirements. Additionally, in 2004 the National Counterterrorism Center was tasked with managing the Terrorist Identities Datamart Environment, intended to be the government's central repository of information relating to international terrorist identities.

Even as biometric collection devices proliferated across the battlefields of Iraq and Afghanistan, DoD struggled to articulate an overall strategic vision for how the new technologies would evolve as a warfighting capability and integrate into the larger national security apparatus. According to one assessment, the DoD biometrics enterprise lacked "specific and measurable strategic goals and objectives for using biometrics" and a lack of common understanding about the purpose and boundaries of the enterprise (Shontz, Libicki, Rudavsky, & Bradley, 2012). This ambiguity contributed to discontinuities in the acquisition program and criticisms that the overall DoD biometrics program lacked a long-range planning horizon. One specialist working on biometrics programs at the Army's Communications-Electronics Research, Development and Engineering Center observed how many of the Quick-Reaction Capabilities fielded during the conflicts were only used for a year or two, then not sustained due to shrinking budgets or changing operational priorities (Jontz, 2015). In the case of biometrics, the focus on rapidly moving collection devices out to units also meant that some new capabilities were fielded without adhering to DoD standards, performance measures, and operational testing and evaluation requirements (Shontz et al., 2012).

The rapid fielding process also had implications regarding preparing the force for integration of the new technologies. Because these technologies were a relatively untested capability, the military had not yet developed the human capital needed to fully exploit their potential. Initially, a relatively small number of trained users and leaders were familiar with the systems. For example, the GAO found that DoD did not sufficiently instruct unit commanders on effective use of biometrics, and noted that many military leaders were unaware of how the technology contributed to identifying



enemy combatants (GAO, 2012). This led to confusion over how and when to incorporate biometrics capabilities into mission planning and how to best employ the systems in the field. A separate study attributed some of these shortfalls to delays in establishing biometrics as a formal Program of Record that would have formalized the process of establishing common training standards (Shontz et al., 2012).

While some units such as Special Operations forces clearly leveraged the new technology to great effect, its operational integration across the force was uneven. Inconsistent training meant that individual units applied significant discretion in terms of what biometric data were gathered and the methods of collection. These training shortfalls affected the quality of biometric data collection, and in some cases resulted in the loss of information gathered from the field and delays in transmission into the centralized, authoritative database (GAO, 2012). In hindsight, rapid fielding was the correct decision from the perspective of supporting soldiers in the field with available technology; however, it was not without consequences. The process was likely a factor contributing to challenges with interoperability and training that ultimately limited the operational impact of a promising new technology.

Other problems encountered during the early deployment of biometrics were not specifically related to the technology itself, but rather reflected bureaucratic challenges involved in the acquisition process. Discussions with DoD's Biometrics program manager suggested that the Executive Agent was not sufficiently empowered to provide effective oversight and strategic guidance across the enterprise as the technology evolved (Vann-Olejasz, personal communication, 2014-2015). This contributed to challenges promulgating and enforcing standards of interoperability as various components pursued independent development programs (GAO, 2012; Shontz et al., 2012). For example, by 2011 the Army had still not fully adopted common biometric standards for its primary handheld collection device, the HIIDE, being used in Iraq and Afghanistan. This left the system unable to automatically transmit biometric data to other federal agencies.



According to the GAO, since the device was developed in response to an urgent mission requirement, it was not required to adhere to DoD's information technology standards.

Other difficulties emerged related to coordination among a diverse range of users, often with differing technology requirements and protocols for handling biometric information. According to the GAO, system capacities developed for different mission needs affected agencies' ability to process one another's queries for biometric information. This complicated the process of developing and approving interagency biometric sharing agreements between DoD and the FBI. Similar problems were encountered establishing direct connectivity between DoD and Department of Homeland Security (DHS) biometric databases (GAO, 2011). Even within DoD, various components were not always able to seamlessly share biometric information using a commonly understood process and methodology. This issue included challenges of passing and comparing information stored on domains of different classification. These examples support Williamson Murray's (2009) contention that technology implementation is an equally important aspect of military innovation as the sophistication of the technology itself.

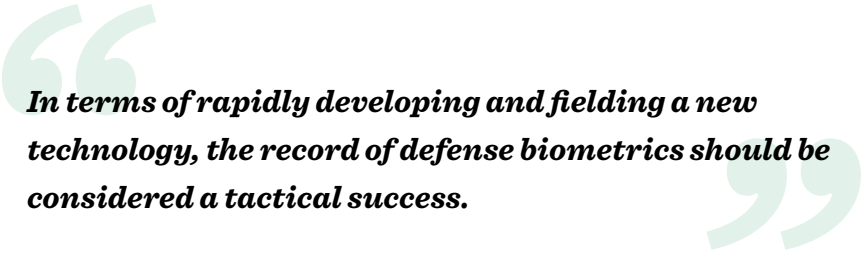
Innovation Lessons Learned from Defense Biometrics

As a recent example of military innovation, biometrics offers a useful case study for understanding how a new and relatively untested technology was integrated into operational use during wartime. At the start of combat operations in Iraq and Afghanistan, the U.S. military had virtually no experience or operational concepts for employing biometrics. However, by the end of the decade the devices had become a commonplace tool on the battlefield and an important enabling technology of counterinsurgency and counterterrorism operations.

Several factors contributed to this outcome. First, within the context of the unique tactical challenges encountered by U.S. forces in Iraq and Afghanistan, biometric technologies had a number of specific and highly relevant use cases. Second, the technology was firmly grounded in a doctrinal framework and overarching warfighting strategy that clearly articulated how the technology could be used to improve the effectiveness of U.S. forces on the battlefield. Third, during the initial developmental stage, multiple constituencies actively pushed for the integration of biometrics technologies for a wide variety of applications. Finally, DoD and other users benefitted from a rapidly expanding commercial marketplace that was able to deliver

cutting-edge technologies, readily adaptable to military use. The combination of these factors played a significant role as catalysts for innovation and facilitated the relatively successful integration of a new military technology.

However, despite these significant achievements, biometrics was not a flawless example of military innovation. Some notable shortfalls related to challenges associated with the rapid fielding process. For example, the urgent demand to move collection devices out to units meant that some new technologies were deployed without adhering to formal performance measures and standards for interoperability. This contributed to difficulties in moving and sharing biometric information among interagency partners. Additionally, as the new tools were placed into units, initially a relatively limited number of users and leaders possessed sufficient knowledge and experience to fully exploit the potential of the new technology. These challenges were certainly not limited to DoD. Indeed, one group of experts recently noted that even as biometrics technologies rapidly evolved over the last decade, the legal, political, and resource framework for how to implement these tools has lagged behind the technological advances (Aughenbaugh, 2015).



In terms of rapidly developing and fielding a new technology, the record of defense biometrics should be considered a tactical success.

In terms of rapidly developing and fielding a new technology, the record of defense biometrics should be considered a tactical success. During the course of the conflicts in Iraq and Afghanistan, U.S. forces generally made effective use of an emerging capability that directly enabled new forms of identity-based operations in response to unique demands of waging irregular warfare. However, the rapid fielding process did reveal shortcomings in how DoD manages military innovation at the bureaucratic level. These challenges are undoubtedly not unique to biometrics and are certainly worthy of future study to better understand how DoD can improve process models for wartime innovation. As one recent study of military innovation noted, militaries exist for war, but they more often innovate during peacetime

(Hill, 2015). Therefore, strategies for innovation must be adaptable to both environments and able to survive the transition from one condition to the next. In the end, this may be one of the key lessons learned from the example of biometrics.

Challenges for the Future

The lessons drawn from the initial experience of fielding biometrics will be particularly important as the technology enters its second generation—an evolution that will most likely progress along a very different developmental path than the initial phase. In this respect, biometrics may offer an example of the changing model for development and acquisition of cutting-edge defense technologies. During the Cold War era, DoD developed many of its most important capabilities within a closed system of innovation dominated by the defense-industrial complex. Most of these technologies were created under the purview of government-sponsored research and development programs, built in collaboration with a relatively small circle of defense contractors. An emerging model of military innovation may increasingly involve a wider range of commercial providers developing new technologies not explicitly designed for defense applications, but later adapted to military purposes. The field of biometrics reflects the dynamics of this transition.

The attacks of 9/11 and subsequent conflicts in Iraq and Afghanistan were important initial catalysts driving the first biometrics revolution. Between 2007 and 2015, DoD drove a sizable portion of new investments in the field with an estimated \$3.5 billion in program spending (GAO, 2011). These requirements substantially defined many of the initial prototype technologies that fueled industry growth rates in excess of 28 percent between 2005 and 2010 (Gelb & Clark, 2013). However, even during this period of rapid expansion, already underway was a gradual transition of the customer base—away from government and military requirements. As the sector matured, it shifted towards new applications in health care, retail services, banking, and consumer digital devices (Biometrics Gets Down to Business, 2006). This trend is only expected to accelerate as DoD represents an increasingly smaller fraction of this rapidly expanding marketplace.

One recent industry report placed the value of the current global biometrics market at \$7 billion annually, projected to reach \$44 billion per year by 2021. However, the key growth areas for the industry will likely come from sectors other than military and defense. Furthermore, the United States will not be the primary driver of this growth with countries such as India, Mexico,

Russia, and China expected to create much of the future demand for biometrics technologies (National Security and Market Watch, 2015; King, 2014). What this means in practical terms is that DoD will increasingly need to look beyond the traditional jurisdiction of government-sponsored research and development programs to access cutting-edge technologies in the field. This will be particularly true across the range of research areas likely to be critical for the next generation biometrics capabilities—areas such as remote sensing, data science and artificial intelligence, information management, and communications. All of these factors suggest that future military innovation will depend largely on DoD’s ability to identify and effectively assimilate commercial technologies from the nondefense sector. The lessons from biometrics suggest a few of the potential challenges.

One recent industry report placed the value of the current global biometrics market at \$7 billion annually, projected to reach \$44 billion per year by 2021.

Biometrics, in particular, is a technology where the benefits derive from network effects, meaning that its utility is directly related to the number of users able to input data, conduct searches, and discover associations within a commonly accessible database. This makes interoperability central to the value proposition of the technology. As the last decade of counterinsurgency and counterterrorism operations demonstrated, U.S. national security strategy increasingly requires a “whole of government” approach based on seamless information sharing between the military, Intelligence Community, State Department, DHS, and law enforcement. Furthermore, transnational concerns about terrorism, organized crime, and mass migrations will require expanded collaboration and greater information sharing across borders and between governments in the future. The issues of interoperability and technology integration will be increasingly critical aspects of innovation as governments adopt strategies based on data-intensive decision making.

Given the rate of change in the commercial sector, DoD will be challenged to keep pace with new developments, continuous upgrades to existing systems, and the rapid evolution of new applications for existing technologies. Furthermore, some of the initiatives intended to spur innovation such as greater service autonomy in acquisition, increased prototyping, and

accelerated fielding may even exacerbate existing challenges regarding interoperability, data sharing, and integration. This also raises concerns about whether doctrinal development, concepts of employment, and force training can keep up with the pace of technological advances. These issues highlight the fact that identifying and acquiring cutting-edge technology is only one aspect of successful military innovation.

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Biography



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#eVALUate:

Monetizing Service Acquisition Trade-offs Using the

QUALITY-INFUSED Price[©] Methodology

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Lt Col Timothy G. Hawkins, USAF (Ret.)*

The federal government persistently fails to make service contracts a managed outcome. Consequently, the three objectives of public procurement (transparency, value for money, and meeting requirements) are jeopardized. This research identifies the culprits as methodologies that are incompatible with the characteristics of services. These methodologies involve best-value source selection and contractor performance-information collection and evaluation. A new method of best-value proposal evaluation is offered that enables the buying agency to validly measure service quality, then to trade off levels of service quality with price, resulting in a Quality-Infused Price (QIP)[©]. The concept is tested on a task order competition using a case study methodology. Findings suggest that service quality can be monetized and that the application of a QIP[©] methodology can result in a superior sourcing decision. Additionally, fewer and higher quality proposals will be received. Based on the findings, conclusions are drawn and suggestions for future research are offered.

Keywords: *supplier performance evaluation, best value, source selection, service quality*



Over the past several decades, the United States transitioned from a goods-based to a services-based economy (McCullough, 2012; Powell & Snellman, 2004). As of 2013, services accounted for 78 percent of the country's gross domestic product and employed 82 percent of the country's workforce (U.S. International Trade Commission, 2015). At 68 percent of total contract spending in 2014, federal spending on services is substantial (Schwartz, Ginsberg, & Sargent, 2015). The Department of Defense (DoD) obligated 45 percent of its contract spend on services—an equal proportion as that spent on goods (Schwartz et al., 2015). While the DoD increasingly relies on defense contractors for services, it lacks the key elements at the strategic and tactical levels to make service contracts a managed outcome (U.S. Government Accountability Office [GAO], 2007a). Improving the tradecraft in services contracting has been a federal focus for some time (GAO, 2006; GAO 2007b; GAO, 2009b; Kendall, 2015; GAO, 2001a, 2001b).

Service has been defined as “the application of specialized competences (knowledge & skills) through deeds, processes, & performances for the benefits of another entity or the entity itself” (Vargo & Lusch, 2004, p. 2). The Federal Acquisition Regulation (FAR) defines a service contract as a “contract that directly engages the time and effort of a contractor whose primary purpose is to perform an identifiable task rather than to furnish an end item of supply” (subpart 37.101). Services are characterized as complex, heterogeneous, intangible (Apte, Ferrer, Lewis, & Rendon, 2006), perishable, and inseparable (Ellram, Tate, & Billington, 2007). First, the intangible nature of services renders specifications and customer expectations to be imprecise (Ellram et al., 2007). Second, services are, by nature, heterogeneous (Hawkins, Muir, & Hildebrandt, 2011). This is especially true of services with a high labor content, as performance will vary between providers and will likely differ between customers and with time required to deliver services (Parasuraman, Zeithaml, & Berry, 1985). Like providers, customers also lack a homogenous definition of service quality for many specified services (Hawkins, Berkowitz, Muir, & Gravier, 2015). Because of this, and since consistency in levels of performance from service personnel is difficult to attain, the level of quality that a service provider expects to deliver may vary greatly from the level of quality that the customer expects to receive (Parasuraman et al., 1985). Third, services are frequently perishable; unlike goods, services cannot be held or stocked in inventory. Whereas inventory policies for goods allow firms to buffer variability in future demand with safety stock, service providers must change service capacity to meet demand fluctuations (Ellram et al., 2007). The perishability of services





also presents challenges for inspection; service outcomes for many services can be inspected or evaluated only at the time of service performance (Hawkins et al, 2011). Given these perplexing challenges, how does the government validly leverage—not eliminate—the use of subjective service quality in both selecting contractors (i.e., reduce the risk of adverse selection) and motivating their performance (i.e., reduce the risk of moral hazard)?

To explore this question, this research supposes two axioms surrounding the objectives of procuring activities. First, the three primary objectives of public procurement are: transparency (Gilbert, Schapper, & Veiga-Malta, 2009), value for money (Gilbert et al., 2009), and meeting agency requirements. Second, the ability to procure services effectively and efficiently is desirable and in the public's best interest (Gilbert et al., 2009).

Agencies constantly trade these objectives based on risk that considers how best to meet agency requirements, gain value for money, and maintain a transparent process. These three objectives do not operate in a vacuum; rather, they are interoperable. If the agency can clearly and efficiently articulate requirements and evaluation methodologies, that clarity should increase transparency and, thereby, reduce the risk of bid protest (i.e., delayed meeting agency requirements). That clarity should also enable offerors to propose best in accordance with the agencies' needs (i.e., yield more value for money). Agencies must strategically assess the three objectives when they determine their source selection methodology along the best-value spectrum, ranging from lowest price technically acceptable (LPTA) to full trade-off of price and nonprice factors.

The ability to define, evaluate, select, award, and then manage service contracts is a problem that has garnered significant attention in the past decade, yet the many identified problems have not been resolved. Further, related problems in these areas and industry feedback have led to a call to “monetize” trade-offs to allow industry to understand the relative importance of evaluation factors in a manner that equates quality/performance to dollars of value (Kendall, 2015). The purpose of this research, therefore, is to provide a new approach that bridges the best-value continuum divide, optimizes the three primary objectives of public procurement, and delivers best value to the public sector by accounting for—rather than ignoring—the inherently subjective valuation of services.

Source Selection

FAR 15.304 identifies that price/cost, quality of the product or service, and past performance must be evaluated when contracting by negotiation. These criteria are considered across the best-value continuum spanning from LPTA to full trade-off in which the noncost factors may be significantly more important than cost/price. Agencies must know their requirements well enough to establish the best evaluation approach for source selection across this spectrum considering the three aforementioned objectives. LPTA generally compares to full trade-off as shown in Appendix A.

Federal acquisition and industry professionals have noted the following issues with LPTA versus full trade-off (Watson, 2015).

- Full trade-off evaluations may be too complex if workforce experience is low.
- Less procurement administrative lead time (PALT) is a driving factor in using LPTA.
- Evaluation criteria need to be better defined to industry. Industry needs to know the relative weight of cost/price to trade factors.
- Industry needs to know the level of performance to offer.
- Industry needs help understanding the competitive effects of a higher performance offer.
- There is a desire to avoid protests (Hawkins, Gravier, & Yoder, in press). Agencies must create meaningful evaluation discriminators.
- Industry can't determine the buying agencies' priorities.
- LPTA is perceived as "low cost/low quality."
- Cost risk does not equate to proposal risk.

The acquisition team's challenge is to find the optimal point within the best-value continuum to deal with these issues. The means by which federal agencies deal with the primary indication of quality and value for money—past performance—must first be explored.

Contractor Performance Rating System

The GAO asserted that contractor performance reports should be timely, accurate, and complete to allow federal procurement officials to make informed source selection decisions in the future. Despite persistent attention from the Office of Federal Procurement Policy (OFPP) and the GAO, Contractor Performance Assessment Reports (CPAR) continue to be plagued by a lack of reporting, untimeliness, incompleteness, and inaccuracies (GAO, 2009a, 2014b; Gordon, 2011). Agencies reported that workforce shortages, work priorities, time constraints, and difficulty obtaining timely feedback from other parts of the acquisition workforce are affecting reporting compliance (GAO, 2013, 2014b).

U.S. Federal Government agencies use the Contractor Performance Assessment Reports System (CPARS) to collect contractor performance information and use the Past Performance Information Retrieval System to access it.

U.S. Federal Government agencies use the Contractor Performance Assessment Reports System (CPARS) to collect contractor performance information and use the Past Performance Information Retrieval System to access it. Additional information that helps buyers reduce the risk of adverse selection is available from the Federal Awardee Performance and Integrity Information System. The CPARS scores contractors using a rating system of criteria including quality, schedule, cost control, management, and small business utilization (GAO, 2014b). To address the weaknesses of the CPARS, assessing “reputation attributes” (Blott, Boardman, Caday, Elliott, Griffin, Mastronardi, & Quinn, 2015) has been suggested to more closely align to commercial, “crowd-sourced” supplier performance evaluations. Such evaluations are updated in real time, known as “point-of-service,” as seen with online platforms such as Amazon, Yelp, Foursquare, etc. (Whetsell, 2015). Point-of-service platforms allow the customer to essentially “score” the vendors on their subjective experience, based on objective realities, in a timely manner that can lead to increased accuracy of reporting (Whetsell, 2015). Currently, CPARS reporting occurs annually with a 60-day contractor review window. Reports are not required until 120 days following the first 365-day period of performance. This means that it can take up to 485

days to officially capture the service quality delivered for an annual service (CPARS, 2015). Crowd-sourced, point-of-service reporting leads to a more holistic view of the contractor's performance in near real-time.

For instance, some customers are satisfied with a small proportion of late deliveries. Yet, others are upset with a contractor's inability to perform to all of the terms of the original contract. Both customers are receiving the same objective performance in the late delivery, but they may reach two different scores when rating the contractor. Many would view this level of subjectivity as a flaw in the rating system; however, the subjective reputation scoring embeds and assesses the contractor's ability to manage across all customers and demonstrates a truer measure of the contractor's customer management abilities. How well a contractor manages relationships across its market share of customers becomes apparent in this type of performance evaluation. This may best demonstrate the risk of partnering with the contractor on future service needs considering their ability to balance their customer relationship priorities. Such scoring methodologies account for the aforementioned characteristics of services—complexity, heterogeneity, and intangibility. This methodology may increase the chances of obtaining value for money in an efficient and effective manner while meeting the agency's requirements.

Quality-Infused Price (QIP)[®]

Tying the best-value source selection method and contractor past performance rating together “monetizes the trade-off” (Kendall, 2015). The source selection method used and the performance assessment method used must enable industry to understand the competitive effects of higher performance offers and to discern the level of performance to propose in response to a solicitation (Watson 2015). Benefits of monetizing the trade-off, aside from the expected better value offer, include faster PALTs and reduced protest risk. Recently, the Under Secretary of Defense for Acquisition, Technology, and Logistics, or USD(AT&L), pointed out that, although the number of DoD protests have increased in recent years (from 2001 to 2013), the sustainability rate of those protests has dramatically declined. The USD(AT&L) concluded that the Better Buying Power initiative to define value better in “best value” may be a significant contributor to that success (Defense Science Board Task Force, 2011). Monetizing trade-offs more clearly defines this value in terms of dollars. The proposed QIP[®] method aligns with and expounds upon the Better Buying Power initiatives.

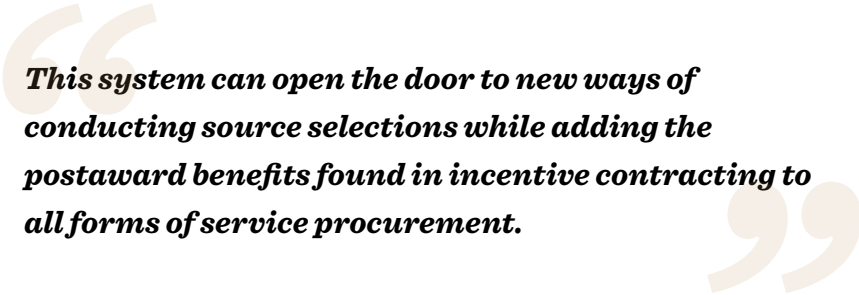
The proposed QIP® concept addresses all three of the public procurement objectives—transparency, value for money, and meeting agency requirements. While the USD(AT&L)’s direction is heavily concerned with defining how much more buying agencies would pay for performance of a system or “thing,” it falls short in defining monetized trade-offs for something as complex, heterogeneous, and intangible as a service. Evaluating services requires a midpoint between LPTA and full trade-off. Such a methodology should seek to give the combined benefit of faster evaluation processes (meeting agency requirements), more clear criteria to aid industry in deciding how to position the quality of their offer versus the costs of their offer (value for money), and an understanding of the agency’s award decision (transparency).

Further, the QIP® methodology should not end with the award decision. Components of the methodology should be used with assessing contractor past performance in a way that becomes a program of record, or “score,” for each firm. Consider an individual’s credit score. Credit scores (e.g., FICO scores) quantitatively encapsulate past financial, contractual, and behavioral performance to indicate the risk of loss of lending to an individual. A similar model can be used by federal agencies to determine the quality risk, management risk, cost risk, and “other” risks related to trusting a particular firm—the firm’s “reputation” currency.

To find the previously discussed midpoint on the best-value continuum, we propose the use of a composite Quality Adjustment Factor (cQAF) in developing a QIP® (i.e., an evaluated price adjusted for service quality) (Finkenstadt, 2015). Such a measure provides for faster PALT, more clear criteria for award, monetizes the trade-off for industry, and creates a past



performance standard that more closely aligns with the shift in commercial performance management. This system can open the door to new ways of conducting source selections while adding the post-award benefits found in incentive contracting to all forms of service procurement.



This system can open the door to new ways of conducting source selections while adding the postaward benefits found in incentive contracting to all forms of service procurement.

The cQAF described previously is a factor that may be greater to, equal to, or less than 1. It is derived from subjective service quality measures. The cQAF is used to assign a relative level of quality to the proposed price, considering factors determined to be germane to service value to the agency (Finkenstadt, 2015).

Once an offeror's prices are determined to be fair and reasonable, the agency applies the cQAF to the prices. Following the intent of FAR 15.304(c)(2), the agency would evaluate the quality of services being proposed by each offeror. To establish a value rating commensurate with the quality of the services being offered, the agency may use one or both parts of this two-part methodology, as shown in Table 1. The first part assesses relevant past performance, and consists of developing a composite Service Value Index (cSVI) using survey data from the offeror's previous customers (Finkenstadt, 2015). Contracts that leverage post-award incentives such as award fees and incentive fees can be considered in the establishment of this cSVI, either by having such ratings impact the score or subjectively as raters consider such factors in determining their level of satisfaction. This element remains to be codified and could depend on the type of service. The second part assesses the quality of the offeror's proposal considering relevant service quality indicators particular to the requirement such as personnel qualifications, technical process excellence, and management capability. The second part results in developing a composite Proposal Quality Rating (cPQR) (Finkenstadt, 2015).

TABLE 1. CQAF CATEGORY RATING TOOL					
PRIMARY CATEGORY	Reliability	Avg Survey Rating	Factor	Aggregate Score	Weight Total Value Indices
	When the contractor's management promises to do something by a certain time, it does so	3	1.00	0.99	0.3
	When you have performance problems, the contractor's management is sympathetic and reassuring	3	1.00		
	The contractor is dependable	5	0.90		
	The contractor provides its services at the time it promises to do so	4	0.95		
SUBCATEGORY	The contractor keeps accurate records	2	1.10		
PRIMARY CATEGORY	Assurance			0.96	0.4
	This rater trusts the contractor's employees	3	1.00		
	This rater feels safe in its interactions with the contractor's employees	3	1.00		
	The contractor's employees are polite, professional, and courteous	4	0.95		
SUBCATEGORY	The contractor's employees receive the support they need from the company to do their jobs well	5	0.90		

TABLE 1. CQAF CATEGORY RATING TOOL, CONTINUED					
PRIMARY CATEGORY	Responsiveness to Requirements	Avg Survey Rating	Factor	Aggregate Score	Weight Total Value Indices
	The contractor met the requirements of the contract	4	0.95	0.98	0.3 0.294
	The contractor satisfied our need(s)	3	1.00		
	The contractor performed the work we needed it to do	4	0.95		
	The contractor's work was timely	3	1.00		
	This rater was satisfied with the quality of the contractor's work	3	1.00		
SUBCATEGORY	Composite Service Value Index (cSVI) Adjustment Factor				1 0.976
PRIMARY CATEGORY	Proposal Process Efficiency and Resource Allocation Plan			1.01	0.5 0.50625
	How satisfied are you with the quality design of process flows proposed?	3	1.00		
	How satisfied are you with the quality of personnel capacity management proposed?	3	1.00		
	How satisfied are you with the quality of demand planning processes proposed?	4	0.95		
SUBCATEGORY	How satisfied are you with the quality of continuous process improvement proposed?	2	1.10		

TABLE 1. CQAF CATEGORY RATING TOOL, CONTINUED						
PRIMARY CATEGORY	Staffing Quality	Avg Survey Rating	Factor	Aggregate Score	Weight	Total Value Indices
SUBCATEGORY	How satisfied are you with the quality of staffing proposed for each line item?	5	0.90	0.90	0.5	0.45
	Composite Proposal Quality Rating (cPQR) Adjustment Factor				1	0.95625

cQAF	Final Composite Rating	Weight	Total Adjustment Factor
cSVI	0.976	0.3	0.2928
cPQR	0.95625	0.7	0.669375
cQuality Adjustment Factor for QIP [®] Calculation			0.962175

Note. Notional, including weighted importance

To establish the final cQAF, cSVI, and cPQR, first a scaled rating system that converts subjective service quality into objective factors is needed. This is the moment in which the trade-off is monetized. As such, these factors should not be established arbitrarily. Each type of service should be investigated using market research to determine the appropriate amount of “value for money” that each level of service quality represents to a majority of customers. This value-for-money scale may be created through market research into leading performance indicators in a particular type of service. A simplified five-point Likert scale is offered in Table 2. Note that the scaling creates “golf-like” reverse indices that increase with negative ratings and decrease with positive ratings (Finkenstadt, 2015).

TABLE 2. CQAF RATING SCALE (NOTIONAL)		
Adjective Rating	Numerical Rating	cQAF
Strongly Disagree	1	1.1
Somewhat Disagree	2	1.05
Neither Agree Nor Disagree	3	1.0
Somewhat Agree	4	0.95
Strongly Agree	5	0.90
Not Rated	None	Not Included

The cSVI is the factor that would become the crowd-sourced reputation score (i.e., the “numerical rating” listed in Table 2). A cSVI survey should be developed using an established scale with valid psychometric properties. The service quality scale included in Table 2 was recently developed for a business-to-business context (Hawkins et al., 2015), but may need further refinement by type of service (i.e., design-engineering services, testing services, facility management services, etc.). These assessments would be subjective in nature and are intended to systematically capture the quality of a particular firm operating within the type of service as assessed by the most recent and relevant customers. This assessment would be solely at the agency’s discretion in determining best value for each requirement. This part of the cQAF could replace the fallible (Blott et al., 2015) CPARS. The cSVI could be used for near real-time ratings that, even if constrained by the current vendor 60-day review window, would reduce final service performance reporting by up to 88 percent when compared to the maximum CPARS annual reporting window of 485 days (CPARS, 2015).

The cPQR is unique to each acquisition and may or may not be used in addition to the cSVI to establish the cQAF. It should be established using questions for the technical/quality evaluation team members to consider in scoring each proposal. This would be similar to the areas that are considered significant technical subfactors within a proposal. The agency would then derive the final cQAF to be used to establish the QIP[®] by combining the cSVI and cPQR factors using an agency-determined weight of importance per factor. These factors can be combined to yield a single cQAF for adjustment or may be used independently as the sole QIP[®] adjustment factor (Finkenstadt, 2015). This process may become agency- and/or service industry-dependent, and should be considered by agencies prior to implementation.

Once the agency calculates the cQAF for each offeror, the agency would apply the cQAF to the total price of each line item within the offeror's proposal (Finkenstadt, 2015). The agency would then award to the conforming offeror demonstrating the best-quality offer in terms of both price and quality ratings—in other words, the lowest evaluated QIP[®] offer.

An example involving advisory services is shown in Table 3. In this example, the cQAF of 0.962 is derived from the calculations in Table 1 by rolling up a notional cSVI at a relative importance weighting of 30 percent and a notional cPQR at a relative importance weighting of 70 percent. The 30 percent weight on cSVI and 70 percent weight on cPQR are notional; the agency would determine these weights depending on what is more important—actual service quality from past work or promises of future service quality in the proposal. The cSVI rating of 0.976 is created by weighting the scores of each primary factor of reliability, assurance, and responsiveness to requirements. The cPQR rating of 0.956 is derived by weighting the firm's process management plan and staffing quality. Again, all weightings are notional and would be established prior to developing the final cQAF. Using this example, the offer would be assessed as having an inherent quality value of \$161,647.79. Award would be made for \$4,273,570.00, but the offeror would get “credit” for having a lower proposed price based on carrying a higher quality rating (cQAF). This is the final step in “monetizing” the trade-off (Finkenstadt, 2015).



TABLE 3. OFFER QUALITY-INFUSED PRICE (QIP) [®] CALCULATION TABLE (NOTIONAL)				
QIP [®] Calculation Example				
	Quantity	Units	Unit Firm Fixed Price	Total Firm Fixed Price
CLIN 0001AA (Base)	25	Lot	\$4,000.00	\$100,000.00
CLIN 0002AA (Base)	25	Lot	\$24,000.00	\$600,000.00
CLIN 0001AB (Option 1)	25	Lot	\$4,400.00	\$110,000.00
CLIN 0002AB (Option 1)	25	Lot	\$26,400.00	\$660,000.00
CLIN 0001AC (Option 2)	25	Lot	\$4,840.00	\$121,000.00
CLIN 0002AC (Option 2)	25	Lot	\$29,040.00	\$726,000.00
CLIN 0001AD (Option 3)	25	Lot	\$5,324.00	\$133,100.00
CLIN 0002AD (Option 3)	25	Lot	\$31,944.00	\$798,600.00
CLIN 0001AE (Option 4)	25	Lot	\$5,856.40	\$146,410.00
CLIN 0002AE (Option 4)	25	Lot	\$35,138.40	\$878,460.00
Total Proposed Price				\$4,273,570.00
Total Proposed Price CLIN 0001 & Options				
				\$610,510.00
Total Proposed Price CLIN 0002 & Options				
				\$3,663,060.00
cQAF				0.962175
Quality-Infused Price (QIP) [®] CLIN 0001 & Options				
				\$587,417.45925
Quality-Infused Price (QIP) [®] CLIN 0002 & Options				
				\$3,524,504.75550
QIP [®] All CLINs & Options				
				\$4,111,922.21
TOTAL ASSESSED VALUE				\$161,647.79

Case Study

A case study methodology was used to test a portion of the cQAF in a recent source selection for administrative support services. This task order included two line items for each year of a 5-year service contract: one line item for contract support services and a second, larger line item for program control (financial) analysis services. The case involved evaluating offerors for task order awards under a prepriced indefinite delivery–indefinite quantity (IDIQ) contract in which 11 offerors could offer better than on-contract pricing, but had to offer no higher than on-contract pricing. The request for proposal allowed the agency to decide on awarding task orders for one or all of the line items. The IDIQs did not allow for past performance evaluations in the base year of the IDIQs, as the agency considered past performance during the base award to be at least satisfactory for all contractors and prohibited further past performance evaluations until the end of the IDIQ base period. This meant that all trade-offs for nonprice factors could not utilize past performance; therefore, the cSVI could not yet be tested. The agency chose this IDIQ for a limited test case due to (a) perceived weaknesses in proposal quality, (b) post-award performance results on recently LPTA-awarded task orders, and (c) a low threat to mission if the evaluation methodology were found to be flawed or was contested.

Only three of the 11 IDIQ holders submitted a proposal. The overall assessed quality of these three proposals was relatively high compared to historical LPTA evaluations for similar services. The lowest priced offeror was not selected due to having the lowest cPQR quality rating. Since the agency stated that quality was considered more important than price, and it did not intend to enter discussions, award was made to the highest rated offeror in terms of quality. All offerors proposed pricing at or below those listed in the base IDIQ. The lowest offeror's pricing was perceived as questionably low and would have driven the team into discussions had their quality rating been higher. This source selection did not fully apply the concept of adjusting evaluated pricing since it was a first trial. The researcher first wanted to determine whether the quality rating system would affect the quality trade-off.

In this case, the highest priced yet highest rated offeror was selected, while the overall price remained 4 percent below the agency's estimate. The cPQR method allowed for a team of three personnel to assess three full proposals in only 3 days. Quality perceived was converted to a rating that yielded the results shown in Table 4. Actual cPQR scores are not available due to source selection material and the sensitive nature of the procurement. However,

this table demonstrates their relative placement after applying the cPQR as a general quality ranking independent of QIP[®] adjustment. The full QIP[®] methodology, applying the cQAF to price in order to rank offerors based on QIP[®], was not completed in the actual source selection. The agency surmised that limited application of the methodology would minimize industry confusion over an unfamiliar evaluation methodology, but would allow for early testing of the concept. This case was a first-off trial, and this research calls for agencies to consider future and full application of the QIP[®] methodology.

TABLE 4. CASE STUDY TRADE-OFF EVALUATION			
Rating Factor	Offeror X	Offeror Y	Offeror Z*
Price (CLIN 0001)	1 of 3	3 of 3	2 of 3
Price Variance from Low	0%	37%	28%
Price (CLIN 0002)	1 of 3	2 of 3	3 of 3
Price Variance from Low	0%	14%	25%
Nonprice (cPQR) CLIN 0001	3 of 3	2 of 3	1 of 3
Nonprice (cPQR) CLIN 0002	2 of 3	3 of 3	1 of 3
*Awarded offeror			

Results

Although no evaluated price calculations were made during the actual source selection using QIP[®], the scaling methodology was maintained to allow the researcher to take actual source selection data and run the scenario utilizing the full QIP[®] scoring concept to identify strengths and weaknesses in the concept post hoc so as not to affect the actual award decision. In this application, the researcher applied a cPQR created by using the program management plan and the staffing quality criteria similar to Table 1, yet heavily customized for each type of service being procured. The weightings of the plan versus staffing quality are source selection-sensitive, but offerors were told which held the greatest importance to aid in proposal development.

Quality trade-offs in a trial service contract source selection resulted in useful measures of service quality, cooperative industry participation, fewer and higher quality proposals (i.e., less risk of adverse selection and greater efficiency), and a different contractor selection than a typical subjective price-performance trade-off. The effectiveness of this QIP[®] methodology

must be supported by scaling that considers relative price variations in the market. Had QIP[®] been applied to the actual source selection, the lowest quality offeror having the lowest evaluated price may have been selected because the quality scaling was not sufficient to overcome the wide variation in pricing. Discussions would have been necessary to determine the reasonableness of the lowest offeror's pricing to reduce the risk of "buying-in." These discussions would have been completed prior to applying the QIP[®] to ensure that the final results were accurate.

When applying QIP[®], the test case shows that the selected offeror becomes more competitive in terms of evaluated price, relative to the low, based on evaluated quality, and does in fact, displace the second lowest offeror from the non-QIP[®] evaluation (Table 5). Thus, the QIP[®] methodology demonstrates the ability to drive value for money into an evaluation and to create source selection results that more closely align to traditional, yet more subjective, full trade-off methods in a rapid manner that is more transparent and easier to use.

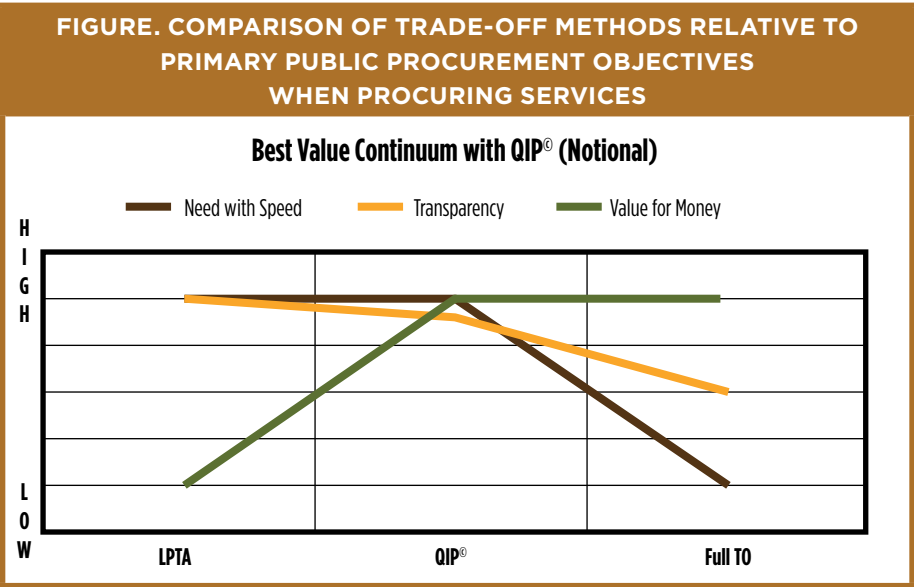
TABLE 5. CASE STUDY QIP [®] -ADJUSTED TRADE-OFF EVALUATION			
Rating Factor (After QIP [®])	Offeror X**	Offeror Y	Offeror Z*
QIP [®] (CLIN 0001)	1 of 3	3 of 3	2 of 3
Price Variance from Low	0%	33% ↓	16% ↓
QIP [®] (CLIN 0002)	1 of 3	3 of 3 ↓	2 of 3 ↑
Price Variance from Low	0%	17% ↑	12% ↓

*Awarded offeror
**QIP[®] best-value offeror

To validate results, a questionnaire was sent to all quality team evaluators postaward (Appendix B). The responses indicated that all evaluators found the cPQR methodology easy to use, easy to understand, asked the right types of questions, and resulted in the best value to the government. The only area listed for cPQR improvement related to requiring the evaluation team to have earlier and more robust input into the relative importance weighting of cPQR categories. The ease of use and ability for lesser trained personnel to administer this methodology show significant promise in reducing the risk to poorly executed, best-value trade-off evaluations that can occur due to less experienced evaluators (Watson, 2015).

Discussion

The Figure demonstrates that while LPTA provides for a faster PALT and is relatively transparent, it sacrifices value for money in service acquisitions. While full trade-off has the capability to maximize value for money, it may reduce transparency if evaluations become too complex, and most assuredly will sacrifice speed of the service acquisition. QIP®, as proposed, would provide a means for monetizing trade-offs. Monetizing trade-offs prevents pre-award questions related to full trade-off ambiguity as well as post-award delays due to protest. The QIP® provides for faster acquisition of needs, with a clearer evaluation methodology and trade-offs that increase both value for money and transparency.



The use of QIP® has the potential to improve or eliminate major gaps found in the current best-value source selection process (Watson, 2015) for services. QIP® provides the following:

- Monetized trade-offs (Transparency)
- Ability to pay more for service quality when prudent (Value for Money)
- Clear communication of federal agency priorities in price and nonprice factors to offerors (Transparency)

- May help to correct for wide price disparities in previously negotiated multiple-award contracts (i.e., when the low would otherwise always win if LPTA were the only option to full trade-off) (Value for Money)
- Rapid evaluation and acquisition capability (Meeting Requirements/Need with Speed)
- Clear evaluation criteria that reduce protest risk (Transparency)

In addition, the QIP[®] cSVI component, as a crowd-sourced form of past performance, has several advantages:

- Encourages higher compliance rates for past performance reporting by providing a clear, easy-to-use format with more resemblance of commercial, crowd-sourced contractor performance reporting
- Fills past-performance assessment repository gaps
- Promotes rapid evaluation and acquisition capability (could replace the entire past performance volume requirement in proposals)
- Encourages better life-cycle performance with contractors (i.e., contractors with lower cSVIs will have price advantages and can offer higher quality services assuming a better QIP[®], while higher cSVI contractors will have to be more aggressive in pricing in the near-term and improve quality in the long-term to keep market share and realize higher future returns)
- Encourages pricing off-sets for performance issues
- Creates clear discriminators for services based on customer ratings (subjective customer quality is a truer way to assess the intangibility inherent in service performance)
- Arms federal agencies with real-time market performance data
- Enables more accurate and more efficient supplier ranking (e.g., DoD superior supplier incentive program). More efficient rankings will enable rankings by type of service rather than be limited to the top 30 business units by dollars obligated annually (DoD, 2015).

Conclusions

A QIP[®] methodology using an established cSVI system shows great promise in progressing the state of the art in contractor performance management while finding a desirable midpoint along the best-value continuum. This research calls for federal agencies to consider adopting such a methodology to meet public procurement objectives. The QIP[®] and cSVI concepts may be seen as “lofty” or even naïve from a historical federal procurement policy vantage point. However, that vantage point is built upon a history of ill-fated service contractor rating systems that never meet the intent of federal agencies to improve transparency, value for money, and requirements satisfaction in highly efficient and effective means. The current CPARS has more focus on getting the reports completed versus the accuracy and value of the reports—particularly for its intended purpose of better informing future source selections. Understanding the higher level impacts of the system as it relates to transparency, value for money, and meeting agency requirements should be the ultimate goal of any contractor performance rating system as well as the source selection process it feeds.

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Critics may question the ability to adjust an offeror’s evaluated price based on subjective evaluation inputs. However, the government does this today with the concept of most probable price and cost evaluations to determine what the agency anticipates the actual cost or price of an offer will be considering all risks. Considering that service quality is a primary risk concern in a services acquisition, the concept of QIP[®] is not a radical idea. Others question the idea of crowd-sourcing something as sensitive as contractor performance for federal contract award decisions. This can be mitigated by controlling the “crowd” as we do today with CPARS. Agencies should ensure that only contracting officers, contracting officer technical representatives, and possibly program managers have access to the cSVI rating system.

Limitations and Future Research Directions

This study is not without limitations. First, it is a limited application of one case. Future research could expand the number and variety of cases of application. Future research employing a quasi-experiment could compare sourcing and performance (i.e., the full service life cycle) of multiple service procurements of the same type of service to examine differences in value and service quality. Further research should also explore the customization of dimensions of the business-to-business service quality measurement scale. Different types of services will likely be more validly measured by customized aspects of service quality. Additionally, since different services span a vast spectrum of scope and complexity, further research could explore whether the proposed QIP[®] methodology will be equally effective across the different types of services. In closing, this article serves as a call to agencies to pilot-test the QIP[®] concept.



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Appendix A

Comparison of Best-Value Source Selection Options Relative to Primary Public Procurement Objectives

Objective	LPTA	Full Trade-off	Rating Rationale
Transparency	High	Low	- LPTA typically defines evaluation criteria in a very clear and objective fashion. Protest risk is minimized if LPTA process is followed. - Full trade-off may allow for high levels of subjectivity at the factor and subfactor level, and runs the risk of being challenged both pre- and post-award.
Value for Money	Low	High	- LPTA clearly states the agencies' desire to pay less for a base requirement and no more. May drive "bare minimum" solutions from industry in an effort to remain competitive. High risk of "buying-in." - Full trade-off establishes areas of trade that are primarily quality- and performance-based; reduces the risk of post-award performance issues (GAO, 2014a).
Meeting Agency Requirements (Need with Speed)	Low	Medium	- LPTA tends to meet timelines and basic requirements. Can be risky if unknowns surface postsolicitation. - Full trade-off expends the greatest amount of time in order to minimize the risk of unknowns insofar as the evaluation criteria plans for it (i.e., assessing proposal risk). However, minimizing unknowns equates to unclear subjectivity that may increase protest risks.

Note. High = highest level relative to alternative; Med = essentially the same as the alternative; Low = lowest level relative to alternative.

Appendix B

Post-award cPQR Evaluator Questionnaire

1. How easy/hard did you find the criteria to understand?
2. Were the evaluation tools easy to use or hard to use?
3. Did we [the agency] ask the right questions in the evaluation or could we have done better?
4. Is there anything you would do to improve this evaluation method in the future?

Appendix C

Post-award cPQR Vendor Questionnaire

1. Was your decision to propose or “no bid” [actual term used within the ordering procedures of the base IDIQ] based on the cPQR methodology used?
2. What, if anything, did you change about your traditional proposal methods in order to meet the requirements of this request for proposal’s cPQR methodology?
3. Was the cPQR evaluation methodology easy to understand?
4. What, if anything, would you change about the cPQR evaluation methodology used?
5. Considering your experience, in the future would you be open to having your evaluated price* adjusted based on the score received using a similar evaluation methodology?
6. Did the cPQR methodology encourage your firm to focus more on price or nonprice (i.e., quality) factors in proposing?

**Note.* The price would be adjusted for evaluation purposes only. The final award price would be as proposed or negotiated with the [agency].

Appendix D

Findings and Lessons Learned

Finding	Lessons Learned
The cPQR primary factors and subfactor areas and questions were highly indicative of a quality proposal from the requiring agencies' point of view	Procuring agencies should develop cPQR satisfaction questions in tight coordination with the requiring activity. Standardized, valid cPQR measures customized to each type of service could evolve over time.
The scaling factor used ranged from 0.85 to 1.15, but was not indicative of the potential pricing variations across the service line-item disciplines being proposed, and was based more on what the procuring agency calculated were rational price variations in typical procurements.	Procuring agencies should develop the scaling factor ranges based on market research into the commercial market's typical price variation across each service type, and not assume what a "fair" scaling should be. Note: This confirmed the risk to utilizing QIP® price adjustments when the scaling has not been developed based on robust market data.
Industry did not question the unique quality evaluation methodology.	Draft request for proposal (RFP) documents were posted to the business opportunity Web site to gather questions from industry and ensure it understood the methodology prior to issuing a final RFP. Draft RFPs and industry engagement are key when introducing new evaluation methods.
Only roughly a third of contractors on the Multiple Award IDIQ proposed to provide these services to the agency. Most no-bid letters received by the agency stated an inability to source personnel who met the quality requirements of the RFP. Anecdotal comparisons of number of offers received on similar RFPs under this IDIQ showed that LPTA yielded higher response rates with lower quality offers.	The agency received offers from only those contractors who could meet the agencies' desired quality needs. The natural desire found in LPTA to "buy-in" was minimized. The risk of adverse selection was mitigated and the selection was more efficient.

Appendix D, Continued

Finding	Lessons Learned
The agency would have reached a different award decision had the QIP [®] been utilized versus leaving the final trade-off to a subjective comparison of cPQR scores versus prices offered.	Agencies must ensure they have robust data to support the cQAF primary categories and subcategory questions, and a solid understanding of the scaling of each rated area and the associated weights to create meaningful discrimination between offers within a service type. Further, the use of cSVI would have had additional effects on the final scoring and should be considered in all future QIP [®] source selections where past performance is being evaluated.

Biographies



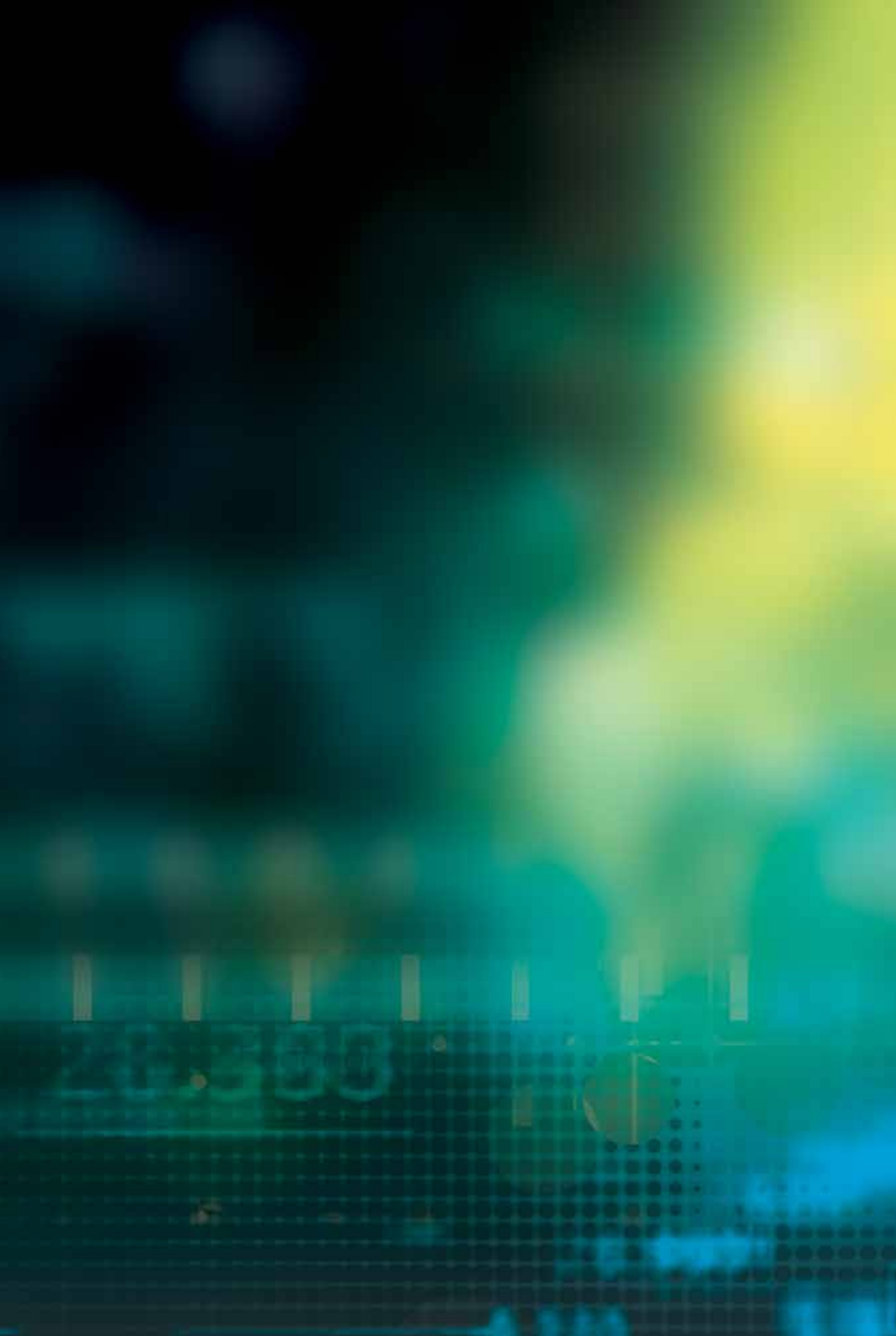
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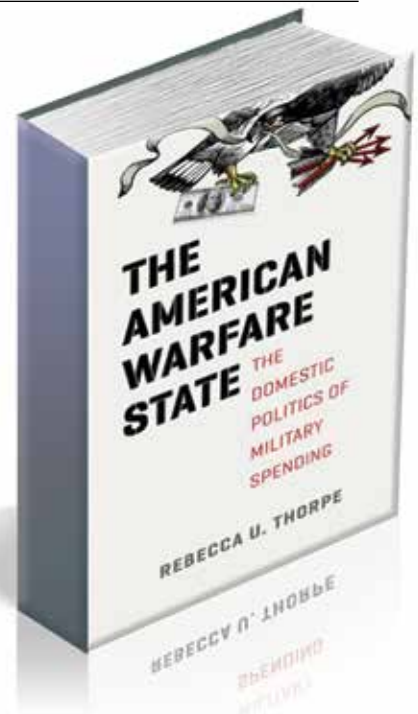
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Reviewed by: Professor Trevor Taylor, Cranfield University, Defence Academy of the United Kingdom



Review:

Most observers would recognize that the size and shape of the U.S. defense budget is determined by more factors than the perceived threats to U.S. security and the endorsed strategy to manage them. This important book focuses largely on one consideration: the concern of members of Congress with defense-related employment in their constituencies.

The broad propositions of the work are that during World War II, defense production became more central to the U.S. economy and moved into new regions. Not least among these were rural areas with few economic opportunities. After 1945, there was a failure to cut defense spending on a significant scale, and more areas became structurally dependent on defense-related jobs. With defense contractors increasingly aware that congressional representatives support programs that bring jobs to their districts, subcontracting on major programs has been spread farther across the country. The resultant wider constitutional consequences are that Congress has largely given up its constitutional role as a second center of decision making regarding the size of the defense budget and whether the United States should commit to the use of military force.

The author has researched diligently in search of statistical correlations to support her arguments, particularly regarding voting patterns and the geographical dispersion of subcontracts. She has assembled a significant evidence base showing that “the shared threat of economic hardship affects legislative voting on targeted and generalized weapons spending” (p. 106).

Although the following points are not made by the author, U.S. defense contracting appears to have some parallels with the “*juste retour*” principle, whereby the proportion of contracts under a particular program awarded to firms from a given country is in proportion to the funding that country has contributed to the program. This principle tends to operate on collaborative weapons programs in Europe and even with offset demands made by many arms purchasing states. Legislators in many states prefer to see the pain of defense procurement spending reduced by ensuring such expenditures generate as much local economic benefit as possible.

The work is not without flaws: in particular, the ongoing sequestration experience is not analyzed and the author does not venture into big questions that the book’s core arguments will suggest to some readers. Is the division of powers advocated by Founding Father James Madison appropriate in the modern age when speed of decision or credibility of commitment may be of greater importance? How serious was the Soviet/Communist threat

after 1945 that gave public justification for the continued defense effort? Is it an inevitable feature of the capitalist system in the United States that some rural areas will remain underdeveloped compared with other areas of the country? Linked to all this is that the book is short on prescriptions for improving the situation, and there is no discussion of the defense industrial “conversion” efforts that occurred in Europe and elsewhere after 1990. Instead, the book is focused on building, in a terse style, a few significant arguments and effectively reinforces the broad point that defense acquisition is as much about politics as it is about management techniques.

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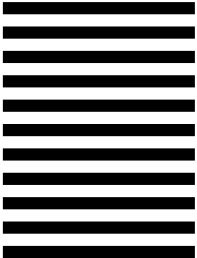
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