Acquisition Research Program | Faculty and Researchers' Publications

2014-07

Summary of the Value Assurance Framework

Gunderson, Christopher R.

Monterey, California. Naval Postgraduate School

https://hdl.handle.net/10945/43272

NPS-IS-14-004

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

Summary of the Value Assurance Framework (VAF)

by

C.R. Gunderson

July 2014

Approved for public released; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE	*Form Approved* OMB No. 0704-0188

1. REPORT DATE ***(DD-MM-YYYY)*** 02-07-14	**2. REPORT TYPE** Technical Report	**3. DATES COVERED** ***(From-To)*** 1 Oct 13 – 30 Sept 14
4. TITLE AND SUBTITLE Summary of the Value Assurance Framework		**5a. CONTRACT NUMBER** HHM402-13-1184 **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR Christopher R. Gunderson		**5d. PROJECT NUMBER** RFGK4 **5e. TASK NUMBER** **5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES) Christopher R. Gunderson Department of Information Science Naval Postgraduate School Monterey CA 93943		**8. PERFORMING ORGANIZATION REPORT NUMBER** NPS-IS-14-004
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) John Snevely Office of the Undersecretary of Defense for Intelligence 1400 Defense Pentagon Washington, DC 20301		**10. SPONSOR/MONITOR'S ACRONYM(S)** OUSD(I) **11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
VAF addresses the globally high failure rate for open Enterprise Information Systems. VAF is based on demonstrated success. Value is modeled as [utility-per-cost] x 1/[development time]. "Utility" means "ability to satisfy requirements." Requirements are expressed as testable MoP for systems and processes, and MoE for operational execution. The exponential improvement in microprocessor utility-per-cost predicted by Moore's Law is a self-fulfilling prophecy. Competitive pressure assures the same improvement is reflected in various COTS EIS, e.g. entertainment systems. This discipline can help EIS integrators more generally. IT evolves rapidly, making risks difficult to predict and control. VAF suggests hedging against EIS risks per financial management. VAF suggests also abstracting the traditional systems engineering tools for controlling risk. Contracts should align with VAF.

15. SUBJECT TERMS
Agile acquisition, systems engineering, open system approach, agile project management, OSA, service oriented architecture, net-, netcentric, network centric, information centric, enterprise information system, agile

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			C.R. Gunderson
Unclassified	Unclassified	Unclassified	UU	28	**19b. TELEPHONE NUMBER** ***(include area code)*** 831 224 5182

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

THIS PAGE INTENTIONALLY LEFT BLANK

NAVAL POSTGRADUATE SCHOOL
Monterey, California 93943-5000

Ronald A. Route
President

Douglas A. Hensler
Provost

The report entitled *"Summary of the Value Assurance Framework"* was prepared for The Office of the Undersecretary of Defense for Intelligence (OUSD(I)) and funded by OUSD(I).

Further distribution of all or part of this report is authorized.

This report was prepared by:

C.R. Gunderson
Research Associate of Information Science

Reviewed by:

Dan Boger, Chairman
Information Sciences Department

Released by:

Jeffrey D. Paduan
Dean of Research

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

VAF addresses the globally high failure rate for open Enterprise Information Systems. VAF is based on demonstrated success. Value is modeled as [utility-per-cost] x 1/[development time]. “Utility” means “ability to satisfy requirements.” Requirements are expressed as testable MoP for systems and processes, and MoE for operational execution. The exponential improvement in microprocessor utility-per-cost predicted by Moore’s Law is a self-fulfilling prophecy. Competitive pressure assures the same improvement is reflected in various COTS EIS, e.g. entertainment systems. This discipline can help EIS integrators more generally. IT evolves rapidly, making risks difficult to predict and control. VAF suggests hedging against EIS risks per financial management. VAF suggests also abstracting the traditional systems engineering tools for controlling risk. Contracts should align with VAF.

THIS PAGE INTENTIONALLY LEFT BLANK

Table of Contents

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

VAF addresses the globally high failure rate for open Enterprise Information Systems. VAF is based on demonstrated success. Value is modeled as [utility-per-cost] x 1/[development time]. "Utility" means "ability to satisfy requirements." Requirements are expressed as testable MoP for systems and processes, and MoE for operational execution. The exponential improvement in microprocessor utility-per-cost predicted by Moore's Law is a self-fulfilling prophecy. Competitive pressure assures the same improvement is reflected in various COTS EIS, e.g. entertainment systems. This discipline can help EIS integrators more generally. IT evolves rapidly, making risks difficult to predict and control. VAF suggests hedging against EIS risks per financial management. VAF suggests also abstracting the traditional systems engineering tools for controlling risk. Contracts should align with VAF.

THIS PAGE INTENTIONALLY LEFT BLANK

VALUE FOCUS

Projects that aim to engineer large distributed EIS fail at an alarming rate, at lest 40% depending on which report you read. (Standish Group International, 2014) This is especially true of government EIS projects. (Powner, 2014) There is consensus among the Information Technology (IT) technical community that the general immaturity of software engineering as a discipline contributes to this issue. According to many watchdog reports, government acquisition practices exacerbate the problem. The Value Assurance Framework (VAF) aims to mitigate both concerns. VAF is a collection of tools, models, and processes for designing, engineering, testing, certifying, and continuously and rapidly evolving large, distributed, software intensive open Enterprise Information System(s) (EIS.) In this sense "open" means that the EIS supports an enterprise whose membership is highly evolutionary, and whose members are not centrally governed or funded. "Open" also means that the EIS capabilities are composed of utilities that are usefully connected via open standard interfaces. VAF aims to iteratively improve the global success-to-failure rates for EIS projects in general, and US governmental EIS projects in particular.

Study of successful and unsuccessful application of architecture, engineering, and procurement of EIS informs VAF. So does study of study of other information-intensive domains, especially financial management. The evidence clearly suggests that defining and providing tangible value-based incentives for all stakeholders is a universal pattern of success for managing and executing complex projects.

"Value" is the perceived worth of a delivered article or service. In a value-based approach, the objective of each project stakeholder is to first assure that measurable value is indeed delivered, and then to maximize the difference between cost, in terms of time, effort, opportunity or money, and the value returned. In other words, the objective is to optimize a "value-delivery-chain." (Porter, 1985)

In the studied success cases, all stakeholders, including members of the supported operational community, participate in the continuous evolution of the value-delivery-chain. Further, the value-delivery-chain integrates back-end architectural, engineering, and procurement activities with front-end operational activities.

MODELING VALUE

The evidence indicates that this ostensibly economic value incentive argument does not depend on financial profit per se. Rather, financial profit is one of any number of possible Measures of Effectiveness (M_E) that depend on properly defining the enterprise value proposition, business model, and supporting value-delivery-chain Measures of

Figure 1: VAF is informed by a broad baseline of research, analysis, tools, and literature. VAF captures recurring best practices in reusable templates.

Performance (M_P).

In other words, profitability, high market share, strong earnings, etc. are only lag metrics for a well-executed value-delivery-chain. These metrics happen to be useful from the perspective of commercial stakeholders. Other value-chain-delivery lag metrics, useful from non-commercial perspectives, might be e.g. reduced criminal behavior, fewer friendly casualties, more neutralized adversaries, or more running water in a third world neighborhood.

VAF defines the architectural, engineering, and procurement parameters of an information-value-delivery-chain. VAF provides design-time, build-time, and run-time tools and methods to plan, assess, and evolve EIS according to carefully defined measures or models of value. VAF asserts that Value is equivalent to Return-on-Investment (RoI). [Value = RoI] is a function of utility, cost, and time. Namely *[Value] is equal to [utility/cost] X [1/time]*. Utility is equivalent to the ability to satisfy requirements, and is measured in the same units as M_P and/or M_E. Cost refers to monetary expenditures across system or component lifecycle. Time is calendar time associated with both fielding new capability, and the perishability of the value of any existing generation of technology.

The traditional systems engineering process identifies M_E that objectively, and testably, describe the outcomes that the system under development seeks to enable. Having identified M_E, systems engineers traditionally identify process-level and system-level performance characteristics that will hypothetically enable the intended outcomes. They assign objective and testable system-level and process-level M_P accordingly.

In this sense, the objective of the systems engineering process is to prove the hypothesis "if we achieve targeted M_P (lead metrics), then we will achieve targeted M_E (lag metrics.) " (INCOSE, 2011) Since M_E describe value delivered, the extent to which this hypothesis proves true, is the extent to which the systems engineering process contributes to a value-delivery-chain. An issue is that the correlation between generic system-level performance improvement and operational-level outcomes is often simply assumed. Further, traditional systems performance metrics and threshold values are often re-applied without thought to the specific outcomes in mind. Arguably, in traditional engineering projects, legacy metrics have proven their worth. In the case of large, open EIS, that is certainly not the case.

Accordingly VAF requires mathematical validation that M_P and M_E are positively correlated. In other words, VAF carefully and objectively tests whether an investment made to improve a system or process actually returns measurably better operational outcomes. The outcome of that test is the basis of awarding contract incentives or penalties.

VAF metrics address cost, performance, and schedule. Measures for "cost" capture lifecycle costs, demonstration of cost avoidance by reuse, and investment in collaborative activities that extend beyond typical project lifelines. Collaborative activities include collecting operator feedback, bundling off-the-shelf components, and leveraging the work of other projects. Measures for "schedule" capture parallelism in developing of EIS components and performing test and certification, and allocation of time and resources for critical collaborative activities. Lead measures for performance quantify concepts like "open," "interoperable," and "scalable." Lag metrics define desired outcomes like better mission readiness, fewer casualties sustained, and more targets neutralized.

For example, VAF considers Information Assurance (IA) in terms of M_P. In that sense, IA is only useful if it is objectively defined and testable, and measurably contributes to RoI. Accordingly, if IA measurably improves, then targeted operational outcomes such as probability of detection, casualties, probability of interdiction, operational readiness, etc. must also measurably improve. Further, the cost and time it takes to develop and certify IA solutions must decrease. Note that an IA strategy that uses expensive, proprietary technology to lock down networked information and resources is not likely to pass these tests. Therefore "more tightly locked down" does not equal "improved" IA. Rather, VAF asserts that improving IA requires explicitly assuring that optimized need-to-protect and need-to-share utilities exist, are affordable, testable, and reciprocally certified.

MOORE'S LAW AS A VALUE BENCHMARK

The utility-per-cost of virtually any mainstream technology tends to increase exponentially as the manufacturing process improves. (Nagy B, 2013) Moore's law is a recent example of this tendency. Accordingly, Moore's Law remains remarkably accurate even as microchip design and manufacturing has become orders of magnitude more complex. This true largely because Moore's Law has become a self-profiling prophesy. That is, the microprocessor industry has turned Moore's Law into a do-or-die competitive objective.

VAF hypothesizes that the *potential utility* of any information system is proportional to the information processing power resident on the network. Microchips are the fundamental unit of processing power. The utility of a given IT artifact, e.g. image resolution, data processing rates, algorithm execution time, etc., depends on availability of processing power. Accordingly, *Potential EIS Utility* – i.e. an abstraction of the combined utility of all the distributed components of a particular EIS -- is proportional to the information processing power represented by Moore's Law. Commercial off the Shelf information systems for home entertainment, travel services, retail purchase, finance, etc. indeed improve exponentially in step with Moore's Law, without increasing in cost. (Kurzweil, 2006)

VAF hypothesizes that a broader community of open EIS integrators can also achieve predictable exponential improvement. To do that, they must likewise embrace the discipline required to assure continuous improvement in the utility-per-cost metric. Accordingly VAF introduces the universal requirement that *M_P and M_E for EIS must be mathematically coupled to Moore's Law.* In other words, as computational power increases exponentially, and associated verified EIS component performance increases exponentially, validated EIS operational outcomes must also improve exponentially.

VAF test strategies and plans focus on the twin requirements that M_P must be positively correlated with Moore's Law, and that M_P and M_E must be positively correlated with each other. For example, an open EIS design might hypothesize that the M_E "Probability of Detection" (P_D) depends on M_P such as camera resolution (R), field-of-view (V), and efficiency-of-detection-algorithm (A). VAF would test to verify that [R] and [V] and [A] improved according to threshold exponential improvement rate. VAF would also test to validate whether the improvements resulted in the threshold exponential improvement in [P_D]. VAF contract incentives and penalties would reward or punish the outcomes appropriately.

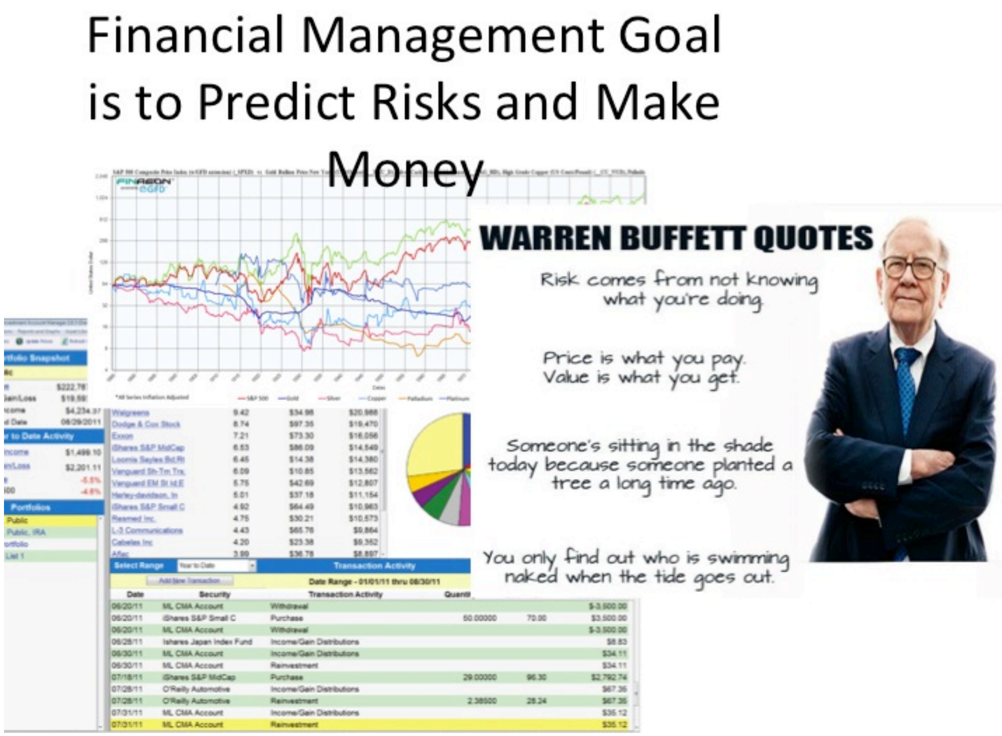

Figure 2: IT is evolving so quickly and unpredictably that it makes sense to manage risks like the most successful financial portfolio mangers. VAF maps traditional acquisition artifacts and processes to the investment portfolio metaphor.

HEDGING BETS TO ASSURE VALUE

Engineering success requires understanding the project risk factors, and the uncertainty associated with these factors. Significantly, the globally high EIS failure rate contrasts with the relatively high global success rate for well-run traditional engineering projects like building bridges or automobiles. In other words, EIS risks are relatively difficult to predict and manage compared to the highly predicable risks associated with traditional engineering projects. Methods for managing risks include controlling risk factors, and/or hedging against risk factors. Traditional engineering best practices tend to control risk

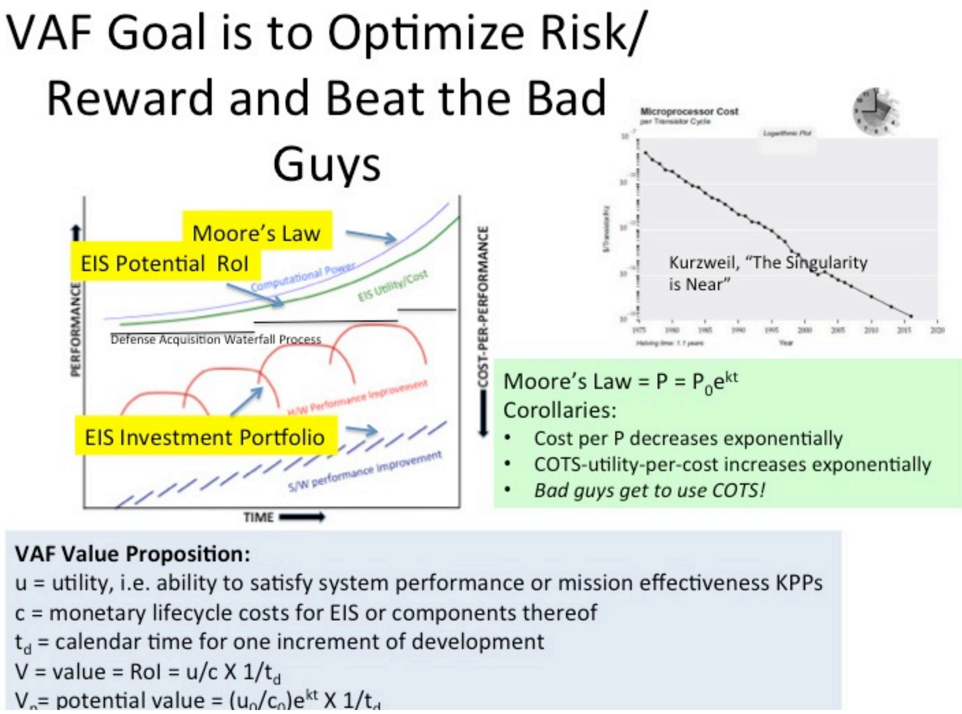

Figure 3: Moore's Law is analogous to the NASDAQ index in that it represents an RoI baseline. The PM's job is assure that RoI, i.e. (utility-per-cost) (per-time-spent-fielding-the-technology) keeps up with Moore's Law prediction.

factors. For example, verifying that tried and true building code is implemented assures that the building won't fall down. Domains where risks are too unpredictable to control, like the financial sector, call for hedging against risk factors. "Balancing" an investment portfolio is equivalent to hedging against the risk that any particular investment will bust.

The ongoing evolution of Information Technology (IT), and associated integration processes, is extremely rapid, and entrepreneurial -- much more so than that of traditional technologies and integration processes. This rapid evolution, therefore, introduces non-traditional risks. Therefore, EIS developers also need a risk management strategy for hedging risks that is much more entrepreneurial than traditional approaches.

Arguably, these rapidly evolving, entrepreneurial risks to EIS are more similar to those associated with financial portfolio management than to traditional engineering.

Accordingly VAF applies lessons learned in the financial sector to mathematically model risks and rewards appropriate for EIS. (Gunderson C. R., 2014)

In this construct Moore's Law represents a baseline analogous to the financial market indices such as the NASDAQ. Traditional engineering and acquisition artifacts all lend themselves to this financial metaphor. *Work Breakdown Structure (WBS)* represents investment in a portfolio of potentially lucrative ventures such as obtaining customer feedback, performing market surveys, collaborating with similar projects, developing or adapting independent capability components, bundling existing capabilities, testing, certifying, etc. *Validation and Verification (V&V)* against expected RoI per Moore's Law, is the method to assess whether an EIS portfolio has accrued or lost value. The *Test and Evaluation Master Plan (TEMP)* organizes these V&V-based value assessments. The EIS *Integrated Master Schedule (IMS)* parallelizes and aligns independent and collaborative project activity across the investment portfolio. VAF EIS Quarterly *Milestone Reviews* include metaphorical "stockholder reports." *Exit criteria* for quarterly reviews includes shedding non-performing aspects of the EIS portfolio; making new investments; and/or increasing investments that have shown good RoI to date.

AVAILABILITY OF VALUE

To control risks, traditional engineering best practices include employing design frameworks based on enduring standard methodologies and materials. For example, architects apply well-established construction standards to design buildings that won't fall down. The evolution of pipe-making technology from copper to PVC did not change the fundamental plumbing standards for pipe dimensions and performance. The rapid evolution of IT precludes establishing enduring design frameworks in the traditional sense. Modern, software intensive, many-to-many networked EIS function at levels of abstraction that are much higher than that of traditional point-to-point information systems. Therefore open EIS design frameworks should be more abstract. This higher level of abstraction introduces non-traditional risks. VAF aims to improving the predicable level of success of EIS projects by providing a more abstract design construct.

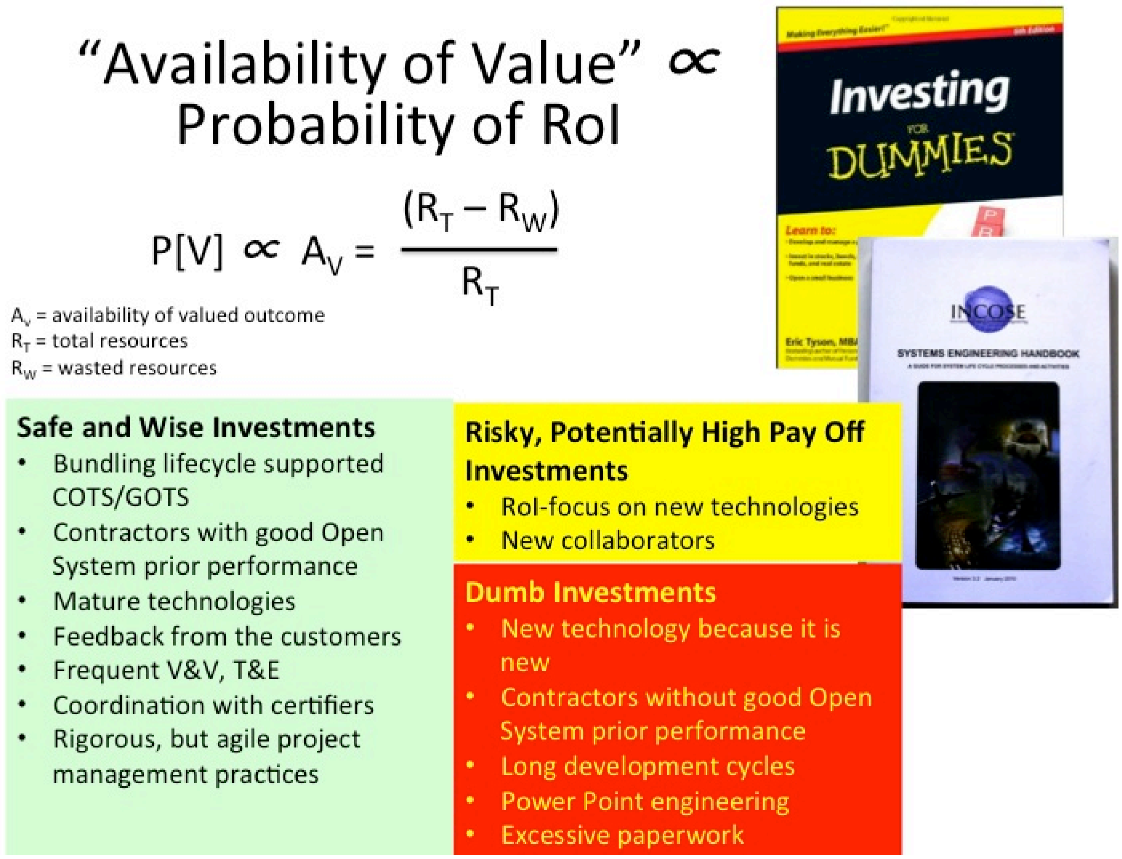

Figure 4: In traditional engineering "Availability" is the MoP that predicts how likely it is that a system will function properly. VAF abstracts the concept of availability as appropriate for EIS systems and processes.

One VAF abstraction addresses Reliability, Availability, and Maintainability (RAM.) (Gunderson, 2014)Engineers have typically used RAM models to assure the success of enterprise systems across their lifecycles. RAM models roll a system's reliability, e.g. Mean Time Between Failure (MTBF), and maintainability, e.g. Mean Time to Repair (MTR), into an M_P called Operational Availability (A_O). A_O is expressed as a ratio that compares the time the system is operating correctly to the total time the system is deployed. In that sense, A_O is equivalent to the likelihood that the system will function usefully. So generally, [A_O] equals [Useful Time] divided by [Total Time]; which equals [Probability that the System will Function Properly]; which equals [Mean Time Between Failure] divided by [[Mean Time Between Failure] plus [Mean Time to Repair]].

VAF applies the RAM concept by defining "Availability" generally as [[Total Expended Resources] minus [Wasted Expended Resources]] divided by [Total Resources]; or equivalently as [Usefully Expended Resources] divided by [Total Expended Resources]. In this sense, VAF applies several availability measures appropriately abstracted for application to EIS.

Availability of Acquisition Efficiency (A_e) is a VAF process-level M_P. Acquisition efficiency means optimizing the utility –per-cost delivered within the period of interest.

Calculating A_e first requires identifying a scheduled development time increment (t_d). Scheduled t_d must be short enough to allow fielding the new capability within its Moore's Law-based value-perishability window. Getting "credit" for accomplishing scheduled activity requires achieving V&V-based exit criteria. A "departure from schedule" is a measure of the time sub optimized due to failure to achieve exit criteria. Given these boundary conditions, [t_d] equals [Time Originally Scheduled to Develop, Test, Certify, and Deliver an Increment of Capability]. Given this definition of t_d, then [A_e] equals [[t_d] minus [Departures from Original Schedule]] divided by [t_d]. If no capability is delivered within the short development increment represented by t_d, then [A_e] is equal to zero. As more successfully verified and validated capability is bundled into the delivery drop, A_e approaches 1.0000. Accordingly, achieving threshold M_P for A_e requires parallelizing development with test and certification; spending quality time with customers; high quality analysis of alternatives; reducing paper work; bundling existing mature technologies rather than chasing new ones; etc.

"Availability of Information Value" (A_{IV}) is a VAF measure of EIS operational efficiency. Operational efficiency means optimizing the utility of the information processed in run time. Calculating A_{IV} requires defining the decision makers' Critical Conditions of Interest (CCI) and associated threshold values associated with M_E associated with targeted use cases. CCI are the specific information parameters associated with establishing or changing a Course of action (COA). Threshold values are the upper and lower limits on CCI that drive selection of one COA over another. When thresholds are crossed, COA should change. Searching through large volumes of data looking for relevant information is not efficient. Receiving concise notifications of CCI threshold crossings is efficient. Given this logic, [A_{IV}] equals [Critical bits of Information Processed] divided by [Total bits Processed].

"Availability of Information Assurance" (A_{IA}) is a VAF M_P for assuring an optimal balance between need-to-protect and need-to-share networked data and other resources. "Optimal balance" means that the risks and rewards of sharing are defined objectively, and in the same time-sensitive decision context. "Critical resources" are information elements or utilities that, if shared within some important use case, would improve the probability of achieving targeted M_E. A "sharable critical resource" is governed by an existing, dynamic, need-to-share policy, and is dynamically deliverable via an existing sharing utility. Given those boundary conditions, [A_{IA}] equals [Sharable Critical Resources] divided by [[Sharable Critical Resources] + [Critical Resources that Can't be Shared]]. Meeting threshold values of M_P requires developing and dynamically applying assured need-to-share polices and services. It also requires achieving reciprocal C&A agreements for this approach across all relevant Designated Approval Authorities.

CONTRACTING TO ASSURE VALUE

Open system development is fundamentally different than traditional waterfall development. Government PMs are especially less likely to be trained in appropriate open system acquisition practices. Likewise, government contractors are typically not expert in open system development. Therefore, in addition to value-based architecting and engineering, VAF includes tools for value-based contracting for open EIS.

The overarching VAF contracting strategy is based on the fundamental truths that "you get what you measure" and "you get what you pay for." VAF asserts that enterprises should write contracts that measure and pay for [[Value] equals [Utility-per-Cost] divided by [Time it Takes to Deliver Utility]]. Accordingly VAF solicitation, source selection, and contract incentives are based on objective V&V as described above. That is, vendors must use VAF tools to verify that their lifecycle system and process performance is consistent with the contractually mandated exponential improvement predicted by Moore's Law. Integrators must then apply VAF tools to validate that verified exponential system and process improvements lead to exponential improvement in targeted mission outcomes, i.e. RoI.

As with architecting and engineering, VAF suggests adapting existing contracting tools and best practices, rather than inventing new ones out of whole cloth, whenever possible. With that in mind, VAF suggests using the Acquisition.Gov Seven Steps to Performance Based Acquisition (PBA) as a means to build value assurance into contract artifacts. (Acquisition.Gov, 2009) Indeed, the Seven Steps provide superb guidance as to how to frame a performance-based acquisition. VAF complements the Seven Steps by providing more specific implementation tools appropriate for Open EIS., and equating "performance" with "assuring value, i.e. RoI" in the case of Open EIS.

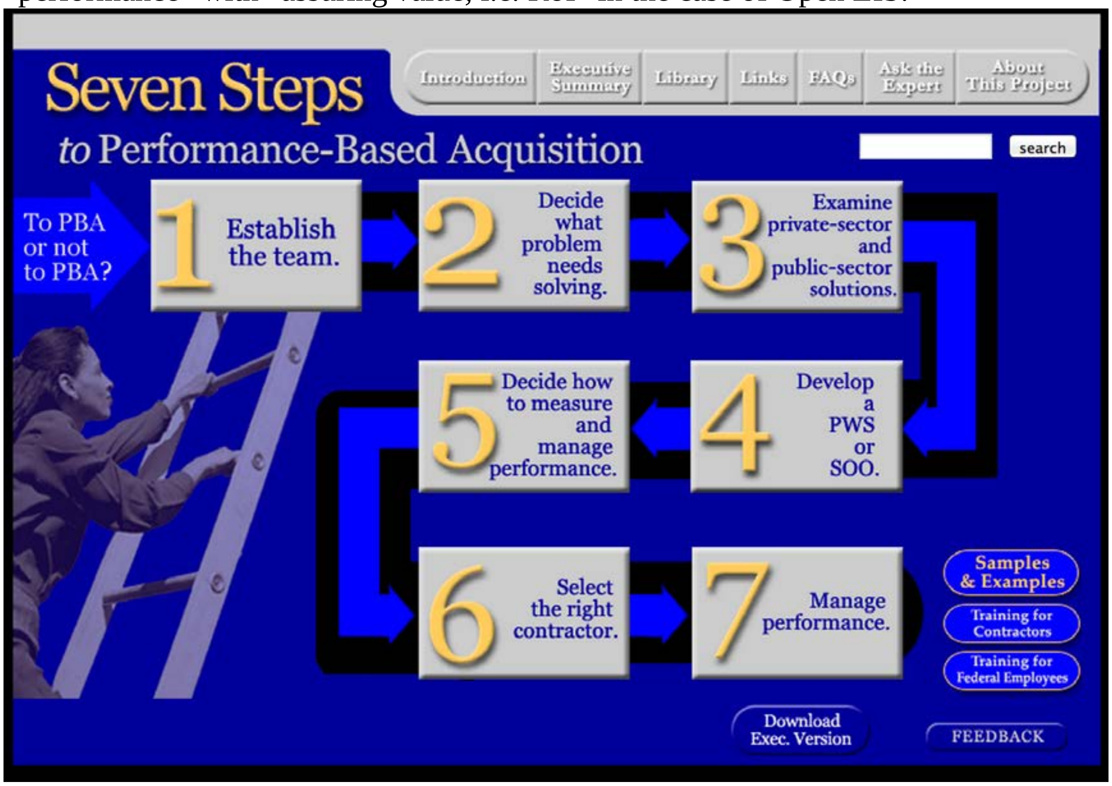

Figure 5: Acquisition.Gov provides tools for Performance Based Contracting that are consistent with VAF.

Consistent with the Seven Steps to PBA, the Defense Acquisition University (DAU) suggests developing a government a Systems Engineering Plan (SEP) and including it as part of the solicitation. (DASD Systems Engineering , 2011)According to DAU, a SEP helps "…Program Managers develop, communicate, and manage the overall systems engineering (SE) approach that guides all technical activities of the program. A SEP documents key technical risks, processes, resources, metrics, SE products, and completed and scheduled SE activities…the Government SEP should accompany the request for proposal (RFP) as guidance to the offerors…" Accordingly, the SEP should explain boundary conditions such as requirements, any mandated standards, enforceable policies, budgets, risk management strategies, timelines, and especially specially targeted outcomes in explicit, objective, engineering terms. The SEP should scrupulously not constrain vendor innovation in the detail of execution! Clearly, VAF principles fit nicely into the standard SEP outline as explained by DAU. Therefore, a VAF-based SEP can inform contract source selection criteria that evaluate the offerors' credibility to assure EIS RoI.

Military Standard (MILSTD) 498 is a traditional tool used by government projects and others to frame contract deliverables for software-intensive projects. (DoD, 1994) It predates, but is consistent with various current commercial standards for program management and systems engineering. Since it efficiently addresses both disciplines simultaneously and complementarily, VAF recommends using it. MIL STD 498 provides tailorable templates called Data Item Descriptions (DID). These templates provide a basis to translate laymen's descriptions of requirements associated with software-intensive projects into clear technical descriptions of contract deliverables. The DID format is agnostic to the proposed technical method. Hence, VAF applies MILSTD 498 to tailor software-intensive Contract Data Requirements Lists (CDRL) according to value-based principles.

WORKS CITED

Acquisition.Gov. (2009). *Seven Steps to Performance-Based Acquisition*. Retrieved June 25, 2014, from http://www.acquisition.gov/comp/seven_steps/home.html

Amoroso, E. G. (2011). *Cyber Attacks: Protecting the National Infrastructure.* Burlington, MA, USA: Butterworth-Heinemann.

Christensen, C. M. (2003). *The Innovator's Dilemma: the rovolutionary national best seller that changed the way we do business.* New York, New York, USA: Harper Collins Publishers Inc.

DASD Systems Engineering . (2011). *Systems Engineering Plan Outline.* Secretary of Defense, Washington, DC.

DoD. (1994, Dec 5). Military Standard 498: Software Development and Documentation. *Mil-Std-498* . Washington, DC, USA: Department of Defense.

Gunderson. (2014). *Value Assurance Framework.* Naval Postgraduate School, Information Sciences. Monterey CA: Naval Postgraduate School.

Gunderson, C. R. (2014, June 5). Enterprise Information System (EIS) Value Assurance Framework (VAF) Risk-Reward Optimization . *Submitted to Journal of Enterprise Transformation* . Herndon, VA, USA.

Hopkins, R. a. (2008). *Eating the IT Elephant: From Brownfield to Greenfield Development.* International Business Machines Press.

INCOSE. (2011). *Systems Engineering Handbook.* San Diego, CA: International Council on Systems Engineering.

Kurzweil, R. (2006). *The Singularity is Near.* London, England, UK: Penguin Books.

Nagy B, F. J. (2013). Statistical Basis of Predicting Technological Progress. (N. U. Lis A. Nunes Amaral, Ed.) *PLOS One* (2).

Porter, M. E. (1985). *Competitive Advantage.* New York, New York, USA: The Free Press.

Powner, D. A. (2014). *Reform initiatives Can Help Improve Efficiency and Effectiveness.* Government Accounting Office, Information Technology Mangement Issues. Washington, DC: GAO.

Schaller, B. (1997). Moore's Law: The Benchmark of Progress in Semiconductor Electronics. *IEEE Spectrum , 34* (6), 53-59.

Standish Group International. (2014). *Big Bang Boom.* Standish Group International, Inc. Boston, MA: Standish Group.

Weatherall, J. O. (2013). *The Physics of Wallstreet: a brief history of predicting the unpredictable.* New York, New York, USA: Houghton Mifflin Harcourt Publishing Company.

Weatherall, J. (2014). *The Physics of Wall Street: A Brief History of Predicting the Unpredicable.* New York, New York, USA: First Mariner Books.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. Research Sponsored Programs Office, Code 41
   Naval Postgraduate School
   Monterey, CA 93943

4. ISR Programs
   Undersecretary of Defense for Intelligence
   Washington, DC