COST AS AN INDEPENDENT VARIABLE: *PRINCIPLES AND IMPLEMENTATION*

Col Michael A. Kaye, USAF, Lt Col Mark S. Sobota, USAF, David R. Graham, and Allen L. Gotwald

Cost as an independent variable is a key tool in the thrust to reduce total ownership cost for defense systems. While the need for CAIV is driven by cost constraints, success relies upon identification and use of viable performance, cost, schedule, and risk "trade space." The Air Force has integrated CAIV concepts with those in the Reduction in Total Ownership Program (R-TOC), and has published a comprehensive guidebook for better understanding.

The Defense System Affordability Council (DSAC) Strategic Plan established Goal 2 to lower the total ownership cost (TOC) of defense products. The plan further established separate, aggressive objectives under that goal for systems in acquisition and fielded systems. These goals are further emphasized in the draft new DoD 5000.1 and 2.

To provide a focal point on all reduction in TOC (R-TOC) efforts, encompassing weapon system, infrastructure, and indirect dimensions, the Air Force established an R-TOC program office (SAF/AQXT). SAF/AQXT and the authors collaborated to publish the R-TOC Guidebook, which integrated Cost as an Independent Variable (CAIV) and a comprehensive R-TOC process for fielded systems (1999). The R-TOC process relies on baselining operating and support costs, identifying TOC drivers, and identifying R-TOC opportunities. CAIV drives system design decisions by providing comprehensive information on alternatives and impacts.

Whereas CAIV and the R-TOC process have many principles in common, CAIV exerts the most leverage when it influences system design and the R-TOC process is most effective on fielded systems. The relationship is shown in Figure 1.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2000**	2. REPORT TYPE	3. DATES COVERED **00-00-2000 to 00-00-2000**

4. TITLE AND SUBTITLE **Cost as an Independent Variable: Principles and Implementation**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Space & Missile Systems Center,Acquisition Support Team,Los Angeles AFB,CA,90245**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

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

13. SUPPLEMENTARY NOTES
Acquisition Review Quarterly, Fall 2000

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**20**	

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

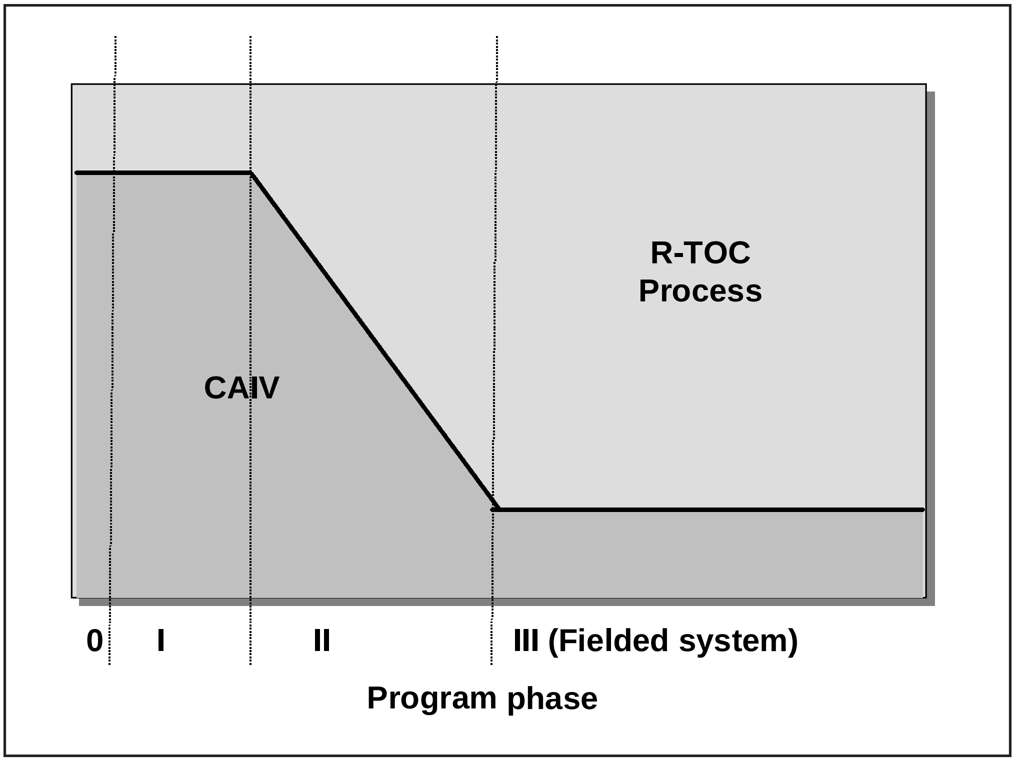


Figure 1. R-TOC/CAIV Effectiveness

CAIV Construct

CAIV is a key strategy for implementing R-TOC in the acquisition process, and is particularly effective during system development. Air Force Instruction (AFI) 10-601 (1998) defines CAIV as "the process of using better business practices, allowing trade space for industry to meet user requirements, and considering operations and maintenance costs early in requirements definition in order to procure systems smarter and more efficiently."

CAIV is founded upon two primary principles: First, system costs are constrained. Whereas some programs do obtain additional funding when needed, such funding is often at the expense of other programs or future modernization. Second, "trade space" is the foundation for smart decisions. Trade space is the range of alternatives available to decision makers. It is four-dimensional, comprising performance, cost (TOC), schedule, and risk impacts.

The Air Force established a set of tenets that are core to CAIV implementation. The concept of well-understood trade space is the capstone tenet that enables decisions critical to meeting user needs while reducing TOC. The remaining five tenets are the pillars that enable trade space to be defined and exploited. Figure 2, the CAIV model, depicts the relationship of the CAIV tenets.

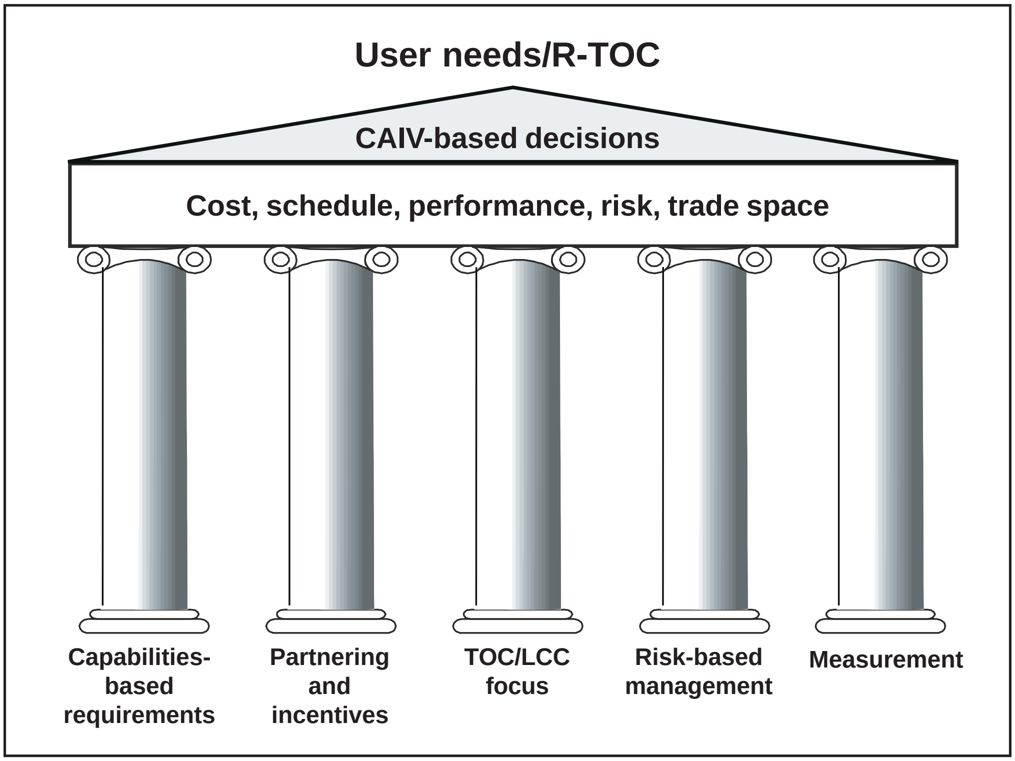


Figure 2. CAIV Model

TRADE SPACE

CAIV provides better support for critical decisions by identifying viable performance, schedule, cost (TOC), and risk trade space. Identification and use of viable trade space, or the range of alternatives, with full knowledge of real and potential impacts, is essential for making the right decisions to meet user needs while reducing TOC. CAIV employs a hierarchy of cost reduction opportunities and tradeoffs to meet aggressive cost targets, first looking to improve acquisition and sustainment efficiencies, then scrutinizing noncritical requirements. Tradeoffs of critical performance requirements are only to be addressed as a last resort, with the agreement of the Milestone Decision Authority and user.

Trade space is commonly defined by alternatives in terms of the performance, cost, and schedule impacts that each alternative presents. Risk must also be included in two ways. First, risk is a fourth dimension in the trade space, recognizing that critical decisions may be driven by the risks of certain alternatives. Second, risk actually "discounts" the anticipated performance, cost, and schedule options; in other words, it lessens the trade space to ensure a decision maker does not trade away something that may not be attainable. For example, assume you have a system with anticipated range of 2000 miles versus a requirements threshold of 1500 miles. You could trade away up to 500 miles of range for a fully tested, validated system and still meet threshold. However, you definitely would not trade away 500 miles of range at the beginning of program definition and risk reduction (PDRR), when there are potential weight growths, fuel consumption increases, etc.

Figure 3 portrays the cost-performance trade space for a key performance parameter (KPP), characterized by threshold and objective values. Note that Figure 3 shows a "risk reserve" line to depict the amount that the trade space is restricted, to prevent trading away what is not yet realized. The "solution set" line represents the optimum cost-performance combinations: Points in the shaded region are solutions, but for any given point, either more performance for the same cost or the same performance for less cost is possible.

The trade space is of course multidimensional, corresponding to the number of KPPs. Tradeoffs can be performed at many levels. In the example above, where a KPP is involved, the user must agree to the tradeoff. When a contractor has configuration control below the "A Spec," then the contractor can make tradeoff decisions as long as the A Spec is met. The key is that the decision maker must fully understand impacts on the other elements, especially cost (TOC), in the trade space.

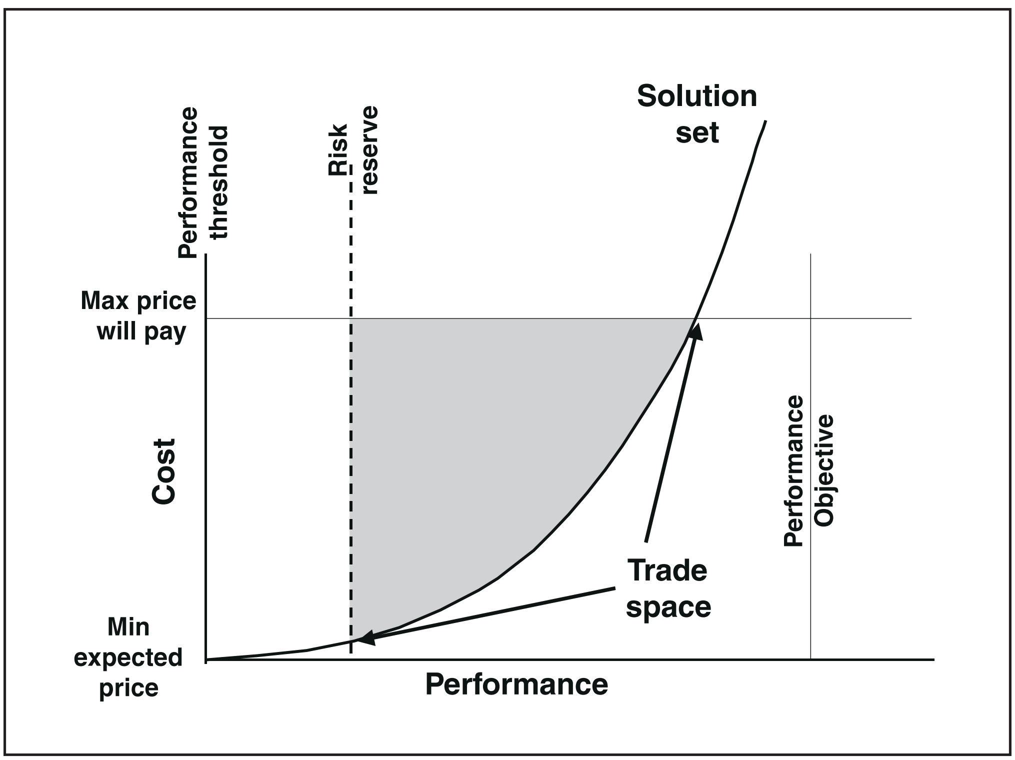


Figure 3. Cost-Performance Trade Space

CAPABILITIES-BASED REQUIREMENTS

CAIV relies upon capability-based requirements. Implementation requires the user to define capability-based requirements, stating what the system needs to do instead of how to build the system and how subsystem allocations are made. Such definition allows the system development team flexibility to define a best-value system meeting user requirements. This requires the development of operationally-oriented performance requirements with a minimum number of KPPs. Requirements-setting authorities must take special efforts to exclude requirements not directly contributing to user needs. Prioritizing requirements helps exclude nonessential requirements while helping system developers maximize use of the trade space by focusing on characteristics contributing most to mission accomplishment.

The requirements process specifies that system requirements be reviewed at each milestone and revised as needed. But system performance thresholds defined at Milestone I (MS I), prior to Phase I trade studies, may be difficult to change in later reviews. That is the most important reason for introducing the cost dimension into the requirements-setting process as early as possible. Beginning with realistic and feasible levels of requirements, within the best available measures of cost estimation, provides the ability to identify a realistic performance requirements baseline. Through CAIV trades, the program can take advantage of alternative approaches and designs to achieve higher levels of performance at the same or lower levels of cost as more information allows cost estimates to become more refined and accurate. Staying flexible in the finalization of requirements is important, as emphasized in the draft new DoD 5000.1 and (2000).

The operational requirements document (ORD) I should identify system characteristics and define threshold ranges required for user effectiveness and be treated as interim versus final. Warfighters and users use mission effectiveness and cost performance analyses as key parts of the analysis of alternatives (AoA). When the preferred approach is identified, users employ mission effectiveness analysis and CAIV principles to set initial weapon system requirements, based on the best insight available to TOC. As a result, ORD I should include TOC objectives.

"Warfighters and users use mission effectiveness and cost performance analyses as key parts of the analysis of alternatives (AoA)."

Phase I trade studies should provide requirements-setters sufficient insight to TOC/LCC impacts for them to set specific threshold levels that ensure both mission effectiveness and affordability. During Phase I, the weapon system IPT uses CAIV to define TOC impacts and conduct trade to refine requirements studies focused on design and sustainment. The derived data enables users. The IPT ensures a continued ability to meet baseline requirements while adapting to requirements evolutions that drive system modifications. Finalization of requirements from the ranges defined in ORD I should occur at this time. Both the Joint Strike Fighter (JFS) and Advanced Amphibious Assault Vehicle (AAAV) have employed this evolutionary approach.

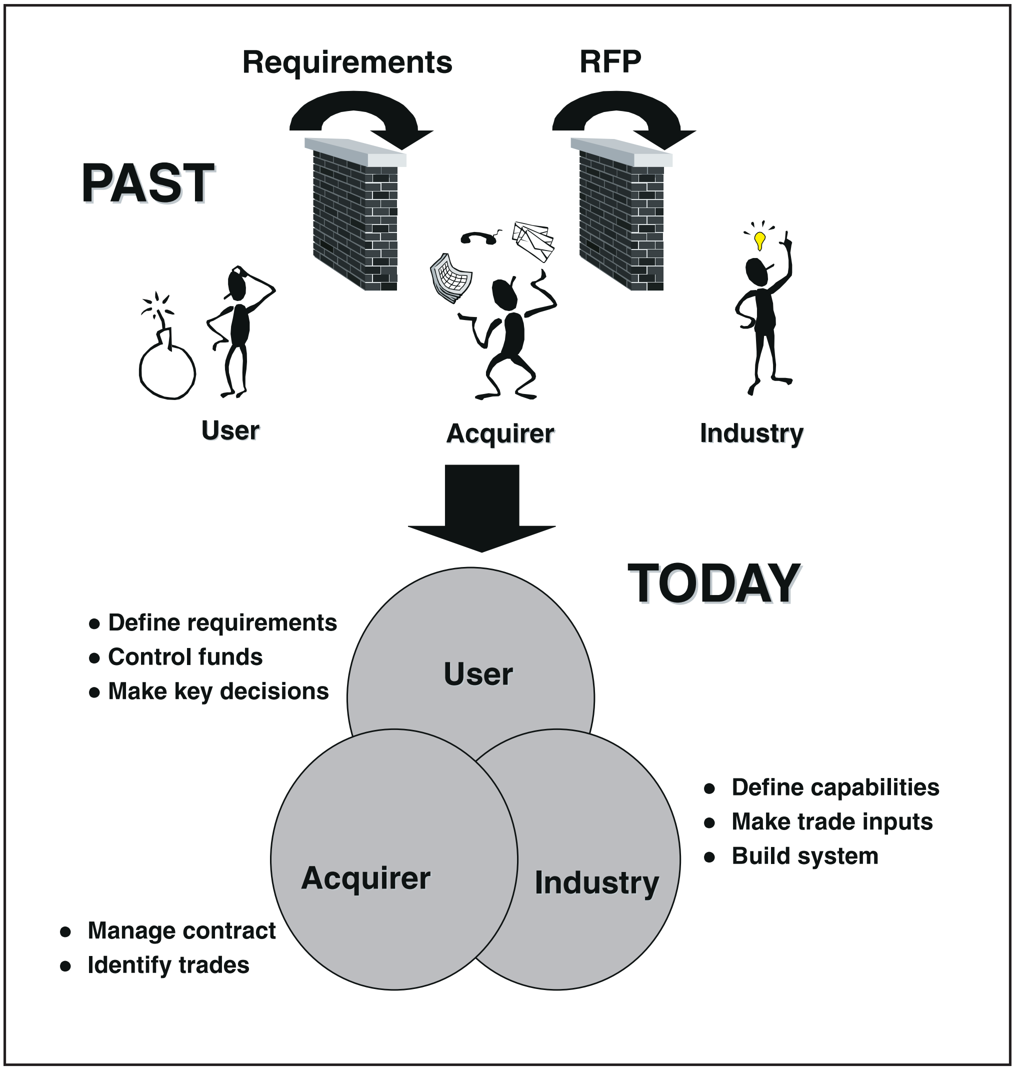


Figure 4. Partnering

PARTNERING

We can no longer allow the sequential, isolated approach to developing systems! CAIV relies on partnered management of the trade space between the user, acquirer, and industry participants, including strong involvement from the sustainment experts in each of the three communities.

In the past, the all-too-common process flow was sequential, with limited part-nering. Under CAIV, the user defines system requirements, with comprehensive input from sustainers. In addition, the acquirer and industry partners support the user by identifying and quantifying the major risks and TOC drivers, thereby enabling better informed decisions. The acquirer leads system development, with strong user and sustainer involvement on potential trades identified by the acquirer or industry. Industry, under contractual incentives, allocates requirements and designs systems for minimized TOC, seeks lower cost and equally capable aternatives for system elements under its control, and makes recommendations for elements not under its control (based on trade studies).

A key element in CAIV success will be the cost performance integrated product team (CPIPT). The CPIPT will complete cost-performance-schedule tradeoffs leading to CAIV-based cost, performance, and schedule objectives. The CPIPT, to include the user, must work closely together to agree on final threshold and objective values for cost, performance, and schedule parameters in preparation for the milestone decision and completion of key documentation.

CAIV-based threshold and objectives for KPPs, life-cycle cost targets, and critical milestones become the core drivers for the subsequent program. These core parameters must be consistent across the ORD, acquisition program baseline (APB), acquisition strategy, and test and evaluation master plan (TEMP) that come together beginning with MS I. The IPT and CPIPT remain active through-out the program life cycle up through Phase III, production, fielding and deployment, and operational support. The CPIPT is the cognizant group to continue CAIV-based cost-performance-schedule trade-offs, to establish cost range objectives for production and sustainment, and to revise performance, cost, and schedule objectives prior to each milestone decision.

After MS I, the contractor should be a major contributor for CAIV-based analyses and tradeoffs. Solicitations need to address life-cycle cost and performance objectives and request industry's approach for implementing and managing the CAIV process. The contractor and government managers should give consideration to establishing a co-chaired hierarchy IPT structure. Working level IPTs, formed around critical subsystems, report to a management IPT through a systems integration IPT.

The core of the CAIV process is tradeoffs conducted by the working level IPTs. Working level IPTs should be given a cost target and chartered to conduct cost-performance tradeoffs to reduce subsystem cost drivers. Cost-performance tradeoffs at the system level depend directly on subsystem level cost and performance tradeoffs. The number and focus of IPTs will change as the program matures from development into production and operation and sustainment.

"CAIV relies on acceptance of higher risk to aggressively pursue a "best value" system for the user."

CAIV relies on acceptance of higher risk to aggressively pursue a "best value" system for the user. Contractors and IPTs should be given incentives to conduct effective and meaningful cost performance tradeoffs.

The contractor is key in cost-performance trades. The contractor-government partnership, in which the customer employs prudent risk management and participates fully in the development of the confidence needed to entrust weapon system development, ensures the success of the contractor's cost-performance trades.

This partnership is the natural evolution of the insight-oversight paradigm.

Promotions and assignment policies must recognize and reward successes and best efforts. Cost-type contracts should include an award fee clause that shares cost savings between the government and contractor. Incentives were a key ingredient in the Peace Shield program's total success in meeting aggressive schedule and performance requirements.[1]

The contractor shared 40 percent of a $50 million incentive bonus with employees. The incentive, combined with an integrated earned value-metrics-schedule system, superb partnering with the acquisition office and customer, and aggressive software management, overcame an early schedule deficit to deliver a validated system six months early.

There are many tools available to motivate contractors: competitions between primes, competition at the component breakout level, award fees, award terms, performance bonuses, value engineering opportunities, and multiyear or sole-source awards. Acquisition offices should address incentives as part of the CAIV plan included in the acquisition strategy. Contractors must be encouraged to meet and exceed life-cycle cost reduction targets, not just near-term cost objectives.

"Promotions and assignment policies must recognize and reward successes and best efforts."

In order to address life-cycle costs up front and early, for example, continuation of a multiyear contract can be tied to reaching or exceeding interim life-cycle cost targets. The contractor could receive a larger percentage of the next production lot or could be awarded the next phase if production unit costs meet or exceed a cost reduction profile. The objective should be to tie life-cycle cost targets and contractor performance together through innovative and aggressive incentives.

TOC/LCC Focus

CAIV requires all team members maintain focus on TOC/LCC. Fiscal constraint is a reality that all Air Force stakeholders must recognize. Based on the determination of resource availability, stakeholders must set an aggressive but realistic TOC target for the system.

At each milestone, decision makers will review targets and progress toward verifying that they will be met. Cost targets shall be addressed in the acquisition strategy and will be included and tracked in the acquisition program baseline (APB). CAIV-based cost targets should be included in requests for proposals (RFPs) and contractors given incentives to achieve cost targets. Also, all personnel must constantly be cognizant of the need to identify cost reduction opportunities and tradeoffs.

Typical targets for procurement and sustainment are average unit procurement cost (AUPC equals total procurement funding/total quantity) and average unit O&S cost (AUO&SC equals unit cost per flight hour, etc.). Each of these metrics can be tailored to the specific system. Procurement targets can be expressed as a cost profile; for example, AUPC versus production lot number. Sustainment targets may be expressed as a percentage reduction relative to O&S costs of a similar system.

Confidence limits for development, procurement, and sustainment cost targets will vary with the phase of the program as well as system complexity and the degree to which it is pushing the state of the art. At MS I, for example, development cost estimates should be more accurate than estimates for O&S costs.

Estimating TOC/LCC poses a significant challenge early in the program, especially for cutting-edge programs. In addition, government and industry have sometimes had large variances in cost estimates, leading to program start complications. SAF/AQ has sponsored a cost estimating reinvention team to address some of these challenges.

Unfortunately, TOC/LCC focus may well be the weakest link in the CAIV process. The reality is that instant-year dollars are politically and practically the driving factor in program decisions. It is easy to say decision makers must make decisions based on TOC considerations, but a lot harder to manage real programs that way. When we see high payoff investments rejected in our programs, it seems we often manage by the "modified Wimpie philosophy," which is not, "I will gladly pay you on Tuesday for a hamburger today," but "I will gladly pay you for three hamburgers on Tuesday for a hamburger today!" While we may bemoan such an approach, we must realize that without the hamburger today, we may starve and not reach Tuesday! The only way we can overcome this malady is with more accurate, believable tradeoff data, so that decision makers will have a better picture of the true impact.

Risk-Based Management

Risk management is an integral part of CAIV. It recognizes we cannot afford to avoid all risk, but rather must manage the critical risks. A comprehensive and disciplined risk management program throughout a program's life cycle is critical to effective management to meet cost, performance, and schedule.

As established by DoD 5000.2-R (DoD, 1998) and AFMCP 63-101, the risk management program identifies and tracks risk drivers, generates risk-handling plans, and provides for monitoring to track risk "retirement" or growth. Risk reduction measures are included in cost-performance tradeoffs, where applicable.

Program partners must jointly identify, analyze, and prioritize critical program risks, then periodically review handling plan progress. Handling approaches can run the gamut from developing alternate designs for critical components to simple monitoring to ensure a risk does not take root and grow. A commonly used tool for identifying and prioritizing risks is shown in Figure 5.

"The reality is that instant-year dollars are politically and practically the driving factor in program decisions."

The risk matrix helps identify the risks that must be addressed—those that have high probability of occurrence and potential high impact. Risk management is not just an engineering function! The team must address programmatic risks and all functions must be involved in the handling

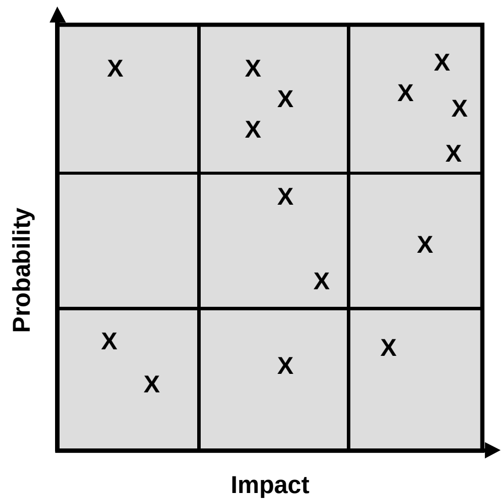


Figure 5. Risk Matrix

plans as appropriate. In fact, any program element associated with cost, schedule, and performance has a direct interface with the risk management process.

It is important to remember that risk management is used throughout a program's life cycle. A risk management plan should be part of the early CAIV strategy. Several programs have reaped benefits by conducting government-industry risk brainstorming and prioritization sessions that directly influenced the RFP (e.g., Space Lift Range Modernization and Satellite Control Network programs). RFPs should require offerors to identify their risk management approach, risks inherent in their design, and risk handling plans.

MEASUREMENT

Setting realistic but aggressive goals for cost and performance is a key element of program management. Measuring progress toward attaining those goals is a challenging but critical element of CAIV implementation. Proper metrics will add value by aiding decision making rather than simply reporting status. Metrics measure a wide range of parameters, including health of critical processes, effectiveness of cost saving initiatives, and status of the "value stream."

The earned value management system (EVMS) and technical performance measurements (TPMs) provide particularly useful metrics. A contractor needs an EVMS to manage complex tasks. Proper partnering will provide government offices insight into the EVMS. TPMs are product design and performance assessments that estimate values of essential performance parameters of the current design. TPMs assist in determining the potential impacts of differences between planned and actual values. Table 1 lists other useful metrics and tools.

Table 1. Illustrative CAIV Metrics and Features

Are cost objectives defined and consistent with requirements programmed and projected fiscal resources?	• Out-year resources identified? (dollars) • Production and O&S cost objectives included in the RFP? • Key tradeoff issues addressed (e.g., in AoA)?
Is the government managing to achieve cost objectives?	• RFP contains a strict minimum number of performance specifications? (number) • CPIPT functioning, tradeoff space identified in program baseline and RFP? • Risks to achieve cost objectives identified and program steps to address these defined? (risk plan) • Incentives for achieving life cycle cost objectives included in the RFP and contract? (percent relative total contract dollars; period of performance tied to life cycle cost target profile) • Mechanism for contractor suggestions to reduce production and O&S costs in place and operating? (value engineering clause) • Allocation of cost objectives provided to IPTs and key suppliers • Measurement and estimation of reliability and maintainability • Robust contractor incentives plan in place?
Are contractors managing to achieve cost objectives?	• Provide appropriate tools for cost-performance tradeoffs (including incentives) and participate in cost-performance tradeoff process (hierarchy IPT structure; award fee flow down to IPT members) • Identifies and implements new technologies and manufacturing processes that can reduce costs • Identifies procedural/process impediments to cost reduction measures • Establishes strong relationship with vendor base, including sound incentives structure

These examples reflect the degree to which a program is structured for CAIV success. They provide important and observable tools that assist in setting aggressive production and operating and support (O&S) cost objectives and management of the program. In some cases, quantitative metrics can be defined as indicated by the parentheses at the end of a process step.

CAIV Evolution Through the Life Cycle

CAIV is initiated at the beginning of a program and evolves through the life cycle. As an acquisition methodology, the application of CAIV varies between each acquisition phase as performance requirements, initially established as a range between required thresholds and desired objectives, narrow as a program migrates toward production. Let's briefly examine the application of CAIV across an acquisition life cycle using the CAIV tenets.

Phase 0

In Phase 0, CAIV supports the analysis of alternatives (AOA) by focusing on KPPs and cost drivers. The R-TOC process provides essential tools with data from existing systems and techniques for baselining cost drivers. At the end of this phase the ORD is established with threshold and objective ranges, funding is assigned for development (where necessary), and a maintenance strategy is proposed to minimize long-term O&S. Unfortunately, current practice provides a detailed ORD, usually based on mission effectiveness analysis, without adequate assessment of TOC impacts.

> **"CAIV is initiated at the beginning of a program and evolves through the life cycle."**

Requirements. The highest Air Force levels ensure that defense system effectiveness is optimized within constraints of available and projected resources. Also, warfighters and users utilize mission effectiveness and cost performance analyses as key parts of the AoA. When the preferred approach is identified, users employ mission effectiveness analysis and CAIV principles to set initial weapon system requirements, based on the best insight available to total ownership cost (TOC). As a result, ORD I should include TOC objectives.

Partnering. The warfighter and user lead the requirements definition efforts, and should have acquirer support if an existing program office or a development planning core team is assigned.

TOC focus. The Phase 0 IPT focuses on the life-cycle aspects of a program by developing and recommending an operation and sustainment (O&S) strategy that will optimize the elements of reliability and maintainability. TOC focus recognizes that the majority of life-cycle cost is in the O&S phase, and the resulting strategy will reflect a system that both maximizes system reliability and requires minimum downtime to fault, isolate and repair problems.

Risk-based management. As much acquirer involvement as possible is desirable to support the user in gaining an early understanding of potential risks and handling alternatives. In preparation for Milestone 1, the acquisition strategy must identify the key risk areas within the proposed solution. These will become integrated into the CAIV strategy and, ultimately, the RFP.

Measurement. Objective TOC should be set in the ORD. The requirements "owner" should estimate which requirements are likely to be cost drivers; and for each such driver, track whether adequate TOC insight has been gained. This is hard! For that reason it is essential that users work with financial experts within acquiring agencies to best estimate total ownership costs.

PHASE I

Maximum leverage for CAIV efforts exists in Phase I, since system design has not yet been finalized.

Requirements. During Phase I, the weapon system IPT uses CAIV to define TOC impacts and conduct trade studies focused on design, particularly as influenced by O&S. Tradeoff data enables warfighters and users to refine requirements.

Partnering. The team now typically includes an acquisition program office and at least one contractor. The acquirer will have the lead for completing PDRR, but must ensure close coordination with the user. Using CAIV, the team should baseline expectations through the following steps:

- Identify common and unilateral objectives to ensure concerted, focused effort.

- Define all interdependencies and organize, plan, and commit to act to meet them. Central to this aspect is analysis of the contractor's network and critical path, and integrated master plan (IMP). Based on this analysis, the government should build its own IMP to ensure government action meets timelines expected by the contractor and does not give any cause for contractor claims.

- Generate a unified risk handling plan.

- Develop a concept of operations (CONOPS) to define management and working level interaction, metrics, etc.

TOC focus. With a funded and manned program, adequate effort can now be expended to identify TOC and risk impacts from design and sustainment trade studies.

Risk-based management. The team should generate a unified risk-handling plan to address high and moderate risk areas. The plan should consolidate previous risk analyses, conduct further brainstorming, prioritize risks, allocate risk-handling responsibilities, and regularly review status. Implementation may include provisions in acquisition strategies, contracts, or parallel efforts. As a minimum, the contract should require the contractor to conduct trade studies to identify trade space.

> **"The team should generate a unified risk-handling plan to address high and moderate risk areas."**

Measurement. The team must continue to track TOC estimates to TOC objectives. In addition, requirements "owners" should continue to track degree of insight to TOC impact for each identified cost driver. The team should track risk drawdown per the handling plans with metrics tied to specific risk reduction accomplishments. Use of TPMs can be very effective for such effort.

Phase II

Early in Phase II, system design freeze limits the ability of CAIV to generate further substantial cost savings. However, focus on producibility and O&S may still yield benefits.

Requirements. The IPT uses CAIV to ensure requirements are met at minimum TOC.

Partnering. The team may expand to include other organizations (e.g., AFOTEC). The same principles of teaming apply as applied in Phase I.

TOC focus. Tradeoff studies will focus on manufacturing and sustainment impacts on TOC and risk. A mature design and testing of components and prototypes should enable more accurate estimates of O&S impacts on TOC.

Risk-based management. The contract again requires trade studies to identify the "trade space," although the ability to make substantive changes decreases as the design matures. The team should employ the same type of risk program definition as described in Phase I.

Measurement. The team continues to track TOC estimates to TOC objectives and risk drawdown through TPMs. In addition, the contractor EVMS, in conjunction with the integrated master plan (IMP) and integrated master schedule (IMS), provide accurate status for completion of development as well as visibility to any potential problems before they get out of hand. Data from prototype and component builds and testing will support production cost estimates. The team will have determined the availability and visibility of such metrics during their partnering sessions.

Phase III

In Phase III, CAIV can generate TOC savings through production improvements prior to delivery of finished systems to the user. For fielded systems, the R-TOC process is primary in identifying cost-saving opportunities, but the CAIV process really starts all over again in support of system modifications.

Requirements. The IPT ensures continued ability to meet baseline requirements while adapting to requirements evolutions that drive system modifications.

Partnering. Although some partners may have changed from earlier phases (especially if major modifications are in process), the same principles apply.

TOC focus. With an eye on reducing immediate costs, contractors are given incentives in production contracts to streamline manufacturing processes to reduce the cost of producing systems. Additionally, all members of the IPT, especially maintainers, work to ensure proposed sustainment processes and practices, maximize system availability, and minimize cost.

Risk-based management. For steady-state systems, teams should focus on risks that may upset the steady state. Risk occurs in all phases of acquisition and it is constantly monitored and re-examined to ensure old risks are managed and new risks are identified.

Measurement. As in previous phases, a well-functioning EVMS along with manufacturing IMP and IMS provide the IPT the necessary information to assess program progress and status.

HYBRIDS

Most acquisition programs consist of modifications and ACAT III acquisition efforts. One of the most innovative aspects of the revised acquisition regulations is the recognition that these systems do not need to go through the classic Phase 0, I, II sequence before being fielded. In such cases, the IPT should review the above guidance and synthesize or tailor to the program at hand. As part of the CAIV process, IPTs are encouraged to minimize acquisition times and costs by streamlining the acquisition processes wherever and whenever possible.

CONCLUSION

CAIV is a viable concept for attaining R-TOC objectives. CAIV and the Air Force R-TOC process go hand-in-hand: CAIV primarily applies to systems in acquisition and the R-TOC process applies to fielded systems. Much of the CAIV construct described here is not new. Parts of it have been applied in numerous programs. The authors, and many other program managers, really used key elements of CAIV before they knew it *was* CAIV. The construct presented here offers a more integrated, definitive CAIV implementation description than has previously been available. In fact, the CAIV construct presented is more a program management construct than pure CAIV.

Challenges to realizing the benefits that CAIV offers still exist. The greatest challenge is the need to make decisions based on future impacts to break the paradigm of continuously mortgaging the future when faced with the reality of the critical exigencies of today. That paradigm leads to Under Secretary of Defense (Acquisition and Technology) Jacques Gansler's "death spiral" (1998). Improved understanding and believable quantification of TOC impacts is critical to overcoming that fate. The key targets to enable better information for our decision makers fall along the lines of the CAIV tenets:

- an improved requirements process to focus on capabilities-based requirements supported by TOC impact data;
- improved, partnered management of the trade space;
- recognition by every member of the user, acquirer, and contractor team that they have an R-TOC role (in addition, improved cost estimating capabilities in government and industry);
- improved understanding and implementation of risk management;
- better metrics;
- integrating all CAIV aspects for effective program management; and
- training users, acquirers, and contractors at all levels on CAIV implementation so that CAIV becomes ingrained in the culture.

Finally, CAIV as a term of art should disappear in the future—but everyone should do it! In 1991, a senior-level government-industry team addressed the problem of excessive engineering change proposals in development by defining Clear Accountability in Design (CAID). CAID determined that the government would not take configuration control below the "A Spec" until generally after physical configuration audit. Most people in acquisition today cannot identify CAID, but it is the standard. CAIV should go the same way.

David R. Graham is a program analyst in the Air Force Deputy Assistant Secretary's Management Policy and Program Integration Division. He began working for the Air Force in 1979 at the Space & Missile Systems Center (SMC), Los Angeles AFB, CA, and has held a variety of budget, cost performance, cost estimator, and program analyst positions up to the present.

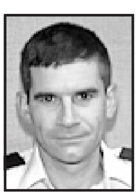
(E-mail address: David.Graham@pentagon.af.mil)

Allen L. Gotwald is a systems engineer working at the Air Force Materiel Command's Engineering and Technical Management, System Engineering Policy Division, at Wright-Patterson Air Force Base, OH. He worked for 7 years within the F-16 program office where he served as lead engineer on the development of mission planning systems and later served as the lead engineer for the F-16 Block 50 program. In 1997 Gotwald was selected as an engineer within the Centralized Acquisition Support Team (CAST) at the Air Force Material Command Headquarters. He later became the co-director for CAIV implementation across the command, helped with the development of the Reduction in Total Ownership Cost (R-TOC) Guide, and developed an implementation workshop for the Integrated Master Plan and Integrated Master Schedule (IMP/IMS). Gotwald holds an M.S. degree in engineering management from the University of Dayton.

(E-mail address: allen.gotwald2@wpafb.af.mil)

Colonel Michael A. Kaye, U.S. Air Force, is the chief of the Acquisition Support Team at the Space and Missile Systems Center (SMC), Los Angeles Air Force Base, CA. He recently headed an Assistant Secretary of the Air Force for Acquisition (SAF/AQ)-sponsored reinvention team focused on boosting CAIV and Sustainment in the requirements process. Prior to assuming his current position, Kaye served as Deputy Program Director of PEACE SHIELD, a $5 billion Command, Control, and Communications (C^3) system installed in Saudi Arabia, which received the 1994 John J. Welch, Jr., Award as the top Air Force program. He holds an M.B.A from Hardin-Simmons University, M.S. in engineering science from Purdue University, and B.S. in physics from the University of Illinois.

(E-mail address: Michael.Kaye@losangeles.af.mil)



Lt Col Mark S. Sobota, USAF, is currently assigned to the U.S. Special Operations Command (USSOCOM) as Chief, Aviation/Space Operational Test and Evaluation Branch at USSOCOM Headquarters, MacDill AFB, FL, and previously served at the Electronic Systems Command, Air Force Flight Test Center, and Air Force Research Lab covering a variety of weapon systems from Joint STARS, LANTIRN, F-16, B-1B, F-15E, and conducted advance research for the F-22. He is a graduate of the Defense Systems Management College's APMC 97-3, received a B.S. degree in chemistry from the Virginia Military Institute, and a B.S. degree and M.S. degree in aeronautical engineering from the Air Force Institute of Technology.

(E-mail address: sobotam@socom.mil)

ENDNOTE

1. The contract bid was a $1.1 billion effort for control software, integration, test, and operational activation of the $5 billion command, control, and communications system for integrated air defense of Saudi Arabia.

REFERENCES

DoD. (1998, March 23). DoD directive 5000.2-R. Mandatory procedures for major defense acquisition programs (MDAPs) and major automated information system (MAIS) acquisition programs (Section 3.3.3). Washington, DC: Author.

DoD. (2000, March). Draft New DoD directive 5000.2-R. Mandatory procedures for major defense acquisition programs (MDAPs) and major automated information system (MAIS) acquisition programs (Section 1.3; 1.4). Washington, DC: Author.

Air Force Materiel Command (1997, July 9). Acquisition risk management (AFMCP Pamphlet 63-101). Wright-Patterson AFB, Ohio: Author.

Gansler, J. (1998, September 2). The revolution in business affairs: The need to act now. Falls Church, VA: Association of the U.S. Army.

Secretary of the Air Force/AQCT. (1999, May 27). R-TOC: Reduction in total ownership cost. In CAIV/TOC Guidebook. Washington, DC: Author.

APPENDIX

RISK MANAGEMENT APPROACH

Let us consider an example of a potential risk management approach. Typically, system weight is a critical parameter that will impact total system performance. Assume that keeping weight under the allocated threshold is particularly vital, as it usually is. Numerous studies have also shown that weight typically grows through development of a system. Figure 6 shows an allocated threshold along with "uncertainty bands" that narrow as the design matures. Clearly, a tested, validated system at Milestone (MS) III should be distinctly characterized. However, at Milestone I, a "paper design" only estimates system weight. Assuming the weight Technical Performance Measure (TPM) will be regularly tracked, we can define four regions on the chart that the TPM may be in.

I: Weight well below threshold; high confidence system will meet threshold at MS III.

II: Weight below threshold; the closer to the threshold, the more active efforts must be to contain growth.

III: Weight above threshold; need aggressive weight reduction program.

IV: Weight well above threshold; low probability to meet threshold even with aggressive program.

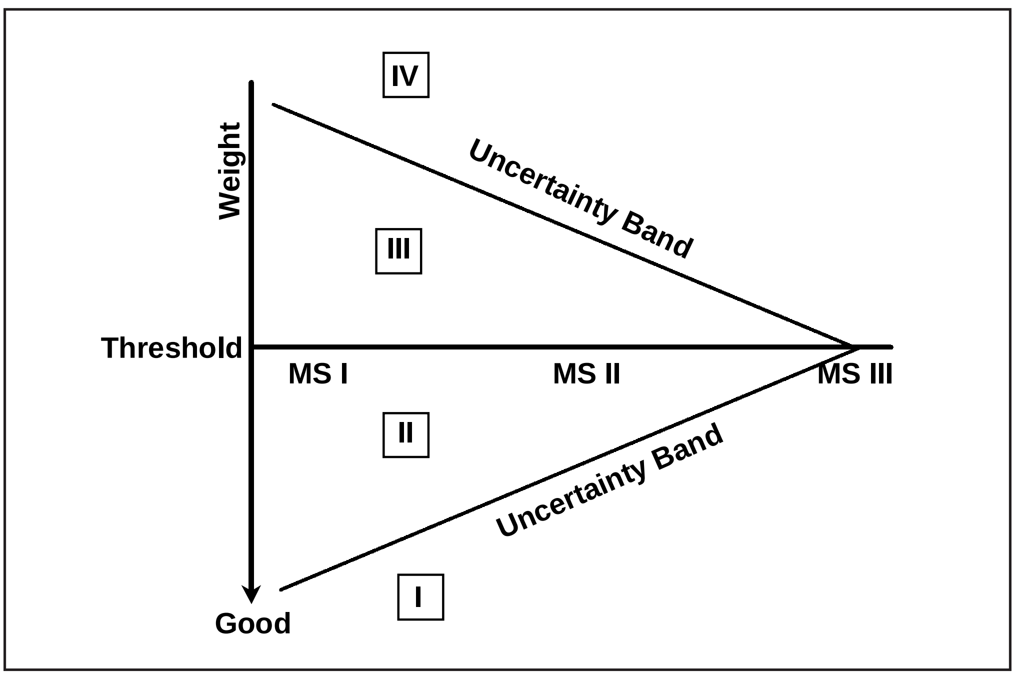


Figure 6. Managing Risk

Cost Driver Calculation

Figure 7 is a simplistic view of a "comb chart" analysis of cost drivers for a system. The costs are divided into RDT&E, procurement, and O&S. Each is further subdivided into WBS elements. Such subdivision should go down as far as practicable. For each element, dollar estimates and percentages of TOC are generated. This analysis will provide a baseline against which R-TOC efforts are compared. Currently, SAF/AQCT is coordinating 10 Air Force pilot programs using this methodology to generate R-TOC plans and associated objectives. We anticipate that this procedure will be directed on almost all programs in the future.

Directions for conducting such analysis are in the R-TOC Guidebook previously cited.

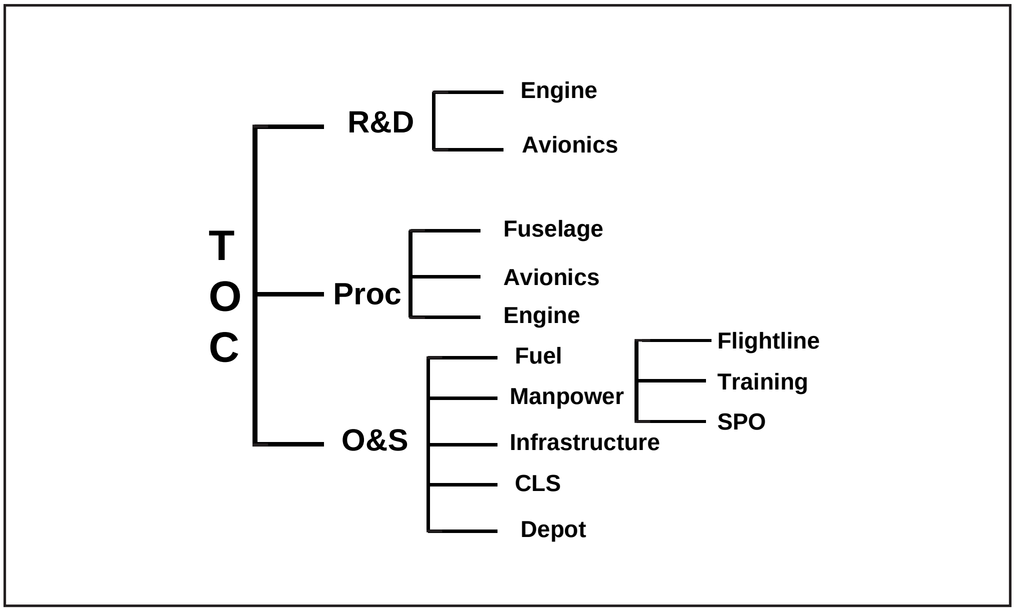


Figure 7. Cost Drivers