

OPERATIONAL ART IN MILITARY SIMULATION (PANEL)

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ABSTRACT

Theater level campaign analyses provide the only meaningful way of estimating the contributions of systems that perform disparate functions in wartime. Hence, increased emphasis on such analyses is needed now, and proper analytic treatment of operational art -- "theater level concepts of force employment" -- must be included in all such efforts. Specifically:

- If analysis is to be useful to high level decision making and to military force planning, then good theater level campaign analyses are important.
- Good campaign analyses demand campaign models which provide proper analytic treatment of operational art for both adversaries. ("Proper analytic treatment" means mathematical search algorithms which find "best use of forces." Analyst input and expert systems don't work well enough.)
- Poor campaign analyses are worse than none at all, and most attempts over the past 20 years have been poor. Reason: Lack of proper analytic treatment of operational art. Result: Campaign analyses have a

terrible reputation among senior decision-makers.

- The requirement for proper analytic treatment of operational art is recognized (e.g. MORS OPARTAN Conference), and is included in such fundamental force planning/acquisition constructs as the Kent "Strategy to Task" force planning analysis framework and DoDI 5000.1/2.
- While difficult, proper analytic treatment of operational art is feasible as demonstrated by two existing approaches (OME-III/IV at STR Corporation and Tac Sage at Rand), and should be incorporated into all theater level campaign simulation models.

1 PURPOSE OF THIS PAPER

My objective is to get you interested in theater level effectiveness analyses, if you aren't already, and to motivate you to do your work (at whatever level you presently happen to be working) in such a way that it will be helpful to high level decision-making.

There are numerous possible good reasons for your

obvious interest in military simulation. You could be bent on improving the effectiveness and lowering the cost of training through simulations involving high fidelity virtual reality. You might be on some engineering team trying to improve the performance of a missile radar. Perhaps you work at the next higher level, helping with the design trades to improve the overall effectiveness in engagements.

You could even be interested in the next level up, attempting to help with decisions on the overall structure, composition, and characteristics of our military forces. If you are, then this paper is for you. If you are not, then please get interested quickly! Why?

- These high level decisions all concern where to spend the really serious money.
- We in the analysis community have not been particularly helpful to decision-makers at this level. (Some even claim we have been detrimental! Imagine that!)
- We need to get helpful -- now!
- If we are to be helpful, then everybody's work needs to fit within a comprehensive "Strategy to Task" planning framework.

The last point needs emphasis. Even though your organization may properly have you working at the more comfortable engineering or engagement levels, there is no lower level effectiveness analysis effort which is immune to the profound influence of decisions made at the force structure/composition level. Conversely, within certain bounds, work at the lower levels should translate to measures of outcome at the higher level at which the heavy decisions are made -- but only if you know the higher level relationships and bounds.

As a preview, the one ingredient of your work essential to being helpful is a proper treatment of how the forces and resources of both sides are used throughout a conflict toward achieving conflicting objectives -- what weight of effort applied against which operational tasks by which resources on what schedule -- i.e. proper treatment of "operational art". We will see that proper treatment of operational art entails imbedding sophisticated mathematical search algorithms (as opposed to direct analyst/operator input, or expert system algorithms) in your theater campaign simulations to help analysts and operators find the best use of forces by both sides, based strictly on the capabilities of those forces.

2 HELP WANTED FOR HIGH LEVEL DECISIONS

If analysis is to be useful to high level decision making and military force planning, then good theater level campaign analyses are important.

While this ought to be self evident, it is not. The water is considerably muddied by the fact that many quite competent decision-makers won't touch theater level campaign analyses with the longest of poles -- which renders "good campaign analyses" a necessary but not sufficient condition for usefulness. What's the problem?

It is environment, not heredity. Those who abhor theater level campaign analyses did not arrive in that condition through genetic mishap, but rather harsh experience. They have been badly burned by bad theater level campaign analyses (as opposed to the good kind to be described shortly); they know that most are bad, and they don't have time to sort out the bad from the good.

To be useful to high level decision-making, analyses must, among other things:

- Directly address the question(s) to be decided.
- Capture the most important elements of the decision-maker's criteria.
- Not take more of the decision-maker's time than the analysis is worth.

If I am trying to decide which one of several candidate new fighter aircraft to eventually buy, and which of the old fighter aircraft to retire, don't serve up an analysis that says that candidate A has a really great radar, and a separate analysis that says that candidate B has superb maintainability. While both may indirectly bear on the question to be decided, neither directly addresses it. I need an analysis that adequately captures the military worth of the great radar of candidate A and the superb maintainability of candidate B (along with all the other characteristics and capabilities of all candidates), expressing this worth in a common metric. I need lines of best investment for various internally self-consistent assumption sets that tell me what I have to believe about certain unknown and unknowable drivers in order for option A (or B, or C ...) to be the correct choice. With that information, I can bring my judgements forcefully to bear. Absent such information, I am stuck with my biases and predispositions.

Such analyses can only be carried out at the theater campaign level, and then only after having answered the crucial political question of "to what purpose?" The full prescription is embodied in the Kent "Strategy to Task" framework -- the only force planning analysis framework found to date which passes the simple test of producing consistent, reliable effectiveness estimates that are independent of analyst opinion on how the forces should be

used. In starkly oversimplified form, the major elements of the "Strategy to Task" force planning analysis framework are:

- At the higher end of the force planning spectrum, political authority establishes our national military strategy specifying our interests in various regions of the world and plausible military threats to those interests. Elaboration leads to the specification of plausible regional scenarios, that include objectives and ranges of threat/allied force capability which should be investigated for purpose of force planning.
- At the lower end of the spectrum engineers, analysts, and operators work together to create viable operational concepts for performing all significant operational military tasks. They estimate how well the tasks can be performed with what losses under what range of circumstances. They also conceive of new engineering designs, create new operational concepts based on them, and estimate improvements in effectiveness and losses as functions of the improved performance. This is the level at which most analytic mental effort is currently expended. Here, with some notable exceptions, we do reasonably well. (The most significant exceptions are failure to assure that operational concepts are sound from end to end, and to thoroughly treat the tactics component of the ops concepts.) The output of this level is a menu of ops concepts for performing operational tasks, each with an associated effectiveness and loss penalty. Unfortunately, no analysis at this level alone can demonstrate that any particular operational task is worth doing, even with the best ops concept you could come up with. The profound consequence is that no compelling argument can be made at this level for buying the equipment that underwrites even the best ops concept (the new radar that you have just made 5 times better than the old one).
- The mid-level activity that connects the national military strategy/regional objective level with the operational task level is theater level campaign analysis, the essential ingredient of which is a proper analytic treatment of operational art. *Proper analytic treatment consists of arranging for mathematical search algorithms that seek out "best use of forces", i.e. the best weight of effort to be applied by both sides to each operational task, each matching available resources to defined ops concepts on the best schedule throughout the campaign, as each side seeks to achieve specified conflicting objectives.* As explained in the next section, user input is hopelessly

inadequate for the task. Formal search algorithms are necessary.

This framework for force planning was developed by Glenn A. Kent, Lt. General, USAF (Retired) of The RAND Corporation and described in "A Framework for Defense Planning", Glenn A. Kent, R-3721-AF/OSD, The RAND Corporation, Santa Monica, August 1989. This particular framework has gained considerable momentum within the Air Force. It is sometimes referred to by the shorthand, "Strategy to Task" framework. *It is uncompromising in requiring that the question of operational art -- theater concepts of force employment -- be analytically treated by the methodology which operates within that framework.*

So, I need a good analysis that puts the military worth of all the resources in a common metric. On the other hand, if you can't furnish an analysis which properly treats operational art, the most important determinant of the relative military worth of A's radar, B's maintainability etc, then I'd rather have no analysis at all. You're wasting my time! Don't torment me with a deluge of data only tenuously related to what I must decide!

3 PREREQUISITE -- PROPER TREATMENT OF OPERATIONAL ART

Good campaign analyses demand campaign models which provide proper analytic treatment of operational art for both adversaries. ("Proper analytic treatment" means mathematical search algorithms which find "best use of forces." Analyst input and expert systems don't work well enough.)

What constitutes "properly treats operational art"? Not analyst input on how the forces are to be used throughout the conflict. Not even analyst input guided by instructions from operators. Nor even "expert systems" engineered to capture the opinions of some expert operators! These schemes all fail the simple criterion of producing consistent, reliable effectiveness estimates that are independent of who does the analysis or which expert opinion has been captured.

Take tactical airpower. The various uses to which tactical air power may be employed throughout a campaign may be viewed conceptually as in Figure 1. Here, for simplicity we have depicted only offensive missions for Blue and defensive missions for Red, but of course all tasks are available to both antagonists. While experts may disagree on precisely which tasks and on what schedule both sides should employ their air power, there should be far broader agreement that what really counts is some combination of firepower against strategic targets, the amount of support provided to the ground forces (CAS,

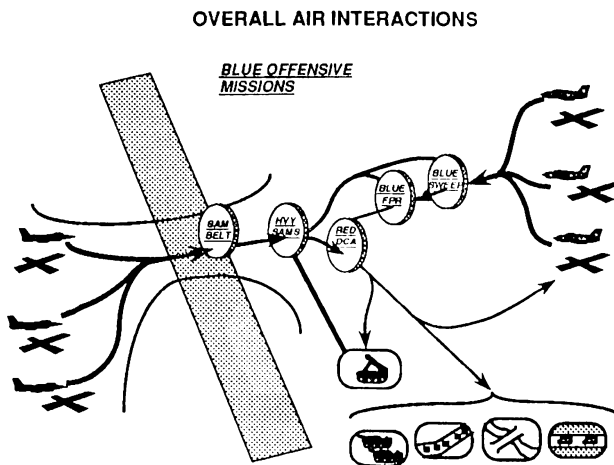


Figure 1

BAI and directly applicable Interdiction), and when it is provided -- the schedule of strategic and ground support sorties. Of equal importance, of course, is keeping Red air off our own ground forces.

How the CAS, BAI and Interdiction sorties are used in support of ground forces and when they are available controls how important and useful they are to the ground forces. Just to keep things simple, the discussion will temporarily ignore this latter complication (along with strategic targets) and concentrate instead on generation of net (Blue minus Red) ground support sorties, since if you cannot generate sorties, the question of their use and timing is moot!

Even with these simplifications, "net ground support sorties" is very strongly dependent on how the fighter forces of both sides are used -- on the tasks chosen for Blue on what schedule and upon enemy counteractions. Should we, for example, configure all F-16s for defensive counter-air on the first day of a campaign or should we load them up to go against the heavy SAMs? Should we have the ATFs perform only sweep against Red interceptors or should we include a healthy dose of standard air defense? How much difference does it make anyhow? *Are the experts sufficiently united in their opinions that the range of outcomes is acceptably small?*

An experiment on this subject was actually performed by the Air Force in the late sixties, as an outgrowth of an experience in which two organizations held opposing views on how sizeable sums of money should be spent, with each justifying their positions using the same model and data! We traced the differences to rather insignificant-looking differences in how the forces were presumed to be used by both sides throughout a ninety-day campaign.

Those in charge had difficulty believing that the outcomes could be so widely divergent when the

differences in assumption concerning how the forces were used throughout the campaign were so seemingly insignificant. (The suspicion was that there was something going on down in the internal works of the models being used that the analysts did not understand and were not taking into account. There was even an occasional subdued hint that the other side's analysts might be crooks!)

In the experiment, experts on Blue and Red force application were interviewed from the Pentagon, Tactical Air Command, USAFE, PACAF; CIA, DIA, and AF/IN -- in all, nearly 200 opinions and variants. These were played against each other using one model and data set. The hope was that a small grouping of outcomes would be obtained and plotted so that one could draw a fairly heavy "X" through the centroid of that set of outcomes, the situation would be resolved, and all would be well in the world of objective analysis.

It was a futile hope. The outcomes corresponding to the range of expert opinion were as depicted in Figure 2.

RANGE OF EXPERT OPINION

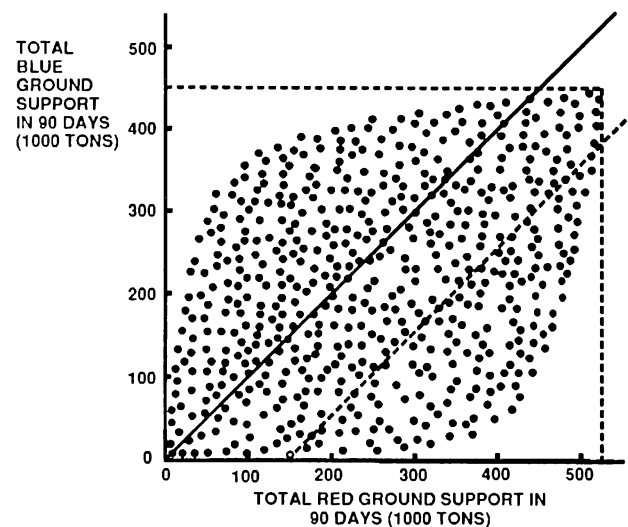


Figure 2

This is a disaster of the first order for analysis. This outcome suggests that as long as we are using expert opinion for how the forces ought to be used in combat, then we can literally get any answer we want (or don't want as the case may be). A new widget or aircraft may represent salvation or perdition, depending on which particular expert judgments are used in the analysis!

This is only one of many possible examples. One of the more modern examples, noteworthy because of the discipline with which the work was accomplished and reported, resulted from Lt Gen Hosmer's research at National Defense University. Using TAC Thunder, and treating both the ground and air battles in a rather classic

European scenario, he found similarly dramatic differences in outcome stemming from different prescriptions for use of the forces, all within the confines of possible force use covered by current doctrine. One result of this experience was a MORS mini-symposium on operational art (OPARTAN). Since a summary of this research has been disseminated to the community in PHALANX and at several MORS conferences, it will not be repeated here.

This experience is continuously repeated by individual analysts working in the field at theater level. For those few who have made serious effort at providing decision-makers with analyses designed to help with high level decisions, the crucial importance of a proper treatment of operational art is no hot news flash.

4 HELPING WITH HIGH LEVEL DECISIONS -- THE DYNAMICS AND CONSEQUENCES

Poor campaign analyses are worse than none at all, and most attempts over the past 20 years have been poor. Reason: Lack of proper analytic treatment of operational art. Result: Campaign analyses have a terrible reputation among senior decision-makers.

This range of outcomes corresponding to the range of expert opinion on how forces ought to be used obviously will not yield any analytical results on which any reputable decision maker would base any decisions.

To aggravate the situation, it is extremely difficult for decision-makers to pinpoint the precise points of disagreement whenever counter-intuitive results (right or wrong) appear at theater level. This is in marked contrast to engagement and engineering level results. At these lower levels, most decision-makers have developed a feel for what range of outcomes might be anticipated for a specified set of conditions, enabling them to rather quickly focus in to discover the source of their discomfort and better judge whether it is their gut feel or the analysis that is wrong.

For example, at the engagement level senior Air Force people may have a reasonable feel for who gets shot and who survives in a specified 2 vs 4 air-to-air engagement because of the substantial storehouse of individual experience built up through years of training and in some cases in actual warfare.

The situation is even better at the engineering level since results can generally be tested -- and most often are.

But no one has built up such a storehouse of personal experience at the theater level. Combined with the extreme sensitivity of outcomes to how the forces are used, this means that even the most thoughtful decision-makers will be poorly equipped by experience to adjudicate between gut feel and analysis result. They may feel that something must surely be wrong here, but be unable to quickly put

their finger on it.

Failing the "quickly" test is often tantamount to total failure, since most are exceptionally busy people. What they need is a simple, concise statement of what criterion was used by the analysis regarding handling of operational art, along with a convincing certification that the criterion was actually met by the process used in the analysis. (The suggested criterion is, "Blue uses his resources to best effect toward achieving his objectives, and Red does likewise.") Few have the time or patience to even examine the day by day tasking of all the force elements, much less the time, experience, confidence or inclination to come on line with what they believe to be a better set. Even if they did, we would still be stuck with the criterion of "This is the best use of forces we could come up with in the time available."

Whenever I have been able to invoke the former criterion, the analysis has invariably been well received and had major impact. Conversely, I have never had much success when stuck with the latter criterion.

Unfortunately, with few exceptions, we as a community have persisted in serving up analyses that use analyst input for how the forces are used throughout campaigns. Hence, it can hardly be a great surprise that decision-makers are quite reluctant to base any decisions on those analysis results.

Still worse, the experience of dealing with this class of theater analyses has taught many decision-makers to disregard all theater analyses, even though theater campaign analyses offer the only hope for help from our community on decisions on the big ticket items. By implication, a large fraction of senior government officials have thus lamentably given up on getting much help on high level decisions. If we are to be helpful, we have much to overcome.

5 PROPER PLANNING (AND ACQUISITION DIRECTIVES!) DEMAND WE DO BETTER

The requirement for proper analytic treatment of operational art is recognized (e.g. MORS OPARTAN Conference), and is included in such fundamental force planning/acquisition constructs as the Kent "Strategy to Task" force planning analysis framework and DoDI 5000.1/2.

Just to add fuel to the fire, for those lost souls who may not yet be persuaded by the overwhelming evidence and logic presented above, not only is proper analytic treatment of operational art the right thing to do, it is required by the force planning and acquisition systems. If either the JROC or Milestone 0 decision authority chooses to get sticky about compliance with DoDI 5000.1/2, then you can't get

by Milestone 0 on your new widget without an analysis technique that assures that no better way of using available forces in combat can be found which can lead to a better enforceable outcome (hence reduced "need") for our side. The applicable quotes:

"Mission needs must first be evaluated to determine if they can be satisfied by nonmaterial solutions. Nonmaterial solutions include changes in doctrine, operational concepts, tactics, training, or organization."

"The (Joint Requirements Oversight) Council reviews each (Mission Need) Statement and confirms that the mission need cannot be satisfied by a nonmaterial solution."

"Studies of alternative concepts and entry into Phase 0 may not be approved unless the milestone decision authority determines that the mission need:

- ...
- ...
- *cannot be satisfied by a nonmaterial solution, and*
- *..."*

This seems reasonably clear. Training and organization can be handled to a first order simply by performing the analysis in such a way that neither training nor organization is presumed to impose any limitations on either how the forces are used or on engagement level effectiveness. Doctrine, operational concepts and tactics are different matters which, as we have seen, do not yield well to a cut and try approach.

Is this to be taken seriously? Is the JROC likely to get sticky about these provisions in future procurements? Can these provisions be safely ignored? As far as I can tell, nobody really knows for sure. In the past, there was clearly a general recognition that this is a difficult criterion, and that the services were not equipped technically to adhere closely to it. It does seem likely that the large cuts in defense procurement dollars will result in stricter adherence to the provisions of the acquisition directives. It also seems likely that those who can closely follow these provisions will fare better in the battle for resources than those who cannot. Of one thing I am certain: the Air Force people at Air Combat Command (formerly TAC/SAC) and Aeronautical Systems Center (formerly ASD) with whom I have worked on various projects take the matter seriously. Typical comment:

"General Goodson, I've got just about everything else figured out, but the one remaining tough hurdle are these 'no nonmaterial solution' provisions. There are just too many combinations of ways to use forces in a campaign that look pretty good on the surface. We can't even try all

those that look the most promising to us at the moment, and if we could, the probability is uncomfortably high that some sharpshooter peddling some competing system might find some different way of using the forces that may seem better under some circumstances, throw grit in the wheels, negate months of good work, and embarrass THE BOSS. I really wouldn't like to put THE BOSS in that position."

Good idea! Neither would I. And under these circumstances, the existence of systematic mathematical search algorithms such as those imbedded in OME-III, which reduce said probability from "uncomfortably high" to "vanishingly small" take on virtues of the Holy Grail.

On the planning side, "best use of force" has been a necessary ingredient of all the various versions of General Kent's "Strategy to Task" force planning analysis framework, from 1968 to my personal knowledge, and based on the firmness with which Gen Kent expressed his convictions at the time, I would judge long before that. I learned early not to trifle with this analysis requirement.

6 WE CAN DO BETTER

While difficult, proper analytic treatment of operational art is feasible as demonstrated by two existing approaches (OME-III/IV at STR Corporation and Tac Sage at Rand), and should be incorporated into all theater level campaign simulation models.

Yes, I must reluctantly conclude that it is difficult. Since the late 1960's experiment described above which resulted in the infamous measles chart, there have been many attempts at an adequate analytic treatment of operational art. I have tried five times myself. Of the five, I would describe the first (TAC CONTENDER, early 1970's) as a partial success, and the last (OME-III) as a success. The other three attempts were failures. Of the many other attempts of which I am aware, I can only classify one, Tac Sage developed at Rand Corporation, as a success.

Both these successful attempts are based on the general concepts that were developed by Dresher and Berkowitz in the mid-fifties at Rand, and both use modern search algorithms in their implementation. They differ from each other in the specific form of the implementation, and in the structure of the battle models, but both provide a decent analytic treatment of operational art. Hence, these are currently the only known methodologies that pass muster.

I will not elaborate on their specific implementations but will mention the concepts on which they are based. After some thought, we can conclude that if we can develop a good estimate of the military potential of the assets (measured in terms of the contribution to achieving the stated military objectives), we can apply game theory

(along with powerful and elaborate mathematical search algorithms) to the question of, "What's the best thing for Blue to do with his resources today, against the best for Red?" Said another way, at any particular point in the campaign, we can see conceptually how to figure out what tasks should be performed with what resources by each side, given that we know the current military potential of the resources.

The problem is further complicated by the fact that the military potential depends on how far along we are in the campaign, and on how the forces are used from now to the end. (My best moves are clearly different if I know the war will be over by this afternoon, rather than six months from now! I must make a totally different trade between doing something with an immediate and direct impact on achieving my objectives, and surviving to perform such tasks later.) Having said that, how do we find the elusive military potential? The current answer is, we invoke the principles of dynamic programming. We start at the end and go backwards, adding to military potential from one day to the next as we get further and further from the end of the campaign. In the case of Tac Sage (as well as the old TAC CONTENDER) this is done iteratively. In the case of OME-III, the potential is captured on a response surface.

Regardless of specific implementation, the critical component of any force planning analysis framework is a methodology that adequately treats the "operational art -- theater level concepts of force employment". Clearly, successful treatment of the operational art is a product of analysis rather than an arbitrary input to it. The OME-III and TAC Sage structures provide this treatment. Hence, we can do better.

7 THE TIME TO DO BETTER IS NOW

Increased emphasis on theater level campaign analyses is needed now, and proper analytic treatment of operational art should be included in all such efforts.

I can think of no time in modern history when a strong, disciplined approach to making decisions on military affairs was more needed than now. The world is in political chaos, military budgets are properly shrinking dramatically, yet there is great uncertainty in political and military forecasts. Under such conditions, a disciplined approach to decision-making under uncertainty is likely to yield results quite superior to an undisciplined approach.

A disciplined approach must include a certain amount of analysis appropriate to the decisions to be made. Proper analysis demands an analysis framework which can cover all important considerations from National Military Strategy to engineering and training levels ("Strategy to Task"). Models are needed within that framework which properly

deal with the most important drivers of the decisions to be made. At the levels at which the most serious money gets spent, the most important driver by far is how the forces are used -- operational art. Methods are now available to properly treat the most important aspects of operational art. The only question is whether we as a community have enough desire to be helpful.

Here's what you can do:

- Get interested in decision support at the higher levels, and recognize the crucial interactions and ties among engineering, engagement, and theater levels -- and the impact on your work, regardless of which level(s) your assigned work may include.
- Recognize the singular importance of a proper treatment of operational art within theater/campaign analyses, and demand (or suggest, if you are in no position to demand) that search algorithms be incorporated in theater tools to assure proper treatment.
- Deal with the argument that the theater/campaign level analysis is really somebody else's business.

The last point is deceptively important. Your organization or company should have a deep appreciation for the complex interactions among engineering, engagement and theater/campaign levels -- an appreciation that is exceptionally difficult to achieve without access to an adequate theater/campaign methodology capable of using lower level outputs in evaluating new or improved concepts for performing operational tasks.

The fact is that unless you are cognizant of performance and cost threshold relationships at the engineering level, and of effectiveness and loss threshold relationships at the engagement level -- which relationships can only be generated by properly prepared analyses at the higher level -- then (you, your organization, your company) are in grave danger of wasting a great deal of time, effort and other resources on things that don't matter much and which ultimately are not likely to be bought.

Lacking such appreciation, you (or your company, or your organization) may lose your shirt while doing the wrong thing exactly right!

PANELIST BIOGRAPHIES

GLENN A. KENT, Lieutenant General, USAF (Ret), while closing a distinguished 33 year career in the United States Air Force with his retirement in 1974, has continued to wield extraordinary influence on defense policy. Perhaps no other individual, inside or outside government, has been

a more articulate or forceful spokesman for structured and disciplined force planning within a logical analysis framework. He has provided a detailed prescription for the framework and how the work should be done within it. His prescription has been adopted by the Air Force and DoD, and is popularly known as the "Kent Strategy to Task" framework. His views on these matters come from years of practical experience on all aspects of force planning and its relationship to defense policy -- in the Air Force and since. General Kent's academic credentials include B.A. in Mathematics, and M.S. degrees in Meteorology and Radiological Engineering from California Institute of Technology and University of California, Berkeley, respectively. He attended the Naval Postgraduate School and the Air War College, and was a research fellow at the Harvard University Center for International Affairs. He served as a weather officer in the Army Air Corps, as a planner in the Armament Division of the Directorate of Research and Development (HqUSAF); then with the AF Special Weapons Center (Albuquerque), Chief of Weapons Plans (HqUSAF), Military Assistant (Strategic and Defensive Systems) in the Office of Defense Research and Engineering (OSD), Assistant for Concept Formulation in Research and Development (HqUSAF), Chief of Development Plans (HqAFSC), Assistant Chief of Staff for Studies and Analysis (Hq USAF), and Director of the Weapon Systems Evaluation Group (OSD). From 1974 through 1982, he managed his own consulting firm, and since 1982 has occupied his current position as Senior Staff Member of RAND, Washington D.C. From 1974-1982 and 1988-present, he has served on the Air Force Scientific Advisory Board.

BRADLEY C. HOSMER, Lieutenant General, USAF, is Superintendent of the United States Air Force Academy. He earned a bachelor of science degree from the U.S. Air Force Academy in 1959, was selected as a Rhodes Scholar, and received his master of arts in international relations from Oxford University in 1962. He served as an instructor pilot at Laughlin Air Force Base, then in the Republic of Vietnam as an Air Liaison Officer, then as a plans officer at 7th Air Force. Following Naval Command and Staff School, General Hosmer was assigned as a planner at HqUSAF. After completing Naval War College in July 1975, he served with the 474th Tactical Fighter Wing (Nellis AFB), then commanded the 479th and 347th Tactical Fighter Wings and the 831st Air Division (Holloman, Moody and George AFBs, respectively). He served at HqPACAF, then as Vice Director, the Joint Staff, Washington D.C., until August 1986 when he was named Assistant Deputy Chief of Staff for Programs and Resources, HqUSAF. His subsequent service as President, National Defense University, provided an opportunity for modern research into the operational art. In Sept 1989, he

became the Air Force Inspector General, and in June 1991, assumed his current position. General Hosmer has flown more than 4000 hours in a wide variety of aircraft.

W. LEON GOODSON, Brigadier General, USAF (Ret), has over 30 years of experience in operations research, as well as fighter and other military operations. An Air Force fighter pilot with 128 combat missions, with a parallel career in force planning and operations analysis, he retired as a Brigadier General after 25 years filling a range of command, staff, and operational positions. He served in the Pacific, Conus and in Europe, and was operationally ready in most fighter aircraft since (including) the F-100C. His academic credentials include a doctorate in Theoretical Astrophysics with minors in Applied Mathematics and Physics from the University of Heidelberg. He is a graduate of the National War College. As a force planner, he served as DCS Plans, HqUSAFE, and in various staff positions at HQ TAC and HqUSAF. As an operations research scientist, he had three tours of duty at Hq. USAF, one in DCS Plans, and two in Studies and Analysis, (the last as ACS). Dr. Goodson is currently Chief Scientist and Executive Vice President of STR Corporation, in which capacity he supervised the development of the OME-III/IV theater level campaign methodology.

CLAYTON J. THOMAS was born as a "doubting Thomas" in the "show me" state of Missouri -- and was naturally attracted to operations research. He has been engaged in military O. R. analysis (applying, developing, describing, and teaching methodology) since 1947: Institute for Air Weapons Research, 1947-55; Air Force Operations Analysis, 1955-71; and in HQ USAF Studies and Analysis, 1971-present (as Chief Scientist since 1985). During World War II he served as a weather officer, U.S. Army Air Force. A member of Phi Beta Kappa (Univ of Chicago, 1942), he has received the ORSA Lanchester Prize, the Air Force Exceptional Civilian Service Award, the Presidential rank of Meritorious Executive, and the Air Force Association Citation of Honor. Mr Thomas has been active in ORSA (Council Member, Assoc Ed of Operations Research, Chair of Committee on Ethics and Professional Practice), and in MORS (past president, Fellow, Wanner Award, and is currently Air Force Sponsor's representative). He has chaired several MORS meetings, including the 1990 Mini-symposium on Operational Art and Analysis.