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COST AND EFFECTIVENESS INTEGRATION

Mary H. Henry DSN 680-5803/5580 &
Wilbur C. Hogan, III DSN 680-5803/5580

ODCST, HQ TRADOC &
ODCSA, HQ TRADOC

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Cost & Operational Effectiveness Analysis

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DoDD 5000.2-M says "There is no magic formula for combining cost and effectiveness measures to identify a preferred alternative." The manual goes on to recommend rank ordering cost, rank ordering effectiveness, and letting the decision maker decide which is most important to him. Pressure in the Department of Defense is strong for a technique or methodology that will provide a point value for alternatives that can be compared to other point values to decide which is most cost effective. This paper describes some of the history of attempts to integrate cost and effectiveness, from the long discredited relative worth approach, through cost-per-kill, to a sufficiency approach. The strengths and weaknesses of the various approaches that have been tried are discussed along with criteria for the proper use of those that offer promise for the future.

Mary H. Henry
ODCST, HQ TRADOC
DSN 680-5803/5580

Wilbur C. Hogan, III
ODCSA, HQ TRADOC
DSN 680-5803/5580

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COST AND EFFECTIVENESS INTEGRATION

by

Mary H. Henry, ODCST, USATRADOC
and
Wilbur C. Hogan, III, ODCSA, USATRADOC

If there is one single most important part of a Cost and Operational Effectiveness Analysis (COEA), it must be that part wherein the cost analysis and the effectiveness analysis are brought together to make the final comparison between alternatives. This is also the area in which we are probably the weakest.

For a time, in the early 1970s, the effectiveness of an alternative relative to the base case was divided by its cost relative to the base case. This resulted in a value called relative worth. The relative worths of the alternatives were compared and the one with the greatest relative worth was considered the most cost effective. That this approach had important drawbacks was soon apparent. For one thing, the relationship assumed that a unit of effectiveness was equal in value to a unit of cost. This was simply not true. The main problem, though, was that illogical comparisons were being made. For example, the relative worth of a wooden round was based on its relative effectiveness divided by its relative cost. The effectiveness could be terrible, but its relative cost was very low so its relative worth was high. Its relative worth was then compared with that of a missile with a smart seeker. Its relative effectiveness is high but so is its relative cost. Its relative worth was often lower than that of the wooden round so it was determined to be not cost effective. Other questions that arose were: 1) do you cost just the weapon or do you cost the weapon and the carrier? 2) Suppose the carrier is a man in one case and an attack helicopter in another (comparing anti-tank weapons)?

Relative worth was replaced with rank ordered effectiveness compared to rank ordered cost. This is the current preferred approach, according to the DOD 5000 series instructions for COEAs. It is a good, honest approach that allows the decision maker to make his choice based on whether cost or effectiveness was more important to him. TRADOC has improved upon this approach by also listing personnel requirements for each alternative. This gives the decision maker one more degree of freedom in making his choice. He can now decide based on what is most important to him. The ranking of effectiveness is often determined by comparison of weighted attributes or measures of effectiveness. Costs are never such an attribute or measure. Cost is a stand-alone consideration against which (as opposed to "to which") effectiveness is compared.

Despite the fact that this is the prescribed preferred approach according to DODM 5000.2M, COEA approval authorities and decision makers still look for a one number determination which can be compared to the one number for other alternatives. Our problem has been to find ways to do this that do not take us back to relative worth and which are meaningful, realistic, and informative.

There is no best way to compare alternatives. Regardless of how it is done, there are factors common to every comparison. For example, effectiveness can be studied within the scope of scenarios used. That is, the COEA can determine the effectiveness of alternatives by looking at representative forces in representative roles. We must consider the alternatives in their primary mission role, but we can limit the force to a brigade or a corps, or whatever is considered appropriate. If the alternatives can be employed in several roles we would probably evaluate their effectiveness in all of those roles, but again using a representative force for each role. The cost analysis is handled differently. It must include all of the systems we plan to obtain for all of the forces in all of the roles. The cost analysis must consider the total requirement for the system, service-wide.

The natural relationship between alternatives is variable cost and variable effectiveness. It is often meaningful to compare alternatives on the basis of equal cost or equal effectiveness. That is, we look at systems that cost about the same (or we make them cost about the same) and see how their effectiveness compares or we look at systems that will do the same job to about the same degree (or we make them do the same job to the same degree) and see how their costs compare. It is important to remember that the equals approach is not necessarily cost and effectiveness integration, although some cost and effectiveness integrations are equals approaches.

An equals approach takes a single dimensional look at a multi-dimensional problem. Nevertheless it can provide valuable insights into the comparison of systems. It's important to remember that an equals approach is only another look. It cannot be the only look. It should be done only when it makes sense. Systems should not be forced into a mold to make this kind of comparison; that is, we should not create unrealistic situations in order to establish equal cost or equal effectiveness. For example, one study compared "smart" sub-munitions carried in missiles to conventional cannon artillery rounds. The study required a very expensive force structure build-up of cannon artillery and manpower to achieve equal effectiveness. Since we operate under severe manpower constraints, such an approach would strain credibility and would create the impression of bias in favor of the far more costly missile/sub-munition solution by making it appear cheaper when compared to the very expensive force structure build-up. Another, more recent study, achieved equal cost through addition of crew served items without adding

the crews. The analysts knew that adding personnel was not acceptable so they didn't. Without the crews the items were useless; the study merely made one alternative more expensive than it was purely to achieve equal cost, its effectiveness didn't change. The message here is that we must compare real alternatives, not make one up just for the sake of comparison.

In addition to the force structure increase, there are other situations in creating equally effective forces in which the analysts must be scrupulously honest in presenting their comparisons. Sometimes effectiveness can be increased through quantity increases that do not require force structure increases. This can occur when the solution to increasing effectiveness is more "bullets." We can sometimes increase effectiveness by providing more or better missiles and sub-munitions to existing artillery units. This will naturally cause a cost increase. If the cost ceiling is reached before the equal effectiveness level, the analyst must point out that the required effectiveness cannot be obtained under existing cost constraints. The constraint must either be relaxed or the alternative abandoned.

Similarly, if additional force structure is required to establish equal cost alternatives, and it can be done within the cost ceiling, the analyst must point out that, while meeting cost constraints, the equal cost solution will require additional personnel which will not be possible under existing manpower constraints unless the increased manning comes from the existing force structure. The analysts need to ask, "What do we give up to provide the necessary people to this alternative?" They don't have to answer the question; they merely have to make sure the decision maker is aware of the fact that an equal cost approach has a non-monetary cost that may be unacceptable.

When integrating cost and effectiveness there are two things to remember: first, peacetime costs and wartime effectiveness are used; and second, the basic assumption is that the force in being is the force with which the war is fought. That is, the system under study (and its alternatives) have been developed, acquired to the total approved or requested program level, and owned for their full operational life. There are no production lines. A piece of equipment lost is effectiveness lost; a piece of equipment that survives is effectiveness retained. Equipment cannot be replaced; it can only be atritted or retained.

Blue equipment lost because one or another alternative was chosen does not represent a monetary loss. It reflects an effectiveness loss. The cost of the lost equipment is sunk; the money has already been spent. It can't be recovered. The argument that there is a replacement cost is invalid because the scenarios used (and modern experience) do not allow time for the manufacture of replacement equipment. There might be an argument that equipment lost represents value lost. This is true, but so what? Dollar value still does not equate to an expenditure of money; consequently, there is no dollar cost. Once again, the

value that is lost is the effectiveness of the equipment. In the same vein, blue equipment that survives because of the selection of a particular alternative does not represent money saved. The money has been spent. Once spent, it can't be recovered. The dollar value of the equipment has been saved, but it's still means nothing. The value doesn't represent money saved or money that will not have to be spent in the future because there was not going to be a future expenditure anyway. The surviving equipment represents effectiveness saved, the ability to continue the fight.

There have been studies in the past in which the principles laid out here were violated. In one tank study the analysts showed that the choice of a particular alternative allowed more blue tanks to survive. The study stated that 75 less blue tanks were killed than would have been and that even more could be bought with the money saved. What money? It's sunk. It's gone. Other studies have shown surviving equipment as a reduction in life cycle costs (while still buying the same program quantity). What could be done, and should be, but never has been, is to say that the simulations show that selection of alternative X will result in a finite fewer number of equipment items being killed. Consequently, if alternative X is chosen, we can probably decrease the item program buy by that number and save their cost. We can then go back to the PM, suggest he reduce his buy, and lower the estimated life cycle costs accordingly. Once again, the analysts must be scrupulously honest in their presentation. If unit cost thresholds are in place, the quantity reduction could cause a unit cost increase that would breech that threshold. In that case the analyst must point out to the decision maker that an increase in the unit cost threshold is necessary in order to reduce overall costs. As we said earlier, we have never gone back and requested a quantity reduction because of better than anticipated effectiveness.

As mentioned earlier, decision makers often look for point values representing the integration of cost and effectiveness into one number which can be compared to the number for each other alternative.

Cost per kill is an increasingly popular parameter for the integration of cost and effectiveness. We don't like it for a variety of reasons, but it is acceptable as an additional piece of information when developed and used properly. It may never be used as the sole decision criteria. Our objections stem from the fact that it is a form of relative worth and it is not appropriate to the way war will probably be fought in the future. Future warfare will most likely be along the lines of contingency operations; it will not be the attrition warfare of the past. Cost per kill also does not recognize the deterrent effect of weapons which results in an infinite cost per kill because nothing is killed when a potential enemy is successfully deterred. Dr. Berenson, Scientific Advisor to the Commanding General of TRADOC tells of convoys during World War II which lost

considerable numbers of ships to German bombers as they approached the British shores. To counter the bombers, .50 caliber machine guns were mounted on the cargo vessels. The ship losses caused by the Germans were cut in half. Sometime later some merchant seamen were asked what they thought of the guns. "They're worthless," was the response, "we haven't shot down a single airplane." They didn't consider that the measure of value was the number of ships surviving which increased because the guns forced the bombers to higher altitudes. The higher altitudes, in turn, significantly reduced the probability of the bombs hitting the ships.

Cost per kill was used in the recent LONGBOW study. LONGBOW is a very effective but expensive improvement to the HELLFIRE missile system seekers and fire control. Affordability has always been a big issue with LONGBOW. Synergistic effects indicate that battlefield effectiveness of LONGBOW will increase almost geometrically as more are added. The study concluded, "We can't afford not to buy LONGBOW." What the study did not discuss was that it cost an additional $12.2 billion to reach that level of effectiveness, that low cost per kill. Affordability is still very much an issue. This study resulted in a TRADOC policy, recommended to OSD PA&E (and concurred in) that cost per kill may not be shown without showing what it cost to achieve it - displayed at the same time and with equal emphasis.

How does cost per kill figure into the new world order of contingency operations? Look at what's happening in Somalia. We announce to the local War Lord when and where we plan to be and what route we intend to follow, and suggest that he and his forces be somewhere else. When we make our move he is somewhere else. What's the cost per kill? Our mere presence, along with the superiority of our arms, carried the day. No one and nothing was killed. The cost per kill is infinite. Does this suggest that cost per kill is inappropriate, given the end of the cold war? Not entirely. What it does suggest is that there is probably a better way of integrating cost and effectiveness and that we have to be aware of the real world application of our forces.

Sufficiency is a promising approach that attempts to answer the questions:

* Why are we interested in this system? What do we want it to do?

* How many are needed to do what we want it to do?

The biggest problem with the sufficiency approach is getting the answers to those questions. The study proponent and the study agency must agree on the definition of sufficiency. It will vary system by system, and study by study for the same system. It is also an equal effectiveness approach which means it must be approached with caution and honesty.

Sufficiency was used as the means of integrating cost and effectiveness in the Deep Fires study. We wanted the system, a missile with smart sub-munitions, to "win the war." We defined "winning the war" as causing Red to change his mind. If Red attacked across the border in Europe, what would it take for him to change his mind and withdraw to the pre-attack positions? The agreed upon answer was to limit his penetration of the Forward Line of Troops, the FLOT, to a specified finite distance. If he could not advance beyond a certain line, he would discontinue his attack and return to his own side of the border. We first played tactical air, as it existed in Europe, and got a FLOT penetration much greater than we considered sufficient. We added the PM's missile program and reduced the penetration, but not to the sufficiency level. We then added missiles and sub-munitions for all the alternatives until we reached the desired level. Tactical air was taken out with no change in the effectiveness. The alternatives were then costed at the quantities required to achieve sufficiency.

This study brought to light some unexpected benefits of the sufficiency approach. We found out that the PM's program was insufficient to do the job by itself. This gives rise to questions that must be dealt with. What do we do if our materiel solution to overcoming a deficiency is inadequate? Is a sufficient program affordable? If not, will mixes, including other service systems do the job? Should the sufficiency criteria, the objective, be reduced? Should we look for another means of meeting the objective? Deep Fires was a cold war study with a cold war criterion. The principles are unchanged for contingency operations; the criteria will change. The problem of definition may be even more difficult to overcome. In the case of missiles like ATACMS, the contingency operation era requirement is most likely deterrence. We need the missiles to prevent some international thug from becoming overly greedy regarding us or our friends. How do you measure the cost effectiveness of deterrence? Certainly not by cost per kill.

We talked to the Army Engineer School to find out why we need the Breecher, the interim to the Combat Mobility Vehicle that will replace the tank dozer, the Combat Engineer Vehicle. The criterion given to us is cold war. The Breecher is intended to help the maneuver forces maintain momentum and the criterion was to breech six miles of minefield in two hours. In the cold war context, this was expanded to breech 150 lanes, each lane requiring five vehicles to ensure proper width. That meant 750 vehicles were required; only 200 plus were programmed. The program was insufficient. What do we want the Breecher, or the CMV, to do in the contingency operation context, or is it now a dinosaur, extinct? The quantity has been reduced to 100 plus and the need is to clear rubble, remove log cribs, and facilitate movement through urban terrain, what the Engineers envision as contingency operation requirements. Measurable parameters can be applied to this sort of need and the sufficiency approach is

valid. Cost per kill is not. The vehicle is not intended to kill anything and the equipment whose movement it facilitates, though shooters, will be expected to deter rather than kill. How do we measure the sufficiency of logistics, management information, and training systems? All of these are intended to support the battle in one way or another. Changing the word "battle" to "operation" makes this a cold war or a contingency criteria. The biggest problem in applying sufficiency to these types of systems is measuring the impact of the system on the battle or operation. The resolution of our simulations may not be up to this. If we can't model these types of systems to that degree of resolution, we must fall back to a cost benefit approach to integration.

Logistics systems run the gamut from trucks, generators, HALO extraction straps, materials handling equipment, and the like, to armored recovery vehicles, armored maintenance vehicle, and armored rearm or re-supply vehicles. Cargo helicopters such as the Chinook could probably be considered a logistics system. What is sufficiency? How do we measure their impact on the operation? What is sufficiency for a transmission test stand in terms of supporting the operation? The test stand is intended to reduce types I and II errors. That is, it is supposed to help us diagnose true problems so we send back only those transmissions with actual failures. It should reduce the number of good transmissions diagnosed as bad and reduce the number of bad transmissions diagnosed as good. Given that the test stand will do this, how do we show the impact on the operation? The Air-Land Battle criteria for availability is 90%. Can we show that the test stand was responsible for an increase of availability to that, or any, level? If so, then sufficiency is a good approach to integrating the cost and effectiveness of the system. If the resolutions are not that good, then we must do a cost vs benefit analysis.

Management information systems are probably even more difficult to evaluate in terms of operational impact. These systems are intended to provide more information faster with greater accuracy. They are largely software programs; in some cases hardware is included. The Standard Army Ammunition System, for example, allows the G-4s to track ammunition stocks by type and location in near real time. How does tracking of stockage support the operation? If the study can show that accurate information allows the ammunition supply people to ensure positive stocks are on hand for all types of weapons and that this guarantee can impact the execution of the operation, than sufficiency can probably be used. Otherwise, back to cost vs benefit analysis. The Department of the Army Movement Management System may be a little easier to apply sufficiency to. It is a system intended to let commanders know where supplies and equipment are while in transit, again in near real time. Air-Land Battle criteria for stockage levels necessary for success is 67% of the requisition objective on-hand. With DAMMS, the commander can redirect supplies or equipment in transit to where

it's needed to ensure his success. Again, if the study can show that adequate re-supply affected the outcome of the operation, sufficiency can be used to integrate cost and effectiveness. If not, then cost vs benefit.

Training systems are probably the most difficult to relate to the impact on a specific operation or type of operation. The enhanced composite maintenance trainer, for example, trains CH-47 troubleshooters. Can we show that this trainer improves trouble shooting to the point where we meet the availability objective (90%, according to the cold war ALB doctrine or some yet to be determined percentage for contingency operations) for the CH-47s? If not then we must, again, resort to cost vs benefit.

Training systems such as the Close Combat Tactical Trainer may be easier to relate to sufficiency if you accept the fundamental assumption under which such systems are developed. If we accept that the CCTT will produce equally qualified operators and maintainers to those trained on the actual equipment, then we can merely accept the effectiveness results using the regularly trained soldiers. The costs saved through operating tempo reduction reduces the overall cost of achieving sufficiency. This would be true of any simulator system that substitutes in total or in part for actual operation of equipment, to include embedded training.

Integrating cost and effectiveness in a COEA type study is not easy. We've been struggling with the problem for years. We've talked about several approaches. There are bound to be others. The best so far, the most honest, appears to be that prescribed in DODM 5000.2M, the separate rank ordering of cost and effectiveness, strengthened by a display of personnel requirements. We intend to keep looking.