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This paper will present some of the problems I have discovered in the use of peacetime and/or wartime costs in limited war cost-effectiveness studies. I will discuss below two basic costing methods currently in practice and how they relate to the question of peacetime and wartime costs. Further, an additional costing method for limited war systems analysis will be suggested.

The terms "peacetime" and "wartime" costs are used throughout this paper. For purposes of clarification in the discussion which follows peacetime and wartime costs will be defined at this point. Peacetime costs are those costs associated with the developing, buying and maintaining a capability for potential war during peacetime. Included in these peacetime costs are the resource implications of buying and maintaining a war reserve. This war reserve is designed to cover the period at the beginning of a war before the economy is able to replace the hardware consumed during the war. The cost of producing and delivering materiel to the theater once the war has stated is a wartime cost, as is the cost of replacing the war reserve if the war terminates during the time the system is projected to be in the active force structure. Wartime costs represent all of the incremental costs above the normal peacetime costs incurred by a weapon system once a war has begun.

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TOTAL PEACETIME SYSTEM COST VERSUS AMORTIZED PEACETIME-WARTIME COST APPROACH

Two basic costing methods have been used for cost-effectiveness analysis of limited war forces. Although both methods make use of peacetime costs, emphasis in one approach is placed on peacetime costs while in the other on wartime costs. The peacetime costs utilized in both of these approaches are based on the total system costing concept.

TOTAL PEACETIME SYSTEM COST

The Total Peacetime System Cost Approach (which has been favored by RAND, RMC, IDA, RAC, PRC, and CNA) is used by OSD* in evaluating justifications for new weapon systems and for additional equipment requirements and procurement. This method depicts the total anticipated costs for the system over its expected life in peacetime--that is, peacetime costs for a wartime capability. The total peacetime system cost approach will include "all costs for the complete system, including all directly related support costs extending over the entire period from the beginning of its development to activation and on through its subsequent operation while still in the active inventory."**

The purpose of the Total Peacetime Cost Approach is to emphasize the probable economic impact of introducing a new capability into the force structure (or maintaining a current system within the force structure). Usually the cost analyst will follow current or proposed procurement policies of the military services and OSD in calculating the resources to be costed. For example, in order to develop a material procurement program, three requirements usually must be quantified: (1) initial allowance; (2) stockage for maintenance and future combat consumption;*** and (3) replacement for peacetime consumption.

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*Saul Hoch, Cost Criteria in Weapon Systems Analysis and Force Structure, OASD (Comptroller), August 1965.

**David Novick, System and Total Force Cost Analysis, The RAND Corporation, RM-2695, April 1961.

***A discussion on one method for computing the requirements for a war reserve is presented in the Appendix.

A number of analysts within the services and industry reject the Total Peacetime System Cost Approach when evaluating limited war weapon systems. The concern is with the absence of wartime costs in that costing methodology. In addition a number of these analysts desire (possibly for the sake of simplicity) to measure effectiveness only for a brief period or "slice" of a war simulation or war game.

AMORTIZED PEACETIME-WARTIME COST APPROACH

The Amortized Peacetime-Wartime Cost Approach includes both wartime and peacetime costs, and depicts the costs in such terms as cost per sortie, cost per mission, and cost per engagement.

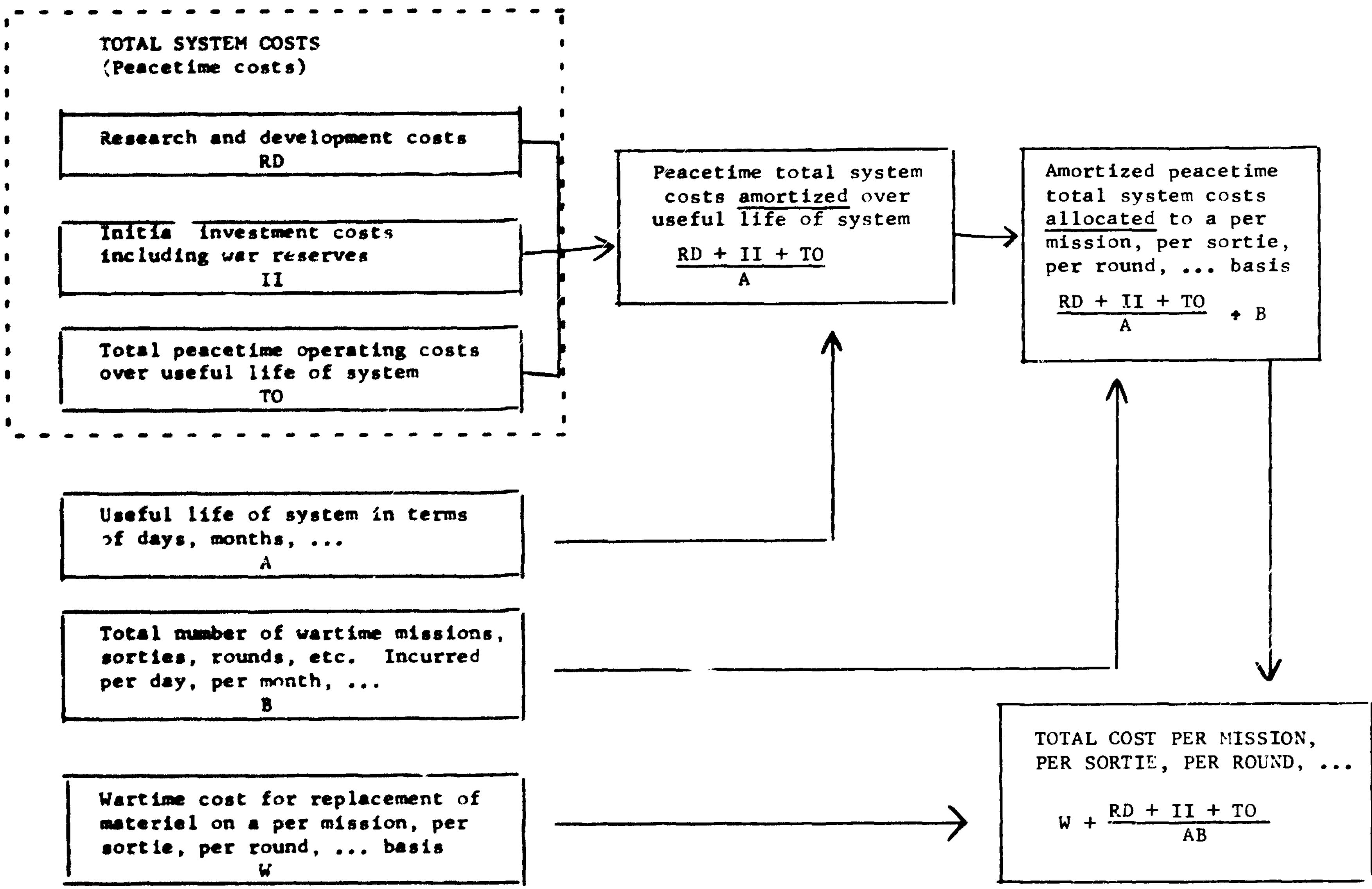
Table 1 illustrates the typical approach that has been used in both Air Force and Army studies. In this approach the total peacetime cost of the system (including directly related support costs and war reserves) is reduced to an annual cost by taking the operating, research and development, and investment costs in their entirety and reducing them to an annual basis by dividing them by their "projected useful life" in years. The amortized peacetime cost is then allocated to the wartime period studied in the analysis. To the amortized, allocated peacetime cost is then added the wartime cost of the engagement. The amortization of peacetime costs tends to be relatively small when expressed on a per day, per round, or per sortie basis.

The differences that can result by using the Amortized Peacetime-Wartime Cost Approach as against the Total Peacetime System Cost Approach are evidenced in the hypothetical and highly oversimplified example presented below.* Two future tactical surface-to-air missile systems are under evaluation. The missiles are identical in both

*While the illustrations presented in this paper are hypothetical, they are representations of examples I have seen in several cost-effectiveness studies. The concepts presented in this paper apply not only to the surface-to-air missile systems but to other types of systems as well. For example, the results of a study may be sensitive to use of wartime and peacetime costs in the comparison of tactical surface-to-surface missile systems with tactical bomber systems. Both systems are designed to deliver munitions to a target. However, the missiles delivering the warhead(s) are used only once: The missiles are consumed in flight. On the other hand, only a portion of the aircraft (those attrited during the air strike) are expended along with their bombs. Using only peacetime costs also could distort the results of this type of limited war cost-effectiveness analysis.

Table 1

AMORTIZED PEACETIME-WARTIME COST APPROACH



systems. The differences in the alternatives are in the sophistication of the ground control equipment, e.g., the acquisition radars, the ground guidance systems, and the electronic counter-countermeasures. The sophisticated missiles system will be called System A and the less sophisticated alternative will be called System B. The criterion for choosing the preferred weapon system is that of "fixed effectiveness": Select that weapon system which has the lowest cost for a given level of effectiveness. In this case, System A and System B were determined to have the same steady state level of effectiveness of "killing" an enemy aircraft when System A fires one missile and System B fires two missiles at an approaching enemy aircraft. The Total Peacetime System Cost is presented in Table 2.

Table 2

TOTAL PEACETIME SYSTEM COST

	System A	System B
Research and development costs	$ 2,000	$ 1,000
Investment costs:		
War reserve missile stockage[a].....	100	200
Other investment costs	1,900	800
Operating Costs (10 years)	7,000	5,000
Total	$11,000	$ 7,000

[a]Peacetime procurement for combat stockage up to the time wartime production equals combat consumption. Twenty days of stockage for both System A and System B. Average unit cost of missiles for both System A and System B is $5. One missile fired per aircraft killed for System A and two missiles fired per aircraft killed for System B.

System A: 20 x 1 x $5 = $100.

System B: 20 x 2 x $5 = $200.

These total system costs reflect the missiles procured in peacetime as war reserves plus research and development, initial investment, and 10 years' peacetime operating cost. The total peacetime system cost for System A is $11,000 and for System B is $7,000. System B with its less sophisticated ground control equipment is the lowest cost alternative and, hence, with equal effectiveness, the preferred system.

Using the same cost information as presented in Table 2 and the amortized peacetime-wartime formula presented in Table 3, the cost analyst may obtain entirely different results as shown in Table 4.

Table 3

TYPICAL FORMULA FOR AMORTIZED PEACETIME-WARTIME COST APPROACH

$$C = M + \frac{O + \frac{R + I}{A}}{365B}$$

C = Total wartime-peacetime cost per aircraft killed.

M = Cost of missiles utilized to kill aircraft.

O = Annual operating cost of weapon system, dollars per year.

R = Research and development cost of weapon system, dollars.

I = Initial investment of cost of weapon system, dollars.

A = Amortization period, years.

B = Number of aircraft engaged per day.

* * * * * *

Table 4

AMORTIZED PEACETIME-WARTIME COST APPROACH EXAMPLE[a]

$$\text{System A:} \quad \$\,5^{b} + \frac{\$700 + \frac{\$2000 + \$2000}{10\ \text{yr}}}{365\ (1)^{c}} = \underline{\underline{\$\ 8 \text{ per aircraft killed}}}$$

$$\text{System B:} \quad \$10^{b} + \frac{\$500 + \frac{\$1000 + \$1000}{10\ \text{yr}}}{365\ (1)^{c}} = \underline{\underline{\$12 \text{ per aircraft killed}}}$$

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[a]Cost figures based on hypothetical data in Table 2.

[b]Two missiles fired per aircraft killed for System B, 2 x \$5 = \$10. One missile fired per aircraft killed for System A, 1 x \$5 = \$5.

[c]If more than one aircraft were engaged per day, the difference in the costs of the systems would become even more pronounced.

Using this approach, System A is the lower cost alternative. The results of the approach are a comparison of system costs in which the principal emphasis is given to the costs expended during one brief period of a conjectured war as against the lifetime costs of research and development, initial investment, and annual operating associated with the weapon systems. This emphasis distorts comparison where systems differ significantly.

Thus, one approach shows System A as being much cheaper, while the other approach markedly favors System B.

The Amortized Peacetime-Wartime Cost Approach <u>should not be considered</u> proper methodology for the following reasons:

(1) Adding amortized costs (peacetime costs) to another annual cost stream (wartime costs) <u>implies</u> that both cost streams represent the <u>same total time duration</u> If this is not the case, then one should not add the two cost streams together. The amortized peacetime costs when added to the wartime costs for missiles <u>implicitly</u> assumes that the war will continue over the <u>entire</u> lifetime of the system.

(2) The cost results computed by this method are also weighted results. Since the wartime costs are not of the same total time duration as the peacetime costs, the results are weighted in favor of the shorter time period--the wartime costs. It is only when the two cost streams are of the same equal length in an amortized formula that the cost results are properly weighted.

(3) There may not be a common measure between the dollar cost of resources procured in wartime as opposed to that procured in peacetime. Military budget constraints during peacetime and resource constraints during wartime may produce entirely different sets of dollar costs for the same military resources. During wartime, direct controls may be imposed on the use of critical resources such as raw materials, machinery, and the mobility of labor. The true opportunity costs for resources in wartime may not exist because these resources cannot respond to price movements which reflect the demand for their use. Since wartime prices under the above conditions may not indicate the relative scarcities, it is possible that minimizing wartime dollar costs as a guide to system selection will not take into account the value to the war effort

of the alternative uses of available resources. The ability to add wartime and peacetime costs together will depend, in part, on such factors as the type and duration of war.

(4) One further reason that the amortized cost approach is questionable is that it does not present a true picture of the total resource implications. Instead, the total peacetime costs are reduced to a yearly, daily, mission or sortie basis. If the system is to be in the force structure for 10 years these amortized costs may look relatively small, yet in reality be relatively large dollar costs. It is the total resource implications of the alternative systems that is of primary concern to the military decisionmaker--not a subset of this cost.

WARTIME-PEACETIME COST STREAM APPROACH

In the preceding discussion it was indicated that the costing methodology used in the amortized peacetime wartime cost approach was highly questionable. But should one look only at peacetime costs as presented in the total peacetime system cost methodology when evaluating limited war forces? The answer to this question usually will be determined by the set of objectives to be accomplished and the criteria for selecting the preferred alternative. There are times when the analyst will require wartime costs in addition to the costs included in the Total Peacetime System Cost Approach.

As mentioned earlier, however, peacetime and wartime costs may be incommensurable. It is best to estimate them separately--the peacetime costs time-phased from the present, and the wartime costs time-phased from the time the projected war is assumed to commence (D-day). If one alternative dominates (provides the given effectiveness for less peacetime cost and less wartime cost) there will be no necessity of reconciling these incommensurables. If no dominance exists (the alternative which is cheaper in peacetime cost is more expensive in wartime cost) the peacetime and wartime costs can be evaluated together by the analyst only by making assumptions about the probability of war occurring, the length of the war, when the war starts, and the relative size of the peacetime and wartime budgets. It would be preferable, and more practical, to present the alternatives to the decisionmaker with the incommensurable peacetime and wartime cost streams, leaving it to his judgment to weigh their relative importance and reach a decision.

The following example utilizing the two surface-to-air missile systems discussed previously will help to illustrate why wartime costs might be required in a cost-effectiveness study as well as how it might be presented to the decisionmaker.

Given the cost information for Systems A and B (as shown in Table 5) one can see that neither system has cost dominance. The assumption as to the number of enemy aircraft to be engaged per day, the number of missiles required to "kill" the aircraft, and the number of days of war incurred over the projected useful life of each system is crucial to the selection of the preferred weapon system.

Table 5

PEACETIME AND WARTIME COSTS OF TWO HYPOTHETICAL SYSTEMS

	System A	System B
Total peacetime system costs[a]	$11,000	$ 7,000
Wartime cost for killing one aircraft, per day (based on the hypothetical steady state effective measure of 2 missiles for System B vs. 1 missile for System A	$ 5	$ 10

[a]Based on hypothetical data presented in Tables 2 and 4.

Assuming commensurability, one may see from Table 6 and Fig. 1 that if the war (or wars) is assumed to last less than 800 days during a 10-year useful life of the systems, then System B would be the lower cost alternative relative to System A. If the war (or wars) continued for more than 800 days, then System A would be the preferred system. For 800 days of war there is a cost indifference between the two systems. By presenting this type of information to the decisionmaker, along with qualitative analysis, the decisionmaker should be in a better position to select the preferred alternative.

Table 6

COST INDIFFERENCE BETWEEN SYSTEM A AND SYSTEM B

	System A	System B
Peacetime costs	$11,000	$ 7,000
Wartime costs for missiles expended during 800-day war[a]	4,000	8,000
Total peacetime and wartime costs for 800 days of war	$15,000	$15,000

[a]System B: 800 days x $ 5/day = $4000.
System A: 800 days x $10/day = $8000.

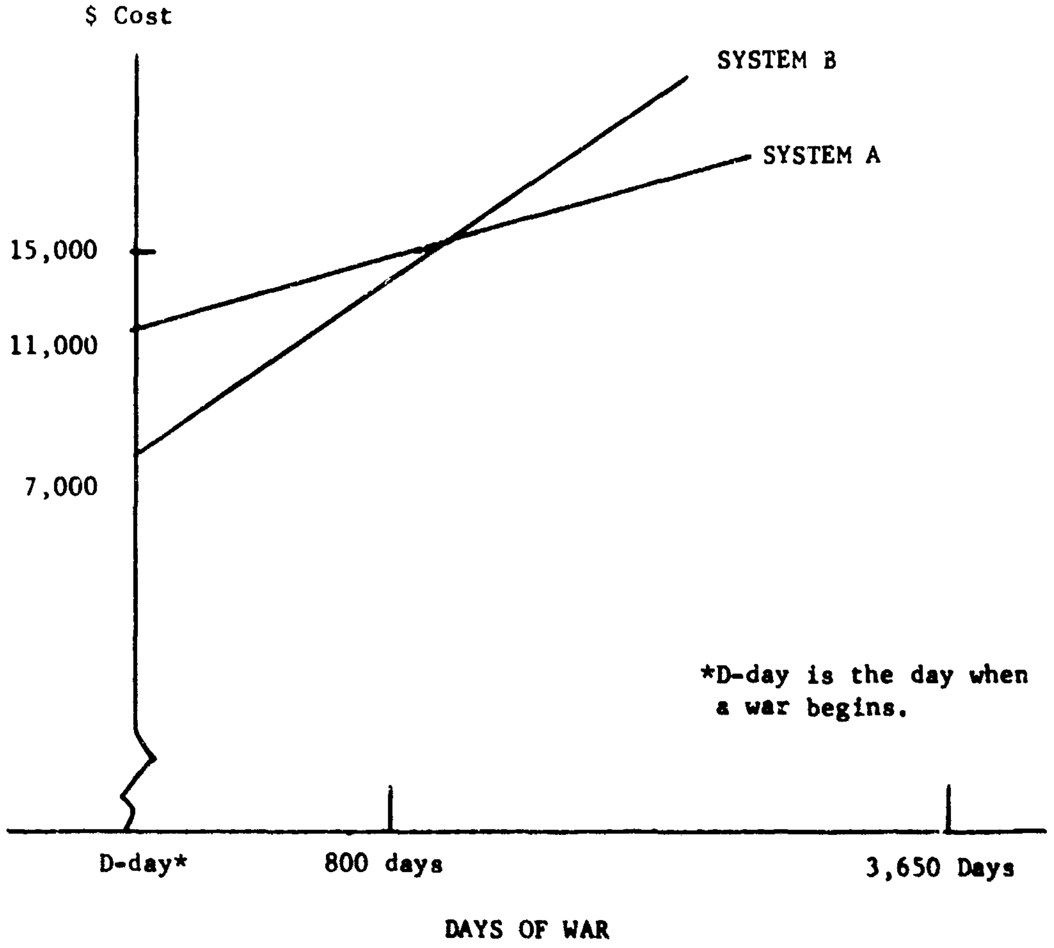

Fig. 1 - System Cost as a Function of the Days of War Over 10 Years' Useful Life

Appendix
A METHOD FOR COMPUTING WAR RESERVES

A method used to estimate the requirements for war reserves is called the D to P Concept. The D to P Concept pertains to the development of combat consumption stockage requirement when anticipated wartime production is considered in the fulfillment of wartime combat consumption requirements. In this concept, the war reserve must be large enough to support the wartime rate of consumption until the point in time when the rate of production is equal to the rate of combat consumption. This point is called P-day. D-day is when the war begins.

The D to P calculations are illustrated in Table 7 for two hypothetical items. The columns entitled Wartime Consumption represent requirements from D-day to P-day--10 time periods in this example. "Hot Base" production means the items in question are already in production on D-day. ("Cold Base" production would mean that machinery and tooling were available for the items but at present there is no actual production.) As already defined, P-day occurs when the production rate becomes equal to the wartime combat consumption rate. P-day may differ for each given item, and according to whether the production base is "hot" or "cold".

To calculate the necessary pre-D-day war reserves to complement production in meeting combat consumption until P-day, the combat consumption requirements are summed for the period D to P; production is also totaled for the period; if the consumption requirements are greater than what is produced, the difference in the quantity is the war reserve requirement. This stockage is a peacetime cost. The cost of producing materiels after D-day is a wartime cost.

Table 7

D-TO-P CONCEPT FOR CALCULATING WAR RESERVES

Time	Wartime Consumption (Estimated)		Production Base (Estimated)	
	System A	System B	System A	System B
	(Units)		(Units)	
D+1	4	7	3	5
D+2	4	9	3	6
D+3	5	9	3	8
D+4	7	10	4	8
D+5	7	11	4	9
D+6	8	11	6	10
D+7	9	11	6	10
D+8	10	11	8	11[a]
D+9	10	--	9	--
D+10	10	--	10[a]	--
Total	74	79	56	67

Required peacetime stockage for war reserves:

System A: 74 - 56 = 18 18 units for System A

System B: 79 - 67 = 12 12 units for System B

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[a]**Maintainable.**