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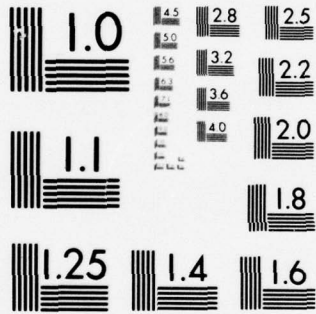
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USAAVSCOM TECHNICAL REPORT 77-13

FOREIGN MILITARY SALES

CONSTRUCTION OF A REPLACEMENT PRICE
(SOME CONSIDERATIONS, PROBLEMS,
AND POTENTIAL SOLUTIONS)

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B.S.

Warren H. Gille, Jr.

February 1977

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Prepared For

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report examines the considerations involved in developing a Replacement Price and makes problem areas more visible. It consists of three basic parts Part One ¹⁵ A brief Historical Sketch of Military Assistance, 1947 to date, especially the transition from Grant Aid to Foreign Military Sales. →		

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discusses
Part Two Construction of a Replacement Price and the considerations involved in estimating today's replacement cost for items purchased in the past.

discusses
Part Three Considerations involved in computing what actual replacement cost would be, taking into account future inflation, number of items procured, spendout, time required for procurement, and other influential factors.

the Purpose: *this report is* To provide insight into the theory of Replacement Pricing. Specifically, to identify problems which might not be evident to some FMS related personnel and provide illustrative examples. Additional information, glossary, charts, and explanations are presented, in order to make the document of use to a broad cross section of the Federal community.

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DISCLAIMER STATEMENT

The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

This paper can be used by all levels of management and types of personnel engaged in the Foreign Military Sales endeavor, such as procurement, materiel, delivery, international logistics, and financial management. Because a replacement price is the basis for recoupment of other charges, it is hoped that this paper sheds some light on our common problem and that the resulting visibility will aid in its solution.

ACKNOWLEDGEMENTS

Appreciation for assistance is extended to Mr. Frank Blackshear and Mr. Andrew Greco of the Comptroller FMS Group, and Ms Barbara Kasper, of the Data Analysis and Control Branch staff, for clerical assistance.

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I. PREFACE

With the passage of the National Security Act of 1947, which established the initial U.S. Government commitment to provide military and economic aid to foreign governments after World War II, the United States made a pledge to deter global conflict through providing countries in jeopardy the equipment and supplies necessary to insure adequate self-defense.

In the early years, even many of the advanced European countries were faced with insurmountable credit problems, and possessed economies which were at a virtual standstill. Under such circumstances, it was evident that outright grants of economic and military aid comprised the only viable solution. As time passed, a number of smaller, less developed countries, caught in the midst of world tensions and threatened by the spectre of external aggression, were added to the program. Because World Security weighed in the balance, despite strong criticism, many observers felt that such grants of equipment were justified, as they did not involve the use of U.S. manpower, which can be the majority of the expense in a defense system's life cycle cost. As the world economic picture brightened, even some third world powers began to attain some degree of financial strength, and it became evident that the situation which had necessitated Grant Aid was changing significantly. The need for high quality military goods and manufactured items, which can only be produced by a major power, was still in evidence, but the "ability to pay" on the part of many countries began to develop

rapidly. The U.S. Government's philosophy changed to "recovery of costs" for such equipment from those governments that did indeed have the ability to pay. Those countries which were now required to pay, would still profit from the best technology, supply support arrangements, and the finest service obtainable on such equipment. In addition, the financial, administrative, and technical services provided by the International Logistics/Foreign Military Sales organization made it possible for countries, inexperienced in the procurement of new items, to have liaison with the contractor which adds reassurance as to contract performance and renders a clear explanation of the specific items or equipment under consideration.

As Grant Aid was rapidly being replaced by Foreign Military Sales, the problem of Pricing became of paramount importance. In the case of a new procurement, the concept of sending the customer an estimated cost, and billing for the actual cost, when known, seemed acceptable. However, in the case of a sale of an item from stock in Army inventory --- which will have to be replaced --- a simple but accurate procedure which applies to all items is not well defined. Due to inflation, varying contractor efficiency, learning in production, dissimilarity among items and types of equipment, and a host of other influences, the calculation of replacement price can be extremely difficult. However, the necessity of insuring that the Army will not lose money on Foreign Military Sales has given "accurate Replacement Pricing" highest priority.

The goals to be achieved by a replacement price, as established by DODI 2140.1, are several. The concept of replacement price centers on recoupmnt of production cost. Since many of the other charges depend on the quantities to be procured or are calculated as a percentage of the replacement price, proper understanding and the refinement of techniques for replacement pricing are central to the success of the Foreign Military Sales managerial effort.

II. INTRODUCTION AND PURPOSE.

When the U.S. Government makes a sale of new non-excess items to a Foreign Military Sales customer from inventory for immediate delivery, basically, two things are being done. First, essentially we are doing the customer a service, because procurement for many items would involve a considerable period of time, and in many instances the purchaser is neither able nor prepared to wait for production. Second, we are depleting our stock and in most cases we will have to replace those items sold. The primary problem lies in obtaining sufficient compensation from the FMS customer to replace the item and to recoup all of the costs associated with the sale and replacement activity --- and nothing more. If our recoupment falls short, we may not be able to replace the entire quantity sold, and thus may not only short-change inventory, but also the materiel strength and effectiveness of our own men in the field.

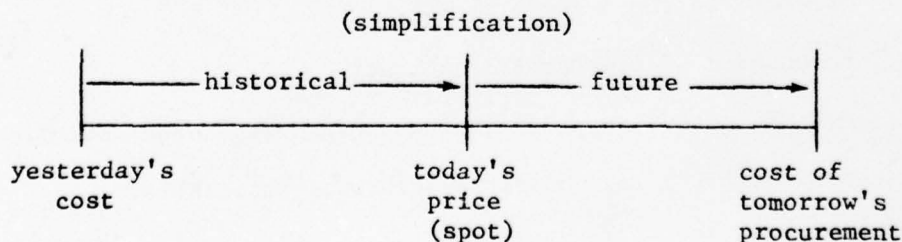
The brief analysis of replacement pricing methodology presented here provides some insight into the potential problems involved in the recoupment process associated with Foreign Military Sales, and identifies a common ground upon which future inquiry can build.

III. CONSIDERATIONS IN THE CONSTRUCTION OF A REPLACEMENT PRICE.

Constructing a valid Replacement Price, one which will fully recoup the Army's total replacement cost associated with an item, is obviously a very difficult task. Measurement problems; comparability of items with regard to number procured, quality, and materials; uncertainty with respect to inflationary trends; and the time pattern of disbursement or spendout are among the more important considerations which Foreign Military Sales (FMS) personnel must take into account. Many concepts of "Replacement Price" have been developed, and many more will be formulated in the future. The objective of this paper is to outline the process by which a replacement price is constructed and some of the problems, both obvious and concealed, which must be identified and solved when developing such a methodology.

A. Statement of Task: FMS.

In plain language, in an FMS sale from inventory, the Army sells items which were bought yesterday (recent or distant past) --- today --- for a sum of money which we hope will be sufficient to replace them tomorrow, and recoup all the associated costs for their sale, development, and physical delivery. Thus, the construction of a replacement price involves a two step process:



Obviously, the challenge lies in establishing a methodology which will effectively accomplish just such an end.

Before attempting to devise a method for developing a replacement price, it would seem reasonable to establish a uniformly acceptable set of basic points, which must be satisfied, for any replacement pricing method to really be "acceptable." Methods can be compared only if the foundation upon which they are built is the same.

One such basis consists of the following points:

B. Some Necessary Conditions for a Replacement Pricing Methodology to be Reasonable.

1. The method must be easy to understand and use by those involved in its application and dissemination.

= This assures that it can be applied correctly, without undue delay, confusion, or misapplication.

2. The method must be clearly justifiable to the customer, as a pricing rationale.

= The most accurate replacement price estimate in the world is of little value, unless it makes sense to the customer. Extremely complicated and obtuse mathematical constructs, which the customer can not understand and does not believe, are detrimental to the purpose of FMS.

3. Recoupment of item cost - Accuracy.

a. The method should minimize the error of each estimate, while concurrently, being understandable and justifiable.

= The error on each estimate should be as small as possible, consistent with other considerations. This is to prevent the line item manager from being shorted on replacement of inventory, on a continual basis.

b. The sum of the errors over all cases should be zero.

= No matter how hard we try, or how "accurate" our methods are, we still produce estimates, which by their very nature are inexact. Since estimates include some error, it would be nice if they "averaged out" to zero over all contracts, so that the Army would not lose money on total sales. Even a very small error, if consistently on the low side, yields a large loss on a high total dollar contract volume. An error as small as .005 yields \$5 million loss, if low, on \$1 billion in sales.

4. The method must be flexible and amenable to change, when conditions change.

= A method which only applies to a limited number of conditions, and is not susceptible to change when needed, is of limited value. A major overhaul of procedures, forms, and pricing techniques can be costly in terms of both money and time. Changes in policy or economic conditions should be incorporated quickly and smoothly, without any excessive cost or undue delay.

C. Considerations in Constructing a Replacement Price.

The one piece of information which we generally do have about an item that we are selling from inventory is a "price." Several questions pertaining to the use of this past procurement price as a start for a replacement price are:

1. Is this price, the price for the "Same" item that will be purchased in replacement?
 - a. Are the previous and replacement items made out of the same materials, by the same methods, with the same mix of machinery and labor?
 - b. Is the quantity to be obtained in the replacement procurement the same as that in the procurement for which we have the last price on record?

Specifically, with regard to quantity:

- (1) Learning curve theory generally predicts some gain in labor's efficiency, and thus lower per unit cost, as quantity produced increases.
- (2) Manufacturer's per unit cost for materials may decline on large orders because of quantity purchases. The bargain obtained on a large previous procurement may be due to variable cost, as well as fixed cost, considerations.
- (3) Manufacturers are often willing to cut per unit profit in order to maximize total profit, when an order's size is expanded significantly.

Once comparability is established, the primary concern is with the historical inflation index to be used.

2. Is a "proper" historical index available and, if so, what qualities determine its accuracy?

An index refers to a commodity or group of such similar items. Some bases for similarity must be established between the item whose price is to be inflated and the items comprising the inflation index used, if the indexing procedure is to yield a meaningfully updated price.

= When one index is used for several "dis-similar" items, very few, if any, of the "updated prices" will be accurate. This amounts to using the average value to predict each value out of which the average was developed.

For example, if the average of seven numbers is 5, one set of dissimilar numbers which will satisfy this is:

$$11 + 9 + 7 + 4 + 3 + 1 + 0 = 35$$

$$\underline{35 \div 7 = 5}$$

Obviously, few of these numbers are close to the average or indexed value of 5. This yields a justification for the construction of separate historical indices on the basis of similarity among indexed items.

In particular, this is the use of an aggregate index to explain "why end item managers may be shorted on items,

even if all of the other problems of FMS were solved."

Although an index may be correct in general, it may not be correct for many particular items. Further, the principle of fairness to the customer may not be upheld. Purchasers of some items might be perennially overcharged, whereas others would continually be undercharged.

IV. EXAMPLE OF AGGREGATE INDEX ERROR, AND ONE POTENTIAL SOLUTION.

Suppose:

1. The cost of an item is 80% materials and 20% labor.
2. That materials inflation is high: 14% (example: Plastics, externally controlled-petroleum related).
3. Labor rate is subject to low inflation: 5%.
4. That the aggregate inflation index for the year under consideration is 8.0%.

Then the index using actual data is:

$$14\% (.8) + 5\% (.2) = 12.2\%$$

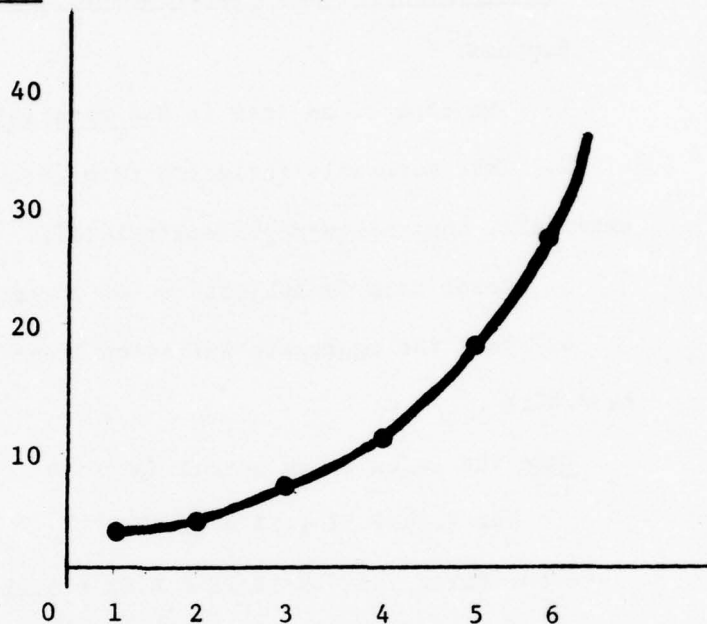
$$\text{error first year is } 12.2\% - 8.0\% = 4.2\%$$

However, over the years the difference becomes much more important:

	<u>Actual</u>	<u>Aggregate</u>	<u>Differences</u>	<u>Error</u>
1st Year	$(1.122)^1$	$(1.08)^1$	$12.2-8.0$	$= 4.2\%$
2nd Year	$(1.122)^2$	$(1.08)^2$	$26.0-16.6$	$= 9.4\%$
3rd Year	$(1.122)^3$	$(1.08)^3$	$41.2-26.0$	$= 15.2\%$
4th Year	$(1.122)^4$	$(1.08)^4$	$58.5-36.0$	$= 22.5\%$
5th Year	$(1.122)^5$	$(1.08)^5$	$77.8-46.9$	$= 30.9\%$
6th Year	$(1.122)^6$	$(1.08)^6$	$99.5-58.7$	$= 40.8\%$

Graphically, the error is as illustrated. Further calculations may be carried out if desired. It is interesting to note that for 10 years, the error is $(1.122)^{10} - (1.08)^{10} = 3.16 - 2.16 = 100\%$

% Error



The error is the difference¹ between two power functions, and it depends on three factors:

1. The relative sizes of the actual inflation factor (i.e., X = 12.2%) and the aggregate inflation factor used (i.e., Z = 8.0%)
2. The absolute sizes of the inflation factors.
3. The number of years, B, in the time period under consideration.

$$\text{Error} = \left| (1 + X)^B - (1 + Z)^B \right|$$

¹Absolute value of difference.

The number which would result from compounding the original 4.2% error is much less than the "actual error" calculated above. For example, for 6 Years: $(1.122)^6 - (1.08)^6 = 1.408$; $(1.042)^6 = 1.28$

Actual error = 40.8%; Incorrect method by compounding (4.2%) yields 28%. The first, or actual, should not be confused with the latter, which is incorrect theoretically.

A number of methods exist for grouping items in aggregates according to similarity. An obvious approach would be to group by similarity of function, construction, appearance, or qualitative features. This is reasonable when the total number of items is "relatively" small, but not so reasonable in the case of, say, secondary items, which number many thousands. Even with 150 items per group, there could be more than 100 indices, all of which would require continual work, maintenance, correction, and update. The reason for using an index is to obtain a good estimate without doing all the computations for every item considered. A tradeoff exists between the increased accuracy and savings derived from a more detailed breakdown (e.g., more indices) and the cost, in both time and money, of doing the additional work.

As well as by stratifying items according to physical similarity, method of construction, or performance of function, indexing might also be done by Inflation-Production Categories. An example is based on

Three Categories of Production

- I. Material Cost = 70% or more
(Labor Cost = 30% or less)

- II. Material Cost between 40% and 70%
(Labor Cost is between 60% and 30%)
- III. Material Cost less than 40%
(Labor Cost greater than 60%)

Two Categories of Inflation

Suppose:	<u>Materials</u>		<u>Labor</u>	
	High	A% 12%	High	C% 9%
	Low	B% 6%	Low	D% 5%

Inflation levels would be included on a current high/low updated basis.² This particular example would result in twelve indices, which would more accurately reflect the price level changes which have occurred for more items. A frequency distribution would be used to determine the average value within a group, which would improve the estimate compared to the previous result, which used the midpoint of the interval. For instance, within the 70% material or more group, the cost of very few items is 100% attributable to materials.³ Most may be nearer the 70% value. The average value used would not be

$$\frac{70\% + 100\%}{2} = 85\%$$

but rather, more heavily weighted toward 70%, possibly closer to 77%, but determined by the facts of the matter.

After insuring that the items to be purchased for replacement are comparable to those to be sold, with regard to physical, production,

²When reassessed periodically, both production and inflation categories would be adjusted.

³Essentially, such an item would be a commodity.

qualitative, and quantitative characteristics, and that this "adjusted cost" is accurately brought up to the present, a spot replacement cost has been determined. The term "spot" merely refers to what the item is "worth" at this point in time --- on the spot. It is possible to sell an item from inventory at a point in time, but unfortunately, in most cases not possible to replace it instantaneously. When time enters into the replacement process, so does future inflation, as well as a number of other considerations which are not as obvious. These must be included if replacement pricing is to generate the funds necessary to actually replace the items sold.

After a spot replacement cost is calculated, the effect of time must be incorporated into the analysis. When historical indices are applied, a cost is translated from a previous year to another (usually the current) year. In procurement, not only must future inflation be taken into consideration, but also the years in which a project's money is to be spent. Historical indices are "compound" in nature --- that is, they only include the effect of an inflation rate and the number of years being considered.⁴ On the other hand, inflation methodology designed to be used for future predictive purposes, such as cost of procurement, must not only acknowledge inflation rates, but also identify the spendout rates and years expected.

⁴Similar to compound interest on a specific dollar sum.

V. COMPUTING REPLACEMENT COST ON FUTURE PROCUREMENT, USING TODAY'S (SPOT) COST.

By definition, the composite inflation index differs from the compound inflation index, because it includes a variable weighting system. Further, the composite and compound indices are designed to be used for different purposes. The composite is used to reduce a flow of funds, scheduled to be spent over a multi-year period, to one cash figure. In a very real sense, a composite index is project oriented. On the other hand, a compound index can only be used to translate a single dollar figure from one year to a different year. Theoretically, any actual disbursement which is based on a compound inflation index will be completed within the single time interval referenced. Due to the realities inherent in the development, production, and delivery processes,⁵ and the fact that most contractors require payment on a percentage of completion basis, the disbursement process usually involves several years, and is anything but uniform. Hence, the genuine need for composite indices.

⁵Even though indices are prepared separately for several activities.

VI. POTENTIAL PROBLEMS CONCEALED IN COMPOSITE INDICES.

Because a specific time horizon and expenditure pattern are embedded in a composite index, (whether or not the analyst is acutely aware of it), a number of potential problems are concealed in the application of such an index, in routine fashion, to projects with distinctly different outlay patterns. For instance, as the rate of inflation increases or decreases between years or as a rapidly moving trend, and as the proportion of project funds spent in each particular time period diverges from the similar project or project "norm", the accuracy of the resulting estimate (e.g., for replacement cost) becomes more seriously compromised.⁶ This occurs in any event, whether the composite index is based on a macro-military equipment aggregate or is related to the cash outlay experience on a specific item of equipment.

The following example⁷ illustrates how variability in weighting affects the accuracy of "results" obtained using a composite index. The item --- 25 "aircraft" --- were completed in year 0 and are to be sold at the end of that period. The problem is to accurately estimate the required replacement appropriation. The cost of the aircraft just completed (year 0) is objectively verifiable, it is assumed that future inflation rates are known with certainty, and it is assumed that all production costs are accurately known.⁸ The significance of the

⁶ Even given perfect knowledge of what inflation rates will be.

⁷ Attached.

⁸ Merely to isolate the effect on the estimate of changing weights.

MATHEMATICAL EXERCISE

1. 25 "Aircraft" @ \$1 million each are delivered in Year 0.
2. AVSCOM sells them from inventory; DA must decide on needed replacement appropriation.

RELEVANT QUESTIONS

1. What is the cost of a replacement run of the same aircraft?
2. Does it vary merely with a change in the delivery schedule and payment pattern? (e.g., weights).

Only Question 2 will be answered, but it significantly affects our universal problem 1.

B = Use of weighting factors on previous run.

A = Use of weighting factors obtained according to current manufacturing conditions.

All problems, except outlay patterns, are assumed away, in order to isolate the effects of an inaccurate composite index weighting structure.

<u>i</u> <u>Year</u>	<u>I_i</u> <u>Inflation</u>	<u>I_i</u> <u>Compound</u>	<u>Weights</u> <u>A</u>	<u>Compute</u> <u>Composite</u> <u>A</u>	<u>Weights</u> <u>B</u>	<u>Compute</u> <u>Composite</u> <u>B</u>	
1	(1.07)	(1.07)	x (10%)	= .107	x (20%)	= .214	
2	(1.10)	(1.177)	x (15%)	= .177	x (15%)	= .177	
3	(1.06)	(1.248)	x (15%)	= .187	x (25%)	= .312	
4	(1.08)	(1.347)	x (20%)	= .269	x (25%)	= .337	
5	(1.11)	(1.496)	x (40%)	= .598	x (15%)	= .224	
				Composite Wt. A	1.338	Composite Wt. B	1.264

Appropriation based on

(B) Replacement Composite w/o "information" = $25 \times 1.264 = 31.60\bar{M}$

(A) Replacement with meaningful weights = $25 \times 1.338 = 33.45\bar{M}$
with "information"

(underappropriation) Net Loss = $(1.85\bar{M})$

example results is due entirely to the production and disbursement time schedules. The net difference is \$1.85 million dollars in appropriations on a \$25 million dollar contract. The inflation rates used are quite ordinary: from 6% to 11%, which is comparable with recent experience. If the inflation rates are still assumed to be known with certainty, but to be somewhat higher, the inaccuracy would be even larger. And if an aggregate composite index had been used, likewise, the appropriation miscalculation probably would have been much greater.

This example, obviously, is highly artificial and is merely a numerical exercise. However, the problems which caused the financial disparities that surfaced in these calculations may be present in any number of actual composite index problems. If nothing else, before using a composite index one should at least be cognizant of the assumptions involved in its individual construction, and how these relate to the problems at hand.

The problem, as depicted through the example, is the converse of the usual economic "present value" calculation, when future monetary returns are not uniform over the payment horizon. In both cases, the use of numerical values based on specific information in the calculations yields a more precise "mathematical solution." The economic viability of such a process depends on the cost --- in time and money --- of obtaining just such accurate information as a problem requires. In the case of replacement of military items sold from stock, the weights might be obtained simply by referencing the replacement contractor, in lieu of using some artificially averaged weighting system obtained from an aggregate composite index.

VII. SUMMARY AND CONCLUSIONS.

In the procurement (or restocking) process, a number of questions must be answered, among them being:

A. What items (e.g., types, characteristics, and quantities) are to be purchased?

B. What will inflation (changes in factor prices --- labor, materials, etc.) be for each, over the relevant years?

C. In what year(s) will the "appropriation under consideration" be spent? That is, how will the outlay or payments to contractors be made over time?

The usual problem thought of as inflation is contained in B. In general, economists use spot price indexes as a tool for measuring "inflation", and are not concerned with many of the specific applications such as the narrowly scoped, but quite useful, composites which can be built using their compound foundation; they treat factor prices as variable and outlays as completed within the current time period. When large sums are spent in different outlay patterns over several years, the question addressed in C becomes relevant. In the preceding aircraft example, the cost of factors (including rate of price increase) was assumed to be known over time, and the cost of the "pattern" in which the project's funds are spent was considered. The item usually thought to be fixed (the outlay pattern in any specific case) was made variable and those which are usually variable (e.g., inflation) were isolated and fixed. The conclusion, based on the mathematical example, was that the outlay pattern, itself, exerts influence on cost, even under normal conditions.

If the error introduced by using a composite index based on general or "averaged" weights were the only source of error, much of the time such error might be of little consequence. However, when this weighting error is compounded by other errors, the original error due to the use of an inappropriate spendout schedule may be magnified many fold. Several statements indicate the potential of this problem.

"It is the interaction of inflation rates with other elements that produces spectacular increases in weapons systems cost estimates --- not underestimates of inflation alone."⁹

Further . . .

"In and of itself, with no schedule changes or other changes in estimates, inflation may add relatively modest amounts to system cost estimates. When inflation is greater than expected, and when schedule changes and other changes also occur, program cost estimates can easily double."¹⁰

As discussed in the preceding analysis, composite and compound indices were devised to be used for different purposes. The compound index, of which the historical index is an example, translates the dollar cost of an item from one point in time to another. It applies to "spot" sales, and should be used only for items which can be restocked during the current period. When dealing with durable equipment (like helicopters), although they can be sold on the spot, it usually takes a significant amount of time to replace the depleted inventory. Future

⁹DOD Study on Cost Escalation, Report to Committee on Armed Services, U.S. House of Representatives, 1972, p. 49.

¹⁰Op Cit, p. 51.

inflation, and the outlay pattern the contract involves, determine the cost of replacement, with today's spot cost being quite different from replacement cost if the items are to be produced over a several (or even five year) period.

In the case of the currently used composite indices, the inflationary trends in the various activities (procurement, RDT&E, etc) are made specific, but the outlay pattern is for each aggregate, and is not tailored to the particular aircraft or project.

In a normal procurement operation, actual spendout rates are eventually known, and supercede the composite when applicable. In Foreign Military Sales, the collection period allows for requesting additional funds from a customer up to two years after the agreement is reached, a length of time which may not permit any substitution of actual rates for the composites. In a sale from inventory, the price quoted represents for all intents and purposes, dollar received. These considerations do not preclude obtaining the best specific information available. The use of information about current production or procurement patterns with regard to the actual outlays involved is somewhat unorthodox with respect to FMS, but possibly quite productive.

A number of considerations pertinent to the construction of a replacement price have been mentioned in the preceding analysis. Many problems exist, especially relating to particular situations at individual commands, and problems will continue to surface. Because the relative cost of a problem, and hence its importance, may differ greatly across commands, disagreement as to which specific replacement

costing procedures should be used will always exist. Nevertheless, it is essential that a common understanding of the major problems faced by each command be reached. Only by achieving such an understanding can a basis for productive work in replacement pricing methodology be established, and creative improvement be perpetuated.

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IX. GLOSSARY.

Absolute Value - the absolute value of a real number, denoted by $|x|$, is that number with positive sign $|-x| = x$; $|x| = x$
 $|9 - 11| = |-2| = 2.$

Aggregate Index - is an index for an aggregate or group of items, as opposed to an index for a single homogeneous commodity.

Compound Index - is the year to year escalation rate compounded over a period of years. If the base year is yr 0, and escalation rate in yr 1 is 5% and in yr 2 is 7%, the compound rate is $(1)(1.05)(1.07) = 1.124$ which translates year 0 dollars to year 2 dollars.

Composite Index - a project oriented index which inflates the percentage spent in each year of a multiyear project by the compound rate which applies to that year and sums them to one base year figure.

Fixed Cost - a cost which is independent of the quantity of items produced. Examples: taxes on contractor's plant, and insurance.

Historical Inflation Index - an index which permits the translation of dollars from one year in the past to the current year or from any year to another year in the set of past years referenced. This type of index makes past costs comparable with current costs for the same item or project, and has wide application in the areas of cost estimation and analysis.

Index - a numerical procedure used for tracking and comparison purposes.

Some indices preserve both order and "first differences."

For example, if an inflation index moves from 1.00 to 1.50 in year 6 and to 2.00 in year 10, the 50% change (1.50 - 1.00) from year 0 to year 6 is comparable to the 50% change (2.00 - 1.50) from year 6 to year 10. This characteristic is one form of the mathematical property called "cardinality."

Inflation - a decrease in the purchasing power of the unit of account (dollar) in general or specific terms. Decreases in purchasing power (price increases) are often ascribed to excess demand, raw material bottlenecks, and passing on of increased costs to the consumer, among other factors. The term inflation rate is sometimes synonymous with escalation rate on a single year basis. The primary problem in measuring inflation is selecting a "typical" basket of items to be indexed. Even among the same groups of items, what is "typical" changes over time.

Learning Curve Theory - a theory concerning the increase in efficiency or productivity achieved as workers obtain additional assembly and production experience on a given system. Theoretically, costs "should" decrease at some predictable rate, as less labor time is required to produce each unit, (i.e., helicopter airframe or tank).

An 80% learning curve means that each time the quantity is doubled, cost for the next lot referenced (1st, 2nd, 4th, 8th . . .) is 80% of the previous lot, in a manner of speaking.

Power Function - A mathematical function of the form Ax^B , where A and B are constants. $1 + x + 2x^2$ is the sum of three power functions: $x^0 = 1$, $x^1 = x$, and $2x^2$.

Projected Index - an index which is designed to describe the future course of inflation, which is based on the use of various economic indicators, (leading, concurrent, lagging), and projected using econometric techniques.

Spendout Rate - in a project which extends over a several year period, a different proportion of project funds may be spent in each year. In a five year program, for instance, 23% may be spent in the 3rd year and 16% in the 4th, and so on. The spendout rate for a particular year is the percentage of project funds spent in that year.

Variable Cost - Cost which depends on the number of units produced, such as quantity of materials used in production of an order. The amount of titanium needed for airframe production obviously depends on the number of units being manufactured. As the number of units being procured is increased, contractors purchase more material inputs and often get a better "buy." Per unit cost for materials may decrease, just as per unit labor costs. (See learning curve theory, above.)