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PROCEEDINGS

PLANNING OF LCC UNDER CONSTRAINT OF LONG TERM BUDGET

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1. ABSTRACT

Life Cycle Cost (LCC) of the system/equipment is used usually as one of the main parameters for choosing the best among the considered alternatives.

The alternatives can be of many kinds: optimal maintenance concept, new design Vs improvement of existing one, purchasing from different suppliers etc.

This article deals with additional usage of LCC as a tool for decision making: adjustments of different expenses, as a part of acquisition and support (LCC distribution over the life time) to long term budget.

2. INTRODUCTION

Recently the policy of purchasing of big, institutional customers was changed. Fifteen-twenty years ago the major parameter for decision to buy or not to buy the system (the functionality is not an issue of this article and is always at the top of priorities) was a price.

Presently the sophisticated customers are interested to know not only about the price of purchased system/equipment, but expected costs for each year of lifetime and of course the total Life Cycle Cost for period of system usage.

Example: buying the private car. To make the decision taking into account different parameters such as car's price, cost of operation (fuel), insurance, maintenance (preventive maintenance, spares, cost and availability).

Even if we are not aware of official name of this considerations, the issue is Life Cycle Cost of the car.

3. COST BREAKDOWN STRUCTURE (CBS)

The LCC can be presented as 3 dimensional analysis, as shown in figure 1. The axes of the graph are the cost, time and considered alternatives.

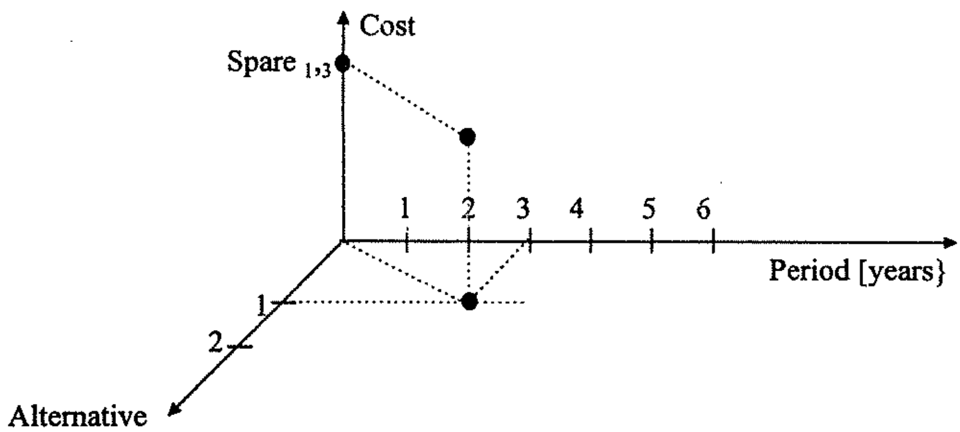

Figure 1 - 3 dimensional LCC presentation

For instance $SPARE_{1,3}$ is the cost of spares applicable for alternatives 1, 3rd year of system life.

4. GENERAL FORM OF CBS

The conventional CBS (see ref. 1) includes two main ingredients: acquisition, cost (even it is spread for couple of years) and support cost for a life period.

Sometimes additional ingredients such as expected engineering changes and improvements, upgrades and so forth are included in typical CBS.

The main components of acquisition cost are:

- System/equipment cost (for of the shelf products).
- Development cost (new design or improvements)
- Documentation cost (operational and maintenance)
- Initial training cost (operational and maintenance)
- Initial spaces for all levels of maintenance
- System/equipment reception (including transportation, installation, acceptant tests etc.)

The main components of support costs are:

- Operation (manpower, energy)
- Manpower for support
- Materials

The organizational changes, such as manpower cutting, new skill level for maintenance teams etc. should be taken into account.

Figure 2 includes schematic presentation of CBS:

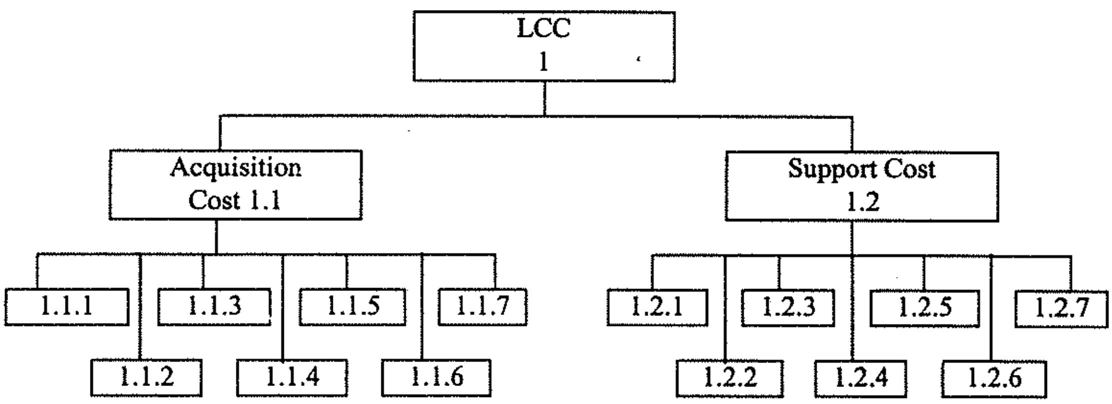

Figure 2 - Schematic presentation of CBS

5. COMPARISON OF COST PROFILES

The results of LCC analysis not always match precisely the "expected values" - budget. As a matter of fact, usually the do not.

If is common practice to compare actual oudget with LCC objectives, defined as a result of LCC Analysis. In case of significant differences additional analysis is usually performed, to find the main cost drives which caused the differences.

Here we are interested in another type of difference between the predicted and observed costs - the dynamics of expense, or "Cost Profile".

Similar total amounts of money may be spent quite differently over time, causing budgeting problems.

It is, therefore, interesting to compare the predicted and observed cost profiles and to find out to what extent the observed cost profile fits the predicted one.

The comparison can be presented graphically by two Bar Charts as shown in figure 3:

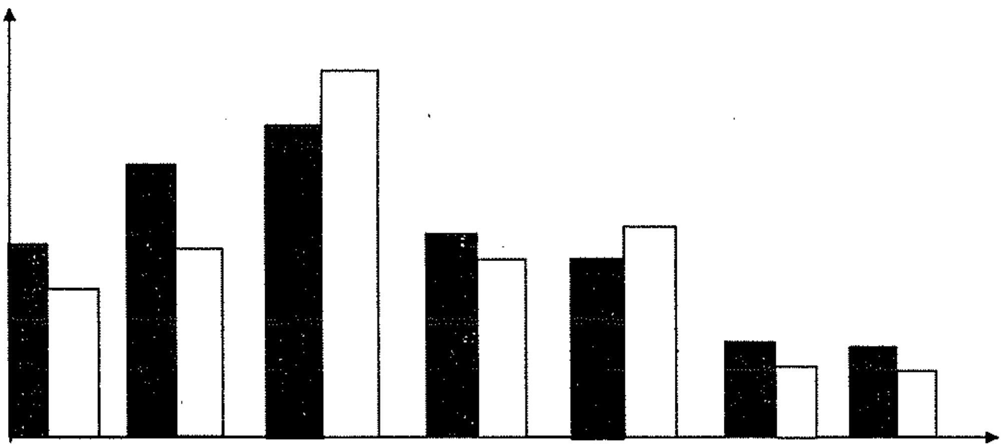

Figure 3 - Comparison analysis

Suppose that the predicted figures (observations) of a life cost for every year of the life time as the result of LCC analysis are $C_1, C_2, C_3,.., C_k$.

The expected figures (the budget) of a life cost for every year of the life time are $B_1, B_2, B_3,.., B_k$.

Year	y_1	y_2	y_3	......	y_k
Predicted LCC	C_1	C_2	C_3	......	C_k
Budget	B_1	B_2	B_3	......	B_k

Very often we want to know: is there significant difference between planned LCC and the budget not only in means of Life time investment but in means of Cost profile, i.e. distribution of the cost over time periods.

DEFINITION of χ^2

A suggested measure of the discrepancy existing between predicted investment (LCC) and a budget is supplied by the statistic χ^2 given by

$$\chi^2 = \frac{(c_1 - B_1)^2}{B_1} + \frac{(c_2 - B_2)^2}{B_2} + \ldots + \frac{(c_k - B_k)^2}{B_k}$$

(1)

The expected values are computed on the basis of a hypothesis H_0. If under this hypothesis the computed value of χ^2 given by the equestion hereinis grater than some critical value (such as $\chi^2_{95\%}$ which is the critical value at the 0.05 significance level) we would conclude that predicted LCC differ significantly from the budget and would reject H_0 at that level of confidence. Otherwise we would accept it or at least not reject it.

6. TEST OF HYPOTHESIS

The following is the suggested algorithm of testing of "goodness of fit".

a. Present the annual budget as a percent of overall life time budget

$$b_i = \frac{B_i}{B} \cdot 100$$

where:

b_i - annual budget as percent of overall lifetime budget
B_i - annual budget
B - life time budget

b. Present the annual predicted investment as a percent of predicted LCC

$$c_i = \frac{C_i}{LCC}$$

where:

c_i - annual predicted investment as percent of predicted LCC
C_i - annual investment

c. Perform test of hypothesis as defined in para. 4 above.

7. CHOOSING THE MOST DOMINANT PARAMETER

In case of significant difference between predicted LCC and budget, the changes should be done in LCC planning. For this purpose the most dominant parameters, that probably caused this difference should be identified.

To choose the most dominant parameter, in purpose to rich a matching between predicted spreadness and required budget, we'll apply the following algorithm:

a. Identify the year with highest deviation from the budget.

b. Sort the cost drivers of that year in descendent order to apply Paretto law (20% of cost drivers cause 80% of investment).

c. Change the dominant parameters (cost drivers) to bring nearer the planned values to budget requirements.

d. Calculate new spreadness of LCC.

e. Perform hypothesis test with new data.

f. If the H_0 hypothesis is still rejected, repeat steps a - e again.

EXAMPLE

The example was prepared using A.L.D. Ltd., ISRAEL software - D-LCC.

Table 1 includes the results of LCC evaluation for project DEMO:

ID	Period / Name	1	2	3	4	5	6	7	8	9	10	Total
1.	LIFE CYCLE COST	4.5	9.4	3.1	2.2	2	2	2	2	2	2	**35.00**
1.1	ACQUISITION COST	3.3	5.9	0	0	0	0	0	0	0	0	**9.20**
1.1.1	PRODUCTION	3.0	4.0	0	0	0	0	0	0	0	0	**7.00**
1.1.2	SUPPORT EQUIPMENT	0	1.5	0	0	0	0	0	0	0	0	**1.50**
1.1.3	DOCUMENTATION	0	0	0	0	0	0	0	0	0	0	**22.02**
1.2	SUPPORT COST	1.2	3.5	3.1	2.2	2.0	2.0	2.0	2.0	2.0	2.0	**22.02**
1.2.1	LABOR	1.2	3.0	2.5	1.5	1.1	1.1	1.1	1.1	1.1	1.1	**14.80**
1.2.2	SPARES	0.0	0.5	0.5	3.1	.65	.65	.65	.65	.65	.65	**8.00**
1.2.3	TE SUPPORT	0.0	0.0	0.0	.22	.15	.15	.15	.15	.15	.15	**1.12**
1.2.4	DOCUMENTATION	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	**0.90**
2	BUDGET	7.0	9.0	4.0	2.0	1.5	1.5	1.2	1.2	1.2	1.2	**29.80**

Table 1

Table 2 includes the data for hypothesis test.

Year	1	2	3	4	5	6	7	8	9	10
C_i	4.5	9.4	3.1	6	2	2	2	2	2	2
c_i [%]	12.9	26.9	8.9	17.1	5.7	5.7	5.7	5.7	5.7	5.7
b_i [%]	23.5	30.2	13.4	6.7	5.1	5.1	4	4	4	4

Table 2

The critical value for $\chi^2_{95\%,\,9}$ (9 degrees of freedom) is 16.9.

In accordance with formula (1) $\chi^2 = 26.1 > 16.9$.

We reject the H_0, that means that predicted LCC differ significantly from budget.

We identify that spares is the most dominant parameter for 4th year of life time.

The plans have been changed. The decision was to bye less spares during 4th year to bring presented LCC nearer to budget. Table 3 includes the updated result of analysis.

ID	Name \ Period	1	2	3	4	5	6	7	8	9	10	Total
1.	LIFE CYCLE COST	4.5	9.4	3.1	2.2	2	2	2	2	2	2	**31.22**
1.1	ACQUISITION COST	3.3	5.9	0	0	0	0	0	0	0	0	**9.20**
1.1.1	PRODUCTION	3.0	4.0	0	0	0	0	0	0	0	0	**7.00**
1.1.2	SUPPORT EQUIPMENT	0	1.5	0	0	0	0	0	0	0	0	**1.50**
1.1.3	DOCUMENTATION	0	0	0	0	0	0	0	0	0	0	**22.02**
1.2	SUPPORT COST	1.2	3.5	3.1	2.2	2.0	2.0	2.0	2.0	2.0	2.0	**22.02**
1.2.1	LABOR	1.2	3.0	2.5	1.5	1.1	1.1	1.1	1.1	1.1	1.1	**14.80**
1.2.2	SPARES	0.0	0.5	0.5	0.5	.65	.65	.65	.65	.65	.65	**5.40**
1.2.3	TE SUPPORT	0.0	0.0	0.0	.12	.15	.15	.15	.15	.15	.15	**1.02**
1.2.4	DOCUMENTATION	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.80**
2	BUDGET	7.0	9.0	4.0	2.0	1.5	1.5	1.2	1.2	1.2	1.2	**29.80**

Table 3

Table 4 includes the data for updated hypothesis test.

Year	1	2	3	4	5	6	7	8	9	10
C_i	4.5	9.4	3.1	2.2	2	2	2	2	2	2
c_i [%]	14.4	30.1	9.9	7.1	6.4	6.4	6.4	6.4	6.4	6.4
b_i [%]	23.5	30.2	13.4	6.7	5.1	5.1	4	4	4	4

Table 4

After adjustment $\chi^2 = 10.9 < 16.9$

The H_0 is accepted.

REFERENCES

1. Logistic Engineering Management - Blanchard
2. Life Cycle Costing - B. S. Dhillon
3. Statistics, Schaum Outline Series by Murray R. Spiegel Ph. D.