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LIFE EXPECTANCY OF FACILITIES

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Army Construction Engineering Research Laboratory

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CERL

LIFE EXPECTANCY OF FACILITIES

CONSTRUCTION ENGINEERING RESEARCH LABORATORY
Champaign, Illinois

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This preliminary report presents a life expectancy of facilities model and explains how to employ the model. Maintenance information on various building materials will be collected from a sample of 286 facilities at six different CONUS locations. The report also outlines the initial features of a data bank to store the maintenance cost information.

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ABSTRACT

This preliminary report presents a life expectancy of facilities model and explains how to employ the model. Maintenance information on various building materials will be collected from a sample of 286 facilities at six different CONUS locations. The report also outlines the initial features of a data bank to store the maintenance cost information.

FOREWORD

The life expectancy of facilities study was performed under OMA Project 4D78012AOK1, "Engineering Criteria for Design and Construction"; Task 02, "Applications Engineering"; Work Unit 101, "Life Expectancy of Facilities." The applicable requirement code is QCR 1.01.005

The work was performed under the technical direction of the Office of the Chief of Engineers, Directorate of Military Construction, Programming and Planning Division. The technical monitor was Mr. Frank Beck, Programming and Planning Division. The study was conducted under the general supervision of Mr. R. L. Trent, Chief, Data Systems Division, Construction Engineering Research Laboratory (CERL).

Col. R. W. Reisacher is Director of CERL and Dr. L. R. Shaffer is Deputy Director.

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LIFE EXPECTANCY OF FACILITIES

1 INTRODUCTION

Objective. The principal objectives of this investigation were to provide the facility engineer: (a) an accurate procedure for estimating the life expectancy of new and existing facilities, and (b) a prototype cost and life expectancy data bank for building components. A secondary objective was the determination of the type and quantity of information required to establish individual electro-mechanical equipment reliability.

Definition of Life Expectancy. Several measures can be used to define the life of a facility.

Physical Life. The time period after which a facility can no longer perform its function because increasing physical deterioration has rendered it useless. Maintenance and repair to prevent deterioration can extend the physical life of a facility indefinitely if there are no cost constraints.

Functional Life. The length of time until the need for the facility no longer exists or until the facility cannot effectively fulfill its original function. An example of the former case would be an aircraft hangar on a closed airfield; an example of the latter is a company-size mess hall located at an installation where the Army wants to use larger and more centralized food service facilities. In either case, the facilities may have a substantial physical life remaining; the functional life is the limiting factor.

Economic Life. The economic life is exhausted when a financial evaluation indicates that replacement is more economical than retention.

Since the physical life of a facility will normally exceed the functional or economic life, the actual life-span of a building is determined by either functional or economic considerations. This investigation principally tries to forecast the economic life of a facility. CERL task 891-01-004, "Functional Life as a Basis for Design," is investigating the functional life of a facility.

Background. The U.S. Army must maintain approximately one billion dollars worth of buildings. Roughly $337 million was expended during FY 71[1] to maintain this 878 million sq ft. Even at this funding level, the Backlog of Essential Maintenance and Repair (BEMAR) has grown substantially in recent years. In 1967 the total BEMAR was $84 million; by 1971 it had increased to $264 million[2]. The efficient allocation of maintenance funds is clearly a necessity. In order to accomplish this goal, buildings must not be maintained beyond their economic life-spans, for such maintenance reduces the funds available for maintaining other buildings and, indirectly, for constructing new buildings.

Current estimating procedures for building life-spans are rough at best. The level of sophistication ranges from an estimate based upon the type of construction (temporary, 0–5 years; semi-permanent, 5–25 years; and permanent, over 25 years) to a table of life-spans for different types of buildings.[3] Field personnel use either of these extremes, some points between, or simply an educated guess to determine the expected life of a building, which is then recorded in the Building Information Schedule (BIS-DA Form 2368-R). The installations and higher echelons use the information contained in the BIS to determine future building requirements. Thus, the improvement of the planning process necessarily requires the improvement of life expectancy estimates generated at the field level and recorded in the BIS.

AR 415-2 (Department of Defense Construction Criteria) requests economic studies to evaluate the life-cycle cost of all projects with an estimated cost over $300,000. These studies determine the minimum total cost of ownership of a project from construction to demolition by calculating the total cost of occupancy for alternative construction materials. This procedure indicates which alternative is actually more economical

[1] *Facilities Engineering Annual Summary of Operations* FY 1971 (Department of the Army [DA], Office of the Chief of Engineers [OCE]), pp 4–5.

[2] *Facilities Engineering Annual Summary of Operations*, p 21.

[3] *Engineering Economic Studies Life Cycle Costing Instructions* (DA, OCE, 1971), p 9.

over the life-span by considering not only the initial cost but also the future operation and maintenance expenses. Effective utilization of this approach tacitly assumes that an accurate life expectancy estimate exists. This assumption is, in fact, unfounded. Improvement of the estimation procedures for life expectancy, therefore, will also improve the accuracy of the life cycle cost calculations.

2 APPROACH

The task has been divided into four phases: formulation of a life expectancy model, selection of a sample of buildings, derivation of a data bank, and development of electro-mechanical data acquisition methods. The first three are proceeding simultaneously, and the fourth has just begun.

The initial life expectancy model is based upon current information, is simple to use, and requires minimal labor input from the facility engineer. As more detailed and accurate information becomes available from the sample buildings being monitored, a more sophisticated analysis will be used to check the model's accuracy and make the necessary refinements and changes.

Information stored in the data bank will be collected not only from the sample buildings but also from existing sources such as life cycle cost studies and estimates supplied by Director Facilities Engineer (DFAE) personnel.

Preliminary data relating to electro-mechanical equipment will be examined to determine whether it can predict individual equipment reliability. If it cannot, the necessary data acquisition procedures will be formulated.

3 FORMULATION OF A MODEL

Commercial Evaluation of Facilities. Commercial real estate personnel have developed procedures that accurately assess the monetary value of structures but not their life expectancies. The actual approaches generally can be categorized into three areas:

Income. The estimated future stream of income over the remaining life span determines value.

Market. The recent market evaluation of similar properties determines value; adjustments reconcile any differences between properties.

Cost. An estimate of the replacement cost less accrued depreciation is used to calculate value. Depreciation is usually divided into the three following components and evaluated separately:

(1) Physical — the actual "wearing out" of the materials.

(2) Functional — changes in usage requirements over time may make the structure less than an optimal design.

(3) Economic — a change in the surrounding economic climate may provide a better utilization of the land and/or structure.

The three components of depreciation are normally evaluated by estimating the dollar equivalent of each. The arithmetic sum gives an overall estimate of how the structure has depreciated, expressed as either curable or incurable depreciation. Curable depreciation can be repaired by minor repair or replacement; incurable depreciation is uneconomical to repair.

Most commercial evaluations stress that the physical life will extend beyond the functional or economic life. For this reason, commercial appraisals almost uniformly assign a 40–60 year life span for buildings.[4] For a structure required beyond that time frame, it is usually more economical to replace the structure with one that fully meets the current needs of the occupant. Tax considerations caused by accounting depreciation policies, although not stated specifically, undoubtedly exert considerable influence upon this decision.

Evaluation of Life Expectancy. Commercial real estate evaluations do not directly address the problem of estimating the life expectancy of a structure. Moreover, neither the income nor market evaluation techniques apply to military structures. Military structures generally have no counterpart in the commercial sector, not because of radical functional differences between military and commercial structures, but because of the specialized environment provided by a military base. The difficulty in equating environments causes the difficulty in comparing private and government facilities. Battelle Memorial Institute encountered just such

[4] E.J. Friedman, *Encyclopedia of Real Estate Appraising* (Prentice Hall, 1968), p 478.

Table 1
Examination of Permanent Facilities

Location	Change in Usage			
	Family Housing		Other	
Ft. Bragg	101/1789	5.65%	31/407	7.60%
Ft. Belvoir	2/231	.87%*	37/247	15.0%
Ft. Devens	23/443	5.19%	18/165	10.9%
Presidio of Monterey		0%	5/15	33.3%
Ft. Ord		0%	30/240	12.5%
Ft. Huachuca	*	*	12/42	8.5%
	126/2463=5.1%		133/1116=11.9%	

* Type of Family Housing not indicated, thus low change rate.

a difficulty when it attempted to develop an equivalency relationship between family housing units and private rental units.[5]

A crude evaluation of functional life was obtained by examining the BIS of six different forts within CONUS. The percentage change of original function for permanent facilities was calculated. Nonchangeable permanent items such as flagpoles, monuments, grease racks, etc, were excluded from the total. Table 1 indicates that complete changes in function of permanent structures, excluding family housing, are minor (on the order of 12%). Thus the bulk of permanent facilities are still being used for their original design purpose. Unfortunately these findings cannot be used to determine how adequately a building meets the current functional needs of the user. Over time, changes occur in the interpretation of what is the best way to perform a specific function. For example, the 326-man barracks were formerly considered good housing. Current thinking, however, calls for shared rooms instead of dormitory quarters. The quantitative evaluation of functional depreciation is beyond the scope of this work unit; close coordination with another CERL task, "Functional Life as a Basis for Design," is being maintained.

Assuming a long-range need for a building exists, economic considerations chiefly determine the life expectancy of a military structure. The life expectancy of a facility is reached when the cost of retaining the facility is greater than that of replacement. For this situation to occur, maintenance costs should reasonably be assumed to increase with building age, although no data collection system has ever collected sufficient information to rigorously test this assumption. The economic comparison required to determine life expectancy assumes that the need for a building will exist for some time into the future since maintenance costs in any one year will never exceed replacement. Often, however, high maintenance expenditures over a few years amount to a substantial portion of the replacement cost, and if this high level of maintenance continues, de facto replacement is accomplished with maintenance funds.

The Corps of Engineers' current approach to life cycle cost (LCC) analysis uses a computer program called LFCY2.[6] This program calculates the annual operations, maintenance, and custodial expenses for a single building component for an assumed building life. Each possible alternative component (e.g., various types of roofing) is evaluated by the program, and the calculated LCC's are reviewed manually to select the lowest LCC alternative. The program offers three separate methods for determining LCC:

OCE Method — Cash flows in the future are escalated to account for inflation, thus producing "constant dollars" over the life-span. The initial cost is treated as a loan amortized into equivalent monthly payments that include principal and interest for the entire expected life-span. The loan amortization and any planned cash flows are combined to produce a cost per year for that alternative. The total cost over the life-span is determined by adding the annual costs.

[5] *Study of Modernization and Replacement, Navy Family Housing,* N62399-69-C-0048 (Battelle Memorial Institute, 1971).

[6] *Engineering Economic Studies Life Cycle Costing Instructions* (DA, OCE, 1971), Appendix B.

Air Force Methods — Future costs are not escalated, although they are discounted to take into consideration the time value of money. In other words, an expenditure in the future is more desirable than a numerically equivalent expenditure at the present. The time value of money is usually evaluated in terms of the interest rate necessary to borrow capital. The determination of the proper interest rate for evaluating alternatives in the public sector is more complicated, but can be developed from treasury borrowing rates or a social opportunity cost.

Life cycle costs of various alternatives are compared at the same point in time by discounting all costs to the present, using Equation 1 to determine their equivalent present worth.

$$PV_n = x \frac{1}{(1+i)^n} \qquad \text{[Eq 1]}$$

where PV_n = present worth of expenditure x during year n

i = interest rate.

The present worth of all anticipated future operation and maintenance expenditures is added to the initial cost to determine the LCC.

Unadjusted Method — The LCC is calculated by simply adding all anticipated costs that will occur during the expected life-span. No price escalation or discounting is used.

Of the three alternative methods of calculating LCC provided by LFCY2, the Air Force approach comes closest to standard practice; however, two critical aspects are missing:

1. The actual future costs should be estimated as accurately as possible, using inflation factors like those used in the OCE method.
2. The present value of salvage value should be included in the calculations.

If the above two factors are considered, the analytical formulation becomes:

$$PV_n = C_1 + O_1 + M_1 + \sum_{j=1}^{n} \left[\frac{1}{(1+i)} \quad (O_j + M_j) \right] - \frac{1}{(1+i)} S_n \qquad \text{[Eq 2]}$$

where PV_n = present value of cost associated with a structure over a time time period n

Cj = initial cost in year j

Oj = operating expense in year j

Mj = maintenance expense in year j

S_n = salvage value in year n

i = discount rate

n = life expectancy.

To determine n, a long period of time m (m > n) is established during which the facility will be required. The total cost associated with keeping the original structure k years and a replacement for m minus k years is then calculated. The value of k that provides a minimum total cost over time period m equals the life expectancy n. This concept is indicated graphically by Figure 1 and analytically by Equation 3.

$$\underset{k}{\text{Min}} \; [PV_I|_0^k + PV_R|_k^m] \qquad \text{[Eq 3]}$$

Where I = Initial structure

R = replacement structure.

Solution of the above equation or the previous generalized LCC equation requires information on maintenance frequencies and expenditures for various building materials. The paucity of long-term maintenance data makes the forecasting of future maintenance frequencies and costs extremely difficult. The establishment of a maintenance data bank (discussed later) will eliminate this problem. Equation 3 also requires that the cost of a replacement facility be estimated.

Regression analysis was used to test the feasibility of forecasting future replacement cost from historical in-place cost. Average in-place costs were gathered for nine types of facilities from AR 415-17's (Empirical Cost Estimates for Military Construction and Cost Adjustment Factors) for the period 1957 through 1970. Attempts were made to fit different functions to the cost versus time data. Reasonably good results, as shown in Table 2, were obtained using linear regressions.

Life Expectancy Model. The procedure described above for estimating life expectancies requires a considerable number of calculations. This level of detail, although it ensures the most accurate estimate, is substantially more than a facility engineer should be required to perform. A first iteration of a short-cut estimating procedure is outlined below.

An economic evaluation requires a forecast of maintenance costs as a function of time. The term "maintenance costs" includes both routine repairs and

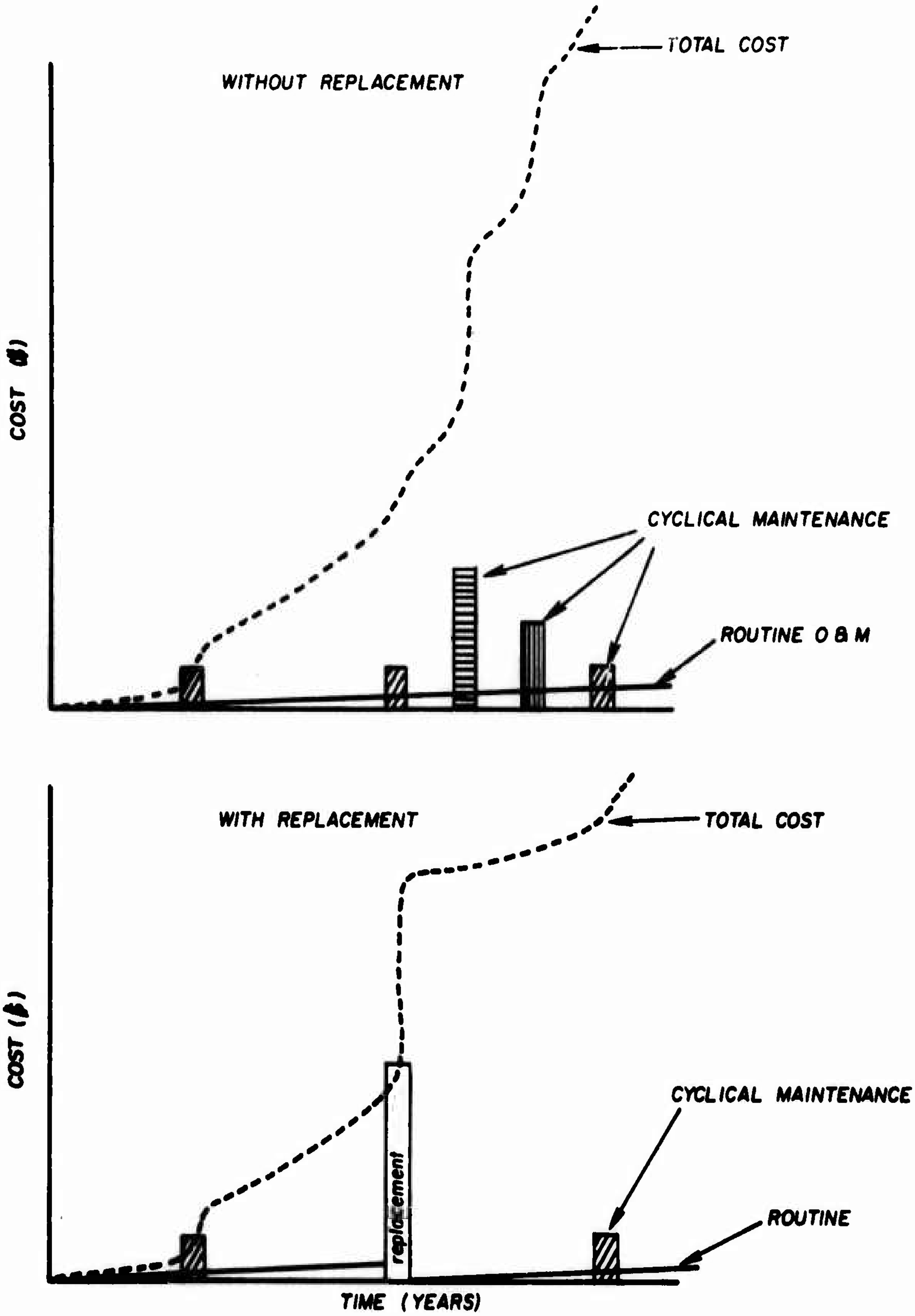

Figure 1. Maintenance cost versus time.

Table 2
Results of Linear Regressions for Replacement Costs

Type of Facility	Description	R^2 *	Derived Equations
Adm & Storage	5 Co 13,000 SF	.76	y = .042x + 14.73
Chapel	300 seat 8159 SF	.62	y = .071x + 23.79
Classroom	Btn 3500 SF	.68	y = .070x + 15.18
Gym	10,200 SF	.77	y = .054x + 16.87
Library	3000 SF	.85	y = .050x + 19.32
Off Mess	open 50-250 mn 6530 SF	.42	y = .059x + 25.02
Post Exchange	15-20k mn 27,250 SF	.66	y = .057x + 16.28
Teleph Exchange	4000 SF	.90	y = .073x + 21.59
Theater	350 seat 5,974 SF	.66	y = .072x + 23.15

y = Estimated Replacement Costs
x = Time in Months from October 1957
* Correlation Coefficient—a measure of fraction of the variance "explained" by the regression.

periodic replacements. At the point when economic replacement is justified, the routine repair level will probably be substantially above the level for a new building, and several periodic replacements of major components will be required (or required shortly). Most of the cost that will justify replacement will be associated with the expense of replacing components, not by the increase in the repair rates of existing components.

A simpler, but less accurate, method could be based upon examination of the remaining life of components that are most expensive to replace. Although blanket techniques for estimating the cost of replacing building components are not readily available, average initial in-place cost data for various components is available. These costs are presumably related, that is, a high initial cost probably means a high replacement cost and vice versa. Thus, although component replacement costs should be used in the simplified estimation process, substitution of initial cost data provides comparable estimates.

The Naval Civil Engineering Laboratory (NCEL) analyzed the construction cost of 65 buildings selected from the 15 highest planned construction category codes proposed for the FY 71-75 MILCON budget.[7] The cost information for the sample was obtained from NAVFAC Form 83, "Schedule of Prices." The costs were aggregated into 17 standard building components.[8] Both the labor and material portions of the cost were obtained. The mean percentage cost for each component was calculated along with 95% confidence limits. Analysis of the confidence limits for each building in the NCEL sample indicated that distribution of original in-place cost was independent of category code. This result is predictable since the sample contained general types of buildings, such as administration and training. Some specialized buildings, e.g., telephone exchanges which have abnormally high amounts of electrical and installed equipment, have different cost distributions. Table 3 indicates the samplewide average distribution of components that amount to 6.0% or more of the in-place cost of a structure. Because item 3, Support, refers to site improvement and utilities outside of the building line, it has no effect on the building life and was removed from Table 3, and the cost distribution was adjusted to 100%.

The first iteration of a life-expectancy model uses the adjusted distribution of initial cost to weigh the age contribution of each of the six principal components. The first step in this procedure involves estimating the remaining life of the six principal components. These estimates are then multiplied by their respective weighing factors and summed to yield an estimate of facility life expectancy. Table 4 illustrates the procedure for a fictitious building.

[7] J.A. South, *Life Cycle Costing of Naval Facilities* (Naval Civil Engineering Laboratory, [in publication]), Appendix A.

[8] *Uniform System for Construction Specification, Data Filing and Cost Accounting* (American Institute of Architects, 1966).

Table 3
Distribution of Initial Inplace Costs

		% of Total Cost	Adjusted % (Excluding 3)
1.	Mechanical	14.2	25.0
2.	Foundations	12.8	22.5
3.	Support	10.8	
4.	Electrical	8.9	15.6
5.	Structural Frame	7.9	13.9
6.	External Walls	7.1	12.5
7.	Plumbing	6.0	10.5
		67.7	100.0

Table 4
Calculation of Life Expectancy

Component		Weight	Est. Life	Life Contribution
1.	Mechanical	.250	10	2.50
2.	Foundation	.225	50	11.25
3.	Electrical	.156	20	3.12
4.	Structural Frame	.139	50	6.95
5.	Exterior Walls	.125	25	3.13
6.	Plumbing	.105	20	2.10
				29.05

Estimated Remaining Life=29 years

This estimate only indicates what an expected life may be, based upon initial in-place cost. A recommendation for either replacing or extensive repairing can only be accomplished by the detailed economic analysis previously mentioned.

The application of the approach outlined in Table 4 will require the repeated solution of the same formula:

$$EL = .250M + .225F + .156E + .139S + .125W + .105P \quad [Eq\ 4]$$

where EL = expected life
M = mechanical life expectancy
F = foundation life expectancy
E = electrical life expectancy
S = structural life expectancy
W = exterior wall life expectancy
P = plumbing life expectancy.

The computations required to solve this equation can become quite tedious, especially if the equation is used more than once. To alleviate this difficulty, two alternative means of solving Equation 4 were developed – a nomograph (also known as an alignment chart) and a computer program (see Appendix A for program and sample output). By using a nomograph, Equation 4 can be solved quickly while eliminating the possibility of arithmetical errors, or the need for computer access.

The six independent variables in Equation 4 would have required an extremely complicated nomograph for a one-page solution. This alternative was avoided by dividing Equation 4 into the following two components:

$$EL = f(t_1) + f(t_2)$$
$$f(t_1) = .250M + .156E + .139S \quad [Eq\ 5]$$
$$f(t_2) = .225F + .125W + .105P$$

The two easy-to-use nomographs, Figures 2 and 3, were then constructed – one for $f(t_1)$ and the other for $f(t_2)$. For convenience, a third nomograph, Figure 4 was constructed to provide a quick summation of the results of Figures 2 and 3.

Using Figures 2–4 to predict expected life is a simple procedure. A straight line drawn through the estimated life of the mechanical and structural frame produces a point on the K_1 scale of Figure 2. A straight line is then drawn from the estimated remaining electrical life through the point on the K_1 scale to

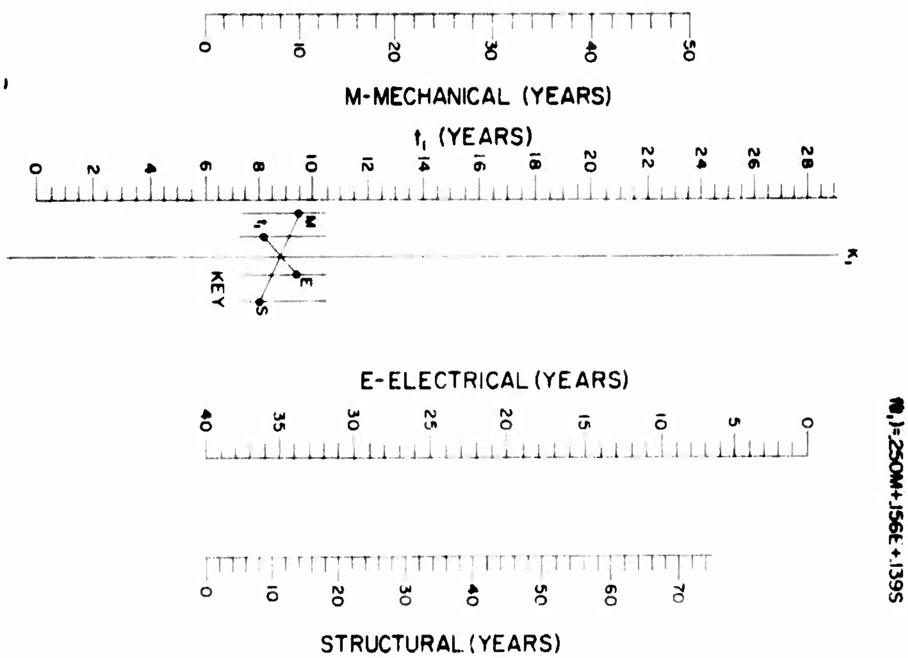

Figure 2. Nomograph for calculating $f(t_1)$.

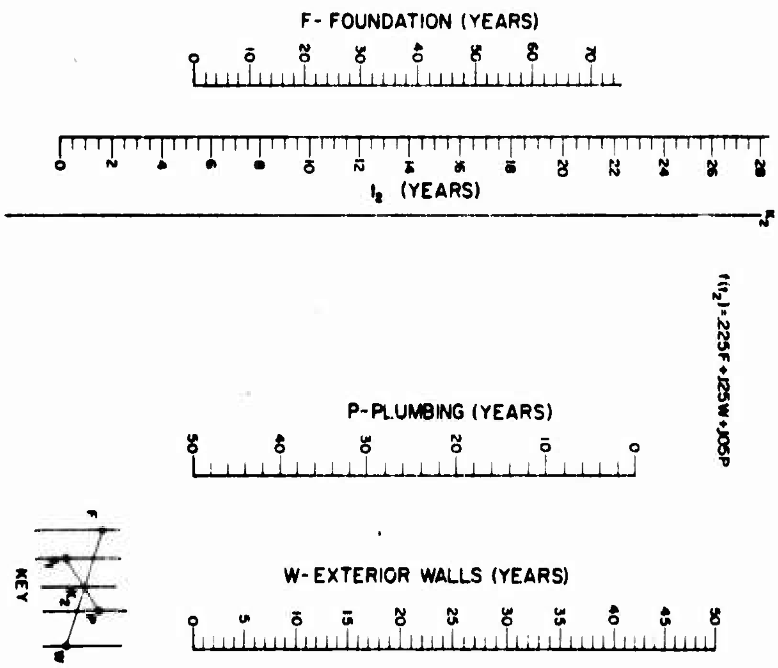

Figure 3. Nomograph for calculating $f(t_2)$.

the t_1 scale. The intersection of the t_1 scale indicates the expected life contribution for those three components. A similar approach in Figure 3 to obtain an evaluation of the age contribution of the other three components $f(t_2)$. A line drawn between the values of (t_1) to (t_2) in Figure 4 will cut the EL scale and produce an estimate of expected facility life.

As soon as good maintenance records are collected, an evaluation will be made of which building

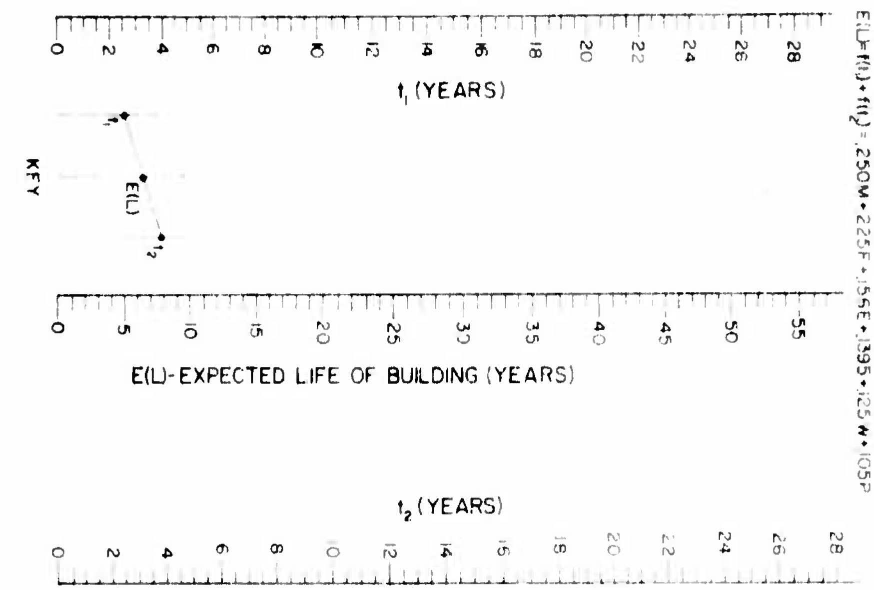

Figure 4. Nomograph for calculating expected life of a building.

components absorb the most maintenance funds. If the high maintenance components, which ultimately determine the economic life, are substantially different or fewer than the initial in-place cost distribution, the model will be modified to reflect this discovery. In the interim the life expectancies of the principal initial in-place components will be used to estimate life expectancy.

4 SAMPLE SELECTION

Little data is available on the cost or frequency of maintenance actions for either Army facilities or the private sector. A sufficient data bank will require a selective data gathering effort. The collection of maintenance data will also provide a data bank for other kinds of life cycle cost studies.

Army maintenance record keeping procedures are not organized for data collection on a per building basis; cost information is normally aggregated by building type (category code). Thus comparison of the average yearly maintenance cost per square foot for various category codes is simple, but comparisons of maintenance expenditures within a category code by building age or material are very difficult. With the exception of Ft. Bliss, which is an Integrated Facilities System (IFS) test location, the retrieval of per building cost information requires a clerical search of contract work and the three categories of in-house work: standing operation orders (SOO), service orders (SO), and individual job orders (IJO). Detailed descriptions of these work orders can be found in Appendix B. The two other possible sources of maintenance actions, preventive maintenance and self-help, are blanket accounts that do not generally record charges on a per building basis.

Since the post engineer's office does not normally retain maintenance records over one year old (current FY and last FY), any short term sampling plan to examine the maintenance cost overtime must have a sample that is stratified by age groups. This approach will allow the collection of maintenance data for buildings with a wide age range in a relatively short time period.

A preliminary sample of buildings was selected from the category codes, as indicated in Table 5, with the highest planned new construction during FY 73-77. Six types of buildings were selected: administration, training, barracks, BOQ's, family housing, and unheated warehouses. Buildings of each type were stratified by age (roughly by ten-year periods). Within each age group, buildings with different exterior-wall materials, foundations and roofing were sampled. Seven different geographical locations were selected to determine the influence of the environment upon maintenance cost and frequency of occurrence: Ft. Belvoir, Virginia; Ft. Bliss, Texas; Ft. Bragg, N. Carolina; Ft. Devens, Massachusetts; Ft. Ord, California; Presidio of Monterey, California; and Ft. Leonard Wood, Missouri. Only permanent constructions were considered in the initial sample.

A later review with the OCE monitor suggested that a larger number of category codes be sampled. A sample based upon a few years of new construction will be biased because new construction is not programmed on a percentage of existing types of structures but designed to replace certain types of structures.

Eight category codes were selected for the sample. Initially, both permanent and temporary buildings were to be sampled. An examination of the BIS's for each of the seven locations indicated that almost all of the temporary buildings were scheduled for demolition before FY 75. Since it is unlikely that normal maintenance policies would be followed so close to

Table 5
Army Planned Construction FY 73-77

Category Code	Description	Value %	(×1000)	Area %	sq ft (×1000)
310	R & D Test Buildings	15.7	165,297	8.1	2,721
721/2	EM Barracks	14.9	157,457	19.1	6,371
610	Administrative Buildings	12.2	129,029	10.9	3,643
171	Training, Other Than Classrooms	10.0	105,138	8.0	2,714
214	Maintenance Tank Auto Shops	8.0	84,190	7.0	2,350
171	Training Facilities, Classrooms	7.0	73,903	7.4	2,471
441/2	Storage, Covered (Warehouses)	5.6	59,445	13.8	4,625
724	Bachelor Officers Quarters	5.3	55,397	5.5	1,845
218	Maintenance Facilities, Miscellaneous	2.5	26,549	2.4	808
141	Operational Buildings	2.5	26,291	2.0	664
211	Maintenance Facilities, Aircraft	1.9	20,029	1.3	426
740	Gymnasiums and Fieldhouses	1.7	17,732	1.9	543
219	Maintenance Facilities, Base Engineer	1.6	17,246	1.9	624
723	Troop Housing, Detached Facilities	1.6	16,436	1.5	496
740	Commissaries and Exchanges	1.5	16,332	1.7	572
723	EM Mess Buildings	1.4	14,975	1.1	381
217	Maintenance Facilities, Electronic Equipment	1.2	12,954	.8	252
740	Chapel Facilities	.9	9,692	.7	226
740	EM Service Clubs, NCO and Officers Messes	.9	8,991	6	209
131	Communications Buildings	.8	8,016	.5	180
550	Dispensaries	.5	5,707	.4	119
432	Cold Storage (Installation)	.5	5,188	2.0	679
540	Dental Clinics	.5	4,795	.3	84
740	Libraries	.4	4,608	.4	128
740	Post Offices	.4	4,468	.3	116
730	Fire Stations	.3	2,688	.2	66
740	Crafts, Hobbies and Workshops	.2	2,429	.2	81
	TOTAL	100.0	1,054,982	99.8	33,394

Table 6
Sample Building Distribution

Location	17120	21410	44220	61050	71115	72210	72410	74050	Total
Ft. Belvoir	14	9	6	1	11	6	7		54
Ft. Bliss	5	9	1	15	22	7	11	5	75
Ft. Bragg	1	11	8	4	12	6	7	5	54
Ft. Devens	8	5	2	2	9	6	3	1	36
Ft. Ord		3	7	3	6	3	6	3	31
Presidio of Monterey	6			2*	3	3+	2		16
Ft. Leonard Wood	1	6		1		6	3	3	20
TOTAL	35	43	24	28*	63	37+	39	17	286

* Category Code for Administration Buildings is not all 61050
\+ Category Code EM Barracks for Presidio of Monterey is 72110

scheduled removal, the sample was limited to permanent buildings.

The sample for each category code was stratified by ten-year age groups and by the three exterior materials: roofing, exterior walls, and foundation. A sample size of three was chosen for each available combination of age, roofing, exterior walls, and foundation. Since not all combinations are present at any one location, the sample size was not excessive. Table 6 indicates the distribution of the sample by location. Detailed building number lists can be found in Appendix C.

5 ANALYSIS OF PRELIMINARY DATA

The IFS deficiency dollar survey at Ft. Bliss was used to indirectly test the assumption that building maintenance costs increase with age. Since deficiency dollars are a result of the previous maintenance policies, good correlation between deficiency dollars and age of structure could only be expected if maintenance expenditures per building tend to be fixed over time. If maintenance requirements increase over time, the deficiency dollars would tend to grow with the age of structure. However, if maintenance requirements per building were never defrayed, the deficiency dollars would always be zero. Since the real world within which the DFAE operates lies somewhere between these two extremes, some correlation was expected.

The average deficiency dollars per square foot by building age were calculated for two category codes: 17115 (FH NCO) and 44270 (storehouse). The family housing units varied in age from 10 to 42 years; the storehouses ranged from 11 to 79 years old. Linear regressions were fitted to the two sets of data. The best correlation coefficient obtained was only .30, so it was concluded that deficiency dollars are not significantly related to the age of the structure.

The DFAE at the Presidio of Monterey has kept accurate records of labor expenditures per building for the last seven years. Material expense is not readily available, although the work management office has determined that material expenses are normally 27.8% of labor expenses. CERL obtained a preliminary sample of the maintenance records for 17 buildings. A computer program was written to efficiently handle data on the 4600 maintenance actions performed on the 17 buildings over a 7-year period. The program determined the annual maintenance cost by building per sq ft.

The 17 sample buildings fell into eight category codes. The effect of age versus maintenance cost for each of these category codes was examined by attempting to fit a linear regression to each set of data. Table 7 illustrates the correlations obtained for each regression. Low correlations do not necessarily imply that maintenance costs are not a function of age. The maintenance data was not initially separated into cyclical and routine components, thus, when a cyclical task like painting was performed, the maintenance cost for that year increased substantially. Since performance of these maintenance actions is independent of the building's age, such actions obscure any correlation

Table 7
Correlation of Maintenance Expenditures and Age

Category Code	Number Observations	Age Range	R^2 Correlation Coefficient Age vs Maintenance
17120	23	0 15	.016
17130	13	0 21	.366
61000	11	0 5	
71111	8	62 69	.275
71112	16	62 69	.079
71113	10	62 69	.045
72110	12	0 15	.114
72410	14	0 16	.037
All	107	0 69	.007

between routine maintenance and age. CERL is currently separating the cyclical costs from the routine maintenance. When this task is complete, the routine maintenance cost over time will be studied.

It should also be noted that the age ranges of the sample buildings in each category code were relatively short. The longest age range was only 21 years, which incidentally had the highest correlation. The short-age time frames tend to magnify the random effects and hamper the observation of any trends in the data. CERL will obtain another sample with larger age ranges to eliminate this difficulty.

One universal problem encountered with gathering maintenance cost data for DOD facilities is the lack of a consistently applied maintenance policy against the building inventory. The facility engineer's recurring problem is lack of either sufficient maintenance funds or of personnel. Thus the data often reflects not the required maintenance at a point in time but rather the maintenance funding for that period. A directive from the CONARC level to the installations that certain buildings be maintained on an "as needed" basis instead of the normal "as possible" basis would facilitate collection of accurate maintenance data.

6 DATA BANK

The formulation of the maintenance data bank using MRI System Corporation's System 2000 for facility components is still in its infancy. A detailed report is scheduled to appear near the end of FY 73, but a brief overview of the anticipated characteristics and data sources is presented below.

Maintenance costs and frequencies of occurrence will be stored for different materials related to the 11 facility components listed in Table 8. These components were selected to be compatible with IFS data requirements. Three principal sources of data will be developed: (1) data recorded for the CERL building sample, (2) data from other life cycle cost studies, and (3) estimates from field personnel. The data source will be carried to help determine the accuracy of the data bank. An annual cost adjustment update feature will be incorporated, each update will automatically reduce the accuracy of the previously stored data. For example, an actual observed cost for built-up roofing three years ago will be of limited value unless it is adjusted for the change in price level. Obviously, the adjusted price is more accurate than the non-adjusted one, but a currently observed cost is more accurate than either.

Wherever possible the data will indicate the type of building and its geographic location. A sufficient collection of data will allow a study of the effects of category code and geographic location.

The data for the CERL building sample will be obtained from IJO's, SOO's, and contract documents. The smaller maintenance actions covered by SO's, self-

Table 8
Facility Component Codes

000*	interior paint
010*	roof
011	roof deck
012	roof surface
013	roof support
020*	structure
021	structural frame
022	foundation
023	exterior walls
030*	exterior paint
040*	floor covering
050*	mechanical
051	heating
052	air conditioning
053	ventilation
060*	interior partitions
070*	plumbing
080*	electrical
090*	installed equipment
100*	ceilings

* IFS Component Codes

Table 9
Preventive Maintenance and Self-Help Expenditures for Supplies – Fort Leonard Wood

	FY-71			FY-72		
Month	**Cantonment**	**Fam H**	**Self-Help**	**Cantonment**	**Fam H**	**Self-Help**
July	$ 760.02	$1,380.36	$9,079.03	$ 806.58	$2,459.03	$2,382.22
Aug	1,483.91	1,539.63	5,128.25	726.96	2,840.06	2,916.03
Sept	1,098.39	1,128.67	4,427.74	1,279.31	2,246.95	2,640.74
Oct	1,000.02	1,306.29	6,124.20	1,465.86	1,718.12	3,971.78
Nov	881.14	3,212.86	3,877.88	928.41	2,239.45	4,539.58
Dec	1,257.23	1,665.61	3,585.53	1,120.77	3,235.65	2,596.68
Jan	1,648.96	1,290.35	5,981.58	1,348.64	2,236.16	4,047.54
Feb	1,172.86	996.27	4,541.50	1,858.81	4,726.14	3,993.62
Mar	3,113.37	2,605.72	6,944.79			
Apr	1,155.83	2,567.35	6,242.13			
May	780.89	1,163.52	4,036.83			
June	3,240.47	592.15	6,965.39			
TOTAL	$17,590.09	$19,448.78	$61,932.85			

help, and preventive maintenance generally involve only a few hours of work. SO's are limited to 16 man-hours or $200; Table 9 indicates the low cost of preventive maintenance and self-help programs. The work costs in these three areas are charged to blanket accounts, making it extremely difficult to recover data on a per building basis. Since their effect on annual maintenance cost is quite small, exclusion of these costs from the data gathering effort should not produce serious errors.

For the initial maintenance data bank, the feasibility of combining two other IFS data files was examined. One of the data files contained information on component inspection requirements and the other IFS component condition ratings. Figure 5 indicates the hierarchical order of the data sets. Future work on the data base will be limited to maintenance information. System 2000 is quite flexible and the other data sets could be added at a later date if deemed necessary.

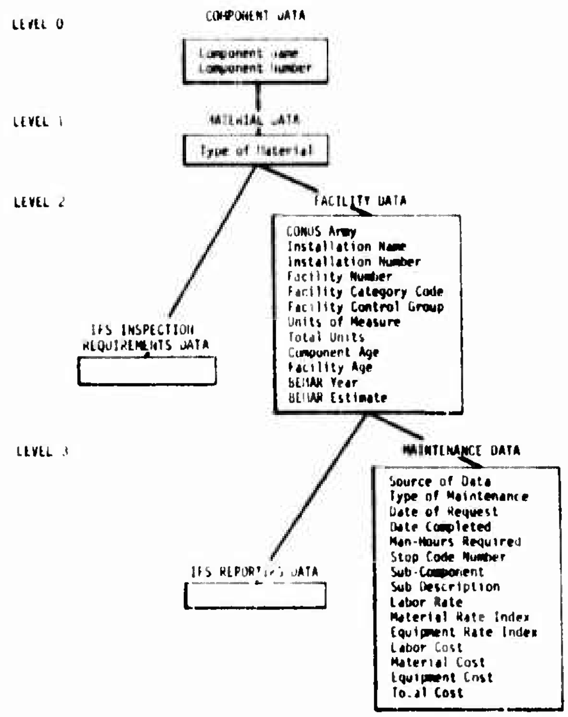

Figure 5. Data base structure.

7 RESULTS AND CONCLUSIONS

Results. A preliminary life expectancy model was formulated based upon an analysis of initial in-place cost. A series of nomographs, as shown in Figures 2–4, were developed to reduce the required calculations to a simple line drawing operation. A computer program was also developed.

A sample of 286 buildings was selected at seven different locations to be monitored for maintenance data. They were selected to provide different combinations of age, roof type, wall type, and foundation type.

The preliminary structure of a data bank to store maintenance cost and maintenance frequencies for various building components is outlined.

Conclusions. The derivation of a life expectancy model based upon initial in-place cost is possible. A similar type of model could be developed by using those facility components responsible for the majority of the maintenance expenditures. The condition of such components may provide a good estimate of life expectancy.

Maintenance costs should be divided into cyclical and routine components in order not to obscure maintenance trends associated with age with cyclical actions independent of age.

A methodology should be developed to measure the performance of a facility in fulfilling the functions for which it was designed.

Maintenance data is often biased by the lack of a consistently applied maintenance policy.

Directives should be issued so that the CERL building sample is maintained on an "as needed" basis

CITED REFERENCES

Department of Defense Construction Criterion, AR 415-2, Headquarters of the Department of the Army (HQDA), effective 1 April 1971.

Engineering Economic Studies Life Cycle Costing Instructions (Department of the Army, [DA], Office of the Chief of Engineers [OCE], 1971).

Facilities Engineering Annual Summary of Operations, FY 1971 (DA, OCE).

Freidman, E.J., *Encyclopedia of Real Estate Appraising* (Prentice Hall, 1968), p 478.

South, J.A., *Life Cycle Costing of Naval Facilities* (Naval Civil Engineering Laboratory [in publication]), Appendix A.

Study of Modernization and Replacement, Navy Family Housing, Contract No. N62399-69-C-0048 (Battelle Memorial Institute, 1971).

Uniform System for Construction Specifications, Data Filing, and Cost Accounting (American Institute of Architects, 1966).

UNCITED REFERENCES

"Architect/Engineers and Military Construction," *The Military Engineer,* Vol 64 (May – June 1972).

Beck, F.B., *Outline Plan for a Composite Program of Design, Construction, and Maintenance of the Army Physical Plant* (DA, OCE, 1965).

Better Cost Accounting Needed for Operations and Maintenance of Military Family Housing (Comptroller General, 1971).

Buildings and Structures Preventive Maintenance Safety Requirements, Repairs and Utilities, Technical Manual TM 5-610 (Department of the Army, 1954).

Butler, D.W., *Life Cycle Facility Planning, A Program Methodology* (DA, OCE [draft, 1970]).

Department of the Army Facility Classes and Construction Categories, AR 415-28 (HQDA, 1967).

Empirical Cost Estimates for Military Construction and Cost Adjustment Factors, AR 415-17 (HQDA, 1970).

Economic Analysis of Proposed Army Investments, AR 37-13, (HQDA, 1969).

"FY 1974 Military Construction, Army (MCA) Program Guidance," ltr AGDA-A(M) (27 Aug) LOG-C-PDBB, 10 Sept 1971.

Hoelscher, R.P., *Graphic Aids in Engineering Computation* (McGraw-Hill, 1952).

Optimal Design of Air Force Family Housing Through Life Cycle Costing, American Institute of Architects (F. P. Cole & Associates, 1970).

Optimal Solution Construction Cost Plus Maintenance Cost Plus Operations Cost (OCE Directorate of Civil Engineering, Housing Division).

Preventive Maintenance, AR 420-22 (HQDA, 1969).

Real Property Appraisers Handbook (DA, OCE, 1954).

Rydell, C.P., *Factors Affecting Maintenance and Operating Costs in Federal Housing Projects,* R-634-NYC (Ranal Institute, 1970).

Self-Help Program, AR 420-24 (HQDA, 1970).

Stone, P.A., "The Economics of Building Design," *Journal of Royal Statistical Society,* Series A, Vol CXXIII, Part 3, pp 237-273.

Study for Allocation of Maintenance Funds, Navy Family Housing, Contract No. N62399-69-C-0043 (Battelle Memorial Institute, 1970).

The Work Management System, Pamphlet No. 420-6 (HQDA, 1968).

The Weathering and Performance of Building Materials, J.W. Simpson, ed. (Wiley Interscience, 1970).

APPENDIX A: PROGRAM AND SAMPLE OUTPUT

A simple FORTRAN IV program for a CDC 6600 computer was written to calculate expected life of a facility. The following information must be read in:

– current date (19xx)	CURDATE
– date built (19xx)	DBUILT
– installation number	INST
– estimates of component lives	comp (1) = mech
– (in years)	comp (2) = foundation
– if no estimate is available, leave blank	comp (3) = electrical
– or enter date of last replacement (19xx)	comp (4) = structural
	comp (5) = ext walls
	comp (6) = plumb

The program checks to see if the data on a building is complete. If a blank is found for a component life expectancy, the program calculates a life by subtracting the difference between the calendar year and the date the facility was built from a blanket estimate for the life-span of a component.

Component	Life Span
Mechanical	20 years
Foundation	50 years
Electrical	20 years
Structural	40 years
Exterior Walls	30 years
Plumbing	20 years

If a replacement date (19xx) is found instead of an estimated life, this date is used as the date built in the previous calculation.

The program uses the actual or estimated component lives to calculate the facility life expectancy. When the results of the calculations are printed out, an indication of the type of data used is made (actual date or estimates). Figure A-1 is a flow chart of the computer program. A copy of the program follows Figure A-1.

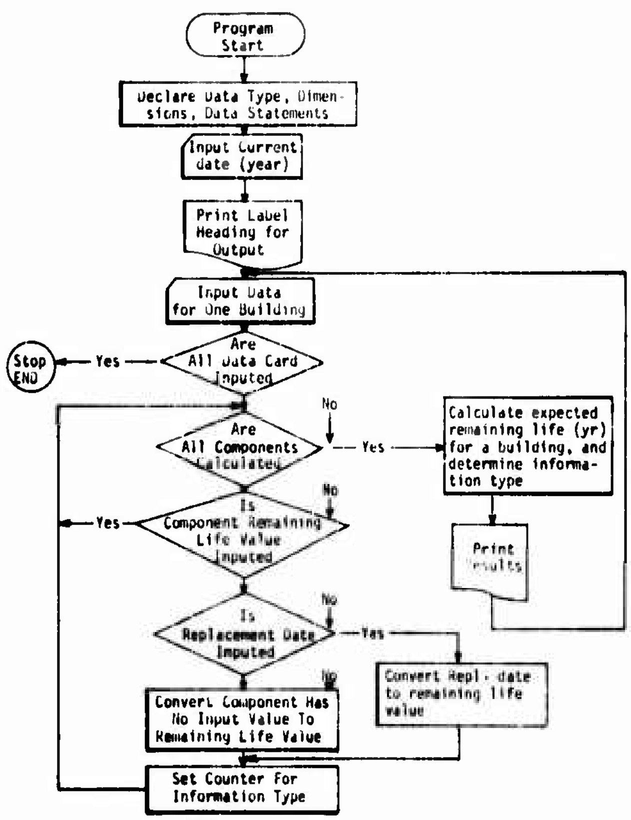

Figure A-1. Life expectancy program flow chart.

```
C  ****************************************
C  * EXPECTED REMAINING LIFE OF A BUILDING *
C  ****************************************
C  SET UP TAPES FOR INPUT AND OUTPUT
      PROGRAM EXPLIF(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      INTEGER       NCOMP(6), COMP(6), CURDATE, DBUILT
      DIMENSION LNFO(6)
      DATA (NCOMP(J),J=1,6)/20,50,20,40,30,20/
C     SET NEGATIVE ZERO(BLANK ENTRY) IN MASK
      MASK = 77770000000000000000B
C
C     READ IN CURRENT DATE
C
      READ(5,10) CURDATE
10    FORMAT(I4)
C
C     LABEL HEADING FOR THE OUTPUT
C
      WRITE (6,1)
    1 FORMAT (≠1≠,T50,≠EXPECTED REMAINING LIVES OF BUILDINGS≠/≠0≠,T50,≠K
     1EY TO CODES FOR TYPES OF INFORMATION≠/≠0≠,T23,≠1--ALL AGES OF COM
     2PONENTS ARE KNOWN≠/≠ ≠,T23,≠2--SOME AGES OF COMPONENTS ARE KNOWN;
     3THE OTHERS ARE ESTIMATED FROM THE AGE OF THE BUILDING≠/≠ ≠,T23,≠3-
     4-ALL AGES OF COMPONENTS ARE ESTIMATED FROM THE AGE OF THE BUILDING
     5≠/≠0≠,T74,≠EXPECTED    TYPE≠/≠ ≠,T47,≠INSTALLATION   BUILDING   REM
     6AINING     OF≠/≠ ≠,T50,≠NUMBER≠,T63,≠NUMBER≠,T76,≠LIFE      INFO≠//)
C
C     READ IN THE DATA FOR ONE BUILDING
C
2     READ(5,3) INST,BLDG,DBUILT,(COMP(I),I=1,6)
3     FORMAT(A5,1X,A5,1X,I4,6(1X,I4))
C
C     CHECK IF ALL DATA CARDS ARE PROCESSED
C
      IF(EOF(5)) 4,5
C
C     DETERMINE IF COMPONENT REMAINING LIFE(YRS) IS INPUTED AND ANY
C     REPLACEMENT HAS BEEN DONE.
C
5     DO 11 J = 1,6
11    LNFO(J) = 0
      TSUM = 0
      DO 6 J = 1,6
C
C     CHECK FOR BLANK ENTRY
C
      MCOMP = COMP(J) .A. MASK
      IF(MCOMP .EQ. MASK ) GO TO 7
      IF(COMP(J) .GE. (+0) .A. COMP(J) .LE. 100) GO TO 6
C
C     CONVERT REPLACEMENT DATE TO REMAINING LIFE
C
8     COMP(J) = NCOMP(J) -(CURDATE - COMP(J))
      IF(COMP(J) .LT. 0)    COMP(J) = 0
      LNFO(J) = 1
```

```
            GO TO 6
      C
      C     CONVERT  COMPONENT THAT HAS NOT INPUTED TO REMAINING LIFE
      C
      7     COMP(J) = DBUILT
            GO TO 8
      6     CONTINUE
      C
      C     CALCULATE THE EXPECTED REMAINING LIFE FOR A BUILDING
      C
            FLIFE = 0.250*COMP(1) + 0.225*COMP(2) + 0.156*COMP(3)
           1 +0.139*COMP(4) + 0.125*COMP(5) + 0.105*COMP(6)
      C
      C     SET LOGIC FOR INFORMATION TYPE
      C
            DO 12 J = 1,6
      12    ISUM = ISUM + LNFO(J)
            IF(ISUM .EQ. 0)  INFO = 1
            IF(ISUM .EQ. 6)  INFO = 3
            IF(ISUM .GT. 0 .A. ISUM .LT. 6)  INFO =2
      C
      C     PRINT RESULTS
      C
            WRITE(6,9) INST, BLDG, ELIFE, INFO
      9     FORMAT(/50X,A5,8X,A5,8X,F3.0,7X,I1)
      C
      C     READ IN NEXT DATA CARD
      C
            GO TO 2
      4     STOP
            END
```

EXPECTED REMAINING LIVES OF BUILDINGS

KEY TO CODES FOR TYPES OF INFORMATION:

1--ALL AGES OF COMPONENTS ARE KNOWN
2--SOME AGES OF COMPONENTS ARE KNOWN; THE OTHERS ARE ESTIMATED FROM THE AGE OF THE BUILDING
3--ALL AGES OF COMPONENTS ARE ESTIMATED FROM THE AGE OF THE BUILDING

INSTALLATION NUMBER	BUILDING NUMBER	EXPECTED REMAINING LIFE	TYPE OF INFO
1000	100	22.	1
1000	200	19.	1
1000	3008	11.	2
2015	45	3.	3
2015	A65	11.	2
3000	4001	29.	3
3000	5002	31.	1
3000	504	20.	2
3000	7211	11.	3

APPENDIX B: DESCRIPTION OF WORK ORDERS

Work Orders. There are three categories of work orders: Standing Operation Orders (SOO), Service Order Jobs (SO), and Individual Job Orders (IJO). A brief description of each is given below.

1. Standing Operation Orders – Those operations and services where specific work and manpower requirements are relatively constant and predictable in advance. The specific work is scheduled and planned for a period of time not to exceed one year. DA Form 2700 is used.

2. Service Order Jobs – Minor maintenance and new work for which the total cost will not exceed 16 manhours or a total of $200. Examples would include the repair of electrical components, building hardware, plumbing, windows, etc. For this classification of work order (DA Form 2699) it is not economically practical to prepare an estimate of the costs. These small jobs generally cover essential work which cannot be deferred to a future year.

3. Individual Job Orders – Maintenance, repair and minor construction which exceeds the scope of Service Order Jobs are classified as IJO. Minor constructions are those projects which are excluded from MCA funding. IJO work (DA Form 2701) is substantial enough to require that estimates of manpower and cost be prepared. This class includes most recurring maintenance. The cycles of recurrence vary. For example, exterior painting of frame buildings may be required each 4 to 5 years; replacement of built-up roofing will probably occur every 20 years.

APPENDIX C: SAMPLE BUILDINGS

Location	Category Code	Building Number	Year Built
Ft. Belvoir	17120	202	1928
		220	52
		221	52
		222	52
		223	52
		247	52
		771	47
		776	50
		791	66
		792	66
		1414	45
		1415	45
		1417	45
		1434	63
	21410	187	40
		189	40
		190	39
		328	42
		788	66
		789	66
		1396	63
		1946	63
		1950	63
	44220	335	42
		702	46
		711	46
		712	46
		1108	55
		1126	55
	61050	219	31
	71115	101	30
		102	30
		103	30
		172	49
		809	50
		810	50
		811	50
		813	56
		900	56
		901	56
		902	56
	72210	201	28
		203	28
		205	28
		206	28
		815	58
	72410	80	47
		81	48
		505	56
		506	56
		507	69
		508	69
		509	69

Location	Category Code	Building Number	Year Built
	74050	—	—
Ft. Bliss	17120	2	54
		645	58
		762	58
		1600	59
		1601	59
	21410	2423	53
		2431	53
		2460	53
		2529	49
		2650	44
		2680	60
		2971	68
		2984	68
		2994	68
	44220	2527	63
	61050	8	1893
		9	1893
		11	1915
		13	1893
		15	1915
		55	16
		125	15
		241	1893
		251	34
		620	58
		649	39
		1660	55
		2010	08
		2020	17
		2022	1897
	71115	317	30
		318	30
		319	30
		344	39
		345	39
		346	39
		1414	56
		1416	56
		1444	30
		1445	30
		1446	30
		1486	30
		1487	39
		1488	39
		1490	56
		1491	56
		1495	56
		1594	62
		1595	62
		1596	62
		1597	62
	72210	500	34

Location	Category Code	Building Number	Year Built
		503	34
		504	34
		512	34
		11174	66
		11175	66
		11265	66
	72410	223	1893
		243	1939
		627	34
		628	34
		629	39
		631	39
		5015	56
		5016	56
		5017	56
		11340	66
		11354	66
	74050	1015	56
		2011	1893
		2408	1957
		2433	55
		2492	55
Ft. Bragg	17120	W1434	63
	21410	C5918	57
		C5919	55
		C6018	71
		C6117	71
		C8030	55
		C8334	71
		D1412	67
		D2026	64
		D2464	61
		D2564	61
		22814	35
	44220	C2222	56
		J2050	53
		J2535	67
		22406	35
		22408	35
		22411	35
		24443	18
		83710	34
	61050	P2938	56
		21133	29
		21361	34
		21728	29
	71115	B1326	57
		B1332	57
		B1425	57
		22042	39
		22142	39
		22355	39
		22337	49
		22535	49
		22540	49
		24044	28
		24045	28
		24046	28
	72210	D2004	66
		D2007	66
		D2420	66
		D3142	71
		D3151	71
		D3238	71
	72410	D3601	66
		D3701	66
		11939	68
		12334	53
		12336	53
		13882	53
		14428	35
	74050	C3429	57
		D2509	67
		D3534	71
		Q2321	54
		69344	53
Ft. Devens	17120	11	40
		12	29
		13	30
		1458	38
		1469	38
		1470	38
		1474	40
		1696	45
	21410	601	69
		602	69
		603	69
		1401	65
		2517	66
	44220	1400	64
		1434	52
	61050	1461	39
		1478	38
	71115	100	31
		101	31
		102	31
		131	40
		134	40
		135	40
		154	57
		155	57
		157	57
	72210	P-467	63
		P-648	63
		P-655	62
		693	70
		695	70
		697	70
	72410	20	65
		21	65
		22	56

Location	Category Code	Building Number	Year Built
	74050	690	70
Ft. Ord	17120	–	–
	21410	4527	53
		4534	53
		4855	53
	44220	2065	52
		2071	53
		2080	42
		2081	42
		2082	42
		2420	41
		2424	42
	61050	14	40
		2798	41
		7922	58
	71115	8401	66
		8404	66
		8405	66
		8451	69
		8452	69
		8453	69
	72210	4451	70
		4452	70
		4454	70
	72410	4360	53
		4361	53
		4362	53
		4364	66
		4365	66
		4366	66
	74050	91	42
		4419	59
		4575	58
Presidio of Monterey	17120	620	65
		624	57
		631	67
		635	67
		636	67

Location	Category Code	Building Number	Year Built
		637	67
	21410	–	
	44220	–	
	61000	632	67
		633	67
	71115	550	66
		551	66
		552	66
	72110	627	57
		629	65
		630	69
	72410	366	56
		367	67
	74050	–	
Ft. Leonard Wood	17120	1606	63
	21410	672	64
		673	64
		680	64
		990	70
		991	70
		998	70
	44220	–	
	61050	2399	64
	71115	–	
	72210	628	64
		652	61
		654	61
		1015	71
		1016	71
		1028	71
	72410	4100	65
		4101	66
		4102	66
	74050	639	65
		744	66
		835	67