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MANAGEMENT PLANNING, SCHEDULING AND CONTROL FOR THE CONSTRUCTION OF LOWER COST HOUSING

by

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The City of Ann Arbor is a university city located in the southeast area of Michigan, the seventh most populous state in the United States. Like many American cities, Ann Arbor has experienced a large population growth in the last decade from 1960 to 1970. Its population has grown from 67,000 to 99,797 (a percentage increase of 49%) in the past ten years. The large population increase has created a severe demand for increased city services. This applies to the normal functions of municipal government including water supply, police protection, fire protection, roads, building inspections, housing, parks and recreational facilities, traffic control, and financial administration. Municipal governments, and in fact governments at all levels, have to provide improved management capabilities in order to meet the ever-increasing demands in America's highly affluent society.

We will discuss in this paper modern management techniques to provide improved government capabilities in a particular area of governmental concern, that being the provision of housing needed in American cities.

The principal management technique discussed is the Critical Path Method, which can be used for management, planning, scheduling control of all city functions, including the provision of lower cost housing. In addition, this paper will outline a model of the use of the technique in a lower cost housing project in the city of Ann Arbor, Michigan.
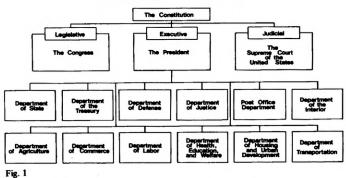
BACKGROUND

Ann Arbor, like most American cities, faces the problem of providing housing for all segments of the community. The need of housing is quite evident in Ann Arbor, a university city consisting of 32,000 students out of a total population of 99,797. The nominal vacancy rate in the city of Ann Arbor has been 2%. This is equivalent to an effective rate of 0% vacancy because of the highly transient mobile character of the community (there are many professors, educators, and researchers as well as students who frequently move in and out of the community).

Throughout the state of Michigan there is a need for housing as well. It has been estimated that in Michigan alone, there are 400,000 units of housing currently needed to meet the demand generated by increased population, new family formations, and a greater level of affluence which provides the mechanism for increasing the desire for improved housing. In addition, during the decade of the 1970's, about 24,200,000 new homes will be built in the United States, according to official forecasts. This average of 2.42 million homes per year compares to 1.65 million built during the decade from 1959 to 1968. This provides for a 49% increase in the annual national level of construction of homes in the decade ahead. Part of this demand will most likely be met by new technologies, such as pre-built housing, prefabricated and modular housing. There will be an increasing involvement and participation by the federal government in the supply of housing through control of financing regulations, by development of new technologies for housing, by influencing local government jurisdictional controls over building codes and by initiating a greater NATIONAL commitment towards the total housing problem.

The Federal Government agency most intimately involved with housing in the United States is the Department of Housing and Urban Development. This agency is one of the twelve departments which are in the Executive Branch of government. The U.S. has three branches of government at the national level which are designed to act as a system of "checks and balances" on each

other. The three branches are legislative, executive and judicial. (For an overview of the executive branch and the departments within it see Figure 1.)

THE GOVERNMENT OF THE UNITED STATES

Fig. 1

HISTORY OF THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

The Department of Housing and Urban Development was established by Act of Congress on September 9, 1965. The Department of Housing and Urban Development Act, which became effective on November 9, 1965, transferred to the Secretary of Housing and Urban Development all of the functions, powers and duties of the Housing and Home Finance Agency (including the Community Facilities Administration and the Urban Renewal Administration), of the Federal Housing Administration and the Public Housing Administration, and of the heads and other officers of those agencies.

The Declaration of Purpose of the Department of Housing and Urban Development Act declares that "the general welfare and security of the Nation and the health and living standards of our people require, as a matter of national purpose, sound development of the Nation's communities and metropolitan areas in which the vast majority of its people live and work."

To carry out this purpose, the Congress charged the newly formed Department of Housing and Urban Development with the responsibilities of administering all of the Federal Government programs which provide assistance for housing and development of communities, assisting the President in achieving maximum coordination of all Federal activities affecting community development and housing, promoting state, regional and local cooperation in matters relating to housing and community development, and encouraging solutions to the problems of housing and development through state, county and local government as well as private action.

HUD FINANCED HOUSING PROJECT IN ANN ARBOR, MICHIGAN

One of the programs by which the U.S. Department of Housing and Urban Development assists urban areas in the construction of lower cost housing is called the "Turnkey Method". Under this method, a local housing authority in cooperation with the Department of HUD acquires land and seeks proposals from developers for construction of a lower cost housing project. The developer to whom the contract is awarded constructs the project in compliance with local and federal specifications and requirements with private financing. After the project is constructed, and if it meets the requirements of the local housing authority and the Department of HUD, the developer is paid with federal funds and the deed is turned over to the local housing authority.

The Turnkey Method was used by the City of Ann Arbor, Michigan for the construction of a lower cost housing project

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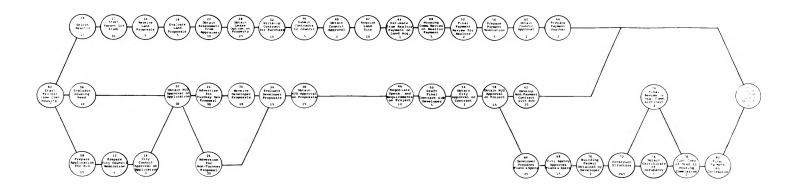*Assistant City Administrator, City of Ann Arbor, Michigan.

NON-OVERLAPPING NETWORK MODEL FOR LOW COST HOUSING PROJECT

Fig. 3

RUN DATE 4 JAN 72   * *   SCHEDULE REPORT   * *   DATA DATE 26 JAN 70

RUN SEQUENCE 0   NETWORK ID 29   LOW COST HOUSING PROJECT (NON-OVERLAPPING)   FROM 26 JAN 70 TO 26 NOV 71

SEQUENCE W I   PAGE 1

WI	DESCRIPTION	TOT DURAT	CAL	START EARLY	START LATE	START FLOAT	FINISH EARLY	FINISH LATE	FIN FLOAT	FREE FLOAT
02	Start Low Cost Housing Project	5.0	51	26 JAN 70	26 JAN 70	0.0	30 JAN 70	30 JAN 70	0.0	0.0
04	Select Realtor	10.0	51	2 FEB 70	24 FEB 70	15.0	16 FEB 70	9 MAR 70	15.0	0.0
06	Evaluate Housing Need	10.0	51	2 FEB 70	18 FEB 70	11.0	16 FEB 70	3 MAR 70	11.0	0.0
08	Prepare Application for HUD	15.0	51	2 FEB 70	2 FEB 70	0.0	23 FEB 70	23 FEB 70	0.0	0.0
10	Start Vacant Lot Study	30.0	51	17 FEB 70	10 MAR 70	15.0	30 MAR 70	20 APR 70	15.0	0.0
12	Prepare Resolution for City Council	5.0	51	24 FEB 70	24 FEB 70	0.0	2 MAR 70	2 MAR 70	0.0	0.0
14	Receive Land Proposals	5.0	51	31 MAR 70	21 APR 70	15.0	6 APR 70	27 APR 70	15.0	0.0
16	City Council Approval on Application	1.0	51	3 MAR 70	3 MAR 70	0.0	3 MAR 70	3 MAR 70	0.0	0.0
18	Evaluate Land Proposals	5.0	51	7 APR 70	28 APR 70	15.0	13 APR 70	4 MAY 70	15.0	0.0
20	Obtain HUD Approval on Application	30.0	51	4 MAR 70	4 MAR 70	0.0	14 APR 70	14 APR 70	0.0	0.0
22	Obtain Assessment from Appraiser	10.0	51	14 APR 70	5 MAY 70	15.0	27 APR 70	18 MAY 70	15.0	0.0
24	Advertise for Turnkey Development Proposal	30.0	51	15 APR 70	15 APR 70	0.0	26 MAY 70	26 MAY 70	0.0	0.0
26	Advertise for Non-Turnkey Proposal	30.0	51	15 APR 70	29 APR 70	10.0	26 MAY 70	9 JUN 70	10.0	10.0
28	Obtain Lease Option on Property	20.0	51	28 APR 70	19 MAY 70	15.0	25 MAY 70	15 JUN 70	15.0	0.0
30	Receive Developer Proposals	10.0	51	27 MAY 70	27 MAY 70	0.0	9 JUN 70	9 JUN 70	0.0	0.0
32	Write-Up Contract for Purchase	10.0	51	26 MAY 70	16 JUN 70	15.0	8 JUN 70	29 JUN 70	15.0	0.0
34	Evaluate Developer Proposals	15.0	51	10 JUN 70	10 JUN 70	0.0	30 JUN 70	30 JUN 70	0.0	0.0
36	Submit Contracts to Council	5.0	51	9 JUN 70	30 JUN 70	15.0	15 JUN 70	6 JUL 70	15.0	0.0
38	Obtain HUD Approval on Proposals	15.0	51	1 JUL 70	1 JUL 70	0.0	21 JUL 70	21 JUL 70	0.0	0.0
40	Obtain Council Approval	1.0	51	16 JUN 70	7 JUL 70	15.0	16 JUN 70	7 JUL 70	15.0	0.0
42	Acquire Land Site	10.0	51	17 JUN 70	8 JUL 70	15.0	30 JUN 70	21 JUL 70	15.0	0.0
44	Estimate for Realtor Payment on Land Acq.	1.0	51	1 JUL 70	2 NOV 71	344.0	1 JUL 70	2 NOV 71	344.0	0.0
46	Negotiate Specs & Requir on Project	10.0	51	22 JUL 70	22 JUL 70	0.0	4 AUG 70	4 AUG 70	0.0	0.0
48	Housing Commiss Review on Realtor Payment	5.0	51	2 JUL 70	3 NOV 71	344.0	8 JUL 70	9 NOV 71	344.0	0.0
50	Draft Final Contract with Developer	5.0	51	5 AUG 70	5 AUG 70	0.0	11 AUG 70	11 AUG 70	0.0	0.0
52	Final Payment Review for Realtor	2.0	51	9 JUL 70	10 NOV 71	344.0	10 JUL 70	11 NOV 71	344.0	0.0
54	Obtain City Council Approval on Contract	1.0	51	12 AUG 70	12 AUG 70	0.0	12 AUG 70	12 AUG 70	0.0	0.0
56	Prepare Payment Resolution	5.0	51	13 JUL 70	12 NOV 71	344.0	17 JUL 70	18 NOV 71	344.0	0.0
58	Obtain HUD Approval on Project	15.0	51	13 AUG 70	13 AUG 70	0.0	2 SEP 70	2 SEP 70	0.0	0.0
60	Obtain Council Approval	1.0	51	20 JUL 70	19 NOV 71	344.0	20 JUL 70	19 NOV 71	344.0	0.0
62	Develop Annual Payment Contracts with HUD	10.0	51	3 SEP 70	10 NOV 71	304.0	17 SEP 70	23 NOV 71	304.0	304.0
64	Developer Prepare Plans & Specs	25.0	51	3 SEP 70	3 SEP 70	0.0	8 OCT 70	8 OCT 70	0.0	0.0
66	Prepare Payment Voucher	2.0	51	21 JUL 70	22 NOV 71	344.0	22 JUL 70	23 NOV 71	344.0	344.0
68	City Agency Approves Plans & Specs	15.0	51	9 OCT 70	9 OCT 70	0.0	29 OCT 70	29 OCT 70	0.0	0.0
70	Building Permit Obtained by Developer	2.0	51	30 OCT 70	30 OCT 70	0.0	2 NOV 70	2 NOV 70	0.0	0.0
72	Construct Structure	260.0	51	3 NOV 70	3 NOV 70	0.0	5 NOV 71	5 NOV 71	0.0	0.0
74	Final Review by Housing Commiss Archtect	2.0	51	8 NOV 71	11 NOV 71	3.0	9 NOV 71	12 NOV 71	3.0	3.0
76	Obtain Certificate of Occupancy	5.0	51	8 NOV 71	8 NOV 71	0.0	12 NOV 71	12 NOV 71	0.0	0.0
78	Turnover of Deed to Housing Commiss	2.0	51	15 NOV 71	15 NOV 71	0.0	16 NOV 71	16 NOV 71	0.0	0.0
80	Final Payment to Contractor	5.0	51	17 NOV 71	17 NOV 71	0.0	23 NOV 71	23 NOV 71	0.0	0.0
82	End-of Low Cost Hsng Project	3.0	51	24 NOV 71	24 NOV 71	0.0	26 NOV 71	26 NOV 71	0.0	0.0

PROJECT BASE DATE 26 JAN 70   PROJECT DURATION 670.0   PROJECT COMPLETION DATE 26 NOV 71

HIS IS RCNTEST1

Fig. 4

which was recently completed. The project that we are considering is a 105 unit High-Rise Structure for the Elderly and Handicapped. The 105 units consist of 102 apartments with one bedroom each and three apartments with two bedrooms. The total project cost was $1,600,000. A photograph of the project as completed during the month of December 1971 is shown in Figure 2.

Fig. 2. High-Rise for the Elderly and Handicapped, Ann Arbor, Michigan

MANAGEMENT FOR HOUSING CONSTRUCTION

The Critical Path Method is a management technique which can be utilized to optimize the planning, scheduling and control of any process. In this case, we are discussing the utilization of this technique for the 105 unit high rise structure constructed for the elderly and handicapped in Ann Arbor, Michigan.

The first item to be performed utilizing the Critical Path Method (CPM) is to determine all of the activities required to construct the project. This process models the entire project plan and is a useful tool in conceptualizing the work flow. The next step in CPM is to draw a diagram of all construction activities to show the relationship between the required activities. This diagram is known as a precedence diagram because it shows those activities that must be completed preceding the start of other related activities.

The precedence diagram for the high rise housing project in Ann Arbor is shown in Figure 3. This diagram is entitled "Non-Overlapping Network Model for Low Cost Housing Project" because it shows every single activity that must be accomplished on the project before it can be considered completed. (Another type of precedence diagram is the "overlapping network model" which groups activities and shows the work process in less detail.) The non-overlapping network model would be the type of diagram used for detail work by a staff member such as the project construction engineer or Director of the Housing Commission. The overlapping network would match the interest of a higher level of management and responsibility. In the case of the Ann Arbor High Rise for the Elderly and Handicapped, the overlapping network would be utilized by the Mayor, City Administrator, Housing Commission and City Council. In a private organization, the less detailed overlapping network would be utilized by such people as the Chairman of the Board, Company President, Chief Financial Officer or Division Supervisor. The precedence or process diagram can be considered the planning phase of the Critical Path Method.

After the precedence diagram or project planning phase is completed, the scheduling and control phase of the Critical Path Method can be initiated. By assigning calendar work days for the completion of each work activity, the start and finish dates for each activity can be ascertained. A review of Figure 4 shows such items as Early Start, Late Start, Early Finish, and Late

Finish. These are defined as follows:

EARLY START DATE - The earliest calendar date or time that the activity can be started. This depends upon the completion of activities that must occur prior to the work activity under consideration.

EARLY FINISH DATE - This is computed as the earliest start date of the activity plus the duration time of the activity.

LATE START DATE - The latest date that the activity can start without affecting the total duration of the project.

LATE FINISH DATE - The latest date that the activity can finish without affecting the total duration of the project.

The calculations for early start, early finish, late start and late finish dates can be made by adding the dates along the precedence network activity paths and the various work flow lines. In addition to the manual calculations method, the computer can be programmed for ascertaining all of the data needed. Figure 4 represents the scheduling and control information as produced by using a computer.

Another beneficial aspect of the Critical Path Method in addition to scheduling is the control function. For example by reviewing Figure 4 many important questions in management control of the project can be answered, such as:

(1) Question: What is the start date of the low cost housing project?
Answer: The early start date is January 26, 1970. This is activity 02, "Start Low Cost Housing Project."

(2) Question: If the project starts January 26, 1970, when would it be finished?
Answer: The earliest finish date is November 26, 1971. This is work item 82, "End of Low Cost Housing Project."

(3) Question: How long will the project take from start to finish?
Answer: The total project duration is 670.0 calendar days.

(4) Question: What are the critical activities for the project? That is, which activities should not be delayed or else it will affect the project completion date?
Answer: All those activities which have a finish float time equal to 0.0 are critical activities; for example, the activities listed below do not have any float time. This means that their delay would affect the project completion date. Activities or work items with no float time include 02, 08, 12, 16, 20, 24, 30, 34, 38, 46, 50, 54, 58, 64, 68, 70, 72, 76, 78, 80, 82 (see Figure 4). The activities listed above are the project's critical activities and they comprise a chain known as the Critical Path. The Critical Path is the chain of activities which require the longest amount of time for completion. Any other path through the projects takes less time and therefore is not critical to project completion.

(5) Question: If work item "Receive Land Proposals" is delayed, how will this affect the project?
Answer: Work item 14, "Receive Land Proposals," has a finish float time of 15.0 days. Therefore it can be delayed a maximum of fifteen days before it will affect the project completion date. If it starts later than April 21, 1970, it will delay completion of the entire project. To avoid this, the activity must start between March 31, 1970 (Early Start Date) and April 21, 1970 (Late Start Date).

The Critical Path Method is one of the best techniques available to optimize and improve the management process. Any process that requires planning and scheduling as well as management control can be aided by CPM. The CPM method can aid in achieving on-time construction of a project at minimum cost and maximum efficiency. It can be implemented to aid management in decisions required due to changes in plans, contingencies, financial conditions, manpower availability or any factor that would influence the project.

As demonstrated by the construction project which was modeled for the Ann Arbor, Michigan High Rise for the Elderly and Handicapped, the Critical Path Method is a management tool which provides widespread benefits to all participants at various levels of management responsibility.