event, and a sort-extract feature can pull out critical items such as all tasks, with the same 'float' value. For those programs which accept non-numeric inputs, print outs with descriptive labelling are available. And for program packages with PERT features, the user can determine the probability of meeting a scheduled project deadline, based on statistical evaluation of the averaged durations and variances furnished at input. A program module furnishing this probability computation has been applied by General Learning Corporation to the critical path of the Secondary Education Complex project.

NETWORK UPDATING
DYNAMIC PROJECT CONTROL

The print-out options available from various computer networking packages will give the project director and the agencies and contractors involved a thorough going initial basis for scheduling and rationalizing the entire project effort. However, in the course of even a moderately long project, changes will occur in the point-to-point timings, in the level of network detail needed at various key points, and even in the task/event relationships initially envisaged.

By posting network changes both to the input documentation sheets mentioned above and directly to the working visual network, the project director can furnish 'live' inputs with which the computer can update the network tabulations 'in real time'. The importance of event numbering keyed to centers of responsibility and spaced sufficiently to permit additions and deletions becomes evident at the point of updating. In addition to revised tabulated print-outs developed during the computer update run, PERT-type programs can furnish current estimates of the probability of meeting deadlines, based on the three timing estimates associated with the new update inputs. At the time the project network is first set up, the project director and those responsible for major project activities should define the reporting and communications linkages required to keep in step with the project network and to update it. Project communication and control can be based on selective dissemination of computer network outputs, for example, and update reporting and status information can be documented in a format such as that used in the Secondary Education Complex project.

In following the guidelines suggested in this discussion and in relating the detailed computer networking techniques which he implements to the broader aims of coordination and project completion, the project director will find the generic model a 'working partner' in creating new facilities for the Boston Public Schools.

DOCUMENT RESUME

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ABSTRACT

A visual, as well as verbal, description is presented of the process by which an educational facility was planned and built in Boston. The graphic display of the generic process represents specific considerations regarding--(1) the development of a capital improvement program, (2) site selection, acquisition and preparation, (3) educational planning, and (4) design and construction. Also included is a description of the implementation of the generic model display network using a critical path method computer program. By utilization of these techniques, agency tasks can be superimposed on the work days of a calendar year; and the exchange of ideas, information, and decisions at the proper time can be assured. (PS)

TASK/EVENT NETWORK FOR SCHOOL CONSTRUCTION,

BOSTON PUBLIC SCHOOLS

GENERIC MODEL

A visual description of the process by which
an educational facility is built in Boston.

GL GENERAL LEARNING CORPORATION • EDUCATIONAL SERVICES DIVISION

Introduction

The Educational Planning Center, charged with the responsibility for preparing the outline of educational requirements for the 5,000 student Secondary Education Complex in Madison Park, identified a need for techniques which allowed them to determine those discrete elements and events which are essential to the process of planning and constructing new school facilities in the city of Boston. Through investigation and analysis undertaken by the Educational Services Division of the General Learning Corporation, the solution evolved into a graphic display of the generic process with an overlay to represent the specific considerations for the Secondary Education Complex (SEC). With the creation of this system, events such as community involvement, interagency cooperation, site planning, educational programming, design and construction can be expedited on route to a projected school opening for the SEC in 1972.

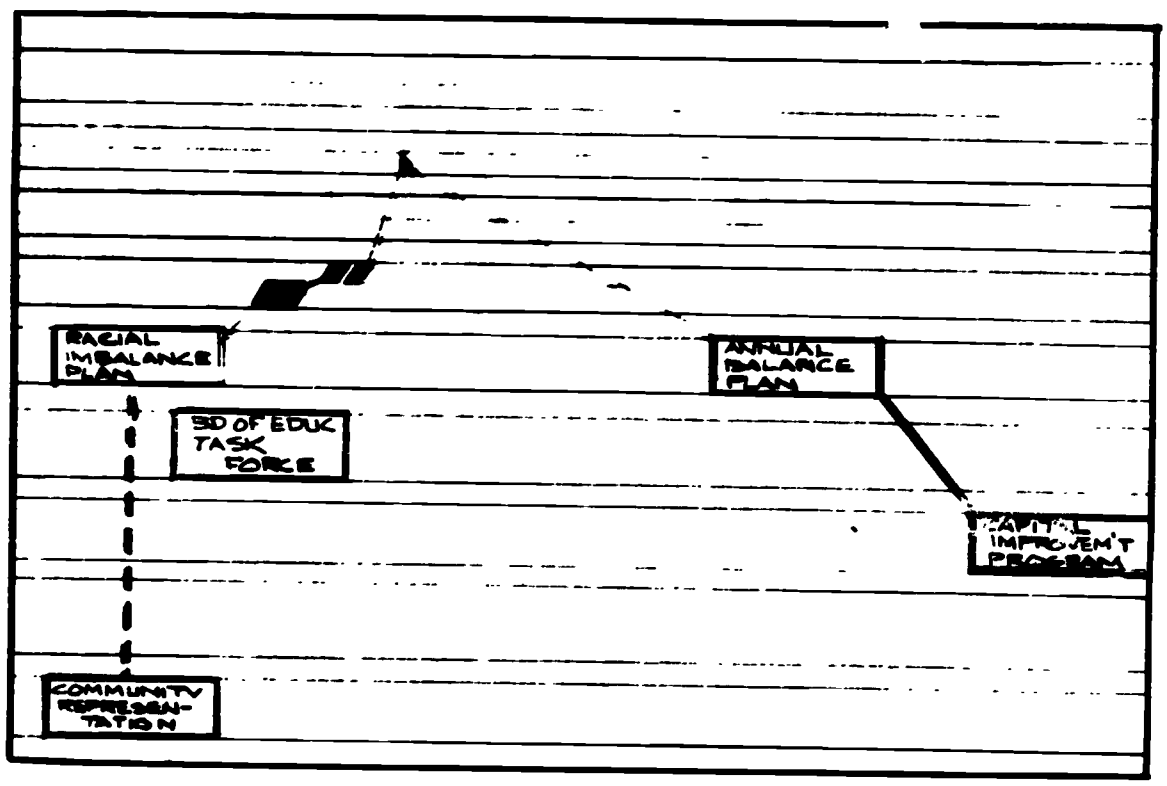
The tasks to be completed for every educational facility include: I. the development of a capital improvement program; II. site selection, acquisition and preparation; III. educational planning; IV. design and construction. When a capital improvement program exists, the three other categories are the responsibility of different agencies and can be carried out concurrently. With the existence of this display network, which has been adapted to a "Critical Path Method" computer program, the tasks for each agency can be superimposed on the work days of a calendar year and the exchange of ideas, information and decisions at the proper time will be assured.

The information following was compiled by the General Learning Corporation with the advice of Mr. William Pear of the Public Facilities Department, and the staff of the Educational Planning Center. Other advice was sought from community organizations, such as the Model Cities Neighborhood Board and the Lower Roxbury Community Corporation, as well as from the Boston Redevelopment Authority Project Director for the Madison Park Urban Renewal site.

DECISION-MAKING BODIES	
FEDERAL	HOUSING & URBAN DEVELOPMENT
	MODEL CITIES
STATE BOARD OF EDUCATION	BUREAU OF RELOCATION
	SCHOOL BUILDINGS ASSISTANCE BUREAU
CITY	REDEVELOPMENT AUTHORITIES (BRA)
	PUBLIC FACILITIES COMMISSION (PFC)
SCHOOL	SCHOOL COMMITTEE
	SUPERINTENDENT
AGENCIES RESPONSIBLE FOR TASKS	
SCHOOL DEPARTMENT EDUCATIONAL PLANNING CENTER (E.P.C.)	
OTHER	
PUBLIC FACILITIES DEPARTMENT (P.F.D.)	
CONTRACTS	
ADVISORY GROUPS	

long range planning

The Boston School Committee has a mandate under the Racial Imbalance Act, Chapter 641 of the Acts of 1965, to provide annually, upon being so notified, a plan to correct racial imbalance which may be found to exist by the State Board of Education. The Public Facilities Commission is responsible for a ten year capital improvement program which may if it chooses utilize the racial imbalance plan. This process is described visually on the display network with further explanation on the following page.



1 SECTION III of Chapter 642 of the Acts of 1966

It shall be the duty of the Public Facilities Commission:

a. To prepare and from time to time amend a long-range capital improvement program designed to provide the necessary structures, facilities and equipment when needed or as soon thereafter as the conditions and adaptability of buildings then existing, the expected availability of buildings then being constructed and the financial resources of the city will permit. Such program shall specify the capital improvement projects to be undertaken in the ten years immediately following the year in which such program is prepared, the estimated cost of each such project, the proposed commencement and completion dates thereof, and, to the extent practicable, the proposed or alternative sites therefor.

FUNDING PROCEDURE FOLLOWING THE DEVELOPMENT OF AN IMPROVEMENT PLAN BY THE PUBLIC FACILITIES COMMISSION

1. Public Facilities Director prepares annual budget request and annual loan order for undertaking capital improvements program.
2. Public Facilities Director submits annual budget and loan order requests to the Mayor's office prior to the first Monday in February.

2a. If this date has passed and additional funds are needed during the year the Director will prepare a supplementary appropriation request and submit this to the Mayor.

3. Mayor approves budget or loan request or supplemental appropriation requests and submits orders to the City Council.
4. The City Council has sixty days to approve, reject or reduce the annual budget and loan order and all supplemental appropriations for the Public Facilities Department.
5. Mayor approves Council action.
6. There is a 20-day waiting period following the Mayor's approval of a loan order to allow taxpayers to initiate a petition for a referendum in order to change the annual budget appropriation.
7. Usually during this time, 20 days, the State Emergency Finance Board is asked to approve the borrowing for certain classes of loans requiring this.
8. The Director of Public Facilities assigns the money for specific projects and construction for particular schools can be carried out.

RACIAL IMBALANCE PLAN

If racial imbalance has been found to exist in the City of Boston, the School Committee with the technical advice and assistance of the State Board of Education task force will annually prepare a plan to correct racial imbalance. This plan will be prepared by a school department task force appointed by the Superintendent, utilizing the capabilities of the Educational Planning Center (EPC); sent to the superintendent for his approval; and passed on to the School Committee for its approval.

Superintendent Review and Approval of task force racial imbalance plan.

School Committee Review and Approval of task force racial imbalance plan.

State Board of Education annual review and approval of the Plan. They will consult their technical assistance task force for advice and assistance.

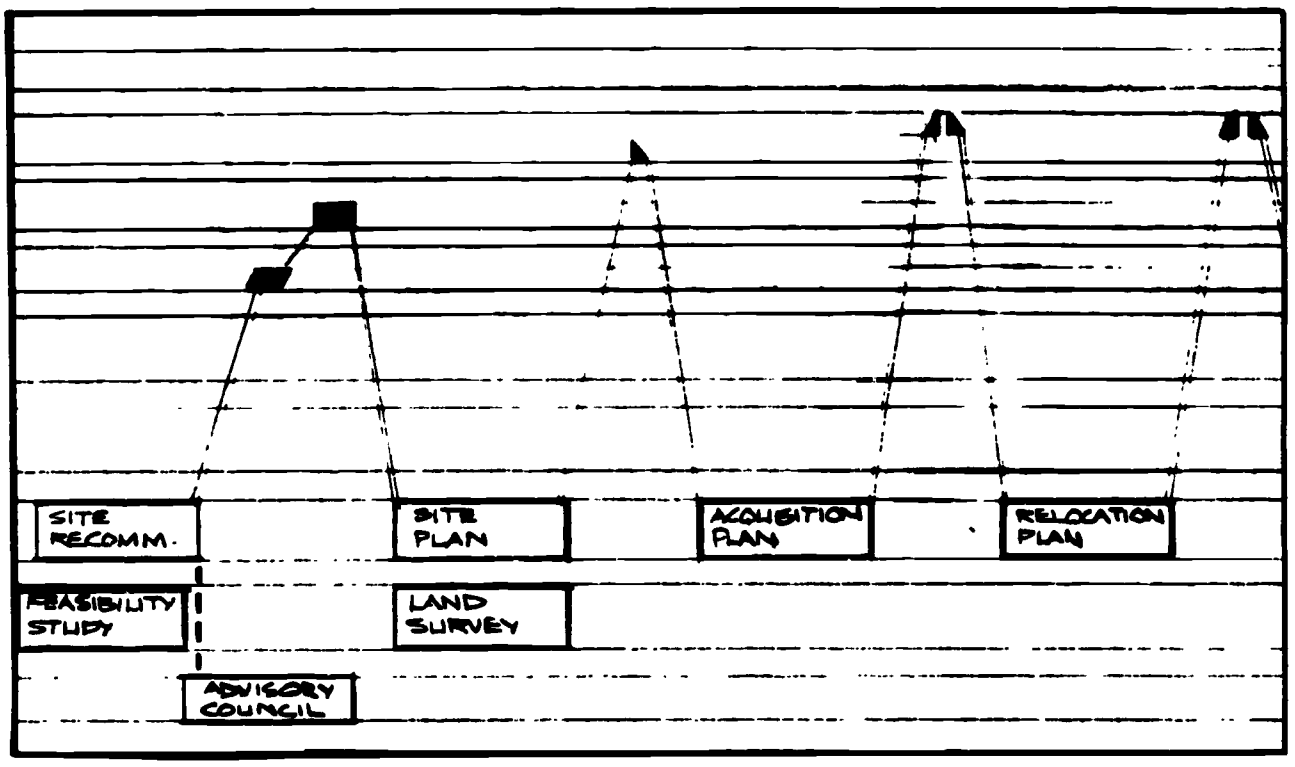
ANNUAL BALANCE PLAN

The School Committee will have at its disposal an approved plan to alleviate racial imbalance. This plan will be transmitted to the Public Facilities Commission whose responsibility it is to develop a long-range capital improvement program for the City of Boston.

CAPITAL IMPROVEMENT PROGRAM

1 The Public Facilities Commission will design a capital improvement program. It will also go through the funding process for the funds for specific projects. Once the Commission has developed a program, this document will be transmitted to the Director of the Public Facilities Department, who will carry it out. This plan will be transmitted through the Superintendent to the Educational Planning Center of the school department in order that it can draw up an educational program for the schools slated for construction by the Capital Improvement Program.

site selection, acquisition and preparation



SUPERINTENDENT'S REVIEW

According to Chapter 642 of the General Acts of 1966, the Director of PFD must give written notice of his proposed site selection to all officers boards or authorities who will be affected by the project. The Superintendent has fourteen days to react. Should he disagree with the site recommendation he may file a counterproposal. The Director may accept and adopt this counterproposal. If there can be no agreement the Director must then submit his own proposal and the Superintendent's counterproposal to the State Commissioner of Education. Within 30 days after these are submitted, the Commissioner must rule on which of the two sites is to be adopted. This decision is binding on the Director and the Commission as well as the school department.

SCHOOL BUILDINGS ASSISTANCE BUREAU (SBAB)

This bureau functions within the State Board of Education to provide technical advice and assistance to local school boards on the planning, design and construction of new facilities or renovations of existing facilities. It is a bureau which must approve consecutive plans if state financial aid is to be awarded. The types of plans and documents to be approved are outlined below:

I. Copies of (1) the educational specifications, (2) the site plan, (3) preliminary plans, (4) final plans and specifications, and (5) cost estimates from contractors must be filed with the Bureau. In each case, after copies have been filed conferences to discuss such plans with relevant parties will be scheduled.

II. Verbal approval by SBAB at each of the above five stages is necessary for the project to continue, and prior to the advertising for bids written approval must be obtained by the school department for the final plans and specifications.

SITE RECOMMENDATION

The Public Facilities Department is responsible for site investigation. Consequently, the Department may contract for a feasibility study of different locations for a particular school and may ask for suggestions from the community, from BRA, from the state and from the school department (EPC) in order to represent adequately these agencies in the location of a facility. This consultation having been accomplished a recommendation will be made to the Superintendent of public schools for a particular site for the particular facility.

2

Superintendent Review and Approval of the PFD recommendation.

The Public Facilities Commission selects the site by approving the Director's recommendation.

SITE PLAN

The Public Facilities Department will prepare a plan for land acquisition. (At this time PFD may contract for a land survey.) PFD will file the site selection recommendation with the School Buildings Assistance Bureau, (SBAB), State Board of Education.

SBAB Review. The Public Facilities Department will file with School Buildings Assistance Bureau a town map, plot plan, topographical map and Department of Public Health approval of sewage disposal where pertinent. PFD will then await SBAB approval.

3 SECTION 31 of Chapter 486 of the Acts of 1909 is amended by Section 12 of Chapter 642 of the Acts of 1962 to read:

Without obtaining the consent of any other board or officer or further authority than that contained in this act, the public facilities commission, in the name of the city, may acquire by purchase, lease, gift, devise or otherwise for any municipal purpose a fee simple absolute or any lesser interest in any land, public or private, within the limits of the city, including air rights and riparian rights, and may take by eminent domain under chapter seventy-nine or chapter eighty A of the General Laws any such fee or interest except in parks and playgrounds and except also, unless there be express consent, in lands belonging to or covered by contract with the United States, the commonwealth, the Boston Housing Authority or the Boston Redevelopment Authority.

ACQUISITION PLAN

3 Following SBAB approval, PFC will develop a land taking proposal and submit this to the State Bureau of Relocation. This must be done no later than 3 months prior to acquisition.

State Bureau of Relocation. This Bureau will qualify the Relocation Assistance Agency of the Boston Redevelopment Authority (BRA) and notify PFC of such no later than three weeks after submission to State Bureau of Relocation.

RELOCATION PLAN

PFC will award relocation contract to the Relocation Assistance Agency of BRA and this agency will prepare a plan.

State Bureau of Relocation review PFC or BRA will file the relocation plan not later than one month prior to land taking.

RELOCATION and ACQUISITION

With the relocation contract approved, relocation will continue (by the BRA) and land acquisition will be completed by PFD.

SITE CLEARANCE

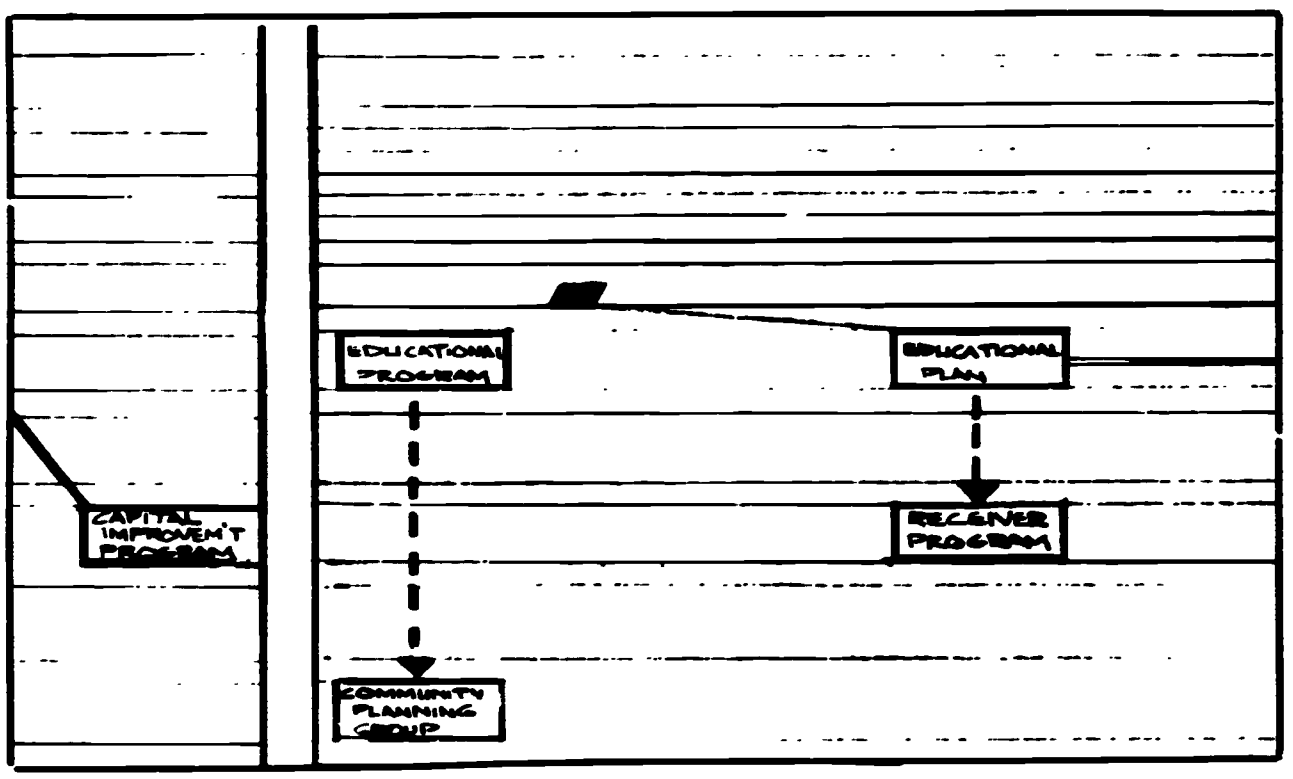
PFD will award a contract for land clearance and will advise contractor when buildings are vacant.

SITE PREPARED

PFD inspects site, contracts are fulfilled and land is prepared.

educational planning

This segment is the development of educational programs by the Educational Planning Center, under the direction of the Superintendent.



4 SECTION V of Chapter 642 of the General Acts of 1966

The school committee may prepare and from time to time amend or supplement a report of educational specifications and programs for the guidance of the commission. The results of all such research and such report of the school committee and any amendment or supplement thereto shall be submitted to the commission, and may also be made available to, and information respecting the same may be disseminated to, appropriate agencies of the city, state and federal governments.

EDUCATIONAL PROGRAM

Upon notification of the capital improvement program by the Public Facilities Department, the Educational Planning Center (EPC) under the direction of the Associate Superintendent in charge of curriculum and planning will prepare educational specifications for a particular school. It will consult an advisory council made up from a wide variety of individuals, representing community groups, colleges and universities and agencies throughout the Greater Boston Area. This program will be submitted to the Superintendent for his approval.

4

It is within the purview of the School Committee to submit educational specifications and programs to the Public Facilities Commission. They may do this at any time and with any recommendations. However, such recommendations are not binding on PFC's course of action.

Superintendent's Review and Approval of educational program.

EDUCATIONAL PLANNING

The Educational Planning Center (EPC) continues to develop the educational program in conjunction with relevant departments of the school system in preparation for the opening of the facility. EPC should communicate the progress of such planning to the architect at regular intervals throughout the design stage of the project.

EDUCATIONAL PROGRAM COMPLETE

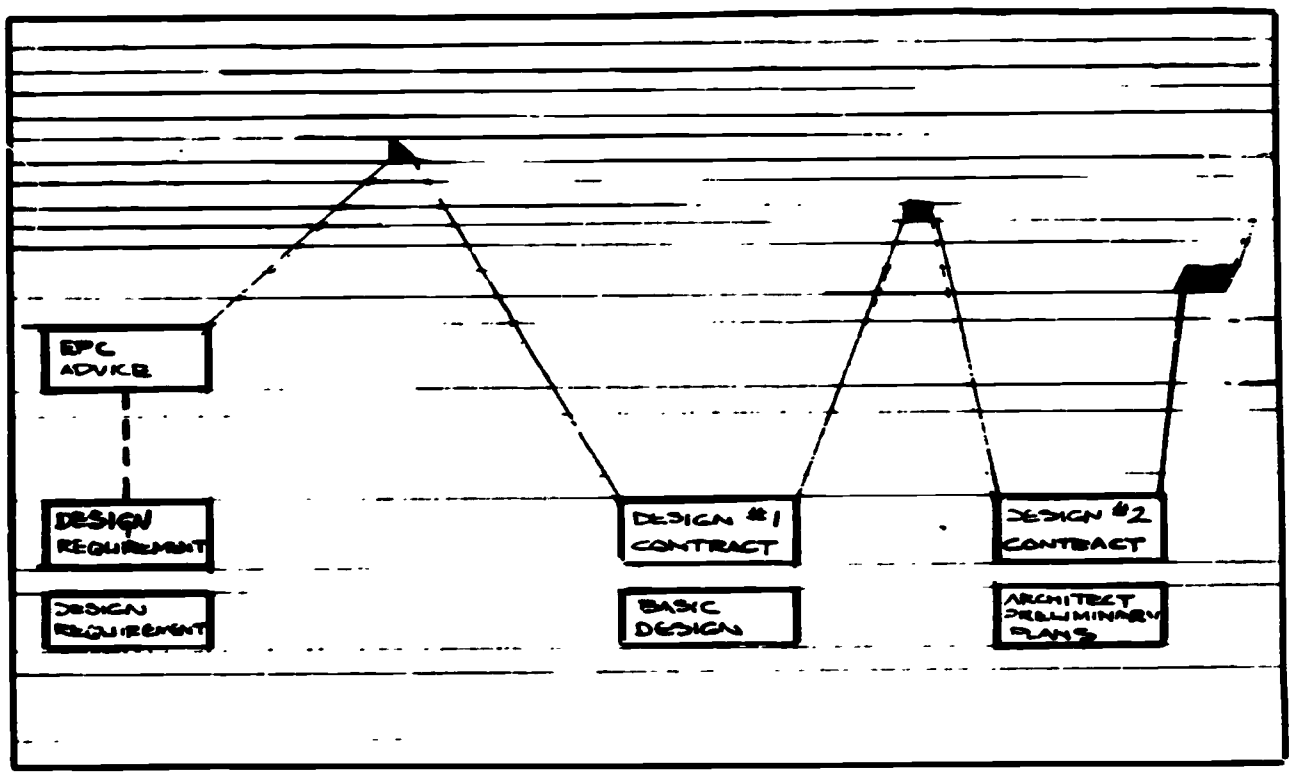
EPC completes program. Prior to the opening of a new facility a principal and teachers are appointed, a curriculum exists and students have been identified.

SCHOOL COMMITTEE ACCEPTS BUILDING

Facility construction is complete, educational program, staffing, and identifying student body is complete. The School Committee receives the building from PFC.

design and construction

The Public Facilities Department is responsible for establishing "design specifications and limitations", engaging an architect for the design and constructing the Facility. This is subject to review and approval of different agencies as described literally in the next pages and visually on the Display Network.



5 SECTION IV, c & d, of Chapter 642 of the General Acts of 1966

c. The commission shall not approve the preliminary studies of any architect or engineer for any structure or facility, unless a statement of functional requirements respecting such structure or facility and such studies shall have been submitted by the director to every board, officer, authority or body to use such structure or facility in the first instance nor until each such board, officer, authority or body has filed with the director written comments with respect thereto or fourteen days have elapsed after the director's delivering such submission without his receiving such comments.

d. Whenever the superintendent of schools in response to a submission of architectural or engineering studies and statement of functional requirements with respect to a school building delivered by the director, as provided in this section four, disapproves such site or the plans for such school building and files within 14 days a counterproposal specifying a site for such school building or specifying particular changes of such plans, without further notice or submissior he director may recommend and the commission may select the site specified in such counterproposal or approve the plans after modification in accordance with such changes of plans specified in such a counterproposal, the director shall submit to the commissioner of education copies of such counterproposal and all accompanying statements of the superintendent of schools together with the notice or submission delivered by the Director and statements of the director in support thereof. Within thirty days after a submission to the commissioner of education pursuant to the preceding sentence, the commissioner of education shall notify the director of his selection of the site or plans as proposed by the director or as specified in such counterproposal, the director shall submit to the commissioner of shall be binding upon the director and commission.

DESIGN REQUIREMENTS

5 The Public Facilities Department (PFD) will prepare design requirements and limitations according to the facilities slated for construction in the Capital Improvement Program. These must be approved by the Superintendent and filed with School Buildings Assistance Bureau of the State Board of Education.

Superintendent's review and approval of the functional requirements and limitations.

School Buildings Assistance Bureau (SBAB) Review. The SBAB requires that educational specifications be filed with them prior to a conference to be held to review these specifications, involving SBAB and PFD.

DESIGN CONTRACT STAGE I

PFD appoints an architect to fulfill a preliminary design contract. The architect completes the schematic drawings. These must be submitted to the Public Facilities Commission for approval.

Public Facilities Commission Approval.

DESIGN CONTRACT STAGE II

The architect continues work and completes preliminary plans or basic design.

Superintendent's Review and Approval. Superintendent must approve the Preliminary Plans or exercise his prerogative to submit a counterproposal.

SBAB Review. PFD will file preliminary plans with SBAB and a conference will be held to review the plans.

Public Facilities Commission Review and Approval. Preliminary Plans basic design is complete, PFC must approve them. The initial design contract has been completed at this time.

DESIGN
CONTRACT
STAGE III

PFD draws up a new contract with the architect. This includes the development of working drawings and contract specifications as well as construction supervision.

PFC reviews the progress of the architect and approves design development.

DESIGN
CONTRACT
STAGE IV

Working drawings and contract specifications are completed by the architect.

Superintendent's Review and Approval of Working Drawings.

SBAB Review. PFD will file working drawings with SBAB and Schedule a conference for review. Written approval by SBAB of final plans should be obtained before advertising for bids.

PFC Review and Approval

CONSTRUCTION
BIDS

The Director of PFD will publicly advertise for bids from building contractors who will bid according to the architect's working drawings and specifications.

BID RECOMMENDATION

The PFD Director will receive all bids and make a recommendation to SBAB if state funding is desired. A conference on grant or reimbursement procedure will be held and PFC will file with SBAB a project number and a "form F" estimating the cost of the project.

PFC Review and Approval. The Commission reviews the Director's recommendation and enables PFD to award contract.

CONSTRUCTION CONTRACT AWARDED

The Public Facilities Department awards the construction contract; the contractor signs the contract; PFD signs contract and it is then certified by the auditor which insures payment. It is then approved by the law department of the City and sent to the Mayor for his approval. Following this the Director of PFD directs the contractor to proceed.

CONSTRUCTION CONTRACT

The construction contract continues under the surveillance of the architect and PFD until the facility is complete.

CONTRACT REVIEW

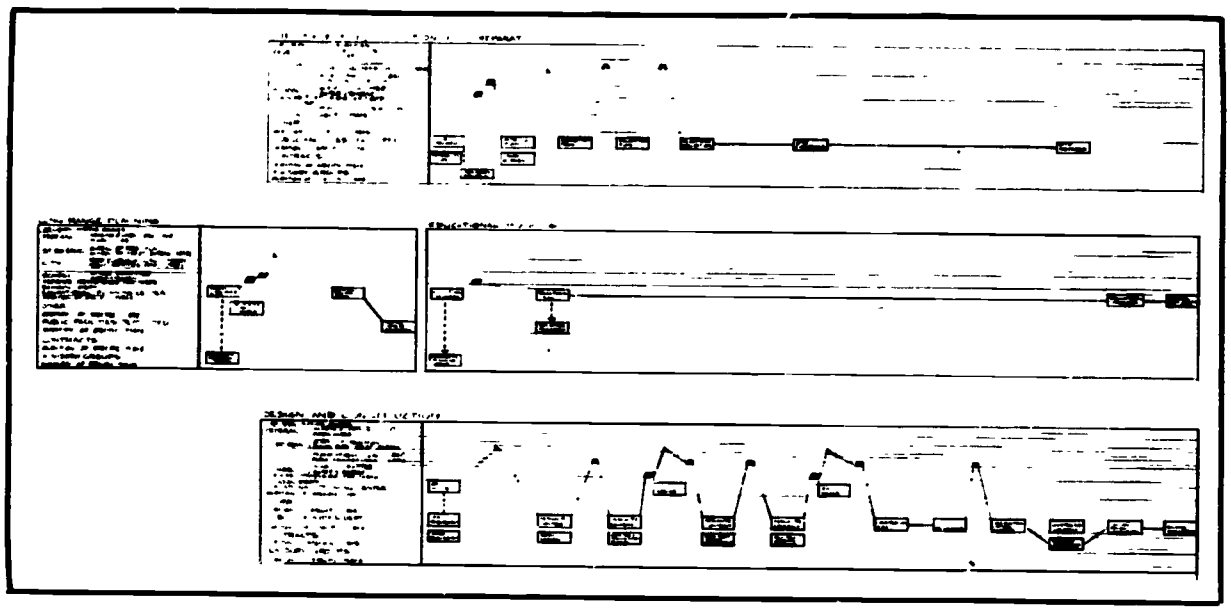
The Public Facilities Director inspects the building, accepts it as complete from the contractor and pays the final fee to the contractor and the architect.

BUILDING TRANSFERRED

The Public Facilities Commission at this time has fulfilled its function as constructor of an educational facility and it turns the building over to the school committee.

implementation of the generic model using computer techniques

Within certain limitations of reliability, the processes and decision points leading to the opening of a new educational facility for the Boston Public Schools can be represented and computed upon as a project network similar to those used in advanced industrial projects. Starting from the generic model and filling out the details on the basis of functional and judgmental information from the entire range of public authorities and contracting parties having to do with the project, the authority responsible for its completion can develop and maintain a point-to-point model of all tasks involved in arriving at the project goal.



In order to implement the generic model, the educational authority responsible for school construction in Boston must undertake a detailed study of the project contemplated, in relation to the model. A basic decision on method is necessary at this stage:

From the outset it must be decided whether or not to utilize computer techniques to implement the non-visual, administrative aspects of the particular project network. In the past ten years a variety of computer program packages has been developed to furnish managers with dynamic, quantitative project control tools. One such set of techniques has already been applied by General Learning Corporation to the Secondary Education Complex. All these packages involve the identification of the critical path in the complete network; that is, the sequence of tasks and events (most simply imagined as points and lines) requiring the longest time to complete, from project start to project finish. Whether the package is labelled Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Least Cost Estimating Schedule System (LESS) or some other acronym, the basis of processing remains the same -- find the critical path and produce management outputs based on the critical-path computation.

In this discussion of network implementation, it will be assumed that computer techniques will be used in dynamically administering projects of the scale indicated by the generic model network. Clerical documentation and calculation of network data is, of course, possible, and would merely involve manual versions of the data manipulations carried out at much higher speeds, and with greater flexibility of output documentation, by existing computer techniques.

The generic visual model, as presented, shows a virtually complete high-level project network. In order to implement it in planning a particular Boston Public Schools project, the project director should select at the outset the computer package to be used, create on the basis of the generic network the project network to work from (visually this is readily done with transparent overlays on the generic network or corresponding to it), and tailor certain aspects of this project network to the input requirements of the particular computer package adopted.

THE PROJECT NETWORK

For the project director, as well as for the majority of 'networking' computer programs available, the project network is best conceptually handled as a completely connected 'directed graph' of points and lines. These points and lines, though their representations may vary in practice, are conceptually distinguished as events and tasks: events are discrete moments in the time-span of a project at which a step in the project is begun or ended; tasks (often referred to as activities) are the processes leading from point to point, sometimes with several arriving at or originating from one event. Neither 'loops' nor 'loose ends' are permitted in the project network; all tasks and events must be located on at least one of the many continuous paths from project beginning to project end. Delays and repetitions of tasks are taken care of separately as timing estimates are associated with the elements of the project network; thus all tasks are seen to be 'goal-directed'. An event from which no real task line leads to another event in the network is not allowed to remain as a 'loose end'; conventionally it is connected forward to some related event and a timing estimate of zero is used to indicate the 'dummy' nature of this connection. Most computer programs for dealing with networks call for a single starting event and a single 'target' end event, and in practice this restriction is easily satisfied.

The job of setting up a real-life project network on the basis of the Boston Public Schools generic network will demand imagination and flexibility of the project directors. The four major areas of activity indicated on the generic network -- Long Range Planning, Site Selection, Acquisition and Preparation, Educational Program and Design & Construction -- will have variations of inter-relationship and of importance in each new project. It may prove necessary to identify a series of intermediate steps (called a 'frag-net' or 'sub-net') between two event points of the generic network. New task relationships within, or between, the four major areas of activity may be discovered during detailed project study -- arising from new jurisdictional or material factors in the Boston area. Different levels of detail will be found meaningful by the varied entities involved in a school construction project; the project director should establish at the outset a project network for the overall management of the project such that a 'walk-through' of that network is understandable to all the parties concerned, public and private. This level of the project network should be the master reference level, and project control as well as all subsidiary networks should depend on this master reference level of the project network.

A final word about the project network: the rigor and tight structuring of networking as found, for instance, in the highly technological aerospace industries, is not to be expected in the less-structured environment in which major urban projects are carried out. The project director should seek to meet the basic technical criteria for computer networking as mentioned in this discussion, while managing the computer network as a means to the end of coordinating all parties involved toward project accomplishment.

TASK/EVENT NUMBERING AND LABELLING

The arrangement suggested by the visual generic network, where centers of project responsibility are separated into distinct levels from "Mayor" to "Contractor", is readily adapted to numbering the events and tasks in a project network. Each such center of responsibility can be assigned a block of event numbers, by the thousands or even the ten-thousands (if the computer network package permits). Events within the level of the same center of responsibility are assigned unique numbers from the relevant block. Event numbers should be spaced within the block as widely as possible to allow both for updating and the numbering of 'frag-nets' between events. For task (activity) oriented computer programs (CPM), tasks are uniquely identified by a beginning and an ending event. All inputs to and outputs from computer networking packages are based on event (or task) numbering that is unique; no duplications are permitted. Most such programs, whether PERT or CPM-like, will accept brief alpha-numeric descriptive labels as additional input and will produce printed outputs using these labels.

TIMING: TASKS AND EVENTS FOR INPUT

The project director should oversee the establishment of timings to be assigned to all events (PERT) or tasks (CPM) in the network. It is essential that the timing estimation be done on a point-to-point basis as far as possible, without juggling adjustments to meet possibly unrealistic intermediate deadlines. Thus, for PERT type computer programs it is usually possible to input three different time estimates, called 'shortest', 'probable', and 'longest', or a calculated mean time and variance based on these three, for the tasks preceding each event. For CPM-type programs a single 'duration' estimate for each task is usually required at input. Both management science textbooks and the user's manuals for computer networking packages can furnish approaches to deriving objective timing estimates, upon which the reliability of the project network will rest.

Facility **S.e.C.**

Date

Task Numbers	Duration: shortest	Duration: probable	Duration: longest	Computer Timing Inputs: mean	Computer Timing Inputs: variance	Task Description	Event No.	Event Description
305-306						The director of Public Facilities Department will now request a review from the Commission.	306	Public Facilities Commission Approval
306-307						The architect will resume his contract making adjustments and completing Working Drawings.	307	Design Contract — Working Drawings
307-308						S. B. A. B. must review the working drawings to make sure they do not conflict with the preliminary plans.	308	S. B. A. B. Approval
308-309						Superintendent, with advice and assistance from the Educational Planning Center reviews again the educational implications of the plans.	309	Superintendent's Approval
309-310						B. R. A. reviews contract drawings to check for conflicts with constraints and parameters and preliminary plans.	310	B. R. A. Approval
310-311						Public Facilities Commission Review	311	PFC Approval
311-312						P. F. D. solicits bids from building contractors.	312	Construction Bids
312-313						P. F. D. director reviews bids, selects one and makes a recommendation.	313	Bid Recommendation
313-314						S. B. A. B. must approve bid if state funding is desired.	314	S. B. A. B. Approval

DOCUMENTATION MEDIA FOR NETWORK INPUT

The typical network documentation sheet illustrated here has been filled out for tasks related to the Secondary Education Complex, but is sufficiently open-ended to serve for most standard networking purposes. Besides serving as 'hard-copy' documentation of the project network from the beginning, loose-leaf sheets such as this example provide for current and easy updating of the computer network.

COMPUTER PROCESSING OF NETWORK DATA

Computer networking programs generally perform preliminary error-finding routines on the inputs described above, testing the completeness and connectedness of the network, as well as detecting 'loops' and 'loose ends' if any are present. Processing then goes on to locate, by a series of sorts and additions, the one sequence of tasks (and events, of course) which has the longest overall duration of all such paths in the network. This unique sequence is identified as the critical path, and all subsequent computations are related to it. Then, for all tasks on paths other than the critical path, a value of 'slack' or 'float' in time units is calculated, telling how much slippage is allowed that task before it affects the critical path scheduling of the entire network. Naturally, critical path tasks have zero float associated with them; any slippage here delays the entire project.

OUTPUT ALTERNATIVES OF COMPUTER NETWORKING PACKAGES

From the inputs and computations described above, the project director can usually obtain a variety of printed project control documents, depending on the features of the package utilized. All programs furnish tabulations of the events (PERT) or tasks (CPM) in the network, highlighting those on the critical path and stating 'slack' or 'float' for all. Tabulation also details earliest and latest start timing and earliest and latest finish timings for each task or event -- earliest and latest timings being identical for all points on the critical path. These results may be furnished either elapsed time units relative to time zero (project start) or in calendarized form in many cases. Usually it is possible to have output sorted on one or more key factors, such as 'float' value or earliest start date for a task or

Start event	End event	Duration	(Cost)	Earliest start	Latest start	Earliest finish	Latest finish	Float	Critical = **
TOTAL NUMBER OF ACTIVITIES=		31	TOTAL COST=		0				
S	F	D	COST	ES	LS	EF	LF	F	**
1	200	0	0	0	0	0	0	0	**
200	204	0	0	0	1	0	1	1	*
200	201	0	0	0	0	0	0	0	**
204	205	4	0	0	1	4	5	1	*
201	320	0	0	0	0	0	0	0	**
205	322	4	0	4	5	8	9	1	*
320	310	0	0	0	0	0	0	0	**
322	206	4	0	8	9	12	13	1	*
310	202	3	0	0	0	3	3	0	**
206	210	0	0	12	13	12	13	1	*
202	101	4	0	3	3	7	7	0	**
101	203	2	0	7	7	9	9	0	**
203	445	2	0	9	9	11	11	0	**
445	210	2	0	11	11	13	13	0	**
210	102	1	0	13	21	14	22	8	
210	300	3	0	13	13	16	16	0	**
102	211	0	0	14	22	14	22	8	
300	211	6	0	16	16	22	22	0	**
211	323	2	0	22	22	24	24	0	**
211	103	2	0	22	28	24	30	6	
323	212	6	0	24	24	30	30	0	**
103	212	0	0	24	30	24	30	6	
212	104	2	0	30	30	32	32	0	**
104	213	40	0	32	32	72	72	0	**
213	301	3	0	72	80	75	83	8	
213	105	2	0	72	72	74	74	0	**
301	214	0	0	75	83	75	83	8	
105	214	9	0	74	74	83	83	0	**
214	215	3	0	83	83	86	86	0	**
215	216	130	0	86	86	216	216	0	**
216	217	4	0	216	216	220	220	0	**

A Simple Example of a Network Tabulation Print-out