Final Report

REGIONAL AIR POLLUTION STUDY: A PROSPECTUS

Part IV — Management Plan

Prepared for:

THE ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ENVIRONMENTAL RESEARCH CENTER
RESEARCH TRIANGLE PARK, NORTH CAROLINA

CONTRACT 68-02-0207

SRI Project 1365

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R. T. H. COLLIS, *Director*
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FOREWORD

This Prospectus was prepared by Stanford Research Institute for the Environmental Protection Agency under Contract No. 68-02-0207. While this Prospectus has been reviewed by the Environmental Protection Agency and approved for publication, approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor is it intended to describe the Agency's program.

The complete Prospectus for the Regional Air Pollution Study is presented in four parts.

Part I	Summary
Part II	Research Plan
Part III	Research Facility
Part IV	Management Plan

A table of contents for all parts is provided in each of the four parts to facilitate the use of the Prospectus.

ACKNOWLEDGMENT

This Prospectus was prepared at the Institute by a project team representing the full range of disciplines necessary for the comprehensive analysis of problems of air pollution. Research team members were drawn from four of the eight Institute Research Divisions, including the following:

Electronic and Radio Sciences
Physical Sciences
Information Science and Engineering
Engineering Systems

Because of the interdisciplinary nature of the effort, the contributions and research findings of many team members are distributed throughout this Prospectus rather than concentrated in one or more specific chapters. Accordingly, contributions are acknowledged below by general areas associated with the study of air pollution problems.

This Prospectus was prepared under the supervision of R.T.H. Collis, Project Director. The Project Leader was Elmer Robinson (now of Washington State University) until 15 January, when Richard B. Bothun, who had been Deputy Project Leader, succeeded him.

The main contributions were as follows:

- Elmer Robinson--Project leadership and the formulation of the Research Plan

- Richard B. Bothun--Project leadership and administrative management and the formulation of the Management Plan.

Technically, the principal contributions were:

- Richard B. Bothun--Management, scheduling, costing, planning

- Leonard A. Cavanagh--Air quality instruments, atmospheric chemistry

- Ronald T. H. Collis--Meteorology, remote sensing, research planning
- Walter F. Dabberdt--Transport and diffusion modeling, meteorology, instrumentation
- Paul A. Davis--Solar radiation, tracer studies
- Roy M. Endlich--Meteorological models, satellite systems
- James L. Mackin--Helicopter and aircraft systems
- Elmer Robinson--Meteorology, instrumentation, atmospheric chemistry, research planning
- Sylvin Rubin--Data processing systems
- Konrad T. Semrau--Source inventory and emissions
- Elmer B. Shapiro--Communication systems
- James H. Smith--Atmospheric chemical transformation processes
- Eldon J. Wiegman--Synoptic climatology

Valuable contributions were made in the latter stages of the project by Dr. W. A. Perkins and Mr. J. S. Sandberg, consultants.

The Institute wishes to express its appreciation for the assistance and provision of information by many staff members of the Environmental Protection Agency, especially Charles R. Hosler, Contracting Officer's Technical Representative; Dr. Warren B. Johnson, Jr., Chief, Model Development Branch; Robert A. McCormick, Director, Division of Meteorology; and Dr. A. P. Altshuller, Director, Division of Chemistry and Physics.

Additionally, the constructive criticism and comment provided by members of the Meteorology Advisory Committee of the Environmental Protection Agency during the preparation of the Prospectus were of significant value, and our indebtedness is hereby acknowledged.

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Chapter XVII

INTRODUCTION TO THE REGIONAL STUDY
SCHEDULING, STAFFING, AND COST

Introduction

The Regional Study will constitute the largest and most comprehensive scientific investigation and analysis of the phenomenology of air quality and pollution yet undertaken. Field data describing air quality, meteorology, and other pertinent factors will be obtained by an instrument and data processing system unprecedented in the study of air pollutants. This critically important effort will require the most careful planning and management both before and during its execution to ensure effective utilization of the facilities and personnel assigned to the Regional Study and the most appropriate expenditure of funds.

This part of the Prospectus presents findings largely applicable to the scheduling, management and staffing, and the estimated costs of the St. Louis facility. However, this chapter also summarizes the estimated costs of the Research Plan presented in Part II of this Prospectus, the costs of the Research Plan as given in Chapter XXI, and the costs of the mixing layer observational program as presented in Chapter XIV. It is clear that the scope of the Regional Study is such that continual review and modification will be required of all the estimated schedules, costs, and other factors presented in this Prospectus. This tends to be of particular importance in regard to the estimated activation schedule, since many policy and design considerations are entailed and not all of them can be anticipated or evaluated at this time. Moreover, several important aspects of the schedule and perhaps certain costs will depend on the actual conditions found to exist in St. Louis after authorization of the Regional Study. Accordingly, the planning factors presented are regarded as having an accuracy and reliability suitable for the planning purposes of this Prospectus and for the purpose of providing a working format for additional and more detailed planning efforts.

The St. Louis Facility

The St. Louis facility, as defined in Part III of this Prospectus, is conceived as ultimately consisting of 77 instrument stations and a central facility housing the necessary data handling and processing and remote recording equipment, as well as office, laboratory, and maintenance space. Six types of instrument stations are included as summarized in Table XVII-1 with respect to their major characteristics and equipment This facility concept is used as the basis for all estimated requirements for personnel, costs, and scheduling.

Strong similarities can be noted among the various station classes. For example, the Class A_1 and A_2 stations are identical, except for the far fewer meteorological instruments allocated to the Class A_2 stations. Both classes include 30-meter towers and are expected to make air quality and meteorological observations at not less than three elevations on the towers. Both are expected to be permanently sited. The Class B_1 and B_2 stations are shown to be identical, except that the eight Class B_2 stations are housed in trailers rather than permanently sited. The stations in Classes A_1, A_2, and B_1 are viewed in a sense as the basic system to be augmented as necessary by the transportable Class B_2, C_1, and C_2 stations.

The four Class C_1 stations are equipped with the 30-meter towers and a complete complement of meteorological instruments. The station is provided with no air quality instruments. The instrument shelters are viewed as consisting of trailers and is shown to be transportable. However, since the station is equipped with a 30-meter tower, freedom of movement will be far less than either the Class B_2 or C_2 stations.

The Class C_2 stations are shown to have minimal equipment. They are intended to be used in direct support of the research experiments and consequently will be equipped with a variety of specialized instrumentation during the Regional Study. Funding for such instrumentation will be allocated to the various research experiments rather than to the facility itself.

The analytically derived pattern of instrument station location, as discussed in Chapter XI of this Prospectus is shown in Figure XVII-1. The ultimate location of the stations will depend on the availability of suitable sites which only a field survey can reveal. For purposes of subsequent discussion, the instrument sites are identified in code defined as follows. First, the sites have been placed in three groups as a function of their distance from the St. Louis arch. Thus, the farthest stations have an initial code entry of "1," while those within

Table XVII-1

CLASSIFICATION OF THE REGIONAL STUDY INSTRUMENT STATIONS

	Class of Station					
	A 1	A 2	B 1	B 2	C 1	C 2
	Number of Instruments					
Air quality instruments						
Carbon monoxide-methane-hydrocarbon	1	1	1	1	--	--
Hydrogen sulfide-sulfur dioxide	1	1	1	1	--	--
Total sulfur	1	1	--	--	--	--
Ozone	1	1	1	1	--	--
Nitrous oxide-oxides of nitrogen	1	1	1	1	--	--
Nephelometer	1	1	1	1	--	--
Carbon monoxide (NDIR)	1	1	--	--	--	--
Hi-Vol sampler	2	2	2	2	--	--
Meteorological instruments						
Temperature	1	1	--	--	1	--
Wind direction and speed	3	3	1	1	3	1
Pyranometer	1	--	--	--	1	--
Pressure transducer	1	--	--	--	1	--
Mercury barometer	1	--	--	--	1	--
Net radiometer	1	--	--	--	1	--
Dew point hygrometer	1	--	--	--	1	--
Rain-snow gage	1	--	--	--	1	--
	Station Characteristics					
Tower height						
30-meter	x	x			x	
10-meter			x	x		x
Data recording						
Remote	x	x	x	x		
Local					x	x
Mobility						
Fixed	x	x	x			
Transportable				x	x	x
Number of instrument stations in each class	9	8	24	8	4	24

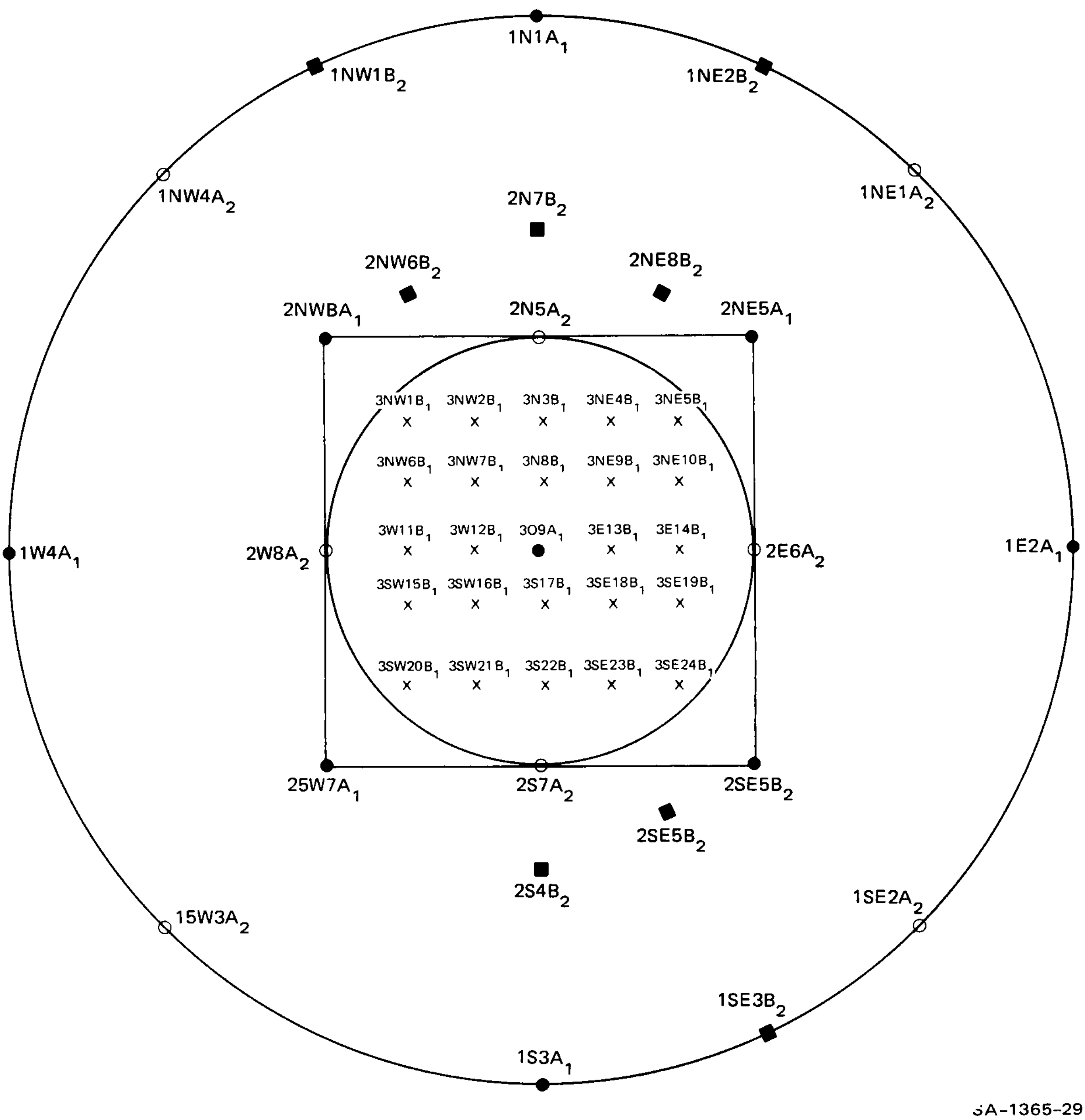

FIGURE XVII-1 ST. LOUIS FACILITY CLASS A AND B INSTRUMENT STATION LOCATIONS the urbanized area have an initial entry of "3." The following letter entry indicates the compass quadrant or cardinal in which the station is located. The St. Louis arch station is indicated by the letter "O." Following the compass notation is the sequential number of each station within its respective class.

The location of the central facility tends to be somewhat flexible. However, since a substantial mixing layer observation program is anticipated, the location of the central is suggested to be most appropriately located in the vicinity of a superior airport. Therefore, two possibilities are suggested, with the first in the Alton-East Alton, Illinois, area near the Bethalto Civic Memorial Airport. The second location is on or near Scott Air Force Base, Illinois.

The central facility will also include maintenance vehicles, instrument station calibration vans, and similar infrastructure components to support both the continuing operation of the instrument system and the research experiments and field activities planned during the five-year period.

Facility Activation Schedule

The activation schedule of the St. Louis facility is viewed as having three principal components. The first covers the design, installation, and shakedown and acceptance of two prototype instrument stations. The second includes the activation of all Class A and B stations. The third provides for completion of the Class C stations.

The overall schedule adopted for the St. Louis facility activation will depend on a number of critical factors. These include the urgency for initiation of the research experiments requiring the full instrument system and the magnitude of funds allocated for the Regional Study. Additionally, as discussed in this Prospectus, a number of alternative methods or rationales may be used to develop the geographical pattern of station location. In one case, all stations could be installed in a continuous sequential schedule on the basis of currently available emission source data and air quality and meteorological information. In the other case, stations might be installed at a far lower rate, so that the first group of stations will be allowed to acquire significant air quality and meteorological data from which possible guidance could be derived for the second group, and so on. The basic concepts of scheduling under each procedure should be essentially the same, and for purposes here the continuous schedule has been selected.

The design, installation, and operational acceptance tests of the instrument prototype stations is estimated to require on balance about 44 weeks. The critical path through the scheduling network consists almost exclusively of the digital data terminal equipment. This situation is caused primarily by the fact that all air quality and meteorological instruments are considered to be standard catalogue items with relatively short procurement times, whereas the digital data terminal equipment consists of a combination of standard and special-designed equipment. The latter group of digital data equipment causes much of the length of the critical path, especially when combined with the design decisions associated with the telephone communication system design.

Two alternatives have been identified for scheduling the activation of all Class A and B stations. The first is to delay all activation until the prototype station has been thoroughly tested and all components have been accepted. Scheduling on this basis is estimated to require an additional 33 weeks for final station completion or 77 weeks for full activation of the St. Louis facility.

The second alternative is to initiate activation before prototype station acceptance. In this case, activation could be started at the end of the acceptance tests of the prototype station air quality instruments, which is estimated to occur 23 weeks after authorization of the Regional Study. Since, as noted above, the prototype station critical path is estimated at 44 weeks, initiation of system activation after prototype operation of the air quality instruments is likely to achieve considerable economies in time. Such overlapping is estimated to bring full system operation 18 weeks earlier than the former schedule, with completion at 59 weeks.

Moderate risk is estimated to exist in continuing station activation without full completion of the prototype stations. This risk arises with the design of the equipment linking the meteorological and air quality instruments with the bulk of the digital data equipment. However, in view of the inherent flexibility of digital data circuitry designs and equipment, any incompatibilities revealed in prototype station design undoubtedly can be corrected in the digital data equipment before installation in the remaining stations.

The Class C stations can be scheduled essentially independently of the other stations, since their digital data terminal equipment provides for local rather than remote recording. The Research Plan indicates a need for about ten Class C_2 stations approximately eight months after authorization of the Regional Study, with the remainder following soon thereafter. Accordingly, initiation of the digital data equipment procurement cycle can be initiated 10 weeks after authorization, with station activation beginning 12 weeks later. An activation rate of one per week brings completion of all stations 51 weeks after authorization, with the first ten available 33 weeks after authorization.

These activation schedules are based on the assumption that the central facility and all instrument stations sites have been acquired before the scheduled station activation. This is regarded as a most critical assumption, and the lack of instrument sites could indeed cause serious delay in system activation. Immediate field survey initiation following authorization of the Regional Study, and preferably before, appears essential to permit station activation to proceed on schedule.

Permanent Management and Staffing

The permanent personnel assigned to the Regional Study are estimated to include 54 staff members. Nine are estimated to be located at the Research Triangle Park and 45 in St. Louis.

The significance of the Regional Study is such that the establishment of the position of Deputy Director for Regional Studies appears appropriate. The Deputy Director will report directly to the Director, National Environmental Research Center, Research Triangle Park. The Research Triangle Park staff will consist of three groups as follows.

- Office of Programs--This Office will provide EPA coordination, budgeting, and planning support throughout the study.

- Office of Interagency Coordination and Technology Transfer--This Office will be charged with providing full coordination among all agencies having an involvement with problems of air pollution The broad scope of the Regional Study is such that programs of other organizations and agencies should be continually monitored to determine possible interfacing points, cooperative ventures, and other modes of joint operation. Conversely, the Office will have the principal task of advising other agencies of the programs planned for the Regional Study to again promote full cooperation. The Office will have the additional responsibility of continual review of findings developed in the Regional Study for application to other areas and experimental efforts.

- Office of Research Operations--The staff of this office will be responsible for the detailed planning, supervision, and quality control of the research tasks constituting the Regional Study.

The office is estimated to require up to three full-time professional and one professional representative from each research Division to coordinate and monitor the research efforts in each Division. The Divisional representatives would remain administratively within their home Divisions but would have scientific and technical reporting requirements to the Division Directors and the Deputy Director.

The St. Louis staff will be largely responsible for the operation of the facility and support of the field research experimental effort. The staff consists of nine professionals and 36 nonprofessionals, with 17 of the nonprofessionals engaged in instrument station maintenance and calibration. The professional staff includes the following:

- Facility Director--The facility director will be responsible for all St. Louis operations, reporting to the Deputy Director for Regional Studies.

- Research Coordinator--The research coordinator will provide all logistic and facility support to special research groups carrying out field data gathering programs.

- Instrument Engineer--Two engineers are estimated for system operation, maintenance, and modification during the five-year program.

- Meteorologist--Two meteorologists are estimated to be required to provide sustained analysis of meteorological conditions in the St. Louis area and to provide direct support to field groups for specific purposes.

- Computer System Engineer--One engineer is estimated to be required for supervision of data handling and recording procedures special computer program preparation, and related duties.

- Control Engineer--The control engineer will be responsible for development and maintenance of the St. Louis emission inventory.

- Effects Research--An on-site professional is estimated to be required for the purpose of providing direct support for all effects research in the St. Louis area; he will arrange for acquisition of all relevant local data necessary for the program

Costs

Permanent Facility and Staff

The initial costs of the St. Louis facility have been estimated at about $3.94 million. This includes all instrument stations, the central facility, and other equipment estimated to be required. These initial costs are summarized in Table XVII-2.

Table XVII-2

ESTIMATED INITIAL COSTS OF THE ST. LOUIS FACILITY
BY PRINCIPAL INSTALLATION
(Thousands of Dollars)

Instrument stations	
A_1	$ 771.3
A_2	625.6
B_1	1,370.4
B_2	455.2
C_1	134.0
C_2	367.2
Subtotal	$3,723.7
Central facility	121.0
Vehicles	98.9
Total	$3,943.6

The estimated initial costs can also be summarized in terms of the principal system components as shown in Table XVII-3.

The air quality instruments account for almost one-half the initial costs at $1.6 million, with the digital data terminals at somewhat less than 18% of the total. One of the lowest cost elements is attributable to the data processing and communication facilities and accounts for slightly more than 2% of the total costs. Significant advances in the state of the art and high volume production of computers and peripheral equipment have combined to create dramatic cost reductions over the past two to three years.

Table XVII-3

ESTIMATED INITIAL COSTS OF THE ST. LOUIS FACILITY BY SYSTEM COMPONENTS (Thousands of Dollars)

Air quality instruments	$1,606.0
Calibration equipment and accessories	392.2
Meteorological instruments	234.2
Instrument spare parts	220.5
Site preparation, housing, fixtures	501.5
Digital data terminal equipment	769.2
Data processing and communication	81.0
General facilities	40.0
Support vehicles	98.9
Total	$3,943.6

The annual operating costs once full operational status has been achieved is estimated at about $1.5 million. This cost includes the staff at both the Research Triangle Park and St. Louis and all standard operating supplies at St. Louis. These costs are summarized in Table XVII-4.

The estimated personnel costs are clearly the chief element of the annual costs, accounting for almost 80% of the total. The remaining elements stand at 6% or less. A particularly uncertain cost is that for rental of the central facility and especially land for the instrument stations. A cost for instrument station sites was taken nominally at $1000 per site. Undoubtedly, there will be large variations in this unit estimate which can be known with certainty only after the actual field survey.

The activation schedule of the St. Louis facility is estimated to span about five calendar quarters following authorization of the Regional Study. The overall expenditure schedule for both the initial and operating costs by quarter are summarized in Table XVII-5. The operating costs in the fifth quarter are judged to typify all subsequent quarters.

Table XVII-4

ESTIMATED TOTAL ANNUAL OPERATING COSTS OF
THE ST. LOUIS FACILITY AND PERMANENT STAFF
(Thousands of Dollars)

Personnel	
Research Triangle Park	$ 225.0
St. Louis	990.0
Subtotal	$1,215.0
Instrument replacement and parts	91.8
Motor vehicle operation	14.5
Telephone communication system	38.4
Building and land rental	78.4
Calibration gases	98.0
Electric power	12.7
Total	$1,548.8

Table XVII-5

ESTIMATED INITIAL AND OPERATING COSTS DURING
IMPLEMENTATION OF THE ST. LOUIS FACILITY
(Thousands of Dollars)

	Quarter				
	1	2	3	4	5
Initial costs	$ 48.8	$347.1	$2,770.2	$470.9	$306.6
Operating costs	99.1	163.3	288.7	349.0	387.2
Total	$147.9	$510.4	$3,058.9	$819.9	$693.8

Helicopter and Mixing Layer Observational Program

The estimated costs of the mixing layer observational program were presented in detail in Chapter XIV. The costs cover the acquisition and operation of one helicopter and a balloon-borne instrument system known as METRAC. Operational costs of the helicopter are based on 18 hours of operation during the period March through November and 12 hours per week for the balance of the year. Total helicopter costs on a quarterly basis for this operational schedule are shown in Table XVII-6.

Table XVII-6

ESTIMATED COSTS OF HELICOPTER OPERATION BY QUARTER (Thousands of Dollars)

Quarter	Cost
January-March	$19.3
April-June	24.1
July-September	24.1
October-December	16.9
Total	$84.4

Research Plan

The estimated costs of the Research Plan as presented in Chapter XXI total $9.7 million and are summarized in Table XVII-7. By far the bulk of the costs are attributable to personnel and account for 85% of the total. Approximately $900,000 is estimated to be required for specialized instruments for selected components of the Research Plan. Because of their specialized nature or because they require additional development to achieve operational status, they were not considered as part of the permanent facility.

Table XVII-7

TOTAL ESTIMATED COSTS OF THE RESEARCH PLAN
(Thousands of Dollars)

Year-Quarter	Personnel	Instruments	Operations	Total
1972-3	$ 175.6		$ 4.0	$ 179.6
-4	232.9	$100.0	4.0	336.9
Subtotal	$ 408.5	$100.0	$ 8.0	$ 516.5
1973-1	304.2		4.0	308.2
-2	338.9	160.0	4.0	502.9
-3	395.9	50.0	4.0	449.9
-4	374.4		4.0	378.4
Subtotal	$1,413.4	$210.0	$ 16.0	$1,639.4
1974-1	480.1	463.3	4.0	947.4
-2	504.5	13.9	96.0	614.4
-3	476.9		96.0	572.9
-4	474.2		4.0	478.2
Subtotal	$1,935.7	$477.2	$200.0	$2,612.9
1975-1	479.1	189.0	4.0	672.1
-2	470.8		96.0	566.8
-3	467.7		96.0	563.7
-4	459.7		4.0	463.7
Subtotal	$1,877.3	$189.0	$200.0	$2,266.3
1976-1	465.7		4.0	469.7
-2	444.2		4.0	448.2
-3	448.6		4.0	452.6
-4	467.0		4.0	471.0
Subtotal	$1,825.5		$ 16.0	$1,841.5
1977-1	442.9		4.0	446.9
-2	430.5		4.0	434.5
Subtotal	$ 873.4		$ 8.0	$ 881.4
Total	$8,333.8	$976.2	$448.0	$9,758.0

Total Costs

The total estimated cost of the Regional Study is summarized in Table XVII-8 by quarter and is almost $21.2 million. The schedule is based on the assumption that the Regional Study will be authorized on July 1, 1972, and that activities are initiated immediately. Earlier or later authorization clearly will cause displacement of the quarterly estimates. The greatest part of the total costs are attributable to personnel with about two-thirds of the total costs. Except for the quarter in which the St. Louis facility is largely completed, the cost within any category does not exceed personnel costs. The research staff costs tend to lie in the range of 1.5 times the permanent staff. Combined instrument costs of the St. Louis facility and the Research Plan are close to $5.0 million or almost 25% of the total estimated cost.

Table XVII-8

ESTIMATED TOTAL QUARTERLY COSTS OF THE REGIONAL STUDY
(Thousands of Dollars)

Year-Quarter	Initial Costs: St. Louis Facility	Initial Costs: Research Instruments	Operating Costs: Equipment: Helicopter	Operating Costs: Equipment: St. Louis Facility	Operating Costs: Equipment: Research Plan	Operating Costs: Personnel: Permanent Staff	Operating Costs: Personnel: Research Staff	Total
1972-3	$ 48.8			$ 2.0	$ 4.0	$ 97.0	$ 175.6	$ 327.4
-4	347.1	$100.0	$ 16.9	12.1	4.0	151.2	232.9	864.2
Subtotal	$ 395.9	$100.0	$ 16.9	$ 14.1	$ 8.0	$ 248.2	$ 408.5	$ 1,191.6
1973-1	2,770.2	160.0	19.3	51.0	4.0	237.7	304.2	3,546.4
-2	470.9	50.0	24.1	57.0	4.0	292.0	338.9	1,236.9
-3	306.6		24.1	83.5	4.0	303.7	395.9	1,117.8
-4			16.9	83.5	4.0	303.7	374.4	782.5
Subtotal	$3,547.7	$210.0	$ 84.4	$ 275.0	$ 16.0	$1,137.1	$1,413.4	$ 6,683.6
1974-1		463.1	19.3	83.5	4.0	303.7	480.1	1,353.7
-2		13.9	24.1	83.5	96.0	303.7	504.5	1,025.7
-3			24.1	83.5	96.0	303.7	476.9	984.2
-4			16.9	83.5	4.0	303.7	474.2	882.3
Subtotal		$477.0	$ 84.4	$ 334.0	$200.0	$1,214.8	$1,935.7	$ 4,245.9
1975-1		189.0	19.3	83.5	4.0	303.7	479.1	1,078.6
-2			24.1	83.5	96.0	303.7	470.8	978.1
-3			24.1	83.5	96.0	303.7	467.7	975.0
-4			16.9	83.5	4.0	303.7	459.7	867.8
Subtotal		$189.0	$ 84.4	$ 334.0	$200.0	$1,214.8	$1,877.3	$ 3,899.5
1976-1			19.3	83.5	4.0	303.7	465.7	876.2
-2			24.1	83.5	4.0	303.7	444.2	859.5
-3			24.1	83.5	4.0	303.7	448.6	863.9
-4			16.9	83.5	4.0	303.7	467.0	875.1
Subtotal			$ 84.4	$ 334.0	$ 16.0	$1,214.8	$1,825.5	$ 3,474.7
1977-1			19.3	83.5	4.0	303.7	442.9	853.4
-2			24.1	83.5	4.0	303.7	430.5	845.8
Subtotal			$ 43.4	$ 167.0	$ 8.0	$ 607.4	$ 873.4	$ 1,699.2
Total	$3,943.6	$976.0	$397.9	$1,458.1	$448.0	$5,637.1	$8,333.8	$21,194.5

Chapter XVIII

IMPLEMENTATION SCHEDULE OF THE ST. LOUIS FACILITY

Introduction

The initiation of many experimental phases of the Regional Study is highly dependent upon completion of a portion and, in some cases, all of the instrument stations and the associated data-handling and processing system. Airborne and perhaps certain ground-based observations and measurements could indeed be initiated quite early in the course of the Regional Study, but comprehensive data-gathering operations must await facility completion. This chapter of the Prospectus provides the estimated schedule from the authorization of the Regional Study to completion of the St. Louis facility. Attention is given to all principal activities required for system implementation, and selected alternative schedules are presented. The implementation schedule is based upon complete activation of all instrument stations of the facility. The extent to which this may be appropriate or desirable during the actual implementation of the facility could of course change as the Regional Study is further clarified and developed through the actual implementation process.

In the review of the estimated schedules presented herein and their expected future expansion and refinement within EPA, special attention should be given to the survey and acquisition of the instrument station sites. A number of difficulties that might easily arise in the course of this effort have been identified in this chapter as well as in Chapter XVI. These potential problems, and perhaps others not foreseen at this time, could delay the implementation schedule and adversely affect significant portions of the research plan. Thus, while the schedule presented here is based upon the initiation of all activities subsequent to authorization of the Regional Study, the initiation of instrument site acquisition procedures even earlier than the authorization date appears to be extremely desirable and strongly recommended. The sites would not necessarily be actually acquired by lease or other means, but their potential availability and locations, and the restrictions on usage due to zoning and other constraints could indeed be identified. Acqual acquisition after authorization of the Regional Study should then be a relatively minor matter. Acquisition of the central facility site should be handled in much the same manner.

The implementation of the complete St. Louis instrument system and data-processing equipment will have three phases. The first phase covers the design, procurement, assembly, and operational test of possibly two prototype Class A_1 instrument stations. Procurement installation and test operation of the central computer facility would also be completed during this phase. Because of the large number of instrument stations and their pioneering design and method of operation, the assembly and test of at least major components of the prototype stations prior to full system implementation is considered mandatory. Full system operation can be delayed because of this requirement, but this penalty is judged to be acceptable in order to achieve the highest possible level of reliable system operation throughout the course of the study.

The second phase follows immediately after successful operation of major components of the prototype stations and covers the procurement, assembly and test of the remaining Class A_1 and the Class A_2, B_1, and B_2 instrument stations within the inner St. Louis area.

The third phase, carried on simultaneously with the first two, covers the activation of the Class C_1 and C_2 stations. The Class C_1 stations, although equipped with 30-meter towers, are defined as nonpermanent or transportable instrument stations and their activation can proceed somewhat independently of the more complex stations. Additionally, the Class C_2 stations are intended for use in direct support of the research experiments, so that their activation would be phased with the appropriate elements of the research program.

Implementation and scheduling of the aircraft system is treated in Chapter XIV of this Prospectus because of the differing organizational elements involved and their utilization within the experimental program.

The implementation schedule for the facility is treated by two complementary formats or techniques in this Prospectus. The first includes a comprehensive critical path network which shows the principal activities involved in the design, acquisition, assembly, and test of the instrument stations, the data processing center, and the system as a whole. The scheduling network is designed basically for a Class A station but is applicable to other stations by the elimination of appropriate activities or assigning them durations of zero.

The second scheduling technique utilizes conventional Gantt chart and treats instrument station installation and other activities in appropriate aggregations of activities shown in detail on the critical path network. Expenditure schedules shown in Chapter XX are based upon the latter format.

A number of alternative schedules are presented. Each depends upon various system design and policy considerations which will require continual review and assessment in further planning and actual implementation of the Regional Study. The sequence of presentation is initiated by the development and analysis of the activation and test schedule for the instrument prototype stations and the central facility. The principal activities are defined and their durations are estimated. The critical path through the network is traced and the total duration for prototype station activation is defined. Selected activities are varied in duration and adjusted in their location within the network to identify the sensitivity of the critical path to the activities.

This analysis is followed by the preparation of estimates of the unit activation times for the Class A and B stations. These estimates are derived from the prototype station activation schedule.

The unit activation times are then combined to develop the estimated duration for activation of the complete St. Louis facility. Two different schedules are considered. The first applies to the case of full prototype instrument station acceptance prior to implementation of any additional stations. The second considers a parallel schedule in which partial activation of stations is initiated prior to completion of the prototype station.

Lastly, the schedules for the Class C stations are developed.

Prototype Instrument Station and Central Facility

Schedule Network and Estimated Activity Durations

The critical path implementation schedule is shown in Figures XVIII-1 and XVIII-2. Activity descriptions are provided in Table XVIII-1. The activity durations are estimated on the basis of past experience with instrument system design and procurement, catalog information, quotations of equipment manufacturers for other instrument systems, and similar sources. Activity durations that are considered of particular importance and at the same time difficult to determine include those having a planning or organization component. For example, the time required to assemble the Regional Study staff or to obtain the necessary contract approvals for instrument procurement is highly dependent upon EPA policy considerations, the priority level assigned to the Regional Study in comparison to other programs, and similar considerations difficult to specify at this time. The sensitivity of the duration of these activities on the

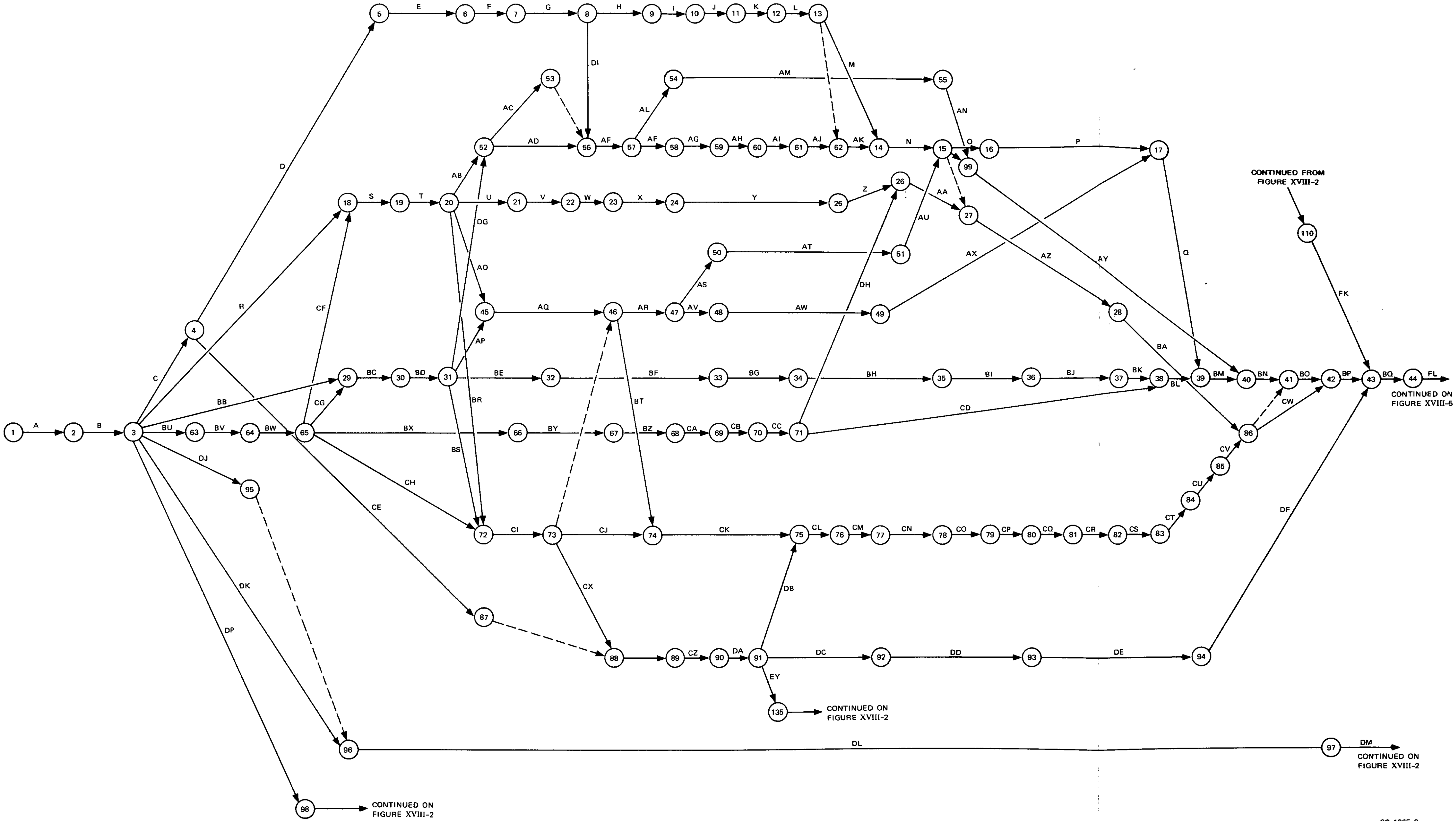

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FIGURE XVIII-1

CRITICAL PATH NETWORK FOR COMPLETION OF A CLASS A PROTOTYPE INSTRUMENT STATION

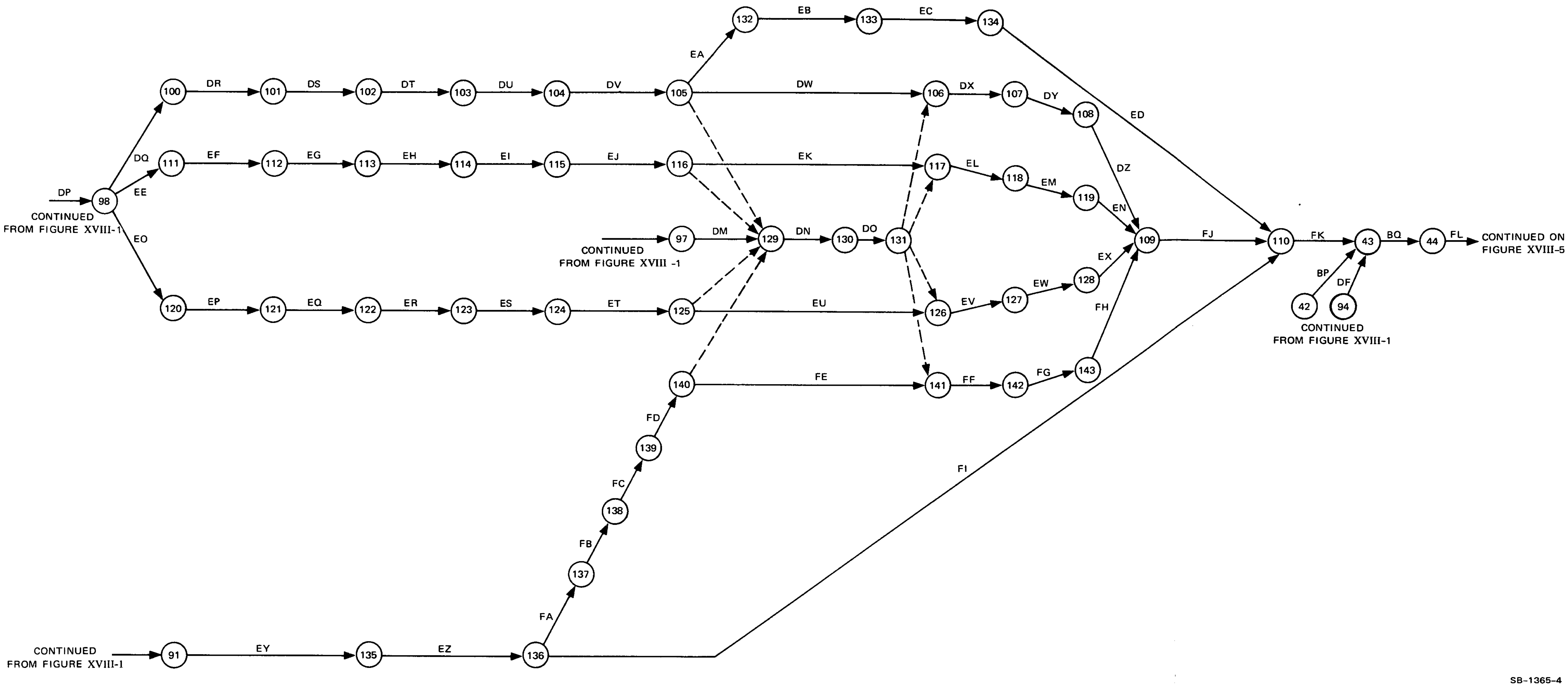


FIGURE XVIII-2

CRITICAL PATH NETWORK FOR COMPLETION OF THE CENTRAL FACILITY DATA PROCESSING SYSTEM

Table XVIII-1

PROTOTYPE INSTRUMENT STATION AND CENTRAL FACILITY ACTIVITIES

Activity	Description	Immediate Prerequisite	Duration (days)
A	Authorization of the regional study		1
B	Complete initial staffing and planning	A	5 (40)
C	Review instrument site patterns	B	5 (15)
D	Field survey of potential instrument sites	C	5 prototype sites; 1 day each for remaining sites or 47 days
E	Rank potential instrument site features by selection criteria	D	5
F	Identify potential instrument site owners	E	0.5, each site
G	Review potential instrument site zoning regulations and other constraints	F	0.5, each site
H	Negotiate instrument site acquisition	F	5 prototype sites; 40 days for remaining sites
I	Design instrument site plot plan	H	2, each site
J	Select instrument site general contractor	I	20
K	Prepare instrument site	J	1
L	Construct instrument site fencing	K	1
M	Pour and cure concrete for tower and instrument housing	L	9
N	Erect instrument tower	M, AK	1
O	Assemble instrument shelter	N, AU	2
P	Install 110/220 electric power	O	2
Q	Install instrument shelter interior fixtures	P, AX	2
R	Review meteorological instrument requirements	B	5 (15)
S	Prepare meteorological instrument RFQ	R, CF	5
T	Approve meteorological instrument RFQ	S	5
U	Distribute meteorological instrument RFQ	T	2
V	Prepare meteorological instrument quotations	U	15
W	Review meteorological instrument quotations	V	10
X	Contract negotiation and award for meteorological instrument procurement	W	5

Table XVIII-1 (Continued)

Activity	Description	Immediate Prerequisite	Duration (days)
Y	Fabricate meteorological instruments	X	20
Z	Deliver meteorological instruments	Y	5
AA	Install meteorological instrument identifier	Z, DH	0.25
AB	Specify meteorological instrument mounts	T	1
AC	Prepare free-standing tower specifications	AB	1
AD	Prepare guyed tower specifications	AB	1
AE	Approve instrument tower and bracket RFQ	AC, AD, DI	5
AF	Distribute instrument tower and bracket RFQ	AE	2
AG	Prepare instrument tower and bracket quotations	AF	10
AH	Review instrument tower and bracket quotations	AG	5
AI	Contract negotiation and award for instrument tower and brackets	AH	5
AJ	Fabricate instrument tower and instrument brackets	AI	20
AK	Deliver instrument tower	L, AJ	5
AL	Specify air sample tubing	AE	1
AM	Procure air sample tubing	AL	20
AN	Deliver air sample tubing	AM	5
AO	Specify meteorological instrument space requirements within instrument shelter	T	.5
AP	Specify air quality instrument shelter space requirements, sample air flow and calibration gas flow requirements, and shelter environmental requirements	BD	5
AQ	Preliminary design of instrument shelter interior and air sampling-calibration tubing and control system	AO, AP	5
AR	Final design of instrument shelter interior incorporating estimated digital data equipment	AQ, CI	10
AS	Specify instrument shelter	AR	2
AT	Negotiate instrument shelter contract	AS	5
AU	Deliver instrument shelter	AT	10
AV	Negotiate instrument shelter interior components	AR	10

Table XVIII-1 (Continued)

Activity	Description	Immediate Prerequisite	Duration (days)
AW	Fabricate instrument shelter interior components	AV	20
AX	Deliver instrument shelter interior components	AW	10
AY	Install air sample tubing system	N, AN	0.5
AZ	Install meteorological instruments	N, AA	2
BA	Acceptance test-meteorological instruments	AZ	10
BB	Review air quality instrument requirements	B	5 (15)
BC	Prepare air quality instrument RFQ	BB	10
BD	Approve air quality instrument RFQ	BC	5
BE	Distribute air quality instrument RFQ	BD	2
BF	Prepare air quality instrument quotations	BE	20
BG	Review air quality instrument quotations	BF	10
BH	Contract negotiation and award for air quality instrument procurement	BG	10
BI	Fabricate air quality instruments	BH	30
BJ	Shipment of air quality instruments	BI	5
BK	Uncrating and simplified operational check of air quality instruments	BJ	0.25
BL	Encoding and installation: air quality instrument identifier	BK, CD	0.25
BM	Installation: air quality instruments	Q, BL	5
BN	Acceptance test: air quality instruments	AY, BM	15
BO	Interconnect and operational check: air quality instrument-data terminal system	BD, CV	1
BP	Local integrated operational check	BO, CW	1
BQ	Final system operational check	BP, DF, FK	10
BR	Formulate meteorological instrument output format	T	3
BS	Formulate air quality instrument output format	BD	5
BT	Define air quality instrument sampling and calibration procedures	AQ	5
BU	Review instrument identifier requirements	B	2 (10)
BV	Prepare instrument identifier RFQ	BU	5
BW	Approve instrument identifier RFQ	BV	5
BX	Distribute instrument identifier RFQ	BW	2

Table XVIII-1 (Continued)

Activity	Description	Immediate Prerequisite	Duration (days)
BY	Prepare instrument identifier quotations	BX	15
BZ	Review instrument identifier quotations	BY	10
CA	Contract negotiation and award for instrument identifier procurement	BZ	5
CB	Design instrument identifier	CA	20
CC	Fabricate instrument identifier	CB	10
CD	Deliver air quality instrument identifier	CC	5
CE	Specify tentative instrument sites	C	5
CF	Specify meteorological instrument identifier mounting requirements	BW	1
CG	Specify air quality instrument identifier mounting requirements	BW	1
CH	Specify instrument identifier output format	BW	0
CI	Consolidate digital data reporting format and operational procedures	CH, BR, BS	10
CJ	Prepare standard and nontelephone interfaced data terminal equipment specifications	CI	10
CK	Prepare design specifications for air quality instrument calibration controller	BT, CJ	15
CL	Prepare telephone interface digital terminal equipment specifications	DB, CK	10 (20)
CM	Integrate nontelephone and telephone interfaced data terminal equipment specifications into RFQ	CL	10
CN	Approve instrument site data terminal RFQ	CM	5
CO	Distribute instrument site data terminal RFQ	CN	2
CP	Prepare instrument site data terminal quotations	CO	15
CQ	Review instrument site data terminal quotations	CP	15
CR	Contract negotiation and award for instrument site data terminal procurement	CQ	10
CS	Design fabricate instrument site data terminals	CR	40
CT	Deliver instrument site data terminals	CS	5
CU	Install instrument site data terminals	CT	3

Table XVIII-1 (Continued)

Activity	Description	Immediate Prerequisite	Duration (days)
CV	Acceptance test-data terminal	CU	3
CW	Interconnect and operational check: meteorological instruments data terminal	BA, CV	0.5
CX	Transmit data reporting format and operating procedures to telephone utility	CI	5
CY	Prepare alternative line routing and network designs	CE, CX	20
CZ	Prepare alternative telephone cost schedules	CY	15
DA	Review and select telephone system operational alternative	CZ	5
DB	Transmit telephone equipment specifications	DA	5
DC	Transmit telephone system equipment requirements to telephone utility	DA	5
DD	Fabricate telephone equipment for instrument site	DC	20
DE	Install telephone equipment at instrument site	DD	1
DF	Install telephone drop	DE	1
DG	Specify air sample tubing requirements	BD	1
DH	Deliver meteorological instrument identifier	CC	5
DI	Specify instrument site restrictions	G	0
DJ	Review central facility support requirements	B	5 (15)
DK	Review central site facility requirements	B	5 (15)
DL	Survey central facility sites	DJ, DK	5
DM	Negotiate central facility acquisition	DL	15
DN	Design central data facility	DM	20
DO	Remodel - modify central data facility	DN	10
DP	Review data processing requirements and define central data facility interfaces	B	5 (15)
DQ	Prepare computer RFQ	DP	5
DR	Approve computer RFQ	DQ	5
DS	Distribute computer RFQ	DR	5
DT	Prepare computer quotations	DS	15
DU	Review computer quotations	DT	5

Table XVIII-1 (Continued)

Activity	Description	Immediate Prerequisite	Duration (days)
DV	Contract negotiation and award for computer	DU	10
DW	Fabricate computer	DV	50
DX	Deliver computer	DO, DW	5
DY	Install computer	DX	5
DZ	Operational test, computer	DY	5
EA	Review and select computer program software	DV	5
EB	Prepare computer programs for instrument station remote read-write	EA	15
EC	Prepare computer program for conversion of instrument digital data to engineering units and for data archiving	EB	30
ED	Prepare computer program for air quality instrument calibration procedures	EC	30
EE	Prepare memory RFQ	DP	5
EF	Approve memory RFQ	EE	5
EG	Distribute memory RFQ	EF	5
EH	Prepare memory quotations	EG	15
EI	Review memory quotations	EH	5
EJ	Contract negotiation and award for memory	EI	10
EK	Fabricate memory	EJ	50
EL	Delivery memory	DD, EK	5
EM	Install memory	EL	2
EN	Operational test, memory	EM	5
EO	Prepare peripheral equipment RFQ	DP	5
EP	Approve peripheral equipment RFQ	EO	5
EQ	Distribute peripheral equipment RFQ	EP	5
ER	Prepare peripheral equipment quotations	EQ	15
ES	Review peripheral equipment quotations	ER	5
ET	Contract negotiation and award for peripheral equipment	ES	10
EU	Fabricate peripheral equipment	ET	30
EV	Deliver peripheral equipment	DO, EU	5
EW	Install peripheral equipment	EV	3

Table XVIII-1 (Concluded)

Activity	Description	Immediate Prerequisite	Duration (days)
EX	Operational test, peripheral equipment	EW	1
EY	Prepare central facility data terminal RFQ	DA	10
EZ	Approve central facility data terminal RFQ	EY	5
FA	Distribute central facility data terminal RFQ	EZ	5
FB	Prepare central facility data terminal quotations	FA	15
FC	Review central facility data terminal quotations	FB	5
FD	Negotiate contract for central facility data terminal	FC	10
FE	Fabricate central facility data terminal	FD	40
FF	Deliver central facility data terminal	DO, FE	5
FG	Install central facility data terminal	FF	3
FH	Operational test, central facility data terminal	FG	2
FI	Prepare computer program for telephone system operation	EA, EZ	20
FJ	Operational test, equipment manufacture standard procedures for integrated operation	DZ, EN, EX, FH	3
FK	Operational test-integrated data processing facility	ED, FI, FJ	5
FL	Evaluation of system performance	FK	10

critical path is pronounced and they should be given additional attention both prior to and in the early period after authorization of the Regional Study. The general effects of variations in the duration of these activities on the critical path are subsequently examined, but the examination of all possible scheduling variations was beyond the scope of the work. For certain activities, however, two durations have been examined as noted in Table XVIII-1, where a second duration is shown in parenthesis.

The durations of some activities within a particular sequence are strongly interrelated and numerous compromises or compensating time assignments appear possible. For example, the procurement of the digital data equipment might be handled in two ways. In the first, a brief set of performance specifications for the equipment could be prepared in, say, five days for inclusion in a Request for Quotation. The burden of complete equipment design could be delegated to the contractor and might require, perhaps, 50 days. The second approach could provide for the preparation of a full set of performance specifications along with a prototype design. This approach would clearly alter the time relationships from the 5-50 shown above to, say 25-30. The same overall duration would apply, but the specific activity durations would have marked differences. The activity durations shown here are intended to portray a schedule in which relatively detailed specifications are prepared from which the contractors essentially prepare final equipment production designs. Alternatives are recognized to exist and indeed may be desirable under certain circumstances. Accordingly, the estimated aggregated duration of a sequence of activities is judged to have greater reliability for planning than each activity itself.

The activities shown are those estimated to require 10 days or longer for completion. However, selected activities of lesser duration are shown for purposes of continuity and in situations where the activity is especially critical in controlling the completion of subsequent activities. To limit the complexity of the network, the activities shown are those associated with each of the principal broad tasks to be accomplished in the implementation effort. For example, even though six to eight types of air quality monitoring instruments are to be included at most instrument stations, their procurement, installation, and test are shown by one sequence of activities rather than in six to eight parallel sequences. The latter presentation would needlessly complicate the network and perhaps imply an unwarranted level of precision of the estimated time required for each activity. During the actual implementation of the facility, however, activity scheduling should be developed in greater detail than shown here to reflect the degree of precision of scheduling information.

The schedule network shown in Figure XVIII-1 generally covers the activities associated with the acquisition of the instrument stations. The network is intended to apply basically to the prototype stations, but it is applicable also to the activation of the remaining stations in that most of the activities will have the same immediate prerequisites and other similarities. These relationships are used in the development of the full system activation schedule as portrayed subsequently in the Gantt format.

Figure XVIII-2 applies primarily to the acquisition of the equipment situated at the central data-processing facility. To provide continuity between Figures XVIII-1 and XVIII-2, selected activities are shown in both. The figures together cover all activities from the regional study authorization up to operational acceptance tests of the prototype stations.

Activity Descriptions

The activity descriptions of Table XVIII-1 were prepared as brief identifiers of each activity; an expanded definition for them is provided in the following discussion. Descriptions of selected activities may be found elsewhere in this Prospectus and these will be noted as appropriate. On the other hand, descriptions of other activities, even though available elsewhere in the Prospectus will be summarized here for purposes of continuity.

The basic premise used in developing the critical path network was the following. First, the air quality instruments represent second-generation designs and have not heretofore been used in operational configurations and procedures incorporated in the instrument stations. Second, with small exceptions, as noted later, the digital data system consists of electronic equipment of proven design with high operational reliability and possesses remarkable flexibility and versatility. Accordingly, the air quality and meteorological instruments incorporated in the system are assumed to have currently accepted design and operating standards and existing measurement output characteristics. All necessary requirements for data reporting, compatibility, commonality of remote control techniques, and similar considerations will be achieved through the design of the digital data electronic components. The sole exception to this premise applies to the instrument identifiers, whose procurement specifications are indicated as being completed prior to preparation of specifications for both the air quality and meteorological instruments. This phasing is necessary so that the physical dimensions, mounting requirements, and similar features of the instrument identifiers can be taken into consideration in the instrument design, primarily the instrument housing. Little difficulty is anticipated with the air quality instruments; however, the compact weather-proof design of the meteorological instruments may pose some difficulty in incorporating the instrument identifiers, so that external mounting may be required.

The schedule can be implemented by either a prime contractor or an EPA intramural program. Certain detail differences in scheduling and activity content may exist between the two methods, but on balance each approach should follow the same overall procedure.

The implementation schedule begins, of course, with the authorization of the study-Activity A. While the act of authorization itself has perhaps no time dimension, the administrative uncertainties associated with the scope of the Regional Study can be such that a definite time increment should be provided.

Immediately following authorization the central project staffing and planning--Activity B--should be completed. Tasks within this activity will include the review of this Prospectus and the adjustment of the scope, schedule, and other factors of the Regional Study to correspond with the funds actually allocated for the Regional Study. Additionally, in the event a decision is reached to utilize a prime contractor for implementation, the contract covering his effort should be negotiated within this activity. Staffing requirements for Activity B are discussed in Chapter XIX.

Following Activity B, the scheduling network expands into nine major activity sequences leading to the completion of the prototype instrument stations. These are as follows listing generally from top to bottom of Figure XVIII-1.

- Instrument site acquisition and preparation--Activities C-M
- Instrument tower procurement and installation--Activities AB-N
- Meteorological instrument procurement, installation, and test--Activities R-BA
- Design, procurement, and installation of instrument shelter and interior components--Activities AQ-Q
- Air quality instrument procurement, installation, and test--Activities BB-BN

- Design and acquisition of instrument identifiers--Activities BV-CC

- Design, procurement, and test of digital data terminal equipment-Activities CH-CW

- Design and planning of telephone communication system--Activities CX-DF

- Instrument installation and operational acceptance tests of the instrument system--Activities BM-BQ.

The remaining activities not included in these principal sequences are generally associated with more than one sequence or are information-transfer activities linking major sequences.

The sequence of activities covering the acquisition of instrument sites--Activities C through H--is somewhat of an anomaly in the scheduling network but the activities are included because of their critical importance. Their anomalous character arises from the fact that site acquisition activities must continue throughout the course of preparation and test of the prototype instrument stations, whereas essentially all other activities are directly applicable to the prototype stations of Phase I with their sequence essentially repeated for Phase II.

The sequence of activities covering the acquisition of instrument sites is covered in Chapter XVI and therefore will not be addressed in detail here. The remainder of the sequence I-M, however, represents a logical extension of the acquisition activities. The initial activity--C--provides for a review of the instrument location pattern as defined in this Prospectus and perhaps modification because of later technical developments or budgetary and policy considerations. Activity D covers the actual field survey of all potentially available sites in the vicinity of the analytically defined locations, as discussed in Chapters XI and XII. In urban or built-up areas, the survey would consist of a street-by-street search and cataloging of all open land perhaps up to one mile from the analytically defined location. In open rural areas, the survey should be considerably simpler because of increased visibility. This initial survey likely can be carried out by the Research Program Coordinator (see Chapter XX).

Ranking potential sites--Activity E--may have two phases. In the first, the survey results are compiled by the Research Program Coordinator in accordance with the selection criteria. These should be reviewed by the interested Divisions at the Research Triangle Park. In the event of unusual conditions or difficulties with a site, a second survey perhaps may be required using members of the Divisional professional staff as consultants. The Research Program Coordinator should continue through the remaining activities until all sites are acquired.

The first instrument sites acquired should, of course, be those intended for the prototype stations. The selection of the general contractor· Activity I--need not absolutely follow site acquisition, except that his submission of a realistic quotation likely will require knowledge of the site conditions and locations. The activation program for Phase II, as discussed subsequently, is estimated to require three general contractors. It appears appropriate for the general contractor selected for the prototype stations to be one of these three.

The following seven activity sequences covering the procurement of the meteorological and air quality instruments, data terminal equipment, and other items have a number of common activities. These include the following:

Review of requirements

Preparation of the Request for Quotation

Approval of the Request for Quotation

Distribution of the Request for Quotation

Preparation of the Quotation

Review of the Quotation

Negotiation of contract for procurement

Fabrication of equipment

Delivery equipment.

These activities should essentially be identical under both an EPA intramural or prime contract facility implementation. In each procurement sequence, the total number of instruments and other equipment is specified. However, delivery is divided into two phases. The first would cover delivery of the instrument(s) for installation in the prototype instrument station. The second provides for periodic delivery in conformance with the facility implementation schedule after successful operation of the prototype. Clearly procurement specifications and contracts must be provided for possible equipment design modifications that may be required as a result of the prototype station operational tests.

Once initiated, the procurement of each instrument and equipment category continues essentially independently of others. However, timing of the initiation of each procurement sequence is interdependent. These interdependencies are summarized below.

Most appropriately, the procurement sequence should be initiated by review of requirements and preparation and approval of the instrument identifiers--BU, BV, and BW. Since these units will be installed within or on the housing of both air quality and meteorological instruments, their physical dimensions, mounting requirements, temperature tolerances, and similar characteristics should be known so that they can be taken into consideration in preparing instrument specifications. (Instrument suppliers, however, likely will not actually install the identifiers.)

During Activities BU, BV, and BW, the requirements for meteorological instruments--Activity R--and air quality instruments--Activity BB--can be reviewed and revised as appropriate to reflect the actual funding level of the Regional Study and other factors. Moreover, preparation of instrument specifications can be initiated. However, prior to final preparation of the Requests for Quotation for the instruments, the instrument identifier specification should be completed and transmitted to the meteorological instrument group--Activity CF--and the air quality instrument group--Activity CG. After these two activities have been completed, instrument procurement can be carried through the delivery of the first item for installation in the prototype instrument station.

Completion of the sequence BU, BV, and BW, of course, leads to the procurement sequence for the instrument identifiers--Activities BX, BY, BZ, CA, CB, CC. Delivery of the identifiers is shown by Activities DH and CD, for the meteorological and air quality instruments, respectively. These are shown separately because some differences in their housing and mounting design may occur as previously discussed.

Installation of the instrument identifiers is shown by Activity AA for the meteorological instruments and BL for the air quality instruments. These two activities could be carried out by EPA or prime contractor personnel at the St. Louis facility. An alternative does exist in that the identifiers could be delivered to the instrument contractors for installation in the instruments prior to delivery. Coding of the identifiers could be completed by the identifier manufacturer. Because of the need to ensure absolute accuracy in instrument identification, this alternative does not appear attractive in that the chances of erroneous coding and installation appear high. The preferable procedure is to code and immediately install all identifiers at a single point, where thorough control and quality record-keeping can be assured.

Initiation of Class A station tower procurement must await the completion of specification and approval for the meteorological instrument Request for Quotation--Activities S and T--and the specification of instrument tower mounts--Activity AB. Additionally, the aggregate station air sampling requirements must be specified in Activity DG, since the air sampling tubing requirements might affect detailed tower design considerations. Two tower designs are contemplated. A free standing design specified by Activity AC and a guyed design specified by Activity AD. Before tower procurement can be initiated in lots, the instrument site survey should be completed and all zoning requirements and available site descriptions must be provided by Activity DI. Quantities of each tower type can then be determined and procurement initiated.

Following the completion of specifications for all instruments and instrument identifiers, the design and procurement of the digital data terminals can be initiated. Meteorological instrument output characteristics are specified in Activity BR, air quality instrument outputs are derived in Activity BS, and instrument identifier output properties are given in Activity CH. These three activities converge to event No. 72 and permit the initiation of Activity CI.

Activity CI provides for the preparation of the format for the digital data flow between the instrument stations and the central computer facility. The activity also includes the definition of station reporting frequencies, required digital data flow rates, and the structure of the remote commands necessary for the central facility to transmit to the instrument stations. Activity CI also provides the basis for digital data design and selection to achieve compatibility among the various air quality and meteorological instruments, and is viewed as one of the more critical activities of the network.

Activity CJ can be initiated immediately after CI and includes the preparation of specifications for the electronic and digital data equipment necessary for air quality and meteorological instrument scanning and analog-to-digital data conversion, for the station memory, and for other equipment. These items are almost entirely standard catalog items with remarkably short order lead times.

A second important activity that can be initiated after instrument specification is the design of the instrument station shelter interior--Activity AQ. Tasks included in the activity cover instrument rack design and instrument layout, 110/220-volt distribution system, heating and cooling design, and the like. One of the most important design problems will be associated with the air quality sampling tubing, pumping, and valving system combined with the instrument calibration tubing and valving system. Several alternative designs are likely to emerge with each and to require careful consideration. Selected station alarm systems likely will be incorporated in the design, such as high or low air sample flow, shelter temperatures, and perhaps detection of unauthorized entry.

Following completion of Activity AQ, the requirements for electronic and electromagnetic control systems and equipment can be formulated as provided in Activity BT.

Activity BT converges with CJ to permit the initiation of CK. This latter activity provides for the design and preparation of specifications of the air quality instrument calibration controller. This device will provide control over the calibration cycles of air quality instruments, and, for Class A stations, it will control the sequence of air sample heights. The calibration controller is not expected to be commercially available as a complete catalog item and will require some original design effort.

Following the completion of Activities CI and CE, an additional important sequence of activities can be initiated. It will be recalled that Activity CI provided for the digital data-reporting format and related specifications. Activity C called for the review of instrument sites. Completion of these activities will permit the transmittal of tentative site locations--Activity CE--and data formats--Activity CX--to the telephone utility serving the central data facility. As previously noted in Chapter XIII, a number of alternatives are available for the design of the reporting system using telephone facilities. Given station locations and reporting procedures, the telephone utility can develop a routing plan and a tariff schedule, Activities CY and CZ, respectively, for each alternative requested. Routing plans should be developed to avoid nonautomated facilities, low quality lines, and similar facilities. Telephone links requiring quality upgrading should be specified by the telephone utility and the costs provided.

These costs and network routings must be reviewed in careful detail by EPA or the prime contractor to achieve economies in initial and annual costs and simultaneously to acquire a communication system suitable to the reporting requirements--Activity DA. The decision specifying the network alternative is viewed as somewhat critical with respect to operating flexibility. The instrument station and central data facility designs provide for the flexibility necessary to support a five-year research effort. Instruments at any number of stations can be modified and changed without affecting other stations. Additionally, instrument stations and the central data facility will be under the control of the EPA. The communication system, on the other hand, does not generally have equivalent flexibility. For orderly communication system management and data flows, reporting doctrines for all stations likely should be identical, and modification of reporting procedures at one or more stations could well affect the complete system. Finally, although telephone utilities provide very acceptable service, their general operational and administrative procedures, service lead times, and related factors frequently do not lend themselves to a research environment. All these factors suggest careful selection of a communication network which to the greatest possible degree matches the flexibility of the instrument stations and central data facility.

Following the decision of Activity DA, the detailed specifications can be developed for telephone utility equipment necessary to interface with the instrument station data terminals--Activity DB.

Activity CL can then be initiated, which provides for the design of the instrument station master controller linking the telephone utility equipment with the instrument station data terminal. As in the case of the calibration controller, this equipment is not a completely standard catalog item and will require some original design.

Activity CM provides for a final integration of all instrument station electronic and electromagnetic equipment and the preparation of the request for quotation for the equipment group. The sequence of Activities CM through CW provides for the acquisition and installation of the digital data system.

Returning to Activity DA, selection of telephone system alternative, the decision is transmitted to the telephone utility--Activity DC. The subsequent Activities DD, DE, and DF cover all the tasks required of the utility to provide the service specified. Activity durations are difficult to specify here but undoubtedly they will be substantially less than the network critical path.

Activity EY also follows Activity DA and covers the design and acquisition of the digital data terminal at the central data facility. Activities subsequent to EY are shown on Figure XVIII-2.

The final activities for instrument station activation are included in BN, BO, and BP, where instrument acceptance tests and local integrated tests are completed. Activity FK covers the completion of the central data facility and is continued from Figure XVIII-2.

Activity BQ applies to both the integrated operational test of the prototype stations functioning with the data center and to each subsequent station as they are completed. Of course, the prototype station tests will likely have considerably greater duration than the later stations.

The final group of activities on Figure XVIII-1 apply to those associated with the central data facility. Activities DP and DK cover the review of planned data processing requirements and central facility requirements, respectively, in light of the actual funds allocated to the Regional Study. Activity DJ covers review of the experimental support requirements to be supplied by the facility. Both of these activities are continued in Figure XVIII-2.

The implementation schedule for the central facility is shown in the network of Figure XVIII-2. In contrast to Figure XVIII-1 which portrays both the prototype station schedule and the subsequent operational station activation schedule, the central facility schedule covers essentially a one-time-only set of events. That is, the central facility serves as its own prototype.

Following the completion of Activity DP, the network diverges into three major activity sequences. The first covers computer acquisition and includes the sequence DQ through DZ. The second provides for acquisition of the memory equipment and includes Activities EE through EN. The third provides for acquisition of the peripheral equipment and includes Activities EO through EX.

The display of these three activity sequences is not meant to imply that three different contractors are to be involved. In fact, other things being equal, a single data-processing equipment contractor would be preferred. However, the major items of equipment required in the central data facility are standard catalog items whose characteristics are well known, so that the acquisition of the major items from separate contractors ought not introduce serious problems of compatibility and the like. Potential problems of compatibility can be treated in Activity DP when specifying equipment interfaces.

A fourth major sequence includes the acquisition of the terminal equipment linking the telephone utility facilities with the data-processing system. As will be recalled, Activity EY as shown on Figure XVIII-1 covered the preparation of specifications for the terminal equipment and was initiated after selection of the communication system configuration and operational mode. Sequence EY through FH covers the acquisition of test of the digital terminal equipment.

The sequence of Activities EA through ED provides for the preparation of the primary computer programs to be used for data acquisition, logging, and processing. This effort can be initiated as soon as the specific computer to be acquired is known since program debugging and test need not be completed at the St. Louis computer.

As noted previously, most of these activity sequences can be carried forth with a minimum of interaction among them. They are to some extent influenced by the schedule for the preparation of the data facility site. Activities DL, DM, DN, and DO cover facility preparation. DM includes site acquisition and DN provides for design. Proper design must consider the equipment to be incorporated, so that Activities DV, EJ, ET, and FD should be completed. The completion of Activity FD appears to be of marginal importance in that space and other requirements for the data terminal could be relatively accurately estimated by at least the end of Activity EY.

Activity DO, preparation of the facility, should be completed prior to equipment delivery. This is not an absolute requirement, but clearly efficiencies would be achieved by final equipment installation upon delivery.

Activity FJ is designed to complete an integrated test of the facility using standard procedures employed by the equipment contractors, and Activity FK provides for a final integrated test of the facility using the programs prepared in Activities EA through ED and FI.

Finally, the full operational test--Activity BQ--is carried out. As noted previously, Activity BQ applies to both the instrument station prototype and subsequent station activation. The operational test of the prototype station undoubtedly will reveal the need for revision of selected equipment and component designs. Activity FL covers the overall review of the prototype performance and the specification of the necessary revisions. Activity BQ will include the field modification of station components and layouts, where malfunctions do occur, and perhaps differing schemes of equipment placement and the like not considered in the original design will be tested. At the conclusion of Activity BQ, a systematic review of performance will be required as provided by Activity FL. A large number of alternative schedules can be devised to accomplish complete activation of the prototype stations, with each having a particular cost and risk. For example, by scheduling more activities simultaneously rather than sequentially, the overall time to completion could be shortened. This practice, however, might require fluctuating staff size during the course of the implementation effort and might thereby create management difficulties and inefficient use of personnel. Additionally, many activities are interrelated in one way or another so that one should be completed before another can be initiated. Thus, as the number of simultaneous activities is increased, a concomitant increase in risk tends to occur, because the assumption must be made that the planning factors will in fact be realized. For example, the network schedule indicates that the development of the specifications for the instrument identifiers--Activities BU, BV, and BW--should be completed prior to completion of the specifications for the air quality and meteorological instruments since the instrument identifiers will require specialized design. This sequence is not absolutely mandatory, however, if the risk is assumed that the instrument identifiers will in fact have final design characteristics virtually identical to the preliminary concepts. In this case the instrument identifiers and the air quality and meteorological instruments could be procured simultaneously. If, however, the assumptions covering identifiers turned out to be false, a penalty could arise from the need subsequently to alter the specifications of the air quality and meteorological instruments.

Network Critical Path

The schedule network shown in Figures XVIII-1 and XVIII-2 is somewhat conservative in that simultaneous scheduling is confined to essentially separate major elements of the project, such as the procurement, installation, and test of the meteorological and air quality instruments, and the digital data terminal equipment.

The critical path through the network was traced for three alternative conditions. The first applies to the network of Figures XVIII-1 and XVIII-2. The critical path from event No. 1 to acceptance of the prototype stations at event No. 44 was found to require 220 working days. The path consists of the following events:

1, 2, 3, 63, 64, 65, 29, 30, 31, 72, 73, 88, 89, 90, 91, 75
76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 41, 42, 43, 44.

The activities of prime importance in the critical path and which should likely be given considerable attention in subsequent schedule analysis are discussed below.

Activities A and B provide for the authorization of the Regional Study and the initial staffing and planning. Activity B, especially, could have very wide time limits depending upon EPA policy and other considerations. For example, a small core group conceivably could continue planning, scheduling, preparation of preliminary specifications, and similar activities throughout the period of review and evaluation of the Regional Study at higher organizational levels. At the time of authorization, augmentation of the core group should prove to be relatively rapid and implementation should proceed without difficulty. The estimate of five days is based upon this situation. On the other hand, because of budgetary or staff limitations, for example, consideration of the Regional Study might be suspended during the period of review and evaluation. At the authorization of the Regional Study, selection of personnel staffing and detailed planning would be initiated. The duration of this effort could well cover six to eight weeks, depending upon the level of priority or urgency assigned to the Regional Study.

The sequence of Activities CX, CY, CZ, DA, and DB might be treated by alternative techniques to shorten the critical path. These activities are associated primarily with the selection of the mode of operation of the telephone communication system linking the instrument stations to the central computational facility. Activity CX provides for the transmittal of the digital data format to the telephone utility. Activity CY of 20 days covers the time required for the telephone utility to prepare descriptions of the various possible modes of system operation, and CZ, DA, and DB include the review and selection of the mode of operation. Activity DB then leads to final design and procurement of the digital data equipment.

This sequence could be both decreased in duration and carried out in parallel with other activities by making the decision perhaps within the context of Activity CI, as to the mode of operation of the telephone communication system. In this situation, the telephone terminal equipment could be immediately specified and the communication network could be designed by the telephone utility without delaying activities otherwise dependent upon the selection of the mode of operation. This approach might involve costs greater than would be required under the sequential activity schedule.

The sequence of activities from CL through CV involves the procurement of the digital data terminal equipment with a duration of 118 days. Some reduction in time for this sequence may be possible by somewhat simultaneous procurement of the standard catalog items and the design and procurement of the nonstandard equipment. However, again the risks involved are clear.

The final integrated station test--Activity BQ--is indicated to have a duration of ten days. All air quality and meteorological instruments are scheduled to have been in operation for at least 15 and 10 days, respectively, and, as will be noted subsequently, could have been subjected to operational tests for considerably longer periods. Accordingly, Activity BQ covers the operational tests of the digital data equipment interfaced with the air quality instruments and the central facility. Some possibility appears that this duration could be decreased given reliable digital data equipment design.

To identify further the scheduling constraints imposed by the activity sequence CX, CY, CZ, DA, and DB, a second case was examined in which Activity DB was shifted to link event Nos. 91 and 82 and was assigned a duration of ten days. The shift in effect substantially reduces the dependence of the design of the digital data terminal equipment on the telephone system mode of operation. Under this schedule the critical path duration was reduced to 204 working days within the critical path including the following events:

1, 2, 3, 63, 64, 65, 29, 30, 31, 72, 73, 74, 75, 76,
77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 41, 42, 43, 44.

As can be noted, the sequence remains the same through event No. 73. The sequence then shifts to event No. 74 and leading to event No. 75 and subsequently following the previous critical path to event No. 44.

It is of interest to note that the next most critical path has a duration of 201 days. The same event sequence is followed through event No. 73 at which point the path includes the following events:

88, 89, 90, 91, 135, 136, 137, 138, 139, 140,
129, 130, 131, 106, 107, 108, 109, 110, 43, 44.

In other words, the critical path in this sequence includes events associated with the instrument station and, from event No. 91 onward, events associated with the central computer facility. The path length again tends to be controlled by the activities covering the analysis of the telephone system. This latter path may be somewhat artificially long because of the scheduling requirement that the central facility communication terminal characteristics be specified prior to design of the facility. This requirement may be overly conservative, in that an experienced electronic or telephone design engineer can likely provide space and other specifications of the terminal equipment with sufficient accuracy to permit the design of the central facility without detailed knowledge of the precise mode of operation of the telephone communication system.

The third case to be considered covers the network of Figures XVIII-1 and XVIII-2 but increases the duration of activities associated with elements of organization and planning. Specifically, the following activities were increased to the indication duration:

Activity	Duration (days) Original	Revised
B	5	40
C	5	15
R	5	15
BB	5	15
BU	2	10
DJ	5	15
DK	5	15
DP	5	15
CL	10	20

These durations may apply to the situation mentioned previously, where further planning and analysis of the Regional Study would not take place during the period of review and evaluation at the higher organizational levels. In this situation a somewhat extended period of orientation, staff acquisition, and project review appears almost unavoidable. These revised activity durations do not affect the critical path sequence but do indeed extend the duration time from 220 to 265 days. This duration could prove excessive given the importance of the Regional Study.

For all scheduling alternatives considered here, the critical path includes many activities associated with the digital data equipment. This situation is not unexpected since several equipment components require specialized design unlike the meteorological and air quality instruments which are assumed to be acquired as standard catalog items.

The critical path as identified allows considerable total float time in the other principal paths through the network. While the high float time allows flexibility in the scheduling of the activities, it also demonstrates that considerable scheduling benefits might be achieved by adopting a crash schedule for the digital data terminal equipment and telephone communication system design. Early relatively high risk decisions could well shorten the critical path duration and all decision options should be continually reviewed during the course of implementation. To show the potential benefits of crash scheduling the critical path, the total float time of the network activities for the 220-day critical path case are given in Table XVIII-2 in alphabetic order.

The total float times of the activities in the critical path, of course, have a value of zero. The longest total float is shown as 153 days, but this covers the instrument site acquisition activities which, as noted previously, require a special interpretation in the schedule development. The float times of greatest interest are those associated with the air quality instrument sequence BE-BN with a float of 85 days and the meteorological instrument sequence U-Z having a float of 118 days. Floats of this magnitude clearly indicate the benefits of reducing the critical path by appreciable margins. However, if reduction of the critical path duration is not possible, the float times can still be used to advantage by providing longer instrument test periods, complete design modification, as necessary, and attempting to resolve any unforeseen problems.

Any number of other alternative scheduling conditions should be examined which incorporate additional simultaneous activities or an increasing number of early decision points having various risks, and such an examination should be a continuing process during the Regional Study. For purposes of overall planning for this Prospectus, however, the analysis of all possible combinations is not appropriate and would tend to imply a level of precision to the analysis which would be unwarranted.

On balance, the activity-event sequences that have been examined lead to the general conclusion that the elapsed time from authorization of the Regional Study to completion of the prototype stations could be expected to have a duration of the order of 220 working days or approximately 10 calendar months. As has been noted periodically, this estimated duration is subject to considerable change depending upon the assumptions utilized in planning and the extent of risk to be taken in scheduling increasing numbers of simultaneous activities. Opportunities do indeed exist for reduction in activity durations to provide a shorter critical path, but, at the same time, unforeseen difficulties in organization and planning, equipment malfunction, and other pitfalls exist in equal or larger numbers.

Table XVIII-2

ESTIMATED TOTAL FLOAT TIME FOR PROTOTYPE INSTRUMENT STATION ACTIVITIES
(Days)

Activity	Time	Activity	Time	Activity	Time
A	0	BO-BQ	0	DQ-DV	86
B	0	BR	7	DW	98
C	42	BS	0	DX-DZ	30
D-L	153	BT	30	EA-ED	86
M	156	BU-BW	0	EE-EK	81
N-Q	103	BX-CD	111	EL-EN	33
R	15	CE	42	ED-ET	103
S-T	7	CF	7	EV	124
U-Z	118	CG	0	EV-EX	36
AA	118	CH	20	EY-FD	33
AB	108	CI	0	FE-FH	25
AC-AK	103	CJ-CK	25	FI	93
AL-AN	142	CL-CW	0	FJ	33
AO	44	CX-DB	0	FK	33
AP-AQ	35	DC-DF	106		
AR	104	DG	103		
AS-AU	124	DH	119		
AV-AX	103	DI	120		
AY	112	DJ	126		
AZ	116	DK	126		
BA	116	DL	126		
BB	8	DM	126		
BC-BD	0	DN	33		
BE-BN	85	DO	33		
		DP	81		

Activation Schedule of Class A and Class B Stations

Unit Schedules

The activation of an instrument station has three principal components. The first includes the preparation of the site, tower erection, and assembly of the instrument shelter. These activities can be constrained by weather and ground conditions and must be scheduled accordingly. Assembly of the instrument shelter and installation of the electric power drop should follow the erection of the 30-meter towers to provide maximum maneuvering room for the erecting crane.

The second component includes the installation and test of all components and instruments within the instrument shelter. Because of space limitations within the shelter, not more than two craftsmen could be reasonably scheduled for work within the shelter at any one time.

The third component includes the installation of meteorological instruments and the air sampling tubing on the tower and other tasks outside the instrument shelter. These can be carried out at almost any time subsequent to tower erection, but tend to be slightly constrained by weather conditions. The estimated elapsed time for the tasks within each of the three components for the 30-meter tower stations is summarized in Table XVIII-3.

The table indicates a total of 50 calendar days required for complete activation and acceptance tests for an instrument station. This interval includes nonworking weekends and eight working days each for the curing of concrete and operational shakedown tests for the instrument station. A total of 20 working days, however, is required for actual on-site effort, assuming that tower instruments and equipment are installed simultaneously with equipment within the shelter.

The implementation time for Class B_1 instrument stations with 10-meter towers is somewhat less primarily because of the absence of the massive concrete work for the 30-meter tower base. Otherwise, the sequence of the Class B stations corresponds almost exactly with that of the Class A stations, as can be noted from Table XVIII-4.

The implementation time for the Class B_2 stations is slightly less than the Class B_1 due to the absence of any concrete work and the fact that the two-day effort to assemble the instrument shelter is eliminated. These two activities are estimated at seven days for the Class B_1 station. Hence, the Class B_2 station activation time is estimated at 23 calendar days or 17 working days.

Table XVIII-3

CLASS A STATION ACTIVATION REQUIREMENTS

Activity	Duration (working days)	Man-Days	Elapsed Time (cumulative)	Remarks
Prepare site	1	2	1	Clear and level; excavate for tower and instrument shelter foundations and fencing
Concrete work	2	6	3	Fabricate forms, install reinforcing bar, and pour concrete
Concrete curing	8	0	11	Complete site paving during curing period
Erect instrument tower	1	3	12	Restricted to periods of stable soil conditions
Assemble instrument housing	2	4	14	
Install electrical system including utility drop	2	4	16	The sequence of these activities may be interchanged depending on the detailed interior design
Install air sampling and calibration tubing system	2	4	18	
Install equipment racks, benches, cable trays, and other fixtures	2	4	20	
Install air quality instruments and initiate test	1	4	21	
Complete calibration of air quality instruments	2	4	23	
Install digital data terminal equipment and test	2	4	25	
Station shakedown operation	10	0	35	Stations maintained by permanent facility staff
Final station test	3	6	38	
Install tower instruments and air sample tubing	2	5	38	Completed simultaneously with air quality instrument installation
Elapsed time modification for two-day weekend	14	0	50	

Table XVIII-4

CLASS B_1 STATION ACTIVATION SCHEDULE

Activity	Duration (working days)	Man-Days	Elapsed Time (calendar time, cumulative)	Remarks
Prepare site	1		1	Clear and level, place intrument shelter piers, erect security fence
Concrete work	1		2	
Concrete curing	4		6	
Assemble instrument shelter	2		8	
Install electrical system	2		10	The sequence of these activities may be interchanged depending on the detailed interior design
Install air sampling and calibration equipment	2		12	
Install equipment racks, benches, cable trays, and other fixtures	2		14	
Install air quality instruments and initiate test	1		15	
Complete calibration of air quality instruments	2		17	
Install digital data terminal equipment and test	2		19	
Station shakedown operation	8		28	
Final station test	2		30	
Install tower and instruments and air sample tubing	1	2	30	

Since the Class B_2 stations are transportable, the opportunity appears to exist for the installation of the instruments, digital data terminals, and other equipment at the central facility rather than at the instrument site itself. This may be especially appropriate for the more remote sites, where excessive travel times may be involved. Equipment shakedown and acceptance tests, however, should be carried out at the site itself to ensure operability after transport and to test the telephone data link.

Scheduling of the Class C instrument stations, as discussed subsequently, has slight similarity with the Class A and B stations. That is, since the Class C stations are intended to be designed specifically for support of the various research experiments, their schedules are closely linked with the experimental research program. In general, equipping and testing the Class C stations is expected to be carried out during the winter months when field work likely will be at a minimum. All work would be carried out at the central facility. In addition to equipping the Class C stations themselves, it is likely that selected Class C station instruments will also be installed in the Class A and B stations from time to time. For instruments designed to be compatible with the Class A and B station design and having instrument identifiers included, their installation likely can be included in the routine maintenance visits made to each station. Instruments requiring special handling and installation would require specialized technicians associated with the experimental research groups.

Sequential Station Activation Schedule and Maintenance Requirements

Marked flexibility exists for the development of the implementation schedule. At the limit, all instrument sites could be prepared simultaneously by a different general contractor. Equipment order lead times are relatively short, so that equipment installation at the instrument stations could likewise be completed in a short time by use of a large field force. Clearly, such a procedure would be administratively difficult and chaotic, and it would entail risks of poor workmanship, possible lack of station uniformity, and other potential disadvantages. Additionally the St. Louis facility staff would be confronted with the overnight existence of the total system and without tested operational routines and maintenance programs. The facility staff could certainly cope better with a more slowly expanding system, developing operational routines with experience.

An additional constraint on the activation schedule arises from the role and capacity of the central facility. The central facility will be the principal receiving point for almost all equipment and supplies necessary for the implementation and operation of the instrument system. Probably, only the instrument towers and instrument shelters will be delivered directly to the instrument sites because of their weight and bulk. The central facility is sized on the basis of system operation rather than implementation, so that massive deliveries and storage of equipment prior to installation do not appear practical.

The most important activities will cover the coding and installation of the instrument identifiers, instrument assembly and preliminary test, and the assembly of the instrument cabling for connection to the digital data equipment. Installation and coding of the identifier is most important and will require competent instrument technicians working under close supervision to eliminate all chances of error.

One aspect of the implementation schedule, which is difficult to treat in this Prospectus, covers the site acquisition and preparation activities. The extent to which the instrument sites have been acquired and prepared for equipment installation clearly will be critical. Site acquisition time is perhaps one of the most difficult activities to estimate in the entire implementation schedule. Yet, it is one of the most critical. The extent to which uncooperative land owners, zoning commissions, and similar groups may delay site acquisition cannot be readily anticipated. Fortunately, past air quality and related studies carried out in the St. Louis area have been well accepted and public cooperation has been provided when necessary. Hopefully, such cooperation will prevail for instrument site negotiation. In a sense, perhaps the instrument sites might be considered as property used for the public good and condemnation procedures instituted for those not easily acquired. However, such procedures are generally lengthy and frequently produce undesirable side reactions. Therefore, unless compelling need exists for such sites, it would appear that generally other, although less desirable, sites should be acquired.

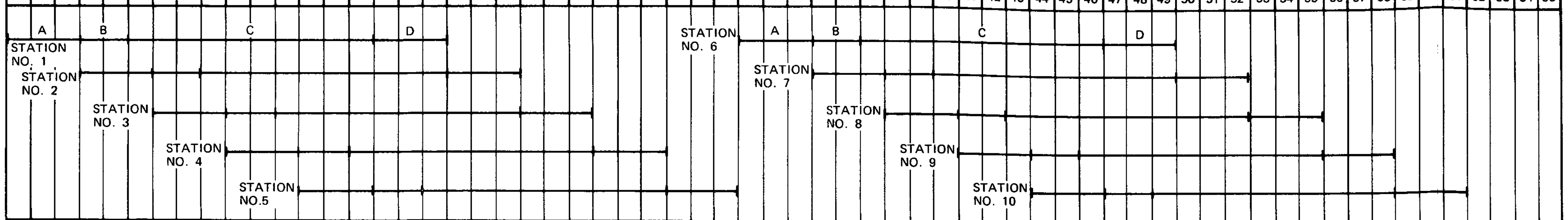
Site preparation activity durations are comparatively simple to estimate in absolute terms but difficult to place in real time. This difficulty arises from the fact that winter conditions in some portions of the study area preclude efficient site preparation, tower erection, and concrete work. Since the initiation date of the Regional Study cannot be predicted with good reliability at this time, the possible constraints due to weather cannot be readily predicted. In the actual execution of the implementation plan, the constraints arising on construction due to winter conditions should be immediately assessed and compared with the expected acceptance schedule of the prototype instrument station. For example, if acceptance is expected in late autumn, then all acquired instrument sites should probably be prepared before the winter construction hiatus to permit subsequent activation. The number of contractors would be derived according to the number and location of instrument sites. On the other hand, if prototype acceptance is expected early or in the middle of the construction season, the site preparation schedule would be developed accordingly with perhaps fewer general contractors.

The installation of the air quality and digital data facilities and subsequent station acceptance tests are the controlling factors of the schedule. These tasks appear as critical because they should most appropriately be carried out for a group of stations by the same technician group. This is not meant to discount the importance of the meteorological instruments. However, their essentially standard design and comparatively well-known operating and reliability characteristics are such that their installation and test procedures offer far less possibility of unexpected difficulty and therefore they need not be the heart of the activation schedule. All other tasks included within the activation schedule, such as assembly of the instrument shelter and installation of the 110/220 volt electrical system, are essentially standard contractor tasks involving no unforeseen risks. Although it is highly desirable that these tasks be completed at a number of instrument stations by the same groups, no truly compelling reason can be identified.

As noted in Table XVIII-3 for the Class A station, the installation, calibration, and operational check of the air quality instruments is estimated at three working days. Installation and operational check for the digital data equipment calibration controller and associated equipment is estimated at two days. Because of space limitations within the instrument shelter, the two tasks probably cannot be carried out simultaneously. Table XVIII-3 indicates a ten-day period for operational shakedown tests.

Using these factors as stated, one possible activation schedule for a group of stations is presented in Figure XVIII-3 which indicates the equipment installation schedule, the shakedown period, and the acceptance test period. Figure XVIII-3 also indicates the supporting technician staffing required during the period as well as the manner in which the permanent instrument technicians can be phased into the system operation. For simplicity, Figure XVIII-3 does not take account of holidays and weekends which can, of course, extend the schedule. However, under certain conditions, the implementation might indeed be carried out on a seven-day week.

TIME — days



A. Air quality instrument installation
B. Digital data terminal equipment installation
C. Shakedown operational tests
D. Acceptance tests

TIME — days	Station No. Visited — Shakedown Operations	Number of Technicians Required (Shakedown)	Station No. Visited — Routine Maintenance	Number of Technicians Required (Maintenance)	Total Number of Technicians Required
1					1
2					0
3					1
4					1
5					1
6	1	1			1
7		0			0
8	1	1			1
9	2	1			1
10	1	1			1
11	2	1			1
12	1, 3	2			2
13	2	1			1
14	1, 3	2			2
15	2, 4	2			2
16	3	1			1
17	2, 4	2			2
18	3, 5	2			2
19	4	1			1
20	3, 5	2	1	1	3
21	4	1		0	1
22	5	1		0	1
23	4	1	2	1	3
24	5	1	1	1	2
25		0		0	0
26	5	1	3	1	2
27			1, 2	2	4
28				0	0
29			4	1	1
30			2, 3	2	2
31			1	1	1
32			5	1	1
34			3, 4	2	2
35			1, 2	2	2
36				0	0
37	6	1	4, 5	2	3
38		0	2, 3, 6	2	2
39	6	1	1	1	2
40	7	1	5, 7	1	2
41	6	1	3, 4	2	3
42	7	1	1, 2	2	3
43	6, 8	2		0	2
44	7	1	4, 5	2	3
45	6, 8	2	2, 3	2	4
46	7, 9	2	1	1	3
47	8	1	5	1	2
48	7, 9	2	3, 4	2	4
49	8, 10	2	1, 2	2	4
50	9	1		0	1
51	8, 10	2	4, 5, 6	3	5
52	9	1	2, 3	2	3
53	10	1	1	1	2
54	9	1	5, 7	2	3
55	10	1	3, 4, 6	3	4
56		0	1, 2	2	2
57	10	1	8	1	2
58			4, 5, 6, 7	4	4
59			2, 3	2	2
60			1, 9	2	2
61			5, 7, 8	3	3
62			3, 4, 6	3	3
63			1, 2, 10	3	3
64			8, 9	2	2
65			4, 5, 6, 7	4	4

TOTAL NUMBER OF TECHNICIANS REQUIRED

SC-1365-7

FIGURE XVIII-3

ESTIMATED INSTRUMENT STATION ACTIVATION SCHEDULE AND MAINTENANCE TECHNICIAN REQUIREMENTS

Instrument installation at each station requires five days with the air quality instrument work preceding the digital data equipment installation. Thus, at the end of the 15-day period, air quality instruments would have been installed at five stations and the first station would have had a shakedown period of 10 days. After the shakedown period has elapsed, installation of equipment at additional stations would be suspended and the technician crews would return to the first station for the final operational acceptance tests covering a period of three days for each station. Following the acceptance tests of the first group of stations, the sequence would be repeated for the second and subsequent groups.

Station acceptance denotes that a station is considered to be ready for full-time operation in the system to monitor and report meteorological and air quality conditions on a periodic basis. It is not meant to imply, however, that all obligations of the instrument and other contractors have been discharged. These obligations should be controlled by the procurement contracts which should contain provisions for parts and workmanship guarantees and related matters for a specified period, perhaps one year, after operation is initiated.

Station acceptance is also regarded as the point at which transfer of responsibility would take place. That is, for example, in the event the St. Louis facility is implemented by a prime contractor, transfer of the station to EPA would occur at acceptance. Other transfer combinations are, of course, possible depending upon the contracting structure chosen by EPA.

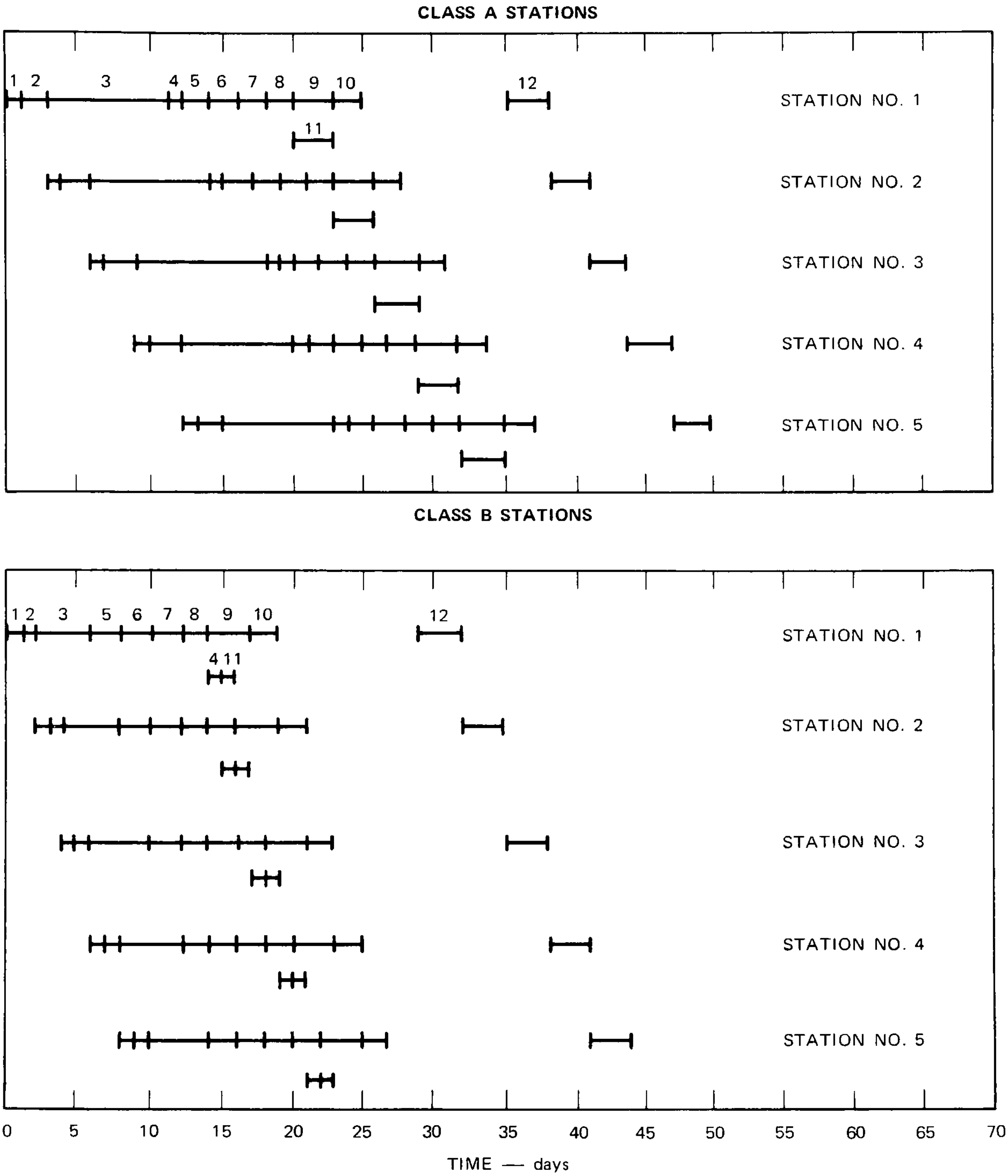
The requirements for technician maintenance of the instrument stations are also shown in Figure XVIII-3. During the period of instrument station shakedown, a station should probably be checked by a technician every other day. Each visit might extend over approximately a two-hour period to provide sufficient time for a thorough check of all facilities. Probably the most time-consuming duty in each visit would be to monitor a complete cycle of the air quality instrument calibration procedure. Replacement of instrument parts of entire instruments will probably be required at certain stations. For a 10-day shakedown, five visits will be required. These are shown to start the day after station activation. The total number of stations visited per day is shown below the visit sequence. Not more than two stations are included in any day, so that this task can be handled by one technician. Although, as noted above, the detailed scheduling of the installation of air quality instruments and digital data equipment may well consider weekend intervals, the technician assignments for the shakedown period should be carried out on a seven-day basis.

After the instrument station acceptance tests are completed, the mode of technician visits shifts to the twice-weekly schedule and subsequently to a weekly basis. The days of station visit are tabulated on Figure XVIII-3 with visits starting one day after station acceptance and thereafter spaced by alternating two- and three-day periods. This would tend to correspond, for example, to a Monday-Thursday schedule.

The necessary buildup of the technician staff is evident. Under this schedule the increase is somewhat gradual, thereby providing a suitable learning period prior to full system operation. The final tabulation on Figure XVIII-3 shows the aggregate number of stations requiring technician visits through the activation of 10 instrument stations. The number of visits start at one per day and gradually increase to a stabilized cycle after acceptance of the tenth station to a maximum of four per day. Again, this scheduling does not recognize weekend intervals and holidays. It would be premature for this Prospectus to recommend the actual technician visit schedule for station maintenance with respect to weekend and holiday duty. Operational considerations and EPA policy are expected to influence such decisions, and these cannot be foreseen at the present time.

The station activation schedule shown in Figure XVIII-3 provides for the installation of eight air quality instruments at each station over a three-day period. Additionally, if the installation of the meteorological tower instruments is scheduled simultaneously or slightly ahead of the air quality instruments, the total number of instruments installed increases to about 15. These instruments will require processing at the central facility prior to their installation. Processing, it will be recalled, includes uncrating, simplified operational checks, and the installation of the instrument identifier. On the average, a one-hour interval was estimated for this activity, so that approximately two days will be required to complete the processing for each station. Close coupling of instrument processing at the central facility and installation at the instrument stations appears desirable in order to eliminate long storage times of instruments unprotected by their shipping containers. An installation schedule of this type would also allow for a sequential delivery of instruments and equipment from the suppliers rather than call for delivery of all instruments at one time.

The timing of the general contractor activities as constrained by the equipment installation activities is shown in Figure XVIII-4. As previously noted, other factors influence the general contractor's schedule, such as the construction season, the pattern of site location, and the site acquisition schedule. Additionally, the general contractor may



1. Site preparation
2. Concrete work
3. Concrete curing
4. Tower erection
5. Shelter fabrication
6. Install electrical system
7. Install air sampling system
8. Install fixtures
9. Install and calibrate air quality instruments
10. Install digital data terminals
11. Install meteorological instruments
12. Operational test and acceptance

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FIGURE XVIII-4 ESTIMATED INSTRUMENT STATION EQUIPMENT INSTALLATION SCHEDULE wish to schedule the activities of site activation with construction projects for other clients to achieve maximum utilization of his equipment and labor force, thereby perhaps lowering his contract price. Detailed matters of this type cannot be specified in this Prospectus, but they should be considered during the actual implementation of the St. Louis facility.

One alternative could be to specify completion dates for each site and allow the general contractor to develop his own schedule within this constraint. This has a potential disadvantage, however, of causing awkward delivery schedules of the instrument shelters and interior fixtures and appurtenances or, on a regular delivery schedule, a need to store the materials at the central facility until the general contractor withdraws them for installation. This potential difficulty notwithstanding, the general contractor might still be granted some flexibility in scheduling his basic construction activities of site preparation and all concrete work not involving prime contractor or government-furnished equipment.

The schedule shown in Figure XVIII-4, as noted above, shows the conditions under the assumption that the general contractor uses one crew for all sites. The use of more than one crew could indeed prove desirable for the more remote stations where travel distances could become excessive.

The schedule shows the sequence in which the first activity--site preparation--is initiated 20 days prior to the installation of the air quality instruments. One activity follows the next without interval. No allowance is made for unforeseen difficulties, except that a two-day period exists between the start-date for each site. This would provide some cushion to cover unexpected difficulties. Additionally, the two-day interval would possibly allow the general contractor to schedule projects for other clients as well. Depending upon the number of stations committed to the general contractor, say 10 in this case, work could continue at the same general schedule for the additional five stations during the acceptance test period of the first five instrument stations.

Full Facility Implementation

General Scheduling Conditions

The planning factors developed previously can now be used in the preparation of the full implementation schedule for the facility. The overall schedule ultimately adopted will depend upon a number of critical factors. First, the urgency for initiation of the research experiments requiring the full instrument system is of vital importance. Second, budgetary or manpower ceilings may impose restraints on the rate of station activation thereby necessitating a longer-term program. A third factor must recognize the possibility that the activation schedule may be rather closely coupled to technical design considerations. That is, elsewhere in this Prospectus the technical concepts covering the instrument location pattern were presented. The first concept included an essentially symmetrical pattern about the St. Louis arch with slight bias toward the north due to the climatological winds. The second, while retaining some degree of symmetry, favored a more pronounced northward bias. Both concepts considered a time-phased schedule in which an initial group of stations was activated prior to the completion of the remaining stations. In this way, the meteorological and air quality information acquired from the first group of stations would provide guidance for the pattern design of the second group.

For overall planning purposes here, the assumption will be made that the Regional Study has an urgency or priority sufficiently high that budgetary and manpower limitations will not constrain the activation schedule. Scheduling in the face of the possible technological alternatives of pattern design is more difficult to treat on a station-by-station basis, but on a system-wide concept a meaningful schedule can be developed. That is, even though the alternative station patterns differ in detail, the differences are such that schedule planning factors for each are essentially identical or applicable to both alternatives.

Two basic alternative schedules appear to be suitable for consideration here. The first applies to the situation where complete prototype station operation has been achieved prior to the initiation of work at any additional stations. The second alternative covers the condition in which work is initiated at additional stations as the major components of the prototype station are being tested and accepted.

Under the first alternative, it will be recalled from Figure XVIII-2 that Activity FL covered the review and evaluation of prototype station performance.

Activity FL led to six parallel activity paths as shown on Figure XVIII-5 and described in Table XVIII-5. The terminal activities in the six sequences--FP, FT, FX, GB, GF, GJ, GN--cover the activation of all stations of the system and lead to full system operation--Activity GO. As in the scheduling of activities in Figure XVIII-1, such as air quality instrument acquisition, where one sequence of activities is used for all instruments rather than one sequence per instrument, one

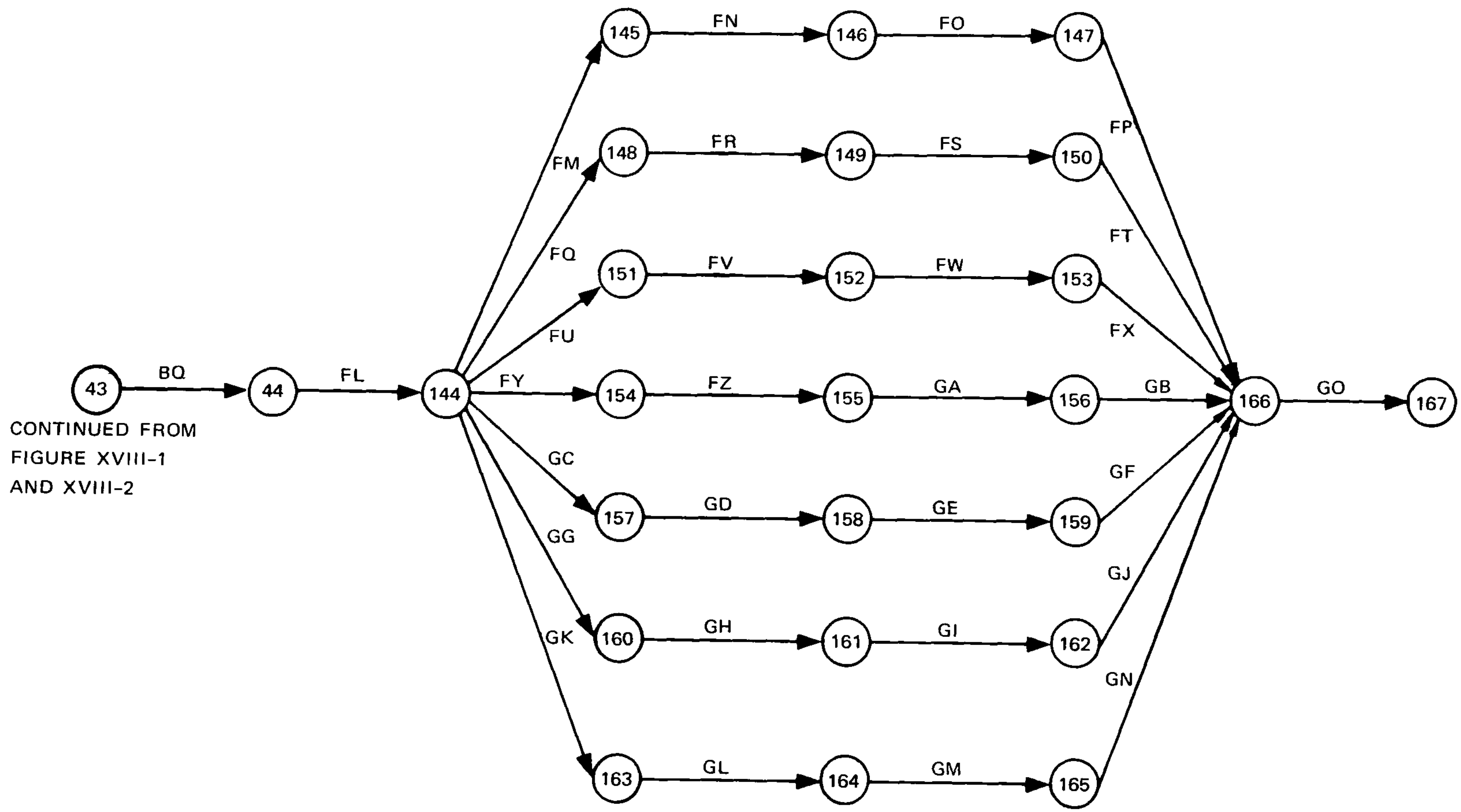

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FIGURE XVIII-5 FULL SYSTEM ACTIVATION CRITICAL PATH NETWORK

Table XVIII-5

ST. LOUIS INSTRUMENT SYSTEM ACTIVITIES FOLLOWING FULL PROTOTYPE STATION ACCEPTANCE

Activity	Description	Immediate Prerequisite	Duration (days)
FM	Review tower design and performance	FL	
FN	Modify instrument tower design	FM	
FO	Negotiate instrument tower design changes	FN	77, see Figure XVIII-6 and Figure XVIII-9
FP	Initiate delivery, installation, and acceptance tests for instrument station tower	FO	
FQ	Review meteorological instrument design and performance	FL	93, see Figure XVIII-6 and Figure XVIII-9
FR	Modify meteorological instrument design	FQ	
FS	Negotiate meteorological instrument design changes	FR	
FT	Initiate delivery, installation, and acceptance tests for meteorological instruments	FS	
FU	Review air quality instrument design and performance	FT	
FV	Modify air quality instrument design	FU	105, see Figure XVIII-6
FW	Negotiate air quality instrument design changes	FV	85, see Figure XVIII-9
FX	Initiate delivery, installation, and acceptance tests for air quality instruments	FW	
FY	Review digital data terminal design and performance	FL	165, see Figure XVIII-6 75, see Figure XVIII-9
FZ	Modify digital data terminal design	FY	

Table XVIII-5 (Concluded)

Activity	Description	Immediate Prerequisite	Duration (days)
GA	Negotiate digital data terminal design changes	FZ	
GB	Initiate delivery, installation, and acceptance tests of digital data terminals	GA	
GC	Review data center design and performance	GB	
GD	Modify data center design	GC	
GE	Negotiate data center design changes	GD	30
GF	Initiate delivery, installation, and acceptance tests of additional or modified data center equipment	GF	
GG	Review telephone equipment design and performance	FL	
GH	Modify telephone equipment design	GG	
GI	Negotiate telephone equipment design changes	GH	30
GJ	Initiate delivery, installation, and acceptance tests of additional or modified telephone equipment	GI	
GK	Review instrument shelter layout and design	FL	
GL	Prepare engineering designs for preassembled interior fixtures	GK	
GM	Negotiate procurement contracts	GL	77, see Figure XVIII-6 and Figure XVIII-9
GN	Initiate delivery, installation, and acceptance tests of instrument shelter and interior fixtures	GM	
GO	Operational check, full system	FP, FT, FX, GB, GF, GJ, GN	

activity is shown here to represent all stations. Indeed, these terminal activities represent a synthesis of almost all activities shown in Figure XVIII-1, which, as previously noted, represents the scheduling network for both the prototype stations of Phase I and the stations included in Phase II. The interdependencies of these six sequences are essentially the same as those presented in Figure XVIII-1. Each path in Figure XVIII-5 incorporates a sequence of activities of the following type:

Review design and performance

Modify design and specifications

Negotiate design changes with equipment contractor

Initiate delivery, installation, and acceptance tests.

A separate sequence is shown for the following major items of equipment:

Instrument tower, FM-FP

Meteorological instruments, FQ-FT

Air quality instruments FU-FX

Instrument station digital terminals FY-GB

Data central equipment, GC-GF

Telephone utility equipment, GG-GJ

Instrument shelter facilities and equipment, GK-GN.

In each sequence of activities for each major type of equipment, the results of the prototype test will provide measures of the extent to which the original procurement specifications will require modification. Overall the greatest cause for design changes may stem from the total operation of the wide variety of air quality and meteorological instruments as an integrated unit. It is not expected that design change will result from malfunctions of individual instruments unless their designs are inherently poor. Consequently, the most significant activity sequences are considered to be those associated with the instrument station digital terminal, due to its incorporation of the calibration controller and master station controller, and the instrument shelter facilities and equipment sequence.

The calibration controller and master station controller, unlike other digital system components, are custom designs rather than standard catalog items. Consequently, some redesign for quantity production can be expected. The calibration controller, additionally, directly interfaces with the air quality instrument complex, so that any unanticipated systemic difficulties arising from the unprecedented combination of air quality instruments could be reflected in design changes of the calibration controller.

The activity sequence GK-GN applicable to the instrument shelter and especially the interior components will essentially cover the design of components for quantity production. That is, the prototype station(s) are expected to be largely assembled in the field from items acquired separately. For example, the air quality sampling system including the tubing, manifolds, valves, pumps, and the like, will be assembled at the instrument site. Following this procedure for all instrument stations would be inefficient and costly. Accordingly, following prototype acceptance, designs for quantity production of interior components, such as a complete air sampling system, will be required.

The methods for initiating quantity deliveries of the instrument station equipment after acceptance of the prototype station(s) appear to have several alternatives. For planning purposes here, the procurement contract for the instruments used in the prototype station is expected to cover all additional instruments as well, provided the instruments function satisfactorily in the prototype. It appears, quite properly, that the procurement contract could specify the delivery schedule of the remaining instruments as a function of the acceptance date. The contract could (and should) make provision for modification of the instruments, if appropriate, with a flexible or negotiable delivery date specified. The alternative--to plan the delivery schedule on the normal procurement cycle--does not appear attractive, especially under a constrained schedule, and centralized control of the schedule would be weakened. In view of the fact that nearly all equipment included in the instrument stations is produced on at least a semi-assembly-line basis, a procurement contract provision calling for a future delivery schedule contingent upon acceptance ought not place an undue obligation on the contractor. Moreover, as will be shown subsequently, the station activation schedule is such that delivery of the full lot need not be completed at one time thereby further easing the obligation for delivery.

The principal and attractive alternative to this scheduling concept is to overlap the assembly and test of the prototype instrument stations with the activation of the remaining stations. Table XVIII-2 identified a float time of 85 days for the air quality instruments, Activities BE-BN, and greater times for the other principal activity sequences.

Although the scheduling networks show Activity FL as providing a review of system performance prior to the initiation of the activation of the remaining instrument stations, a low risk decision should indeed be considered to initiate partial activation prior to the completion of Activity FL. That is, Activity BQ leading to FL provides for the complete integrated station operation test, including all digital data terminal equipment. Activity BQ is estimated to begin 194 working days subsequent to initiation of the Regional Study. However, a number of instrument station components, such as the instrument shelters, their interior fixtures, and the instrument towers, have no direct interface with the digital data terminals. Accordingly, the prototype design of these components could indeed be reviewed, modified as appropriate, delivery orders placed, and field installation completed long before Activity FL. A similar but higher risk decision would involve the air quality and meteorological instruments.

The risk is higher because the instruments directly interface with the digital data terminal equipment, so that assurance of compatibility in operation may be significant. However, since the instrument scanners and the analog-to-digital data converters--the direct digital data links to the instruments--have known standard characteristics and do not require basic original design for use in the instrument system, the risk tends to be moderated. Balancing the risk is the advantage to be gained by earlier operation of the air quality and meteorological instruments. Although data would not be systematically recorded at the central data facility, manual operation of the stations would be possible in support of selected studies. Indeed, analog recorders, if appropriate, could be utilized at some stations. A possible added advantage of implementation overlap is that more extensive operational and maintenance experience would be developed prior to full system operation. As discussed in Chapter XIX, the planning factors used for facility staffing should be verified at the earliest possible time and adjusted as appropriate. It is generally anticipated that the air quality and meteorological instruments will account for the bulk of the maintenance effort, so that staff planning factors can be almost fully developed in the absence of the digital data terminal equipment.

The location pattern of the 17 Class A and 32 Class B stations is such that the use of three general contractors appears to be most appropriate and would result in approximately 16 stations per contractor. Three contractors should provide for a relatively short period for activation of all stations and should not cause undue administrative difficulties or overtax the central facility instrument processing capability. The symmetrical station location pattern results in 18 stations situated in Missouri and 31 in Illinois. Thus, one contractor might be used for all Missouri instrument stations and the Illinois stations split between two contractors on a north-south geographical basis. The Illinois-Missouri division appears desirable for two reasons. First, the scope of the instrument station activation effort is not inordinately large, so that interest will likely be limited to the smaller general contractors. Since certain statutory requirements most likely exist in each state for contractor licensing, bonding, and the like, it appears probable that many smaller contractors may not be in a position to function in both states. Thus, the contractors expected to have the greatest interest in the work would be ruled out of competition if a single contractor were sought for all instrument stations.

Second, the Mississippi River stands as a natural barrier between the two states with few bridges outside the immediate St. Louis area itself. Thus, movement of one contractor's equipment and labor force among stations could require excessive travel distances for some stations regardless of where the contractor's base of operations was situated.

The Illinois division between north and south is somewhat more arbitrary. However, except for a relatively large contractor, 31 stations appears somewhat large and distances for movement of equipment appear excessive. A division into 15 north stations and 16 south stations should be an appropriate planning factor with the southern group including the Illinois stations on the St. Louis arch latitude and all those further south.

Table XVIII-6 summarizes the distribution pattern of instrument stations within each of the three areas.

Table XVIII-6

INSTRUMENT STATION LOCATIONS BY CONTRACTOR AREA

Station Type	Missouri	Illinois North	Illinois South	Total
A_1	4	3	2	9
A_2	3	2	3	8
B_1	11	5	8	24
B_2	--	5	3	8
Total	18	15	16	49

Slight adjustment of the table should be made to account for the two prototype stations. The discussion of selection of the central facility and prototype instrument sites suggested that they be in relatively close proximity. The two most appropriate central facility sites appear to be either near the Civic Memorial Field at Bethalto, Illinois (near East Alton), or Scott Air Force Base. Both of these locations are relatively near Class A_1 and Class A_2 instrument stations which could serve as prototype stations with perhaps both designed as Class A_1 stations and allocated the full complement of equipment. For purposes here the central facility location will be taken to be near the Civic Memorial Field, so that the number of Class A_1 instrument stations in the north will be decreased by two in developing the activation schedule. This reduction might suggest a slight adjustment between north and south Illinois to equalize the number of stations. However, since the Missouri area contains the greatest number of stations, the completion of the activation schedule will depend upon the Missouri sequence.

Class A and B Station Activation with Prior Prototype Station Acceptance

Combining the scheduling estimating factors previously developed results in the stationwide schedule as shown in Figure XVIII-6. This scheduling example is based upon the premise that the implementation of the stations is initiated after acceptance of the prototype stations. The Class A_1 and A_2 stations are shown to be completed first with the Class B stations following immediately thereafter. Depending upon the numerous technical concepts and questions discussed in Part II of this Prospectus, this time phasing perhaps may be changed to provide for some delay in the completion of the Class B_1 and B_2 stations, especially the Class B_2. Station equipment is installed in groups of five stations, as previously shown, where more than five are involved. Again, this method is somewhat arbitrary and more attractive alternatives may be found during the actual implementation. For example, seven Class A_1 and A_2 stations are situated in Missouri and these are shown in two groups of five and two stations, respectively. For various reasons, the equipping of all seven stations before acceptance tests may be preferred to the five and two sequence shown here. Moreover, for many possible technical, logistical, and administrative reasons, some mix in the activation sequence of the two principal classes of stations may be desirable over the completion of all Class A stations before the Class B. For example, if the digital data communication system is designed such that six to eight instrument stations report over a single circuit, the station activation sequence might be designed around grouping stations in this manner. This would certainly appear attractive in regard to coordination with the telephone utilities.

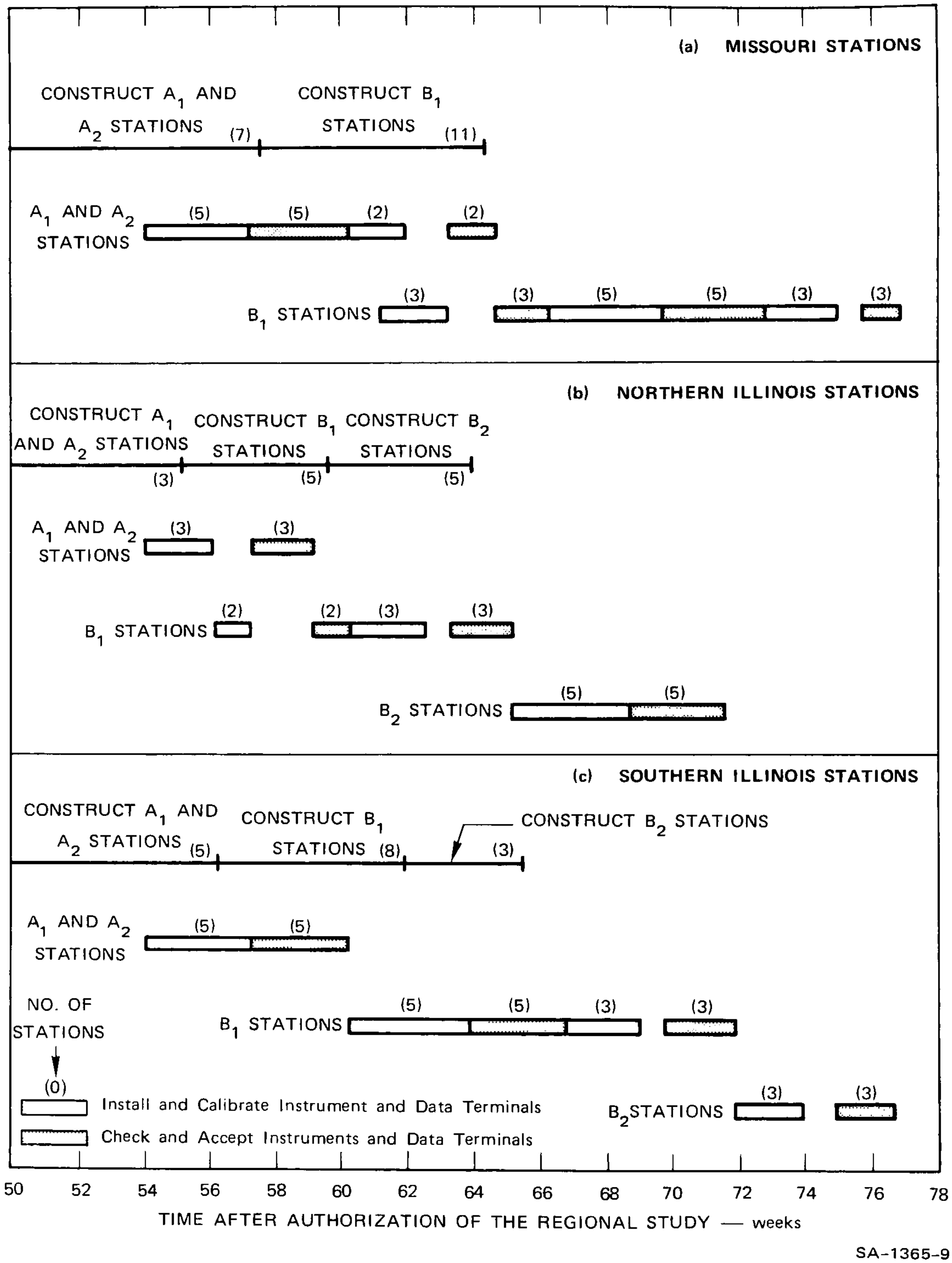

FIGURE XVIII-6 CLASS A AND B INSTRUMENT STATION IMPLEMENTATION SCHEDULE WITH PRIOR PROTOTYPE STATION ACCEPTANCE

The full system activation schedule is shown in Figure XVIII-7. Under the planning assumption that instrument station activation is not initiated until prototype station acceptance, the full system is estimated to be operational 77 weeks subsequent to the authorization of the Regional Study. This might be regarded as a minimal risk schedule, since it involves a relatively small number of simultaneous activities. With the instrument station activation starting 50 weeks after authorization, ample time should be available for instrument site acquisition, contractor selection, and the completion of all other detailed planning and scheduling matters. The rate of station activation does not appear to impose unreasonable requirements for delivery of instruments and other equipment from suppliers. Sufficient time should be available to permit the central facility to be fully operational to support the instrument station implementation effort. Any number of alternatives to this particular schedule naturally can be defined which will result in greater or lesser durations and have varying degrees of risk. All of these, of course, cannot be examined here, but one particular alternative to the schedule of Figure XVIII-7 is of particular interest.

Class A and B Station Activation Without Prior Prototype Station Acceptance

As discussed previously, the activation schedule of the prototype stations includes appreciable float time in the activity sequences associated with the air quality and meteorological instruments and most other important sequences. Only the central facility sequence approaches the critical path. These float times are readily apparent from Figure XVIII-7. In view of these lengthy float times, the possibility clearly exists, as previously discussed, to initiate activation of the instrument stations before completion of the prototype stations.

The activation schedule under this premise is shown in Figure XVIII-8 and in greater detail in Figure XVIII-9. The planning assumptions provide for the following actions. First, the air quality instruments would be installed at the prototype station with test operation during the 20th to the 23rd week. Any necessary design modifications would be negotiated with the manufacturer and delivery would be initiated at the 26th week. Installation at all stations would be initiated as shown in Figures XVIII-8 and XVIII-9 with completion at the 48th week. Second, this installation schedule clearly requires prior initiation of instrument station construction and procurement of instrument towers and shelters and other station fixtures and appurtenances.

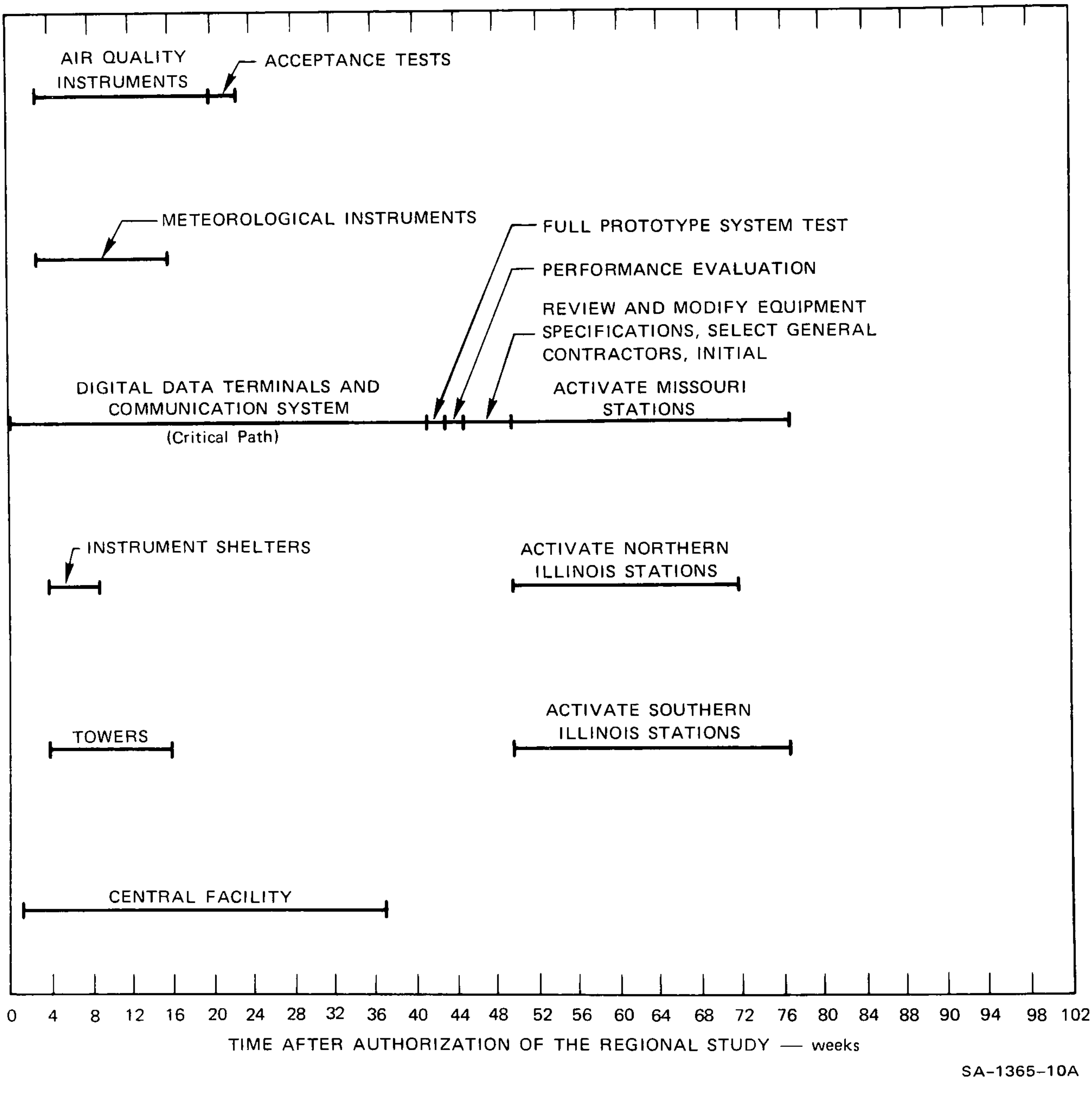

FIGURE XVIII-7 ST. LOUIS FACILITY ACTIVATION SCHEDULE WITH PRIOR PROTOTYPE STATION ACCEPTANCE

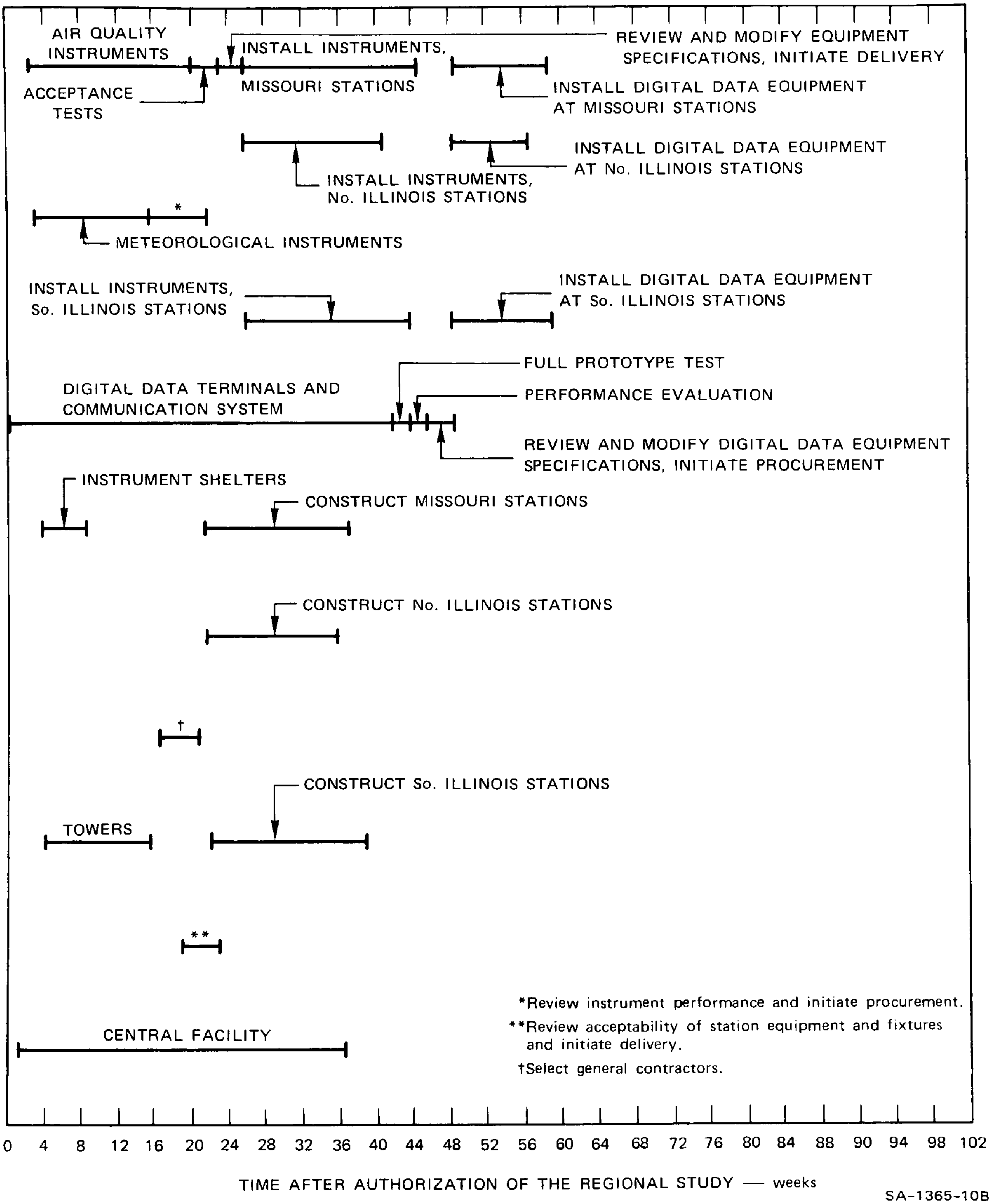

FIGURE XVIII-8 ST. LOUIS FACILITY ACTIVATION SCHEDULE WITHOUT PRIOR PROTOTYPE STATION ACCEPTANCE

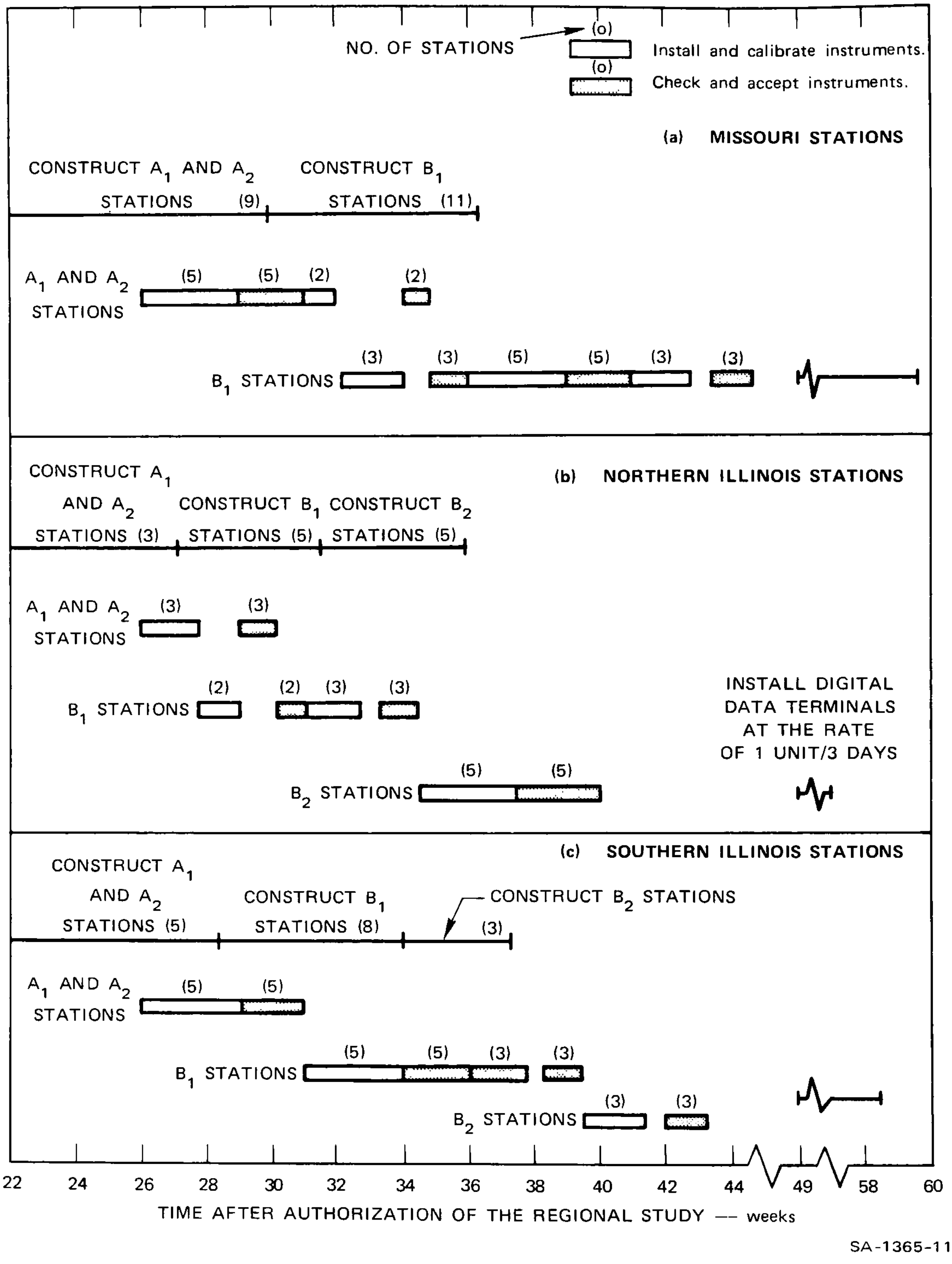

FIGURE XVIII-9 CLASS A AND B INSTRUMENT STATION ACTIVATION SCHEDULE WITHOUT PRIOR PROTOTYPE STATION ACCEPTANCE

The final task covers the installation of the digital data terminals. The duration of this activity is estimated at three days per terminal for a total of 10 weeks for the Missouri and southern Illinois stations and eight weeks for the northern Illinois stations.

As can be noted from Figure XVIII-8, a total of 59 weeks is estimated for completion of the entire system--19 weeks less than under the more conservative schedule. The achievement of this schedule would not be without some possible difficulty. This would likely be especially true with respect to the acquisition of the instrument station sites. Construction is indicated to start in the 22nd week of the schedule. Ideally all instrument sites should have been acquired by this time in order to permit an optimal or minimal cost schedule of construction. Given the potential problems of site acquisition a period of 22 weeks may not be sufficient, and construction scheduling would be carried out on a somewhat flexible basis possibly resulting in slightly higher costs. The more compressed schedule of 59 weeks brings the advantage of early instrument delivery for possible use of some in the Class C stations, or conversely temporarily equipping some of the Class A and B stations with local recording instruments intended for use with the Class C stations.

Class C Station Activation Schedule

The Class C stations have the least complex design of all classes of stations in that they have a minimal complement of equipment and most is of standard catalog design. The Class C_1 stations are limited to meteorological instruments alone. The Class C_2 stations consist of the basic trailer equipped to accommodate a variety of instruments as provided by the research experimental groups with the instruments not considered as part of the permanent facility. The initial activation schedule, as well as subsequent modification program of the Class C_2 stations, should be based upon the timing of the various field research experiments in which they will be used. Review of the Research Plan reveals that the initial field experiments requiring the use of Class C_2 instrument stations are scheduled about eight months subsequent to authorization of the Regional Study. This eight-month period, however, is in part contingent upon an assumed authorization of July 1, 1972. Alternative authorization dates could affect the initiation date of the field experiments and the corresponding requirements for the Class C_2 stations.

The number of Class C_2 instrument stations required to support the initial research experiments can of course vary to some extent depending on the detailed experimental design. As a planning factor for scheduling purposes, here, a total of 10 fully equipped Class C_2 stations will be taken as required eight months after authorization of the Regional Study with the additional provision that the first units be available at six months or approximately 26 weeks to allow for first-item installation and testing of the necessary instruments and related equipment provided by the research experimental groups.

An activation schedule to meet the required delivery date of six months subsequent to authorization of the Regional Study, of course, can have any number of configurations. The principal decision affecting the schedule lies in the selection of the digital data terminal equipment. Two major alternatives appear at hand. The first is to acquire standard catalog items which include a scanner, analog-to-digital converter, magnetic tape recorder, and all control equipment. Acquisition lead times, including the complete Request for Quotation sequence of activities, is estimated to be at the most 65 working days. The sequence of activities would be largely analogous to that associated with the procurement of the air quality and meteorological instruments as shown in Figure XVIII-1.

The second alternative would be to include the design and acquisition of the digital data terminal equipment for the Class C_2 stations as an adjunct to the terminal equipment for the Class A and B stations. Careful consideration of this alternative, however, will be necessary, even though virtual standardization of terminal equipment for all stations would be achieved. In the scheduling network of Figure XVIII-1, Activity CJ covers the preparation of standard data terminal equipment specifications. These include the scanner, analog-to-digital converter, clock, and related equipment not directly associated with the communication system interface equipment. These items of equipment are required for both remote and local data recording operation. Activity CJ terminates at event No. 74 following study authorization by an estimated 51 days. Subsequent activities in the digital data terminal equipment path provide for incorporation of the telephone interface equipment, calibration controller, and related equipment, which results in an integrated design of the terminal equipment. Virtually all of these later items of equipment, however, are not required for the Class C_2 stations. Thus, the question arises as to the appropriateness of independently initiating the procurement of the Class C_2 terminal equipment subsequent to event No. 74, rather than treating it as an integral part of the procurement activities for the Class A and B terminal equipment. If, indeed, the Class C_2 stations will be required in six months, it is clear that the later alternative is unacceptable because of the overall duration of the digital data terminal equipment activity sequence. The risk of initiating procurement of the Class C_2 terminal equipment subsequent to event No. 74

independently of the Class A equipment would be expected to arise from the extent to which the design of the telephone interface and remote reporting equipment affects the terminal equipment common to all stations, i.e., the scanner, and the like. The likelihood of any effects cannot be foreseen at this time, but their impact would be expected to result in the lack of standardization among digital data terminal equipment. No impairment in operational capability would be expected. This would also be the case if the first alternative of procuring standard catalog items for the Class C_2 station was selected.

Thus, on balance, the scheduling of the Class C terminal equipment following event No. 74 is judged to be the more desirable procedure, although during the actual implementation of the St. Louis facilities, alternatives should be continually reviewed.

Independent scheduling of the Class C terminal equipment within the context of the major implementation associated with the other station classes, as noted above, can be initiated 51 days or approximately 10 weeks subsequent to authorization of the Regional Study. Using the estimated duration for the Request for Quotation cycle of seven weeks and a six-week period for any special equipment design and production problems, delivery of the first terminal unit is estimated at the 23rd week or about three weeks prior to the required availability date.

The rate of equipment delivery should be specified during procurement negotiations; however, it would be expected that any limitation on station activation would arise from the equipment installation schedule at the central facility rather than from the equipment delivery rate by the manufacturer.

The scheduling of the remaining components of the Class C stations, such as the trailers and interior fittings and appurtenances, can be largely discretionary, since their procurement lead times are relatively short.

The overall scheduling of both the Class C_1 and C_2 stations are shown in Figure XVIII-10. For scheduling purposes here the complete complement of four Class C_1 and 24 Class C_2 stations are shown. The activation of the four Class C_1 stations is shown to follow the Class C_2 stations. This schedule is based on the activation schedule of the Class A and Class B stations, so that the site preparation for the Class C_1 follows with the same general contractors, and the meteorological instruments are installed by the same technician crews.

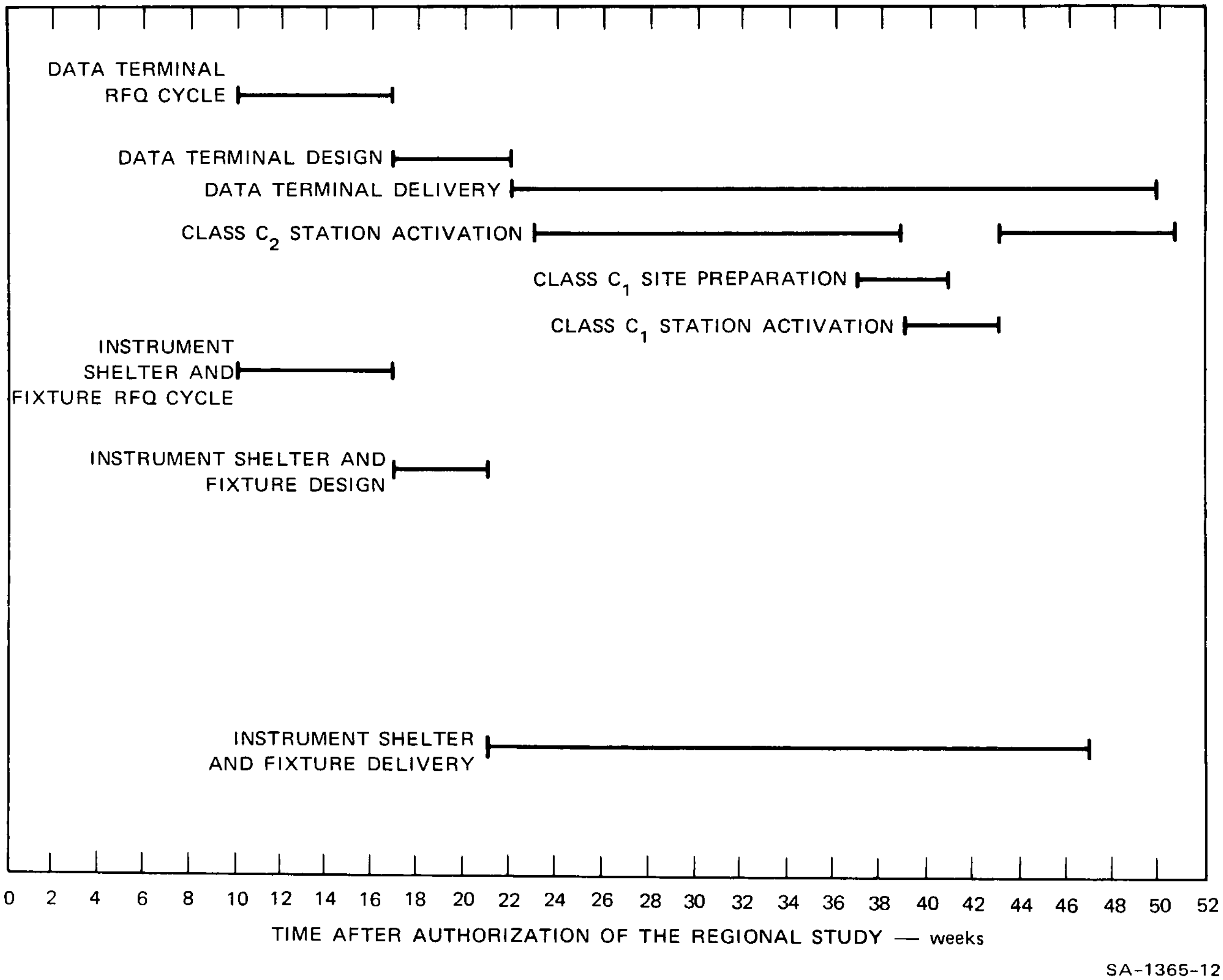

FIGURE XVIII-10 CLASS C INSTRUMENT STATION ACTIVATION SCHEDULE

Activation of the final 14 Class C_2 stations will, of course, depend intimately on the precise timing of the various research experiments and their need for Class C_2 stations, so that some may be delayed for varying periods of time. However, delivery of digital data terminal equipment for all stations may be appropriate, if its design includes any appreciable nonstandard components or subassemblies. Acquisition of nonstandard equipment on a periodic basis could incur severe cost and schedule penalties.

Aggregate Facility Activation Schedule

The overall facility activation schedule as derived from Figures XVIII-8 and XVIII-9 is summarized in Table XVIII-7 by quarter for each station type following authorization of the Regional Study. Station activation is grouped within three major categories. Station preparation covers the preparation of the site, all concrete work, tower installation, and the assembly of the instrument structure, if any, and the installation of all equipment, fixtures, and appurtenances within the instrument structure or trailer. The second includes installation of the air quality and meteorological instruments and their operational acceptance tests. The third covers the installation of the digital data terminal equipment. The quarters are shown also during which the principal activities covering the central facility and the acquisition of vehicles are carried out. The scheduling assumptions employed here provided for completion of the Class A stations prior to the Class B units. Accordingly, the Class A_1 and six of the Class A_2 stations are shown as completed in the fourth quarter with all the Class B_1 and B_2 stations completed in the fifth quarter.

The aggregation of the activation schedule on a quarterly basis provides for the development of both the initial cost schedule as developed in Chapter XX and the staffing schedule of Chapter XIX.

The aggregation of the activation schedule on a quarterly basis provides for the development of both the initial cost schedule as developed in Chapter XX and the staffing schedule of Chapter XIX.

Table XVIII-7

FACILITY COMPLETION SCHEDULE BY PRINCIPAL ACTIVITY GROUPS
(Number of Stations)

Activity	Calendar Quarters 1	2	3	4	5
Station Preparation					
Prototype		2			
A_1		7			
A_2			8		
B_1			24		
B_2			8		
C_1			2	2	
C_2		5	13	6	
Instruments and Accessories					
Prototype		2			
A_1			7		
A_2			8		
B_1			24		
B_2			5	3	
C_1				4	
C_2		3	13	8	
Digital Terminals					
Prototype			2		
A_1				7	
A_2				6	2
B_1					24
B_2					8
C_1				4	
C_2		4	13	7	
Central Facility					
Data Equipment			1		
General Facilities	1				
Equipment	1				
Vehicular Support					
Calibration Vans		1	2		
Maintenance Trucks	2	4	3		
General Transport		1			

Chapter XIX

PERMANENT MANAGEMENT AND STAFFING

Introduction

The management and staffing requirements for the Regional Study have two principal elements. The first includes essentially permanent groups located at the Research Triangle Park and St. Louis having responsibilities, respectively, for overall management and coordination of the Regional Study and for design and operation of the St. Louis facility and field support of the research experiments. The second element includes the special requirements arising from specific needs of the various research experiments and analyses as specified in the Research Plan. Staffing requirements for the latter element are expected to have considerable variation during the course of the Regional Study.

This chapter of the Prospectus covers the organizational requirements and responsibilities of the permanent staff. The requirements stemming specifically from the Research Plan are presented in Part II of this Prospectus and summarized in Chapter XXI.

The general responsibilities and functions of the permanent staff are discussed in the following sections with staff requirements phased over time as a function of the facility activation schedule. Personnel requirements are estimated for both facility activation and full operation for conditions of a complete EPA intramural effort as well as a prime-contractor-supported program.

Discussion of detailed staffing requirements for aircraft operation, maintenance, and related functions are provided within the integrated discussion of aircraft measurements of Chapter XIV and the various research experimental programs requiring airborne instruments.

Regional Study Management

The Regional Study is considered to be one of the principal research efforts supported by the Environmental Protection Agency. As demonstrated by the research plan, it will provide a comprehensive examination of air quality problems and will require the coordinated efforts of a large interdisciplinary task group. Within the National Environmental Research Center at Research Triangle Park, the Divisions of Chemistry and Physics, Meteorology, and Atmospheric Surveillance will be heavily committed over virtually the entire period of the Regional Study. The Division of Effects Research, while not as fully involved in the execution of field experiments for model verification and similar studies, will profitably utilize the accumulated air quality data as well as pollutant concentration predictions and other results developed by the transport and diffusion models.

Additionally, other organizational elements within the Environmental Protection Agency will undoubtedly interact extensively with the Regional Study through the use of experimental data and in an advisory and consultative role for the design and execution of selected research experiments and data acquisition programs. Such interactions could go beyond air quality interests alone and include water quality, solid waste disposal, and other areas.

Given the scope of the Research Study and the intensive involvement of numerous EPA organizational groups, the management of the Regional Study, of necessity, should be lodged at an organizational level above that of the Divisions at the National Environmental Research Center, Research Triangle Park. At the same time, to provide efficient coordination among Divisions and promote a smoothly functioning interdisciplinary program, the Regional Study management should most appropriately be placed within the organization of the Research Triangle Park facility. Accordingly, the most appropriate assignment of the Regional Study management responsibility appears to be in the Office of the Director, National Environmental Research Center, Research Triangle Park. Two options appear open for consideration. The first is the establishment of the position of Assistant Director for Regional Studies to function in parallel with the two currently established Assistant Director positions for Operations and Special Staff. The second option is to establish the position of Deputy Director for Regional Studies reporting to the Director. The basic distinction between the two options is that the former is essentially a staff position while the latter is a line position. Since the duties assigned to the position, as discussed below, involve the overall responsibility for the management and control of the St. Louis Regional Study as well as possible planning and implementation of additional regional studies conducted concomitantly or following the St. Louis Study, the position is most appropriately established as a line-function: Deputy Director for Regional Studies.

The principal responsibilities of the Office of the Deputy Director will include the following:

- Acting as Contracting Officer's technical representative for procurement, installation, and acceptance of all equipment, and facilities of the St. Louis facility.

- Management of the St. Louis facility staff and equipment.

- Master scheduling of facility use in support of research experiments, including priority assignments for experiments, and allocation of facility personnel for support.

- Coordination and preparation of annual budgets for the St. Louis facility and all research experiments using the facility.

- Assignment of Research Triangle Park Divisional resources as required for interdivisional Regional Study research experiments.

- Coordination of Regional Study programs with EPA elements not located at the Research Triangle Park.

- Policy development and coordination with non-EPA institutions carrying out experimental and other efforts in the St. Louis area.

Staffing of the Deputy Director's Office will have two components. The first will include personnel required for the procurement and subsequent operation of the St. Louis facility itself. The second component, located at the Research Triangle Park, will include the necessary staff to handle the various tasks associated with the overall research program and coordination activities.

Additionally, because of the clearcut need for close cooperation and coordination among the various organizational units having vital interests in the Regional Study, the Deputy Director should be supported by two consultative groups. Membership in the groups should not be fixed but should change as the requirements of the research program evolve.

The first group, the Interagency Coordinating Committee, consists of a representative from EPA Headquarters and one from each of the federal organizations having pronounced interests or ongoing activities in meteorology or air quality or both. These agencies include the following:

Atomic Energy Commission

Department of Defense

National Oceanic and Atmospheric Administration

National Research Council

National Science Foundation

National Center for Atmospheric Research.

The second group functions as an EPA Advisory Committee composed of representatives of the interested Divisions based at the Research Triangle Park. These include the following:

Division of Physics and Chemistry, Research Triangle Park

Division of Meteorology, Research Triangle Park

Division of Atmospheric Surveillance, Research Triangle Park

Division of Effects Research, Research Triangle Park

Office of Air Programs.

Additionally, for purposes of coordination and liaison with state and local groups--private and public--the Advisory Committee should profit by the membership of two regional administrators; specifically:

Regional Administrator, Region V (Illinois study area)

Regional Administrator, Region VII (Missouri study area)

The structure of the overall organization is summarized in Figure XIX-1.

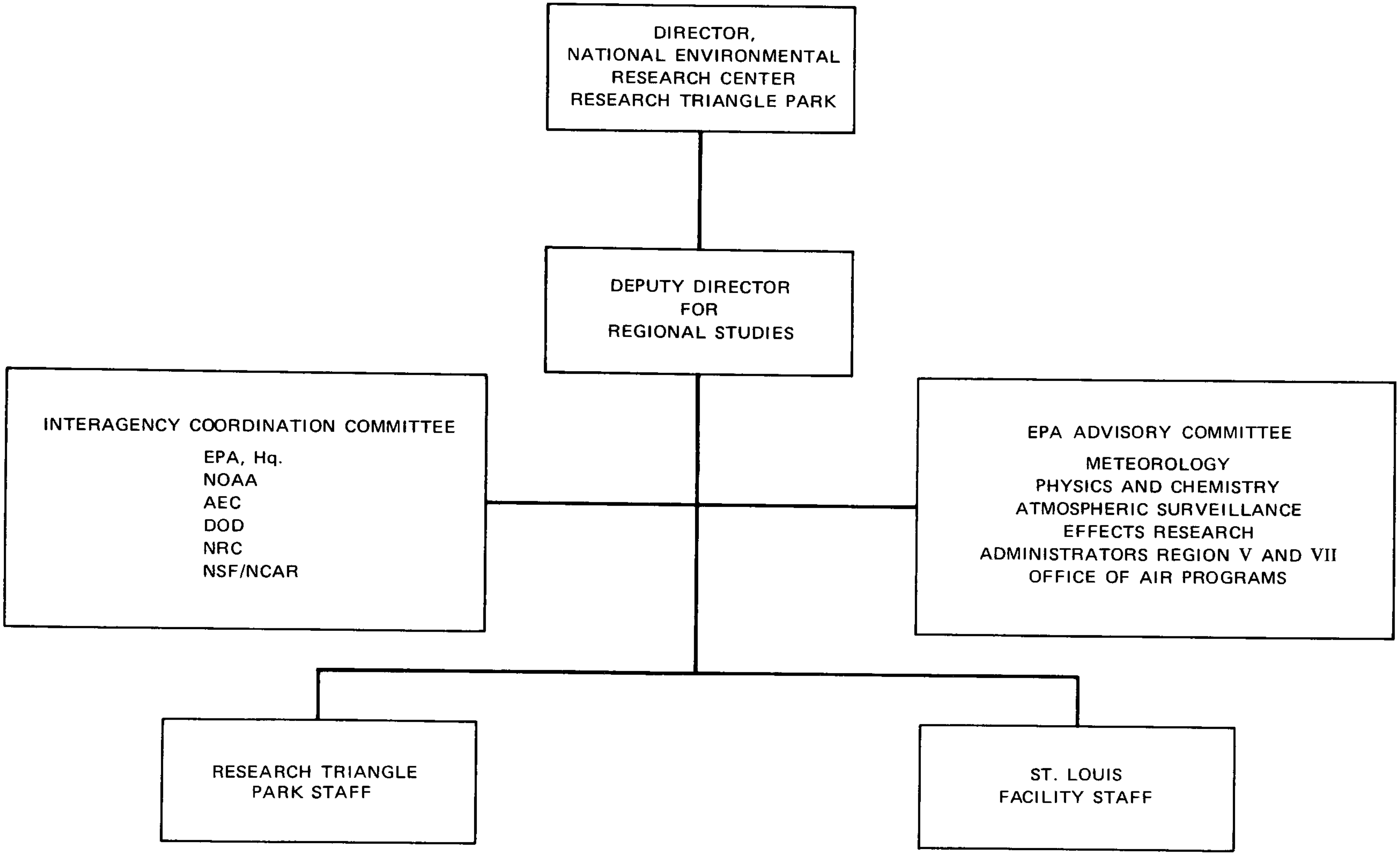

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FIGURE XIX-1 SUMMARY ORGANIZATION OF THE REGIONAL STUDY

Research Triangle Park Staff

The staff of the Deputy Director for Regional Studies at the Research Triangle Park will provide direct support to the Deputy Director in the development of the overall Regional Study program.

The staff is anticipated to have three major operational components as shown in Figure XIX-2. The first may be defined as the Office of Programs, the second as the Office of Interagency Coordination and Technology Transfer, and the third as the Office of Research Operations. The functions of these offices are highly complementary and close coordination will be required. The first will provide administrative support for the Regional Study by ensuring proper scheduling of research experiments and completion of logistic support and all budgetary procedures.

The Office of Interagency Coordination and Technology Transfer will be concerned with the technical and scientific aspects of the Regional Study. This office will require personnel with broad scientific backgrounds capable of integrating the research findings of all disciplines involved and extending the research findings to other disciplines as well. These two offices would be expected to function largely in a staff advisory capacity rather than as line offices. The Office of Research Operations provides the direct link between the research experiments carried out in the St. Louis area and the EPA Divisions at the Research Triangle Park and perhaps elsewhere.

The staffing requirements are difficult to estimate at this date. The Office of Interagency Coordination and Technology Transfer will probably grow as the Regional Study evolves, since the volume of research findings will grow over time, thereby causing increasing possibilities of technology transfer and increased multidisciplinary involvement. Initially, however, the Offices of Programs and Technology Transfer are estimated to require two professional staff members each with three clerical staff members to serve both offices and the Deputy Director. The Office of Research Operations is estimated to require up to three permanent professionals.

Office of Programs--The principal responsibilities of the Office of Programs include the following:

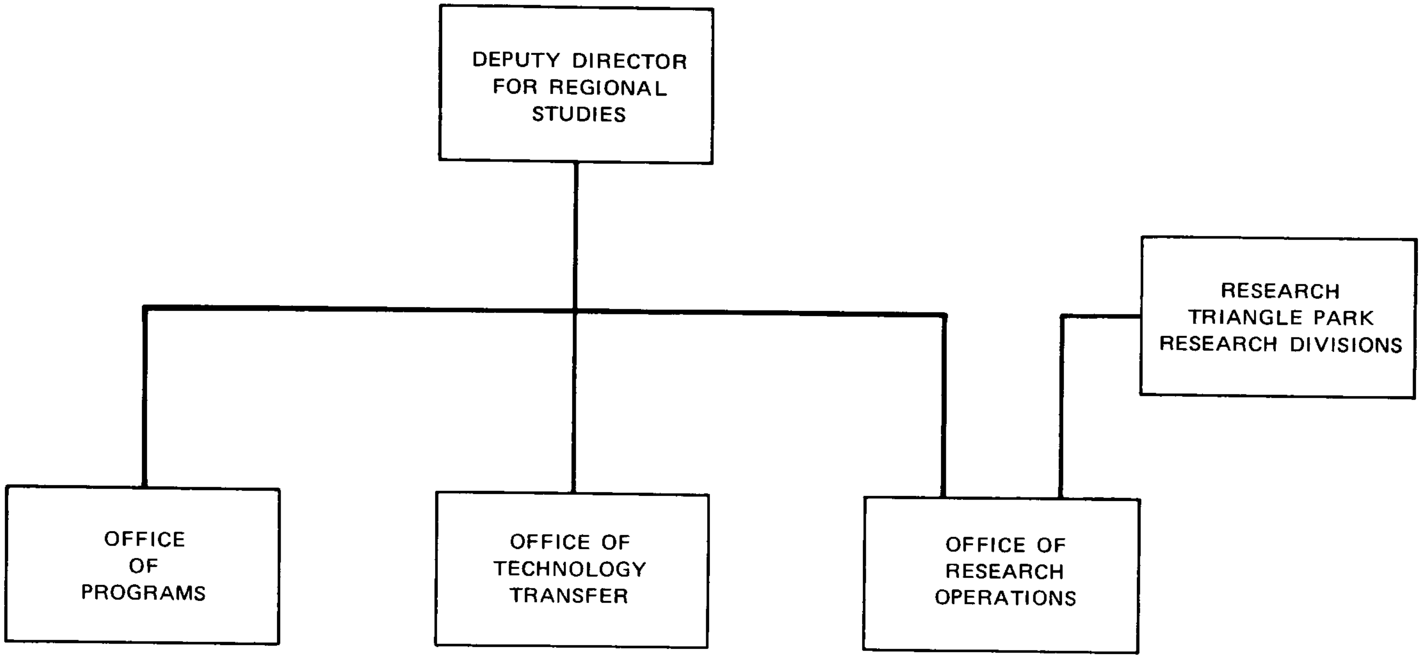

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FIGURE XIX-2 RESEARCH TRIANGLE PARK ORGANIZATION FOR THE REGIONAL STUDY

- Regional Study Scheduling

In cooperation with the appropriate divisions, the staff will prepare, using this Prospectus as a guide, increasingly detailed overall research programs for the study. This will include the time phasing of all research programs and the preparation of supporting information on costs, staffing, equipment requirements, and other necessary documentation. The level of detail to which the program elements are treated will vary with the scheduling of work. The Regional Study must remain responsive to overall federal and EPA budgetary policies and related considerations and must take complete advantage of all changes in the state of the art in air quality analysis, modeling, and control strategy.

- Regional Study Coordination

The staff will coordinate the various research experiments planned by the EPA divisions and by other agencies and institutions to achieve the maximum utilization of the St. Louis facility as well as all special equipment and personnel relocated to St. Louis. The activities of other agencies and institutions may impact on the independent EPA research schedule, and adjustments in the EPA schedule may be appropriate. Such priority adjustments would be a matter for the attention of the Deputy Director. Inherently, this duty also includes the evaluation and judgment of which research experiments are indeed a legitimate component of the Regional Study. Such evaluation should include not only the research experiments planned for future implementation in the Regional Study but also the research programs scheduled elsewhere in the EPA. As the Regional Study evolves, some interchange of planned research experiments between the two will likely be found to be desirable.

- Regional Study Participants

Research tasks of the Regional Study likely will be allocated to EPA organizational elements, to other federal agencies, and to contractors. Standard considerations will be involved in the allocation, including competence of the respective groups, EPA personnel availability as compared to the required staffing of the research experiment, and the timing of the experiment. For example, a two-month research experiment requiring a 10-man field team might be more appropriately carried out by contractor personnel rather than EPA, if use of EPA personnel caused difficulty with other EPA-staffed programs. Solicitations for research experiment proposals from contractors, where use of the St. Louis facility is planned, should have the approval of the Deputy Director as recommended by the Research Triangle Park staff.

Office of Interagency Coordination and Technology Transfer--The activities of the Office of Interagency Coordination and Technology Transfer are, in a sense, in support of both the EPA Advisory Committee and the Interagency Coordinating Committee, although additional duties are also involved. The principal tasks are shown below.

- Develop Applications of the Regional Study Technology and Research Findings to Other Geographical Areas and Environmental Tasks

  These applications should have a variety of forms. The instrumentation and data-processing facilities to be employed in the Regional Study are unprecedented in environmental studies. The design and operational experience gained from this system should have direct application to air quality and meteorological monitoring systems planned for establishment elsewhere. Such systems need not be research facilities alone but can include operational systems for day-to-day use in control and abatement programs, episode control, and other purposes. Additionally, the operational experience should also be of significant value in the design of systems to monitor other environmental factors, such as water quality.

  The large air quality and meteorological data base developed in the Regional Study combined with the results of the research experiments should have application in many other city-rural areas of the nation. This would most likely be true for the areas enjoying the Continental climate exemplified by St. Louis, but selected findings of the Regional Study may well have even wider applicability. Accordingly, constant surveillance of the Regional Study results should be maintained to identify and utilize such results.

- <u>Prepare Periodic Regional Study Reports</u>

The size and scope of the Regional Study combined with the wide range of disciplines represented in the participating groups should create intense interest in the activities. To provide a comprehensive overview of the Regional Study and to facilitate interdisciplinary communications, periodic reports covering all aspects of the Regional Study should be prepared. The status of all active research experiments should be included, along with those firmly scheduled in the near term. These research experiments should be treated individually and as groups wherever interrelationships exist. The operational status of the St. Louis facility should be reviewed periodically along with the services provided by the facility to the research experimental groups. It is imperative that these reports carry a format and literary style such that a research experiment in any discipline can be fully understood by all investigators in all the other disciplines. Without this characteristic, the reports would have marginal value. Technical reports, of course, will be prepared for each research experiment and the progress reports should in no way attempt to duplicate these. A skilled technical writer with a broad background and an interest in all phases of the Regional Study would be most appropriate for assignment to this task.

- <u>Organization of Complementary Multidisciplinary Research Experimental Tasks</u>

The research experiments identified in this Prospectus are designed to achieve the purpose and goals of the Regional Study; as the Regional Study evolves additional research experiments will doubtless be conceived which have less relevance to the Regional Study but which can profitably utilize the St. Louis facility and the accumulated air quality and meteorological data. The St. Louis facility could provide the framework in which these more limited-scale projects in one discipline could interact with complementary work in others. This should be of especial importance to individuals and small groups not having administrative, logistic, and other support for large programs.

Specifically, the functions to be carried out include: (1) the identification of appropriate generalized research themes; (2) the solicitation and review of proposals from individuals and groups to carry out studies associated with these themes; and (3) the appointment of theme leaders to coordinate the various disciplines involved and to integrate the results into final reports. The theme leaders could be either contractors from universities and research institutions or governmental agencies. The Office of Interagency Coordination and Technology Transfer would provide overall guidance to the theme leaders.

A typical example of the type of problem amenable to this approach is the investigation of the role played by the biosphere in restoring the polluted atmosphere. Given this general theme, a number of research projects could be carried on by groups of botanists, soil chemists, agriculturists, geographers, and other disciplines. Their link to the Regional Study would be the use of the results of investigations concerned with the downwind dispersion of pollutants emitted by the urban center.

- Interaction with Other Programs

The broad scope of the Regional Study is such that programs of other organizations should be constantly monitored to determine possible interfacing points, cooperative ventures, and other modes of cooperation. The number of occasions where these opportunities may arise is not fully known, since the preparation of this Prospectus did not include an exhaustive review of agency programs likely to interact with the Regional Study. Typical of these programs, however, are the NASA Earth Resource Satellite program and the studies by the National Center for Atmospheric Research. The former program may provide opportunities, for example, to correlate on-site measurements and visual observations with satellite measurements. Clearly, both programs would profit by such analysis. In the latter program, covering portions of the same geographical area would permit exchange of data and other cooperative activities which would clearly be of considerable value.

Office of Research Operations--The Office of Research Operations is viewed in a sense as a hybrid organizational element which provides the direct technical link between the Research Divisions at the Research Triangle Park and the St. Louis facility. The Office would be staffed by at least one technical representative from each of the Research Divisions but who would remain administratively within the Division. The chief responsibility of each representative would be to organize and supervise the research programs within his Division that will make use of both the routine and specialized data acquired by the St. Louis facility. In a research project to verify a transport and diffusion model, for example, the appropriate Divisional representative will be responsible for specifying the exact data requirements and carrying out all the necessary tasks with assistance, as necessary, from personnel in his Division.

The Divisional representatives would be expected to allocate at least 50% of their time to the Office of Research Operations in dealing directly with Regional Study matters. This time division should ensure a close coupling of the Regional Study and other EPA research programs, so that each will derive the maximum benefit from the other. The Office, in effect, should constitute an integrative force at the technical level comparable to the same force at the administrative level through the EPA Advisory Committee.

The professional research personnel within EPA that will be assigned to the various programs as outlined in Part II of this Prospectus could be in a sense lent to the Regional Study usually for significant intervals. These groups could be assigned by one of two organizational arrangements. In the first, they could be incorporated outright within the Office of Research Operations reporting technically and administratively within the Regional Study organizational structure. This organizational form, however, would create in a sense an additional research Division at the Research Triangle Park which would be a composite of the existing Divisions. The second and more attractive alternative is to retain the participating personnel within their respective Divisions, even though they may carry long-term commitments to the Regional Study. For administrative purposes, they could be considered as an integral part of their Division. Scientific and technical supervision and research quality control would be provided by the Divisional representatives of the Office of Research Operations acting for the Deputy Director for Regional Studies and the Division Director. Thus, while the dual nature of the scientific and technical control in this organizational format may be of some disadvantage, the retention of the participating staff in their home Divisions should lead to stronger links between the Regional Study and other EPA research activities.

The same general organizational concept should be applicable to the use of contractors in the Regional Study. That is, contractors could function as a quasi-dedicated staff group with the appropriate Divisional representative of the Office of Research Operations functioning as the Contracting Officer's Technical Representative. This should ensure that the contractor satisfactorily utilizes the St. Louis facility in the course of his work and otherwise performs in an acceptable scientific and technical manner.

St. Louis EPA Operating Staff with EPA Operation

The staff of the St. Louis facility shown in Table XIX-1 is expected to consist of 45 personnel assigned on a permanent basis. The facility staff will have the responsibility to maintain and operate the facility and to provide the framework and support for research experiments carried out by other groups.

The organization of the facility staff and their principal functions are summarized in Figure XIX-3. Normally each organizational group will report directly to the system chief. The groups have relatively well-specified tasks so that the span-of-control of the system chief ought not be exceeded. Selected duties and characteristics of each group are discussed as follows.

System Chief--The System Chief is the local senior official having overall authority and responsibility for personnel and equipment associated with the Regional Study facility. Within the guidelines of the Regional Study Program, the System Chief will establish policies and procedures covering the use and operation of the facility and will be responsible for initiating negotiations and carrying out agreements with state and local organizations and agencies.

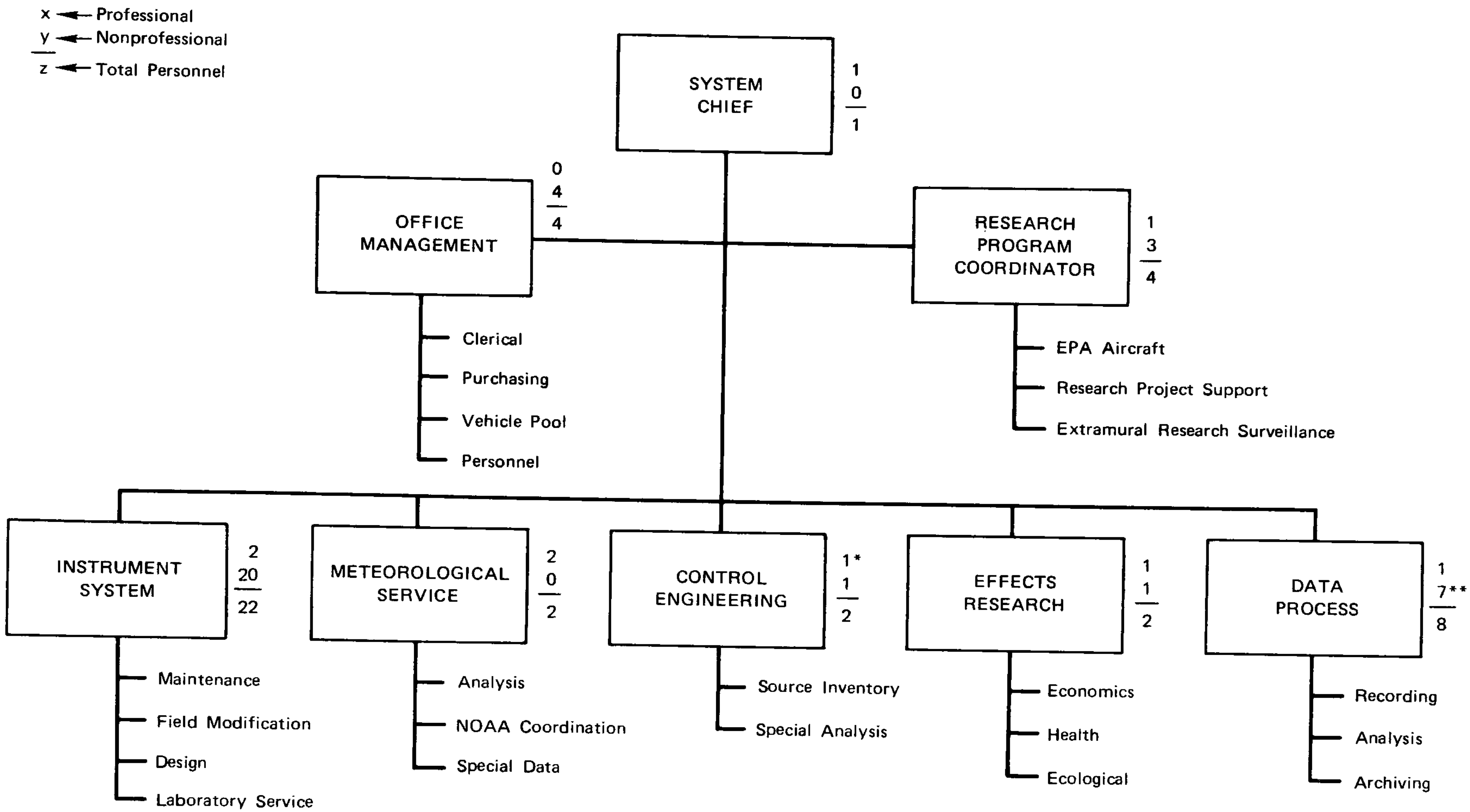
Research Program Coordinator--The Research Program Coordinator acting under the System Chief provides support and liaison with all groups carrying out research experiments that require data and assistance from the facility. Based upon the research experimental design and schedule, he will ensure that the facility has the proper operational configuration and that appropriate personnel are available. The Coordinator will also provide required logistical support to the experimental group, including equipment installation and maintenance, personnel and equipment transportation, and standard laboratory supplies. The Research Program Coordinator will also maintain cognizance of the progress and status of research experiments conducted by agencies and organizations other than EPA groups in the St. Louis area.

The Research Program Coordinator should be assigned initially a group of three experimental technicians. Their principal responsibility will be to provide assistance to the research experimental groups for the installation, calibration, maintenance and other tasks associated with any research instrumentation requirements. Since these technicians will frequently be working with advanced instrument designs and in an experimental environment rather than on routine tasks, their general

Table XIX-1

ST. LOUIS FACILITY OPERATING STAFF

Group and Staff Titles	Number of Personnel: Professional	Support	Total
System Chief	1	0	1
Research Program Coordination			
Coordinator	1	0	1
Experimental Technicians	0	3	3
Instrument Systems			
Senior Engineer	1	0	1
Engineer	1	0	1
Technicians	0	20	20
Meteorological Service			
Senior Meteorologist	1	0	1
Meteorologist	1	0	1
Control Engineering			
Senior Engineer	1	0	1
Data Aid	0	1	1
Effects Research			
Senior Analyst	1	0	1
Data Aid	0	1	1
Data Processing			
Systems Engineer	1	0	1
Systems Programmer	0	1	1
Data Aid	0	1	1
Center Attendant	0	5	5
Clerical	0	4	4
Total	9	36	45



*Supported by additional contractor personnel.

**Includes part time personnel.

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FIGURE XIX-3 ORGANIZATION—ST. LOUIS FACILITY competence and appreciation of experimental procedures should be significantly greater than those of the instrument technicians discussed subsequently. At the discretion of the System Chief, however, these experimental technicians should be assignable as supplemental support to the instrument technicians in the event of gross system malfunction or unusually high instrument failure rates.

Instrument Systems--The types and complexities of the instruments included in the regional facility are expected to range from simple temperature sensors to complex pollutant sensors and to have various combinations of electronic, mechanical, and chemical components. The instrument system engineering group, accordingly, must have a broad capability to calibrate, maintain, and perhaps complete field modifications of the instruments. Since the larger part of the instrumentation system is expected to consist of pollutant sensors and their complexity tends to be greater than the electronic and other components of the facility, the senior engineer should be primarily competent with pollutant sensing instruments. The junior engineer should provide general engineering support with marked competence in the electronics field.

Instrument Technicians--Technicians will require the general capability to carry out independently routine maintenance and adjustment of all instruments and associated devices and to replace pollutant sensor reagents on a periodic basis. They should be capable of reading and interpreting engineering drawings, electrical schematics, and similar data for purposes of maintenance and field modifications.

The staffing plan for the instrument technicians presents unusual difficulties arising from a combination of factors including the following. First, the sheer size of the area over which the instrument sites will be distributed and the number of instruments at each site is unprecedented in air quality studies. Simple linear expansion of the technician staffing based upon smaller existing instrument systems tends to result in an exceedingly large technician staff. Second, a number of the instruments planned for installation are relatively new designs; consequently, detailed operational experience on reliability, component failure rates, calibration frequencies, and similar data necessary for precise technician specification is not available. Installation and use of less-advanced and less-proven instruments would, of course, virtually eliminate this problem, but such a solution does not appear justified for the St. Louis facility.

Accordingly, technician staffing for the facility as provided below is intended to be primarily applicable for the first year of combined system shakedown and operation. The technician staff can be divided into three groups. The first includes the technicians required for maintenance and servicing of the instrument stations. The second covers the instrument calibration requirements, and the third covers the technician staffing normally assigned to the central facility.

Instrument Station Maintenance--Instrument station maintenance has two principal components. The first provides for maintenance of the air quality instruments and all other equipment within the instrument station shelter, and the second includes the tower-mounted meteorological instruments. Air quality instrument maintenance as discussed in Chapter XVIII is estimated to have two phases. In the early period of system operation, each station is estimated to require two visits per week for a two-hour period. As the reliability of the instruments and the characteristics of the stations are revealed by operational experience, it is quite likely that visits to a large portion of the stations could be reduced to once per week for a two-hour period. The number of technicians, however, would remain essentially the same because, although corrections for equipment malfunctions during the early period of system operation may be largely the responsibility of the equipment manufacturer, failures later in the course of operation will require correction by the facility staff. This shift in responsibility is estimated to result in the requirement for two to three instrument technicians at the central facility for major instrument repairs. These technicians should be expected to have greater capability than the roving instrument station maintenance personnel and to be on call for specialized maintenance at the instrument stations.

Station maintenance on a once or twice weekly basis will include the following responsibilities:

- Station component replacement, as necessary
- Replacement of calibration gas cylinders
- Refilling of water reservoir of the hydrogen generator
- Replenishment of air quality instrument reagents
- Visual inspection of meteorological instruments
- Replacement of filters and clean hi-vol unit

- Check of precipitation gauge
- Check on barometric pressure
- Checking of shelter heating and cooling systems and replacing air conditioner filter, as necessary
- General site clean-up and housekeeping
- General observation of instrument and digital data operations to detect incipient failures.

The development of the estimated number of technicians to execute the maintenance task is significantly complicated by the pattern of station location. For some stations the travel time might well exceed the time at the station. Some stations might well be 100 road-miles from the central facility thereby causing excessive travel times, when the technicians must visit the central facility to exchange instruments, replenish spare parts supply, and the like. The location of the technicians' residences can also play a part in determining the number of personnel required because of travel-time considerations.

These difficulties notwithstanding, a reasonable estimate of personnel required can be developed by grouping the instrument stations in geographical clusters to include the stations that can be visited on any one day. The grouping is somewhat arbitrary at this point, but a total of 20 instrument clusters have been identified. Nine clusters contain three instrument stations each, and 11 clusters contain two instrument stations. These are shown in Table XIX-2.

Generally the stations situated within the urbanized area are contained in the three-station clusters, and the wider-spaced stations in the rural area form the two-station clusters. The groupings are expected to be strongly influenced by the highway network and the associated travel time among stations. This is particularly important for the stations in the rural portions of the southwest quadrant, where principal highways are relatively scarce and station location may be largely constrained by the requirement for convenient access to the station.

The clustering of stations in this manner results in the requirement for eight maintenance technicians working a 40-hour week to carry out visits twice per week at each station. Technician work weeks will have to be staggered to complete station visits on a regular basis and would have the following general pattern.

Table XIX-2

INSTRUMENT STATION CLUSTERS FOR MAINTENANCE TECHNICIAN ASSIGNMENT

Two Station Cluster	Three Station Cluster
1SW3A$_2$ - 1S3A$_1$	2SW7A$_1$ - 3SW20B$_1$ - 3SW21B$_1$
1W4A$_1$ - 2W8A$_2$	3SW15B$_1$ - 3SW16B$_1$ - 3W11B$_1$
2NW8A$_1$ - 2NW6B$_2$	3W12B$_1$ - 3O9A$_1$ - 3N8B$_1$
1NW4A$_2$ - 1NW1B$_2$	3NW1B$_1$ - 3NW6B$_1$ - 3NW7B$_1$
1N1A$_1$ - 2N7B$_2$	3NW2B$_1$ - 3N3B$_1$ - 3NE4B$_1$
1NE2B$_2$ - INE1A$_2$	2N5A$_2$ - 2NE8B$_2$ - 2NE6A$_1$
1SE3B$_2$ - ISE2A$_2$	3NE5B$_1$ - 3NE9B$_1$ - 3NE10B$_1$
2E6A$_2$ - 1E2A$_1$	3E13B$_1$ - 3S17B$_1$ - 3SE18B$_1$
	3S22B$_1$ - 3SE23B$_1$ - 2S7A$_2$
	2S4B$_2$ - 2SE5B$_2$ - 2SE6A$_1$
	3E14B$_1$ - 3SE19B$_1$ - 3SE24B$_1$

Work Week	Number of Technicians
Monday-Friday	2
Friday-Tuesday	2
Saturday-Wednesday	2
Wednesday-Sunday	2

This estimated personnel requirement is judged to be somewhat conservative, so that no additional staff is added to compensate for annual leave, sickness, and the like. Moreover, depending upon the schedule for research experiments and the technical requirements for the data more routinely collected by the instruments, some possibility appears to exist to suspend operations at selected stations for portions of a year. For example, it is likely that field experimental efforts might be discontinued during the winter months and instrument station data from, say, the southwest quadrant might be of marginal value. This would, of course, lighten the maintenance load and thereby permit, for at least selected personnel, annual leave.

The maintenance of the meteorological instruments is estimated to require three technicians occupied on a full-time basis. This estimate is based upon the need to inspect and calibrate the bulk of the meteorological instruments every 60 days or two months. The effort would, of course, require lowering the station tower. The 21 30-meter tower stations, including the Class C_1 stations, are estimated to require three men one day each for inspection and maintenance. The 56 stations with 10-meter towers (Class B_1, B_2, and C_2) are estimated to require two men for one-half day or 28 days total. This scheduling allows a float of approximately one man for a 28-day period out of the 60-day maintenance and calibration cycle. It must be expected that some portion and perhaps all of this float time will be required for emergency maintenance caused by vandalism and perhaps severe weather conditions.

As noted above, meteorological instrument and tower maintenance for Class C_2 stations is considered as a function of the facility maintenance staff. These are essentially standard equipment items and present no unexpected difficulties. The situation with respect to the air quality instruments tends to be somewhat more uncertain. In some cases the Class C_2 instruments may be identical to one or more of those at a Class A_1 station, while at other times they will be of specialized design or perhaps "bread board" units requiring specialized knowledge for their maintenance and operation. Accordingly, maintenance of the Class C_2 stations might be divided among three groups. First, the maintenance of the standard instruments could be assigned to the facility maintenance technicians. Their duties would also include the collection of the locally recorded data tapes, replenishment of fuels for those stations having engine-generator units, and similar more-or-less routine duties. The maintenance of the nonstandard Class C_2 stations could be divided among the three experimental instrument technicians reporting to the Research Program Coordinator and the technicians accompanying the research experimental field team.

Air Quality Instrument Calibration--As discussed in Chapter XII of this Prospectus, the air quality instruments will require on-site calibration and standardization among stations on a once-per-month schedule. Generally, calibration would be limited to the permanent facility stations, although on occasion selected Class C_2 stations might also be included. The calibration effort is estimated to require an average time of one day per station. Accordingly three calibration vans are estimated to be required with two technicians per van for a total of six calibration technicians.

Laboratory Service--The functions covered by laboratory service are intermixed between operation and maintenance of the instrument system itself, and the development of experimental and routine field data. The functions include, for the most part, chemical analyses and similar duties. The function of laboratory service is currently considered to be a part of the instrument system staff component with the Senior Engineer providing administrative and technical supervision. However, unlike most other functions carried out by the St. Louis staff, the possibility appears that the demands for laboratory service could increase markedly beyond that presently foreseen. Such changes will depend upon many factors, including the emergence of a need to monitor additional pollutants, or a need on the part of the experimental research groups for increased facility support because of staff deficiencies or conflicting requirements with their organization. In this event, the function of laboratory service could indeed be redefined as a separate group headed by a chemist or chemical engineer or it could be transferred to the Research Program Coordinator.

The functions provided by the laboratory service include the following. First, general support will be provided for the preparation of reagents and routine analyses requested by the research experiment groups. Analyses will also be provided using the gas chromatograph, as required.

Second, support for the instrument system maintenance and operation will be provided by carrying out instrument calibration tests, gas sample analyses, tests of new instruments, and similar tasks. This task would be supported by the central facility instrument technicians at the time instrument station maintenance visits are reduced to one per week.

Third, the analysis of materials accumulated by the hi-vol samplers will be continued on a routine basis. This function is expected to undergo marked change during the term of the Regional Study, since the design of these instruments is currently being intensively examined. Designs are moving in the general direction of increased automation, so that technician staffing for hi-vol analysis may be reduced over time.

A total of three laboratory technicians are estimated to be required for these tasks with two heavily occupied with the hi-vol sampler analysis.

Technician Scheduling Analysis--During the first year sufficiently detailed operational experience should be developed to permit a system analysis of technician staffing for the remainder of the life of the facility. Moreover, this analysis should also yield findings applicable to other monitoring systems used as both research and air quality management systems. Such an analysis would provide guidelines in the following principal areas.

Work Shift Assignment--Shift assignments are customarily made on the basis of five eight-hour shifts per week with allowance for overtime as appropriate. In view of the large areas over which the instrument sites are distributed, significant times are required for travel among stations, especially in the rural areas. With an estimated site-servicing period of two hours each, it is clear that the latter parts of many shifts will not be productive if the technician arrives at a site less than two hours before the end of his shift. The condition is made more difficult if shift assignment is made on a portal-to-portal basis. Several alternatives appear worthy of consideration. The first covers the possibility of differing shift assignments. That is, technicians covering the St. Louis metropolitan area, where station locations are relatively dense and travel times are low, might be assigned the standard eight-hour shift. On the other hand, technicians in the rural areas may be more efficiently assigned on four 10-hour shifts. A second alternative covers a situation of flexible shift assignment wherein technician time is based solely on a 40-hour week wherein shifts may vary from, say, 12 hours to six hours depending upon the pattern of instrument sites assigned for a particular shift. These two alternatives are based upon the technician operating daily from a single base, normally his residence. Thus, a third alternative, especially in the rural areas, would include placing the technician on a travel status for a portion of each week with shift assignments flexibly designed as in the second alternative.

Contract Maintenance--Since travel times for instrument technicians will be unavoidably large, an attractive possibility is to contract at least routine station maintenance in the rural areas to local units near an instrument site. Typical organizations which might be considered are television repair shops, appliance repair shops, and plumbing and heating system installation and repair shops. The extent to which contract maintenance is appropriate will depend upon the instrument performance and, of course, the competence and interest of the local groups. After the first year of system operation the possibility of maintenance by contract should be analyzed in detail.

Technician Dispatching--During the shakedown and early operation of the facility, routine periodic visits at each instrument site are anticipated. As operating experience is gained, a routine of more selective site visits likely may be possible. With the central computer facility obtaining periodic instrument calibration data, actual and perhaps potential instrument malfunctions will be known at the computer facility. Accordingly, the possibility should exist to schedule technicians on a day-to-day basis from the computer facility by advising the technicians at their residence each morning of their schedule for the day. Flexible shift scheduling may be desirable with this method of operation. Periodic visits to each site may nevertheless be required for general surveillance and inspection.

Meteorological Service. Adequate support of the various research experiments will require an experienced air pollution meteorologist. He will develop and implement meteorological forecasting and descriptive techniques for the region based upon meteorological data gathered by the study facilities and from other sources. He will also assist in the maintenance of the meteorological instruments and provide general synoptic data as well as detailed special-purpose reports as may be required by individual experimental research groups. If detailed forecasts are needed at least two meteorologists will be needed.

Control Engineering--The control systems engineer will have responsibilities covering routine facility operation and special support of research experiments. These duties primarily involve the execution and archiving of the emission inventory for the region and the preparation of specialized data for research projects. Although the initial emission inventory will be developed under a separate research program, as discussed in Chapter V, probably with the control system engineer as project officer, the updating and maintenance of the inventory will be a major continuing effort. Individual research experiments will need a variety of emission data taken, for the most part, from the inventory files, but some special studies involving detailed source analyses should be anticipated.

Effects Research--The effects research coordinator will be expected to function as liaison with Effects Research groups in both the Research Triangle Park and elsewhere within the EPA. In this capacity he will be responsible for support of all direct effects research in St. Louis and will arrange for the acquisition of all pertinent local data appropriate for the Effects Research program which are not readily available from standard sources. The St. Louis area tends to be sufficiently large and contains a heterogeneous mix of population groups, industry, agriculture, and other components, so that it should prove to be an excellent base for application of models and other studies of the economics of pollution control and abatement. Considerable local data will be required for these research efforts.

Data Processing--Personnel requirements for data processing are estimated to include the following:

Computer/Communication System Engineer
System Programmer/Computer Operator
Data Aid
Data Center Attendants.

This requirement is based upon five necessary data-processing tasks:

- Data recording from continuously reporting fully automated facility instruments

- Data recording from manual and partially automated facility instruments

- Data processing to support research experiments, including data recording, retrieval, and possible additional processing of facility instrument data, and other specified procedures

- Data archiving, reformatting, and related procedures

- Real time observation of data.

The system engineer should be fully conversant with all equipment in the data center and capable of routine maintenance. He would also monitor on a sample basis the incoming data thereby requiring an understanding of the nature of the data. The systems programmer/computer operator would develop all general purpose computer routines for data storage and retrieval. He would also prepare special purpose programs at the request of groups involved in research experiments of the Regional Study. The data aid will handle and record all appropriate data for computer processing and will provide assistance as necessary in data analysis and processing.

The requirement for computer attendants arises from the anticipated need to staff the data center on a three-shift basis. This causes the requirement for two full-time attendants (Monday through Friday) and three part-time attendants for eight-hour weekend assignment. Routine duties, such as data recording from nonautomatically reporting stations, can be assigned to the computer attendants during their shift but these duties should be limited in complexity to prevent unnecessary upgrading of the position.

Clerical--At least four clerical personnel are estimated to be required to provide general support to the facility staff.

St. Louis EPA Staff with Prime Contractor Operation

As a matter of EPA policy, the St. Louis facility operation could be carried out by either a contractor or the EPA itself. The mode of operation selected will depend upon several factors. The number of personnel positions authorized for EPA could, of course, be a significant factor in determining contractor versus EPA operation. Additionally, although the Regional Study is expected to continue for five years, the advisability of increasing the EPA staff by the magnitude required without some generally specified need for the staff at the conclusion of the Regional Study should be given some consideration. The number and responsibilities of the staff members should be essentially identical for each alternative. Under either method of operation, however, the staff should include EPA representatives as follows. First, the system chief most appropriately should be associated with the EPA. A facility of the size and complexity considered here clearly justifies a senior member of the EPA staff to be present in St. Louis. Additionally, the necessary interactions and negotiations with state and local public and private groups and the general public suggests such a staff member.

Second, the Research Program Coordinator function appears most appropriately filled by an EPA staff member. He will likely work with both EPA and contractor research groups in providing all support, including perhaps government furnished equipment and experimental apparatus. The task will involve close coordination with other EPA groups and may require access to information considered proprietary to EPA.

Third, the facility meteorologists most properly should be EPA staff members. Considerable interaction is expected with other federal organizations, including NOAA, and the U.S. Air Force, so that an EPA staff member fully conversant with federal procedures and programs is appropriate.

Lastly, the positions of control engineer and effects research coordinator tend to be most appropriately filled by EPA personnel. The development of the emission inventory, the principal responsibility of the control engineer, will be a long-term task, since the inventory will be constantly changing. Coordination with the Regional Administrators will likely be necessary and most effectively accomplished within the EPA. Similarly, the effects research coordinator's responsibilities will require extensive interaction with numerous groups in the EPA, and contractor personnel do not appear appropriate for this role.

The remainder of the facility staff should be essentially identical with operation by either a contractor or the EPA itself. Contractor operation, however, may require one additional staff member for contract management and personnel supervision. Ideally this function would be carried out by contractor staff resident in St. Louis for other purposes of the contractor. Alternatively, the contractor might select one of his senior professional staff members, such as the senior instrument engineer, for contract management.

St. Louis Facility Implementation

The implementation of the St. Louis facility, including the design, procurement, and installation of all instruments and equipment, can be carried out by two principal methods. The first would provide for essentially a complete EPA intramural program, in which procurement of all instruments, data-handling facilities, and other equipment would be carried out by a procurement group established within the Deputy Director's organization.

The second method would provide a prime systems contractor responsible for the implementation of essentially the entire St. Louis facility. Technical monitorship would be lodged within the Deputy Director's organization.

The choice between these two alternatives is judged to be a matter of EPA policy as well as of considerations of the availability of qualified personnel and related factors. Recommendations concerning a preferable alternative are judged to be inappropriate here. Each method, however, is discussed in the following sections with respect to staffing requirements, management control and related items.

Under both alternatives the Deputy Director's staff at the Research Triangle Park would be expected to have substantially the same organizational configuration and responsibilities. Activation of the Office of Programs could be expected to be required during the first six months following authorization of the Regional Study, whereas the Office of Technology could be established at approximately the end of the first year of full facility operation.

EPA Implementation--The implementation of the facility within EPA will require the establishment of an initially small core group which expands as the St. Louis facility evolves toward operational status. Implementation can be divided into three principal phases.

Phase I--The staffing requirements can be tied directly to the implementation schedule. For staff planning purposes, the schedule has six distinct components as follows:

- Development of Requests for Quotation and procurement of standard catalog instruments and data-processing equipment
- Specialized designs for instrument station interior components and layouts
- Preliminary design and development of Requests for Quotation for nonstandard electronic and electromechanical equipment
- Site selection in the St. Louis area
- Installation and shakedown of central data-processing facilities and prototype instrument stations in St. Louis
- Implementation of the complete system.

The initial group is estimated to consist of nine professional staff members, excluding the immediate staff of the Deputy Director. The group would be headed by a senior professional proficient in administrative and contractual procedures who would function as the chief Contracting Officer's Technical Representative for all equipment and other procurement. The group head preferably should be selected with the intent that he would be assigned to the position of facility chief in St. Louis for at least a portion of the Regional Study. The professional staff members functioning under the group head will have the following responsibilities.

Two staff members are estimated to be required for the preparation of specifications and Request for Quotations and all related activities concerned with the procurement of the air quality and meteorological instruments. It is expected that these instruments will essentially be standard catalog items that are thoroughly familiar to EPA. Most if not all have been used in the field or at least laboratory tested by EPA personnel. Accordingly, design and performance specifications should be readily available for use but adapted as appropriate for the St. Louis facility. All procurement specifications should be coordinated with the interested divisions at the Research Triangle Park. Selection of these two professionals may properly be made with the intent that they be assigned to the St. Louis staff as the senior instrument system engineer and the instrument system engineer, respectively.

One staff member will be required for preparation of specifications and request for quotations and related activities for the electronic data-processing equipment to be installed at the central facility. This professional might well be selected with the intent of subsequent assignment as the data-processing systems engineer in St. Louis.

Two professionals are estimated to be required for the procurement of all digital data equipment and the calibration controller. As noted in Chapter XVIII, the basic concept in the design of the instrument station is to select standard catalog instruments of known characteristics. Any necessary modifications of instrument reporting format to achieve compatibility or for other reasons will be accomplished in the digital data and control system. Thus, although most of the components of the system are standard catalog items, some components will require special design. Moreover, the proper interfacing of the standard components will have to be considered in the system design.

The air quality instrument calibration controller has perhaps the least standard design of any item of equipment at an instrument station. Because of these factors, the two professionals should be highly conversant with electronic and electromagnetic technology. The depth to which the noncatalog equipment should be designed for incorporation into the equipment Request for Quotation is difficult to specify but at least all performance specifications should be clearly defined.

A seventh professional will be required for general engineering designs of the instrument towers, station interior layout, preparation of instrument station and central facility layouts, maintenance vehicle specification, and similar activities.

The eighth professional will have the general responsibility for selection of the central facility site as well as the instrument station sites. It appears imperative that this position be filled early in the staffing process and his permanent transfer to St. Louis be carried out soon thereafter. This staff member might well continue in St. Louis as the Research Program Coordinator.

The ninth professional will be responsible for the emission inventory. This task should continue throughout the course of the Regional Study and, depending upon the course of events and perhaps local St. Louis interest, it could be continued on a permanent basis. Initiation of the emission inventory and selection of contractors, as appropriate, could be carried out from the Research Triangle Park location. However, to facilitate the inventory effort and achieve the greatest degree of cooperation with the local agencies and the EPA Regional Administrators, the transfer of this activity to the St. Louis central facility should likely be carried out at the earliest date.

Phase II--Subsequent to the award of all principal equipment contracts and the establishment of firm delivery schedules, Phase II is initiated. This is a transition period covering a small increase in staff size in the Research Triangle Park followed by significant personnel transfer to St. Louis. The first staff addition should be the Systems Programmer/Computer Operator, and he will be responsible for the preparation of all computer routines used at the facility. His assignment should be scheduled after computer equipment award so that the available computer software can be fully identified. Two types of programs will be required. The first covers those necessary for the logging of real-time monitoring data from the facility instrument stations. Preparation of these programs will involve close coordination with the Research Triangle Park instrument groups. The second type of program will cover those necessary to reformat and convert the monitored data to be compatible with the existing and planned computer routines at the Research Triangle Park facility and other EPA installations. Since both types of programs require close coordination with Research Triangle Park personnel, the initial assignment of the Systems Programmer at that installation appears most appropriate.

Further staff additions appear unnecessary until transfer to St. Louis occurs after acquisition of the central facility. At this time the principal professional personnel identified in Phase I would be transferred to St. Louis to continue their activities with respect to the acquisition of instruments and other equipment and to initiate the activation of the prototype instrument stations. Professional staff members remaining at the Research Triangle Park would be reassigned as the prototype stations reach their completion. Maintenance technician staffing would be initiated at the rate of two per prototype station. Additionally, depending upon the scheduling of research experiments and the need for the Class C_2 stations, the experimental technician staff would be acquired during the first six months following authorization of the Regional Study.

Phase III--The final phase of implementation includes the activation of all instrument stations. As discussed in Chapter XVIII, two distinct scheduling options are readily apparent with many alternatives between the two. Facility staffing timing clearly will be affected by the activation schedule selected, although the final staff requirements will be the same. For purposes here, the overlapping activation schedule for facility staffing will be used, wherein the station activation schedule is initiated upon acceptance of the air quality monitoring instruments and not delayed until acceptance of the digital data terminal equipment.

The overall St. Louis facility staffing schedule based upon this station activation schedule is shown in Table XIX-3. Scheduling of the professional staff members, such as the meteorologists, is somewhat arbitrarily shown and will likely be dependent upon the detailed scheduling of the research experimental program.

Prime Systems Contractor Implementation--The implementation of the St. Louis facility by a prime systems contractor naturally creates a considerably different staffing and management program within EPA. A systems contractor can, of course, be required to function in a wide variety of modes depending on his contract specifications and scope of work. These factors are clearly subject to EPA policy and related constraints. The general tasks of the prime contractor, however, should parallel those shown for an intramural EPA implementation program.

In general, a system contractor would be obligated to deliver a fully operational facility on schedule. He would procure all catalog and standard items of equipment by subcontract from qualified vendors and would design and fabricate special purpose equipment himself or by subcontract, as appropriate. The prime contractor would be responsible for all coordination among vendors and suppliers in the maintenance of equipment, delivery and installation schedules, and system shakedown tests.

Under a system prime contractor implementation program, the internal EPA staffing pattern has slight resemblance to the intramural approach. In this implementation procedure, the staffing for the Regional Study would be divided into two phases.

Phase I--During Phase I the staff is estimated to consist of four members, excluding the immediate staff of the Deputy Director. The principal staff member would function as the Contracting Officer's Technical Representative in providing guidance to the system prime contractor throughout the course of the contract. He should be supported by one general engineer. Since the contractor will be responsible for all detailed planning and scheduling and other activities of the facility implementation, no major additional staffing on a full-time basis for this function appears justified. However, resident staff members at the Research Triangle Park facility should be available to the contract monitor on a consultative basis. Such an arrangement is especially important in the selection of air quality instruments. Even if the types of air quality monitoring instruments are specified in the prime contract thereby providing the contractor with no latitude in this regard, the dynamic state-of-the-art in instrument design necessitates constant review of instrument selection until at least the actual instrument procurement phase is reached.

A third staff member, as before, will be required for early assignment in St. Louis for instrument site survey and acquisition and similar efforts. Although in some respects this task might be assigned to the prime contractor, it appears more appropriate that the task be handled directly by a federal EPA staff member. Site acquisition directly by EPA rather than by the prime contractor for subsequent transfer to the EPA should avoid many administrative problems.

The fourth professional staff member will be required for the initiation of the emission inventory.

Phase II--Additional EPA staffing would not be anticipated until the St. Louis facility is nearing completion. Of course, the staffing pattern will depend upon the manner in which the St. Louis facility is to be operated--contractor or intramurally. In the event the former method is selected, EPA staffing of the professional positions previously identified should occur at approximately the completion of the prototype instrument station. If the decision is for EPA operation itself, then staff additions should generally follow the pattern shown in Table XIX-3.

Staff Scheduling

Chapter XVIII provided the estimated activation schedule of the St. Louis facility and Table XVIII-7 provided a summary of the schedule on a quarterly basis. For planning purposes of this Prospectus, the quarterly schedule summary is considered to be sufficiently detailed for use in estimating staffing requirements during the implementation of the St. Louis facility. These cumulative staffing requirements over time are presented in Table XIX-3. Both the Research Triangle Park and the St. Louis staff are shown in terms of the principal categories previously identified. In general it is anticipated that the staff members shown will be required at the start of the respective quarter rather than at a later time. Staffing subsequent to the fifth quarter is estimated to remain at the fifth-quarter level.

Initially, the Research Triangle Park staff is estimated to consist of eight professionals and four clerical personnel. As previously discussed, their principal responsibility would be to initiate the acquisition of instruments and equipment for the St. Louis facility. The research coordinator, or equivalent, in St. Louis, however, is considered absolutely essential to immediately begin the acquisition of the central facility and the instrument sites.

A decrease in the Research Triangle Park staff results from the transfer of personnel to St. Louis. The procurement director at the Research Triangle Park is assumed to be the facility director in St. Louis, for example, and similarly in the case of engineering personnel. The general design engineer and the digital data system design personnel would be phased out of the program as designs are completed and equipment delivery is initiated. Staffing of the various offices supporting the Deputy Director of Regional Studies is estimated as shown.

The St. Louis staffing levels show a continual upward trend until the permanent staff level is reached at the fifth quarter. Some

Table XIX-3

REGIONAL STUDY STAFF REQUIREMENTS
(Number of Personnel)

	Quarter 1	2	3	4	5
Research Triangle Park staff					
Professional					
Deputy Director	1	1	1	1	1
Senior Engineer	1	0	0	0	0
Engineer, Instrument	1	0	0	0	0
Computer Systems Engineer	1	1	0	0	0
Digital Data Systems Design	2	2	1	0	0
Design Engineer	1	1	1	0	0
Office of Programs	0	1	2	2	2
Office of Technology Transfer	0	0	0	1	2
Office of Research Operations	0	1	1	1	1
Procurement Director	1	1	0	0	0
Subtotal	8	8	6	5	6
Clerical	4	3	3	3	3
Total	12	11	9	8	9
St. Louis staff					
Professional					
Facility Director	0	0	1	1	1
Research Coordinator	1	1	1	1	1
Instrument Engineer	0	1	2	2	2
Meteorologist	0	0	1	2	2
Computer System Engineer	0	0	1	1	1
Control Engineer	1	1	1	1	1
Effects Research	0	0	0	1	1
Subtotal	2	3	7	9	9
Technician					
Instrument Maintenance	0	4	8	8	8
Tower Maintenance	0	0	0	3	3
Calibration	0	2	6	6	6
Research	0	3	3	3	3
Laboratory	0	0	1	2	3
Subtotal	0	9	18	22	23
Data Processing	0	0	3	7	7
Data Aid	1	1	1	2	2
Clerical	1	2	4	4	4
Subtotal	2	3	8	13	13
Total	4	15	33	44	45
Grand Total	16	26	42	52	54

professional staff positions tend to be fixed as a function of the completion of the instrument system, such as the computer system engineer. Others, however, such as the meteorologists and effects research personnel, appear to be more closely associated with the Research Program and their assignment timing may be considerably more flexible.

Technician staffing tends to be closely associated with the facility completion schedule. The instrument maintenance technician staffing is based upon continual operation of the instrument stations after installation and acceptance of the air quality instruments. The four technicians shown in the second quarter are expected to be primarily engaged with assembly and test of the prototype stations in the second and third quarters. The research technicians shown in the second quarter would be primarily engaged in the activation of the Class C_2 stations.

Overall, a total of 54 permanent members are estimated to comprise the permanent Regional Study staff, including those at the Research Triangle Park and St. Louis. As the Regional Study evolves, continual review of staffing requirements should, of course, be undertaken with emphasis on the 23-man group of technicians. Professional research requirements may also change with time, depending upon the evolution of the Research Plan.

Chapter XX

ST. LOUIS FACILITY INITIAL COSTS AND ANNUAL OPERATING COSTS

Introduction

The facility costs of the Regional Study can be divided into two principal categories. The first includes the initial costs of the St. Louis instrument system and its associated communications network, data-processing equipment, and the like. The second covers the annual operating costs of the St. Louis facility including all personnel costs of the permanent staff located at both St. Louis and the Research Triangle Park. Other costs covered elsewhere in this Prospectus include equipment, personnel, costs associated with the research experiments and analysis carried out during the Regional Study, and the costs associated with the monitoring aircraft. In a sense the aircraft operation and its ground support equipment and personnel might be regarded as an additional component of the St. Louis facility and be treated in the same manner as, say, the maintenance of the Class A_1 instrument stations. However, since the aircraft operation will have a somewhat unique set of requirements for operation and maintenance and may function within the Regional Study by differing organizational and administrative arrangements, it appears more appropriate to consider its costing as a distinct element of the Regional Study rather than as a facility component.

Initial Costs of the St. Louis Facility

The initial costs of the St. Louis facility include the acquisition, installation, and test of all air quality and meteorological instruments, digital data transmission and processing equipment, and all supporting facilities and equipment expected to be used essentially on a continuing basis throughout the Regional Study. The estimated costs cover the completion of all instrument stations, except the Class C_2. For these stations the costs include the acquisition of the instrument trailer and 10-meter tower, meteorological instruments, the basic interior fixtures and appurtenances, and the digital data terminal equipment. No costs are included for air quality instrumentation; these are considered to be a part of the equipment costs of the various research programs rather than the facility.

The estimated initial costs of the St. Louis facility can be divided into five major categories. These are:

- Air quality and meteorological instruments
- Instrument station preparation, facilities, and appurtenances
- Digital data terminal and communication equipment
- Central facility and equipment
- Vehicular support facilities.

The estimated costs of all standard catalog items of equipment represent a synthesis of quotations acquired from selected instrument manufacturers and a review of published prices. The costs are based upon instruments having the specifications established in Part III of this Prospectus. The estimated costs do not provide for quantity discounts or similar adjustments which might well be realized in view of the quantity of instruments to be acquired. The costs estimates of nonstandard items of equipment have been based upon a general estimate of the equipment complexity. Costs of equipment design are considered to be included in the unit costs of equipment. In general, the nonstandard items of equipment are simply a combination of standard components and subassemblies into a unit to provide a required function, and their design requires no advance in the state of the art in electronic system design. Accordingly, their estimated costs are considered to be sufficiently reliable for the overall planning purposes of this Prospectus.

Cost estimates for instrument site and central facility preparation and construction by general contractors have been developed by standard engineering estimating procedures available in the F. W. Dodge Co. publications and similar sources. These estimated costs are judged to be less reliable than the instrument and other equipment costs, because they can be markedly affected by the actual conditions in St. Louis itself. Instrument costs, on the other hand, are essentially insensitive to the location of their installation.

Factors to treat escalation of equipment and labor costs are not included. Moreover, the economies of assembly-line production may provide unit cost reduction or at least compensate for inflationary and other factors. Labor costs for equipment installation might benefit from an escalation factor, but soundly acceptable values are difficult to develop for the specific St. Louis area. Moreover, since labor costs are small in relation to equipment costs, any changes will have almost negligible impact on the total system cost.

The estimated costs presented in this section are given first for the major cost categories identified previously. These costs are then aggregated to define the total initial cost for each type of station. Finally, on the basis of the activation schedule, the costs are spread over time.

Air Quality and Meteorological Instruments

The costs of the air quality and meteorological instruments are summarized in Table XX-1 along with the equipment and accessories necessary for air quality instrument calibration. All costs are shown for the six types of instrument stations considered to be included in the permanent facility. The air quality instrument costs are the same for the Class A_1 and A_2 stations and for the Class B_1 and B_2 stations. The difference between the two groups arises from the fact that the B_1 and B_2 Class stations do not have the capability for measurement of total sulfur and they lack the nondispersive infrared carbon monoxide instrument. The estimated costs represent the approximate average of currently available second generation instruments designed to utilize the measurement processes discussed in Part III of this Prospectus.

The estimated costs of the calibration equipment and accessories for the air quality instruments are shown in Table XX-1 since they are an essential part of the air quality instrument system. Differences in cost among stations have the same pattern as the air quality instruments themselves. The air quality valving and manifolding system of the Class B_1 and B_2 stations is less complex than that in the Class A_1 and A_2 stations.

The estimated costs of the meteorological instruments show considerable variation among stations. The Class A_1 and C_1 stations have the full complement of meteorological sensors, whereas the remaining stations are limited to wind measurement and temperature equipment in the Class A_2 stations.

The Class C_2 stations are shown to be limited to the air sampling tubing and associated equipment and wind sensors. As discussed in Parts II and III of this Prospectus, the Class C_2 stations will be used in the support of the various research experiments. Air quality instrument acquisition costs are considered to be included within the costs of the research experiment for which the instruments are required.

Table XX-1

INITIAL UNIT COSTS OF INSTRUMENT STATION AIR QUALITY, METEOROLOGICAL INSTRUMENTS, AND CALIBRATION EQUIPMENT
(Thousands of Dollars)

	Station Class					
	A_1	A_2	B_1	B_2	C_1	C_2*
Air quality instruments						
Carbon monoxide-methane-hydrocarbon	$ 7.4	$ 7.4	$ 7.4	$ 7.4	--	--
Hydrogen sulfide-sulfur dioxide	5.6	5.6	5.6	5.6	--	--
Total sulfur	5.0	5.0	--	--	--	--
Ozone	4.2	4.2	4.2	4.2	--	--
Nitric oxide-oxides of nitrogen	6.8	6.8	6.8	6.8	--	--
Nephelometer	5.0	5.0	5.0	5.0	--	--
Carbon monoxide	3.0	3.0	--	--	--	--
Hi-Vol sampler	0.3	0.3	0.3	0.3	--	--
Hydrogen generator	0.7	0.7	0.7	0.7	--	--
Subtotal	$38.0	$38.0	$30.0	$30.0	--	--
Calibration equipment and accessories						
Permeation tube-sulfur dioxide	2.8	2.8	2.8	2.8	--	--
Ozone generator	1.4	1.4	1.4	1.4	--	--
Mass flow meter	2.1	2.1	2.1	2.1	--	--
Regulators	0.5	0.5	0.4	0.4	--	--
Air sample valving, tubing, and manifolding	1.5	1.5	1.0	1.0	--	$0.2
Subtotal	$ 8.3	$ 8.3	$ 7.7	$ 7.7	--	$0.2
Meteorological instruments						
Temperature	1.5	1.5	--	--	$ 1.5	--
Wind direction and speed	2.9	2.9	1.0	1.0	2.9	1.0
Pyranometer	1.0	--	--	--	1.0	--
Pressure transducer	0.5	--	--	--	0.5	--
Mercury barometer	0.2	--	--	--	0.2	--
Net radiometer	0.8	--	--	--	0.8	--
Dew point hygrometer	3.7	--	--	--	3.7	--
Rain-snow gage	0.3	--	--	--	0.3	--
Wind shield	0.1	--	--	--	0.1	--
Subtotal	$11.0	$ 4.4	$ 1.0	$ 1.0	$11.0	$1.0
Total	57.3	30.7	38.7	38.7	11.0	1.2
Spare parts @ 10%	5.7	5.1	3.8	3.8	1.1	0.1
Grand total	$63.0	$55.8	$42.5	$42.5	$12.1	$1.3

* Air quality instruments for the C_2 stations will vary throughout the Regional Study with their costs included in the respective research experiments.

Instrument Station Preparation, Facilities, and Appurtenances

The estimated costs covering the acquisition and installation of the instrument station towers and shelters and all fixtures and appurtenances within the station shelters are shown in Table XX-2. Estimated costs for site preparation are also shown. The estimated costs are for the station components in-place.

Table XX-2

INITIAL UNIT COSTS FOR INSTRUMENT STATION SITE PREPARATION, HOUSING, FIXTURES, AND APPURTENANCES (Thousands of Dollars)

	Station Class					
	A_1	A_2	B_1	B_2	C_1	C_2
Site preparation						
Clearing, grading, paving	$ 1.0	$ 1.0	$0.5	$0.3	$0.5	--
Concrete	1.0	1.0	0.3	0.1	1.0	--
Fencing	1.5	1.5	0.3	0.3	0.3	--
Subtotal	$ 3.5	$ 3.5	$1.1	$0.7	$1.8	--
Shelter, fixtures, and appurtenances						
Tower	4.3	4.3	0.2	0.2	4.3	$0.2
Instrument shelter	2.0	2.0	2.0	2.8	1.8	1.8
Air conditioning-heating	0.7	0.7	0.7	0.5	0.4	0.4
Racks, benches, cabinets, electric system	0.9	0.9	0.9	0.5	0.2	0.2
Subtotal	$ 7.9	$ 7.9	$3.8	$4.0	$6.7	$2.6
General contractor fees	1.7	1.7	0.7	0.7	1.2	--
Total	$13.1	$13.1	$5.6	$5.4	$9.7	$2.6

The work would most likely be carried out by a general contractor, so that a factor of 15 percent of the costs has been added to cover his general overhead and fees. These costs are judged to be less reliable than instrument costs, for example, because they are highly dependent upon the actual field conditions found in St. Louis. This is especially true for the costs of site preparation. Moreover, the estimated costs will likely be dependent upon the sequence by which the sites are constructed. For example, if the Missouri stations were scheduled for construction on a smooth north-to-south or east-to-west sequence, the costs likely will be less than if construction equipment must be moved back and forth during construction, as might be the case if the instrument sites have not been fully acquired prior to initiation of construction.

Digital Data Terminal and Communication Equipment

The unit cost of the digital data terminal equipment is summarized in Table XX-3.

Table XX-3

INITIAL COSTS OF THE INSTRUMENT STATION
DIGITAL DATA TERMINAL EQUIPMENT
(Thousands of Dollars)

	Station Class					
	A_1	A_2	B_1	B_2	C_1	C_2
Instrument scanner	$2.0	$2.0	$2.0	$2.0	$ 2.0	$ 2.0
Identifier-interrogator	0.2	0.2	0.2	0.2	0.2	0.2
Clock	0.2	0.2	0.2	0.2	0.2	0.2
Analog-to-digital converter	0.8	0.8	0.8	0.8	0.8	0.8
Local memory	1.0	1.0	1.0	1.0	--	--
Parallel-to-serial converter	1.0	1.0	1.0	1.0	--	--
Master control	1.0	1.0	1.0	1.0	1.0	1.0
Telephone system modem	0.5	0.5	0.5	0.5	--	--
Calibration controller	1.5	1.5	1.5	1.5	--	--
Local recording unit	--	--	--	--	6.0	6.0
Subtotal	$8.2	$8.2	$8.2	$8.2	$10.2	$10.2
Instrument identifier	0.9	0.6	0.3	0.3	0.5	0.2
Subtotal	$9.1	$8.8	$8.5	$8.5	$10.7	$10.4
Spare parts @ 5%	0.5	0.5	0.5	0.5	1.0*	1.0*
Grand total	$9.6	$9.3	$9.0	$9.0	$11.7	$11.4

* 10% due to local tape unit.

The terminal design concepts used for this Prospectus provide for the use of the same components to fulfill the same required function at all stations. Accordingly, the same equipment unit costs apply for each type of station, where the same functions must be performed. An alternative approach would consist of the individual design of the terminal equipment for each station. Although this method would avoid the inherent excess capacity of the digital data equipment at the less complex stations few, if any, economies could be expected. Moreover, the advantages of standardization and full interchangeability of terminal equipment among stations would be lost. A number of components, such as the clock, analog-to-digital converter, and the telephone system modem, tend to be insensitive to the number and type of instruments, so that the potential for specialized designs appears to be limited in any event.

The Class C_1 and C_2 stations, of course, have substantial variations in cost because their design incorporates a local data-recording capability rather than the telemetry system used in the other station classes. The functions performed by the local memory and the parallel-to-serial converter are combined in the local nine-track tape recording unit, whose initial cost is estimated at $6000 each. The telephone system modem function is, obviously, unnecessary when data are locally recorded.

As can be noted, even though the Class C_1 and C_2 stations incorporate a relatively small number of instruments, the cost of their digital terminal equipment is approximately 25% greater than that of the more complex stations. This differential is caused by the high-cost nine-track local recording unit and its associated control equipment. The cost difference raises the question as to whether local data recording should indeed be considered for all Class C_1 and C_2 stations. For the most part, the Class C_1 and C_2 stations will be served by utility electric power, although on occasion at very remote sites a local engine-generator unit may be required. The manner in which the electric power connection is made may vary markedly. In some cases a special utility-provided power drop may be necessary, while in other cases power may be available at the instrument site through arrangements with the site owner. Thus, the installation of a telephone system drop may be quite appropriate and feasible, at least at those stations provided with an electric power drop. The desirability of telephone drop will, of course, also be dependent upon the period at which the instrument station will remain at a site.

With remote recording, the data are immediately available at the central facility and data archiving can be carried out with minimal effort. The locally recorded data, on the other hand, will require additional handling and processing.

Standard designs for digital data equipment are available for essentially all functions required, except the master communication and control logic unit and the air quality instrument calibration controller. Where appropriate, standard catalog costs have been used to formulate the estimated costs shown in Table XX-3. An important exception to this procedure, however, applies to the instrument scanning equipment. The smaller commercially available scanners potentially suitable for use at the instrument stations have scanning rates in the order of 12 channels per second with a capacity of 25 channels. The costs of these units approximate $2400 each and their associated slave units are typically $2000 each. The number of instrument and instrument identifier channels at the Class A_1 station, for example, is such that two master and one slave scanner will be required at a total cost of $6800. Somewhat reduced costs could be attributed to the smaller less complex stations.

An alternative to these commercially available scanners exists in the special design of the scanners and associated equipment with lower scan and data-handling capacities. Considerable economies could be expected with unit costs approximating $2000 in a production lot of 50 or more units. The quantity production is necessary to achieve the low unit cost with the result that all stations, regardless of their instrument mix, would be equipped with the same scanning system. Some stations, accordingly, would have scanning units with considerable excess capacity, but the advantages of standardization among all stations would be achieved. It should be noted, moreover, that use of commercially available equipment would also result in a form of excess capacity.

All special equipment design factors must be weighed against the estimated implementation schedule in which the digital data and control equipment form the bulk of the critical path. Wide departures from standard equipment components and designs could indeed lengthen the schedule to an unacceptable extent and force the acquisition of currently available equipment. Nevertheless, for system costing purposes here, the special-design scanning terminal equipment at a unit cost of $2000 will be used for all stations. The calibration controller, as previously discussed, requires an original design using standard components. It is similar to standard industrial process controllers, however, so that the estimated costs are comparable to these units.

The costs of instrument identifiers are somewhat more difficult to establish due to the somewhat unique purpose for which they will be used at the instrument stations and to the rapid and continuing reduction in the price of many electronic components. Approximately 600 to 650 identifiers will be required. Procurement in quantities of this magnitude could indeed reap the benefits of mass production and considerable unit cost reduction. A reasonable cost estimate for the identifiers is judged to be $50 each for large lot procurement, or $30,000 total. Over time this unit cost may be reduced to some extent to reflect the advances in the state of the art of electronic component design and production. The initial costs of the instrument identifiers as shown in Table XX-3 are based upon equipping each planned instrument at each station with one identifier at the unit cost of $50.

Central Facility and Equipment

The initial costs of the central facility include three principal elements. These are: (1) data-processing and communication equipment, (2) general facilities, (3) laboratory and shop equipment. The costs are summarized in Table XX-4.

The data-processing and communication equipment, while constituting the heart of the St. Louis facility, is one of the least costly components of the system. As shown in Table XX-4, the data-processing equipment itself is estimated at $56,000 total with the essential telephone system equipment at $25,000. These costs represent a synthesis of current commercially available equipment having the necessary technical characteristics as discussed in Chapter XIII. Computer costs have experienced very sharp reductions over the past several years, so that the computer unit cost is the least of all the data-processing equipment. Costs may continue to decline over time but not likely at the past rate, so that the computer cost estimate is considered reliable. The unit costs of the remaining data-handling equipment tend to be relatively high because of their high precision mechanical and electromechanical components. The extent to which future cost reduction for these items will occur is difficult to estimate, but clearly the greatest cost savings can be achieved by their careful procurement.

The estimated costs of the data-processing equipment are based upon their outright purchase. This is not meant to exclude the alternative of equipment rental or lease. A marked advantage of leasing the equipment lies in the fact that equipment maintenance can be included as a part of the lease agreement. Maintenance of the mechanical and electro-mechanical equipment is required at very frequent intervals by highly competent technicians. Some question can be raised in regard to the desirability of including a computer maintenance position in the permanent St. Louis staff, especially with the problems of weekend maintenance, sick leave, annual leave, and the like. Assigning two technicians to the permanent staff perhaps would be required at the most. For purposes of this Prospectus, however, the data-processing equipment is considered as purchased with

Table XX-4

INITIAL COSTS OF THE CENTRAL FACILITY
(Thousands of Dollars)

Data-processing and communication equipment	
Computers, two required	$ 6.0
Disk memory, two required	13.0
Disk controller	5.0
Tape drives, four required	24.0
Tape drive controller, two required	8.0
Communication controller	18.0
Telephone system modem, seven required	7.0
Subtotal	$ 81.0
General facilities	
Office and data central modification	8.0
Furnishings	5.0
Wet laboratory installation	12.0
Humidity controlled storage	4.0
Spectrometer laboratory	2.0
Shop modification, benches	4.0
Subtotal	$ 35.0
Laboratory and shop equipment	
General laboratory equipment	2.0
General shop equipment	3.0
Subtotal	$ 5.0
Total	$121.0

maintenance provided by the facility staff. Other options, of course, should be carefully examined during the facility implementation.

The telephone controller and modems are of essentially standard design. Any substantial change in the mode of communication system design and operation from that considered in this Prospectus, however, could substantially alter the costs of the modems, since one per telephone circuit is required.

The initial costs of the general facilities are especially difficult to estimate. In general, they include the costs of building modification to accommodate desired office and shop space and related requirements as discussed in Chapter XVI. These costs are largely dependent upon the precise details of the actual structure acquired for use. Moreover, alternative rental or lease arrangements can be negotiated, wherein the lessor provides a space configuration as required with a concomitant increase in lease rates.

For estimating purposes here, the assumption is made that building modification is carried out by the lessee. General office and shop space modification is taken at $2 per square foot, and the wet laboratory installation at $30 per square foot. Preparation of the 100-square-foot humidity controlled storage area for retention of the Hi-Vol sampler filters is estimated at $4000 for filter storage equipment and control equipment. The modification of the general shop and service area and the acquisition of test benches and related facilities is estimated at $4000.

The estimated costs for the laboratory and shop equipment are necessarily general. Laboratory costs cover, for example, standard glassware utilized in routine chemical analyses. The costs of specialized laboratory equipment, such as a mass spectrograph and analytical balances, are included within the costs of the various research experiments for which they will be required. Costs of the shop equipment and tools are intended to include common hand and small power tools and standard electronic test equipment.

Vehicular Support Facilities

The estimated costs of the vehicular support facilities are shown in Table XX-5. The support facilities consist of 13 vehicles and their associated equipment. An estimated total of three mobile calibration units have been estimated to be required to provide field calibration and standardization of air quality instruments on a 30-day period. The equipment requirements for the units are discussed in Chapter XII of this Prospectus.

Nine maintenance vehicles of standard pick-up or panel truck design are estimated to be required. The maintenance schedule was indicated in Chapter XVIII to require initially a twice weekly visit to each instrument station, and this would require eight technicians and eight maintenance vehicles. Over time this maintenance schedule can likely be modified to a weekly maintenance visit with a concomitant decrease in the "roving" technicians to five and the reassignment of three to the central facility for instrument maintenance tasks which cannot be carried out in the field. Since these technicians would be on call to assist the roving

Table XX-5

INITIAL COST OF VEHICLE SUPPORT FACILITIES
(Thousands of Dollars)

	Unit Cost	Total Cost
Mobile calibration unit, 3 required		
Van or modified truck	$ 8.0	$24.0
Sulfur dioxide permeation tube	2.8	8.4
Ozone generator	1.4	4.2
Mass flow meters	2.8	8.4
Air conditioning	0.5	1.5
Electric power generator	0.4	1.2
Permeation tube bath transformer	0.5	1.5
Racks, benches, cylinder mounts	0.6	1.8
Manifolding, valving, tubing, regulators	1.1	3.3
Subtotal	$18.1	$54.3
Maintenance vehicle, 9 required		
Truck pick-up or panel	4.0	36.0
Maintenance equipment	0.2	1.8
Brackets and restrainers for transporting instruments and calibration cylinders	0.2	1.8
Subtotal	$ 4.4	$39.6
General equipment transport truck, 1 required	5.0	5.0
Total	$27.5	$98.9

technicians in the more complex instrument maintenance tasks, the service vehicles would continue to be required. The ninth vehicle would provide general purpose transportation for other personnel and would serve as a substitute during maintenance of the others.

The general equipment transport truck is expected to be required for movement of the bulky or heavier items of equipment, such as groups of instruments, some of which weigh in the order of 250 pounds, and fencing for the transportable Class B_2 and C_2 stations. The truck should also be capable of towing the transportable stations. The frequency of usage of this vehicle may prove upon further examination to be sufficiently low to suggest the use of a rental vehicle rather than purchase.

The costs of vehicle support for administrative and other duties are considered to be subsumed within the personnel cost factors subsequently discussed and are therefore not specified here.

Total Initial Costs

The estimated total initial unit cost of the six types of instrument stations is summarized in Table XX-6.

Table XX-6

ESTIMATED TOTAL INITIAL UNIT COST
OF THE INSTRUMENT STATIONS
(Thousands of Dollars)

	Station Class					
Station Component	A_1	A_2	B_1	B_2	C_1	C_2
Air quality instruments	$38.0	$38.0	$30.0	$30.0	--	--
Calibration equipment/ accessories	8.3	8.3	7.7	7.7	--	--
Meteorological instruments	11.0	4.4	1.0	1.0	$11.0	$ 1.0
Instrument spare parts	5.7	5.1	3.8	3.8	1.1	0.1
Site preparation, shelter fixtures	13.1	13.1	5.6	5.4	9.7	2.6
Digital data terminal equipment	9.6	9.3	9.0	9.0	11.7	11.4
Total	$85.7	$78.2	$57.1	$56.9	$33.5	$15.1

For most stations the air quality instruments represent approximately one-half the total station cost. These station unit costs are aggregated in Table XX-7 to show the total estimated initial cost of the instrument system along with the estimated initial costs of the central facility and support units. The total estimated initial cost for the facility is $3,943.6 million. More than 90% of the cost is associated with the instrument stations and about 2% is attributable to the data-processing and communication system. The Class B_1 instrument stations account for approximately one-third of the initial costs primarily because of the large

Table XX-7

ESTIMATED TOTAL INITIAL EQUIPMENT COSTS OF ST. LOUIS FACILITY
(Thousands of Dollars)

	Station Class						
	A_1	A_2	B_1	B_2	C_1	C_2	Total
Station component							
Air quality instruments	$342.0	$304.0	$ 720.0	$240.0	--	--	$1,606.0
Calibration equipment/accessories	74.7	66.4	184.8	61.6	--	$ 4.8	392.3
Meteorological instruments	99.0	35.2	24.0	8.0	$ 44.0	24.0	234.2
Instrument spare parts	51.3	40.8	91.2	30.4	4.4	2.4	220.5
Site preparation, shelter, fixtures	117.9	104.8	134.4	43.2	38.8	62.4	501.5
Digital data terminal equipment	86.4	74.4	216.0	72.0	46.8	273.6	769.2
Subtotal	$771.3	$625.6	$1,370.4	$455.2	$134.0	$367.2	$3,723.7
Central facility and support							
Data processing and communication							81.0
General facilities							35.0
General laboratory and shop equipment							5.0
Support vehicles							98.9
Subtotal							$ 219.9
Total	$771.3	$625.6	$1,370.4	$455.2	$134.0	$367.2	$3,943.6

quantity of stations in this class. Aside from the four Class C_1 stations, the 24 Class C_2 stations comprise the lowest cost element. These stations, however, have no air quality instruments installed. Hence, their full cost as an operating unit will be considerably greater depending upon the nature of the instruments installed in support of the various research experiments.

The overall facility activation schedule presented in Table XVIII-7 by quarter following authorization of the Regional Study can be used to define the expenditure schedule for the St. Louis facility.

Table XX-8 summarizes the schedule for all classes of instrument stations within the three activity categories used in Table XVIII-7. Additionally, expenditure schedules are shown for the central facility and vehicular support. Expenditures are shown within the quarter in which the indicated activities are completed. The greatest level of expenditure is estimated to occur during the third quarter and is caused primarily by acquisition of the air quality instruments for the Class B_1 stations. Otherwise, expenditure levels for other quarters tend to be relatively constant. Alternative activation scheduling will, of course, markedly affect the expenditure schedule for the St. Louis facility. Significant budgetary limitations or other constraints imposed on the Regional Study or elsewhere may indeed cause adjustments in the expenditure schedule shown in Table XX-8. This of course could have serious implications on the implementation schedule and require extensive reevaluation of the complete facility. Such analyses are beyond the scope of this Prospectus, but they would be expected to be continually undertaken during subsequent planning and implementation of the Regional Study.

Annual Operating Costs

The estimated annual operating costs are presented in this section. The reliability of these estimates vary appreciably among the cost categories because their bases can be defined to differing degrees of certainty. Some costs, for example, will be highly dependent upon actual conditions found in St. Louis, whereas others are largely independent of the area. Generally, the larger operating cost elements have been examined in greater detail than the lesser elements. For planning purposes of this Prospectus, the effort to develop rigorous methods to estimate the latter cost elements is judged to be inappropriate as their contribution in some instances is 3-5% or perhaps far less than the principal elements. Accordingly, in these cases these estimates should be regarded essentially as an order-of-magnitude indication of the anticipated cost.

Table XX-8

ESTIMATED INITIAL EXPENDITURE SCHEDULE
FOR ACTIVATION OF THE ST. LOUIS FACILITY
(Thousands of Dollars)

	Quarter					
	1	2	3	4	5	Total
Shelter, appurtenances, towers, site preparation						
Prototype		$ 26.2	$			$ 26.2
A_1		91.7				91.7
A_2			$ 104.8			104.8
B_1			134.4			134.4
B_2			43.2			43.2
C_1			19.4	$ 19.4		38.8
C_2		13.0	33.8	15.6		62.4
Subtotal		$130.9	$ 335.6	$ 35.0		$ 501.5
Instruments and accessories						
Prototype		$126.0				$ 126.0
A_1			$ 441.0			441.0
A_2			446.4			446.4
B_1			1,020.0			1,020.0
B_2			212.5	$127.5		340.0
C_1				48.4		48.4
C_2		3.9	16.9	10.4		31.2
Subtotal		$129.9	$2,136.8	$186.3		$2,453.0
Digital terminals						
Prototype			$ 19.2			$ 19.2
A_1				$ 67.2		67.2
A_2				55.8	$ 18.6	74.4
B_1					216.0	216.0
B_2					72.0	72.0
C_1				46.8		46.8
C_2		$ 45.6	148.2	79.8		
Subtotal		$ 45.6	$ 167.4	$249.6	$306.6	$ 769.2
Central facility						
Data equipment			$ 81.0			$ 81.0
General facilities	$35.0					35.0
Support equipment	5.0					5.0
Subtotal	$40.0		$ 81.0			$ 121.0
Vehicular support						
Calibration vans		$ 18.1	$ 36.2			$ 54.3
Maintenance trucks	$ 8.8	17.6	13.2			39.6
General transport		5.0				5.0
Subtotal	$ 8.8	$ 40.7	$ 49.4			$ 98.9
Total	$48.8	$347.1	$2,770.2	$470.9	$306.6	$3,943.6

Personnel

By far the greatest component of annual operating cost is attributable to the Regional Study permanent staff. The overall direct and indirect costs of personnel can be developed by a wide variety of techniques depending upon the mix of personnel levels or grades composing the organizational unit and the general scope of their activities. For overall planning purposes of this Prospectus, the most appropriate method is judged to be the use of a single man-year cost factor applied to all personnel of the Regional Study staff. The development and application of methods to estimate total staff costs by each element--direct compensation, benefits, travel, general support, and the like--tends to be unnecessarily complex and to provide a misleading measure of accuracy to the estimates.

The Regional Study staff has two general components with one at the Research Triangle Park and the second in St. Louis. The Research Triangle Park group is composed largely of professional personnel who will be expected to have considerable travel requirements in the execution of their assignments and will generally have appreciable clerical and other support requirements. On the other hand, the St. Louis facility staff has an appreciably greater proportion of nonprofessional personnel whose base salary is less than that of the typical professional and whose requirements for travel and support personnel will be substantially less. Accordingly, the staffing costs estimated for the Regional Study will utilize two man-year factors. The Research Triangle Park staff will be taken at the rate of $25,000 per man-year, and the St. Louis staff will be taken at $22,000 per man-year. These factors incorporate all direct and indirect costs, including employee benefit programs of all types, travel costs, and other support costs. These man-year cost factors have been found to apply generally to non-Washington, D.C., field installations of the EPA, and somewhat similar factors apply to the private sector as well. Accordingly, these man-year factors as extended to the Research Triangle Park staff and the St. Louis facility staff result in the annual personnel costs as shown in Table XX-9.

Instrument Replacement and Spare Parts

The annual costs for instrument replacement and spare parts must be tentative since little operational experience and few measures of reliability of instrumentation are currently available, especially for the air quality instruments. Instrument and parts replacement rates are expected to be nonlinear in time with the rate gradually increasing. For planning purposes here, the average estimated equipment and parts

Table XX-9

ESTIMATED ANNUAL PERSONNEL COSTS
OF THE REGIONAL STUDY
(Thousands of Dollars)

	Man-Year Cost	Total Cost
St. Louis facility staff		
Professional, 9	$22.0	$ 198.0
Nonprofessional, 36	22.0	792.0
Subtotal		$ 990.0
Research Triangle Park staff		
Professional, 6	$25.0	150.0
Nonprofessional, 3	25.0	75.0
Subtotal		$ 225.0
Total		$1,215.0

replacement cost is $100 per year for each air quality instrument and $25 per year for each meteorological instrument. The meteorological instrument cost is based upon normal instrument operational degradation. In the event of severe vandalism, this estimate could prove to be markedly lower than would actually be experienced.

Overall station replacement parts, such as air conditioner filters, solenoid valves, tubing, and manifolding are taken at $200 per year per station or 10% of their original cost at a Class A_1 station, except for the Class C_2 stations which are taken at $100 per year because they are not expected to be in operation throughout the year. Digital data equipment replacement components are taken at 5% of their initial cost or $400 per year per station. The data terminal costs may be slightly low for the Class C_1 and Class C_2 stations because of their use of the nine-track tape system which undoubtedly will require maintenance in considerable excess of the solid-state system components. These unit costs extended to a per-station basis result in annual operating costs as shown in Table XX-10.

Table XX-10

ESTIMATED ANNUAL COST FOR INSTRUMENT STATION
EQUIPMENT REPLACEMENT PARTS AND GENERAL MAINTENANCE
(Thousands of Dollars)

	Station Class					
	A_1	A_2	B_1	B_2	C_1	C_2
Unit station cost						
Air quality instruments	$ 0.9	$ 0.9	$ 0.7	$ 0.7	--	--
Meteorological instruments	0.3	0.1	0.1	0.1	$0.3	$ 0.1
Digital data equipment	0.4	0.4	0.4	0.4	0.4	0.4
General maintenance	0.2	0.2	0.2	0.2	0.2	0.1
Total	$ 1.8	$ 1.6	$ 1.4	$ 1.4	$0.9	$ 0.6
Total system cost						
Air quality instruments	8.1	7.2	16.8	5.6	--	--
Meteorological instruments	2.7	0.8	2.4	0.8	1.2	2.4
Digital data equipment	3.6	3.2	9.6	3.2	1.6	9.6
General maintenance	1.8	1.6	4.8	1.6	0.8	2.4
Total	$16.2	$12.8	$33.6	$11.2	$3.6	$14.4

Telephone Communication System

The annual operating costs associated with the full-duplex telephone leased facilities are based upon a unit charge of $4 per mile per month which is representative of tariffs in many urban areas of the nation. Lower charges approximating perhaps $3 per mile per month are frequently applied to facilities located elsewhere, provided that service drops can be relatively easily installed from existing facilities. In the event that substantial effort is required to provide telephone service, a higher unit cost results. Since a number of the more remote instrument stations, especially those in the southwest quadrant, may not be conveniently near existing facilities having the required transmission characteristics, the unit cost of $4 per mile per month is used for the entire system to compensate for possible appreciable installation efforts in this quadrant.

Clearly, any number of routing patterns to link the remote reporting stations to the central facility are possible. These will be determined by telephone line quality, circuit availability, cost, and numerous other factors that require extensive analysis by the telephone utilities. For purposes of estimating the average annual cost, a total of seven full-duplex leased circuits have been assumed with seven instrument stations per circuit. A possible routing pattern having a relatively low, but not absolutely minimal, total circuit mileage was established and is summarized in Table XX-11 showing the stations on each circuit, and the total mileage per circuit to the central facility assumed to be located in the Alton, Illinois, vicinity. Total circuit mileage for this network approximates 800 miles. The corresponding monthly rental is therefore $3200, or $38,400 annually.

Table XX-11

ESTIMATED INSTRUMENT STATION REPORTING
CIRCUIT ASSIGNMENT AND CIRCUIT LENGTH

Circuit Number						
1	2	3	4	5	6	7
$1SW3A_2$	$1S3A_1$	$1SE3B_2$	$1SE2A_2$	$2SE6A_1$	$1E2A_1$	$1W4A_1$
$2SW7A_2$	$3SW21B_1$	$2S4B_2$	$2SE5B_2$	$3SE24B_1$	$2E6A_2$	$2W8A_2$
$3SW20B_1$	$3SW16B_1$	$2S7A_2$	$3SE23B_1$	$3SE19B_1$	$2NE5A_1$	$2NW8A_1$
$3W15B_1$	$3W12B_1$	$3S22B_1$	$3SE18B_1$	$3E14B_1$	$1NE1A_2$	$1NW4A_2$
$3W11B_1$	$3NW7B_1$	$3S17B_1$	$3E13B_1$	$3NE10B_1$	$2NE8B_2$	$1NW1B_2$
$3NW6B_1$	$3NW2B_1$	$309A_1$	$3NE9B_1$	$3NE5B_1$	$2N7B_2$	$1N1A_1$
$3NW1B_1$	$3N3B_1$	$3N8B_1$	$3NE4B_1$	$2N5A_2$	$2NW6B_2$	$1NE2B_2$
Total Mileage						
90	90	90	100	70	160	200

Motor Vehicles

Motor vehicle operating costs are primarily related to the instrument station maintenance and calibration schedule. This schedule can have an almost endless number of variations and in the final analysis would be determined by the operational experience and demonstrated reliability of each station. Accordingly, an estimate of motor vehicle operating costs can at this point be only an order of magnitude.

A reasonable approximation of maintenance vehicle movement distances can be derived from the telephone circuit mileage estimate. The total circuit length of this system was estimated at 800 miles. With a maintenance schedule involving a stop at each station twice per week, this basic distance could be doubled to 1600 miles. The communication circuit length was developed on the basis of point-to-point distance measures. The standard correction of 1.2 should be applied for an aggregated estimated maintenance vehicle movement 1900 miles per week or about 99,000 miles per year. At a unit cost of $0.10 per mile, the total annual cost for maintenance vehicles is estimated to be $9900.

The operating cost of the three calibration vans will be substantially less because of the more limited requirement of monthly instrument station calls. The basic 800-mile circuit would be traversed on a once-per-month basis but with a substantial correction factor for frequent return to the central facility. This correction factor can be only an outright assumption at this point and will be taken as a value of four to assume a once-per-week return to the central facility for a total of 3200 miles per month. Adjusting by the factor of 1.2 for surface movement results in a total of approximately 3800 miles per month or an annual cost in the range of $4600.

Building and Land Rental

The estimated building and land rental costs for the St. Louis facility present similar difficulties, especially for the instrument site costs. The space requirements for the central facility were estimated in Chapter XVI at 5600 square feet. The character of the facility is expected to be typical of a single-floor light manufacturing plant with office space included. Rental rates will naturally vary considerably depending on location and other factors but in general a rate of $0.20 per square foot per month should be an appropriate estimating factor. At this unit cost the annual facility rental costs would be $13,400.

Land requirements at the central facility were estimated at 30,000 square feet for parking and outdoor equipment storage. These uses imply a finished surface over at least most of the area with asphalt or gravel with proper drainage and the like. The storage area should be fenced and perhaps lighted. With these requirements the unit cost should approximate $0.02 per square foot per month for an annual rental of $7200.

The land requirements for the instrument stations will vary in area and certainly in rental rates. Sites in urbanized St. Louis are expected to be difficult to acquire and could indeed carry rental rates of several thousands of dollars per month. On the other hand, acquisition of the rural sites likely will be considerably easier and rates significantly lower. In some cases, both urban and rural sites might be situated on public lands for which no or at most a token rent might be involved. No satisfactory method is at hand to develop a highly dependable estimate of these rental rates. The Class A stations should preferably be situated on about a one-fourth acre, whereas the Class B station could be confined within an average urban or suburban building lot. If for example these lots were taken in the average as having a value of $5000, a $1000 annual rental would not be unexpected. The bulk of the Class A stations are situated in a considerably more rural environment, where land costs will be somewhat less, but the land requirements are greater than those of the Class B stations by approximately a factor of two.

For planning purposes here, the assumption was made that these two factors are compensating, so that sites on the average have an annual rental of $1000. Thus, the total annual rental rate is estimated at $49,000 and an additional $4000 is to be included for the Class C_1 stations.

Site rentals for the Class C_2 stations tend to be even more elusive because of their probable short duration at any one site and their varying location requirements. Conceivably many of the Class C_2 locations might be situated at places carrying a token or no cost, such as residential back yards, cemeteries, and parks. On the other hand, some sites may of necessity be situated in downtown office buildings and not in trailers, where rental rates may be as high as $0.30-$0.40 per square foot per month. The fact that the Class C_2 stations are expected to be utilized for only selected portions of the year also introduces additional complexities in determining station cost. Thus, any rental planning factor stands only as a first approximation and should be treated accordingly. For purposes here an annual unit cost will be taken as $200/station or one-fifth the larger station sites for a total of $4800 per year for all 24 Class C_2 stations.

Miscellaneous

An enormous number of lesser operational costs will clearly arise during the Regional Study. For the purposes of this Prospectus, the identification and costing of each does not appear appropriate, since their effect on planning and budgeting generally fades to insignificance when compared with, say, personnel costs. Several of these, however, are worthy of note and are discussed below. The remainder, however, are judged to be most appropriately developed in later more detailed planning and actual implementation of the facility.

An operating item of particular importance is the calibration gases required for the air quality instruments. The costs of these gases can vary significantly with their purity. For example, ethylene gas required for calibration of the ozone-monitoring instrument may vary in cost by roughly a factor of 10 between 99.8% and 99.9% purity. For field instrument calibration it would appear that a purity of 99.8% should suffice. As an order of magnitude cost calibration, gases--span and zero--are estimated at $2000 per station per year. With a total of 49 stations utilizing approximately the same mix of air quality instruments, the total estimated annual cost should be in the order of $98,000.

An additional operating cost of some significance is expected to be electric power. The power costs for instrument operation itself should be relatively low, but costs for heating and air conditioning the instrument shelters may be significant, especially if the shelters are not well insulated. Electric power costs might be expected to average about $20 per month per station, so that total power costs should be in the order of $12,700 per year for all but the Class C_2 stations.

As noted, other costs could be identified, such as utility costs at the central facility, office supplies, and numerous others. Some of these are subsumed within the man-year estimating cost factor, while others might be considered as covered by the central facility rental cost. Final development of cost estimates for these and similar details will generally require more exact information than is presently available and therefore will not be undertaken for this Prospectus.

Total Estimated Annual Operating Costs

The estimated annual operating costs, once full operational status has been achieved, are shown in Table XX-12. Annual personnel costs account for almost 80% of the total. As will be recalled, they include expenditures for travel and other purposes as well as direct salaries, benefits, and indirect costs. The cost of air quality instrument calibration gases represents the second largest component of the operating costs with slightly over 6% of the total, closely followed by instrument replacement and spare parts with slightly less than 6% of the costs. The remaining components are estimated to contribute generally less than 3% of the total costs.

The operating costs during the early portion of the Regional Study are, of course, substantially less than the costs during full operation. Table XVIII-7 summarized the activation schedule of the St. Louis facility whereas Table XIX-3 indicated the staffing schedule. On the basis

Table XX-12

ESTIMATED TOTAL ANNUAL OPERATING COSTS
OF THE REGIONAL STUDY
(Thousands of Dollars)

Personnel	$1,215.0
Instrument replacement and parts	91.8
Motor vehicle operation	14.5
Telephone communication system	38.4
Building and land rental	
Central facility	20.6
Instrument sites	57.8
Calibration gases	98.0
Electric power	12.7
Total	$1,548.8

of these data, the operating costs by quarter following authorization of the Regional Study have been estimated as shown in Table XX-13. Operating costs are shown through the fifth quarter, at which time the steady-state expenditure level is estimated to have been reached. Personnel costs at the Research Triangle Park are shown at $75,000 during the first quarter and decreasing until the fifth quarter. This trend results from the transfer of some staff members to St. Louis in the early quarters and the completion of various tasks at the Research Triangle Park covering acquisition of the equipment and instruments.

The personnel costs tend to increase with the level of completion of the facility. The exception to this trend is the estimated costs for instrument replacement and parts. No operating costs for this component are shown until the fifth quarter under the assumption that all instruments will be covered by manufacturer's warranty or similar features during at least the first six months following initiation of operation.

Table XX-13

ESTIMATED QUARTERLY OPERATING COSTS DURING ACTIVATION OF THE ST. LOUIS FACILITY
(Thousands of Dollars)

	Quarter				
	1	2	3	4	5
Personnel					
Research Triangle Park	$75.0	$ 68.7	$ 56.2	$ 50.0	$ 56.2
St. Louis	22.0	82.5	181.5	242.0	247.5
Subtotal	$97.0	$151.2	$237.7	$292.0	$303.7
Instrument replacement and parts	0	0	0	0	22.9
Motor vehicle operation	0	2.0	3.8	3.8	3.8
Telephone communication system	0	0	0	6.0	9.6
Central facility, rental	2.0	5.1	5.1	5.1	5.1
Instrument sites, rental	0	3.0	14.4	14.4	14.4
Calibration gases	0	2.0	24.5	24.5	24.5
Electric power	0	0	3.2	3.2	3.2
Subtotal	$ 2.0	$ 12.1	$ 51.0	$ 57.0	$ 83.5
Total	$99.1	$163.3	$288.7	$349.0	$387.2

Chapter XXI

RESEARCH PLAN COSTS

Introduction

Part II of the Prospectus presents the Research Plan for scientific and technical analyses and field experimental and data gathering efforts that are expected to constitute the principal components of the Regional Study. Specific tasks of the Research Plan are grouped in four primary program elements and numerically encoded for ease of identification. These program elements and their principal components are shown as follows:

- 100 Model Verification
  - 101 Boundary Layer Meteorology
  - 102 Emission Inventory
  - 103 Air Quality Measurement
  - 104 Model Verification
- 200 Atmospheric Chemical and Biological Processes
  - 201 Gaseous Chemical Processes
  - 202 Particulate Formation
  - 203 Other Pollutant Processes
  - 204 Atmospheric Scavenging
  - 205 Biosphere Scavenging
  - 206 Atmospheric Dispersion
- 300 Human Social and Economic Factors
  - 301 Human and Social Factors

302 Economic Factors

400 Transfer of RAPS Technology for Control Agency Applications

401 Source Inventory Procedures

402 Atmospheric Monitoring

403 Data Handling

404 Modeling Technology

405 Other Significant Factors in Control Strategy Formulation

This chapter presents the estimated requirements for personnel, major equipment, and the costs of these programs. Although these estimates are judged to be suitable for the planning purposes of this Prospectus, they will require continual review and modification in further planning of the Regional Study and during its execution. This is especially important for the estimates in the later time periods. The estimates presented are intended to cover the requirements of each particular program component, and all are considered as a part of the Regional Study. Further consideration of the Research Plan and perhaps EPA policy considerations may result in the transfer of part or all of certain program components from the Regional Study to other components of the ongoing EPA research program.

Personnel

Requirements

The estimated requirements for personnel stemming from the Research Plan are presented in Table XXI-1 for professional and support personnel. Scheduling is shown on the assumption that the Regional Study is authorized July 1, 1972. A total of 1,244.85 man-quarters, or slightly more than 311 man-years of professional and technical support personnel, are estimated to be required to carry out the Research Plan. Almost one-half of the personnel requirements stem from the 100-series tasks--Model Verification--alone. Within this series about one-half of the personnel are associated with the critical 104 component which covers the specific efforts associated with model verification. The 100 and 200 series have a ratio in the range of two-thirds to three-fourths between professional and technical support personnel, which tends to be appropriate in view

Table XXI-1

ESTIMATED PROFESSIONAL AND TECHNICAL STAFFING REQUIRED TO CARRY OUT THE RESEARCH PLAN
(Men by Quarter)

Program	1972				1973								1974							
	3		4		1		2		3		4		1		2		3		4	
Component	P*	S*	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
100																				
101	1.5	1.0	1.5	1.0	1.5	1.0	2.5	2.0	1.5	1.0	1.5	1.0	1.5	1.0	2.5	4.0	2.5	4.0	1.5	1.0
102	1.0		3.0	2.0	5.0	4.0	5.0	6.0	8.0	8.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
103	1.0		2.5	2.0	2.5	2.0	2.25	2.5	2.25	2.5	2.5	3.5	2.5	3.5	2.5	3.5	2.5	3.5	2.5	3.5
104	6.5	14.0	6.5	14.0	6.5	14.0	6.5	14.0	7.5	14.5	8.0	14.5	8.0	14.5	8.0	14.5	8.0	14.5	8.0	14.5
Subtotal	10.0	15.0	13.5	19.0	15.5	21.0	16.25	24.5	19.25	26.5	18.5	25.0	18.0	25.0	19.0	28.0	19.0	28.0	18.0	25.0
200																				
201	1.25		1.25		1.25		1.25		1.25		1.25		2.75	3.25	1.75	2.0	2.25	2.0	2.50	3.0
202													1.00	5.00	1.25	5.0	1.25	5.0	1.25	5.0
203									0.25		0.25		0.50	0.50	0.50	0.5	0.50	0.5	0.50	0.5
204			0.50	0.5	0.50	0.5	0.50	0.5	0.50	0.5			0.40	1.50	0.40	1.5	0.40	1.5	0.40	1.5
205															0.25	1.0	0.25	1.0		
206									1.00	1.0	1.0	1.0	1.00	1.00	1.50	1.0	1.00	1.0	1.50	1.0
Subtotal	1.25		1.75	0.5	1.75	0.5	1.75	0.5	3.00	1.5	2.5	1.0	5.65	11.25	5.65	11.0	5.65	11.0	6.15	11.0
300																				
301					1.0	1.0	1.0	1.0	1.0	1.0	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.0
302					1.0	1.0	1.0	1.0	1.0	1.0	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.0
Subtotal					2.0	2.0	2.0	2.0	2.0	2.0	2.00	2.0	2.00	2.00	2.00	2.0	2.00	2.0	2.00	2.0
400																				
401																				
402							1.0		2.0		2.00		2.25		2.25		0.75		1.75	2.0
403																	0.50		0.50	
404					0.5		0.5		0.5		0.50		2.00	1.50	2.00	1.5	0.50		0.50	
405					1.0	1.0	1.0	1.0	1.0	1.0	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.0
Subtotal					1.5	1.0	2.5	1.0	3.5	1.0	3.50	1.0	5.25	2.50	5.25	2.5	2.75	1.0	3.75	3.0
Total	11.25	15.0	15.25	19.5	20.75	24.5	22.5	28.0	27.75	31.0	26.50	29.0	30.90	40.75	31.90	43.5	29.40	42.0	29.90	41.0

* P = Professional
S = Technical support.

Table XXI-1 (Concluded)

Program Component	1975								1976								1977				Total	
	1		2		3		4		1		2		3		4		1		2			
	P*	S*	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
100																						
101	2.5	1.5	3.5	4.5	4.5	5.5	3.50	2.5	3.5	2.5	3.5	2.5	2.5	2.0	2.5	2.0	2.5	2.0	2.50	2.0	49.00	44.00
102	4.5	4.5	4.0	4.0	2.5	2.5	2.50	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.50	2.5	81.00	79.00
103	2.5	3.5	2.5	3.5	2.5	3.5	2.50	3.5	2.5	3.5	2.5	3.5	2.5	3.5	2.5	3.5	2.5	3.5	2.50	4.5	48.00	61.50
104	8.0	14.5	8.0	14.5	8.0	14.5	8.00	14.5	8.0	14.5	8.0	14.5	8.0	14.5	8.0	14.5	8.0	14.5	8.00	14.5	153.50	288.00
Subtotal	17.5	24.0	18.0	26.5	17.5	26.0	16.50	23.0	16.5	23.0	16.5	23.0	15.5	22.5	15.5	22.5	15.5	22.5	15.50	22.5	331.50	472.50
200																						
201	2.5	3.5	2.25	4.0	2.75	4.5	2.50	4.5	2.75	4.50	3.00	4.50	3.50	5.00	3.25	5.0	3.75	2.0	3.75	2.0	46.75	49.75
202	1.0	3.0	1.50	1.5	1.00	1.0	0.75	1.0	1.00	3.00	1.00	3.00	0.75	2.50	1.00	2.5	0.50	1.0	0.50	1.0	13.75	39.50
203	1.5	2.5	1.00	2.5	1.50	4.0	1.75	4.0	0.75	2.25	0.75	2.25	2.00	1.25	2.00	1.0	0.50	0.5	0.50	0.5	14.75	22.75
204	0.4	1.5	0.40	1.5	0.40	1.5	0.40	1.5	0.40	1.50	0.40	1.50	0.40	1.50	0.40	1.50	0.40	1.5	0.40	1.5	7.60	23.00
205					0.25	1.0	0.25	1.0	0.50	0.20	0.50	2.00	0.50	2.00	0.50	2.00	0.50	1.0	0.50	1.0	4.00	14.00
206	1.0	1.0	1.00	1.0	1.00	1.0	1.00	1.0	1.00	1.00	0.50	1.00									12.50	12.00
Subtotal	6.4	11.5	6.15	10.5	6.90	13.0	6.65	13.0	6.40	14.25	6.15	14.25	7.15	12.25	7.15	12.00	5.65	5.0	5.65	6.0	99.35	161.00
300																						
301	1.0	1.0	1.00	1.0	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	18.00	18.00
302	1.0	1.0	1.00	1.0	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	18.00	18.00
Subtotal	2.0	2.0	2.00	2.0	2.00	2.0	2.00	2.0	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.0	2.00	2.0	36.00	36.00
400																						
401	1.00	1.0	1.00	1.0													1.00	1.0	1.00	1.0	4.00	4.00
402	1.75	2.0	0.75		0.25		1.25	2.0	1.25	2.00	0.25		0.25		1.25	2.00	2.25	2.0	2.25		23.50	12.00
403																	0.50		0.50		2.00	
404	0.50		0.50		0.50		0.50		0.50		0.50		2.00	1.50	2.00	1.50	2.00	1.5	2.00	1.5	18.00	9.00
405	1.00	1.0	1.00	1.0	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	18.00	18.00
Subtotal	4.25	4.0	3.25	2.0	1.75	1.0	2.75	3.0	2.75	3.00	1.75	1.00	3.25	2.50	4.25	4.50	6.75	5.5	6.75	3.5	65.50	43.00
Total	30.15	41.5	29.40	41.0	28.15	42.0	27.90	41.0	27.65	42.25	26.40	40.25	27.90	39.25	28.90	41.00	29.90	36.0	29.90	34.0	532.35	712.50

* P = Professional
S = Technical Support.

of the extensive laboratory and field efforts expected. The 300 and 400 series tend to require considerably fewer technical support personnel in comparison to professionals, because far less field efforts are expected.

Each of the four major program elements would be expected to be coordinated by the various research division representatives in the Office of Research Operations. Major program components, especially those continuing throughout the life of the Regional Study, would necessarily have full-time supervisors within the respective interested research divisions. The extent to which contractor participation will be necessary and appropriate is difficult to state and is likely to depend on the balance between program requirements in terms of scheduling and capability and the available resources within EPA. However, total personnel requirements should remain substantially identical regardless of the manner in which the effort is carried forth.

Professional and technical support personnel were estimated on a task-by-task basis from their descriptions in Part II of this Prospectus. An additional component of the staffing will be clerical support. For planning purposes, clerical personnel requirements are estimated on the basis of one per six professionals.

Total personnel requirements are shown in Table XXI-2 by Research Plan element. A total of 328 man-years is estimated to be required to complete the Research Plan.

Costs

The total estimated costs of personnel associated directly with the tasks included in the Research Plan are presented in Table XXI-3 based on the requirements shown in Tables XXI-1 and -2. The estimated costs as discussed in Chapter XIX are based on a unit cost of $25,000 per year per staff member regardless of his labor or job classification. With the mix of classifications estimated to be required, the aggregated estimates should be valid. Estimates for the smaller components of the Research Plan, which have a less balanced staffing pattern, would tend to be less reliable. The unit cost includes direct salary, benefits, travel, and all other funds necessary for support.

Total personnel costs directly associated with the Research Plan are estimated at about $8.3 million. The costs tend to be relatively constant over the life of the program at an expenditure level in the range of $475,000 per quarter. The estimated cost on an annual basis

Table XXI-2

SUMMARY OF PERSONNEL REQUIREMENTS FOR THE RESEARCH PLAN
(Man-Years)

Program Element	Professional	Technical Support	Clerical	Total
100	83	118	14	215
200	25	40	4	69
300	9	9	2	20
400	16	5	3	24
Total	133	172	23	328

is summarized in Table XXI-4 for each of the four principal elements of the Research Plan.

Instrumentation and Equipment

The bulk of the instrumentation and equipment necessary for execution of the Research Plan is included in the St. Louis facility as discussed in Chapters XI-XII and XVIII. These items are generally expected to function throughout the life of the Regional Study. However several major items of equipment are more appropriately included in the costs of the Research Plan than in the St. Louis facility. The first includes the METRAC balloon-borne instrument system discussed in Chapters III and XIV for observations in the mixing layer. Estimated costs for additional research and development were estimated at $100,000 in the first year after authorization of the Regional Study. If the development is successful, an additional cost of $376,000 has been estimated for full implementation of the system having a capability to simultaneously track six balloons. The estimated costs by quarter are shown in Table XXI-5.

Table XXI-3

ESTIMATED PERSONNEL COSTS TO CARRY OUT THE RESEARCH PLAN
(Thousands of Dollars)

Program Component	1972		1973				1974				1975				1976				1977		Total
	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	
100																					
101	$ 15.6	$ 15.6	$ 15.6	$ 28.1	$ 15.6	$ 15.6	$ 15.6	$ 40.6	$ 40.6	$ 15.6	$ 25.0	$ 50.0	$ 62.5	$ 37.5	$ 37.5	$ 37.5	$ 28.1	$ 28.1	$ 28.1	$ 28.1	$ 580.9
102	6.2	31.2	56.2	68.8	103.1	78.1	75.0	75.0	75.0	75.0	56.2	50.0	31.2	31.3	31.2	31.3	31.2	31.3	31.2	31.3	999.8
103	6.2	28.1	28.1	29.7	29.7	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	684.3
104	128.1	128.1	128.1	128.1	137.5	140.6	140.6	140.6	140.6	140.6	140.6	140.6	140.6	140.6	140.6	140.6	140.6	140.6	140.6	140.6	2758.9
Subtotal*	$156.1	$203.0	$228.0	$254.7	$285.9	$271.8	$268.7	$293.7	$293.7	$268.7	$259.3	$278.1	$271.8	$246.9	$246.8	$246.9	$237.4	$237.5	$237.4	$237.5	$5023.9
Clerical	10.4	14.1	16.1	16.9	20.0	19.3	18.8	19.8	19.8	18.8	18.2	18.8	18.2	17.2	17.2	17.2	16.1	16.1	16.1	16.1	345.2
Total	$166.5	$217.1	$244.1	$271.6	$305.9	$291.1	$287.5	$313.5	$313.5	$287.5	$277.5	$296.9	$290.0	$264.1	$264.0	$264.1	$253.5	$253.6	$253.5	$253.6	$5369.1
200																					
201	7.8	7.8	7.8	7.8	7.8	7.8	37.5	23.4	26.6	34.4	37.5	39.1	45.3	43.8	45.3	46.9	53.1	51.6	35.9	35.9	603.1
202							37.5	39.1	39.1	39.1	25.0	18.8	12.5	10.9	25.0	25.0	20.3	21.9	9.4	9.4	333.0
203					1.6	1.6	6.2	6.2	6.2	6.2	25.0	21.9	34.4	35.9	18.8	18.8	20.3	18.8	6.2	6.2	234.3
204		6.2	6.2	6.2	6.2		11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	191.4
205								7.8	7.8				7.8	7.8	15.6	15.6	15.6	15.6	9.4	9.4	112.4
206					12.5	12.5	12.5	15.6	12.5	15.6	12.5	12.5	12.5	12.5	12.5	9.4					153.1
Subtotal*	$ 7.8	$ 14.0	$ 14.0	$ 14.0	$ 28.1	$ 21.9	$105.6	$104.0	$104.1	$107.2	$111.9	$104.2	$124.4	$122.8	$129.1	$127.6	$121.2	$119.8	$ 72.8	$ 72.8	$1627.3
Clerical	1.3	1.8	1.8	1.8	3.1	2.6	5.9	5.9	5.9	6.4	6.7	6.4	7.2	6.9	6.7	6.4	7.4	7.4	5.9	5.9	103.4
Total	$ 9.1	$ 15.8	$ 15.8	$ 15.8	$ 31.2	$ 24.5	$111.5	$109.9	$110.0	$113.6	$118.6	$110.6	$131.6	$129.7	$135.8	$134.0	$128.6	$127.2	$ 78.7	$ 78.7	$1730.7
300																					
301			12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	225.0
302			12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	225.0
Subtotal*			$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 25.0	$ 450.0
Clerical			2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	37.8
Total			$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 27.1	$ 487.8
400																					
401											12.5	12.5							12.5	12.5	50.0
402				6.2	12.5	12.5	14.1	14.1	4.7	23.4	23.4	4.7	1.6	20.3	20.3	1.6	1.6	20.3	26.6	14.1	222.0
403									3.1	3.1									3.1	3.1	12.4
404			3.1	3.1	3.1	3.1	21.9	21.9	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	21.9	21.9	21.9	21.9	168.6
405			12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	225.0
Subtotal*			$ 15.6	$ 21.8	$ 28.1	$ 28.1	$ 48.5	$ 48.5	$ 23.4	$ 42.1	$ 51.5	$ 32.8	$ 17.2	$ 35.9	$ 35.9	$ 17.2	$ 36.0	$ 54.7	$ 76.6	$ 64.1	$ 678.0
Clerical			1.6	2.6	3.6	3.6	5.5	5.5	2.9	3.9	4.4	3.4	1.8	2.9	2.9	1.8	3.4	4.4	7.0	7.0	68.2
Total			$ 17.2	$ 24.4	$ 31.7	$ 31.7	$ 54.0	$ 54.0	$ 26.3	$ 46.0	$ 55.9	$ 36.2	$ 19.0	$ 38.8	$ 38.8	$ 19.0	$ 39.4	$ 59.1	$ 83.6	$ 71.1	$ 746.2
100-200-300-400 Subtotal*	163.9	217.0	282.6	315.5	367.1	346.8	447.8	471.2	446.2	443.0	447.7	440.1	438.4	430.6	436.8	416.7	419.6	437.0	411.8	399.4	7779.2
Clerical	11.7	15.9	21.6	23.4	28.8	27.6	32.3	33.3	30.7	31.2	31.4	30.7	29.3	29.1	28.9	27.5	29.0	30.0	31.1	31.1	554.6
Total	$175.6	$232.9	$304.2	$338.9	$395.9	$374.4	$480.1	$504.5	$476.9	$474.2	$479.1	$470.8	$467.7	$459.7	$465.7	$444.2	$448.6	$467.0	$442.9	$430.5	$8333.8

* Professional and technical support.

Table XXI-4

SUMMARY OF THE ESTIMATED COSTS OF PERSONNEL REQUIRED BY THE RESEARCH PLAN
(Thousands of Dollars)

Calendar Year	100	200	300	400	Total
1972	$ 383.6	$ 24.9	$	$	$ 408.5
1973	1112.7	87.3	108.4	105.0	1413.4
1974	1202.0	445.0	108.4	180.3	1935.7
1975	1128.5	490.5	108.4	149.9	1877.3
1976	1035.2	525.6	108.4	156.3	1825.5
1977	507.1	157.4	54.2	154.7	873.4
Total	$5369.1	$1730.7	$487.8	$746.2	$8333.8

Program element 200--Atmospheric Chemical and Biological Processes--is estimated to require certain additional instrumentation and equipment not included in the St. Louis facility. Their costs are included within those of the Research Plan rather than the St. Louis facility. Table XXI-5 presents the estimated costs of these instruments and equipment by program component and date of acquisition. In comparison with personnel costs, these expenditures tend to be modest, except for the gas chromatograph-mass spectrometer estimated at $100.000. This unit would be installed at the central facility with the bulk of the remaining items installed mainly at selected Class A and B stations as discussed in the Research Plan.

Finally, the research effort under program element 402--Atmospheric Modeling--will require the use of two Atmospheric Sounders and three thermosondes early in 1973. The estimated costs of these units are also presented in Table XXI-5.

Table XXI-5

ESTIMATED COSTS OF SPECIALIZED EQUIPMENT FOR THE RESEARCH PLAN
(Thousands of Dollars)

Program Component	Equipment Description	Quantity	Cost	Acquisition Date Year/Quarter
103	METRAC system development	--	$100.0	1972/4
	METRAC procurement and installation		376.0	1974/1
201	Gas chromatograph	3	18.0	1975/1
	Electron capture gas chromatograph	3	14.0	1975/1
	G. C. mass spectrometer	1	100.0	1975/1
	Correlation spectrometer	1	10.0	1975/1
	Recorders for gas chromatographs	6	6.0	1975/1
	Sample vessels, valving, standard units	--	10.0	1975/1
	Total		$158.0	
202	Electron mobility counter	2	40.4	1974/1
	Royco photometer counter	5	41.3	1974/1
	Anderson impactor	5	5.6	1974/1
	Total		$ 87.3	
203	Atomic absorber	1	4.0	1975/1
	Transmissometer	3	27.0	1975/1
	Radiative balance instruments		50.0	1973/3
	Total		$ 81.0	
204	Digital pH meter	5	5.0	1974/2
	Tipping bucket rain-gage	10	3.2	1974/2
	Fabrication of precipitation pH measurement and calibration	5	2.5	1974/2
	pH meter	1	1.8	1974/2
	Chemical electrodes	7	1.4	1974/2
	Total		$ 13.9	
406	Thermosonde	3	120.0	1973/2
	Acoustic sounder	2	40.0	1973/2
	Total		$160.0	

Operations

Execution of the Research Plan will involve certain direct operating costs in both the 100 and 200 series of the Research Plan. In the 100 series, significant costs are estimated to be associated with the 101 component for the operation of the METRAC system during wind transport and tracer studies. The Research Plan indicates the execution of the wind-tracking experiment during the second and third quarters of 1974 and tracer studies in the same quarters in 1975.

As noted in Chapter XIV, the estimated operating costs of the METRAC system are $8,000 per month per balloon launch point for an intensive experimental effort. Thus, if the METRAC system is taken as having four launch points, the total operating costs would be $32,000 per month. Under the research schedule shown above, the quarterly METRAC operational costs expected are shown in Table XXI-6.

Table XXI-6

ESTIMATED OPERATIONAL COSTS OF THE METRAC SYSTEM
(Thousands of Dollars)

Year/Quarter	Cost
1974/2	$ 92
1974/3	92
1975/2	92
1975/3	92
Total	$368

Operating costs of the efforts in the 200 series are expected to cover consumable and expendable laboratory supplies and equipment. The costs of these items should be insignificant in comparison with personnel costs, for example, so that a detailed estimate does not appear warranted. Accordingly, an average cost of $4,000 per quarter will be taken as the cost of these consumable and expendable items.

Total Cost

The total estimated cost of the effort covered by the Research Plan is summarized in Table XXI-7 by quarter. A total of $9.7 million is estimated with about 85% of the total cost attributed to personnel. On an annual basis costs tend to peak in 1974 at $2.6 million, caused primarily by higher costs of equipment acquisition and operations.

Table XXI-7

TOTAL ESTIMATED COSTS OF THE RESEARCH PLAN
(Thousands of Dollars)

Year/Quarter	Personnel	Instruments	Operations	Total
1972/3	$ 175.6	$	$ 4.0	$ 179.6
4	232.9	100.0	4.0	336.9
Subtotal	$ 408.5	$100.0	$ 8.0	$ 516.5
1973/1	304.2		4.0	308.2
2	338.9	160.0	4.0	502.9
3	395.9	50.0	4.0	449.9
4	374.4		4.0	378.4
Subtotal	$1413.4	$210.0	$ 16.0	$1639.4
1974/1	480.1	463.3	4.0	947.4
2	504.5	13.9	96.0	614.4
3	476.9		96.0	572.9
4	474.2		4.0	478.2
Subtotal	$1935.7	$477.2	$200.0	$2612.9
1975/1	479.1	189.0	4.0	672.1
2	470.8		96.0	566.8
3	467.7		96.0	563.7
4	459.7		4.0	463.7
Subtotal	$1877.3	$189.0	$200.0	$2266.3
1976/1	465.7		4.0	469.7
2	444.2		4.0	448.2
3	448.6		4.0	452.6
4	467.0		4.0	471.0
Subtotal	$1825.5		$ 16.0	$1841.5
1977/1	442.9		4.0	446.9
2	430.5		4.0	434.5
Subtotal	$ 873.4	$	$ 8.0	$ 881.4
Total	8333.8	976.2	448.0	9758.0