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REGIONAL AIR POLLUTION STUDY PROGRAM OBJECTIVES AND PLANS

by

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FORWARD

This task order was conducted during the period of November 1973 to June 1974. The Final Report was revised in December 1974.

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INTRODUCTION

This report presents an integrated program for the conduct of the St. Louis Regional Air Pollution Study (RAPS). Its purpose is to provide the Environmental Protection Agency with an aid to (a) the effective management of the RAPS, (b) the implementation of a systematic and logical direction and coordination of the laboratory and field programs of the RAPS, and (c) assurance of flexibility in evolution of the experimental program of the RAPS.

ST. LOUIS REGIONAL AIR POLLUTION STUDY (RAPS)

The St. Louis Regional Air Pollution Study is the most ambitious study of its type ever attempted. The three major objectives sought of the RAPS are:

1. Develop, evaluate and validate air quality simulation models (AQSM) on a regional scale covering urban/rural stationary and mobile sources.
2. Develop, evaluate and validate models of local-scale phenomena which complement regional-scale models.
3. Create a comprehensive, accurate and readily retrievable data base for all criteria pollutants and selected non-criteria pollutants to use in evaluating future air quality simulation models and effects models.

As currently envisaged, a spectrum of regional air quality simulation models will be produced for all criteria pollutants, plus sulfates, nitrates and selected aerosols (e.g., fine particles), which have been validated against St. Louis field data.

This spectrum will incorporate subsidiary meteorological and chemical mathematical models which are needed as inputs to the AQSM and are capable of predicting analytically the atmospheric concentrations of pollutants as functions of pollutant levels, urban structure and heat emissions.

Within these objectives, the highest priority will be given to sulfur oxides. The rationale behind choosing these materials for focus at highest priority is that acid sulfate aerosols, which originate principally from sulfur dioxide oxidation, adversely affect human health, vegetation, materials and visibility.

A RAPS PLAN

The experimental plan described here focuses attention on the RAPS objectives. The specific purposes of the plan include:

1. Development and organization of existing information of the RAPS plans, ideas and concepts.
2. Establishment of a framework for the scheduling and control of the RAPS operations, including measurements and to a lesser extent modeling and data management requirements.
3. Provision for focusing the mainstream of the RAPS effort while allowing for incorporation of new experiments and new knowledge to be accounted for in establishing acceptable air quality models.

To achieve these goals, a dynamic procedure was chosen (after discussion with EPA/RAPS management) that can be used to review the progress of the project with maximum flexibility, but with necessary conformity to scheduling, utilization of resources, reporting procedures, etc.

REPORT ORGANIZATION

An overview of RAPS is presented via a discussion of the five basic elements of activity within the RAPS: 1) Model Development and Evaluation, 2) Emission Inventories, 3) Aerometric Measurements, 4) Data Management and 5) Program Management.

The essential role of each activity is then established by illustrating the logical relationship between all RAPS technical elements. Specifically, for all technical elements discussed their role in model development and evaluation is presented schematically in terms of the parameter(s) measured and model requirements.

Procedures for reviewing the various pieces of the RAPS are discussed and specific recommendations made. All of these elements are then brought together in time via a Master Milestone Chart of the entire program. Finally, the use of the procedures recommended is demonstrated for the summer '74 field expeditionary program plan.

1 RAPS STRUCTURAL PLAN

The past experience in comparing air quality simulation models with observations has provided only limited knowledge of the model sensitivity to key elements, particularly those which define the meteorological processes and the atmospheric chemistry and transformation processes involved. In addition, there has been a general absense of simultaneous measurement and data collection for defining these processes. In this respect, the development of air quality models has suffered from the lack of simultaneous measurements of parameters needed for model validation. Qualitatively, it is clear that one can expect that the key features for satisfactory modeling must center around the accuracy of:

- pollutant measurement
- the emission inventory,
- the characterization of meteorology on a maximum scale of tens of kilometers,
- the material balance of the pollutant species in question.

Thus, the RAPS must address itself to establishing an improved knowledge base for these elements; their relationship to AQSM output must reflect the regulatory requirements of the 1970 Clean Air Act.

Although the development of local scale models is not a major objective of RAPS, such models would indeed complement the regional scale models being produced. The aerometric measurements gathered in the St. Louis bi-state area will be added utility for more limited-scale studies that are undertaken through other programs.

PROGRAM MANAGEMENT

The implementation of the proposed plan requires either the existence or establishment of program management. This is a vitally important element of the RAPS structure. This effort must be successful in planning, organizing, directing and controlling the resources, skills and knowledge to complete the RAPS (by 30 June 1977) in an orderly manner and meet established objectives in time, budget and technical results.

The plan proposed herein is intended to be consistent with our current understanding of the EPA/RAPS program management. In Figure 1 the principal members of this management team are given along with the geographical location.

Program Element Director (Dr. J. Thompson, RTP)	- responsible for overall program management
Field Director (Mr. F. Schiermeier (Acting))	- responsible for all aspects of St. Louis field operations
Research Coordinator (Dr. F. Pooler, RTP)	- responsible for providing scientific liaison between the participating EPA Divisions to insure that all RAPS research activities are consistent with RAPS purposes; identifies program inadequacies; with NERC program managers the needed budgeting and planning information of EPA headquarters is furnished.
Data Manager (Mr. R. Browning, RTP)	- responsible for establishing and maintaining a data management system which converts participants' data requirements into design and operation specifications for the data processing formatting, storage and retrieval systems; provides assistance to RAPS participants in obtaining and interpreting needed data from the RAPS data bank.
Manager for Research Operations (Mr. S. Kopczynski, St. Louis)	- responsible for monitoring contract operations in matters affecting the scientific applicability of the data; assists EPA/RAPS participants in arranging for and carring out out field expeditionary data acquisition; ensures data applicability of special expeditionary measurements and monitors data quality.
Facility Manager (Mr. J. Reagan, St. Louis)	- responsible for RAMS network operations and maintenance; monitors data applicability and quality of special expeditionary instrumentation; responsible for St. Louis data processing, storage and retrieval activity.
Field Operations Coordinator (Mr. F. Schiermeier, St. Louis)	- responsible for planning and execution of EPA/RAPS field expeditionary data acquisition; coordinates EPA/RAPS field data acquisition activities in the St. Louis area with those of other agencies; provides meteorological services in support of RAPS field activities.
Administrative Assistant (To be filled, St. Louis)	- responsible for monitoring contractual programs and the maintenance of all fiscal records in St. Louis.

Figure 1. RAPS Management Summary

TECHNICAL ELEMENTS OF THE RAPS

The RAPS can be structured in different ways to implement programs for achieving its objectives. We have chosen to structure the program as indicated in Figure 2 with an operational classification in terms of four basic elements: a) model development and evaluation, b) emissions inventories, c) aerometric measurements, and d) data management.The data management function serves as a bridge between the model development and the emissions and aerometric measurements efforts to insure the interaction and feedback between field oriented activities and data utilization or interpretative activities (a project breakdown structure with significantly more detail may be found in Appendix A).

The structure and content of the proposed plan benefitted measurably from the RAPS No. 1 Study Plan even though when its content is compared with Figure 2 it may not be readily apparent. As will be evident later, virtually every component of the Study Plan remains.

In the sections which follow, the roles of each of these principal elements will be discussed.

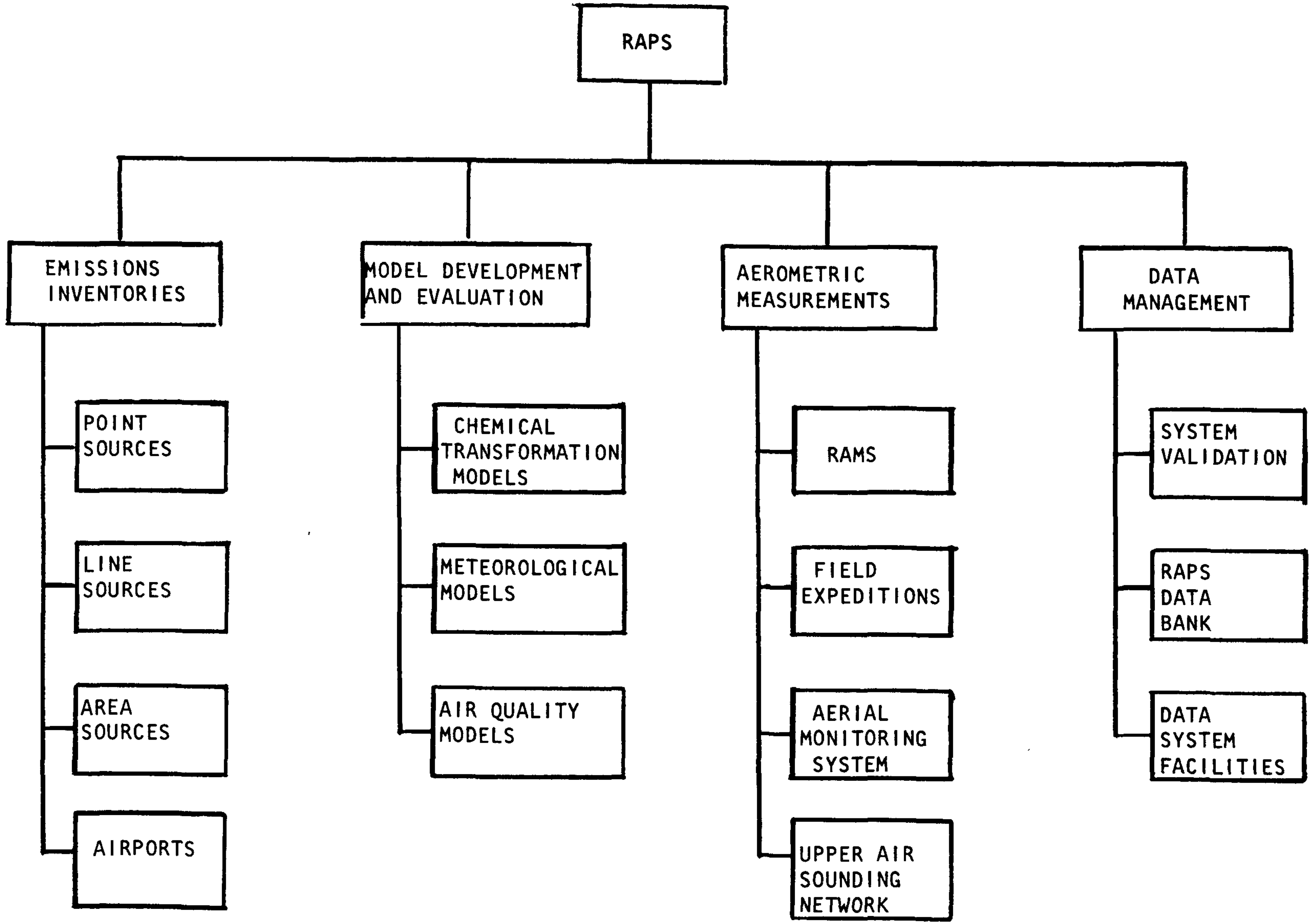

Figure 2. Principal Elements of Regional Air Pollution Study (RAPS)

MODEL DEVELOPMENT AND EVALUATION

In the plan proposed, the model development and evaluation efforts take a leading and crucial position. Of the variety of models to evolve under the RAPS framework, the initial effort will be concentrated on the emissions and aerometric models. The development of the ecological and economic models are not within the scope of this report. Although these depend on the emission and aerometric models, they can be derived partially in parallel.

Objectives of Model Development and Evaluation Program

The objectives of the RAPS model development and evaluation activity are:

1. Establish criteria for evaluation of air quality simulation models consistent with RAPS objectives.
2. Establish a protocol for the quantitative validation and acceptance of each model or sub-increment within the context of the present ambient air quality standards.
3. Quantitatively test and evaluate existing models or submodels for the applicability to the regional air quality specification.
4. Identify the critical elements and limitations (quantitatively whenever possible) of the models that require further improvement to meet acceptable levels of model performance.

A Plan for Model Development and Evaluation

The importance of technical leadership by the model development and evaluation team cannot be overstated. A schedule for the overall modeling activity is given in Figure 3. Leadership by the modelers is established through periodic and formal recommendations reports. As a minimum, these reports are to be concerned with improvements in aerometric measurement, emission inventories and data management operations and procedures. As Figure 3 shows, two full years for model evaluation are available following the conversion and implementation of all models for the St. Louis Air Quality Control Region (AQCR).

BROAD SCHEDULE FOR MODELING ACTIVITY

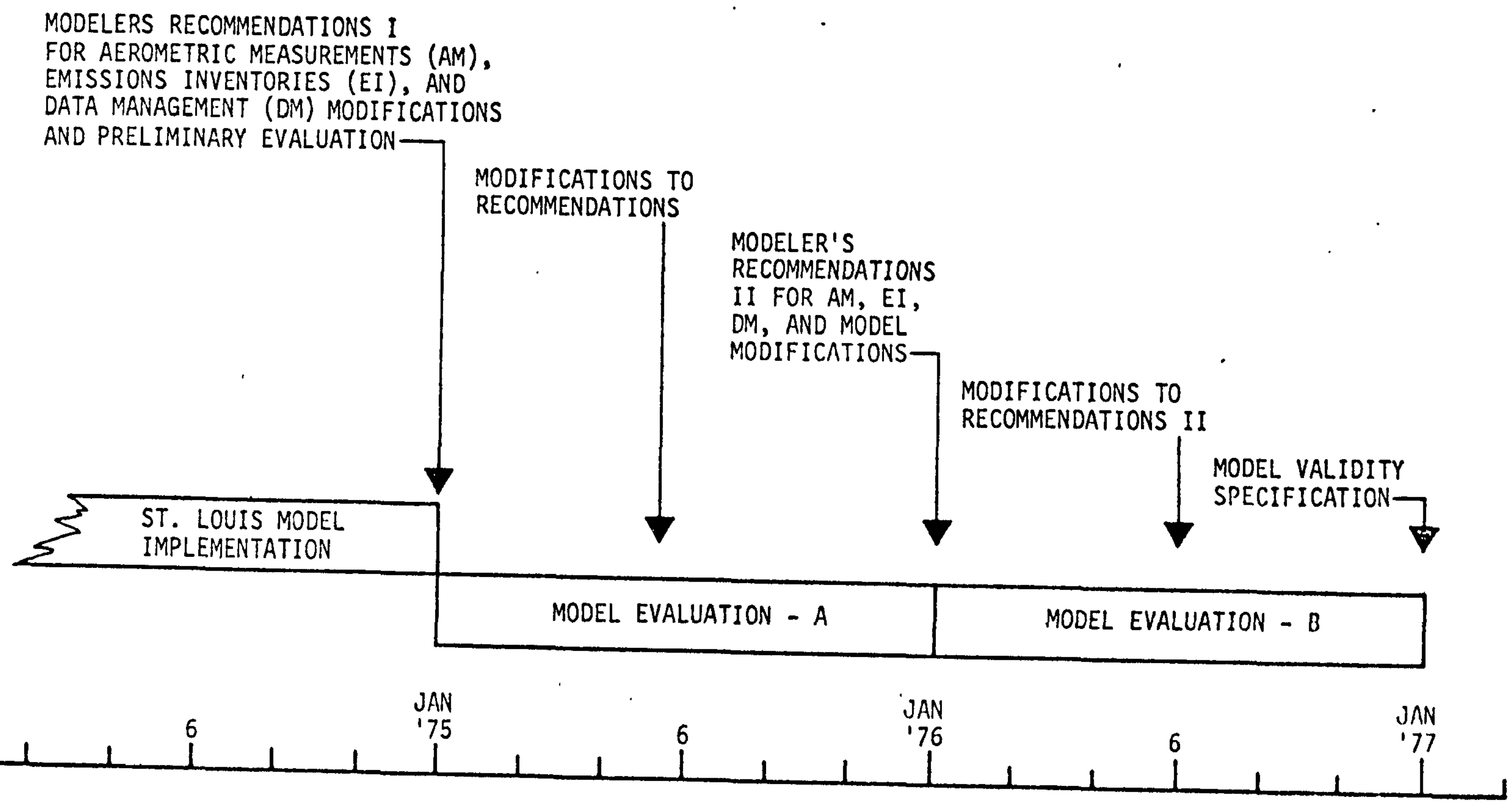

Figure 3. Broad Schedule for Model Development and Evaluation Program

During this period, nearly two full years of data will be accessible.

Figure 4 presents a relatively detailed flow chart for carrying out the modeling activity through the first full year of evaluation (up to January 1976) for each and any model applicable to the RAPS objectives.* The second year of evaluation is similar to the first year of evaluation and, along with the full modeling effort, is presented in the PERT NETWORK (Figure B.1 in Appendix B).

Estimates of time for each activity in the network (represented by the horizonal lines in Figure B.1) are given only for the period following January 1, 1975. The status of current models with respect to conversion and implementation to the St. Louis AQCR is strongly determined by the particular model being considered.

The flow diagram in Figure 4 is, in principle, applicable to each model. Thus, the progress of the models considered applicable to the RAPS objectives can be followed by reference to it. In implementing this plan, it is therefore recommended that the status of each model under consideration be assessed according to this chart. With this information a more detailed schedule would then be established and the network in Figure B.1 also implemented.

Finally, the importance of establishing evaluation criteria in the very early stages of the model development program cannot be overemphasized. It is recognized that these may change in the course of the RAPS, but the direction these criteria will give to the modeling effort and therefore to the entire RAPS is paramount.

Recommendations

In summary therefore, the following recommendations are made:

- The leading role of the modelers be established and implemented.

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* A relatively complete list is in Figure A.1 in the Project Breakdown Structure

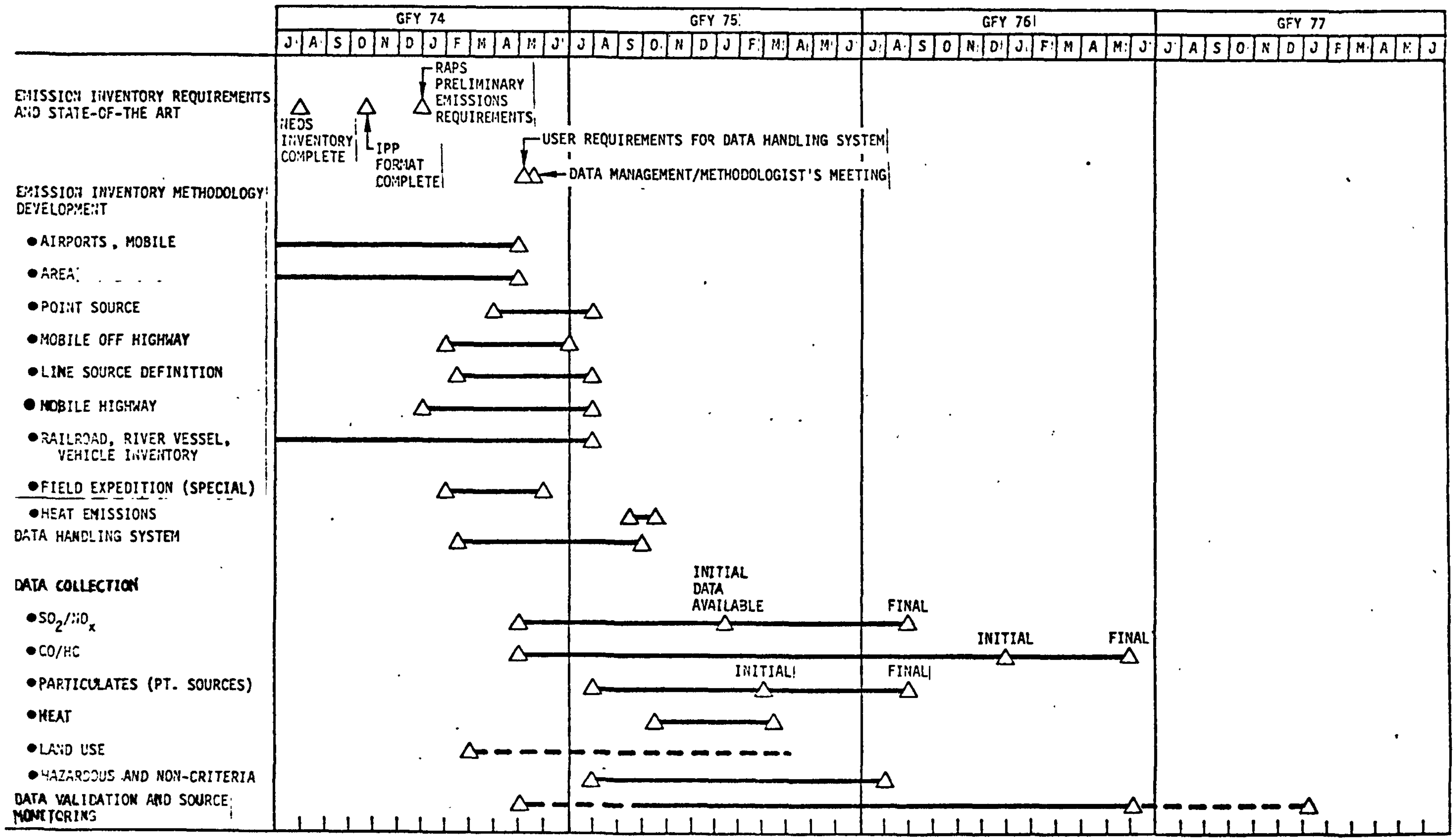


Figure 5. Schedule for Emission Inventory Activity

requirements and current state-of-the-art, 2) emission inventory methodologies (by source types), 3) emission inventory data handling system, 4) emission inventory data collection, and 5) data validation and source monitoring.

As indicated in Figure 5, the first step in this plan is virtually complete. The existence of the NEDS inventory for St. Louis in IPP format has been completed. This data base insures that emissions data are available for the early exercising of RAPS models. It is recognized, however, that such information (although capable of being used) is based upon an annual time scale and relatively low spatial resolution and is therefore inadequate to meet the final RAPS objectives. The recommended uses of the NEDS inventory (for RAPS purposes) are clearly indicated in the study by Stanford Research Institute, A Regional Air Pollution Study (RAPS) Preliminary Emission Inventory, under Contract 68-02-1026. This study presents an operational plan for providing emissions data for RAPS as well as reviews in detail the emissions models used in the past to provide emissions data.

The second major element in the emissions plan, establishment of methodologies for emissions data, is underway, either under contract or in cooperation with other governmental agencies. The objective of this effort is to develop a detailed methodology to acquire the data to bring the individual sources and emission inventory items up to the minimum specification of the RAPS. The data included in this methodology include emission estimates, operational variations (as a function of time of day, season, or year), product(s) produced, control equipment information, temperature, geographical identifiers and physical data such as stack height, diameter, etc.

Presented in Table 1 is a list of the participating groups with their respective responsibilities. Both the SRI report and the NEDS inventory provide the base from which these groups work. From this base, supplemental data requirements are identified which could include finer detail and analysis concerning process or operational variations or continuous emission monitoring

TABLE 1

PARTICIPANTS AND RESPONSIBILITIES FOR METHODOLOGY DEVELOPMENT (AND DATA COLLECTION) FOR RAPS EMISSION INVENTORY

Group	Classification	Nature of Effort*
AMC Rockwell International	Point Sources	M (+ D later)
GCA Corp.	Airports, mobile	M (+ D later)
ESE	Stationary Area	M (+ emission factors)
SWRI	Mobile, off-highway	M
DOT	Railroad, river vessels	M + D
WU	Mobile Source	Line Source, highway methodology for St. Louis
Dept. Federal Highway	Mobile, freeways	M + D
AMC Rockwell International	Special Expeditionary Support	M for emissions related to field expeditions
AMC Rockwell International	Heat Emissions	M + D

*M = methodology development

D = data collection

of selected (and identified) sources. Sensitivity analysis is then employed to determine the significance of these (potential) requirements. The completion date for all methodology development is March 1, 1975.

The third element of the RAPS emission inventory data handling system can be carried out in parallel with the methodology development element, but not completely independent of it. It is the objective of this effort to design, implement, execute, and demonstrate a system capable of recording, storing, retrieving, editing, and updating all data required for the computation of emissions on an hourly basis with a spatial resolution commensurate with RAPS modeling requirements.

We recommend that, for those models already identified in the detailed project breakdown structure (Appendix A), user (modeler) requirements of emissions data be specified by mid-March. It must be realized at the outset of this effort that the utility and efficaciousness of any data handling system will be determined to a significant extent by the incorporation of user design requirements. It is recognized that this requirement is difficult to achieve at this time (i.e., prior to exercising all of the RAPS candidate models); however, every effort must be made to specify the user design requirements.

We also recommend that meetings be established between key individuals in groups indicated in Table 1, EPA/RAPS emissions personnel, and the data handling personnel to insure the establishment of a properly designed data handling system.

The components required to complete the data handling system, which is being carried out via a task order agreement with the Rockwell Air Monitoring Center are:

- input record format and content design
- retrieval format design
- file design

- systems design
- systems implementation and software development
- demonstration

It is planned that this effort be completed by November 30, 1974.

The fourth major element given in Figure 5 (emission inventory activity) is data collection. This effort is designed to follow an iterative data upgrading procedure. With the currently available NEDS inventory, AQSM's can now be exercised. As methodologies are developed and data collection begins, the data handling system will be implemented; its designed capability of updating by source and/or by pollutant classifications insures the upgrade of the emission inventories as an on going activity.

We recommend that a mechanism be established to assure close working relationships at the NADB and Model Development Branch interface. This is essential for the RAPS objectives to be served.

The final element of the emission inventory effort is data validation and source monitoring, currently planned to be initiated in early GFY '75 for point, mobile and area source classifications. Although the nature and scope of the source testing and monitoring plans have yet to be specified, we concur with the SRI recommendations that, as a minimum, emphasis be given to emission validation during periods of intensive field activity.

Summary of Recommendations

The following recommendations are made:

- User requirements of the emissions data be specified by mid-October, 1974.
- Meetings be arranged between key individuals in groups indicated in Table 1, EPA/RAPS emissions personnel and the data handling personnel by mid-August, 1974, with the purpose of insuring that

the emissions data handling system design is compatible with the data being collected.

- A close coordination between EPA/RAPS Program Management, NADB personnel and Model Development be maintained.
- Data validation procedures be included as part of future methodology development upgrading.
- As soon as possible, a methodology for obtaining a land-use inventory be initiated and completed by December, 1974. As such an inventory is one of the basic differences between St. Louis and a different region, the RAPS models must be parameterized according to this information. The nature of this effort should be coordinated with J. McElroy of Monitoring Systems Research and Development Laboratory, NERC, Las Vegas

AEROMETRIC MEASUREMENTS

The aerometric measurements program constitutes the largest and most concentrated effort ever undertaken to define and describe the state of an urban atmosphere. As indicated in Figure 2, this program consists of: 1) an extensive (regional) ground-based air monitoring system (RAMS); 2) a vertical extension of the RAMS which consists of three fully-instrumented helicopters, one of which serves as backup; 3) an upper air sounding network, and 4) a series of concentrated field expeditions using portable samplers conducted during special periods.

Objectives of Aerometric Measurement Program

The objectives of the aerometric measurement program are:

1. Produce a documented and validated data base of sufficient scope (variety of meteorological/pollutant conditions in space and time) to support the objectives of the model development and evaluation program.
2. Extend the understanding of atmospheric phenomena as required to support the model development and evaluation program.

A Plan for Aerometric Measurements

In designing an operational plan for an aerometric measurement program, two guiding principles must be employed. First, the capricious nature of the weather requires a certain vagueness when it comes to specifying the scope of a data base required to meet the RAPS objectives. This will be particularly true in the early phases of the study and may be expected to improve in the latter phases. Therefore, extensive and continuous data collections are required despite the fact that the use of some data may be infrequent. Secondly, there must be specified predetermined periods wherein a maximal effort by all investigators toward the collection of data is made, i.e., a portion of time where most of the measurements are being made for most of the time. These periods are selected on the basis of historical meteorological/pollutant conditions.

The Regional Air Monitoring System (RAMS)

By any means of evaluation, the RAMS is a most essential element of the aerometric measurement program. It is the objective of this network to provide a long term, uniform, verified data base of ground-based measurements. In fulfilling its objective, the RAMS is expected to be used to test the ability of aerometric models to provide quantitative measures of regional air quality based exclusively on a monitoring network. It is presently projected to operate continuously over the two-year period from September 1974 to December 1976.

The RAMS consists of 25 remotely operated, automated stations controlled and polled via telemetry to a central data aquisition system. The stations are "managed" by a mini-computer which provide for automatic calibration of the pollutant gas instruments.

The principal features of the RAMS instrumentation are listed in Table 2. The allocation of special instrumentation is presented in Table 3. The site locations for the RAMS stations are shown in Figure 6.

The network layout, as well as cirteria for specific station sitings are presented in a paper by F. Pooler, "Network Requirements for the St. Louis Regional Air Pollution Study." A restatement of these criteria is outside the scope of this report. The stations are arranged in concentric circles centered on Site 101, located in downtown area just north and west of the St. Louis arch. The radii of the concentric circles are 4, 9, 20 and 40 km.

The RAMS will be operated for the EPA by the Rockwell Air Monitoring Center team through at least the first six months of its operation.

The Aerial Monitoring System

It is the objective of the aerial monitoring system, which is operated by NERC, Las Vegas, to provide a uniform data base for aerometric measurements aloft. The aerial system consists of three Sikorsky-58 helicoptors which have been modified to carry two complete aerial monitoring systems; the third unit serves as a helicoptor back-up only.

The principal features of the aerial monitoring system are given in Table 4. Industry-compatible tapes from the data acquisition system are to be translated and verified using the PDP 11/40 mini-computer at the RAPS St. Louis facility.

Data will be collected to yield vertical distributions and pollutant maps aloft. In addition to providing data for model validation, initial and boundary conditions will be obtained. Although the flight plans have not been formally finalized at this time, they will include the

TABLE 2

RAMS INSTRUMENTATION

Network

25 Stations

Automatic operation, PDP - 11/40 central computer

Telemetered digital information plus data acquisition each station

1-minute interrogation

Display by CRT and printer/plotter

Mag tape storage

Station Instrumentation (all stations unless specified)

Ozone

NO, NO_2, NO_x

CO, CH_4, NMHC

Total Sulfur (12 sta)

H_2S, SO_2, TS (13 sta)

Gas Bag Samplers

Particulates: Hi-vol filters (10 sta)
Nephelometer
Dichotomous sampler (10 sta)

Wind, speed and direction

Ambient temperature

Differential temperature (12 sta, 30-meters)

Dew Point

Pressure (7 sta)

Solar radiation:
4 stations: three spectral pyranometers
one direct pyrehellometer
one long wave pyrogeometer
2 stations: two spectral pyranometers

Turbulence (5 sta, u, v, w, local recording only)

TABLE 3

SPECIAL DISTRIBUTION OF INSTRUMENTATION FOR ST. LOUIS RAMS

Station ID	Complete Radiation	Simple Radiation	Turbu-lence	Temp Diff	Pres-sure	Sulfur G.C.*	Hi-Vol	30-m Tower	Dichotomus Sampler
101				x	x	x		x	
102				x				x	
103	x					x	x	x	x
104		x		x		x		x	
105			x	x		x	x	x	x
106				x		x	x	x	x
107			x	x				x	
108		x				x	x		x
109			x	x	x			x	
110									
111			x	x				x	
112				x	x		x	x	x
113			x	x		x		x	
114	x					x			
115						x	x		x
116						x			
117									
118	x						x		x
119								x	
120						x	x	x	x
121						x			
122	x			x	x	x	x	x	x
123				x	x			x	
124					x		x	x	x
125					x			x	

*Remaining 12 stations receive Total Sulfur only

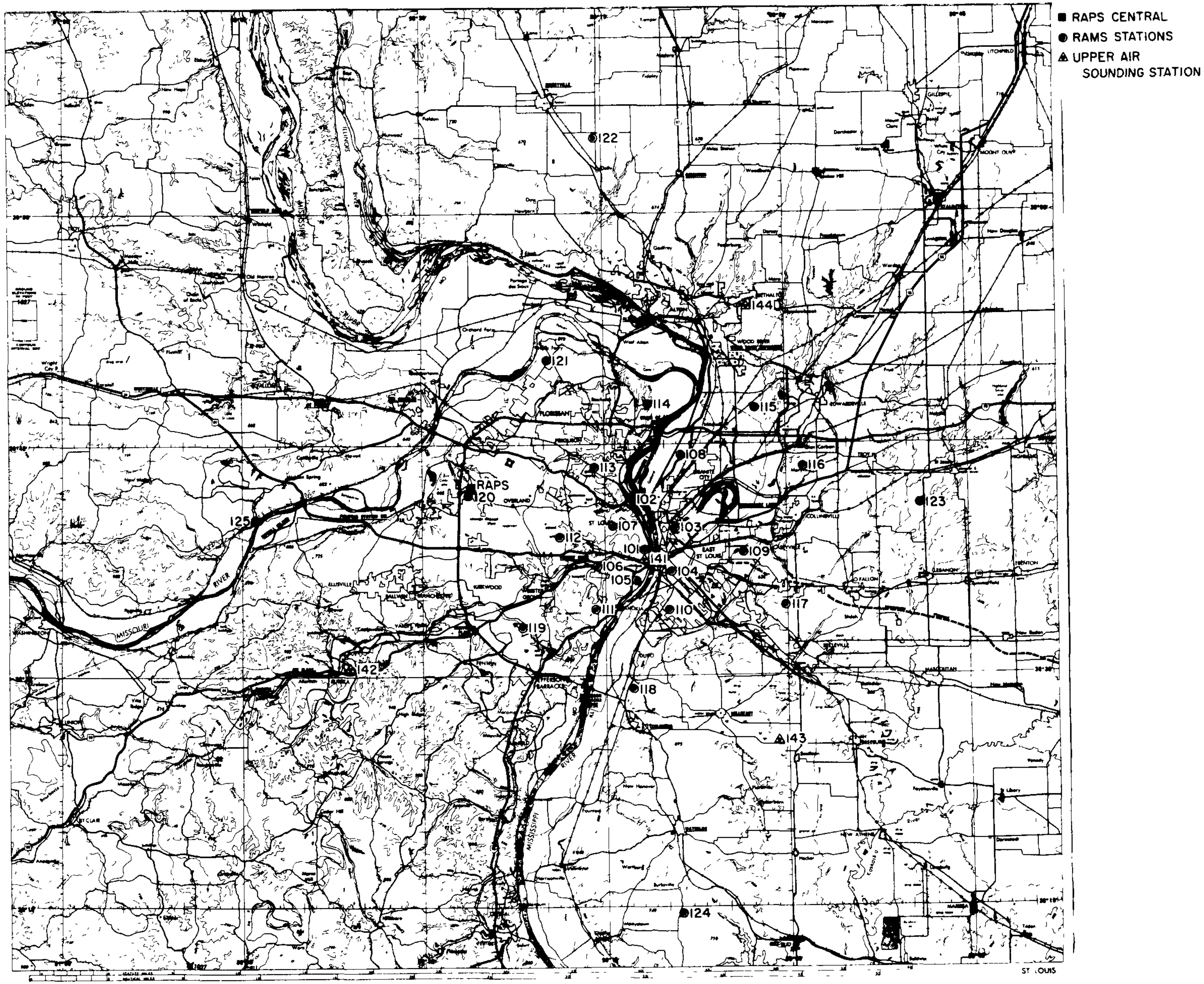


Figure 6. Geographical Locations of RAMS Stations

TABLE 4

HELICOPTER INSTRUMENTATION

Type Instrument	Model Designation	Quantity
Fluorescent particle counter	MEE 110	2
Particle size counter	Royco 220	2
Nephelometer	MRI 1550B	2
$NO-NO_x$ analyzer	TECO 14B	5
O_3 analyzer	REM 612B	3
CO analyzer	Andros 7000	2
SO_2 analyzer	Meloy SA 160	2
CH_4 - THC analyzer	MSA 11-2	2
Bag Sampler	EPA	2
Temperature and dewpoint	Cambridge CS-137	2
Pressure altimeter	Computer Instrument Corp.	2
Data logger, A/D converter	Monitor 7200	2
Tape deck	Cipher 70SE	2
Strip Chart, 4 channel	MFE M-24 CRAHA	2

capability of providing time histories of boundary conditions.

The general aspects of the flight plans call for two missions per day with the two helicopters flying in concentric circles -- the inner flight circle covers the core of the RAMS while the outer flight circle covers the outer RAMS sites. Each flight is intended to be approximately two hours in duration with the first starting at 0600 and the second at approximately 1330. To the circular horizontal flight pattern will be added seven to eight downward spirals (for each helicopter) with the location of spirals chosen as closely as possible to the RAMS site. Vertical profiles will be obtained from near ground level to 200-500 ft. (61 - 152 m) above the top of the inversion.

Although discussed informally from time to time, more serious consideration should be given to nighttime flights. These are particularly valuable in establishing initial and boundary conditions as well as determining the formation and disappearance of materials in the absence of solar radiation.

The helicopter aerial monitoring operations are scheduled during field expeditionary periods from August 5, 1974 through 1976. A total flight time of approximately 20 hours per week per helicopter is planned during each expeditionary period.

For the immediate helicopter program, we recommend that debriefing reports and procedures be established following each mission. These will not only aid in data interpretation efforts later, but would be of significant value in the data validation procedure. We also recommend that photographs of observations be included as part of each mission and that these be logged into the RAPS data base.

Finally, we recommend that consideration be given soon to the incorporation of particle collection devices compatible with (subsequent) chemical analysis. Although we have sulfate and nitrate analyses in mind, heavy metals analyses, via X-ray fluorescence, would be of definite value in assessing the variety of probable mechanisms for sulfate and possibly nitrate formation. The SO_2 oxidation rate (which leads to sulfate formation) in aerosols is known to be enhanced by the presence of heavy metals (e.g., Mn^{++}).

Upper-Air Sounding Network(UASN)

The RAMS network provides a relatively dense data base of surface winds, temperature and relative humidity. The combination of these data with those obtained from upper-air soundings allows the determination of changes in winds, local stability, and mixing depth throughout the area, particularly as they relate to terrain features and synoptic scale meteorology. It is the objective of the upper-air sounding network to provide a data base of the upper air structure over the St. Louis AQCR. This data base will consist of winds, temperature, dew point and relative humidity aloft. Special emphasis is given to the lower ($\leq$ 700 MB) levels. Temperature resolution is $\pm$ 0.5^{o} C. The frequency of observation of winds aloft is every 30 sec.

This sounding network consists of four fixed stations which have been given numerical designations of 141 through 144. Their locations are indicated on Figure 6. Table 5 shows the periods of operation and kinds of soundings taken for each site.

The simultaneous operation of the upper-air sounding network and RAMS will provide: 1) a means of correlating air quality measurements with mean transport across the St. Louis ACQR: 2) determination of variations in mixing heights; and 3) definition of atmospheric stability classes associated with the distribution of pollutant concentrations in the St. Louis AQCR.

Installation and operation of the network, which includes quality control procedures, is the responsibility of the Rockwell Air Monitoring Center. Data from the upper air sounding network will be available on a semi-real time basis for forecasting purposes during intensive periods of study as

TABLE 5

SUMMARY OF UPPER AIR SOUNDING NETWORK

Station ID	Period(s) of Operation	Soundings	
		Rawinsondes	Pibals
141, 142	5 days/week, 24 hrs/day from October 1974 thru December 1976; 7 days/week during the intensive study periods	4 per day at 6-hour intervals to 9.8 kft (3.0 km)	20 per day at hourly intervals between radiosondes
143, 144	7 days/week, 24 hrs/dy during the intensive study periods	Same as 141 and 142	Same as 141 and 142

well as in a form suitable for subsequent entry into the RAPS data bank. Graphical data will be provided on standard NOAA low-level sounding adiabatic charts. Radiosonde angular observations and reduced radiosonde wind directions, wind speeds, and heights are provided on formatted forms designed for 30-second intervals and consistent with the requirements of the RAPS Data Manager. Pibal theodolite data are provided also on formatted forms designed for 30-second intervals. It is recommended that post-analysis summaries of meteorological conditions be available to the RAPS participants during the intensive expeditionary periods.

Field Expeditions

A great body of earlier work has demonstrated that the observational data base required for model validation substantially exceeds that provided by a routine monitoring network. Thus, the principal objective of the field expeditions is to supply short term, detailed atmospheric observations in support of the development and validation of the RAPS aerometric models. Based on present knowledge, there are four major classes of expeditions (as shown in Figure 7). The objective of each is described as follows:

1. Meteorological Characterization

Objective: To supplement the routine meteorological elements of the RAPS with data sufficient to characterize the micro-scale and boundary layer phenomena with respect to its varying (spatial and temporal) mechanical, thermal and optical properties. Successful completion of this element of the RAPS can only be achieved if a land use inventory is available. It is recommended that arrangements for this be started immediately.

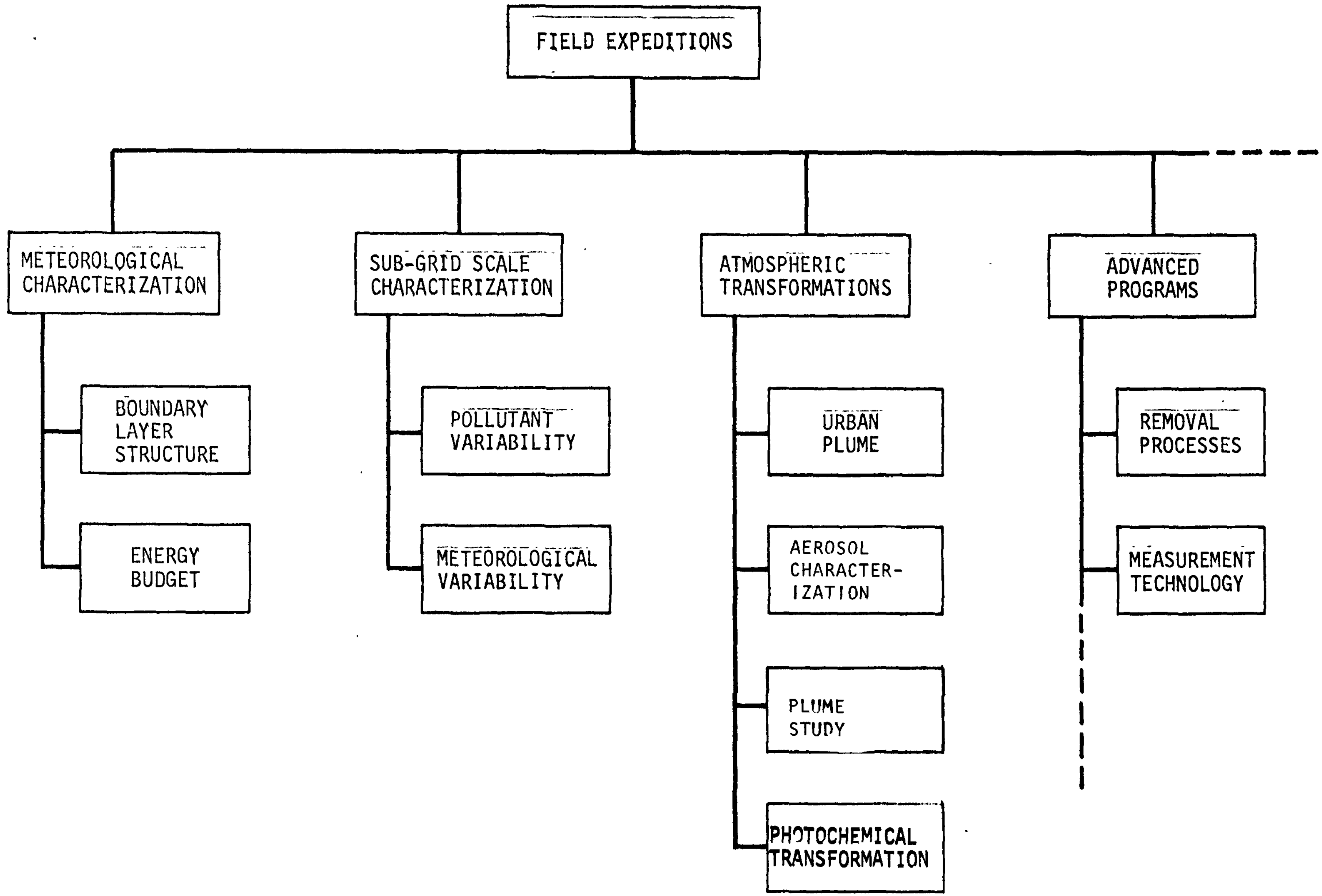


Figure 7. Elements of Field Expeditions Program

2. Sub-Grid Scale Characterization

Objective: To develop and implement a methodology to establish a relationship between stationary point (RAMS) measurements and average measurements in a grid approximately one km square.

3. Atmospheric Transformations

Objective: To characterize the complex physical and chemical transformations of an air mass over the St. Louis region.

4. Advanced Field Programs *

Objective: To enhance the RAPS data base by a) improving the phenomenological characterization of uncertain processes, such as removal processes and interactions with water clouds and precipitation, and b) developing new measurement techniques for characterizing trace constituents in urban areas, especially related to the sulfur cycle.

Each of the four classes of expeditionary projects listed above can be further subdivided. At the outset we make two recommendations. First, we recommend that uniformity be adopted with respect to the periods within each season that field expeditions are to be conducted. The need for this already has been mentioned (Page 19). Second, we recommend that field expeditions conform to a schedule which consists of the following phases: 1) an experimental design phase at the end of which its approval from EPA/RAPS management is obtained; 2) a preparation phase; 3) a measurement or an experiment phase; and 4) a data validation and analysis phase. Discussions with the majority of the RAPS investigators lead us to believe that these recommendations are acceptable.

Meteorological Characterization. Referring once again to the elements of the Field Expeditionary Program (Figure 7), it is seen that the meteorological characterization experiments consist of atmospheric boundary layer

* The function of this class of expedition is to provide flexibility to RAPS experiments in allowing for growth into new areas which appear promising (but whose technology may not be well established)

structure and energy budget studies. This work is planned to be performed primarily by EPA/ML staff, supported by Rockwell Air Monitoring Center.

Boundary Layer Structure

Objective/Purpose: Experimentally specify the three-dimensional structure and temporal variations of the boundary layer over the St. Louis region in order to define model boundary conditions, to parameterize the turbulent mixing processes, and to validate and advance the model development and evaluation program.

Approach: This study is to be divided into two phases. The first consists of defining and specifying the boundary layer structure, while the second phase will consist of validation and verification via tracer studies. Daytime and nighttime measurements will be made. Vertical temperature profiles from aircraft (helicopter and fixed wing) ascents will be made with major emphasis being given to the region at the top of the mixing layer. Due to the lowering of the mixing layer at night, the time for each profile is reduced which allows an increase in the number of ascents. Other measurements to yield vertical wind profiles and horizontal trajectories will be made to supplement the upper-air sounding network. In addition, lidar scans of the aerosol loading to determine the degree and variations in mixing will be made.

Schedule: Effort on Phase I began in 1973 and is currently planned through summer of 1975. The experimental activity on Phase II is scheduled to begin in summer of 1975 and extend through 1976.

Energy Budget

Objective/Purpose: Experimentally determine the components of the energy budget over the St. Louis AQCR, document differences in urban and rural energy budgets for the surface (land use) and boundary layers, and quantitatively assess the effects that variations in the energy budget have on the boundary layer.

Approach: The study is divided essentially into three parts: the determination of (1) the radiation, (2) the sensible heat flux, and (3) the energy storage terms of the energy balance equation. To determine the components of the radiation term, airborne and ground-based measurements will be made over rural and urban areas. The airborne program will provide measurements of the surface albedo over representative land use areas and vertical solar flux measurements. Airborne measurements include six pyranometers, three of which look up and three look down in order to measure the incident global solar irradiance in UV, visible and IR bands. Ground surface temperature, dew point and aerosol measurements will be made.

The sensible heat flux term will be determined via airborne and ground-based measurements using the eddy correlation method. Two approaches will be used: the first (airborne)employs taking the product of the coincident measurements of turbulent vertical velocity and temperature fluctuations, while the second (ground based) uses a device called a fluxatron, which makes the above computation in "real-time."

The storage term will be measured by imbedding thermistors at various depths below representative surfaces at RAMS sites.

Schedule: Initial efforts begin in the Summer, 1974 with the exeption that measurements of the storage term are not planned. These (latter) measurements will begin in the Fall, 1974 period. The energy budget study is planned to continue through 1976.

Sub-Grid Scale Characterization. The criteria employed for siting RAMS stations were instituted to provide data representative of the area monitored, i.e., to minimize unrepresentative siting effects. Similarly, instrument related errors are minimized through the quality control (QC), quality assurance (QA), and data validation (DV) procedures used in the RAMS measurements. Sub-Grid Scale Characterization Studies are planned in order to assess quantitatively the nature of these fluctuations and, in turn, the representativeness of the RAMS air quality and meteorological observations. The studies will also allow assessment of the degree of ambient variability (involved in the verification of computations) depends upon emissions field and land use variations. They will be conducted initially on an exploratory basis as functions of selected meteorological conditions and various source-receptor combinations deemed most important by the model development and evaluation team. Moreover, the scope of these studies must be sufficiently large to permit a determination of the extent to which the observed variabilities are determined by both emissions and land use variations. It is clearly recognized that without such a determination the transfer of RAPS models to other ACQRs would be speculative, however without any experimental data, specific field studies related to the assessment of emission and land use variations cannot be recommended. It is recommended that these studies be followed very closely as they are of great significance to the model verification and evaluation portion of the RAPS. Furthermore, it is through these studies that one of the most vital interfaces of RAPS participants--that of the interface between the participants involved in modeling, meteorological measurement, emission measurement and the investigation of atmospheric chemistry and physics processes--will be established.

The studies currently planned are: 1) Pollutant Variability, and 2) Meteorological Variability. It can be expected that the scope of these studies will expand and, although specific studies are not recommended, field programs which examine sub-grid emission variabilities and land use variabilities should be anticipated. These latter studies may be more theoretical than experimental initially and some field work should be expected.

Pollutant Variability

Objective/Purpose: To determine, for specified grid areas, the pollutant heterogeneities (or homogeneity) in order to parameterize the relationship between point (station) measurements and grid-averaged measurements.

Approach: The basis for the approach is the use of mobile units carrying an array of air quality instrumentation and individual, portable sampling units. Bag samplers are also included. In addition, long-path optical measurement techniques will be employed, including laser and non-laser techniques. The initial efforts on the PV Study will be to develop a coordinated methodology; more extensive field expeditions will occur during subsequent periods. In the initial efforts, measurements of SO_2, O_3 and CO will be made with the portable sampling units, while with the mobile unit, NO_x, hydrocarbons and aerosol (nephelometry) measurements will also be possible. This collection of instrumentation will be used in two ways. Firstly, at specified RAMS sites (initially 103, 105, 108 and 123) the portable sampling units will be used to validate the time and spatial averages determined from the long-path methods. Secondly, the portable and mobile units will be deployed to determine the spatial and temporal pollutant variability. For both measurements, the methodologies would be the same, i.e., the sampling unit will either travel along prescribed paths or be stationed along prescribed paths. In either case spatial and temporal variabilities are obtained from which averages and their variances can be calculated which would then provide information with which the RAPS AQSMs would be compared. Finally, in these initial phases, the mobile (Winnebago) monitoring unit will serve as the principal means by which preliminary surveys of pollutant variability for candidate grid areas are made. The unit is equipped with instrumentation which will allow its position to be located during movement.

Schedule: Initial measurements in St. Louis at sites 103, 105, 108 and 123 will begin in mid-July, 1974 for SO_2, O_3 and CO, with some hydrocarbon, NO and NO_x measurements done in an exploratory manner. With the field methodology developed and refined and the RAMS fully operational, the program should be expanded in the winter, 1975 period.

Meteorological Variability

Objective/Purpose: To determine, for specified grid areas, the meteorological heterogeneity in order to parameterize the relationship between point (station) measurements and grid-averaged measurements.

Approach: The basis for the approach is to employ a mobile van traversing specified 1 km^2 grid areas possessing

relatively homogeneously (i.e., approximately the same aerodynamic roughness) land use patterns.*
The van will make temperature and moisture measurements initially. Current plans call for the van to first take measurements along the grid perimeter and then enter the grid and take measurements by traveling a saw-tooth route. The measurement period is completed by retracing the route about the grid perimeter. This cycle is repeated on an hourly basis during transitional periods. It should be expected that this effort will increase in scope in subsequent expeditionary periods.

Schedule: Exploratory studies of the type outlined above will begin in summer, 1974 program over only one land use area. Candidate areas are: downtown, old residential, new residential and heterogenous areas (50% park and 50% houses).

Atmospheric Transformations. It is the objective of the five studies indicated here to characterize, in either physical or chemical terms, the transformations taking place in a moving air mass as it moves across the city and into the surrounding area. Existing AQSMs currently account for SO_2 transformations, simply via an empirically derived disappearance rate factor. Laboratory studies establish that the observed factors are much too fast to be due solely to photooxidation via direct photoexcitation of SO_2. A myriad of other processes are possible, which include other photooxidation routes, and range from homogeneous chemical to heterogeneous chemical and physical processes. The relative importance of any one process has yet to be established. The success of the RAPS will be determined partially by success in this area. The time frame and available monetary resources of the RAPS requires emphasis

*The need for a land use inventory for St. Louis is once again indicated here.

on field studies; nevertheless, semi-controlled experiments (e.g., bag irradiation of St. Louis air samples) are required.

The studies planned are: 1) Urban Plume, 2) Aerosol Characterization, 3) Point Source Plume and 4) Bag Irradiations.

Urban Plume Study

Objective/Purpose: To determine urban plume size and composition under a variety of meteorological conditions in order to identify the major rate processes, such as chemical reactions, gas-particle conversion and dry deposition (removal), which take place in the urban air mixture.

Approach: The basis of the approach is the use of an instrumented aircraft. Flight patterns and measurements are made which lead to the construction of three dimensional maps of gaseous pollutant concentrations, particulates, and related meteorological parameters. Measurements of SO_2, O_3, CO, NO, NO_2, total light scattering, CNC, sulfate and particle size are made. Cross-sections of the urban plume are determined by making three to five traverses across the plume at different altitudes at the top and within the mixing layer and for three to five distances downwind of the urban complex.

Using wind field data, the total flux of pollutants are determined and compared with the corresponding emission flux to assess the importance of conversion processes and/or the quality of emission inventories. By comparing SO_2 to total sulfur (SO_2 + $SO_4^{=}$)at various distances downwind, the importance of chemical conversion can be determined; by comparing the changes in the total mass of the aerosol and size distributions, gas-particle conversion rates can be estimated. These determinations, when combined with emissions data and vertical pollutant profiles, afford a method for determining the importance of dry deposition. (Note approach to study of removal processes, where the determination of the deposition velocity of SO_2 on three to five representative surface classifications is described.)

Schedule: Exploratory measurements were completed in summer, 1973 which demonstrated the feasibility of the above approach as well as providing useful data. Additional experiments are planned to begin in August, 1974 and the winter of 1975.

Aerosol Characterization

Objective/Purpose: To characterize the aerosols sampled in the St. Louis AQCR in terms of their physical and chemical properties and their probable origins and evolution.

Approach: An extensive array of instruments and devices are assembled into two moveable laboratories, each with a computer compatible data acquisition system, in order to measure the chemical and physical properties of the St. Louis aerosol. One of the units makes both chemical (vapor and particulate) and physical measurements, while the second investigates principally the optical properties. Measurements are made in either real time or (in the case of aerosol samples) collected for subsequent chemical analysis using XRF, NAA, HRMS, ESCA and more traditional methods. In addition, a network of portable aerosol (Nelson) samples located at the RAMS sites will be operated.

Schedule: This program started in the summer, 1973 period and measurements were made in the winter of 1974. Measurements will also be made in summer, 1974 period as well as the winter, 1975 period. During the 1974 program this study is to be closely coordinated with the urban plume and point source plume studies. This will require that the relatively immobile trailers be placed in representative locations.

Plume Study

Objective/Purpose:

1) To determine the diurnal variation in sulfur dioxide and the extent to which it is converted to sulfate in plumes (in order to elucidate the role played by humidity).

2) To determine the rate of oxidation of nitric oxide to nitrogen dioxide and the extent to which nitric acid is formed in power plant plumes.

Approach:

The basis of the approach is to use a fixed wing aircraft containing real-time gaseous monitors and particle sampling devices to provide the construction of three-dimensional maps of a power plant plume at numerous downwind distances. Both plume location and pollutant dilution are determined by using SF_6 tracer techniques (frontal chromatography with EC detection). In addition, measurements of SO_2, $SO_4^=$ (Isotopic Ratio Tracer method), NO, NO_2 and HNO_3 are made. SF_6/SO_2 ratios for the various downwind distances yield SO_2 loss rates (other than by dilution) while $SO_4^=$ measurements yield $SO_4^=$ formation rates. Similar analyses allow determination of NO_2 and HNO_3 formation rates.

Schedule:

Exploratory measurements were made in mid-June, 1974 and more extensive measurements are planned for the summer, 1974 period. Additional measurements are planned for the winter, 1975 period. It is recommended that the aircraft be outfitted with an ozone chemiluminescent monitor. Moreover, it is recommended that particulate samples be collected for subsequent heavy metal analysis and ESCA. Finally, the measurement capabilities should be expanded to include particle size distribution mapping.

Photochemical Transformation (Bag Irradiation) Study

Objective/Purpose: To ascertain the photochemically stimulated transformations in the sulfur cycle in order to develop a chemical kinetic model of the processes involved.

Approach: The initial approach taken in this study will be to isolate chemical effects from meteorological and variable emissions effects by irradiating representative atmospheric samples in irradiation chambers. In these studies Tedlar bags are used and irradiations are conducted at the Central RAPS St. Louis facility. Two identical air samples are collected in the bags. The contents of one bag is modified either by the addition or removal of particular materials. During the simultaneous irradiation of the two bags the comparative results are noted and related to known and/or postulated chemical and physical phenomena. The processed data are sent to SAI for chemical kinetics model development work. Initial experiments will determine: 1) the effects of SO_2 on NO oxidation and O_3 formation, 2) the effect of toluene on smog formation, 3) the effect of particulates from auto exhuast, and 4) effect due to atmospheric dilution with clean air. Measurements of SO_2, NO, NO_2, O_3, CO, non-CH_4, CH_4, hydrocarbon distribution, CH_3, CHO, PAN, particle size and % RH are made. Measurements of other sulfur compounds should also be included. If not in these initial experiments, measurements of H_2S and other reduced sulfur compounds should be planned for later efforts as they are known to react with O_3 in the presence of particles. Irradiation intensity is determined by measuring the disappearance of NO_2 during an experiment containing NO_2 and N_2 only.

Schedule: Initial experiments are scheduled to begin during the summer, 1974 expeditionary period, using the above approach. It is recommended that for subsequent experiments ammonia measurements, as well as sulfate measurements, be made if the results of these initial experiments warrant it.

Advanced Programs (Recommended). The studies in this classification represent activities that are important to RAPS objectives but represent a leading edge of knowledge that may be of principal significance in pollutant material balance or in characterizing materials that heretofore have not been measurable (reliable or otherwise). It is expected that, with further definition, portions of these studies would become independent studies or be incorporated into an expanding study already mentioned.

Removal Processes

Objective/Purpose: To determine the rate of removal of SO_2, CO and NO_x via dry deposition (surface absorption and adsorption on ground and vegetation), aerosols and water cloud processes.

Approach: In initial study efforts the basis for determining the dry deposition of SO_2 (as a function of different land classes) involves the use of the flux gradient method where the deposition velocity is defined through the mass transfer relationship and experimentally determined via direct measurement of SO_2 vertical concentrations gradient near the surface. Measurements made over areas of homogeneous surface types (3 to 5 different surface classifications), using an instrumented mobile van and 10 m tower (with automatic recording capability), is the basic measurement system.

Plans for an expanding effort must be forthcoming and this effort must include (in addition to increasing the scope of the SO_2 measurements) measurements for CO and NO_x. In laboratory studies, it has been shown that CO concentrations are very effectively reduced by ground absorption processes (specifically, bacterial activity). O_3 has not been given as great as an importance in these efforts because of the low concentration levels and the difficulty in measurement of gradients. The design of all of these experiments, as a minimum, requires knowledge of the St. Louis AQCR land use. Measurements over vegetative (three to five classifications), soil and covered surface (cement, blacktop, etc.) areas throughout the day for different stability classes are required in order to elucidate the diurnal variations due to plant and bacterial activity (for the different modeling classes). Use of the gradient method provides the basis for a measurement approach.

The interface of the Removal Process Study with the Aerosol Characterization Study is apparent. As the nature of the data from this study becomes available (size spectra as well as chemical composition), an experimental approach to refine the gas-particle removal process can be developed. Although this is one of the goals of the Aerosol Characterization Study, the removal process aspects should be brought out separately and given greater focus after the development of the St. Louis aerosol data base. It is intended that this will insure important direction and definition in future field studies.

In order to elucidate the importance of precipitation scavenging in the removal process (to include the transport of material to the scavenging site, in-cloud scavenging by the cloud elements and precipitation and below-clowd scavenging by the precipitation) it is recommended that use be made of the METROMEX/RAPS interface. Through the acquisition of only a few pollutant monitors and their use in the METROMEX aircraft, important data may be acquired. The principal disadvantage with this approach is the time differences between the RAPS and METROMEX schedules.

Schedule: Initial measurements of SO_2 deposition were scheduled to begin in the summer 1974. Measurements under the recommended program of expanded scope should start no later than the winter, 1975 expeditionary period. Initially, the expanded effort should coincide with those RAMS stations which possess the turbulence instrument package. Design of the study requires the availability of a land use inventory. Efforts to secure this must be forthcoming. Additional instrumentation is also required. At a minimum this will require approximately 10 - 15 additional pollutant monitors. The results of the initial SO_2 Dry Deposition Study should be studied closely. If the gradient method employed is deemed successful, then additional (three to five) instrumented mobile 10 m towers will be required. These are available from the NERC-LV. Data acquisition and processing systems may be obtained from those portions of the EPA CHESS program which have been replaced by the CHAMP network.

<u>Measurement Technology (Recommended)</u>

Objective/Purpose: To make the EPA/RAPS management aware of new, significant advances in measurement principles and technology as it relates to the model development and evaluation program and the aerometric program. In addition to the measurement of substances deemed important, but heretofore not measured or measureable, emphasis is placed on QC and QA practices.

Approach: At least three important activities are currently required. The first, a NO_2 monitor comparison test, consists of comparing the NO_2 chemiluminescent monitor with a NO_2 laser induced fluorescent monitor. This comparison will be made in St. Louis. The second activity is the application of a recently developed sulfuric acid monitor to the RAPS. Although not completely field evaluated at this time, the field performance of this instrument is expected to be characterized prior to completion of RAPS field studies. Progress toward achieving field reliability should be monitored closely. Such an instrument, when implemented on even a limited basis, would provide the extremely valuable data needed for elucidating the role this material plays in the SO_2 oxidation/sulfate formation mechanism. The third need, currently not planned but strongly recommended, is the establishment of a mobile quality control unit. As a minimum this unit would contain a complete set of air quality and meteorological instruments (including devices required for their calibration). This unit would serve as the focal point for all measurement related quality control activities (e.g. calibration of RAPS measurement systems and intercomparisons between RAPS measurement systems).

Schedule: The NO_2 monitor comparison is to begin during the Summer, 1974 expeditionary period. The initial comparisons will be between a Bendix NO-NO_2-NO_x monitor and the Aerospace Corporation NO_2 fluorescence monitor. It is recommended that this comparison be made during each of the expeditionary periods for at least one year. Furthermore, it is recommended that as soon as possible a comparison be made at one or more of the RAMS stations. This allows a more direct comparison with the RAMS' NO_2 monitor which is manufactured by Monitor Labs. The particular RAMS station should be selected following a review of the overall RAMS data in the late fall 1974.

At this writing, there exist no definite plans for application of the sulfuric acid monitor in the RAPS. It is recommended that arrangements begin in September to have the existing unit field operated in St. Louis during the winter 1975 period. If the results are encouraging, a broadened program should be developed for the summer 1975 expeditionary period.

Moreover, it is recommended that consideration be given as soon as possible to placing sulfuric acid monitors in the RAPS Aerial Monitoring System (the helicopters).

As with the development of a program for use of sulfuric acid monitors, no plans exist for use of a QC van. It is recommended that such a van be equipped for and operated during the winter 1975 period. Based upon the number of expeditionary measurement systems currently participating in the RAPS (mobile units, trailers, aircraft, etc.), as well as the extent of the St. Louis AQCR, this QC van can be expected to be utilized virtually full-time during the expeditionary periods.

Recommendations

The following recommendations are made:

- Uniformity should be adopted with respect to the periods within each season that field expeditions are to be conducted.
- Each study program should maintain conformity to a schedule consisting of the following four phases:
  1) experimental design with EPA/RAPS management approval;
  2) preparations; 3) measurements; and 4) data validation and analysis.
- With the coordination of the Meteorology Laboratory, Chemistry and Physics Laboratory, and the National Air Data Branch, action should be taken to start development of the St. Louis AQCR land use inventory no later than October 1, 1974.
- Special awareness should be given to the Sub-Grid Scale Characterization program.
- Greater emphasis should be given to Removal Process studies. Although some experiments are now planned, this area requires more attention.
- The development of field programs focussed on the sulfur cycle should be closely monitored.
- An advanced program concept should be added which consists of early activities that can be expected to play an important role in meeting the RAPS objectives (e.g., an NO_2 monitor comparison test and a program for use of sulfuric acid monitors are two specific recommendations).
- A mobile quality control van should be equipped and placed into service during the winter 1975. The unit should contain a complete set of air quality and meteorological instrumentation and serve as the focal point for all measurement related QC activities during the expeditionary periods.

DATA MANAGEMENT

Just as the Model Development and Evaluation Program provides the direction and focus for the RAPS, so the Data Management effort serves as the "glue" which keeps the RAPS together. The massive quantities of data from the RAMS, the great variety of data from the Field Expeditionary and Emission Inventory Programs and the large number of organizational entities, personnel and scientific disciplines presents the RAPS with an extraordinary data management task.

Objective of Data Management Effort

The objective of the data management effort is to develop and maintain a data management system responsive to user requirements within the framework of RAPS objectives. At the same time data integrity must be maximized and the impact on computer resources minimized. This requires efficient storage and retrieval software, simple on-line display and analysis capability, timely distribution of data in user specified formats, periodic data base summary reports and adaptability to changing needs and schedules.

A Plan for Data Management

In addition to the final operations phase, the data management task can be divided into design and implementation/demonstration phases. Figure 8 illustrates a logic flow diagram for planning this effort. For the most part Mr. R. Browning has implemented a plan for the development of a data management system which leads to the elements illustrated to the right of Figure 8.

Separate from the management of data from the routine measurement elements (RAMS and Upper-Air Sounding Network, etc.) and consistent with the user oriented data management objective, Mr. Browning has requested data plans m each RAPS principal investigator prior to each field expeditionary '. This data plan is used by the data management personnel to prepare for acquisition, storage, retrieval and analysis. Additional cri of this plan is deferred to sections in this report describing 'l design and preparation of phases of the field expeditionary

Plans for storage and user access of RAMS and upper air data may be obtained from Mr. Browning. Briefly, the data management system being implemented for RAPS allows an investigator to obtain RAMS data for any station, on any day, for any measured parameter. This is accomplished via the use of System 2000 data management language. At this writing turn around times for such request have not been specified, although availability in near real-time is desired by some principal investigators.

Recommendations

Two additions to planned data management operations are recommended. Firstly, it is recommended that pollutant distribution and wind field maps, based on RAMS and upper air soundings, be made available to RAPS participants following the special expeditionary periods. Maps for days of particular interest or, as appropriate to the investigation, maps for the entire length of certain expeditionary periods should be provided upon request of a RAPS principal investigator. The nature of the requests, i.e., number of maps, specific parameters, hourly summaries vs. daily summaries, etc., will depend upon the nature of the investigation and should be coordinated during planning of the field expeditionary exercise.

Secondly, it is recommended that pollutant distribution and wind field maps for several meteorological conditions be made available to RAPS participants as soon as the RAMS becomes operational. These maps would be prepared on a selective basis and would be representative of general meteorological conditions of interest to all investigations. For example meteorological conditions may be those which are: 1) typified by wind fields with flow from each of the four cardinal directions with associated pollutant distributions for a range of stability conditions observed; 2) representative of those situations which have a high expected frequency of occurrence for each month or season; and 3) considered to be examples of extreme situations, i.e., intense inversions, fumigation situations, extremely unstable air mass, etc. A more precise definition of the requirements and the means for sorting data by category should be coordinated among the RAPS participants to insure maximum usefulness of the information. Such maps would greatly enhance the planning of the special field expeditions, particularly in planning times of day, month or season for experiments, location of mobile equipment and types of measurements desired.

II. INTEGRATION AND SYNTHESIS OF THE RAPS ELEMENTS

The elements of the RAPS discussed in previous sections all focus on achievement of program objectives. It is the purpose of this section to discuss those aspects of the RAPS required to establish: (1) the logical relationship between RAPS elements and program objectives; (2) operational aspects of these elements as they relate to management factors; (3) the scheduling requirements; and (4) what elements are missing and/or need strengthening, if any.

Thus, presented in this section are the "pieces" of RAPS and their "products", as they relate to the principal program objectives--validated models. With these relationships established, operational procedures for the conduct of field expeditions are presented. This is then followed by the presentation of a Master Program Schedule.

LOGICAL RELATIONSHIPS BETWEEN RAPS ELEMENTS

The relationship between the various pieces of the RAPS and model development and evaluation can be illustrated by considering the schematic diagram in Figure 9.

Whatever the application chosen, air quality models relevant to RAPS focus on establishing the relationship between emissions and ambient air quality as defined by the existing or projected regulatory structure. With the exception of the regional heating or energetics (heat balance and radiative interaction) model, air quality represents a solution to the mass conservation for pollutant species S, which is given in mathematical shorthand by Equation (1) in Figure 9. Nomenclature used in Figure 9 may be found in Table 6. This expression must include boundary and initial conditions, as illustrated. In the case of sulfur, for example, total sulfur can be expressed in terms of gaseous components Sg and particulate components, Sp. That is S=Sg+Sp.

In a turbulent medium, such as the atmosphere, the trace pollutants fluctuate in concentration with variations in the fluid. For averaging over a given time (or over space), Equation (1) in Figure 9 can be rewritten with well

TABLE 6 NOMENCLATURE FOR FIGURE 9

S	concentration of pollutant
t	time
$\vec{v}$	wind velocity
D_s	molecular diffusivity of species S
K	eddy diffusivity coefficient
k	chemical rate constant
α	loss rate coefficient
E	emission rate
L	loss rate
S_T	total time derivative (dS/dt)
S_t	partial time derivative ($\partial S/\partial t$)
v	wind field
S_x	spatial derivative of S, ∇S
S_{xx}	Laplacian of S, $\nabla^2 S$
T	temperature
RH	relative humidity
$h\nu$	radiation as a function of frequency, ν
I	light intensity
Q	heat flux
z	vertical coordinate
χ	horizontal coordinate
χ_s	location of source S
z_s	height of source S
Δt	time interval of source measurement
v	volume of aerosol particle
n	particle size number density function
d_s	surface loss coefficient
C	corrosion rate
b_{scat}	integrated extinction coefficient for scattered light
b	lidar back scatter coefficient
H	mixing height

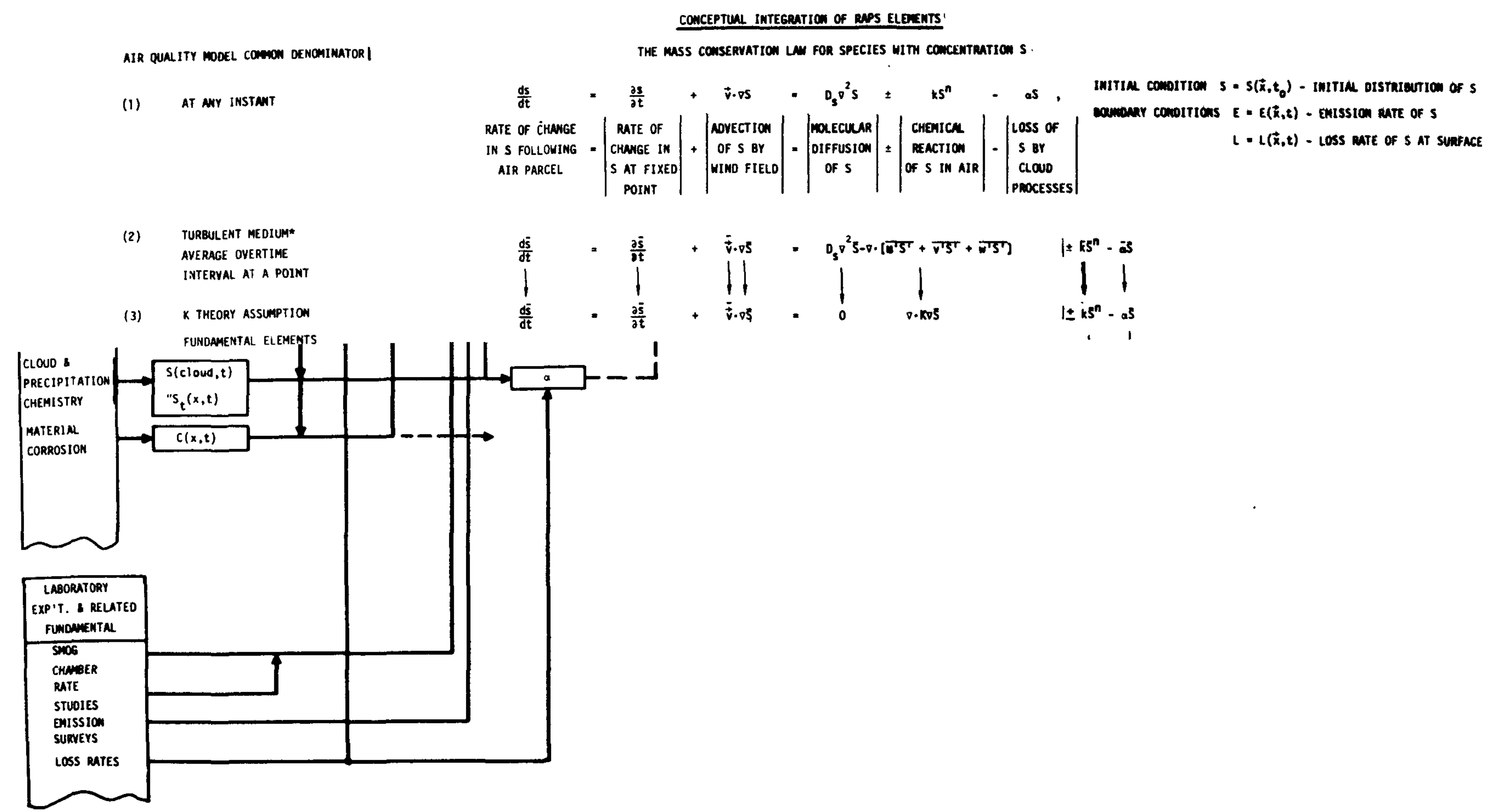


Figure 9. Conceptual Integration of RAPS Elements

known approximations as Equation (2). Here the time averaged pollutant concentration $\overline{S}$ relates to transport and source or loss contributions in a manner analogous to the expression for the instantaneous concentration, S. Formally, Equation (2) also could be written in terms of a spatial average $\langle S \rangle$ or a spatial/temporal average $\langle \overline{S} \rangle$, with suitable assumptions.

Existing air quality models simplify Equation (2) of Figure 9 further by disregarding molecular diffusion and simplifying the eddy-diffusion terms with the K-theory approximation, as indicated in Equation (3)

Accepting the K-theory model on a conceptual basis, the fundamental elements of the RAPS can be identified with the various terms of the mass conservation equation. These elements are classed as (1) directly calculated with no physical assumptions, and (2) those derived parameters based on theory, laboratory experience or the history of previous field study parameterizations. Within this framework, the various elements of the RAPS can be linked to the model heirarchy as shown in Figure 9.

On the left side, the RAPS currently planned experiments are listed. These have been classified as routine and non-routine field studies, and laboratory or other fundamental studies. The field programs generate and list measurement outputs. Fundamental elements of the models are deduced from the measurements. These, in turn, are used to establish the inputs and the initial boundary conditions for the model heirarchy. Through the exercise of the model inventory and associated development work, the experiment (measurement) output is interfaced with the model output for comparison and validation. This interface is defined by the protocal for test and validation. The protocol must be laid out on a rational basis and it must take into account model applications, application requirements and the known limitations of the individual models.

The heart of the RAPS experiment achievements center around the intercomparison module shown conceptually at the middle right hand side of Figure 9. Although no explicit mention is made of data management, it should be obvious that it is related to virtually every element of the program

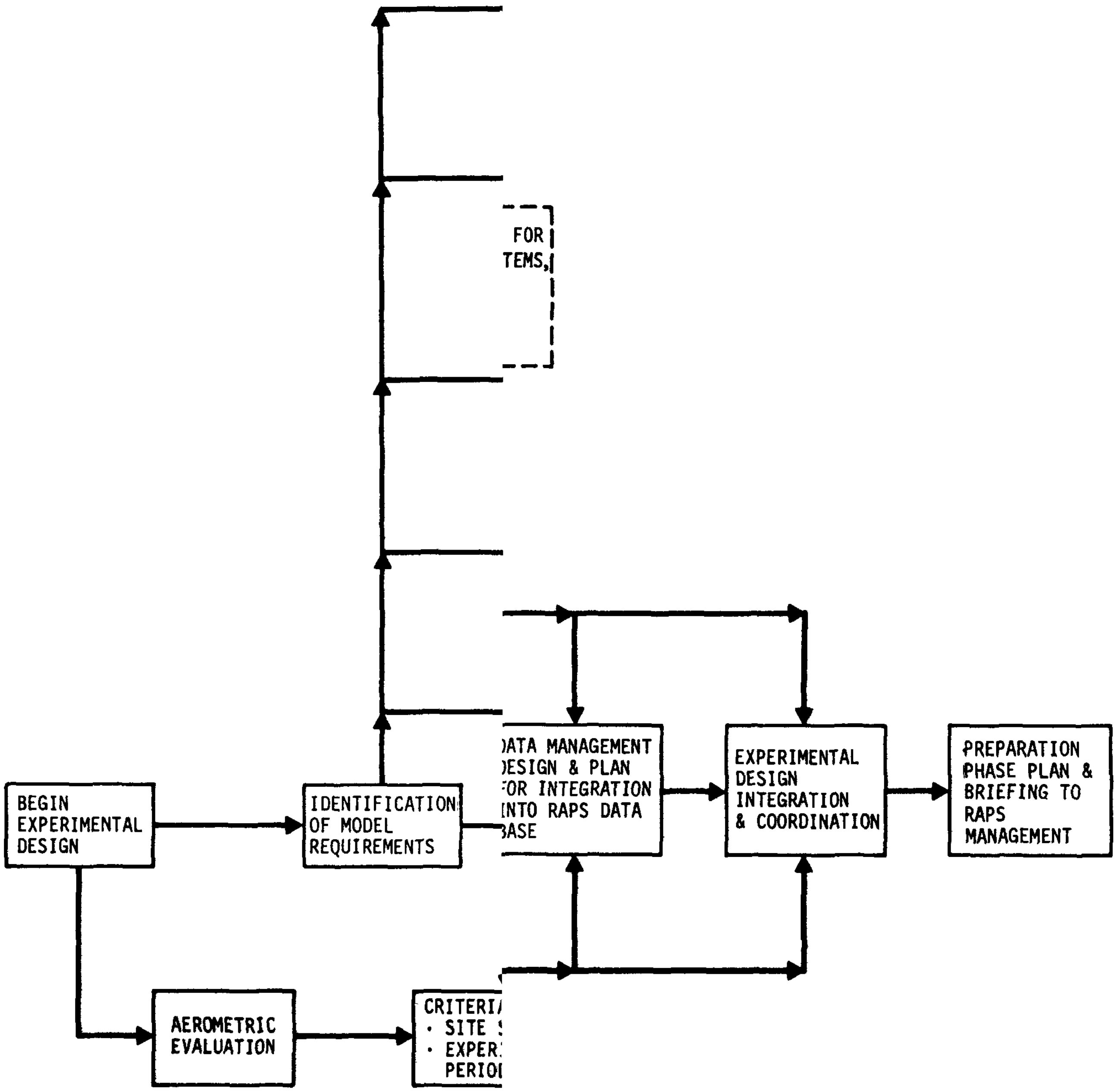
OPERATIONAL PROCEDURES FOR THE CONDUCT OF THE RAPS FIELD EXPEDITIONS

The relatively large number of RAPS participants, along with their varied interests and activities, requires that standardized operational procedures be established. It is therefore recommended that all field expeditions conform to a schedule which consists of the following phases: 1) an experimental design phase at the end of which its approval from EPA/RAPS management is obtained; 2) a preparation phase; 3) a measurement or an experiment phase; and 4) a data validation and analysis phase. The duration of any phase for a particular expedition may be different. Discussions with virtually all RAPS investigators lead us to believe this recommendation is acceptable. Not only will this make program control more possible, it also affords management the opportunity to maintain and disseminate efficiently to all participants information vital to the conduct of an informed program.

Elements of Field Expedition

Figures 10 and 11 depict logic flow charts of the elements comprising each phase. These figures are intended to stand alone and therefore do not require extensive discussion; however, for purposes of completeness a discussion follows.

At the outset it should be recognized that not all elements are necessarily applicable. As indicated in Figure 10 the experimental design begins with two activities occurring in parallel, the identification of model requirements and an aerometric evaluation of the St. Louis AQCR with respect to the particular expedition being proposed. This might include consideration and evaluation of available aerometric data from RAMS, the upper air sounding network (UASN), the aerial monitoring system (AMS) and the air monitoring networks of St. Louis City, St. Louis County, Illinois and Missouri. Consideration of these data, coupled with the identification of model requirements which are consistent with established RAPS objectives, enables development of criteria for when and where the expedition should be conducted. For the candidate locations and periods of interest,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TEMS,
BEGIN EXPERIMENTAL DESIGN
IDENTIFICATION OF MODEL REQUIREMENTS
AEROMETRIC EVALUATION
CRITERI
· SITE
· EXPER
PERIO
ATA MANAGEMENT ESIGN & PLAN OR INTEGRATION INTO RAPS DATA ASE
EXPERIMENTAL DESIGN INTEGRATION & COORDINATION
PREPARATION PHASE PLAN & BRIEFING TO RAPS MANAGEMENT

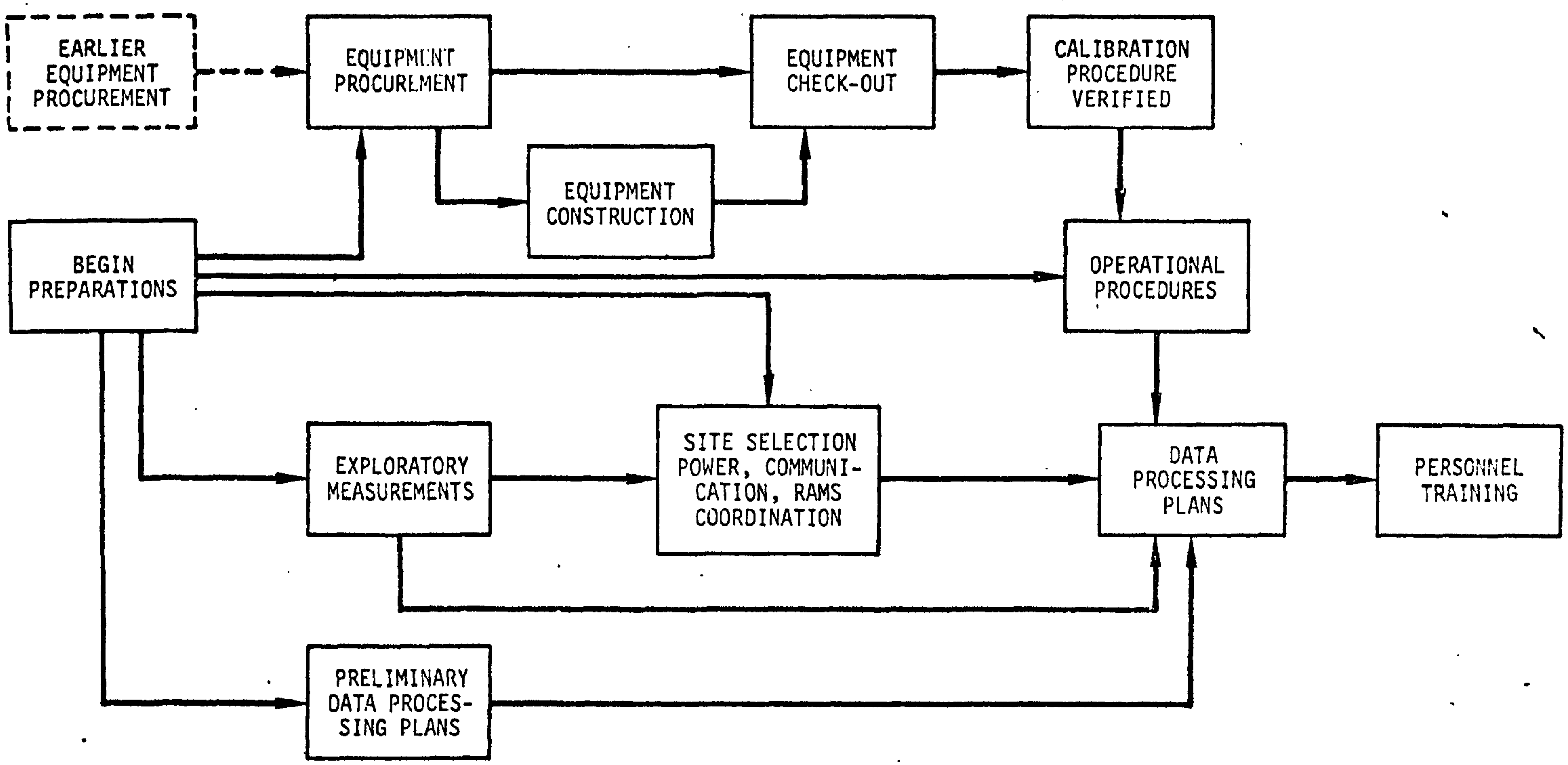


Figure 11. Flow Chart for Preparation Phase

meteorological and pollutant conditions are examined. A number of data requirements may then be specified for the particular expedition. Following instrument selection, procurement arrangements (as well as the final specification of data requirements) would be initiated. Consideration of the operational and logistical aspects (along with the development of candidate measurement schedules and patterns) and requirements from the RAPS St. Louis facility, leads to the design of a data management plan.

The nature of the data management plan requires additional comment. It should include a description of the proposed data flow, the medium upon which the data are collected, EPA computer use requirements, RAPS-St. Louis computer use requirements and a quality control plan.

The completion of the data management plan logically is followed by the development of an integrated experimental design that contains a schedule to completion, which is to be forwarded to RAPS management. Subsequent to this a briefing may be deemed necessary.

The duration of the entire experimental design may take a few days to a few weeks. Regardless of the time, it is the most effective means to communicate the plans of the investigator, not only to RAPS management, but also to other participants. As these plans can be expected to change, RAPS management can be kept informed, and all the benefits of this communication disseminated to the rest of the program participants. If plans for support from Rockwell are required, Rockwell may also be given advance notice along with copies of the relevant design elements.

With completion of the Experimental Design Phase, a planned field expedition enters the Preparation Phase. Figure 11 depicts the logic flow charts for this activity. For the most part, this diagram also stands alone. It should be pointed out however, that both preliminary data processing plans as well as any required exploratory measurements which would further advance the expedition would be started immediately.

Moreover, if Rockwell support is required during the expedition, there should be sufficient time to allow for participation in personnel training.

Obviously the nature of the measurement and data analysis phases cannot be discussed in any detail; however, as demonstrated in the discussion of the Master Program Schedule, every effort must be made to get tabulated, if not analyzed, valid data into the RAPS Data bank as soon as possible.

Management Utilization of Experiment Designs

The delivery of properly developed Experimental Designs (ED) will provide RAPS management with a great deal of information designed to maintain up-to-date program status. It is the purpose of this section to indicate some of the uses.

The ED will obviously specify who the participants are, what they will be doing, where they will be doing it, when they will be doing it and with what they will be doing it. In addition, coordination requirements with the RAMS, UASN, AMS, the RAPS St. Louis facility, and other field expeditions will be indicated. Finally, the media upon which all data are collected can be inventoried and evaluated in advance against available resources.

All of these data can be collated and presented in easily maintainable matrices. Thus, a number of hardware allocation matrices (one each for mobile units, trailers, aircraft, tracers, etc.) can be maintained, which keeps track of when and where a particular unit is to be used and who is responsible for the unit. A RAMS/Field Expeditionary utilization matrix can also be developed and maintained which indicates what stations are to be used, by whom, when the users intend to be there and what are their station requirements. A matrix indicating which Field Expeditions require data from the RAMS, UASN and AMS can be maintained. Finally, a Field Expeditionary coordination matrix can be developed and maintained which indicates which investigators wish to coordinate their activities either via measurement systems, data exchange, site location, etc.

MASTER PROGRAM MILESTONE SCHEDULE

In previous sections of this report the logical development and relationships of the RAPS elements have been presented. Integration of these elements with time included is best accomplished through the use of a Master Program Milestone Schedule.

As indicated earlier, the RAPS is viewed as being comprised of five major tasks: 1) a Model Development and Evaluation Task, 2) an Aerometric Measurement Task; 3) an Emission Inventory Task: 4) a Data Management Task; and 5) a Program Management Task. Whereas the plan proposed herein places the Model Development and Evaluation Task with the overall guidance in the technical sense, it is the Program Management Task which provides the overall guidance in the timing and resource sense in order to comply with the RAPS objectives on schedule and within budget.

A master milestone chart for these five tasks is presented in Figure 12. Only those specific events (milestones) which are presently considered as important reference points in meeting the objectives have been included.

Program Management Task

Starting at the bottom of Figure 12, it is noted that the Program Management Task consists of five parts. Short term and annual progress is monitored via approvals of experimental designs, kick-off meetings just prior to the periods of field expeditionary activities and annual status reports of the principal investigators which are phased (dotted lines) with the annual critical RAPS review meetings. Program direction is achieved through the experimental design reviews and program control meetings. Moreover, as previously indicated, program status of the important field expeditionary program is maintained via the experimental designs and is

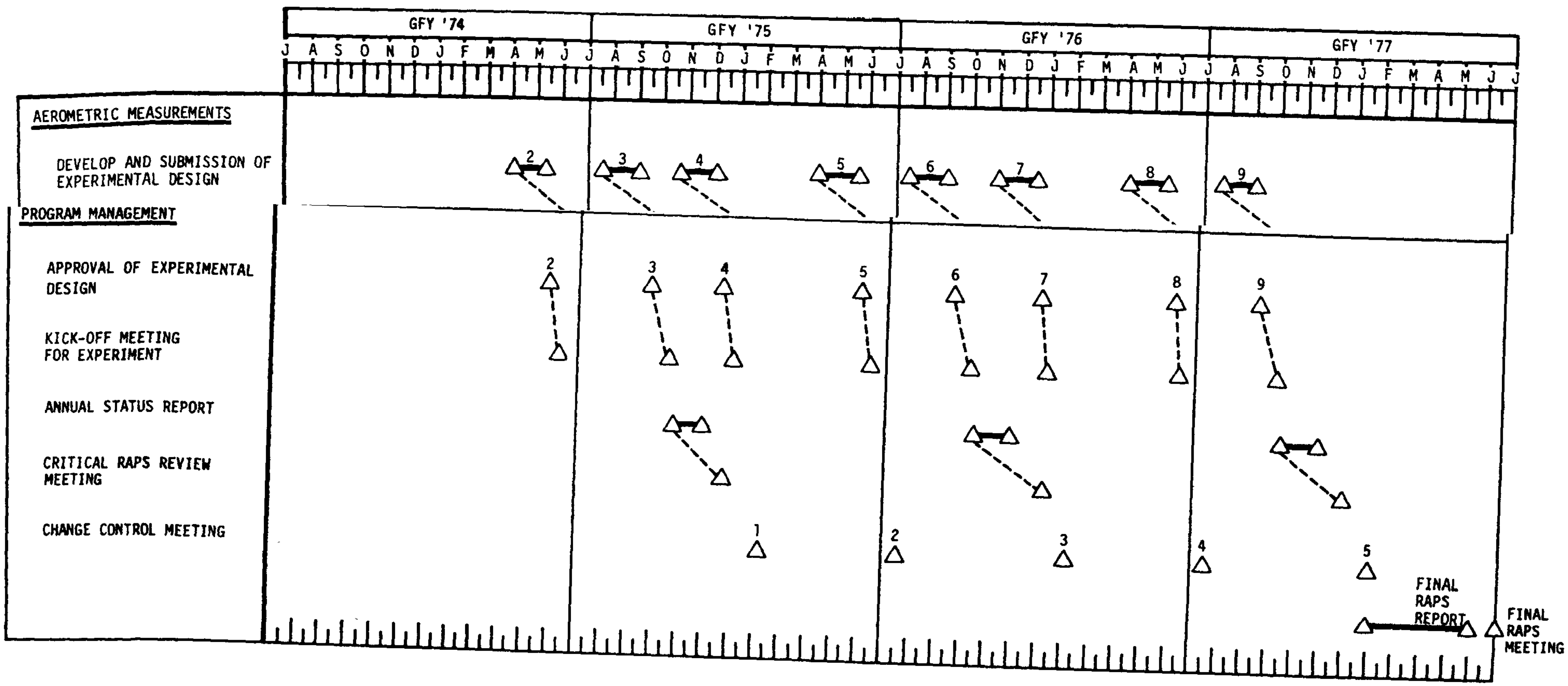


Figure 12. Master Milestone Chart

the responsibility of the Field Director. The overall status of the RAPS is formally communicated to the participants through the critical RAPS review meetings. Responsibility for overall RAPS final reporting lies with the Program Manager. Although the scope of the Program Management task as recommended is deemed adequate, it is not considered excessive for an effort of the magnitude and complexity of the RAPS.

Model Development and Evaluation Task

The model evaluation (and evaluation criteria) and the recommendations to the emissions, measurement and data management task constitute the key milestones of this effort. The former are phased with the RAPS critical meetings while the latter are phased with the program control change meetings of the PM task. The need for early consideration for establishing evaluation criteria is clearly established by examination of the timing. In fact, this should be considered a critically important item at this time.

Aerometric Measurement Task

The organization of this task assumes that the recommendation made earlier concerning the adoption of specified period for intensive field expeditions was accepted. Thus, the numbering in Figure 12 denotes the first such period, the second such period, etc. The field expeditionary programs begin with the development and submission of experimental designs and, following the measurement period, pass through an initial data validation and experimental analysis phase. Two expeditionary activities have been conducted without formal experimental designs. While the first was small and consisted of only two investigators, the second was quite large and traumatic in the early preparation activities due to the lack of adequate communication. The second activity constitutes a first-cut at data collection and analysis. With the RAMS systems acceptance test (SAT) completed in early October, formal operations begin; however, as early as July, partial operations will begin.

The specific nature of the field expeditions planned for each expeditionary period are indicated in Figure 13. The nature of these studies was discussed on Page 18, while their relationship to the RAPS "product" is indicated in Figure 9. In Figures 14, 15, and 16 are indicated the specific hardware systems planned for the various expeditionary periods. Thus, it is seen that the summer period is scheduled to have approximately 12 mobile units and 9 aircraft taking measurements in the St. Louis AQCR. Furthermore, it is seen that tracer studies begin in the summer '74, with more intensive activities beginning in the summer '75 period.

Data Management Task

The Data Management(DM) Task consists (cf. Figure 12) of the development of the DM system, system (field expeditionary) validations, and operational/procedural modifications. The system validations efforts are phased with the initial data validation efforts of the aerometric measurements task and constitutes a machine validation of the field experiment data. Operational/procedural modifications are phased with the program change controls as derived from the PM task.

Emissions Inventory Task

The first four broad segments of the emission inventory task represent a condensation of the schedule presented in Figure 5 with the one exception of the modifications which are, once again, phased with the program change controls.

As indicated by the schedule, emission data from the data collection activity will not be available until late in the program. It should be noted that the NEDS inventory can be used for initial model testing; however, critical delays (depending upon the vagaries of the industrial and local authorities as to data attainability) in model evaluation and validation are possible. At this writing cooperation by local industry appears to be favorable.

Field Tasks	Field Expedition Periods								
	1	2	3	4	5	6	7	8	9
Boundary Layer Study	x	x	x	x	x	x	x	x	x
Energy Budgets Study		x	x	x	x	x	x	x	x
Aerosol Studies	x	x	x	x	x		x	x	
Point Source Plume		x	x	x	x	x	x	x	x
Urban Plume	x	x	x	x	x	x	x	x	x
Surface Deposition		x	x	x	x	x	x	x	x
Pollutant Variability		x	x	x	x	x	x	x	x
Bag Irradiation		x			x			x	
Measurement Technology		x	x	x	x	x	x	x	x

Figure 13. Field Expeditions Planned for Duration of the RAPS

Field Expedition Periods

Mobile Unit Description	1	2	3	4	5	6	7	8	9
General Electric Trailer 8' x 20', McClenny/Chaney		x			x				
EPA Motor Home (Lincoln Lab), McClenny/Chaney		x			x	?	?	x	?
Meteorology Panel Van Elroy	x	x	x	x	x	x	x	x	x
Mobile Lidar Truck McElroy/Peterson		x	x	x	x	x	x	x	x
U. of Wyoming Mobile Unit #1, McElroy		x			x				
U. of Wyoming Mobile Unit #2, McElroy		x			x				
BNL Mobile Unit Newman		x	?	x	x		x	x	
Moveable Aerosol Lab Wilson	x	x	x	x	x		x	x	
Winnebego Kopczynski		x	x	x	x	x	x	x	x
Mobile Tower Wilson		x		?	?		?	?	
Whitby's Mobile Unit Wilson				x	x		x	x	
Scott Office Trailer 35', Wilson (Optical Instr.)		x		?					

Figure 14. Hardware Allocation (by Field Expedition Period) Matrix

Field Expedition Periods

Aircraft	1	2	3	4	5	6	7	8	9
Helicopter (Fostaire or equiv), McElroy	x	x	x	x	x	x	x	x	x
Penn State Fixed Wing (or equiv), McElroy/ Peterson		x	x	x	x	x	x	x	x
Las Vegas C-45 or B-26, Peterson		x	x	x	x	x	x	x	x
U. of Wyoming Queen Air, McElroy		x	x		x				
NCAR Fixed Wing McElroy		x							
MRI Fixed Wing Wilson		x	?	x	x		x	x	
BNL Fixed Wing Newman		x	?	x	x		x	x	
Las Vegas Helicopter #1, Evans		x	x	x	x	x	x	x	x
Las Vegas Helicopter #2, Evans		x	x	x	x	x	x	x	x
Las Vegas Helicopter #3, Evans		x	x	x	x	x	x	x	x

Figure 15. Aircraft Allocation (by Field Expedition Period) Matrix

Field Expedition Periods

Tracer Description	1	2	3	4	5	6	7	8	9
SF6, BNL Newman		x	?	x	x		x	x	
FP McElroy, Pooler					x	x	x	x	x
SF6 McElroy, Pooler					x	x	x	x	x
Freons McElroy, Pooler, Dickson					?	x	x	x	x

Figure 16. Tracer Allocation (by Field Expedition Period) Matrix

III. SUMMER 1974 FIELD EXPEDITIONARY EXERCISE

The summer '74 Field Expeditionary Exercise will constitute by far the largest RAPS activity to date. More than twelve intensive activities are planned to begin in late July and continue through most of August. A few studies will run through mid-September.

One of the authors spent approximately seven weeks at the NERC, RTP, working with investigators and other RAPS participants to develop plans for the summer activities. Although experimental designs were necessarily brief, through the use of questionnaires and extensive personal discussions, sufficient information was gathered to prepare the schedule of activities for the summer period indicated in Figure 17. Activities were planned such that the majority of the effort is to be expended in August.

The field expeditionary coordination matrix for the summer period is presented in Figure 18. The matrix identifies those investigators who desire coordination in the conduct of joint experiments, in the sharing of instruments or in performing joint data analysis. The media upon which the data will be collected for expedition is shown in the matrix of Figure 19. By developing a Field Expeditionary/Routine Measurement Coordinator matrix (shown in Figure 20), those activities which are interfaced with the RAMS, UASN, AMS and EPA/RAPS St. Louis facility are easily displayed. For those expeditions requiring RAMS use, the specific site is given in the RAMS Station/Field Expeditionary Utilization Matrix in Figure 21. The matrices in Figures 18-21 should allow the Field Director to monitor continuously the summer '74 activities

FIELD EXPEDITIONARY TASKS

BOUNDARY LAYER STUDIES (BLS)
- HELICOPTER
- MOBILE VAN
- GROUND BASED LIDAR (LIDAR VAN)
- FIXED WING AIRCRAFT (LIDAR, NERC-LAS VEGAS) SECOND VEHICLE FOR SURFA

ENERGY BUDGET
- PENN. STATE UNIV. (PSU) AEROCOMMANDER
- GROUND BASED LIDAR (LIDAR VAN) SEE BLS ABOVE
- RAMS RADIATION MEASUREMENTS

AEROSOL SPECIAL STUDIES
- MOVEABLE AEROSOL LAB
- AEROSOL OPTICS LAB
- RAPS MOBILE LAB (WINNEBAGO)
- MRI AIRCRAFT
- BROOKHAVEN AIRCRAFT
- MOBILE PIBAL UNITS - MRI OR EQR TECHNICAL SERVICE AGREEMENT
- RAPS HELICOPTERS

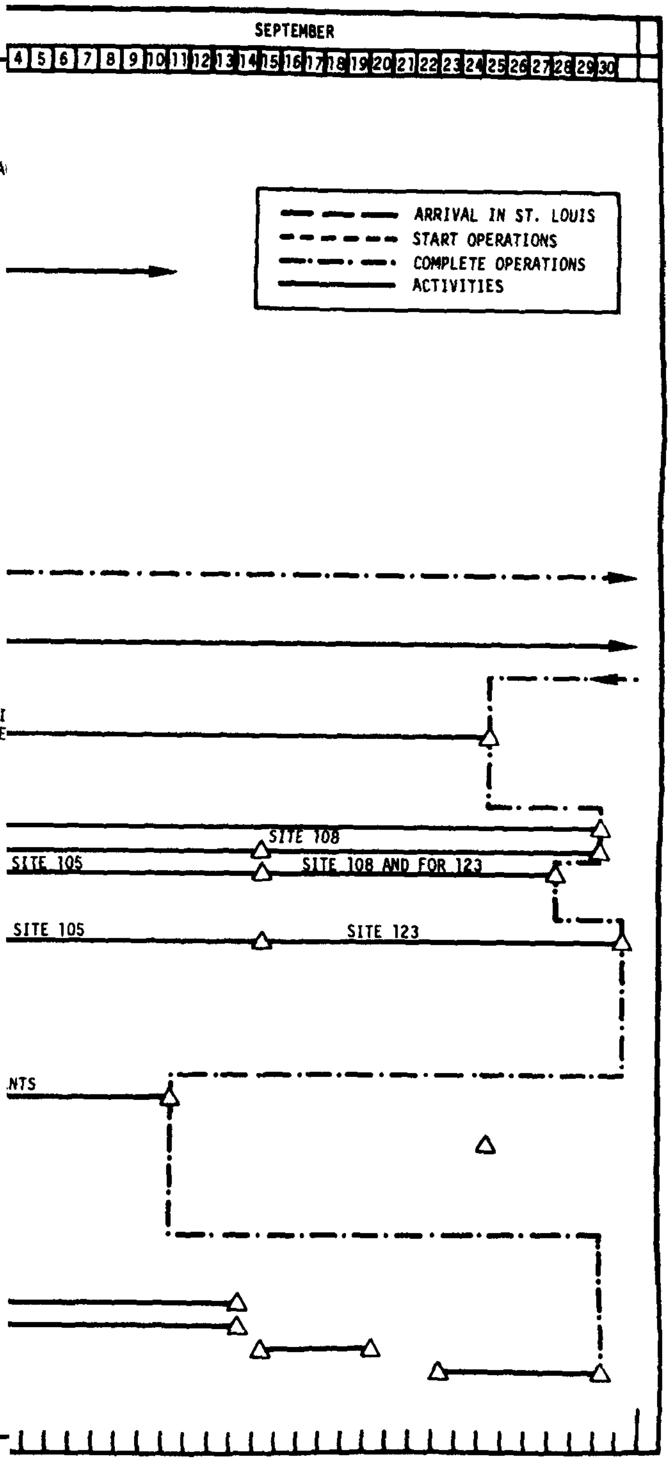
MEASUREMENT TECHNOLOGY
- NO_2 FLUORESCENCE - NO_x CHEMILUMINESCENCE COMPARISON {ST. LOUIS UNI / AEROSPACE - E

LONG PATH MEASUREMENTS
- LINCOLN LAB TRAILER
- GE TRAILER
- EMI - BARRINGER

POLLUTANT VARIABILITY – PORTABLE MONITORS
- PORTABLE MONITORS, TRAINING OF STUDENT OPERATORS
- BAG SAMPLING AND FIELD MEASUREMENTS
- SITES (103,105,108,123)

BAG IRRADIATION STUDIES
- SITE SURVEY FOR SAMPLE COLLECTION
- IRRADIATION CHAMBER
- INSTRUMENTATION AND MATERIAL
- SAMPLE COLLECTION AND IRRADIATION
- DATA TO SAI

POLLUTANT VARIABILITY - WINNEBAGO
- SITE 103 AND 105
- INTERSTATION POLLUTANT DISTRIBUTION
- URBAN AND STACK PLUMES
- RAMS SUPPLEMENT
- SOURCE CHARACTERIZATIONS
- SITES 102 AND 109



	BLS	EB	PSPTS	PSPS	UPS	ACS	PV	LMP	PMV	METROMEX	NASA LANGLEY
Boundary Layer Struc. (BLS) McElroy		x				x			x	x	
Energy Budget (EB) Peterson/McElroy	x					x		x		x	x
Point Source Plume Transformation Study L. Newman (PSPTS)				x	x						
Point Source Plume Study (PSPS) Wilson/Blumenthal			x		x	x					
Urban Plume Study (UPS) Wilson/Husar/Blumenthal			x	x		x					
Aerosol Characterization Study (ACS) Wilson/Durham	x	x	x	x	x						
Pollutant Variability (PV) McClenny/Chaney									x		
Long Path Measurements (LPM) McClenny/Chaney		x									
Pollutant Mapping & Variability (PMV) Kopczynski	x						x	x			
METROMEX	x	x									

Figure 18. Summer '74 Field Expeditionary Coordination Matrix (Expedition #2)

RAPS MEASUREMENT ELEMENT	STANDARD TAPE	NON-STANDARD TAPE	PAPER TAPE	CARDS	FORMS IN CARD IMAGES	STRIP CHART	JOURNALED DA.	SPECIFY OTHER
RAMS	X							
METEOROLOGICAL SOUNDING NETWK.								CHARTS
RAMS VERTICAL EXTENSION	X							
CAMP STATION	X							
G. E. TRAILER	X							
EPA MOTOR HOME (LINCOLN LAB)	X							
METEOROLOGY PANEL VAN						X		
MOBILE LIDAR TRUCK	X							POLAROID FILM
U. WYOMING UNIT #1						X		
U. WYOMING UNIT #2						X		
B.N.L. MOBILE UNIT						X		
MOVEABLE AEROSOL LAB	X			X	X	X	X	
WINNEBAGO		X				X	X	
MOBILE TOWER		X						
SCOTT OFFICE TRAILER		X						
FOSTAIRE (or equiv) HELICOPTER						X		
PENN STATE FIXED WING	X							
U. WYOMING QUEEN AIR	X							
NCAR FIXED WING	X							
MRI FIXED WING		X						
BNL FIXED WING						X		

Figure 19. Summer '74 RAPS Measurement Element Data Classification Matrix

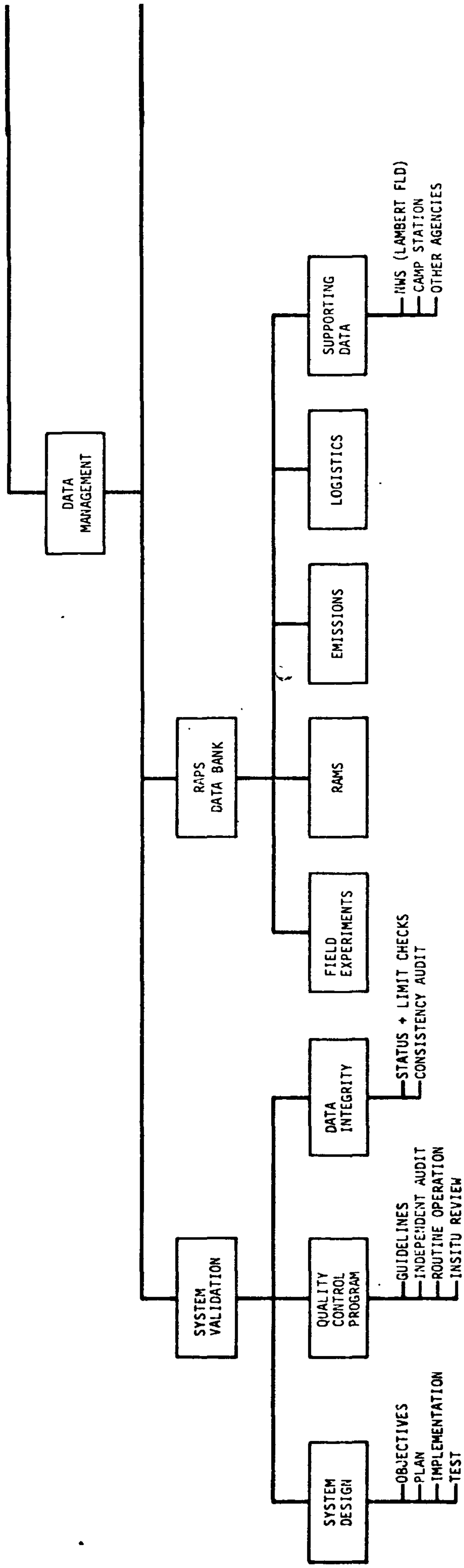
Special Field Expedition	RAMS	Upper Air Sounding Ntwk	Air Monitoring System	Central Facility
Boundary Layer Structure (McElroy)		X	X	X
Energy Budget (Peterson/McElroy)	X			X
Point Source Plume Transformation Study (Newman)		X		
Pollutant Variability (McClenny/Chaney)	X			X
Long Path Measurements (McClenny/Chaney)	X			X
Pollutant Mapping (Kopczynski)	X	X	X	X
METROMEX		X		
Bag Irradiation				X
Urban Plume Study (Wilson/Husar/Blumenthal)	X	X	X	X
Aerosol Characterization Study (Wilson/Durhan)	X	X		X

Figure 20. Summer '74 Field Expeditionary Measurement Coordination Matrix

RAMS Station Numbers	Field Expeditionary Periods 2	3	4	5	6	7	8	9
101								
102	G. C. Bag Samples							
103	E.B. (R) P.V. G.C. Bag Samp		E.B. (R)	E.B. (R) P.V. L.P.	P.V. L.P.	E.B. (R) P.V. L.P.	E.B. (R) P.V. L.P.	
104								
105	E.B. (R) (HF) P.V.L.P. G.C. Bag Samp	E.B. (HF)	E.B. (R) (HF)	E.B. (R) (HF) P.V. L.P.	E.B. (HF)	E.B. (HF) (R) P.V. L.P.	E.B. (HF) (R) P.V. L.P.	E.B. (HF)
106	G.C. Bag Samp							
107								
108	E.B. (R) P.V. L.P. G.C. Bag. Samp.		E.B. (R)	E.B. (R) P.V. L.P.		E.B. (R) P.V. L.P.	E.B. (R) P.V. L.P.	
109								
110								
111								
112								
113	G.C. Bag Samp							
114								
115	E. B. (R)		E.B. (R)	E.B. (R)		E.B. (R)	E.B. (R)	
116								
117								
118	E.B. (R)		E.B. (R)	E.B. (R)		E.B. (R)	E.B. (R)	
119								
120	G.C. Bag Samp							
121	E.B. (H.F.)		E.B. (H.F.)	E.B. (H.F.)	E.B. (H.F.)	E.B. (H.F.)	E.B. (H.F.)	E.B. (H.F.)
122								
123	P.V. L.P.			P.V. L.P.		P.V. L.P.	P.V. L.P.	
124	E.B. (R)		E.B. (R)	E.B. (R)		E.B. (R)	E.B. (R)	
125								

E.B. = Energy Budget
(R) = Radiation
L.P. = Long Path
(H.F.)= Heat Flux

Figure 21. RAMS Station Field Expeditionary Utilization Matrix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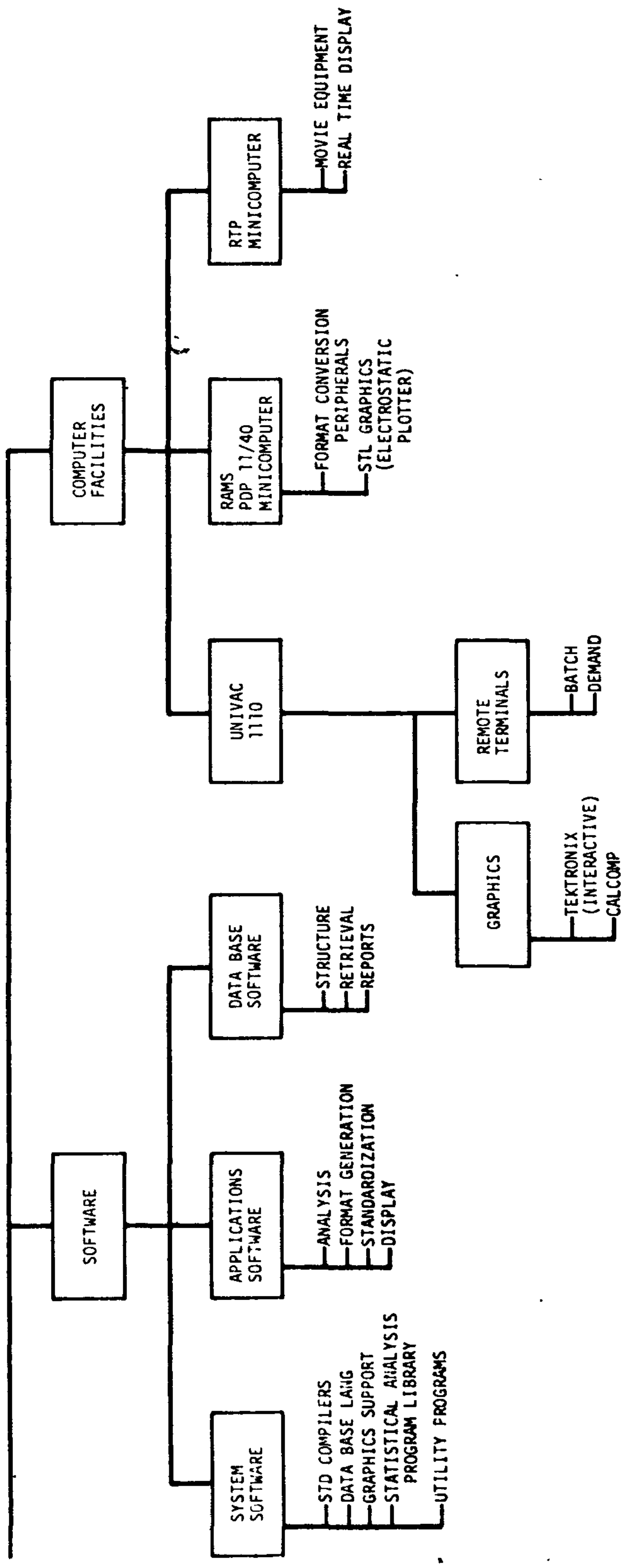
RAPS DATA BANK
SYSTEM VALIDATION
FIELD EXPERIMENTS
RAMS
EMISSIONS
LOGISTICS
SUPPORTING DATA
NWS (LAMBERT FLD)
CAMP STATION
OTHER AGENCIES
SYSTEM DESIGN
OBJECTIVES
PLAN
IMPLEMENTATION
TEST
QUALITY CONTROL PROGRAM
GUIDELINES
INDEPENDENT AUDIT
ROUTINE OPERATION
INSITU REVIEW
DATA INTEGRITY
STATUS + LIMIT CHECKS
CONSISTENCY AUDIT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RTP MINICOMPUTER
MOVIE EQUIPMENT
REAL TIME DISPLAY
RAMS PDP 11/40 MINICOMPUTER
FORMAT CONVERSION PERIPHERALS
STL GRAPHICS (ELECTROSTATIC PLOTTER)
UNIVAC 1110
REMOTE TERMINALS
BATCH
DEMAND
GRAPHICS
TEKTRONIX (INTERACTIVE)
CALCOMP
SOFTWARE
DATA BASE SOFTWARE
STRUCTURE
RETRIEVAL
REPORTS
APPLICATIONS SOFTWARE
ANALYSIS
FORMAT GENERATION
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SYSTEM SOFTWARE
STD COMPILERS
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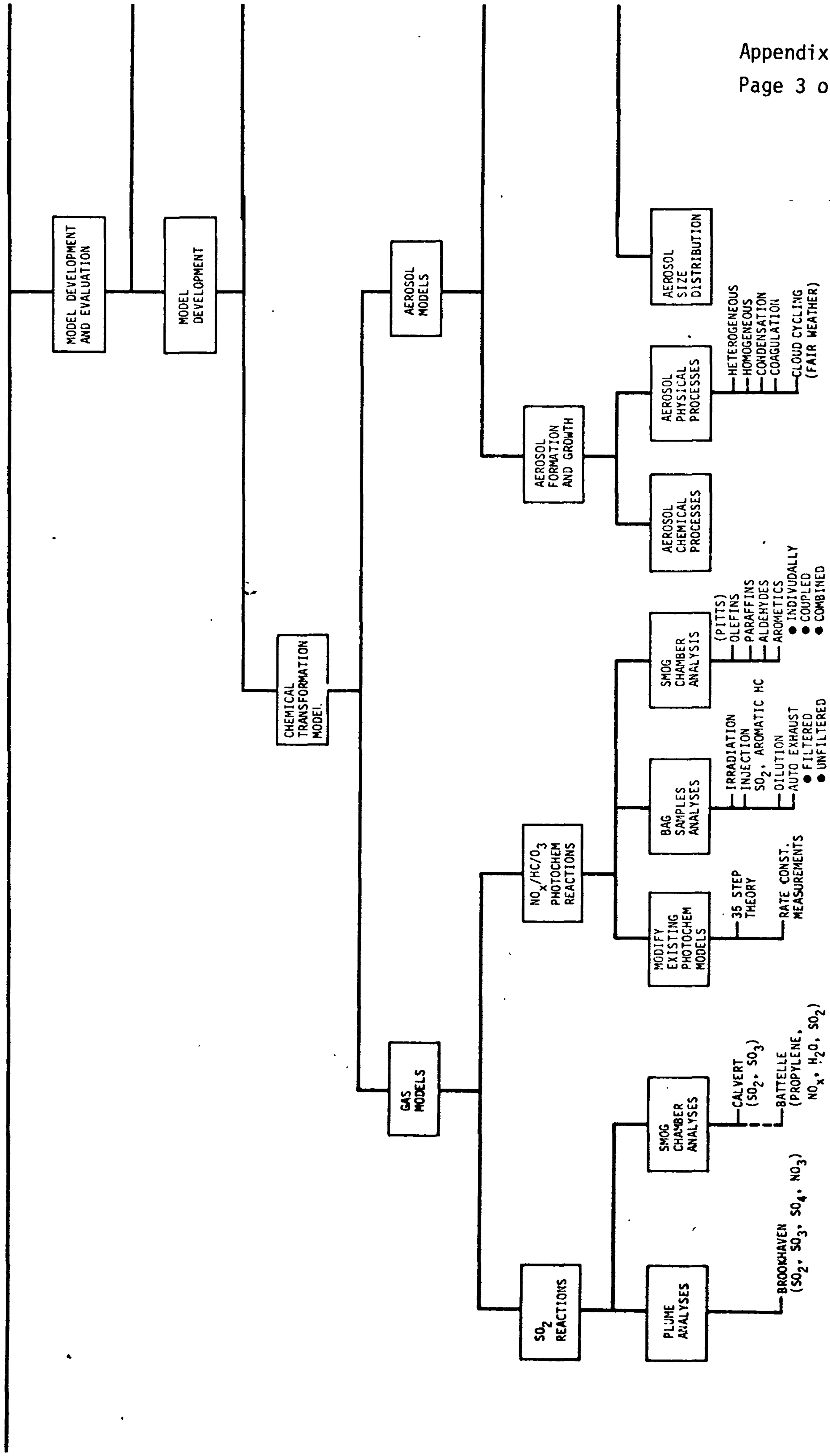
GRAPHICS SUPPORT
STATISTICAL ANALYSIS PROGRAM LIBRARY
UTILITY PROGRAMS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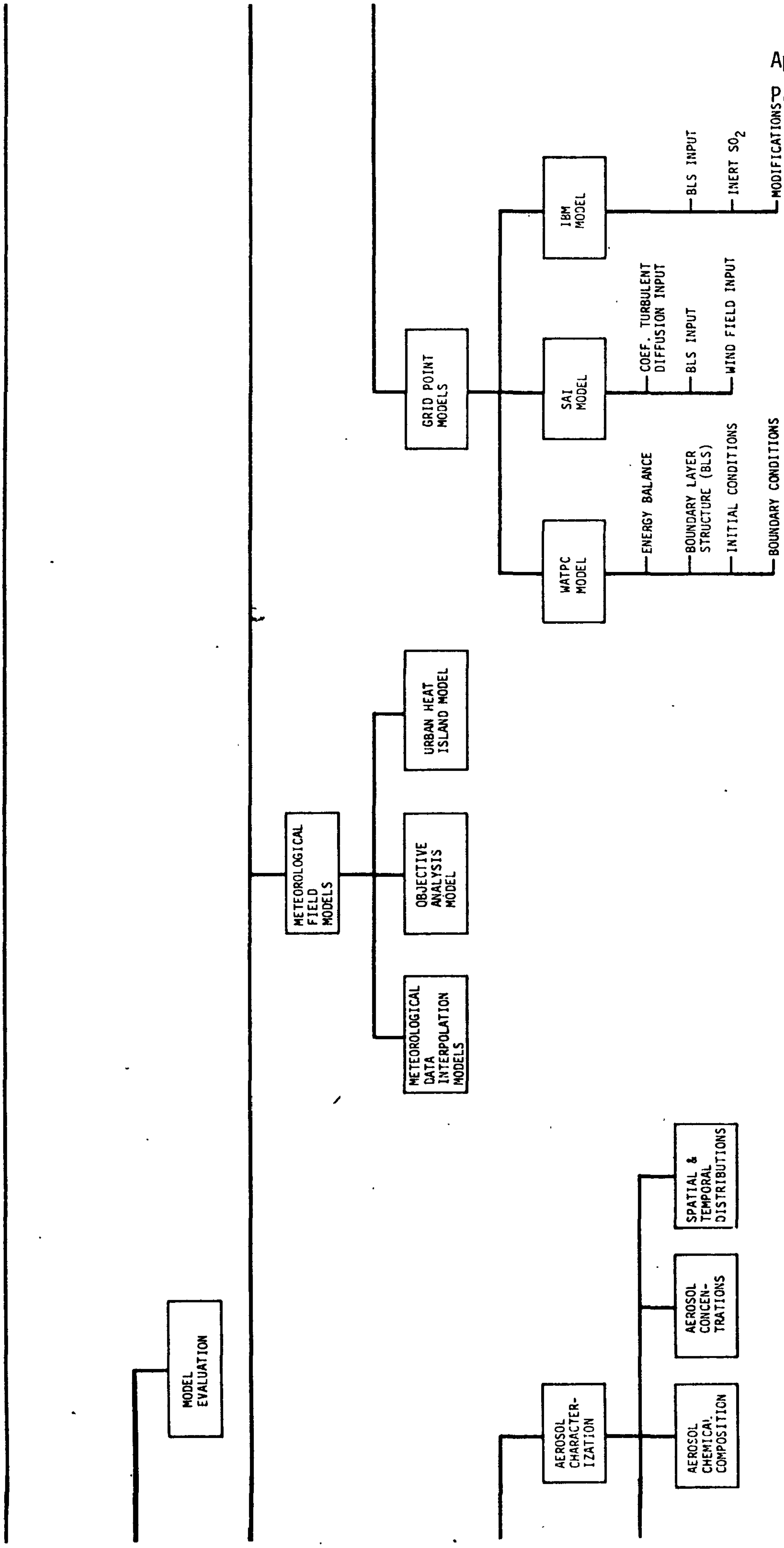
MODEL DEVELOPMENT
CHEMICAL TRANSFORMATION MODEL
AEROSOL MODELS
GAS MODELS
AEROSOL SIZE DISTRIBUTION
AEROSOL FORMATION AND GROWTH
AEROSOL PHYSICAL PROCESSES
HETEROGENEOUS
HOMOGENEOUS
CONDENSATION
COAGULATION
CLOUD CYCLING (FAIR WEATHER)
AEROSOL CHEMICAL PROCESSES
NOx/HC/O3 PHOTOCHEM REACTIONS
SMOG CHAMBER ANALYSIS
(PITTS)
OLEFINS
PARAFFINS
ALDEHYDES
AROMETICS
● INDIVUDALLY
● COUPLED
● COMBINED
BAG SAMPLES ANALYSES
IRRADIATION
INJECTION
SO2, AROMATIC HC
DILUTION
AUTO EXHAUST
● FILTERED
● UNFILTERED
MODIFY EXISTING PHOTOCHEM MODELS
35 STEP THEORY
RATE CONST. MEASUREMENTS
SO2 REACTIONS
SMOG CHAMBER ANALYSES
CALVERT (SO2, SO3)
BATTELLE (PROPYLENE, NOx, H2O, SO2)
PLUME ANALYSES
BROOKHAVEN (SO2, SO3, SO4, NO3)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IBM MODEL
BLS INPUT
INERT SO_2
MODIFICATIONS
SAI MODEL
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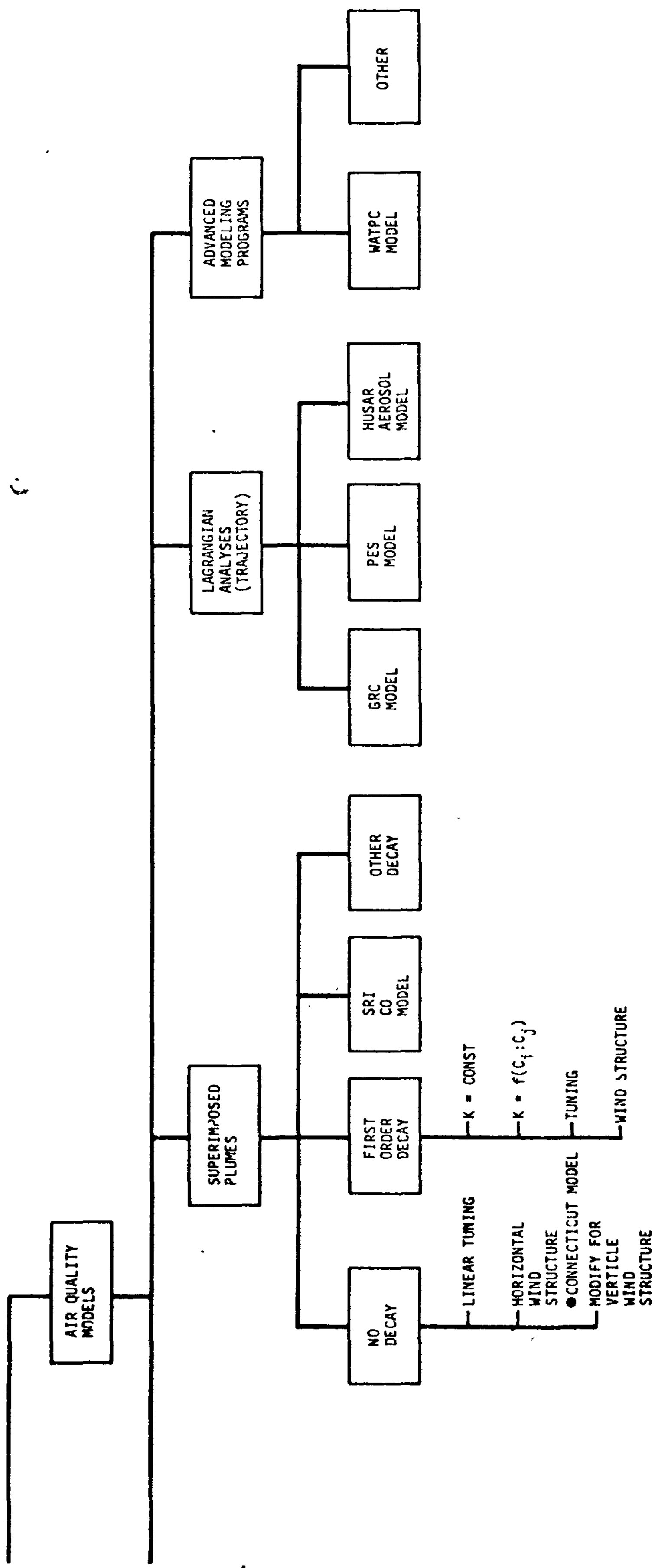
WATPC MODEL
ENERGY BALANCE
BOUNDARY LAYER STRUCTURE (BLS)
INITIAL CONDITIONS
BOUNDARY CONDITIONS
METEOROLOGICAL FIELD MODELS
URBAN HEAT ISLAND MODEL
OBJECTIVE ANALYSIS MODEL
METEOROLOGICAL DATA INTERPOLATION MODELS
AEROSOL CHARACTER-IZATION
SPATIAL & TEMPORAL DISTRIBUTIONS
AEROSOL CONCEN-TRATIONS
AEROSOL CHEMICAL COMPOSITION
MODEL EVALUATION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SUPERIMPOSED PLUMES
LAGRANGIAN ANALYSES (TRAJECTORY)
ADVANCED MODELING PROGRAMS
NO DECAY
FIRST ORDER DECAY
SRI CO MODEL
OTHER DECAY
GRC MODEL
PES MODEL
HUSAR AEROSOL MODEL
WATPC MODEL
OTHER
LINEAR TUNING
HORIZONTAL WIND STRUCTURE
●CONNECTICUT MODEL
MODIFY FOR VERTICLE WIND STRUCTURE
K = CONST
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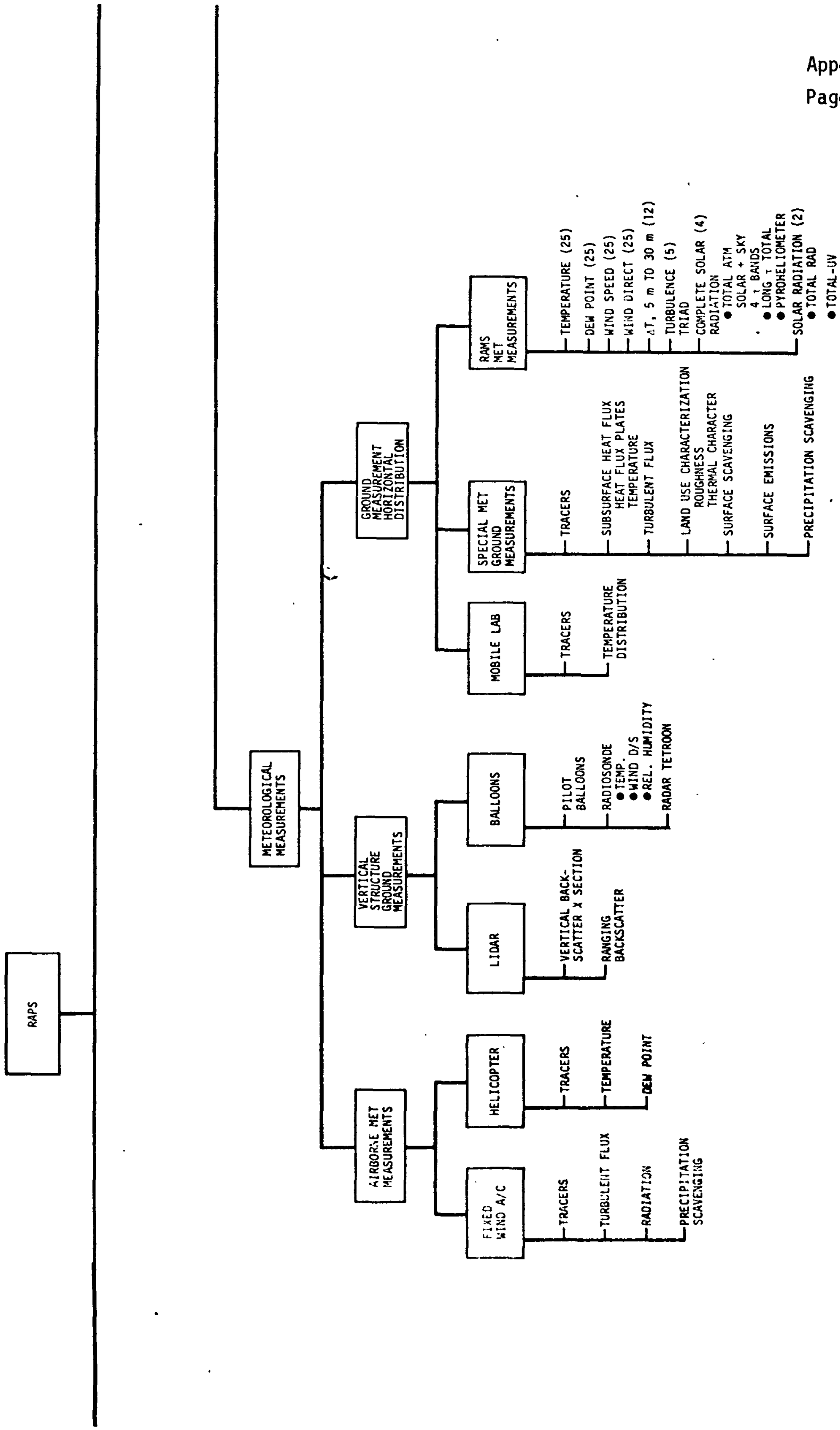
TUNING
WIND STRUCTURE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GROUND MEASUREMENT HORIZONTAL DISTRIBUTION
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TEMPERATURE (25)
DEW POINT (25)
WIND SPEED (25)
WIND DIRECT (25)
ΔT, 5 m TO 30 m (12)
TURBULENCE (5) TRIAD
COMPLETE SOLAR (4) RADIATION
● TOTAL ATM SOLAR + SKY
4 ↑ BANDS
● LONG ↑ TOTAL
● PYROHELIOMETER
SOLAR RADIATION (2)
● TOTAL RAD
● TOTAL-UV
SPECIAL MET GROUND MEASUREMENTS
TRACERS
SUBSURFACE HEAT FLUX
HEAT FLUX PLATES
TEMPERATURE
TURBULENT FLUX
LAND USE CHARACTERIZATION
ROUGHNESS
THERMAL CHARACTER
SURFACE SCAVENGING
SURFACE EMISSIONS
PRECIPITATION SCAVENGING
MOBILE LAB
TRACERS
TEMPERATURE DISTRIBUTION
VERTICAL STRUCTURE GROUND MEASUREMENTS
BALLOONS
PILOT BALLOONS
RADIOSONDE
● TEMP.
● WIND D/S
● REL. HUMIDITY
RADAR TETROON
LIDAR
VERTICAL BACK-SCATTER X SECTION
RANGING BACKSCATTER
AIRBORNE MET MEASUREMENTS
HELICOPTER
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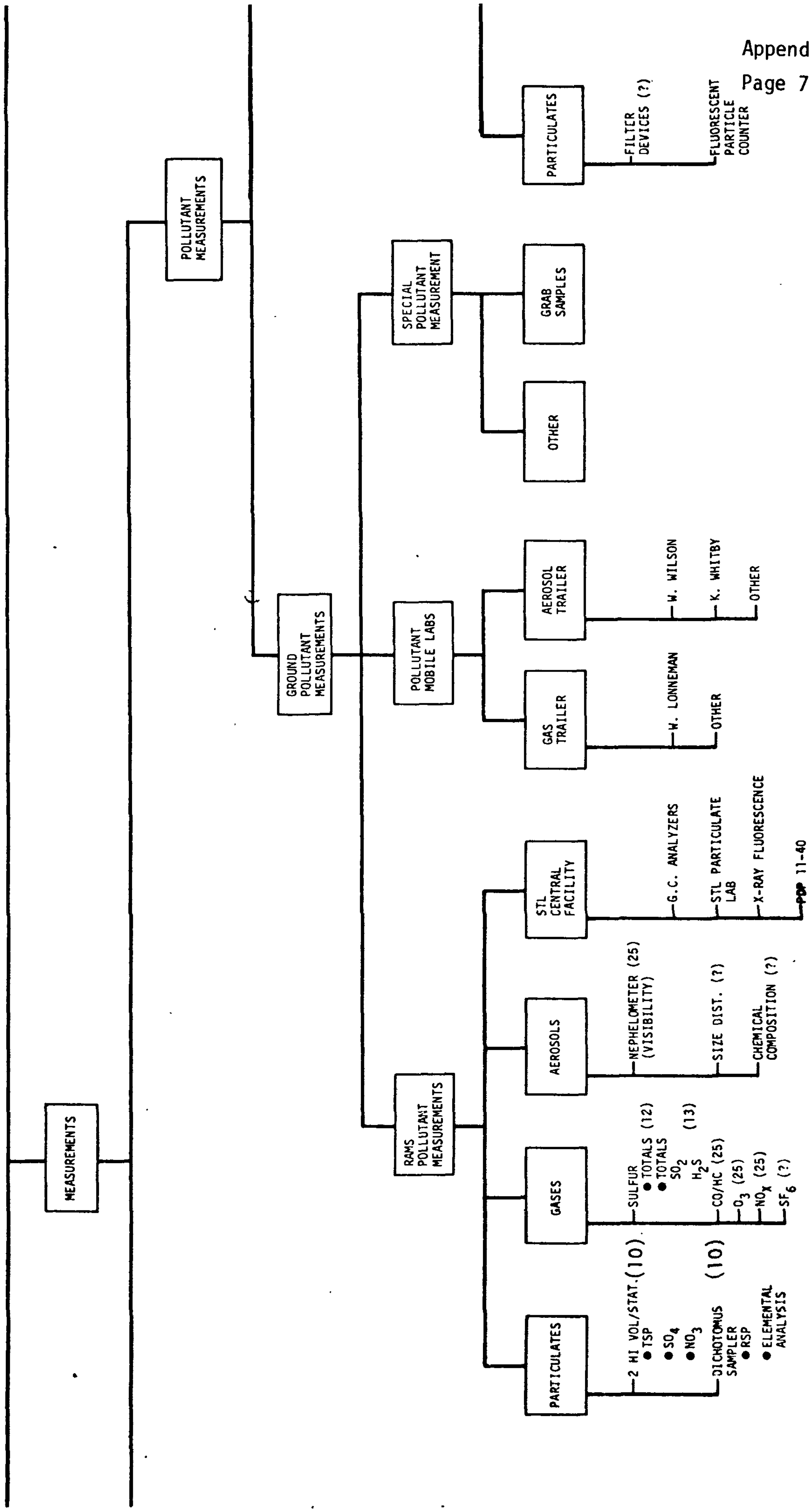
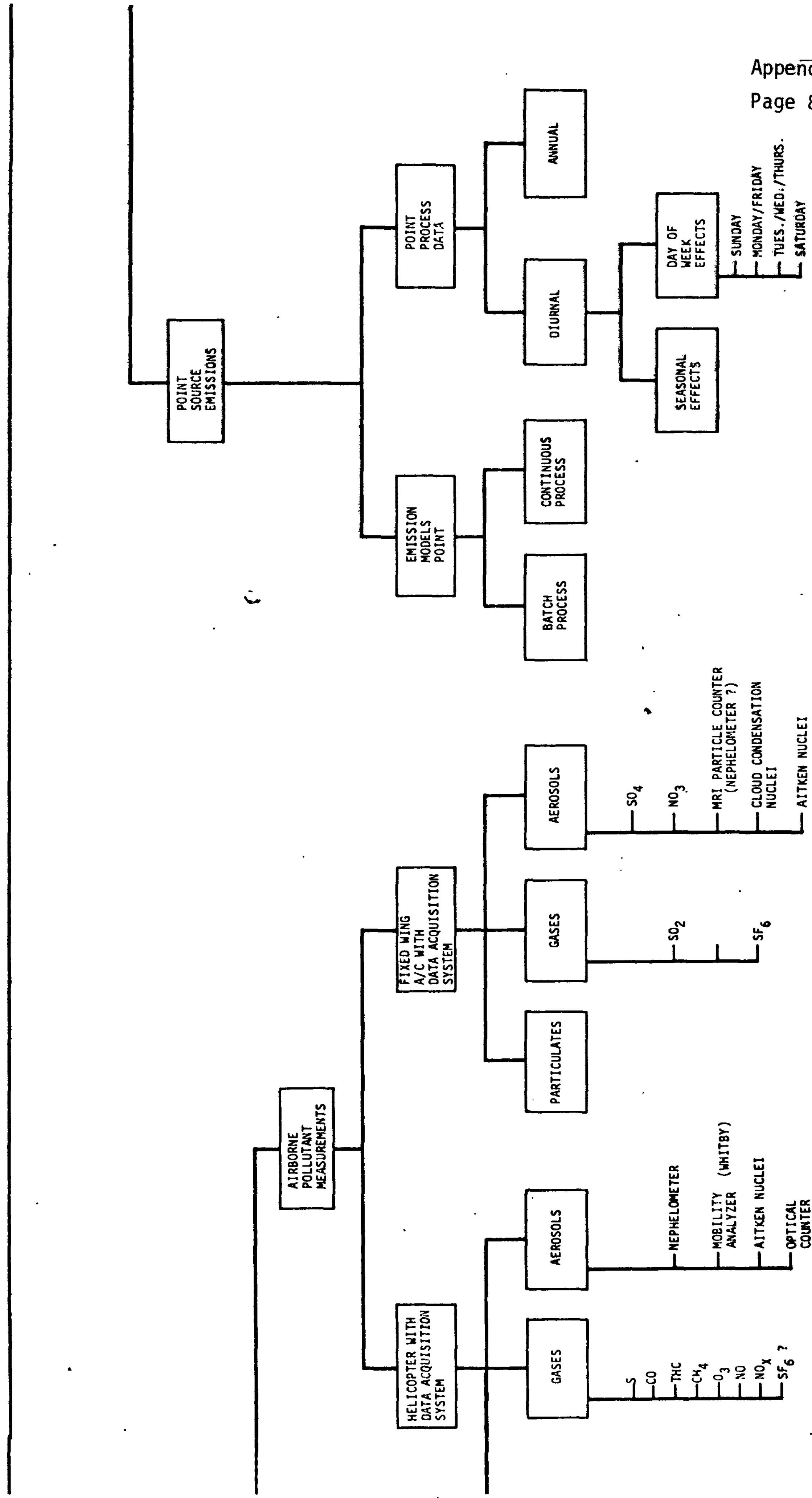
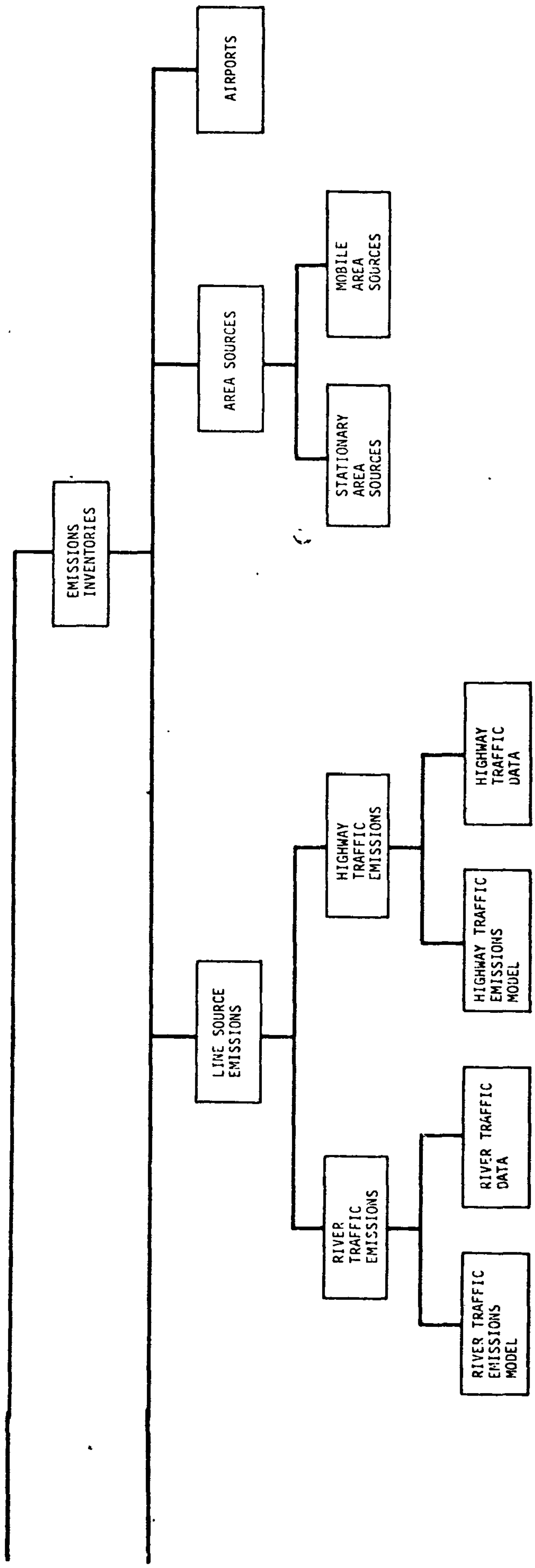
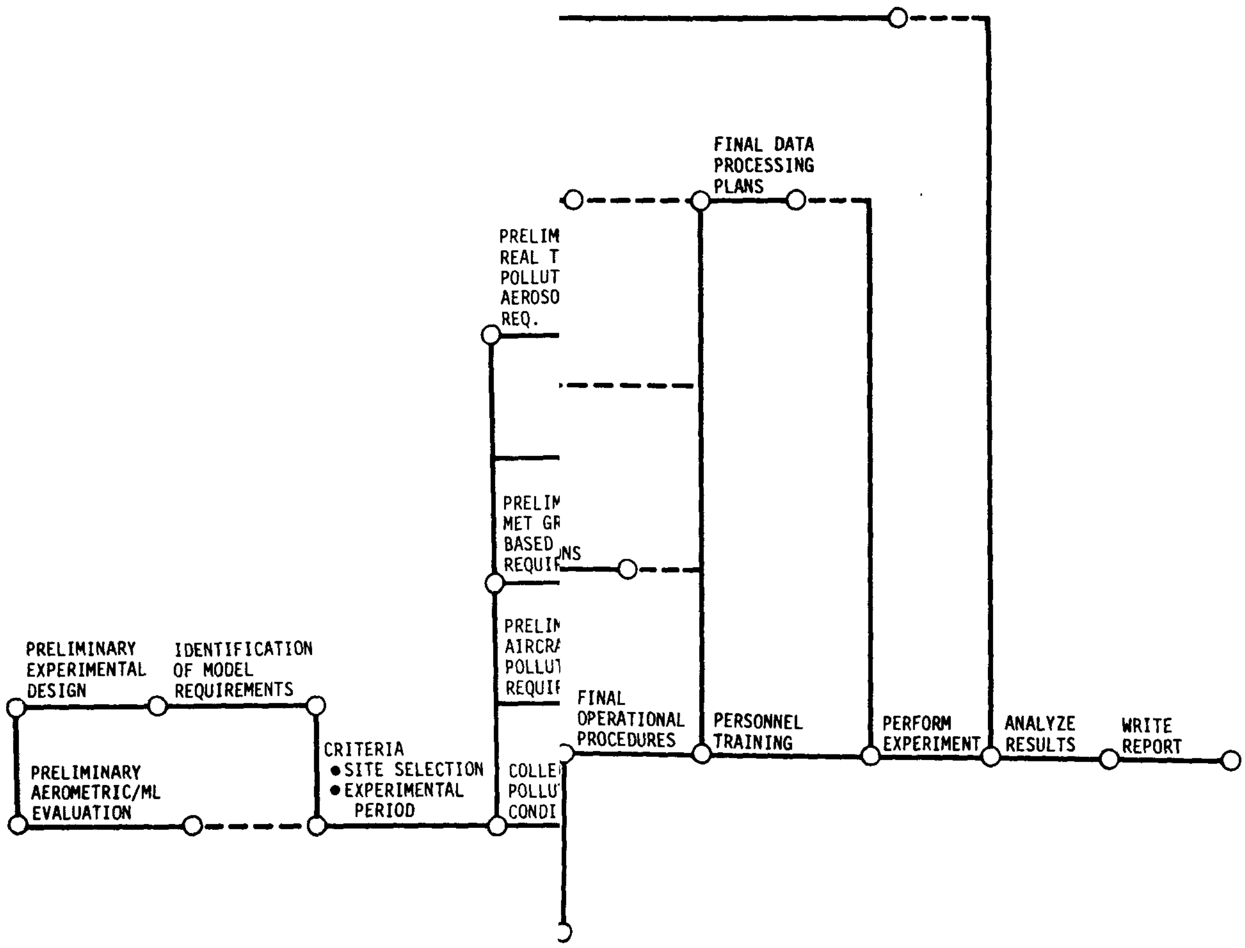
TRACERS
TURBULENT FLUX
RADIATION
PRECIPITATION SCAVENGING

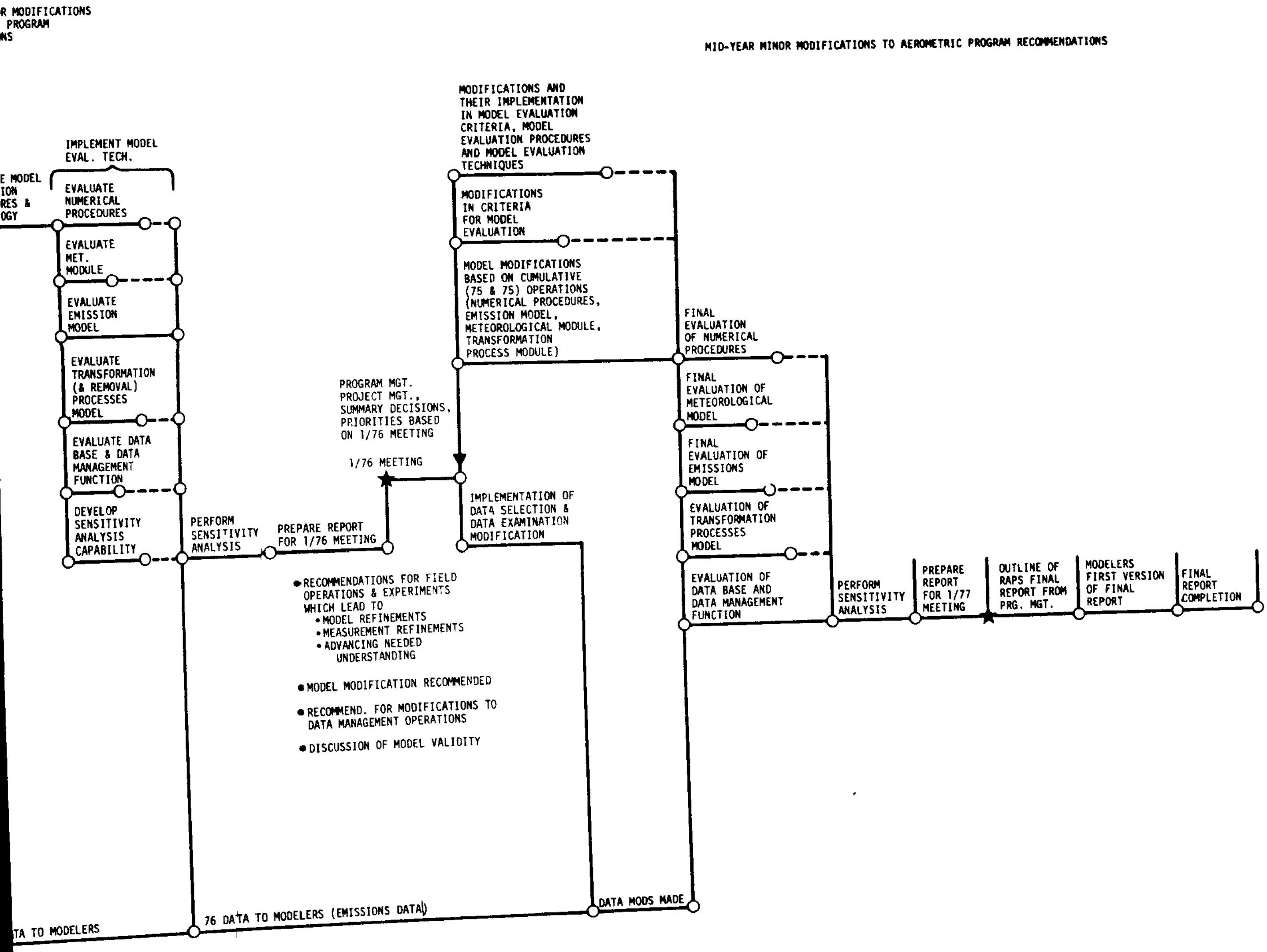

MEASUREMENTS
POLLUTANT MEASUREMENTS
SPECIAL POLLUTANT MEASUREMENT
PARTICULATES
FILTER DEVICES (?)
FLUORESCENT PARTICLE COUNTER
GRAB SAMPLES
OTHER
GROUND POLLUTANT MEASUREMENTS
POLLUTANT MOBILE LABS
AEROSOL TRAILER
W. WILSON
K. WHITBY
OTHER
GAS TRAILER
W. LONNEMAN
OTHER
RAMS POLLUTANT MEASUREMENTS
STL CENTRAL FACILITY
G.C. ANALYZERS
STL PARTICULATE LAB
X-RAY FLUORESCENCE
PDP 11-40
AEROSOLS
NEPHELOMETER (25) (VISIBILITY)
SIZE DIST. (?)
CHEMICAL COMPOSITION (?)
GASES
SULFUR
● TOTALS (12)
● TOTALS (13)
SO_2
H_2S
CO/HC (25)
O_3 (25)
NO_x (25)
SF_6 (?)
PARTICULATES
2 HI VOL/STAT. (10)
● TSP
● SO_4
● NO_3
DICHOTOMUS SAMPLER (10)
● RSP
● ELEMENTAL ANALYSIS


POINT SOURCE EMISSIONS
POINT PROCESS DATA
ANNUAL
DIURNAL
DAY OF WEEK EFFECTS
SUNDAY
MONDAY/FRIDAY
TUES./WED./THURS.
SATURDAY
SEASONAL EFFECTS
EMISSION MODELS POINT
CONTINUOUS PROCESS
BATCH PROCESS
AIRBORNE POLLUTANT MEASUREMENTS
FIXED WING A/C WITH DATA ACQUISITION SYSTEM
AEROSOLS
SO4
NO3
MRI PARTICLE COUNTER (NEPHELOMETER ?)
CLOUD CONDENSATION NUCLEI
AITKEN NUCLEI
GASES
SO2
SF6
PARTICULATES
HELICOPTER WITH DATA ACQUISITION SYSTEM
AEROSOLS
NEPHELOMETER
MOBILITY ANALYZER (WHITBY)
AITKEN NUCLEI
OPTICAL COUNTER
GASES
S
CO
THC
CH4
O3
NO
NOx
SF6 ?


EMISSIONS INVENTORIES
AIRPORTS
AREA SOURCES
MOBILE AREA SOURCES
STATIONARY AREA SOURCES
LINE SOURCE EMISSIONS
HIGHWAY TRAFFIC EMISSIONS
HIGHWAY TRAFFIC DATA
HIGHWAY TRAFFIC EMISSIONS MODEL
RIVER TRAFFIC EMISSIONS
RIVER TRAFFIC DATA
RIVER TRAFFIC EMISSIONS MODEL

PERT FOR FIELD EXPERI




R MODIFICATIONS
PROGRAM
NS
MID-YEAR MINOR MODIFICATIONS TO AEROMETRIC PROGRAM RECOMMENDATIONS
E MODEL
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RES &
OGY
IMPLEMENT MODEL EVAL. TECH.
EVALUATE NUMERICAL PROCEDURES
EVALUATE MET. MODULE
EVALUATE EMISSION MODEL
EVALUATE TRANSFORMATION (& REMOVAL) PROCESSES MODEL
EVALUATE DATA BASE & DATA MANAGEMENT FUNCTION
DEVELOP SENSITIVITY ANALYSIS CAPABILITY
PERFORM SENSITIVITY ANALYSIS
PREPARE REPORT FOR 1/76 MEETING
1/76 MEETING
PROGRAM MGT. PROJECT MGT., SUMMARY DECISIONS, PRIORITIES BASED ON 1/76 MEETING
MODIFICATIONS AND THEIR IMPLEMENTATION IN MODEL EVALUATION CRITERIA, MODEL EVALUATION PROCEDURES AND MODEL EVALUATION TECHNIQUES
MODIFICATIONS IN CRITERIA FOR MODEL EVALUATION
MODEL MODIFICATIONS BASED ON CUMULATIVE (75 & 75) OPERATIONS (NUMERICAL PROCEDURES, EMISSION MODEL, METEOROLOGICAL MODULE, TRANSFORMATION PROCESS MODULE)
IMPLEMENTATION OF DATA SELECTION & DATA EXAMINATION MODIFICATION
• RECOMMENDATIONS FOR FIELD OPERATIONS & EXPERIMENTS WHICH LEAD TO
• MODEL REFINEMENTS
• MEASUREMENT REFINEMENTS
• ADVANCING NEEDED UNDERSTANDING
• MODEL MODIFICATION RECOMMENDED
• RECOMMEND. FOR MODIFICATIONS TO DATA MANAGEMENT OPERATIONS
• DISCUSSION OF MODEL VALIDITY
FINAL EVALUATION OF NUMERICAL PROCEDURES
FINAL EVALUATION OF METEOROLOGICAL MODEL
FINAL EVALUATION OF EMISSIONS MODEL
EVALUATION OF TRANSFORMATION PROCESSES MODEL
EVALUATION OF DATA BASE AND DATA MANAGEMENT FUNCTION
PERFORM SENSITIVITY ANALYSIS
PREPARE REPORT FOR 1/77 MEETING
OUTLINE OF RAPS FINAL REPORT FROM PRG. MGT.
MODELERS FIRST VERSION OF FINAL REPORT
FINAL REPORT COMPLETION
TA TO MODELERS
76 DATA TO MODELERS (EMISSIONS DATA)
DATA MODS MADE

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16. ABSTRACT

The immediate goal of the Regional Air Pollution Study (RAPS) is the evaluation of existing local and regional scale air quality simulation models. Inherent in this effort is the creation of a comprehensive, accurate, and readily-retrievable data base containing emission rates and concentrations of atmospheric pollutants, and pertinent meteorological variables. An integrated program plan has been prepared for the conduct of the RAPS. Its specific purposes are to provide the Environmental Protection Agency (EPA) with guidelines for: (a) the effective management of the RAPS; (b) the implementation of a systematic and logical direction and coordination of the laboratory and field programs of the RAPS; (c) the assurance of flexibility in evolution of the RAPS experimental program. Existing information is summarized and future efforts are outlined for the basic elements of activity within RAPS: (a) Model Evaluation and Development; (b) Emission Inventories; (c) Aerometric Measurements; (d) Data Management; (e) Program Management. The essential role of each activity is established by illustrating the logical relationship between all RAPS elements. Finally procedures are established for on-going review of the RAPS elements and specific recommendations made.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Field Studies RAPS Program Management Model Evaluation Emission Inventories Aerometric Measurements Data Management		

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