Title
PROPOSAL FOR AN ENVIRONMENTAL MONITORING FACILITY

Author
Graven, Robert M.

Publication Date
1972-04-10

LBL-910
c.1

PROPOSAL FOR AN ENVIRONMENTAL MONITORING FACILITY

Robert M. Graven

April 10, 1972

AEC Contract No. W-7405-eng-48

PROPOSAL FOR AN ENVIRONMENTAL MONITORING FACILITY

Robert M. Graven

Lawrence Berkeley Laboratory
University of California
Berkeley, California

April 10, 1972

ABSTRACT

It is proposed that the Lawrence Berkeley Laboratory at Berkeley, California design, build and evaluate an Environmental Monitoring Facility. A primary purpose of the proposed facility is to develop a tool for environmental research and development experiments. The proposed facility would provide (1) for evaluating new monitoring instruments; (2) a versatile configuration of test sites; (3) sufficient computer power for rapid collection, reduction, correlation and display of information; and (4) a mechanism for easy distribution of both the raw and reduced data. Dynamic synergistic and antenogistic studies of how a contaminant travels, disperses, concentrates, or reacts with the environment must be done for many contaminants. The proposed facility will provide a versatile and expandable system for performing environmental experiments using the environment as a laboratory.

DRAFT -- April 10, 1971

Retyped -- April 10, 1972

PROPOSAL

FOR AN ENVIRONMENTAL MONITORING FACILITY

1. Introduction

The present state of the environmental measurement art is far from satisfactory; therefore, the National Scientific Foundation has contracted with the Lawrence Berkeley Laboratory at Berkeley, California to perform a survey of instrumentation techniques which will provide comparisons and recommendations of environmental quality monitoring techniques. To complement that study, we propose to develope and information-handling system for an environmental monitoring facility.

Many organizations are developing better sensors and instruments to monitor our environment; however, there is little appreciation of the need to reduce the vast amount of data to a readily understandable form. Producing accurate information is only the first step; it is equally important to collect, store, retrieve, correlate, and distribute the data. Such a system must be highly reliable, since it is expected to perform "forever". To promote a long and useful life, the system must be modular in construction, so that (1) new techniques can be easily incorporated into the system as they become available; (2) obsolete techniques can be eliminated; (3) rapid determination of faulty instruments can be performed; (5) simple maintenance by unskilled operators is provided, and (5) the inventory of spare parts can be minimized.

In order to provide the maximum degree of confidence in a measurement, it is necessary to check the results. One way to do this is to provide a redundant measurement of the same parameter, another way is to recalibrate the original instrument. Surely it will be necessary to provide irrefutable data to enforce or prosecute present pollution laws. Therefore, error checking at the data-source instrument and for the local recorder or modem will be necessary. Further, it has been our experience that whenever an interested informed person is provided with a little bit of data, that it acts to stimulate his appetite for more detailed and complete information. This need should be anticipated and provided for, particularly in a field which itself is rapidly expanding. The result is usually a deeper understanding of the subject, and therefore better service to the population whom the information serves.

It would also be desirable to implement a system whose specifications are acceptable at a local, state, national, and international leve, (an immense task). We propose to use a set of internationally accepted standards* for digital dataway systems, since the biosphere will eventually need to be considered in determining some cause-and-effect relations. Code converters for ASCII, EBDIC and other locally popular codes are available as modular units. It will be possible to specify only those modules that you need and can afford. The dilemma here is "standards" vs. "versatility." Hopefully, by beginning with a versatile internationally agreed on standard, we can convince our border states to adopt the standard, and their border states, etc.

The calendar time required to build and evaluate a prototype is quite important. Almost all of the data-handling hardware is available from a broad manufacturing capability based in several countries. Our proposal is to assemble, test, and evaluate such a system using a pollution district, (e.g., the Bay Area) as a test site, or a part of that district (e.g., Berkeley, California).

It has not escaped our notice that regions of severe air pollution are also usually areas of severe water pollution. The air-water interface and dynamics (e.g., evaporation increases humidity, decreases temperature, and provides a carrier for biological and particulate matter), will require spatial and temporal correlations of a large amount of data for a comprehensive study of synergistic effects. The proposed system will provide guidance for later implementation of these capabilities.

The proposed system also includes the ability to serve a user who may only want a more detailed description of a thermal plume, or one who wishes to do a short-term low-budget study of a particular pollutant. Portable battery-operated sensors and recorders as well as mobile-van or trailer-mounted recorders could be rented by experimenters for various small experiments. This proposal includes design and testing of modifications to commercial equipment to provide the facility with this capability.

This proposal also provides considerations for processing data from users who may occasionally need to make correlation studies to a meterological data base. The system must be easy to use in order to serve many users having

---

*U.S.A., Canada, Austria, Belgium, Britain, France, Germany, Holland, Italy, Switzerland, and Yugoslavia are using CAMAC as a standard for information collection.

a wide variety of needs.

A primary result of this proposed project will be to serve as a model for environmental monitoring facilities that can be established at other national laboratories.

A real-time system with error checking is necessary to (1) establish the validity of the data base; (2) allow conducting real-time studies of the dynamics of various pollutants; (3) rapidly diagnose errors in the data-handling portion of the facility during development and during later maintenance periods; and (4) provide sufficient warning in order to predict, and therefore avoid, pollution alerts, warnings and emergencies.

The proposed facility can be considered as a concatenation of four components:

1. Data acquisition

   Modular, versatile hardware will be used at monitoring sites that is capable of collecting information from many different sensors, transducers, and instruments. Both local and remote calibration and read-out will be provided.

2. Data transmission

   Telephone lines, or portable recorders and technicians, will be used to transmit the raw data from monitoring sites to a local computer. Error checking of the data collection and transmission will be provided.

3. Data reduction and storage

   Raw and reduced data will be stored in digital form using magnetic tapes or disk packs which are almost unlimited in storage ability. Our data banks will take the form of a small bank (branch banking) whose information can be transferred by request to large central banks (e.g., SORAD, air quality information for APCO/EPA or STORET, water quality information for WQO/EPA). Recommendations for the format and storage of raw and reduced data will be included in the final report, with a comparison to other proposed or existing formats.

4. Data distribution

Government agencies, industry, airlines, research labs, radio stations, etc., will make different demands on an environmental monitoring facility. We will focus our efforts toward serving our particular community of research scientists and educators. We will also document by whom and how the system is used, and include a list of recommendations written by the users.

The National Weather Service, the U.S. Geological Survey, the Forest Service, etc., should be able to contribute data and extract information from an environmental monitoring facility. The proposed facility allows raw data acquisition and/or readout of reduced data at any site where a telephone can be installed by anyone who knows the access codes.

2. Preliminary Description

Three possible implementations for an environmental monitoring facility are briefly described to illustrate the concepts.

Example A (Fig. 1) is intended to serve the need for small, portable, low-cost, short-term studies (e.g., plumes) where interaction with a computer is not required, except for off-line reduction of the data. A block diagram of the hardware for example A is shown in Fig. 1. A CAMAC crate is used as an enclosure for the electronic circuits that will collect and assemble the environmental information. Four of these systems would be built. Two would be battery-operated and required to operate for two weeks without maintenance. The other two would use 117 volt A.C. power and include thermostatically controlled heating and cooling of the electronics for service in severe environments (e.g., -30°F to +130°F).

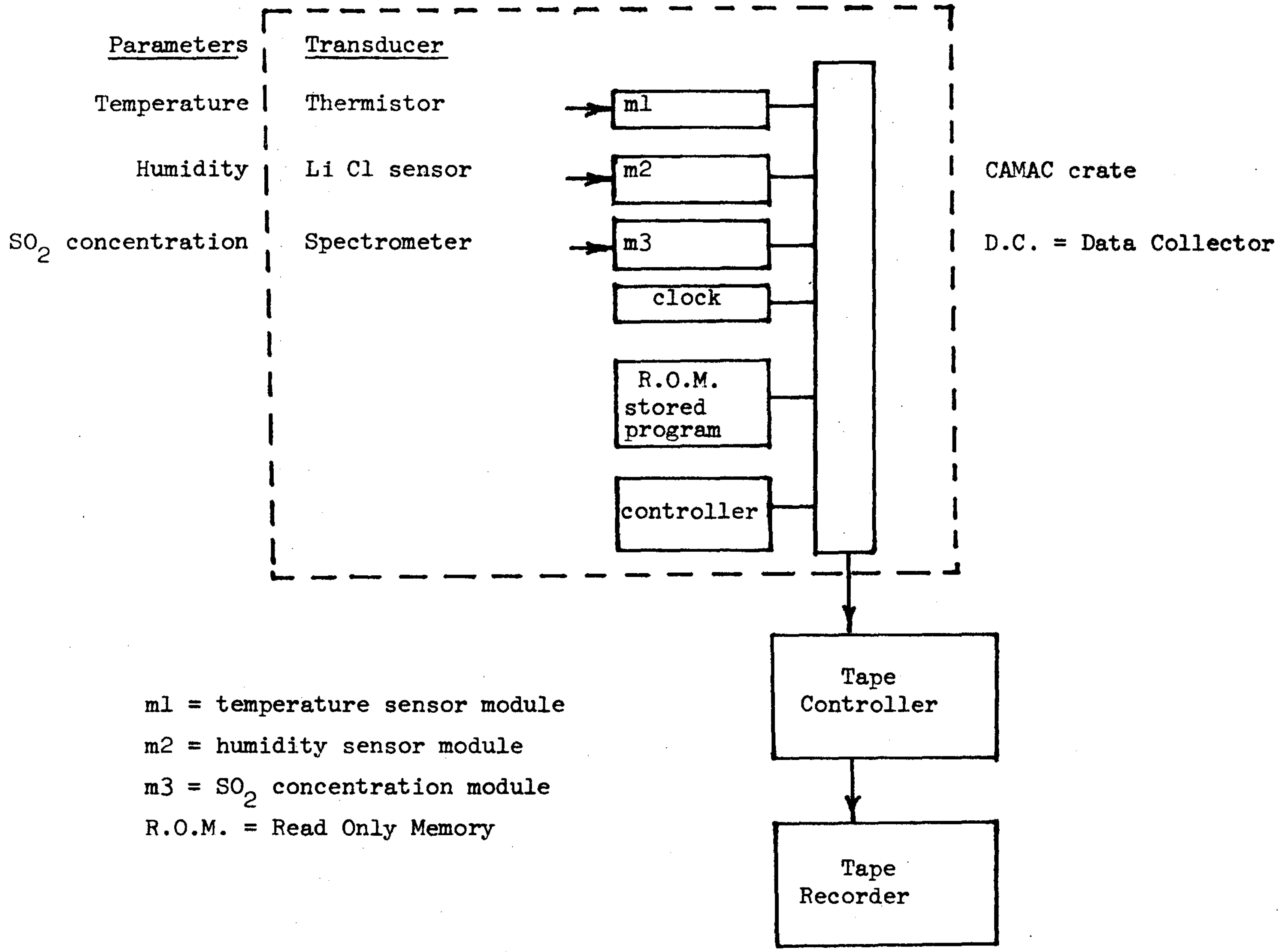
This data collection system is inexpensive, versatile, and reliable, which encourages many other laboratory applications. The CAMAC data bussing system is a non-proprietary specification which is freely available to all and we have had experience in using modular circuits from three countries that were simply plugged in and worked!

Four tape controllers will be built, one for paper tape recorders, two for digital casette recorders and one for IBM compatible magnetic tape recorders. Four tape recorders will be purchased. A "clock" and "stored program" ROM module will be designed and built to provide a free-standing data collection device. Transducer modules indicated as m1, m2, and m3 in Fig. 1 will be either purchased (e.g., analog-to-digital modules, scalers, etc.) or designed and built if a commercial unit is not available. Controllers that interface to various computers are commercially available which allow using the hardware in many different configurations than are shown here.

Also, the proposed system can be mounted in a van, boat or aircraft for performing mobile survey studies. Any rugged pollution sensor that can provide an electrical signal as an output can be connected to the proposed facility. The improved data collection and reduction efficiency will permit precise knowledge of dynamic pollution peaks and contours; which will be necessary for enforcement of present and future laws.

Example A

Portable recorder



m1 = temperature sensor module

m2 = humidity sensor module

m3 = SO_2 concentration module

R.O.M. = Read Only Memory

Block diagram of a small portable environmental sensing station.

Figure 1

Example B illustrates a medium-sized, fixed location system to collect data from several monitoring sites. A similar system having six sites will be designed, built, and tested using Berkeley, California (population about 125,000) as a laboratory. We have lots of polluted air, contaminated water, and radiation with which to test the system.

Figure 2 illustrates a timeshared data collection, analysis and distribution system. It is based on the Project GENIE timesharing system that has been operating here in Berkeley for six years. Essentially, the data source terminals of that system are being replaced by electronic environmental Data Collection crates (D.C.). Each D.C. may represent one crate or a collection of several crates for large fully instrumented sites.

Each CAMAC crate contains up to 22 different module positions. Each module can be used to address up to 16 different sensors. Each sensor can be commanded to perform up to 16 functions (e.g., recalibration) under program control. Each module can be individually serviced without interferring with other modules. Any module can issue alarms, interrupts, or "look-at-me" signals. The reader is referred to the CAMAC tutorial issue of the IEEE Trans. on Nuclear Science, Vol. NS-18, No. 2, April 1971 for a more complete discussion of a CAMAC data-handling system.

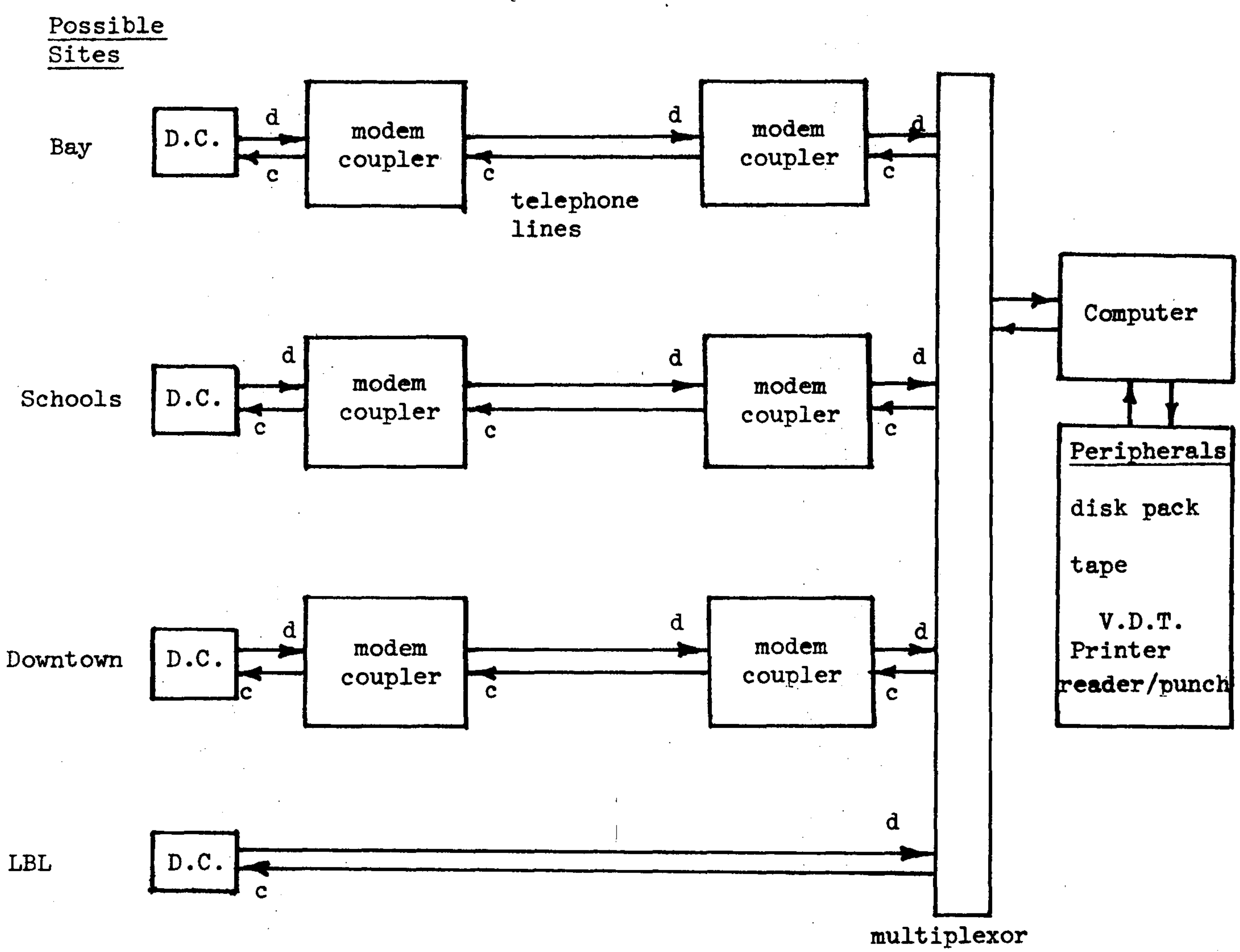
A Video Display Terminal (V.D.T.) is listed as one of the peripherals at the data reduction and analysis center to be used for manipulating and displaying the data in both alphanumeric and graphical form. A printer, card reader/punch, and magnetic tapes will provide the other usual peripheral services.

An analysis of which computer to use will be one of the first tasks to be performed. It is expected that a machine about the size of a Xerox Data Systems Sigma Seven (XDS 7) or a Digital Equipment Corporation PDP-11 will be required.

Six modem modules will be built for the data collection crates and connected to modem couplers (e.g., Western Electric Model 201 data sets). Two acoustic coupler modem modules will also be purchased.

Example B

Small city monitoring system



D.C. = Data Collection Crate

c = Control signals

d = Data signals

Proposed Environmental Monitoring Facility

Figure 2

Example C illustrates how the system can be expanded to serve the needs of a large pollution basin (e.g., the Bay Area Pollution District). Recommendations for the design of such a large scale facility based on the experience gained during the design and use of the proposed Example B system will be included in the final report.

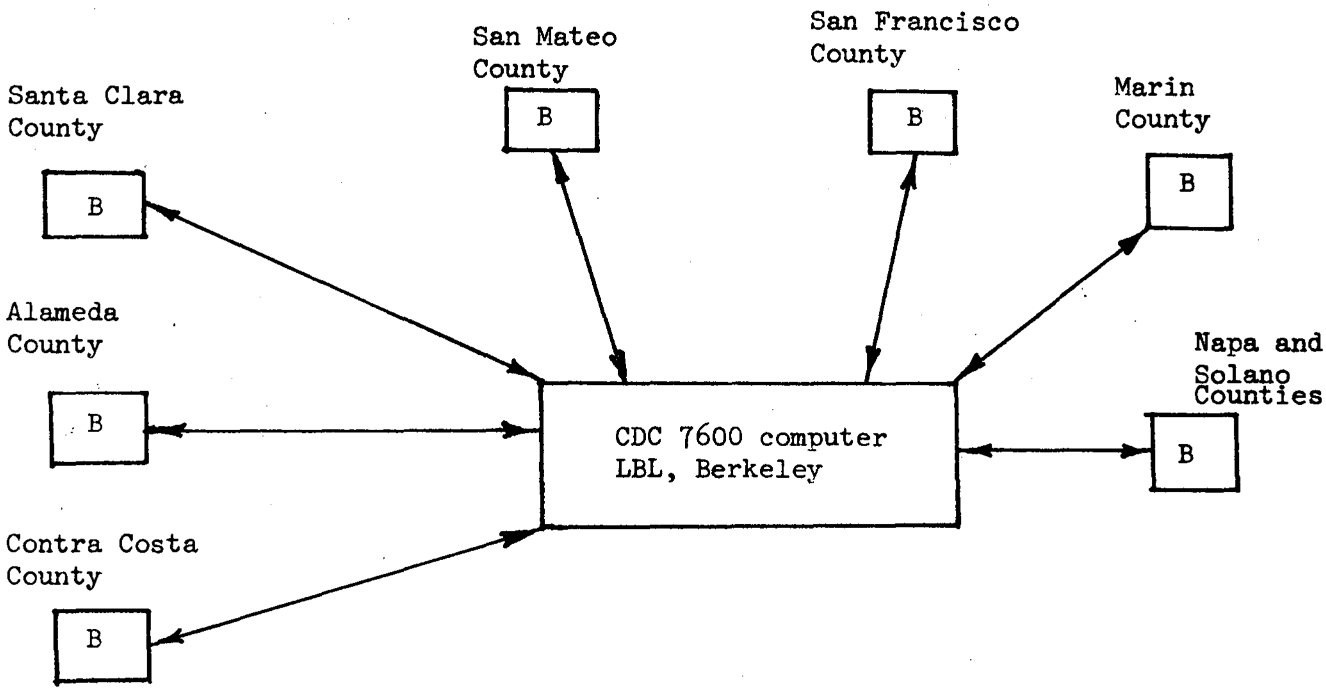
The advantages of using a timeshared organization including the CAMAC system are:

1. Immediate availability of hardware.
2. Non-proprietary system design.
3. International data-bussing standard.
4. Simple modular maintenance at site.
5. Alarm or "look-at-me" signals.
6. Remote control activation, and deactivation, of sensors.
7. Accepts analog or digital input signals.
8. One crate can control many modules.
9. One module may serve many sensors.
10. One sensor may interact with several modules.
11. Remote calibration of sensors.
12. Modular selection of contaminants to be monitored.
13. Simple installation of fixed test site (1 telephone line)
14. Rapid replacement of obsolete sensing techniques.
15. Easy addition, deletion or moving of test sites.
16. Data available in parallel or serial modes.
17. Interfaces easily to many different computers.
18. Can eliminate intermediate recording of data.
19. Encourages modular software routines.
20. Allows interactive graphical displays (pollution contour maps).
21. Broad manufacturing base to purchase equipment from.
22. Employs reliable integrated circuit technology.
23. Capable of low or high frequency operation.
24. Many experimenters can simultaneously access the same data.
25. Programmable temporal and spacial tolerances for pollutants.

26. Programmable alert and warning levels.
27. Programmable data protection and access.
28. Unlimited number of instruments per site.
29. Raw or reduced data available by request at any telephone terminal.
30. Enables prediction of pollution hot spots.
31. Allows time for aleviation action.
32. Simplifies testing for yet unknown pollutants.
33. Processes data from mobile surveys (continuous).
34. Encourages model and simulation studies.
35. Eliminates the need for an analog recorder at each sensor.
36. Compact machine readable data storage.
37. Encourages digital sensor development.
38. Permits simultaneous sampling at widely distributed locations.
39. Allows means for digitizing data from sample collection surveys (discrete).
40. Capable of measuring radiation, noise, earthquakes, and, contaminates in air and water simultaneously.

Example C

Pollution district facility



B = Example B systems

Future Environmental Monitoring Facility

Figure 3

3. Summary

We propose to study, design, build, and evaluate a research-oriented environmental monitoring facility using a small city as a test site. We will provide a series of reports documenting the reasons for selecting a particular system configuration, and provide a number of recommendations for both larger and smaller facilities, including cost estimates. Operation and maintenance manuals will be provided for the facility which will serve primarily as a research tool to investigate various needs of a scientific community of users. One question to be studied is; "How should a small, medium, or large data base of meterological data be maintained in a machine readable form?"

All sensors connected to the proposed data-collection facility will be required to present their information in the form of either analog or digital electrical signals. Optional capabilities will include remote calibration, on-off activation, and electronic test circuits that simulate transducer signals to check the information handling system.

Three different possible implementations are presented to illustrate the versatility of the concept. These preliminary descriptions will serve as references to be improved upon and modified as the system design and testing progresses.

We propose to provide an environmental monitoring facility:

1. For performing research experiments (Example; correlation studies e.g., CO vs. Temp).
2. For development of sensors and monitoring instruments. (Gas, noise, radiation, water monitors.)
3. For performance comparisons of several instruments under the same operating conditions. (Accuracy, stability, maintenance.)
4. Which can measure a large variety of parameters at widely separated places at the same time.
5. Which can measure a large variety of parameters at the same place, very rapidly (look for fast reactions and pollution peaks) or very slowly (decreases of contaminants vs. calendar time).

6. Which is capable of rapid, inexpensive up-dating and/or maintenance of instruments.
7. Which is capable of rapid, inexpensive relocation of monitoring sites.
8. Which can be controlled by many different types of digital computers.
9. Which does not require a computer to operate.
10. Having a high probability for international acceptance.
11. Which can be expanded to meet expanding needs, and contracted when the need disappears.
12. Which allows both local and remote recalibration and error analysis.
13. Which can perform complicated synergistic studies.
14. Which can perform simple plume studies.
15. Which can easily service occasional users.
16. To serve as a prototype for other research facilities.
17. Which can process raw and reduced data.
18. Which can do statistical analysis.
19. Which can distribute the results automatically or by request at any telephone terminal.
20. Which has a high performance/cost factor.
21. Which can respond rapidly and reliably.
22. Which can provide legally acceptable data.
23. Which can predict pollution alerts to allow enforcement of counter measures to avoid them.
24. Which can process data from mobile surveys.
25. Which can compare measurements and predictions to evaluate models.
26. Which provides automated data reduction for sample collection surveys.

4. References

1. "CAMAC, A Modular Instrumentation System for Data Handling," Aug. 1970. (Information requests to Louis Costrell, National Bureau of Standards, Washington, D.C. 20234.
2. Dick A. Mack, "Summary of CAMAC: Status and Outlook." IEEE Transactions on Nuclear Science, April 1971.
3. Frederick A. Kirsten "Some Characteristics of Interfaces Between CAMAC and Small Computers." IEEE Transactions on Nuclear Science, April 1971.
4. W. W. Lichtenberger, "Tentative Specifications for A Network of Computers," U. of California, Berkeley, E.E./C.S. Sept. 1966.
5. John L. Mills "Continuous Monitoring" Chemical Engineering, April 27, 1970, p. 217-220, Los Angeles County A.P.C.D.
6. Edward K. Bowdon "Priority Assignment in A Network of Computers" IEEE Trans. on Computers, Vol. C-18, No. 11, p.1021, Nov. 1969.
7. P. C. Lockemonn and W.D. Knutsen "A Multiprogramming Environment For On-line Data Acquisition and Analysis," Communications of ACM, Vol. 10, pp758-764, Dec. 1967.
8. William T. Sayers "Water Quality Surveillance: The Federal-State Network". Environmental Science and Technology, Vol. 5, No. 2, p. 114-119, Feb. 1971.
9. Peter J. Piecuch "ORSANCO: Pioneer With a New Mission" Environmental Science & Technology, Vol. 5. No. 1, p22, Jan. 1971.
10. Philip C. Wolf "Carbon Monoxide Measurement and Monitoring in Urban Air." Environmental Science and Technology, Vol.5, No. 3., p.212-218, March 1971.
11. Y. Tokiwa and P. K. Mueller "Status of Measuring Air Quality" California Dept. of Public Health, Berkeley, Calif. April 28, 1971.
12. George B. Morgan, Curtis Ozolins, and Elbert C. Tabor, "Air Pollution Surveillance Systems" Science, Vol. 170, Oct. 16, 1970.

5. Possible Pilot Experiments

1. Distribution of CO in Berkeley from the East Bay freeway due to westerly winds.
2. Concentration of lead near paint manufacturing plant.
3. Monitoring of the San Francisco bay water at Berkeley pier.
4. SO_2 concentration in Richmond, California.
5. Development of an accurate ozone monitor.
6. Population radiation at Berkeley.
7. Continuous monitoring of NO_x over the bay area to determine necessary test site locations.
8. Effect of air pollution on the astronomy program at Lick Observatory.
9. CO peaks in the Caldecott tunnels.

6. Relation to other work in this field

Previous studies of air monitoring facilities have concentrated on studying the monitoring instruments. For example, "Designing An Air Monitoring Facility" by J. Golden and T. R. Mongan, the MITRE Corp., Aug. 1970, recommends general criteria for selecting sensors, shelters, sampling techniques, and instruments.

This proposal anticipates many rapid improvements in sensors, transducers, and instruments by encouraging replacement of obsolete methods. It also allows renting of competing sensors until one product demonstrates its superiority.

CAMP (Continuous Air Monitoring Program) and NASN (National Air Surveillance Network) are air pollution networks operated by the EPA. Only ten cities, (not including Los Angeles, New York, or San Francisco) have CAMP stations, and the single station in each city only measures eight parameters. These inadequate systems need R&D support.

"Is There A System for Pollution Madness" by R. P. Ovellette, D. M. Rosenbaum, and R. F. Greely of MITRE in Datamation, April 15, 1971 pleads for a reliable, responsive, data-handling facility.

"Continuous Monitoring" by John L. Mills of the Los Angeles Country Air Pollution Control District, published in Chemical Engineering, April 1970, describes the air monitoring facility for Los Angeles. The lessons learned about the need, design, implementation, and use of this system have already contributed to the proposed facility for Berkeley. The installation of this continuous air monitoring system was the result of a $300,000 contract to Litton Industries from the Los Angeles Air Pollution Control District. A primary purpose of their air monitoring system is to provide the data base for calling air pollution alerts, restricting traffic, and shutting down industries, based on measurements from 12 stations with a maximum of 16 instruments per station. Nine known pollutants and five meterological parameters are currently being monitored.

The scope and purpose of our proposed facility is quite different from the Los Angeles system. We propose a research oriented system designed to facilitate the study of contaminants that are not now being monitored, cumbersome to monitor, or are being monitored poorly. The emphasis will be to develop a facility for monitoring a wide range of pollutants using the air, water, and land of Berkeley, San Francisco Bay, and California as our laboratory.

William T. Sayers (Plans Evaluation Officer, Water Quality Office, EPA) begins his paper "Water Quality Surveillance: The Federal-State Network" in Environmental Science & Tech., Vol. 15 No. 2 Feb. 1971 with "Monitoring is at the heart of the nation's water quality management effort; without it, enforcement and cleanup programs can be of only limited effectiveness." He concluded with a statement of R and D needs including:

"Development of automated instrumentation (portable and fixed) that is capable, with minimal maintenance, of accurately measuring a wide variety of water quality indices over long periods, and telemetering the data to a central location."

"Development of new, more inclusive water quality indices that can better lend themselves to automated sensing techniques."

These statements are cited as justification for this research and development proposal.

Instruments used to monitor the Ohio river for the ORSANCO Quality Monitor system show the need for reliable, continuous, and timely monitoring of our water basins.

In a "Proposal for a study of the Heat Budget of Lake Tahoe" by the University of California at Davis and the Lawrence Berkeley Laboratory, a detailed plan is presented for measuring local atmospheric conditions, lake currents, wave motions, temperature profiles, etc. This proposal is cited as an example of the instrumentation required to study air-water interactions.

Techniques for measuring radiation are ideally suited for a CAMAC data collection system. The Lawrence Berkeley Laboratory is well-known for its leadership in developing nuclear physics instrumentation.

Instruments for measuring noise and earthquakes are also well suited for this automated electronic data handling system. Occasional users may desire to correlate their data to a meterological data base including radiation data.

The purpose of the proposed system is not only to provide Berkeley's data for air alerts to the Bay Area Pollution Control District, but also to provide an expandable, changeable system for studying potentially toxic pollutants which are known but not being monitored, e.g., lead, cadminium, D.D.T., asbestos, methyl-mercury, etc. Further, it can serve as a testing tool to compare yesterday's instruments with today's, and help predict what will be needed for tomorrow's measurements. In addition, the proposed facility will help to define the instrumentation needs of a scientific community of users who are attempting to study dynamic synergistic environmental reactions, and pollution sources and sinks. Finally, it will add insight to determine how the raw and reduced data should be maintained and displayed for immediate use, for short-term (weeks), intermediate (months), long-term (years), and infinite storage. The construction of a machine-readable meteriological data base should inspire new experiments to expand our knowledge of the environment.

7. Justification

At the Lawrence Berkeley Laboratory we have internationally recognized authorities and a broad base of support personnel connected with real-time data collection and analysis of scientific information. We also have the physical plant, computer power, and interface design experience to develop the proposed facility. Further, a unique collection of experts (e.g., leading experts in the trace element detectors and the U.S. representative on an international digital standards committee) are on our staff. We feel that we are uniquely and ideally suited for, and can significantly contribute to the proposed task.

As a scientific national laboratory, we are anxious to respond to scientific national needs asthey are assigned new priorities by the congress (i.e., the people). High energy nuclear physics requires very fast systems capable of correlating many spacial, temporal, and statistically varying quantities, and our experience in these fields can easily be applied to a slower, less demanding information-processing system.

Very few organizations have the quantity and quality of personnel and equipment to approach the synergistic questions that arise when one attempts to trace a contaminant with respect to time, space, biological, chemical and physiological parameters.

A strong background in both real-time scientific data-collection and time-sharing systems is required for the design of the proposed information handling facility. Implementation, maintenance, and cost considerations require a complete knowledge of the available hardware and extensive experience in developing and maintaining both the hardware and the software for such systems. The Lawrence Berkeley Laboratory has the necessary combination of industrial experience, academic ability, and isolation from a proprietary line of products.

Another approach is to collect air and water samples each day, or several times a month which could then be sent to a service organization which will provide a paper printout or machine readable listing of the concentrations of various pollutants. Such an approach does not allow dynamic studies of rapidly changing concentrations (e.g., a rapid dangerous build-up of CO in a tunnel during a peak traffic period). Further, it does not allow immediate checking of the measurement, nor does it satisfy the need to collect a large number of simultaneous samples from widely separated points. Unless you use many messengers, and have a large sophisticated 24-hour sample collection staff, this approach will not satisfy the need for continuous monitoring of our environment. However, any continuous monitoring system should be able to accept data from a sample collection survey.

The question of how to provide a simple mechanism for collecting and correlating data from short intensive studies and relating it to a large base of meterological information is answered by the three examples of this proposal.

Having one central data collection station on-line to many remote sites removes the need for a recorder at each site and the uncertainty concerning the operation of each site.

Description of Services

The Electronics Engineering Department at LBL-Berkeley consists of approximately 360 technical people, of whom 85 are professionals. Members of the department supply engineering and technical support for all phases of the Laboratory research program. From the initial concept of an experiment or accelerator through its design, construction, check-out and operational phases, department personnel are actively engaged in all electronics engineering aspects of the program. Circuit design and construction techniques are employed that extend the present state of the art to obtain improved resolution, timing, and operational control of experiments and accelerators.

The professional staff includes internationally recognized engineers knowledgeable in the fields of instrumentation, radiation detection data handling, computer control, radio-frequency power generation, pulse techniques, the use of semiconductor devices and properties of plasmas. The staff are constantly on call as consultants to other laboratories, universities and manufacturers.

The Fabrication Shops are capable of constructing short production run models of equipment employing discrete semiconductor components, integrated circuits or power tubes. Most construction is done on glass-epoxy printed-circuit boards. The shops use a tape-controlled drill, a tape-controlled wire wrap machine and a wave-soldering machine.

The Drafting Department employs a digitizing coordinator to supply the necessary punched-tape information.

For priority jobs the turn-around time for drafting, circuit board construction and component loading can be as short as one week.

The technical support and maintenance capability includes the evaluation and procurement of commercial instrumentation, the preventive and emergency maintenance of both commercially and laboratory constructed equipment and the operational maintenance of small-to-medium-sized computers and and associated peripheral equipment.

The Laboratory Stores Department keeps an inventory of approximately $700,000 in electronic and semiconductor components.

A modest voltage-and frequency-standards laboratory is also maintained.

Specific Capability

A few representative areas of interest are described in more detail:

The Nuclear Chemistry Instrumentation Group continues to be one of the world's leaders in the development of radiation detectors and the associated electronics and data handling systems for radiation measurements. Recently the group has been active in the development of semi-conductor materials for radiation detectors, in the design of low signal level electronics needed with these detectors, and in the application of these systems to analytical applications such as activation analysis and X-ray fluorescence analysis. Figure 2 shows an array of four diffused silicon radiation detectors which were employed in a recoil experiment at the Hilac. Figure 3 is an internal view of an instrumentation module containing seven printed circuit boards.

In recent months interest has extended to photoelectron spectroscopy and a new type of low-energy electron spectrometer exhibiting high efficiency and relatively low cost has been developed.

The Physics Instrumentation Groups are experienced in applying the capabilities of contemporary state-of-the-art electronics engineering to the needs of the research scientist. A great deal of experience exists in the application of digital computers to data acquisition and recording. The group is responsible for nine computers that are used continuously. These include four PDP-5's, one PDP-8, two PDP-9's, one PDP-15 and one IBM-1130. Some are permanently attached to certain data-gathering devices, such as film scanners and digitizers. Others are outfitted so that they can easily be applied to a wide variety of experiments and peripheral equipment.

The application of integrated circuit logic is an everyday task; a large part of the work falls into the category of specialized and unique data-handling instruments to satisfy specialized requirements. There is a continued awareness of commercially available instruments that could be applicable to laboratory needs.

A great deal of time has been spent on developing electronic circuits for measuring images on photographic film with a high degree of precision.

Members of the staff are particularly concerned with light-sensitive devices, including photomultipliers and image amplifiers.

Computational Facilities

Many of the elements of the program of the proposed Division of Environmental Research will require the use of a high-quality computing facility. Such a facility is available at UCLRL, Berkeley.

This facility includes an integrated complex of modern high-speed, general-purpose digital computers, an experienced operations staff, and a highly qualified group of systems and application programmers. Also, available are well developed interactive and real-time capabilities, graphic output devices, and a sophisticated mass storage system.

A group of applied mathematicians and computer scientists is also available at the Laboratory. Members of this group have extensive experience in the techniques of mathematical modeling required in the study of environmental systems.

General-Purpose Computing Facilities

The Laboratory's general-purpose computing facility present contains two CDC 6600 Computers linked together by a CDC 6411 Input-Output Module. Each 6600 has 131,000 words of central memory.

All input-output equipment, except for magnetic tape drives and mass storage devices, is attached to the 6411. This equipment includes nine high-speed line printers, three card readers, a card punch, four Cal-Comp Plotters, and 50 teletypes. Each of the 6600's has ten tape drives and two magnetic discs attached to it; in addition, the two 6600's share an IBM Data Cell Drive and two disc packs. The IBM Photo-Digital Storage System is attached to one of the 6600's.

This hardware is operated under the BKY Operating System, includes all of the standard CDC compilers. Users who have been running under a standard SCOPE Operating System encounter few difficulties in converting to the BKY System.

BKY is a multiprogramming operating system which is designed to maximize the throughput of the Laboratory's general-purpose computers. It supports a simple control card language which allows the user to run his problem with minimum knowledge of the system.

The LRL, Berkeley, computing facility is operated 24 hours per day, seven days a week. It is an open shop center with respect to programming and a closed shop center with respect to operations.

Time-Sharing Facility

A time-sharing facility called BRF (Berkeley Remote Facility) is supported on the Laboratory's 6600 computers. This facility is available via teletypes connected either to dedicated lines or to accoustic couplers.

BRF includes a FORTRAN interpreter, an editor, a desk computation facility, connections to a permanent storage system, and capabilities for remote submission of jobs into the standard batch stream.

Interactive Graphics

Attached to one of the 6600's is an interactive graphic console system. This system, a CDC 250, includes a controller with 8000 24-bit words of memory and character and vector generation capability, five user consoles, and a microfilm recorder.

A set of FORTRAN callable subroutines has been provided to allow the user to interact with a CRT Console by means of keyboard, function switches, or light pen.

Many interactive applications programs are available in the Computer Center's library. These programs provide for the interactive examination of large data bases, the design of magnets, composition and editing of text, and interactive design of printed circuit boards.

Mass Storage Systems

An IBM Photo-Digital Storage System with a capacity of $3X10^{11}$ bits has been in operation at the Laboratory's Computer Center for over a year. Sophisticated software is provided to allow the user convenient access to this device.

The Photo-Digital Storage System is a unique facility for the storage of large data bases. This system would lend itself well to the establishment of "data banks" in the environmental field. In addition to the Photo-Digital Storage System, the Computing Center provides a program storage system which uses an IBM data cell drive as a storage element. This system, which is accessible from both 6600's, provides a convenient facility for the storage of programs and of small data sets. It is accessible interactively via the BRF System, as well as through the normal batch stream.

User Services

A User Services Group provides consultation, documentation, library and education services to users of the LRL, Berkeley, Computer Center. A library of mathematical subroutines and applications programs, together with appropriate documentation is maintained. A programming consultant and a program librarian are on duty during the day shift. The Library is open and operates on a self-service basis at other times.

The User's Services Group periodically offers training courses in higher level languages and in features of operating systems.

Mathematical Services

The Mathematics and Computing Group has a staff of seven Ph.D. mathematicians who are available for consultation in various phases of applied mathematics.

Members of this Group work in such fields as: numerical solution of ordinary differential equations, normal linear spaces, linear programming, computer-assisted manipulation of symbols, and mathematical modeling of biological systems.

Applications Programming Services

A group of 40 professional programmers offers applications programming services to the scientific staff of the Laboratory. Members of this group have experience in the applications of computers to the solution of a wide variety of scientific problems.

Problem areas in which members of this group are especially experienced include: analysis of data from bubble chamber and spark chamber experiments, design of accelerators and magnetics, mathematical modeling in biology, Monte Carlo simulation of physical systems, the use of small computers in various control and data-taking applications, and interactive design of electronic circuits.

Another area of special competence in applications programming is the design and implementation of computer-controlled measuring systems. Several such systems have been implemented by members of the Mathematics and Computing Group using a variety of computers as control elements.

Computer Operations

A group of 65 people provides operational services to the Laboratory's Computer Center. These services include operation of the general-purpose computing machines, maintenance of a magnetic tape library containing 60,000 reels, operation of a courier service, and operation of a key-punching service.

The Future

The Laboratory's general-purpose computing facility was supplemented in April 1971 by an additional large-scale CDC 7600 computer. A time-sharing facility for sharing this valuable resource with outside users has been implemented on this machine.

The Campus

Project GENIE (funded by the Advanced Research Project Agency) in the Department of Electrical Engineering and Computer Sciences is a computer system specifically designed as a time-sharing facility. It has been a model for other medium-scale interactive computing systems for seven years. The experience gained here in providing for new needs, continuous maintenance, and the development of an interactive computer system has contributed to this proposal.

TECHNICAL INFORMATION DIVISION
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720