RESEARCH PROPOSAL SUBMITTED TO THE NATIONAL SCIENCE FOUNDATION

BY

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
CENTER FOR RESEARCH IN MANAGEMENT SCIENCE
BERKELEY, CALIFORNIA 94720

"Control Organizations" and Their Interactions with Operating Entities: An Experimental Investigation

Amount Requested: $206,286.00

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"CONTROL ORGANIZATIONS" AND THEIR INTERACTIONS WITH OPERATING ENTITIES: AN EXPERIMENTAL INVESTIGATION

Abstract

"Control organizations" are defined in this research as organizations which do not produce anything themselves, but which impinge on one or more productive organizations or operating entities, modifying what these entities produce or otherwise affecting their behavior. From new work on the definition and structural classification of control organizations and a discussion of their intervention processes and modes of interaction with operating entities, a proposed program of laboratory experimentation is developed.

The laboratory experiments will have empirical reference available from previous research in several fields. Experiments will be designed to give insight into such questions as : (1) What are the effects of varying the frequency and the informational detail of contact between the control organization and the operating entities? (2) How does the control organization differ as a function of the homogeneity or heterogeneity of the set of entities with which it must interact? (3) What are the effects of intervention at different decision-points in the operating entities? (4) What are the effects of varying the mix of incentives and sanctions in the control relationships?

"Control Organizations" and Their Interactions with Operating Entities: An Experimental Investigation

1. The Nature of "Control Organizations"

Productive organizations, or operating entities, use economically valuable resources to produce specific desired outputs. Whether these are "market-sector" or "public-sector" operating entities, they are ordinarily construed to have outputs that can be evaluated either by the market-place or by some procedure of public judgments; and they face an efficiency discipline, either through the market or, again, through public judgment, that relates the desired outputs to the costly productive resources that must be used.

A "control organization" may be defined for the purposes of this research as an organization that impinges upon one or more of these operating entities. The control organization may, like the regulatory agencies in the public-utilities field, supply valuation (price) controls or set qualitative-service requirements. It may, as in the field of environmental protection, impose limitations on the production choices that operating entities are allowed to make; or it may be the headquarters of a multi-unit corporation or of a public organization having numerous dispersed operating units, its function being to set and enforce performance standards for these operating units, allocate budgetary resources among them, and determine strategic directions for the whole.

The essence of it is that the control organization does not produce any direct, operating outputs whatever, but is, rather, a conscious

constrainer of what the managers of the operating entities may do as they go about the tasks of economic production.

By defining explicitly this functional separation between the output-producing entities and those that exist purely for purposes of control, we have been able to set forth a detailed conceptual argument and a structural classification of control organizations in the accompanying paper, "On the Definitional Properties of Economic Control Organizations, and Some Structural Distinctions among Types" (Berkeley, Center for Research in Management Science, University of California, CP-395, March 1977). That paper is Appendix A of this proposal.

We summarize briefly the types of control organization that have been identified, referring the reader to that paper for more details. Control organizations may have different foci of intervention into the operating entities. In the terminology of the activity-analysis model of the productive organization or operating entity, the control organization may concentrate on the net revenue function (exerting price regulation); or it may specify minimum or maximum amounts of certain outputs (required service levels); or it may intervene into the productive organization's technology, specifying required values of some activity-coefficients (engineering requirements for construction strength or for emission control); or it may modify the constraining resources available to the productive organization (capital subsidies); or, finally, it may add new goal constraints or requirements to those that the productive organization must take account of in its output determination (affirmative action).

Control organizations also differ in that some deal only with a restricted class of entities facing similar markets and using the same technology (e.g., the firms in a regulated financial industry, such as

commercial banking), while other control organizations face a different boundary definition on more heterogeneous operating entities with which they must interact. Also, some control organizations are concerned mainly with instances in which firms or other operating entities want to make changes: (a) in their investment base or (b) in their market structure or (c) in their product technology.

A particular control organization may of course be assigned to carry out several functionally different types of roles with a set of operating entities, and the kind of interaction appropriate for one of these roles may be in conflict with what is best for another.

This definition and structural classification schema will serve as one part of the conceptual foundation for the program of experimental research that is outlined in this proposal. The other part of the conceptual foundation is the working paper "Intervention Processes, Modes of Interaction, Incentives and Sanctions in the Operation of Control Organizations (Berkeley, Center for Research in Management Science, University of California, CP-396, March 1977, included as Appendix B of this proposal). In the paper, I discuss the scope and character of interactions between a set of operating entities and a control organization.

The intervention processes include the setting of informational or reporting requirements (and the determination of the extent of public disclosure of the resulting flow of information); the setting of fixed operating targets or the approval of yes-or-no requests for permits to take actions; the setting of certain crucial, continuously adjustable operating variables by the control organization and their imposition on the operating entities; the imposition of general rules or standards, rather than of particular targets or variable values; and strategic

control, via the selection of leadership personnel or some other element of the productive organization that determines what basic direction it will take.

Interaction modes may vary from that of continuous, detailed, essentially intimate relations between the operating entities and the control organization to infrequent contacts on a fixed cycle. Also, the modes of interaction are greatly conditioned by the environments faced by control organization and operating entity. In some instances, both face the same environmental constraints and shocks, whereas, in other cases, the control organization faces a set of environmental pressures quite different from the market environments of the operating entities. Also, these environmental inputs to control organization and operating entities may be either benign or threatening, thereby affecting the kind of interaction between them.

Finally, the control organization enforces its relationship with operating entities. The two may have the same length of decision horizon through time; or, as in the case of the financial regulator who restrains the speculative propensities of certain financial firms, the control organization may have a longer horizon than the operating entity. The enforcement signals may range from pure incentive to the exclusive use of forceful sanctions, but most of the interesting cases of these relationships involve mixtures of incentives and sanctions. These are intended to act through the goal structure of the operating entities so as to evoke predicted responses, desired by the control organization, to the action possibilities confronting these operating entities.

The two papers just summarized are the first major products of my program of research on control organizations. With these as foundations,

it is now possible to identify issues for further theoretical development, to indicate the nature of needs for controlled experiments on this phenomenon, and to define the general outlines of the experiments that it is proposed to conduct.

The sections of the proposal to follow will cover the following topics: Section 2, Significance of the Phenomenon of Control Organizations for Organization Theory and for Public Policy; Section 3, The Case for Laboratory Experiments on Control Organizations; Section 4, Parallel Empirical Research Interests; and Section 5, Organization of the Research, and Its Relation to Other Projected Research in the Management and Behavioral Sciences Laboratory.

2. Significance of the Phenomenon of Control Organizations for Organization Theory and for Public Policy

In the neoclassical economic theory of the firm, analytical constructs were developed to deal with problems of price- and output-determination and optimal choice of inputs. The nature and character of internal organization of the firm were not much considered. An early exception to this in the mid-Fifties was an essay by A. G. Papandreou, "Recent Developments in the Theory of the Firm," which stressed the significance of the "peak coordinator" as a determiner of the likely operating characteristics of the enterprise (Haley, Ed., 1952).

There is now, with the work of modern economists on the extended theory of the firm and of decision-theorists on uncertainty and information, a much-quickened interest in the internal organization of the firm as it affects efficiency and resource allocation. Particularly prominent are the contributions to the economic theory of teams (Marschak and Radner, 1971), Arrow's concern with "the limits of organization"

(Arrow, 1974), and Williamson's Markets and Hierarchies (Williamson, 1975). To emphasize this trend, the Bell Journal of Economics, of which Williamson is Editor, published a symposium on the economics of internal organization of the firm (BJE, Spring 1975). Thus, the proposed research, while a natural extension of my own long-standing interests, may also contribute to quite current analytical developments.

Modern organization theory developed in a fashion largely autonomous from economic theory, with its two most prominent contributions that of Chester I. Barnard, The Functions of the Executive (1938) and Herbert A. Simon, Administrative Behavior (1947). Both authors approached the fundamental problems of organization from a behavioral, process-oriented point of view. Their influence, particularly that of Simon, is evident in the book by Cyert and March, A Behavioral Theory of the Firm (1963), that, in the mid-Sixties, offered a bridge between micro-economics and organization theory. I used the Barnard-Simon framework extensively for the process analysis in Managing Today's University (Balderston, 1974).

While organization theory in the tradition of Barnard and Simon gives extensive treatment of the flows of decisions, authority and communications between levels in a formal organization, there is not an emphatic functional separation between the control group or control organization, on the one hand, and the operating units on the other. Barnard does discuss the special focus of the executive functions and process (Barnard, 1938, Chapters 15 and 16), but he seeks to portray these in a general fashion which would be as applicable to a unitary organization as to a highly ramified, multi-unit organization. Both Barnard and Simon were, in fact, largely anti-normative and anti-structural in their intellectual strategies for the development of modern organization theory, for the

excellent reason that they were constructing a view of the phenomenon alternative to, and more comprehensive than, the traditional management theories. The approach to control organizations that is the basis for my proposed program of research does admit of structural differentiation and specialization in a direct manner, and I believe that this will yield worthwhile insights into the properties of complex organization. Structural differentiation has already proved useful in two previous papers (Balderston, 1962, and Balderston, 1970).

Both Barnard and Simon, from their process-analysis vantage point, emphasized that the legal or conventional boundaries of an organization could not necessarily be regarded as determinative of its functional boundaries. This important proposition is relevant to the proposed strategy for studying control organizations of the regulatory type. As is emphasized in the two appended working papers, fresh insights into the regulatory process may be obtained by regarding the regulated firms and the regulatory agency as parts of one interactive, organizational system. When this is done, the properties of the control organization and the type of design appropriate to fulfill a particular regulatory mandate can be explored in a new way.

There seems little doubt that in the increasingly interdependent societies of the Western post-industrial world, control organizations are a prominent "growth industry," growing in numbers and in types of mission. A better understanding of them is very much needed for better public policy. Yet, even as the political authorities respond to new public concerns by enacting laws that create new types of control organizations, the intellectual foundation for control organizations, in the sphere of economic activity at least, has come under increasingly powerful attack.

There is now such disenchantment with the efficacy of much public regulation that important spokesmen among the legatees of the reformist, liberal dispensation have joined free-market conservatives in urging "de-regulation." (See, for example, Almarin Phillips, Ed., Promoting Competition in Regulated Markets, Brookings, 1975.) Some of the criticism is directed against regulatory systems that are designed and operated in such a way that their side-consequences outweigh in perverse effect whatever direct public benefits are supposed to be achieved. Better design may improve the effectiveness of regulation and make it more acceptable in those instances where it is indeed needed in the public interest. Thus, the proposed research may contribute to public-policy goals as well as to the progress of theory.

3. The Case for Laboratory Experiments on Control Organizations.

The previous discussion has shown the variety of structurally different control organizations and of the different modes of interaction between control organization and operating entities. Here are several researchable questions:

First, what are the effects of varying the frequency and the informational detail of contact between the control organization and the operating entities?

Second, what are the similarities and the differences in the control organization's required mode of behavior, depending on whether it impinges upon one operating entity (or a small number of them, each considered a unique case), upon a population of highly similar entities, or upon a population of highly heterogeneous entities?

Third, what are the similarities and differences in mode of behavior if the control organization intervenes in the operating organization at

different points in the decision process: (a) by affecting valuation and pricing, (b) by affecting the supply to the operating organization of a critical constraining resource, (c) by affecting the kind of production technology available to the operating organization?

Fourth, how should the control organization be designed if its main reliance is upon <u>incentives</u> in its impinging relations upon the operating organization, and how should the control organization be designed if it relies heavily upon <u>sanctions</u>?

These questions are appealing for laboratory investigation because, with the background provided by the two working papers (Appendix A and Appendix B) it should now be possible to define a few significant structurally different cases and then, for each of these, vary the informational conditions or permissible mode of interaction experimentally.

The essential feature of the relation between control organization and operating entities is that each, as an organization, responds to stimuli from the other and from a defined environment. The properties of this interactive system ought to be investigated experimentally for the following reasons:

(1) The situational definitions have strong structural components or features, and it would be very difficult to uncover some of the important implications except through explicit structural variation.

(2) Questions of the assimilation of goals and criteria for good action, and the ability to absorb information pertinent to decisions, demand a behavioral interpretation obtainable by putting human subjects into the context where their responses can be observed and calibrated.

(3) It can be expected that, by means of a program of experiments, some types of interactive response will be found to change smoothly with experimentally controlled changes in a crucial variable, whereas other interactions will turn out to be qualitatively altered. A priori reasoning concerning this type of interactive pattern should be supplemented and stimulated by experimental evidence.

The design of the details of an experimental setup and the statistical experimental design are part of the proposed program of research. At this juncture, I can offer only tentative comments about both.

First, the experimental setup will need to be designed to permit sharp definition of each structural variant, and to permit quick and inexpensive shifts from one structure to another. Second, the interaction processes between control organization and operating entities will have to be carefully specified and extraneous stimuli excluded; and then the experimenter will need to be able to alter these interaction processes conveniently and measure the impacts of such changes.

I expect that a small set of carefully designed experiments, elaborated in an experimental design, may be used to shed light on all four of the above questions. It should not be necessary to design completely separate experiments for each question. Before this experimental design is frozen, it will be necessary to do further work to define specific working hypotheses for the set of experiments to be conducted.

The nature of the problem permits a step-by-step build-up from a relatively simple dyadic relation between control organization and each operating entity toward a fully complex framework. Thus, it will be

possible to explore in a step-wise fashion how to enrich the experimental setup. This property of the problem area should cut the risks of developing the computer programs that will define the experimental situation and its variations.

In the next section of the proposal, I discuss parallel empirical research interests. These will have a definite bearing on the situational description and the structural design of the program of laboratory experiments, for it will be possible to use empirically defined situations as background for the design and for the derivation of important values. The experimentation will not be done in a vacuum. Rather, the purpose will be to develop a complex process having an empirical referent, and then to bring it under control for the application of experimental variations. This strategy was successfully followed in the joint work with A. C. Hoggatt on a large-scale, computer-only simulation of market processes (Balderston and Hoggatt, 1962).

4. Parallel Empirical Research Interests

I am interested in four empirical areas for which theoretical work and laboratory investigation of control organizations has pertinence. These areas are: (1) financial regulation; (2) higher education systems, coordination and control; (3) multi-unit corporations; and (4) regulation of energy production and usage. Each of these is discussed briefly in this section of the proposal.

4.1. Financial regulation

In the early 1960's, I designed and recommended new policies and procedures for the issuance of new charters and branch licenses in the California savings-and-loan industry. I was then asked to serve as

Savings and Loan Commissioner for the State of California. This interval of service, from 1963-65, stimulated an article on "Financial Regulation As a Control System Problem" (1966). I was in the midst of research on the savings-and-loan industry when called to service in the central administration of the University of California.

During sabbatical leave in the Spring Quarter 1975-76 and the Fall Quarter 1976-77, I developed a conceptual approach and assembled base data for a study to determine the economic and managerial impact of these regulatory decisions concerning charters and branches. I am in process of revising the design of this study. If support is secured to pursue it, it could be very usefully conducted in parallel with the work contemplated in this proposal.

A financial regulation agency is a well-defined type of control organization. Savings-and-loan institutions are, by statute and regulations, required to do a very specialized type of business as financial intermediaries. There is already in the program library of the Management and Behavioral Sciences Laboratory an interactive model for financial planning of a savings-and-loan association, developed by Clifford Olsen in fulfillment of a requirement for a master's degree. It is quite likely that this model can be revised to become a building block in an experiment involving interaction between a regulator and a set of savings institutions. The empirical background is a rich one on which to draw. Also, it is likely that some industry executives and regulatory personnel could be recruited to serve as subjects in the Laboratory, as an alternative to the more usual process of training university students to serve as subjects.

4.2. Higher-education systems

I served as a vice president in the central administration of the University of California for four years, from 1966-70. One of my duties in that period was to serve as co-principal investigator, together with then President C. J. Hitch, of our Ford Foundation Program for Research on University Administration. After returning to faculty duties, I continued to serve part time with President Hitch until he resigned in June 1975. One of my continuing duties was to oversee the work of that research program until the grant ended in October 1973. The technical reports of the program are still in active demand around the world. My book, Managing Today's University, was an effort to draw out of the specialized findings of the research program some insights about the process of university planning and management.

One tool developed with the support of the Ford Foundation Program by George Weathersby, Jeffrey Moore, and me was a multiple decision-center exercise, "Little University." After the new Laboratory computer system was operational, this program was revised and rewritten in CRMS/APL. It has been used with a wide variety of student groups, business executives, and educational administrators.

Again, the existing computer program, with the substantial background of development investment and successful usage, is available to serve as a building block for a control-organization experiment. In most states, the state government has established a coordinating agency for higher education. Many state universities are themselves multi-campus rather than single-campus institutions. Using the existing computer program as a building block, I would find it possible to design an experiment by writing a program for the interactions of several "Little Universities"

with a coordinating agency or a multi-campus system headquarters to serve as a control organization. Once again, the empirical background is rich, and the data for realistic setting of parameters are readily available. The necessary additional steps, for the purposes of this research program, would be to design a type of control organization and specify the information flows and incentive/sanction relations between the individual institution and the control organization.

4.3. Multi-unit corporations

My interest in the analysis of structurally complex firms began with my doctoral dissertation and the subsequent article, "Scale of Output and Internal Organization of the Firm" (1955). Subsequently, I considered the problems of the multi-unit organization composed of a headquarters and a set of more or less homogeneous branch units, one empirical referent being the multiple-branch banking organization. This interest eventuated in the article, "Models of Multiple Branch Organizations (1962) and "Two Problems in the Study of Multiple-branch Organization: Goal Configurations and Strategies of Branch Location" (1964).

This interest has continued with opportunities for close observation of the internal patterns of several large multi-unit business firms.

In due course, I expect to undertake some comparative studies of corporate headquarters organizations in several industries, utilizing the framework that is being developed here. Assuming that it is possible to secure financing of the program of experiments on control organization that is proposed here, I expect to undertake that first, using the empirical cases of financial regulation and of higher-education systems as guides to the experiments.

4.4. Regulation of energy production and usage

Since July 1976, I have served as chairman of a committee, jointly appointed by Dr. Andrew Sessler, Director of the Lawrence Berkeley Laboratory, and Chancellor Albert Bowker, of the Berkeley Campus of the University of California. This committee is composed of senior faculty who are directors of several research organizations on the Berkeley Campus and of several senior staff members of the Lawrence Berkeley Laboratory. Our purpose is to join together the competences of the Laboratory and the Campus in cooperative research on energy and environmental-policy analysis.

The Energy Research and Development Administration, which provides budgetary support for the Lawrence Berkeley Laboratory, is likely to finance a major study of decentralized energy systems; and the committee of which I am chairmen will have responsibility for enlisting the involvement of qualified researchers from various fields in the study group.

I have been asked to contribute some basic concepts of regulatory control over the transition from one energy system to another. This is a task exactly fitting the characteristics of the control-organization framework that is the focus of the research discussed in the present proposal. Assuming that the appropriate backing is secured, there will be early opportunity to undertake an exploratory application of the new control-organization framework to regulation of energy systems. My own involvement in this would be mainly that of advisor and director of modelling and programming efforts, with the technological information and economic parameters supplied by professional staff at Lawrence Berkeley Laboratory.

5. Organization of the Research, and Its Relation to Other Projected Research in the Management and Behavioral Sciences Laboratory

As Principal Investigator, I would expect to do a great deal of substantive work in the proposed project, from conceptual design to the conduct of experiments and to the analysis of data and results. My obligations as a member of the faculty in the Schools of Business Administration and as Chairman of the Center for Research in Management Science will not prevent me from maintaining an active research schedule throughout the academic year; provision is also made in the budget for two months of summer research salary in the summers of 1977 and 1978 and one and one half months in the summer of 1979 prior to the end of the second project year on 7/31/79.

The first project year will be occupied with further analytical development of control organization concepts and with the design and programming of one or more pilot experiments. For this work, I will need full access to the physical and computer facilities of the Management and Behavioral Sciences Laboratory, as well as the help of several types of people.

The Laboratory's history and its present system for computer support of controlled experimentation are described in an extended excerpt from the final report of the 1971-76 Laboratory Development grant, NSF-GS-32138 and SOC75-08177. This is presented as Appendix C. Perhaps it suffices to say here that the basic characteristics of the Laboratory are admirably suited to the kind of research outlined in this proposal.

The kinds of professional, technical, and other research assistance that will be needed for the project are indicated in the budgets for the two years of the proposed grant, from 8/1/77 to 7/31/78 and from 8/1/78

to 7/31/79, respectively. These include, in order to enlist graduate students fully in the research enterprise, two graduate research assistants throughout the two-year period.

Programming assistance is called for in both years. The design, programming, debugging, and operating of experiment programs, the handling of extensive data files, and the provisions for analysis will require substantial and continuing programming assistance.

In addition, the budget reflects payments for the help of Principal Programmers each year, to obtain the help of the Laboratory system's designers for a few software modifications that this set of experiments may require, and also to supervise the work, in the second project year, of acquiring and installing graphics-display equipment. Each research project in the Laboratory must bear whatever special costs of modifying and improving the Laboratory system are made necessary by the demands of that research program. In this instance, several cost elements of this type have been included in the budget, and these are discussed in the budget notes.

This project will also require special expertise in areas of the statistical design of experiments and in statistical inference that I do not possess. Provision is made, therefore, in both project years for a consultant to assist with this crucial aspect of the research program.

Finally, personnel support is required in administrative and clerical areas for both years, and this is discussed in detail in the budget notes.

One of the anticipated strengths of the proposed program of research is that it should be possible to share insights with those involved in

other research and educational usage of the Laboratory. Here is a list of other research projects proposed for the Laboratory in the next two years:

(1) Professors Martin Shubik and Garry Brewer, Yale University, research on three topics: bidding and markets, oligopoly experiments, and scenario developments and assessment.

(2) Professor A. C. Hoggatt, University of California, Berkeley, research on the replication of controlled experiments.

(3) Professor Jeffrey Moore, Stanford University, experimental study of resource allocation in decentralized organizations.

(4) Professor Mark Garman, University of California, Berkeley, research on the securities exchanges.

(5) Professors John G. Myers and Thomas Reynolds, University of California, Berkeley, research on design and implementation of a new type of inquiry system.

As these projects come on stream, we expect to maintain an active colloquium for sharing of research problems and interim results. When there is sufficient progress to warrant the convening of a conference so that interested scholars can be invited to discuss these efforts, possibilities for such a conference will be explored with the National Science Foundation.

No other research proposals are currently pending. If a proposal is submitted and budgetary support for a financial-regulation study is secured from NSF-RANN, care will be taken to assure conformity to NSF limitations on faculty summer-salary support and to coordinate the research covered in this proposal with other research obligations.

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BUDGET

BUDGET NOTES

D R A F T
25 March 1977
A. C. Boggatt

STUDIES IN THE PRECISE CONTROL OF SUBJECT TREATMENT IN ECONOMIC AND SOCIAL EXPERIMENTS BY USE OF COMPUTER-CONTROLLED TELEVISION AND BY USE OF ROBOTS WITH CAPABILITY FOR "FACE-TO-FACE" INTERACTION VIA TELEVISION

It is time to calibrate the unique instrument which has been developed in the Management and Behavioral Sciences Laboratory of the Center for Research in Management Science. We propose to do this over a two-year interval. Initially, during the first year, we propose to develop a TV controller which can be integrated with the CRMS video-display system so that digital display and video pictures can be simultaneously presented on the high-resolution monitors in the Laboratory. This will be used to standardize briefings and debriefings and to provide for display of short segments of prerecorded material in such a way as to simulate "face-to-face" interaction between subject and robot via television. The detailed description of this project is outlined in Section 1.

Second, we propose to replicate two experiments which have been completed and reported in the literature: One is a test of the Harsanyi-Selten Bargaining Theory. The other is a just-completed experiment by C. Plott and D. Grether, of California Institute of Technology. The Harsany-Selten experiment will be replicated and then extended, using statistical techniques which have recently been developed in our Laboratory with James Friedman. The Plott-Grether is already a replication of a result obtained by psychologists which attacks the entire basis of choice theory. If these results stand, they will make it impossible to apply the received theory of microeconomics

to the study of economically motivated human behavior. It is of crucial importance, therefore, to replicate this situation and seek to understand it. The detailed manner in which this work is to be carried out is discussed in Section 2.

Third, we propose to place this developed capability at the disposal of Brewer and Shubik for implementation of their work on the study of scenarios and their impact on experimentation. As their work is being submitted separately, no further discussion of that work will be discussed in this proposal.

NSF GRANT PROPOSAL BUDGET

Period August 1, 1978 to July 31, 1979

	Monthly Salary Rate	Support Required: Man Months CAL	ACAD	SUM	NSF Funded
A. SALARIES AND WAGES					
1. Senior Personnel					
a. Co/Principal Investigator(s) Title & Step					
Balderston, F.E. Res. Economist VI (38,700) S'78	$ 4,300	x		1.0	$ 4,300 +
Balderston, F.E., Res. Economist VI (41,603) S'79	4,623	x		1.5	6,935 +
		x			
		x			
		x			
		x			
		x			
		x			
		x			
b. Faculty Associates					
Subtotal	xxxxxx	x	x	x	11,235 +
2. Other Personnel (Non-Faculty), Title & Step					
a. Research Associates - Postdoctoral					
			x	x	
			x	x	
			x	x	
			x	x	
b. Non-Faculty Professionals					
			x	x	
			x	x	
			x	x	
			x	x	
			x	x	
c. Graduate Students					
2 Research Asst. 2 mos. 100% @ $1041/mo.					4,164 #
2 Research Asst. 9 mos. 50% @ $1041/mo.					9,369 #
2 Research Asst. 1 mo. 100% @ $1119/mo.					2,238 #
d. Secretarial/Clerical					
1 Sr. Typist Clerk, Step 5 11 mos. 10% @ $943/mo					1,037 *
1 Sr. Typist Clerk, Step 5 1 mo. 10% @ $1014/mo					101 *
1 Prin. Typist Clerk, Step 5 11 mos. 20% @ $1078/mo					2,372 *
1 Prin. Typist Clerk, Step 5 1 mo. 20% @ 1159/mo					232 *
1 Admin. Asst. II, Step 2 11 mos. 40% @ 1082/mo					4,761 *
1 Admin. Asst. II, Step 3 1 mo. 40% @ 1217/mo					487 *
f. Technical, Shop, and Other					
1 Sr. Programmer, Step 3 5 mos. 50% @ 1963/mo					4,908 *
1 Sr. Programmer, Step 4 6 mos. 50% @ 2061/mo					6,186 *
1 Sr. Programmer, Step 4 1 mo. 50% @ 2216/mo					1,108 *
2 Principal Programmer, Step 5 100 hrs. @ $15.00/hr.					3,000 *
Total Salaries and Wages					51,198

BUDGET (con't FOR PERIOD August 1, 1978 to July 31, 1979

			Support Required	
			NSF	Funded
B.	FRINGE BENEFITS (charged as a direct cost)			
20%	of salaries marked with * ($24,192)			$ 4,838
1.76%	of salaries marked with + (11,235)			198
.96%	of salaries marked with # (15,771)			151
	Total Salaries, Wages & Fringe Benefits (A&B)			56,385
C.	PERMANENT EQUIPMENT (Costs include taxes, shipping & installation)			
	Graphics Display Equipment for monitoring and control			5,000
	Total Permanent Equipment (Not subject to indirect costs)			5,000
D.	EXPENDABLE EQUIPMENT AND SUPPLIES			
	Misc. Office supplies, telephone, xerox, etc.			3,000
	Total Expendable Equipment and Supplies			3,000
E.	TRAVEL 1. Domestic (including Canada)			
	2 RT Berkeley/East Coast Conference	Airfare		800
		Per Diem		240
		Registration		50
	2. International			
	Total Travel			1,090
F.	PUBLICATION COSTS 2 Papers @ $275/ea.			550
G.	COMPUTER COSTS			
	Computer Time, 2000 hrs. @ $ 5.00 /hr.			10,000
	Includes terminal, CPU, Disc storage and run-off for 2 papers (above)			
	4 hrs. CDC 6400 @ $420/hr.			1,680
H.	OTHER COSTS			
	100 Subjects 8 hrs/ea. @ $4.25/hr.			3,400
	Consultants Fee for design and statistical inference			6,000
I.	TOTAL DIRECT COSTS (B through H)			87,105
J.	INDIRECT COSTS On Campus 29 %; Off Campus ___ % of Modified Total Direct Costs $ 82,105			23,810
K.	TOTAL COSTS (I plus J)			$ 110,915

Remarks: The University will cost share in accordance with current NSF policies.

(CRO Form #2)
4/15/75

BUDGET NOTES

A.2.c - Graduate Students

The budget provides for two graduate research assistants in both the first and the second year. Involvement of graduate students in this research is important, first, because they can contribute great energy and dedication to the research process and to the attainment of research objectives; second, and equally significant, is the opportunity that this will give for deep exposure to experimental methodology in the unique setting of the Management and Behavioral Sciences Laboratory. These two research assistants are budgeted at 50% time during the academic year, which is the maximum permitted under the rules of the Graduate Division of the University, and at 100% time during each summer of the project.

A.2.d - Secretarial/Clerical

A senior typist clerk is provided for, at 10% time, to handle accounting and grant reporting for this project under the supervision of the senior administrative staff of the Center for Research in Management Science. A Principal Typist Clerk, at 20% time, is provided for, to prepare report materials, experiment documentation reports via the Laboratory's RUNOFF editing system, and other clerical assistance to the Principal Investigator, research assistants, and programmers.

A.2.d (cont.)

An Administrative Assistant II, is provided for, at 20% time in the first year and 40% time in the second year to administer the flow of experimental subjects for the project. The many tasks involved in this process, include the interviewing and screening of potential subjects; scheduling for initial briefing and training and the conduct of those portions of the briefing and training that are not dealt with by means of closed-circuit TV; scheduling for pilot experiments and experiment runs; arrangement for debriefing of subjects at the end of their involvement in the experiment series; and arrangement of compensation of subjects. Administrative studies of past experiments have shown that this process takes about one hour of administrative time per hour of net subject time actually utilized in experiments. This is the reason for the provision of this much AA II time in the proposal budget.

A.2.e - Technical, Shop, and Other

There is provision in this budget for a senior programmer at 50% time in the first and second years. This programmer will have two roles for the proposed research project: (1) under the general guidance of the Laboratory's original system designers, the programmer will undertake modifications and improvements as necessary in the system to accommodate the experiments contemplated by the Principal Investigator; and (2) the senior programmer will design, code and test applications programs for the contemplated experiments. In the second year, also, the senior programmer will undertake to

A.2.e (cont.)

extend the available data management programs of the Laboratory system and will utilize the data link to the Berkeley campus CDC 6400 for statistical analysis of experimental data. Over and beyond the standard commands of APL, the Laboratory system has provisions for interprocess communication so that an experimenter's console can control one or more interrelated terminals and can maintain control of stimulus display to the subjects. Programming needs for experiments using this extended system are budgeted within the 1/2 time senior programmer provision, although some routine work may be done by hiring, within the budgeted funds, a more junior-level programmer or coder and reducing the dollars spent at the senior programmer level accordingly.

The Laboratory's technical systems designers, carried part-time as needed on the Laboratory recharge account are two Principal Programmers. These positions are occupied by Dr. Charles Grant and Dr. Mark Greenberg, who have led the successful design and implementation of the Laboratory system. Budgetary provision is made here, in the first and second years, for 100 hours of additional time of these senior people, in order that extensions and modifications of the system can be undertaken in response to the demands of the contemplated experiments. (If either Grant or Greenberg becomes unavailable, the funds would be used for equivalent engineering and systems consultancy.)

In the first year, the main systems tasks will be to extend interprocess capabilities to accommodate experiments for this project.

Also, some work will need to be done to accommodate the use of remotely located subjects if the pilot experiment proves the need.

In the second year, it is proposed to purchase and adapt to the Laboratory system some graphics display equipment for monitoring and control. It is expected that the first year's experiments, plus design consultancy involving the Principal Programmers and the senior programmer, will provide a good basis for setting specifications for this. The basic idea is to add special equipment that will facilitate information handling and rapid-feedback interventions by a decision-making team in the role of a control organization that is monitoring and controlling a set of operating entities.

C. - Permanent Equipment

In the first year, two permanent equipment additions are included in this project budget:

1. Core memory boards 8K X 18-bits. The Laboratory system has not in the past had the full complement of core memory for which the original design had made room. The proposed project, with its needs for extensive experiment programming and for large-scale use of the system during experiment runs, will add to an already diverse user community. To fill out the design complement of core and thus increase response speed, and to provide a backup memory board for quick re-placement in the event of failure during an experiment, the budget provides $4,882.

2. One DTC terminal. During the whole of the two year project, it is expected that a terminal will need to be reserved for the use

C. (cont.)

of the Principal Investigator and for placement off-site to try out possibilities for inclusion of a remote subject in experiments. This terminal would be fully compatible with those in the present configuration. The present complement of eighteen terminals has proved to be strained at times, and it is very difficult to arrange for release of terminals to off-site locations because they are needed on the system. Purchase of this additional terminal will facilitate this research project immensely.

In the second year, a budgeted amount of $5,000 is provided for the purchase of graphics display equipment for monitoring and control. Specifications for this will be developed through the experience of the first year's pilot experiments, and through design efforts of the Principal Programmers and the senior programmer. (See A.2.e for the personnel component of this.)

D. - Expendable Equipment and Supplies

The project will involve two research assistants, a half-time programmer, and numerous experimental subjects. It is anticipated that routine S&E costs will be $2,500 in the first year, and $3,000 in the second year.

E. - Travel

Domestic travel to two scholarly meetings each year is provided in the budget, for presentation of papers based on the research to be done.

F. - Publication Costs

Preparation, reproduction and dissemination costs are provided for at the rate of $250 per technical paper in the first year and $275 per paper in the second year. These costs, however, do not include connect time for the use of the Laboratory's RUNOFF editing system for manuscript preparation. This usage is included in part G below.

G. - Computer Costs

Computer time on the Laboratory system will be required for: (1) some programming of systems modifications, discussed under A.2.e; (2) programming of experiments and of the associated data handling requirements; (3) connect time for pilot experiments and for experiment runs; and (4) connect time for use of the Laboratory's RUNOFF system to prepare and edit documentation reports and technical manuscripts. We have estimated usage of 1,400 connect-hours in the first year and 2,000 connect hours in the second. These are budgeted at an average rate which covers connect-time, CPU time, and disk storage.

In addition, time on the Berkeley campus CDC 6400 will be needed for data analysis; the budget covers 2 hours in the first year and 4 hours in the second. There is a data link between the Laboratory system and the Berkeley campus Computer Center to facilitate this work.

H. - Other Costs

Other costs include the following:

1. Compensation of experimental subjects: 50 subjects @ 8 hours in the first year, and 100 subjects @ 8 hours in the second. At this stage, it is difficult to specify how much subject usage will be necessary in the experiment series, but this allocation is believed to be at a prudent level.

2. Consultant fee--experimental design and statistical inference: There are numerous special problems of experimental design and statistical inference in the conduct of a series of experiments. The Principal Investigator feels well-qualified to do the conceptual design, identify parameter values for use in the decision models, and undertake analytical interpretation of the problems of organization theory that are to be studied. He will need expert, highly professional help for certain of the problems of this Laboratory research, in order to capitalize on the special capabilities of the Laboratory for running an experiment series and in order to extend and utilize program packages for analytical inference. The budget therefore provides for consultant services to the extent of $5,000 in the first year and $6,000 in the second. At this time, no individual has been approached for these tasks.

APPENDICES

APPENDIX C

Management and Behavioral Sciences Laboratory

Center for Research in Management Science

University of California, Berkeley

EXCERPTS FROM

FINAL REPORT

PROGRAM FOR FACILITIES DEVELOPMENT AND EXPERIMENTAL RESEARCH

Center for Research in Management Science

Management and Behavioral Sciences Laboratory

NSF-GS-32138 and SOC75-08177

December 1976

1. History of the Laboratory and NSF Support 1971-76

The Management and Behavioral Sciences Laboratory of the Center for Research in Management Science is a uniquely designed facility for controlled experimentation in the social, behavioral, and decision sciences. Established in 1964, the Laboratory is operated by the Center for Research in Management Science, one of Berkeley's organized research units.

Faculty members and students in Business Administration, Economics, Computer Science, Sociology, Education, Engineering, and other fields have used the special capabilities of the Laboratory for both research and instructional purposes; and research scholars from a number of other universities in the U. S. and abroad have been attracted to the Laboratory.

The Laboratory contains about 3,000 square feet of floor area, including the computer and equipment and control rooms, two briefing rooms, four fixed experimental cubicles, and an open experimental area that can be rearranged quickly for different uses by moving sound-proofed partitions into place on overhead tracks. The Lab's wiring connects to twenty-four locations for computer terminals, TV display, TV camera, and audio communication. The closed-circuit TV capability has been used for the briefing of experiment participants and also for recording activities of seminar groups so that they can later assess their own performance.

Beginning in 1970-71, NSF support enabled the Laboratory's faculty-investigator group and its systems group to cooperate in the construction of a system of computer support for stimulus display to subjects, communication between subjects under experimenter control, on-line response by subjects to stimulus and immediate source-program response to subjects'

responses, and data capture and logging. The heart of the Laboratory's new system is a dedicated time-sharing system based on two microprogrammable META4 computers, with a shared core memory of 120,000 32-bit words; two disks having storage capacity totalling 24 million words; a magnetic-tape unit for backup and data preparation; a link to the Berkeley Campus CDC 6400 computer; modems for linkage to users and other systems outside the Laboratory; eighteen hard-copy terminals; and a CRT display system consisting of twelve CRT screens with keyboard and light-pen and a PANTEX support unit.

The resident language for experimenters in this system is APL, to which have been added the following special features: (a) capabilities for interprocess and interterminal communication such that the experimenter can put under the control of his source-program the activities of a number of subjects who are interacting with one another and with the source-program via separate terminals; (b) a powerful editor and debugger; (c) a text-editing capability that permits quick and expert preparation of documents concerning experiments and findings. The operating system is designed to give priority to multiterminal use, in order to protect the requirement of rapid response time to experiments in execution. Laboratory users who are undertaking APL program development can be accommodated at the same time as multiterminal users, but at a lower priority level. Modems permit users not in the Laboratory to enter the system.

First, the Laboratory is designed to implement experimentation methodologies that are of interest to investigators in numerous disciplines who are interested in a variety of theoretical and empirical questions. Second, the Laborntory has a large potential throughput capacity for the support of experiments. Third, the Laboratory system has been designed in

such a way that additional peripherals, including instrumentation for collecting additional types of data, can be added at low marginal cost for engineering interface work, thus enabling us to accommodate additional kinds of experimentation interest over and beyond those that were of such high priority, in the judgment of the Laboratory Advisory Committee, as to be incorporated in the present system's user specifications. Fourth, we believe that the Laboratory system is responsive economically to the user who is not normally located at Berkeley.

During the 1971-75 development interval, members of the Laboratory Advisory Committee, who constituted the investigator group under NSF's development grant SOC75-08177, and their doctoral students undertook to develop and use a significant number of experimental control programs. These efforts had two purposes: first, to make substantive progress with certain research topics, rather than delaying work on them until the new system was ready; second, and equally important, to assure that the performance specifications of the new system were shaped to the needs of the user community and to provide a dialogue for conceptualization and testing of the configuration and software design. It was difficult to do the development and the research in this way; but now that the system is successfully operational, we are able to point proudly to a collaboration that has realized a system uniquely suitable for controlled experimentation...

2. Summary of the Laboratory Systems Development by Mark Greenberg and Charles Grant, Co-leaders of the Systems Group

The following pages describe the CRMS Computing System developed for use in the Management and Behavioral Sciences Laboratory. The computing system has been in successful operation with ever-growing capabilities since 1973. The use of the system for both instructional and research

purposes was maintained concurrently with continuing development of the system. All original major objectives for the computing system have been accomplished.

SYSTEM ARCHITECTURE

The current configuration of the CHAM system is shown in Figure 1. Each of the two processing units is a high-performance MOS/LSI microprocessor with 90 ns microinstruction execution time. The utilization of microprocessors has allowed for great flexibility in the design of the system architecture:

1. Most of the functions of the disk controllers and the terminal multiplexor normally performed in hardware have been implemented in firmware.
2. Specialized instruction processing units for APL and the system programming language were designed and emulated as microprograms.
3. The primitive-operating-system functions for virtual segmented memory, interprocess communication and synchronization, process scheduling, and a capability-based protection system were all efficiently implemented in microcode.

The APL processor and central processor both have access to all of the primary memory. The sole function of the APL processor is to execute APL programs under control of the central processor. The central processor handles control of the input/output devices, as well as the execution of all system programs (e.g., the operating system and the text editor).

The primary memory of the system is implemented by 1 μs cycle-time core memory, expandable to 128K 32-bit words. The secondary memory of the system consists of two 20-surface, 400-track disk memories with a capacity of 12 million 32-bit words each. A tape unit is provided for the purpose of off-line storage and computer-to-computer information transfer. Up to

32 hard-copy terminals of varying speeds may be connected to the system. The system also includes a 12-terminal, full-graphics display system. Each display terminal includes a high-resolution display and a light pen for pointing to information on the display. The input/output interface was designed so that other devices could easily be installed in the system. In addition, the CRMS system is interfaced to a remote-job-entry port of the Campus Computer Center CDC 6400.

OPERATING SYSTEM

The operating system is software which manages all the resources of the CRMS computer system in such a way as to provide interactive service to multiple simultaneous users. The operating system schedules the use of the processors, allocates disk and core storage and schedules the transfer of information between them, and provides user facilities, such as a multi-level directory hierarchy for the cataloguing by symbolic name of programs and data. Furthermore, the operating system manages the sharing of information among users and guarantees that there will be no unauthorized interference among users' programs and data.

The operating system software was implemented in a higher-level systems programming language (SIMPLE), which was designed in conjunction with the instruction processing unit of the central processor. This language includes the following features: (1) a complete block-structured control mechanism for specifying iterative and conditional control structures; (2) convenient methods for accessing and manipulating partial word values, one dimensional arrays of various element sizes (with automatic bounds checkings), strings of characters, and ring buffers; (3) efficient recursive functions; and (4) a macro facility.

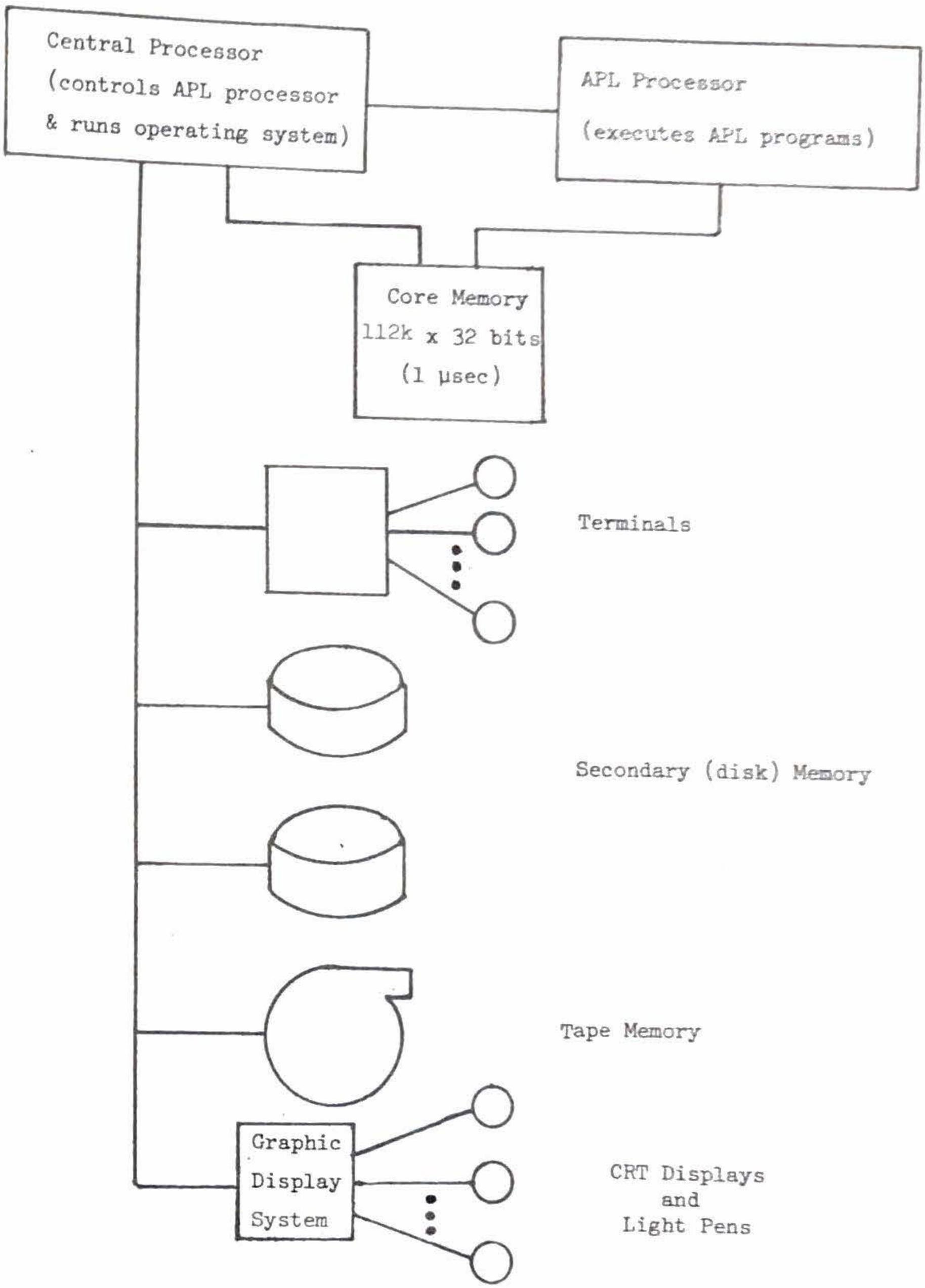

Figure 1

CRMS Computer System Configuration

APL LANGUAGE SYSTEM

The APL language system is a subsystem of the total CRMS computer system. It is one of the two language systems currently implemented (the other is SIMPLE). Nearly all research and instructional programs are implemented in the APL language. The APL language system provides service similar to that of APL 360. It is an integrated system of firmware, operating system software, and APL language software.

APL programs are translated into an internal form before they are executed. The APL microprocessor is then able to execute these programs with great speed, thus allowing real-time multiple-subject experiments to operate without significant delays.

In order to handle the special needs for experimentation in the social sciences, extensive additional features have been added to APL. A multiple-process capability allows several independent programs to operate under common control. The multiple-terminal capability allows the multiple processes to control input and output to up to 32 terminals. The file access capability allows logging and recovery of data during execution of an experiment program.

RUNOFF

A document-preparation system called RUNOFF has been developed for use on the CRMS computing system. RUNOFF allows the text of documents to be typed into the computer system. Mixed with the text are commands which specify the format in which the text should be printed. This text and command file is then processed by RUNOFF and a finished document can be printed. The RUNOFF system facilitates such documentation features as margin justification, page heading, footnotes, identation, page numbering,

underlining and centering. Existing documents can be modified easily or corrected by using the text-editing facilities.