

## MANAGEMENT PLAN FOR PROJECT MAC

Purposes of Project MAC: To understand and develop man-computer interaction and interactive multi-access information processing; to contribute to the melding of the fields of computing and communication and to understand and develop computer networks and information utilities; to learn how to make computers carry out sophisticated processes that involve heuristic methods; to contribute to the construction of a theory of computation that will provide a foundation for advances in computer science and engineering; and to contribute to the education of a new generation of computer scientists and engineers.

Purpose of this plan: To reshape and expand the research program in order to bring it better into line with the stated purposes and to turn Project MAC into a Laboratory for Computer Science and Engineering (LCSE).

Time scale of this plan: The next three years -- February 1, 1968, to February 1, 1971. Transition from Project MAC to LCSE, September, 1970.



9. Developing good (or better) programs in "hot" areas of computer science and engineering: data management, computer graphics, computer networks.

10. Realizing the longstanding (and now beginning to be realizable) dream of comprehensive, significant, and effective on-line computer assistance to people in problem solving and decision making -- well beyond the realm of programming, which has already been greatly facilitated.

Over-all size:

	1968 (Actual)	1969 (Target)	1970 (Target)	1971 (Target)
People				
Faculty members	42*	50	54	56
Graduate students	70**	76	85	100
Undergraduate students	35	45	55	65
Research staff members	44	35	28	20
Technical staff members	27	28	29	30
Office staff members	28	31	35	40
Others	9	10	10	10
Total, people	255	275	296	321
Funds, in thousands	\$3,700	\$5,080	\$6,000	\$7,000

\*Number given is total number of faculty participants.

Average participation is 0.275 of full time. I shall try to increase that fraction to about 0.4 by 1971.

\*\*Of the 70, thirty are on the payroll as graduate assistants. That ratio will continue to hold, approximately.

Distribution of funds among research areas, each year's total being used as the base for the year's percentages:\*

<u>Research Area</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>
Theory of computation	0	1	2	3
Theory of automata	1	1	1	1
Artificial intelligence	23	12	15	13
Computer languages	3	5	8	8
Linguistic theory	(2)	(2)	(3)	(3)
Language development	(1)	(2)	(3)	(3)
Natural-lang. processing	(0)	(1)	(2)	(2)
Computation structures	2	3	4	4
Computer system research	61	31	14	12
Computer networks	2	4	8	11
Computer graphics	2	11	12	12
Modeling and simulation	0	11	12	12
Man-computer symbiosis	1	3	4	4
Data management	1	3	4	4
Management applications	3	3	4	4
Medical applications	0	2	5	5
Educational applications	0	2	4	4
Mathematical applications	1	2	3	3
Total (per cent of base)	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>
Base (thousands)	<u>\$3,700</u>	<u>\$5,080</u>	<u>\$6,030</u>	<u>\$7,000</u>

\* Administration and support distributed among research areas.

Distribution of funds among research areas, the 1968

total being used as the base for all the percentages.<sup>‡</sup>

<u>Research Area</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>
Theory of computation	0	1	4	6
Theory of automata	1	1	2	2
Artificial Intelligence	23	25	24	25
Computer languages	3	7	13	15*
Linguistic theory	(2)	(3)	(5)	(6)
Language development	(1)	(3)	(5)	(6)
Natural-language processing	(0)	(1)	(3)	(4)
Computation structures	2	4	6	8
Computer system research	61	44	22	23
Computer networks	2	6	13	21
Computer graphics	2	15	19	23
Modeling and simulation	0	15	19	23
Man-computer symbiosis	1	4	6	8
Data management	1	4	6	8
Management applications	3	4	6	8
Medical applications	0	3	7	8
Educational applications	0	3	6	8
Mathematical applications	1	3	5	6
Total (per cent of 1968 base)	100	137*	162*	189*
Base (thousands), 1968	\$3,700	---	---	---

‡ Administration and support distributed among research areas.

\* There is a slight discrepancy here, due to rounding, between the sum of the percentages and the percentage corresponding to the sum.

Sources of support:

(Entries in thousands)

<u>Source</u>	<u>Actual 1969</u>	<u>Target* 1969</u>	<u>Target* 1970</u>	<u>Target* 1971</u>
Advanced Research Projects Agency				
Task 1, main	\$3,000	\$3,000	\$3,000	\$3,000
Task 2, artificial intelligence	700	700	700	700
Special incremental funding**		150		
Dynamic modeling		780	720	620
Computer science parts of CAM		120	200	200
Office of Naval Research		200	200	200
National Library of Medicine		80	200	300
National Aeronautics and Space Agency		50	100	150
Others***			880	1,830
<b>Total</b>	<b>\$3,700</b>	<b>\$5,080</b>	<b>\$6,000</b>	<b>\$7,000</b>

\* Anticipated, hoped for

\*\* For acceleration of research in computer networks, computer graphics, and mathematical applications (computer-based mathematical laboratory): approved.

\*\*\* "Others" includes National Science Foundation, foundations, and private philanthropists.

Summary of status of Multics:

1. Multics software is judged very valuable because it provides the large, manifold address space required for programming complex software, because it facilitates sharing of programs and data in an unrivaled way and at the same time provides graded control of access, and because it has succeeded in bringing together in one system almost all of the other advantageous design features thus far defined for interactive multi-access systems.
2. The Multics basic operating system is now running, and the path to reliable operation is clear.
3. For the potential value of Multics to be realized, a computer must be made available with advanced technology and favorable pricing.
4. The General Electric (GE) 645 computer complex on which Multics is now being developed consists of two parts, one rented to Project MAC for \$1 million\* per year (maintenance included) and the other (which would rent for about \$720,000 per year) devoted to Multics without charge by GE. Project MAC has operated both parts of the complex. Since the complex has not been usable for other purposes than development of Multics, the whole cost to Project MAC has had to be assigned to the Computer System Research Group. That fact, together with the facts that the CSR Group is large and has used much time on the 7094 Compatible Time-Sharing

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\* \$1,000,020

System (CTSS) in the process of developing Multics, accounts for the disproportionate cost of the CSR Group shown in the 1968 columns of preceding tables.

5. Beyond its basic operating system, Multics needs a complement of programming languages, service commands, allocation and accounting systems, etc., to make it useful to potential users as distinguished from system programmers.

1-5. So Multics should be continued and there should be a good follow-on to the 645 computer. A way should be found for Project MAC to pay less for use of the 645 computer. And a wider potential usership should be found to support the exploitation of Multics.



Summary of preferred projection of Multics: This describes the course most preferred by Project MAC. Contingency plans pertinent to it will be described later.

1. Multics work continues and achieves a solid, reliable, useful Multics System on the 645 computer by the end of September, 1969.
2. GE pays for the \$1-million-a-year part of the 645 complex while it is being used in Multics development, and Project MAC pays for the less expensive part.\* The less expensive part is augmented temporarily (six months, while a critical part of the software development is being carried out), and the rental is \$72,000 per month while augmented, \$60,000 while not augmented. If the development period runs to the end of September, this arrangement saves Project MAC about \$150,000 during 1969. The two parts of the complex are operated by Project MAC as two separate computer systems -- A, the smaller, and B, the larger.
3. As soon as the software is working reliably (which must be by the end of September), Project MAC makes Multics available

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\* This is based on the impression, drawn from conversations with GE representatives but not specifically checked for validity, that GE will continue to extend this part of its proposal even though Project MAC does not take GE up on another part of the proposal that precludes GE's offering of a Multic Service. See "Summary of preferred projection..."

at least on a regular service basis to as wide a potential user-ship as can be arranged for at M.I.T., among the New England Colleges and Universities\*, and among ARPA and other DOD contractors. Project MAC pays for computer B, now that it is being used in service instead of development, and money collected from users outside Project MAC offsets some of the cost. The amount recovered during 1969 is not great, but the amounts recovered thereafter are significant.

4. After the service has been launched, the CSR Group of Project MAC continues to work on improvement of the Multics operating system and, with other groups, on development of user-oriented software, but the CSR Group decreases in size. Project MAC pays in whole or part for software-development efforts that are judged to enhance the value of Multics; it provides computer access to those efforts or adopts them as its own, wholly or in part. Project MAC's total expenditure on Multics therefore exceeds the CSR Group allotment of funds indicated in the tables, but some of the support for Multics is derived from the computer-access funds of other groups within Project MAC. The ceilings on Project MAC's payment for

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\* A group of colleges and universities with which M.I.T. is presently cooperating.

Multics, from the funds allocated to the CSR Group and from other Project MAC funds, are shown in the following tables:

Funds Available and Required for Multics			
	1969	1970	1971
CSR Group	\$800	\$ 350	\$ 350
Other Project MAC	50	400	250
Total available from Project MAC	850	750	600
Total required	850	1,000	1,000
Needed income from use outside Project MAC	0	250	400

If the amounts indicated opposite "Needed income from use outside Project MAC" do not materialize, Project MAC requests special funding by ARPA to make up the deficit.

5. At the end of 1969, Multics functions as the main computer system of Project MAC. Other Project MAC computers are connected to Multics, and Multics begins to become the focus of the long anticipated "on-line community."

6. Starting at once, the CSR Group devotes an increasing amount of its effort to organization, documentation, and publication of Multics.

1-6. The foregoing provides a very favorable opportunity for Multics to be developed fully and for it to become the prototype

computer system of the "information utility." At the same time, it saves Project MAC about \$150,000\* on the 645 computer during 1969 and in ensuing years distributes the cost over a wider base than Project MAC, alone, can provide. It begins to decrease the size of the CSR Group and thus to permit a balancing of group sizes within Project MAC and a reduction of full-time research staff in favor of faculty and graduate students. It publishes information about Multics and makes Multics available outside M.I.T.

7. In order to provide assurance of the availability of a good follow-on to the 645 computer, GE agrees (has agreed) to deliver an advanced Multics (hardware) computer within 18 months of receipt of a firm order. The new computer -- the "6450", to give it a name for present purposes -- uses advanced technology now under development and in part demonstrable. The logic is about three times as fast as that of the 645. GE will provide further information upon request.

8. The CSR Group studies the question: What changes should be made in the Multics hardware design to incorporate into the one follow-on computer the insights gained since the G.D. 645 was designed? Concurrently, with the aid of consultants, Project MAC studies the adaptability to the Multics software of certain other currently operational computers and their

follow-ons -- and the adaptability of the computers to the Multics software.

9. At once, Project MAC determines from GE the requirements that must be met by a "firm order" for a follow-on Multics computer -- e.g., whether purchase or only a one-year rental agreement is required. If possible, as soon as conclusions derived from the preceding studies are firm, Project MAC orders a follow-on Multics computer.

Contingencies in preferred projection of Multics:

1. If Multics is not operating solidly by the end of September, then the CSR Group, the Project MAC Planning Committee, the ARPA Review Committee, and I, -- all -- have been wrong, and the only reasonable thing to do is to concede defeat and salvage as much as possible through writing.
2. If GE does not pay for computer B (and pays only for computer A), then in 1969 this plan is \$150,000 less attractive than anticipated, and the next-preferred projection (see next section.) becomes the preferred projection.
3. If arrangements cannot be affected to make Multics available to at least two of the four groups -- M.I.T. outside Project MAC, New England Colleges and Universities; ARPA contractors, and other DOD contractors -- then the next-preferred projection becomes the preferred projection.

4. If ARPA is not willing to make up possible deficits in "income from use outside Project MAC" -- \$250,000 is needed from such use in 1970, \$400,000 in 1971 -- then the next-preferred projection becomes the preferred projection.
5. If GE's plans for the "6450" turn out not to be satisfactory and cannot be made so, then great emphasis is placed upon the adaptation studies.
6. If then the adaptation studies turn out to be negative, or to require so much software revision as to make it necessary in effect to begin a new project, it will be best to concede defeat at least temporarily and to salvage as much as possible through writing.
7. If it proves to be beyond Project MAC's financial means to order a follow-on Multics computer, Project MAC will request special funds for that purpose.

Summary of next-preferred projection of Multics: This describes the second-most preferred course. Contingency plans pertinent to it will be described later.

1. Multics work continues and achieves a solid, reliable, useful Multics System on the 645 computer by the end of September, 1969.
2. GE pays for the \$1-million-a-year part of the 645 complex; Project MAC rents and pays for the less expensive part; the less expensive part is augmented temporarily (six months while a critical part of the software development is being carried out), and the rental is \$72,000 per month for six months, then \$60,000 per month for six months, or a total of \$792,000 for the year 1969; the two parts of the complex are operated by Project MAC as two separate computer systems -- A, the smaller, and B, the larger.
3. As soon as the software is working reliably (which must be by the end of September), GE launches a limited, special commercial service with computer B, seeking users who can appreciate and exploit the features and capabilities of Multics. The service is<sup>^</sup> priced for the marketplace."
4. After the service has been launched, the CSR Group of Project MAC continues to work on improvement of the Multics operating system and, with other groups, on development of user-oriented software, but the CSR staff decreases in size.

Project MAC software researchers and developers have free second-priority access to the service computer (i.e., computer B) and any other Project MAC people who want to use it have a reduced rate (that reflects housing and operation of the machine by Project MAC). Project MAC has full access, of course, to computer A, but it is too small (now that its augmentation has been removed) to be useful in anything but program-system development.

5. Beginning now, the CSR Group devotes an increasing amount of its effort to organization, documentation, and publication of Multics.

6. The proof of Multics is its acceptance in the marketplace. It is judged successful -- and GE presses on with the service -- if, by the end of six months from launching, the service has at least 10-15\* users on line, on the average, during prime time. Project MAC is counter-proposing that the critical date be June 30, 1970 -- nine months after the end of September, 1969.

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\*Logically, that means at least 10, but GE's proposal said "at least 10-15."



1-6. The foregoing provides for an orderly and reasonable test of Multics. It introduces Multics at an early date to potential users who need it. It saves Project MAC about \$225,000 on 645 hardware during 1969. It offers a way of continuing to work on Multics without having to pay indefinitely for a whole 645 computer. It begins to decrease the size of the staff of the CSR Group and thus to permit a balancing of group sizes within Project MAC and a reduction of full-time research staff in favor of faculty and graduate students. It lets the world understand and use Multics.

From this point on this "next-preferred" projection is identical with parts 7-9 of the preceding "preferred" projection.

Contingencies in next-preferred projection of Multics:

1. If Multics is not operating solidly by the end of September, then (as said earlier) we concede defeat and salvage through writing.
2. If M.I.T. decides\* it cannot follow the projected course (e.g., because it involves too-close association with a commercial enterprise), then we go back to preceding projection if it is still viable -- otherwise we concede and salvage.

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\* The proposal that is the basis of this projection was made by GE to Project MAC on January 10, 1969. There has not been time for due deliberation by the administration of M.I.T.

3. If Multics is not successful according to marketplace test, then we go back to preceding projection if it is still viable -- otherwise we concede and salvage.

Computer facilities for Project MAC: This is a problem now because Multics is not yet ready for regular use and one CTSS has been taken out of service. Project MAC will continue to make some use of CTSS -- the remaining one. Multics will be opened in February to use by tolerant programmers outside the CSR Group. The PDP-10 in the Artificial Intelligence Laboratory of Project MAC -- at present just a processor with 16K words of memory and a display unit -- will be used, beginning now, as an interim computer for graphics research. A new PDP-10, for which we have submitted a letter of intent and which we shall order firmly as soon as we can get permission, will, by summertime, provide an excellent vehicle for computer graphics research in Project MAC while it is being developed into a facility for dynamic modeling in the behavioral sciences. The PDP-10 in the AI Laboratory will be augmented as soon as possible to absorb some of the load of other parts of Project MAC. Three courses of augmentation are being studied: (1) to incorporate the PDP-10 into the PDP-6 system and thus increase its capacity, (2) to make a separate PDP-10 system that will run the time-sharing system already developed for the PDP-6, and (3) to make a separate PDP-10 system that will run the time-sharing system being developed at Bolt Beranek and Newman. The first course will have to be adopted for the interim, and it may be adopted for the long term, but both the second and third courses are attractive. Either of the latter courses could blend into a program to adapt Multics and the PDP-10 to each other if the study of Multics adaptation leads to a conclusion favoring such a program. In addition to the 645, the remaining 7094 CTSS,

the PDP-6, and the two PDP-10's that are in the picture, There are a PDP-7, a PDP-8, and a PDP-9, all associated with graphic displays, that will be used in graphics research and dynamic modeling. The foregoing plan for Project MAC's access to computers will have the effect of concentrating the project's work mainly on DEC\* equipment until Multics comes into more or less regular operation, at which time the work that requires or contributes to the Multics capabilities will move to Multics and the remainder will stay with the PDP's.

Relation of Project MAC to the PDP-10 dynamic-modeling facility:

Project MAC has submitted a proposal to ARPA to develop a facility for, and to conduct research in, dynamic modeling. The main application area is to be the behavioral sciences. Project MAC will develop and operate the facility, use the facility in Project MAC research, and -- as the facility progressively becomes useful -- make the facility available to behavioral scientists outside of Project MAC.

Relation of Project MAC to CAM: "CAM" is the temporary name of a behavioral-science program in computer analysis and modeling that M.I.T. has proposed to ARPA. Although the relation of MAC to CAM has not been fully determined, it is clear that members of Project MAC will participate in CAM methodological research and in fostering interaction between computer science and behavioral science. The extent of this participation was estimated earlier at \$120,000 in 1969, \$200,000 in 1970, and \$200,000 in 1971.

Research supported by National Library of Medicine: Project MAC now has a small contract for research on computer problems in connection with the Biomedical Communications Network.

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\* Digital Equipment Corporation

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Research proposed to the office of Naval Research: Project MAC has made a proposal to ONR for research in man-computer symbiosis and for studies of the application of interactive multi-access computing to the management of a research project (Project MAC).

Research to be proposed to National Aeronautics and Space Agency: Project MAC has discussed with NASA a small program of research in vision based upon computer tracking of eye movements.

Other proposals: Professor Dennis has submitted a proposal through Project MAC to the National Science Foundation for research on the specification of a machine-oriented language to facilitate interchange of computer programs. Two or three other proposals are being formulated. All are small, insofar as funds for 1969 - 1971 are concerned. Collectively, they represent an effort to supplement the basic ARPA support in the manner envisioned by ARPA and M.I.T. at the time of the formation of Project MAC.

Transition from project to laboratory status: As soon as most of the computer-science-oriented faculty members of M.I.T. are participating in Project MAC and the ratio of faculty members to research staff members is 2:1, Project MAC will be given the status of an M.I.T. interdepartmental laboratory. The target date, as indicated earlier, is September, 1970.

Building, space near academic departments: The first step is now being taken to lay out a rough plan and to make cost estimates for a building on campus for Project MAC/LCSE. There is no promise from the administration of M.I.T. that such a building will be approved. The immediate purpose is to see whether building one would cost less, when amortized over a period of years, than renting space in Technology Square. For the near term, Project MAC is investigating the possibility of operating one small "branch laboratory" at the other end of the campus from Technology Square and another in the more centrally located building occupied by the Information Processing Center.

Artificial Intelligence Group: A plan for improving the productiveness of the AI Group at the level of over-all hardware-software systems and in relating AI systems to theory -- while maintaining the present high level of productiveness at the level of component ideas and programs -- was recently submitted and approved. That plan will be implemented.

Sources of additional talent for Project MAC: About two years ago, the number of faculty members active in Project MAC decreased as the Multics requirement for funds increased. I hope to reinvolve some of the professors who formerly were active. There are many other faculty members whose interests and capabilities make them excellent prospects.

Moreover, since the computer field is continually increasing in size and significance, it is appropriate that M.I.T.'s computer science and engineering faculty grow. Project MAC has lists of the outstanding people in the various areas of computer science and engineering and is eagerly awaiting the budgetary opportunity -- which is offered by this plan -- to try, in cooperation with the academic departments, to attract some of the best to M.I.T.

J. C. R. Licklider  
Director, Project MAC  
January 13, 1969