NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

JAN 14 1966

Mr. Harlen E. Anderson, Vice President
Digital Equipment Company
Main Street
Maynard, Massachusetts

Dear Mr. Anderson:

It was a pleasure to meet you at the NASA briefing on computer procurement. We are transmitting herewith a summary transcript of the morning session.

As we indicated to you during the briefing, the work of our committee on computer procurement is still under way. We expect to undertake a more thorough review of at least three aspects of the subjects which were not discussed in great detail at the briefing. The first of these, as I mentioned, was the question of how to promote greater competition in the computer procurements made by our major contractors. A second area is that of technology utilization, in which we are concerned with a better dissemination of information throughout industry on design, engineering, and development advances which result from NASA's contracts on computing systems. A third subject is the problem of more effective spare parts provisioning and product support. These are the areas of concern at the present time; however, there may be others as we proceed.

If your company would care to offer any suggestions or comments pertaining to the above areas, or on any other related matters with which you feel we ought to be concerned, they would be most welcome. As you know, this is a complex subject, and we believe there is much that NASA and the computer industry can do to improve the overall situation.

Once again, let me express appreciation for your attendance at the briefing. I shall look forward to hearing from you at your convenience.

Sincerely yours,

William Rieke
Assistant Administrator
for Industry Affairs

Enclosure

Stenographic Transcript of

NASA INDUSTRY BRIEFING ON COMPUTER PROCUREMENT

December 21, 1965

Gentlemen, it's a pleasure to welcome you here this morning. I hope you will accept our apologies for any inconvenience we may have caused you in scheduling this meeting so close to Christmas.

By way of introduction, my name is Bill Rieke. As you may see on the briefing agenda we gave you when you came in, I am the Deputy Associate Administrator for Industry Affairs. My office is responsible for procurement policies and for facilitating communication between NASA and industry.

I think it would be appropriate to begin with a few introductions. I will assume that most of you from the computer industry know each other from past association or that you met one another as you came in. Therefore, I will just introduce some of my NASA colleagues.

On my left here, Mr. Edwin C. Buckley. Mr. Buckley is Director of the Office of Tracking and Data Acquisition and has the functional responsibility for ADP management throughout NASA.

On Mr. Buckley's left is Lieutenant General Frank Bogart. General Bogart, a former Comptroller of the Air Force, is now a Deputy Associate Administrator in the Office of Manned Space Flight. The Office of Manned Space Flight, as you may know, is responsible for three of our major centers, those at Houston, Huntsville, and Cape Kennedy.

We also have with us here Mr. George Vecchietti. Mr. Vecchietti is our Director of Procurement.

The Administrator of the Space Agency, Mr. James Webb, will be joining us later on this morning and will be introduced at that time, and I think he will have a few words for us.

Our purpose here today is to discuss with you some of the steps that NASA proposes to take in the future procurements of large-scale, general purpose computing systems. Our invitation was extended to fourteen companies and the reason for limiting it to your companies is that we are going to talk mostly about large-scale computing systems. However, we do plan to distribute a summary of today's meeting to the computer industry at large, and to the industry associations, so that other companies such as component manufacturers and support service organizations will be fully informed of what took place here today.

Actually, we are making a transcript of this morning's session and copies will be mailed to you in the near future.

For your general orientation, the day's schedule breaks down into two parts. This morning we shall talk about the overall management policy aspects of the subject, with an opportunity for questions and answers later on this morning, and we hope to develop a good discussion with you.

This afternoon we shall discuss two specific forthcoming competitions for ADP systems.

Mr. Buckley will share the honors here with me this morning. Mr. Vecchietti, together with representatives from Langley and Marshall, will handle the briefings this afternoon. We plan to finish up no later than four-thirty and hopefully somewhat earlier.

Now a bit of background. As you know, there has been growing concern in recent years throughout government on the subject of computers. The expanding ADP inventories and the increasing dollar expenditures of computing equipment and the related services are the principal causes of this concern. The recently passed Brooks bill is evidence of this concern throughout government.

Now Mr. Buckley may want to comment later on this Brooks bill but I believe we do not yet know what the impact will be other than it seems certain to have an important effect on how the federal agencies procure and manage their ADP resources.

There is also a government-wide cost reduction program -- I'm sure you've heard lots about it -- to which the Administration has given a great deal of emphasis. Government agencies are being asked by the President to find more economical ways of doing their work, and the purchase and use of computers by government agencies is no exception to that requirement for economy.

NASA occupies a unique position among the federal agencies with respect to the utilization of automatic data processing equipment. The majority of our ADP installations are used in connection with scientific research and development, and I believe that we lead all other federal agencies in such use, both in the size of the installations and in the state of the art of our equipment and operating programs. NASA is second only to DOD in the total ADP effort when both the scientific and administrative applications are included.

In the seven years since NASA was formed, we have done a lot of business with the computer industry. It's pretty obvious to all of us here that we could not have entered the space age without your help. Our association with you has been a cooperative effort to advance the state of the art in computer technology and your industry has really made a major contribution to the space program. We are very grateful for this and we're confident the relationship will continue.

In past ADP procurements NASA has obtained as wide and perhaps a wider degree of competition than has been true of the federal government as a whole. Taking into account both special purpose and general purpose ADP equipment procurements, I am told that the distribution of NASA contract dollars is at least as widely spread among the individual companies as is the case with other federal agencies which are major users. But this does not mean that we are anywhere near being satisfied that we have achieved the extent of competition that would be best for the government and for industry progress and development. In fact, we see a real need to increase competition and it is our intention to eliminate sole-source procurement except where it is impossible to do so.

We also plan on letting your industry know as far in advance as possible what our requirements are going to be so that all firms in the computer industry which are potentially capable of making a contribution to the space program will have an opportunity to compete on future procurements.

NASA anticipates a continued need for expanded computer capability. We foresee a need for better, larger, faster computing systems which will involve substantial dollar expenditures. We expect you to help us find ways of meeting this need and improving services to our users at an economical cost.

I don't want to create the impression that NASA no longer needs small computers. We will still require a significant number of smaller computers to perform specific tasks in connection with spacecraft check-out, communications processing, network controlling, telemetry preprocessing, et cetera. We expect this need to continue and we'll still be in the business of buying smaller equipment. But large-scale, general purpose computing systems are the principal concern at this time.

In some of our installations the type of ADP equipment and facilities which NASA requires is changing significantly. We are shifting from individual procurements of a number of small ADP installations to the installation of a few very large central ADP complexes.

This change entails the installation of so-called third generation computing systems. These systems are, as you know, large central complexes with tremendous power, greatly expanded range, almost unlimited flexibility, and large memories. We expect considerable benefits from these large complexes in terms of increased capacity and flexibility, more effective utilization, reduction of operating costs, and improvement of man-machine relationships.

In buying these large central complexes, we need to be more cost conscious than ever and our goal, of course, will be to obtain increased capability for less cost.

Now this shift to large central complexes introduces some hazards and benefits to the computer industry. It reduces the number of anticipated procurements but it increases significantly the dollar value of each individual contract. For this reason we would expect much keener competition in each procurement action.

A second important factor affecting the industry because of this shift to large central complexes is the fact that future additions or changes to these large installations tend to be limited to the incumbent contractor for several years after the initial procurement.

As you know well, until advances in equipment design induce a changeover to new generation equipment, incumbent contractors tend to be locked in. Perhaps some steps can be taken to make these systems additions more competitive but this tendency to lock-in must be recognized and it makes even more important the attainment of open competition on the initial systems contracts.

That is the general background on why we are talking to you today. With this overall situation in mind, and with the objective of assuring true, open competition on major ADP procurements, Mr. Webb directed me a few weeks ago to form an ad hoc committee to recommend an appropriate course of action. This committee was made up of key people in NASA Headquarters and from two of our field centers. We included people who were experts in the technical aspects of computers as well as individuals versed in procurement management.

In addition to General Bogart, George Vecchietti and me, the committee included Mr. Ken Webster, who is Mr. Buckley's right-hand man in ADP management here at NASA Headquarters; Mr. Paul Fuhrmeister, of Langley Research Center, you'll meet him this afternoon; Mr. Darin Gridley, of Goddard Space Flight Center; and Mr. Bernard Moritz, NASA's Assistant General Counsel for Procurement.

This committee has prepared a preliminary report to NASA management, as a result of this review of the overall situation. We have recommended that certain steps be taken to increase competition and to improve NASA's internal ADP management and procurement. These recommendations form the substance of our briefing this morning. I would like to summarize them for you briefly, after which Mr. Buckley and I will discuss them with you in greater detail.

Basically, the committee recommended three major areas of effort:

First, that NASA take steps to improve the exchange of information with the computer industry; specifically, that we do a better job of informing you of our anticipated needs, our problems, and our desires for improving computer technology, and additionally, letting you know about the projected procurements; also, that we make this a two-way street and have you brief us on your plans, problems and developments.

We believe that by promoting a more effective exchange of information between us we can assure healthy competition and improve ADP procurement management.

The second major recommendation of the committee dealt with decreasing NASA's dependence on specific computer equipments. I believe the experts use the term "machine independence" to describe this objective. Mr. Buckley is best qualified to discuss this but briefly the intent of the recommendation is to promote the use of standards, emphasize the importance of machine-independent programming languages, and work more effectively with other organizations who are striving to improve the definition and use of standards in ADP.

The third major recommendation pointed up the need to strengthen NASA's internal planning and procurement of ADP equipment. It was recognized that we must take some positive steps to assure careful planning by the NASA centers. Such planning should reduce the number of situations in which lack of lead time has tended to restrict competition.

We must provide written guidelines to the centers in support of our objective of increased competition and the avoidance of locked-in situations. We saw a need to strengthen the coordinating role of our existing inter-center ADP committee.

Finally, we recommend that in all future major procurements the specifications be reviewed by Mr. Buckley's experts here at Headquarters to assure that they are not unduly restrictive and are not drawn in such manner as to favor any one manufacturer.

That covers the three major areas of recommendations made by our committee. We would like to dwell on each one in greater detail and we have divided this job between Mr. Buckley and me. I will deal with the proposal to improve the exchange of information and Mr. Buckley will tackle the more difficult subject of machine independence and ADP management.

As I said earlier, we look upon this communications matter as a two-way street. Both NASA and the computer industry need to do a better job of keeping each other informed. For our part, we want to do a better job of letting you know as far in advance as possible what needs we foresee in terms of systems and technology, what general trends we anticipate in terms of expenditures for lease or purchase, and for support services; what problems we are facing which require joint effort between us to solve them; what specific procurements are we planning.

We feel that these kinds of information will be beneficial to you in planning your product development and production and assisting you, hopefully, in determining just where and how you should commit your company resources and marketing efforts.

On your part, we will be looking to you to keep us more adequately informed with respect to your plans and activities, which should be of interest to us: What developments in computing systems technology are you working on which may be relevant to the space effort? What kinds of new equipment or modification of existing hardware are you working on which would be of interest to NASA? What problems are you encountering either in working with us or in grappling with the technology, on which more effective joint effort between us might make for more rapid advancement?

These are the kinds of information which would be helpful for us to get from you.

We propose to do three things in order to promote this improved exchange of information between us. First, we plan to hold annual industry briefings to outline our plans, problems, and anticipated needs. The first of these briefings will be held next spring when we are far enough along in our budget hearings in Congress to give you a reasonable prediction regarding fiscal 1967 requirements. We would like to be more definite as to when we will schedule the first industry briefing, but I am sure you realize why we can't be. Our near-term plans are so closely tied in with the budget process that we need to see how the hearings are going before we try to give you any idea of our anticipated procurement.

We are shooting for a mid-May date for the first briefing, at which time, of course, we intend to outline also those factors related to NASA's long-range needs, which should enable your industry as a whole to be better informed and responsive to our requirements.

As a second step toward improving the exchange of information between NASA and the industry, we will provide an opportunity each year for individual companies to brief NASA's ADP management and technical personnel on its plans, activities, and problems. We recognize that your marketing people actually are engaged in doing this most of the time but what we want to improve is the coordination of this effort for your benefit as well as for ours.

By arranging these briefings between NASA Headquarters and your representatives we can see to it that the right people from the right centers are present to benefit from your information. This will also enable us to do a better job of bringing in the Headquarters program people who have an interest in the subject.

Let me reassure you on two points: We plan briefings from single companies; we have not thought of joint industry briefings because we realize you may sometimes present to us plans or ideas which you are not ready to have your competitors informed of. Second, we will work out dates for each company to suit your wishes, recognizing that the right time for you to brief us can best be decided by you in light of your new product developments and planned announcements.

Perhaps during the discussion period later this morning some of you will have some suggestions on how we should go about planning these briefings.

The third step we are proposing in this communications area is an expanded use of an approach that has been employed before and that is to hold, when appropriate, what are referred to as "pre-specifications conferences" in connection with large or unusual ADP procurements. As I mentioned earlier, we want to see to it that the specifications which are drawn up for our computer buys are not unduly restrictive, so there will be a true opportunity for competition among all the companies which are potentially capable of getting in on these procurements.

When we are planning to buy a large or unique computing system which has restrictive requirements it would be beneficial for us to review the proposed system of requirements with you and to obtain your help in analyzing what should go into the specifications that will become the basis of the request for proposal.

The ad hoc committee has some unfinished business. I stated earlier this is a preliminary report, and we have several things to work on yet. We did not overlook the fact that we have numerous large contractors in the space program who make major ADP procurements. The manner in which their procurement decisions is derived is important to us and it seems possible that through them we can further our goal of increased competition and the avoidance of sole-source buying. However, much more thought and study is required in that area. We are not prepared at this time to set forth any specific plans with respect to how we might work with our contractors.

Another area that we want to study further is the matter of spares provisioning. I think we have not given enough attention to this. We have some rather large contracts, and the dollar expenditures involved warrant a full study of such procurement.

A third matter that we want to address ourselves to is the matter of technology utilization. We have with us this morning Mr. Breene Kerr, who is the Assistant Administrator responsible for our technology utilization program and we hope to involve him in the discussions later. Some of you may not be familiar with this general subject but we have required of our major contractors, whenever they engage in any design, engineering or developmental work using NASA funds, to report advances in technology, achieved under these contracts for dissemination for the benefit of industry at large.

We have not really gone into this matter too far as it affects computers but we intend to do this and you will probably hear more on that subject in the spring briefing. And perhaps Mr. Webb will want to comment a little today on it, too.

I have mentioned the three major areas of the committee recommendations and covered in some detail the first one of these: communications.

I would like now to have Mr. Buckley, NASA's Director of Tracking and Data Acquisition, discuss the other two areas.

Mr. Buckley.

MR. BUCKLEY: Good morning, gentlemen.

As part of his presentation, Mr. Rieke gave you a review of the results of the recent committee study aimed at improving management of our ADP resources. including long-range planning, increasing competition, and reducing costs.

I will start in by giving you further background on the parts played by various organizational elements of NASA and, in doing this, I will occasionally be referring back to parts -- to many, in fact -- of Mr. Rieke's remarks.

The Office of Tracking and Data Acquisition, of which I am the Director, has been assigned the responsibility for the review, the evaluation, and recommendations to NASA general management concerning all ADP utilization; also for requirements for new ADP systems, and for means for acquisition or disposition. As such, it will review all requirements of ADP for possible consolidation or integration, for use of available facilities, and the acquisition of new facilities as they may be deemed necessary.

As Mr. Rieke mentioned, OTDA -- using the initials of my office -- is also responsible for the review of procurement specifications of all major computer procurements before release, to insure the maximum degree of competition.

My office also assists in long-range policy formulation and assures that NASA procedures reflect the guidelines imposed on ADP by the Bureau of the Budget and other governmental agencies. This last function takes on special significance in view of the intense interest being accorded computer acquisition by all elements of the federal government, and we are trying to assess the impact Public Law 89-306 -- familiar to all of us, I guess as the Brooks bill -- will have on our agency.

However, at this moment we can only say that the guidelines from General Services Administration are not yet available and until we receive these guidelines we certainly can't worry very much about the impact of the Brooks bill.

In order to better coordinate and formalize ADP acquisitions, NASA, in July issued in a draft form a NASA handbook entitled "Management Procedures for Automatic Data Processing Equipment." This handbook established the policy and responsibilities of all levels, starting with our centers, for proposed new ADP acquisitions.

The handbook places emphasis on the control of general purpose equipment and it prescribes guidelines for use in planning for, procuring of, and use of such equipment. The handbook is now being put in final form and we expect the approved version to be available in February.

I believe it should be pointed out that we will not be concerned today with the specially designed and developed computers for special uses. One example would be the onboard computer for Gemini. We are going to be concerned with the general purpose, commercially available computer systems.

Going from the responsibilities of my office to the responsibilities of some of the other organizational elements, I think we should have a knowledge of all those groups which play a major role in reaching the final decisions, especially regarding acquisitions. Therefore, it seems best in explaining the NASA management channels for the procurement of the ADP equipment to start with the user, the Center.

The requirements for such equipment are generated in the Centers and are consolidated and evaluated against existing capacity that the Center may have. The request for new or additional computers is submitted then by Center management to Headquarters.

The Centers are responsible for the management of those resources that they have and that are under their control and for conducting long-range planning pertaining to the Center.

The appropriate Headquarters office, that is, the Office of Manned Space Flight, the Office of Space Science and Application, and the Office of Advanced Research and Technology, are responsible for the overall management of their respective Centers, including the ADP resources. In these offices, the Center's requirements are reviewed, evaluated and coordinated with the Headquarters program needs. Validated requirements and requests for new acquisitions are then submitted to my office for review before being submitted to our general management for approval.

The Centers are responsible for the actual procurement of the computers after approval is obtained from NASA Headquarters. I want to emphasize that point. The Centers will have the responsibility for the ADP procurements and we are not planning to change that responsibility.

So much for the procedural aspects of ADP management.

Certain areas of our technical management functions have such an important bearing on improving competition that I believe it necessary to point them out and go into them in some detail. These areas include standardization and long-range planning.

One of the major deterrents to full competition in our ADP procurement is the lack of compatibility between present computer systems. This refers to both hardware and software. The net result of these incompatibilities has been to create situations whereby we are placed in a noncompetitive procurement climate. It's either that or face additional costs for conversion devices or additional software costs, and usually a time penalty.

NASA is seriously concerned over this problem and we have examined possible means of solving the incompatibility problem but it appears that the only real solution is to achieve effective standards that will increase our flexibility.

We believe it is mutually beneficial to both NASA and the computer industry that we achieve as much standardization as possible and as quickly as possible. Only then can we have full competition and the freedom of applying the best equipments from each of your companies in building the computer complexes that have become necessary in NASA.

We are concentrating our efforts in two ways. Within NASA we are attempting to establish standards that will facilitate better cross-use of ADP resources. This effort will reduce conversion costs, eliminate redundancies by promoting sharing of techniques, data, and programs and will reduce our communications interface costs. Thus our efforts will be concerned with programming language, Data Elements and Codes, documentation and formats.

Incidentally, personally I want to add terminology. Sometimes if we had a little standardization in terminology it would help. I ran a little experiment awhile ago in getting a definition of software from several of the major companies and they differed quite markedly. I'm quite serious about that, the standardization of terminology would help.

The other thrust in the standards effort will be to provide active support to the Bureau of the Budget and the Bureau of Standards in their efforts to achieve federal standards, and to assist the respective subcommittees in the American Standards Association in their ADP efforts. For instance, NASA will support the Bureau of Standards in its efforts to have the American Standards Code for Information Interchange accepted as a federal standard.

We will place every emphasis on planning at the Center and Headquarters levels. Our procedures require a planning document covering planning data over a five-year period, recognizing of course that firm data will not be very easily available for more than a two-year span.

We believe this emphasis on planning to be necessary in a business with such long lead time between conception and final implementation, as there is with ADP. It should aid NASA in making decisions whether to purchase or lease and it should enable us to make better plans for acquiring and utilizing ADP equipment.

Most important of all, it should provide longer lead time for procurements. In this sense, planning will aid in improving competition and we intend to utilize it to the fullest for this purpose.

An important spin-off from this planning effort should be information on trends and the utilization. This information will be made available to you, as Mr. Rieke mentioned, in the annual briefing for the computer industry. I believe this briefing will be helpful to you in your product development and market evaluation efforts.

In turn, as Mr. Rieke mentioned, we will be looking to you to keep NASA's technical personnel advised of advanced development work, for discussion and incorporation in NASA planning.

Information on specific procurements will be included in the NASA briefings wherever possible. We believe we can indicate areas of growing workload, system changes of large scope, and hardware and software trends. We certainly can point out changes in policies and practices as they occur.

In line with this intent, I want to highlight a major need within NASA for procuring computer systems. These systems which we are now procuring have such vastly increased power and flexibility that without executive and monitor programs it is nearly impossible to approach reasonable utilization. Our users need the compilers, assemblers, diagnostic routines to make efficient use of the computers.

As you well know, the large systems will be servicing a variety of users by means of remote stations, real time connections and by conventional batch production methods. For proper utilization management, these systems require sophisticated control, checking and accounting routines, and other supporting software.

These systems programs, as a package, are referred to in NASA as "systems software," and we believe it to be a necessity for the computer manufacturer to supply these with the hardware.

The designers and builders of software systems must consider carefully the unique hardware features of their computers in order to take full advantage of the special features and allow for the many hardware-software trade-offs available.

We believe it should be a standard practice to design the hardware and software concurrently for these reasons. It is difficult for a user to make such trade-offs after he acquires the hardware. We realize the software development costs are as heavy as the hardware costs but we believe you can amortize these heavy costs over many machines rather than having a user such as NASA absorb this cost in the procurement of one or two machines.

Not only will we not ask industry to supply our user application programs as part of the procurement package, but we believe these programs should be developed by the user, although we will certainly use any available programs developed by other users. In other words, we strongly support cross use and sharing.

We have and will continue to have programming contracts where necessary to aid in developing this user software; in other words, the applications programs. We believe it is wise to separate this effort from our computer procurements as much as possible.

NASA will insist on the computer manufacturer supplying us with a workable system which includes the necessary software along with the hardware. The software required will certainly vary with the size and scope of the procurement.

This afternoon two of our Centers will give you some idea of their computer requirements, which you will note will include the software. You will be asked to give appropriate attention to our software requirements in your proposals and the proposals will be evaluated accordingly. We will base our acceptance criteria on both the hardware and the software availability and we will hold you responsible for failure to meet criteria in either area.

In short, gentlemen, we are no longer procuring hardware: we are now asking for systems.

At this point I would like to turn the meeting over to Mr. Rieke.

MR. RIEKE: Thank you.

I think what we want to accomplish here if we can is a good discussion -- perhaps we should take a short break.

John, do we have some coffee out there? If we do we will take a short break before we proceed with this discussion.

MR. COLE: It will be a few minutes.

MR. RIEKE: All right, fine. We will go ahead.

Let me start out, if I may, by asking if any of you has any suggestions on this matter of briefings? Does the idea appeal to you of an opportunity for each company to brief us at least once a year, properly arranged, scheduled and so forth? Do you have any comments on that?

I see some nodding heads; a few people approve.

Does anyone feel this is a waste of time or a burden to you?

MR. PFEIFER: I'm Ralph Pfeifer from IBM.

You mentioned that we could select the time. Would this be through the whole span of the year, any time during the twelve months, or would you be inclined to hold it to a quarter of a year? What did you have in mind there? You mentioned that perhaps we'd want to time it with some pending announcements.

MR. RIEKE: Yes. Mr. Pfeifer, I guess I have to back off just a little bit. As the contracts people say, we'll arrive at something mutually agreeable, but the intent here is to take into account your problems and you will control as far as what you can or want to do. But we may have some problems, we may want to give you a little argument if you decide to do it on the Fourth of July.

Yes, sir?

MR. (inaudible) : Scientific Data.

Do you have any idea when you might start these briefings?

MR, RIEKE: I would think that we should not start the briefings from you to us before we first accomplish this overall industry briefing. In other words, if we can make our May 15 date, I think we can schedule these after that. If you would like to do it sooner, I think this could be worked out. We'd have no reason why we shouldn't do it sooner.

We've mentioned in some detail, perhaps belabored, the list of things that we intend to cover in our briefing to you on this annual briefing. Do you think we have covered everything? Anything you'd like to have us talk about that we didn't mention?

I would be interested in getting some comments from you on the use of the prespecification approach. We're going to turn right around this afternoon and discuss a couple of specific procurements on which we have not done this. They've reached that point in the procurement cycle, and I think the circumstances are such, that the idea cannot and should not be applied to these particular procurements, but we intend to do this down the road, particularly where we feel something might be unduly restrictive.

May I have comments on this? Does the idea appeal to you? Anybody have any objection to it?

It's an agreeable group. I appreciate your nodding your heads.

(Laughter.)

Getting back to our basic intent here of achieving competition which we think is good for us and good for the industry, since your industry is so basic to economic progress -- I think that anything that stimulates, develops and advances your industry is good for the world. So we feel we have a worthy cause here but we need your help.

We have had an internal committee try to work out the things that we can do, as we see it, to foster better competition. But I am sure that some of you, particularly those who perhaps lost recent competitions might have some comments on this. Do you have any suggestions or any steps that a government agency can take to make for more open competition?

MR. LUKAS (from Honeywell): You didn't mention anywhere in that process the subject of benchmarks. What will NASA's attitude be on benchmarks?

MR. PAUL FUHRMEISTER (from Langley): We're going to have benchmarks in our procurement this afternoon. I think that at least our attitude on this is a little bit different from some of the other government procurements.

The benchmarks that we're asking for are smaller and designed in such a way for you to tell us specifically something about your equipment's ability to do our job. So they will not be the large, complete problem type of benchmark but there will be benchmarks included.

Does that answer your question or not?

MR. LUKAS: Well, I think I was interested in the general NASA statement: Is this going to be applied across-the-board to the other operations also?

MR. BRADSHAW (from Huntsville): We have a feeling that in the particular procurement we're talking about here we doubt the benefit of across-the-board type of benchmarking. So I think that our interest is, in this particular instance, will be quite small as far as benchmarking where large jobs are concerned.

Now I think you are asking, though, does NASA have a position on this and I guess Paul can help you.

MR. WEBSTER: I think I'd better answer that.

We are most certainly going to have benchmarks, as these two people mentioned, but they will be controlled by the Center. We do not plan to have overall benchmarks as some agencies do.

Does that answer the question?

MR. LUKAS: It comes closer.

MR. RIEKE: Do you have a recommendation on this for us?

MR. LUKAS: Well, I believe in benchmarks.

MR. RIEKE: Do you think we ought to have an overall agency policy? You would argue with Mr. Webster on this.

MR. LUKAS: Yes. I think this will improve competition.

MR. RIEKE: The committee will take that under study.

Any other comments on this? Do the rest of you agree with Mr. Lukas?

MR. HIX (from UNIVAC): I would like to make a comment. I think one of the problems we have had up to this point has been all our specs that we have received have been hardware oriented. In other words they stated how fast the core should run and things of this nature. We at Univac feel this should be more systems oriented where you present your problem and let us come in with an answer so far as our equipment is concerned. I would like to offer that as a consideration.

MR. RIEKE: I think it's a good one. I think we agree with you. Mr. Webster, do you want to comment on that?

MR. WEBSTER: Well, I recognize that the systems approach is very good and in the administrative side of the house it's about the only way to go. On the scientific side you have got to recognize that many times we do have restrictions. We do know approximately what core size and what speeds we have to have, so we do put these in. This makes us a little bit more hardware oriented, that's true. But that's because of our typical job, not because we want to be that way.

MR. RIEKE: But to the extent we can --

MR. WEBSTER: To the extent that we can we will.

MR. RIEKE: There's no point in specifying hardware capability if we can instead specify performance capability in terms of what we need in a total system, right? Good suggestion.

I think we are moving in that direction and we will move faster. Any other suggestions?

MR. HENRY FORREST (CDC): Getting back to the discussion on benchmarks, I just make a plea for early advice on the benchmark requirements because, particularly in the big systems, the contractor's investment and lead time in order to set up a system and make it available, do the programming and run the problem, is rather substantial and we need a lot of time to get ready for these benchmarks to be utilized.

MR. LUKAS: I would certainly be interested in hearing more comments from other manufacturers on this benchmark problem, because I think this is a big one.

MR. RIEKE: Here's your chance to get your ideas across, fellows. Let's hear from you. Do you think perhaps, Paul, that there are some here who are opposed to the idea?

MR. FUHRMEISTER: I wouldn't be at all surprised.

MR. RIEKE: Yes, sir?

VOICE: Along the lines of standardization, is there any hope of standardizing the benchmark?

MR. WEBSTER: No. Benchmarks have to follow our workload and our workload is changing constantly.

MR. HIX: Benchmarks only prove how good your programs are rather than how good your machine is. In some cases, even though a manufacturer came in earlier with them and he ran fast and everything ran fine, they gave the other manufacturers a chance to reprogram and reprogram in order to bring out the better, salient features of the machine, rather than to prove that one group has a better group of software people on it than the other group.

I think if you miss this point you might buy the services of the company versus the hardware features and software features of the equipment.

GEN. BOGART: Of course, that may be what you're driving at. You may be trying, when you are talking about buying systems, why you are not just necessarily talking hardware at all, you are talking software to a very large degree. That's one of the reasons for running benchmarks.

MR. RIEKE: I think it is important that we get this point over that Mr. Buckley has made, that we are talking about buying systems capability. I get the feeling that in some of our recent decisions we have been greatly influenced by people who had a systems software capability; we felt they could take the system and make it work, where others had not really stepped up to this and just didn't have people who could come in and do the job. Maybe I'm wrong on this, but this is the impression I have received and Mr. Buckley has felt it necessary to make it clear that in these major procurements, we are going to be holding systems competition and the capability, the quality of the people who can come in and get the system working right is extremely important to the competition.

You had a comment, sir?

MR. McGURK (of SDS): I think the only reason people are afraid of benchmarks is that they are afraid that their competitors have written the benchmark, and therefore they are at an actual disadvantage.

I think that's the reason to look for generalized and standardized ones. The local Center that might particularly like one manufacturer can have their people write a requirement that makes one machine shine against another. I think that's the only reason to be against it. If that is controlled, there should be no problem.

MR. RIEKE: You would be in favor of benchmarks established by us, but of course not by your competitors?

MR. McGURK: That is correct.

VOICE: I think that emphasizes the need for these prespecification type briefings we're talking about where these will inherently be discussed and you will be given your opportunity to make known your feelings when they are restrictive.

MR. McGURK: That brings up another point. I think all of us are probably happy to see this greater depth of planning and early discussion of specifications. My company's experience with NASA, however, is that the lead time is rather short so that if we set up a process which with approvals and prespecifications of proposals and benchmarks, you can only propose it to run benchmarks, machines that are in existence, and the procurement process takes a tremendous amount of time. In other words, we might get unrealistic.

VOICE: That is exactly the reason why I don't want to have centralized benchmarks.

MR. WEBSTER: We are too far in the state of the art. We can't realistically do this.

MR. FUHRMEISTER: I think, following up on your comment, Mr. Forrest here, and this ties in with my comment on benchmarking, the system that we look for, the total system, we know no one will have that in existence. We'll have so many remote stations and we think to properly benchmark this, the whole system should be benchmarked and we don't know what it would cost the manufacturer to throw this thing together to benchmark it, because ours may be the first such system which he delivers and has experience.

MR. RIEKE: Well, let's try another subject, the active promotion of standards. Anyone care to make a comment on what steps can be taken to promote standardization? Everybody in favor of this?

I don't see the nodding heads on this one.

VOICE: You'd have to be somewhat more specific.

MR. RIEKE: Mr. Buckley, do you want to take on this discussion?

MR. BUCKLEY: Well, it's a pretty difficult one to get started on.

MR. RIEKE: Let's start. Coffee isn't ready anyway.

(Laughter.)

MR. BUCKLEY: Actually, it is going to be a government objective, the Bureau of Standards attempting to do it and the Bureau of the Budget pushing it. I think that the weight of large government organizations behind these standards will get something done. I heartily admit that I don't know exactly how or what but I think that the weight of NASA and perhaps a couple of other major government installations will help get this thing rolling.

Ken, have you got any problems? Paul?

MR. WEBSTER: Certainly standardization is something you approach with a little caution but we do have essential needs in this area. Mr. Buckley, you mentioned two. One, we are going to be internally concerned with standards that are probably not your concern whatever except for the programming language.

Externally, we do need standards in many areas; especially in the parts that are being played at the American Standards Association, We need some interface standards, ie. definitions of what goes across an interface and perhaps even into the electrical. We need code standardization of some sort.

We have many communications problems and we will have worse communications problems as we go along, so we have to standardize somewhere along the line. We can standardize within NASA but this wouldn't really help us when we have to speak to other people besides NASA, so we would sooner have this be a concerted effort by the manufacturers and by industry as a whole, in which the government can play a part. That's why we will emphasize very strongly working with the Bureau of Standards and the ASA subcommittees.

MR. CHOLLAR (National Cash Register): I might make a comment on this, Mr. Chairman. I happen to be Chairman of the International Standards Organization TC-97 on computers and information processing, of which the ASA Committee X-3, the equivalent committee, is a part, and I'm sure I don't have to speak for any one of the manufacturers here. All of us have many, many men associated with this effort for the preservation, standard-wise, in the future, covering all these areas that have been mentioned before, of which NASA and other federal agencies do play a part, because there is a three-way split, the user, the government, and the manufacturer, in the standard program.

I think that if there is any one thing we encourage -- I happened to have played an active part in the Bureau of Standards activity in the reconversion standards program and so forth under this, the one thing prime in our concern internationally and nationally and through ASA, and that is that the government play more of an active personnel role in the participation on the subcommittees of the committees in these areas that you have mentioned. We certainly encourage it. There are far, far many more manufacturers even than users and we try to encourage that. But it is also true that we do need more major participation, I would say, and I am quite sure that the manufacturers who have men on these committees would support what I have just said.

So we are all in favor of standardization in the directions we are carrying it. All these will help us.

MR. RIEKE: An excellent suggestion.

Mr. Webster, I guess that's your field. You took that down about seeing they are better represented, right?

VOICE: That's right.

VOICE: I think we all pretty well understand each other on this, too, because we are together on it. That's the one thing we look for.

MR. RIEKE: Incidentally, for my own education, I am not clear on how this industry ties in with industry associations. Is your principal activity with EIA or BEAM?

VOICE: The prime organization in this case is BEMA -- Business Equipment Manufacturers Association -- which has been given the responsibility by the American Standards Association. Under the American Standards Association Committee, X-3 on Computers and Information Processing, it is the ASA's committee. Under this role ASA also is the member body of the International Standards Organization, so has the one representation for International Standards, too. So it has given to BEMA. BEMA has actually carried that role with user groups as well as with manufacturers in this area. As I say, probably -- and I probably struck them down by this comment -- there is perhaps no other committee at the moment which has as much active support and participation, and literally dollars being spent throughout industry, than in this area of standardization under ASA .

There is association with EIA and many others, liaison groups, cross-referenced at the international level.

MR. RIEKE: There is no smaller, more restrictive group that represents primarily people here today?

VOICE: No, I would say, unless anybody wishes to contradict me again, that probably BEMA pretty well represents the industry groups represented here today. It's restrictive in terms of the area covered but it doesn't happen to be small, because of the importance of the effort, the major effort, and as I say, hundreds of people in these sympathetic groups. But we do need more federal activity with us. I'm not talking about money, but activity.

MR. RIEKE: If you fourteen companies sat down together objectively to figure out what could be done to stimulate competition or make for more healthy competition, you'd come up with some ideas that we haven't touched on, and I'm searching for those. Anyone have any suggestions?

I assume you all agree that competition is a good thing?

VOICE: Yes.

(Laughter.)

MR. RIEKE: Any further thoughts or suggestions along this line?

Well, we are not above friendly criticism for our past handling of some of these procurements and if anyone wants to comment specifically on any of our handling that might help us here to figure out now to do a better job, we'll listen in an open-minded fashion.

MR. McGURK: I have a general question. Recently I'm told there has been a division between two kinds of computers within NASA, A and B category. I wonder if you would tell us what the purpose and significance of that is?

MR. RIEKE: Mr. Webster made the definition so we'll let him.

MR. WEBSTER: We have tried to follow the Bureau of the Budget A-54 guidelines. You recognize that the interest displayed throughout the government is on the general purpose usage, sharing, utilization and everything else, and the Category A pretty well covers these types of procurement. These are the normal Center complexes that everybody can use.

Category B now is something that has come up -- strong in the last four or five years; because when I was in the Navy I had to deal with it there, too -- and this is the sort of system that the Defense Department had a perfect out on. They called it a weapons system, and put a real nice classification tag on it and we can't do that. So what we had to come up with was some definition that placed those systems which we can only manage along with the overall system, in Category B. In other words, something we cannot manage, we cannot take care of its utilization, we cannot really specify any particular criteria on. So we are talking about those computers that are used as a control element or computational element in an overall system that is not basically computational in nature.

And we add another part on to this definition and we say: where general purpose use is not operationally practical. That is the definition we use.

Now we refer primarily to (we have a lot of examples) the spacecraft checkout computers, the communications processors.

Mr. Buckley's on-site data processing out in his tracking stations certainly would have to qualify because no one could ever get to those computers that are all over the world. And they are dedicated. We do not intend to keep usage figures and utilization figures. We do not intend to report these to the Bureau of the Budget as such with utilization figures. We will report an inventory.

This was basically an idea to distinguish our management rather than any other distinction.

MR. RIEKE: I take it today's discussion then is largely about Category A?

MR. WEBSTER: It largely is about Category A although we hope there will be -- in fact, we insist -- that competition exist on Category B.

MR. RIEKE: Very good.

Although we have not covered it in our committee report I would like to invite your comments on spares support and spares provisioning. I don't know just what your policies are in this, company by company. I've been a little alarmed at some of the things I've seen in the way of requirements to commit for rather substantial spares purchases which I suspect include common items that should be available off the shelf.

I would like to invite your comments on this general subject. I don't personally know how our practice compares with that of DOD.

Do you have any problems in this area or any suggestions for improved handling on our part? Should this, for example, be made an element of the initial competition?

MR. McGURK: Don't do it like the DOD. I think their requirements in general foresee equipment of this kind in environments such as battle conditions, shipboard, and that sort of thing. My experience with spares provisioning with the Defense Department is they want to make any spares or any support activities of that kind a government-issue sort of a thing.

I think in the discussion we are having today you are talking about generally available commercial equipment and as a normal matter of practice I believe all the manufacturers provide spares and provide maintenance of various kinds. Going to a special category of government numbers and stocking and that sort of thing is probably inappropriate and expensive.

MR. RIEKE: Anyone have any comment on past provisioning practice? Are we buying things we don't need or failing to respect your problems?

Everybody is happy with our provisioning practices?

Yes, sir?

MR. McGURK: Again our experience has been that perhaps some of the guidelines in spares provisioning do stem from military-type requirements where I think they are actually needed. I don't know, perhaps you have taken into consideration in your Headquarters operation some kind of guidelines in the Centers of provisioning which might make more sense, I don't know.

MR. RIEKE: Have you noted generally a lack of standardization or similarity in the way the Centers handle their spares provisions?

MR. McGURK: I don't have any personal experience on this line myself

I would say a lot of spares provision stem from the military background.

VOICE: I think some of us would like to address ourselves to the problem if we had a more specific problem to answer.

MR. RIEKE: Very good. We'll try to cover this more fully next time and be more specific.

Well, let's see if I can stimulate a little discussion here on the use of support service contractors, let's say the software industry as distinct from your industry.

I assume that you follow us here pretty well when we are talking systems software. We recognize a certain type of software that can and should come only from the manufacturers. You have the engineers and the knowledge of the equipment to make your equipment work together as a system. But when we come to the user programming, we probably will tend to keep this competition open to companies that are not necessarily in the hardware business.

Anybody want to comment on this, on our past practices or the direction we are going?

We are interested there in competition and we have not seen, at least I have not seen, a need to keep this tied into the hardware business as we do the other more sophisticated type of software work.

VOICE: I think I would like to ask a question first on that.

MR. RIEKE: Yes, sir.

VOICE: Is it going to be NASA's philosophy to continue to handle this sort of thing?

MR. RIEKE: Yes, as we see it today.

I'm trying to stimulate a little industry reaction here and comment on this area.

If it will help stimulate you, the answer is yes.

(Laughter.)

MR. RIEKE: John, are we --

MR. COLE: I have to apologize. We had a logistics slip on the coffee. Messengers were dispatched 32 minutes ago and they have not returned.

(Laughter.)

VOICE: We expect the signal momentarily.

Well, let's take a break and hope that the coffee shows up here in a few minutes, and we'll come back and Mr. Webb will be with us shortly.

(Short recess.)

MR. RIEKE: May I have your attention, please?

It is my pleasure now to introduce to you the Administrator of NASA, Mr. James Webb.

MR. WEBB: Good morning, gentlemen. I'm certainly glad to see so many friends here. I know some of you from my experience in industry and in government, and maybe some of you in connection with universities.

My purpose this morning is not to do what the agenda calls for, that is, give concluding remarks. I don't insist on the last word this morning. Instead, I'd be very happy to conclude with your speaking to us if you have any remarks that you would like to make.

I think it has been made very clear to you that we will be glad to sit down with each of your companies individually to discuss your company matters. We will preserve your confidence on matters that you would like to talk to government officials about but not have transmitted to your competitors or, shall I say, to some of those who may want to cooperate with you in the future, because you may not want to spell out your negotiating position.

In any event, I would like to make it clear that what we are doing here today is nothing more than what we regard as a common-sense, practical way to extend the policies that we believe have been demonstrated as successful. We believe that the Gemini VI and VII flights, with all of the "Perils of Pauline" features, do demonstrate that we can run large engines for a little over a second and when we find out that one of them is not performing accurately, we can stop it and open it up and find out what caused the trouble and put it back together and fly. These flights also showed that we can train an astronaut to so completely understand the system so that even though he knows that the engine started and then stopped, he doesn't pull the D-ring.

I should say all of that is related very directly to management: management of energy, management of human beings, and management of carrying out a very careful design with predetermined limits beyond which some indication will be given for either man or the machine to do something. To better understand this management and what it means to you in the computer industry today, we believe it well to call to your attention the basic principles we stated in our second conference for industry back in February 11, 1963.

Very few people believed Hitler when he wrote Mein Kampf. Also, almost nobody in industry believed that we would tell them what we really were going to do when we had an industry conference. Therefore, I am going to read to you the statements that we made back in '63 and then say a word or two about what I think they mean now.

This is from my talk during that meeting, in '63, of industry people. You may remember that we couldn't get them all in one auditorium. We had to have a second auditorium set up with loudspeakers, there was that much interest in industry. So there's nothing secret about any of this, there were lots and lots of people there.

First, I used a quotation from the Chairman of the House Committee on Science and Astronautics, George Miller of California, in these words -- these are Miller's words, in '63 -- "People look to Congress and to NASA for the assurance that our National Space Program, especially the Manned Lunar Landing, will be conducted with the utmost vigor possible and in turn Congress and NASA look to private industry in order to achieve in practical terms all of our objectives."

Now the point I would like to make is that the reason the President last night was able to say to the German Chancellor if you are prepared to join with us in the cooperative development of your resources in spacecraft operation, we are prepared to cooperate with you. And if you look at Gemini VI and VII, Mr. Erhard, you will see that we have been able to get most of that last 3 to 5 percent efficiency out of technology that makes such flights possible. This last increment of efficiency is really what makes the difference. While we have serious reservations about cooperation with respect to nuclear weapons with anybody that would add to the number of states having them, and we have the most serious reservations about cooperating with states with respect to delivery systems, because we feel that the future of the world rests on something better than proliferation of either, we are prepared to cooperate in the area of spacecraft technology. And I don't have to express my opinion about whether or not we have something to offer you. All you have to do is look at Gemini VI and VII and you will see that American industry under the system worked out by NASA and announced in 1963 has been able to achieve in practical terms this kind of capability.

To go back to what I said in 1963, "The achievement of United States objectives stated by President Kennedy, that is, pre-eminence in space, and the utilization of the skills and knowledge gained for the benefit of all our citizens and those of other nations, is a truly national undertaking which will demand the test of all of us."

In one way President Johnson was saying to Chancellor Erhard that in some segments of space pre-eminence like spacecraft we, under proper conditions, might be able to join with 200 million people in Western Europe and another 100 million in Japan in a great international undertaking that might advance the capability of the human race to avoid war and to develop high level technical capabilities that will translate into an important ability to do the things that need to be done without having to develop them through military systems.

I think this may turn out to be quite an important initiative by the President.

Returning to 1963, I went on to explain why we chose the Lunar Landing as one of our main objectives. I would just like to read you the words I used:

"Why, some ask, the Moon? The answer is, of course, that valuable scientific information relating to a clearer understanding of the universe can be gained and success in achieving this goal requires essentially the same progress in science and technology which will be required to achieve our broader objective, that of becoming the world's leading space-faring nation. Our reasons for exploring the Moon are for the most part identical with those which prompted us to undertake an accelerated space program in the first place."

Against the idea that some people have tried to advance that the Lunar Landing is just a stunt, I have listed a number of reasons. Again I am going to read you what I said in '63, and I wouldn't change a word of it today.

The reasons, stated in more detail, include:

First: "Vital scientific knowledge can be gained. Exploration of the Moon is important because its surface has preserved the record of its history for a much longer period than the Earth and promises to yield information dating billions of years into the past."

Second: "Continued superiority in science and technology is essential to our leadership of the free world and our prestige among the non-committed nations. Exploration of the Moon requires the kind of overall, much expanded competence in space which we can develop on a timetable competitive with the capacity of the U.S.S.R. to do the same."

I should add here that if anybody is still inclined to doubt the capability of the Russians in space, or in other fields where they decide to focus a very large amount of resources, I'll simply state to you categorically it is still very competitive, and will remain so for a number of years to come. Some of you I think will be surprised to learn that the position officially taken with Congress a year ago, although maybe a year or two too early, will probably be realized in this next year, namely, that the Russians are by no means through and they are now in the position of having launched a hundred Cosmoses. They have moved from 22 launchings in all the years up to '64 to 27 in '64, to 49 already this year, of which two were Protons with four times the weight of Gemini. They have gone into all the major areas that we are in. They have launched four vehicles this year intended for soft landing on the Moon, and they have two spacecraft on the way to Venus right now.

So if you don't think that when we stated in '63 that we thought we could develop the overall, much expanded competence in space on a timetable competitive with the Russians -- we said quite a bit -- then I suggest that maybe you ought to go back and take another good hard look at it. It will be competitive.

Now, third: "Our national security demands that we act to ensure that no hostile power will use space as an unchallenged avenue of aggression against us. The scientific knowledge and technological skill developed in our program of lunar exploration will give us that assurance and will form the basis for any military application which the national interest will require."

Now I think if you will look at what we have been able to accomplish in seven Gemini flights and contemplate that the first unmanned Apollo will probably be launched next month, and that the Apollo will give us not only the capability of going to the Moon, orbiting that body, and landing on it, but also the capability for manned synchronous orbital systems for extended stay times up to 45 days or maybe even as long as 90 days, then I believe you will realize we have a good deal of room for scientific work in the lunar excursion module and the Apollo if we want to use them as a first sort of breadboard, mockup or prototype of orbital systems.

I think what we said in '63 is just as true today as it was then, that is, the scientific knowledge of the environment to which engineers have to work, and the technological skill developed in the program of lunar exploration will give us the assurance that no hostile power will be able to use space as an unchallenged avenue of aggression against us.

If you look at the Russian parade of what they called orbital systems that could put a bomb somewhere either on the first or any other orbit, and if you look at the fact that you can go up and find another satellite of your own, like Gemini VII, then you know you can go up and not find yourself thrown out of space. At least you can find out what's going on there, and you can understand the technology the other guy has to master.

So I would say again that Gemini VI and VII demonstrated the value of the lunar exploration program, and I would like to predict that Apollo will go very much further in demonstrating what it takes to get that last increment of capability out of very complex equipment that will operate in an environment that is becoming increasingly known and measured, and toward which engineers can use very precise designs.

The fourth reason I gave in '63 for the Lunar Landing was: "Practical applications of space technology would expedite our economic growth in such areas as more efficient utilization of energy, advanced electronics and new materials."

Regarding new materials, most of you know that in the interdisciplinary materials research program something like $117 million has been spent by federal agencies. There are 16 major basic research centers in the program. I think most of you know that NASA has had perhaps the most vigorous effort anywhere in the government to pick up and make practical applications of the results of this hundred million dollars of research. Many, many openings to the future are in this field. I don't have to say that you have seen extruded from the total capability developed in atomic matters, ballistic missile systems, and in NASA's effort the Communications Satellite Corporation, a military communications system, and a world-wide weather observation and reporting system. Now this capability is about to extrude a manned orbital laboratory for the military and a supersonic transport.

In my view you are going to see some extrusions of very large operational systems out of this very large bank of knowledge, particularly the knowledge of new materials, the utilization of energy in very large and small amounts, and advanced electronics.

Dr. Van Allen said, and I quoted him in '63: "This matter of manned lunar exploration is an undertaking of truly heroic proportions. It provides a graphic test of our national technical capabilities and our national fortitude and integrity. I for one," Dr. Van Allen said, "would be most distressed to see the United States shrink from this challenge."

I think that basically has been the position that the government has taken, and I think we have met the test. We have had about $22 billion dollars appropriated to this agency since 1961 and will have about another $5 billion more or less, depending on the final budgetary situation coming up. So you are going to have seen about $27 billion by the time Congress finishes its next session, out of the $35 billion we said we'd spend within 10 years. This is about two-thirds of one year's military budget spent over 10 years in aeronautics and space.

But now here's what I said to industry: "To achieve mastery of space requires that we add substantially to our scientific knowledge and to our utilization of technology. The NASA program is moving forward on both these fronts. It is a complex effort conducted in a new medium about which much is yet unknown and the scientist and engineer must work closely together and grow increasingly dependent upon one another. In the exploration of space the scientist must depend upon the engineer to design the equipment which will enable him to investigate conditions and forces which exist there, but at the same time the engineer must look to the scientist for precise knowledge which will enable him to design equipment which will operate or sustain human life in this harsh and unfamiliar environment. Therefore, NASA must expand both science and technology, moving forward on a broad front, not trapped in an air program nor one limited to developing only the technology needed to reach the Moon with state-of-the-art hardware."

In other words, we said we're going beyond the state-of-the-art hardware, although being perhaps the most conservative engineering organization in the world, but we are not going much beyond the state of the art with respect to the operational systems to which we have trusted human life in the first flights.

I pointed out that if we were not wise enough to reach out into the future and did limit ourselves to state-of-the-art hardware, we might well find some years hence that we had won the battle of landing on the Moon and lost the war as far as ultimate and enduring superiority in space is concerned.

I went on to say how we were going to work, outlining the steps which we are now expanding in this meeting with you of the computer industry. I said let's look at some examples of the steps we have taken to assure competition and broaden opportunities for participation in space work by industries of every size throughout the nation.

First, we have taken steps to try to make certain that contracting patterns would not become frozen, that major areas of competence would not be pre-empted or locked in by single sources. I'm reading from the talk I made in 1963.

Typical of our actions under this policy was the establishment, for the assembly and testing of our new multi-million pound thrust boosters, of the Michoud Assembly Plant at New Orleans and the nearby Mississippi Test Facility as government installations with resources available to private contractors selected through competition.

This decision that the assembly and testing of our largest boosters would be carried on in centrally located government facilities was made with the deliberate intention, among others, of keeping open a continuous competition within the industry for the contracts to build future stages.

Second, in the area of manned spaceflight we have developed through Bellcom. an engineering group, organized by AT&T, with the capacity to assist us to continuously examine the developing state of the art in the areas that are central to our success and to continuously match the results against the concepts and assumptions underlying our program and relate this matching to the hardware and mission profiles toward which we are working.

Through the General Electric Company we were endeavoring to provide a means for measuring and storing in computers performance and test data on the vital components and the finally assembled boosters and spacecraft in an effort to substantially increase reliability.

I went on to say these arrangements will not be used to provide crutches for NASA contractors, but rather to measure and ensure competence on the part of the contractor. And I added one last little point. I said, "I might add we have resisted every impulse to establish these groups as nonprofit corporations."

We have never established one. We have JPL in the field, where we have herded it and we have tried to keep it vigorous as a means of comparing what could be done in that kind of framework with our other operations, forcing our attention on the difference between the two.

Third, we said that we would insist that prime contractors obtain components from those sources which have already developed reliable hardware, not use government money to develop competition for those who have already achieved competence and reliability with their products.

Perhaps I can conclude to say that I believe we have pretty well done what we said in '63 we were going to do. I think this is borne out by the fact that we have maintained about 90 percent of our dollars going outside the government and yet have been able to achieve the demonstration that we did with Gemini VI and VII, and the position we now occupy, which is about 15 or 16 billion dollars worth of equipment in the pipeline with the end result flowing toward Cape Kennedy; also, that we have put into being about over 30 facilities in which we can simulate the space environment and learn to operate with large, complex systems and their components so we get the information before we fly. Further, we have been able to put in place almost 3 billion dollars of heavy engineering installations in the United States that permit this end result of 15 or 16 billion dollars worth of equipment being made by American industry to actually fly when it gets to the Cape.

I don't mean all that the 15 billion dollars will pay for is going to fly, but the end result of it is going to fly. In the interim period the rest of the equipment is going to prove itself out in the various environmental testing facilities.

We are moving into a period when we must, in my view, extend what we have said is our policy to a close examination of the computer industry. It is never a happy thing to be charged by the General Accounting Office or anybody else, like Members of Congress, with using sole-source procurement as a means of getting away from the true intent of the procurement system, and yet we have used sole-source procurement time and time again to get help when it was needed.

I don't think anybody has found us too timid to take the steps that were necessary. We have tried to be fair to industry. We have talked deliberately, frankly, and openly. We are prepared to talk with you in any way that you want to talk, through industry committees or groups, or directly on behalf of your own company. In other words, the choice is yours. But we will be taking some action aimed at getting more competition.

MR. RIEKE: Thank you very much, Mr. Webb.

Gentlemen, it is unfortunate that we must split the group in our luncheon plans today. Some of you are having lunch with Mr. Webb and I believe the arrangements have all been made. When you leave the room here those of you who are having lunch with Mr. Webb, if you will turn left and go through the double doors -- I explained to you earlier that Mr. Webb is just tearing this whole place apart up here and I hope that room is still there.

(Laughter.)

MR. RIEKE: And I think Mr. Vecchietti, Mr. Cole and others will see that the rest of you don't starve.

Thank you very much.

MR. WEBB: Now wait, Bill. Do we have a few minutes before lunch in case somebody wants to ask a question in the larger group?

MR. RIEKE: Mr. Webb, I would like to explain, if I may, that before you came in I tried valiantly to get a wide open discussion among these gentlemen and I find that they don't discuss things very openly. Whether this is because of competitive pressures or not, I don't know.

(Laughter.)

MR. RIEKE: You do have a recognized ability to accomplish such things -- if you would like to undertake where I have failed?

(Laughter.)

MR. WEBB: Forget the computer business and think as United States' citizens. Are there any questions about things not related to the computer business you want to ask? We'd be glad to talk about those, too.

I would say that the next session of Congress is going to provide a very lively debate as to where this country is going in science and technology and you are going to see, over the next 2 or 3 years, a lot of discussion as to whether the plan developed by NASA should be applied in oceanography and other areas.

There is a strong drive to go ahead with many areas of measurement of a new environment and technological development to utilize that environment and find out what it can mean.

I believe that the President is now in the process of taking the steps that will make it clear to the world that when you set up a specialized research and development agency like NASA, give it a job to do, and it operates as I said in '63 we would, and as I believe we have, and it does bring in industry in the proper way, and brings in science in a proper way, you can achieve something that the United States can offer to the world as a hope for the future. In a sense I think that is going to go along with this very vigorous debate in Congress as to what science and technology can really mean.

I will give you one other thought, since it may generate a question. There's been a lot of debate among theoretical people, including scientists, as to whether we are using the right criteria to allocate our resources, whether more money shouldn't go to cancer research instead of landing a man on the Moon, and a lot of things like that. However, in my view, a feeling is gradually crystallizing that the best thing this country can do is sort of apply a little of the hair of the dog that bit you. The feeling is that we have a pretty good government, that we have a pretty good system for making decisions, that it is rather remarkable that we have developed an aeronautic industry and that we have developed the capability that we have in space, that electronics now is widely available for use in industry and any other place that it can serve in the country, and that, by and large, instead of inventing a whole lot of new ideas as to who should determine what should be done, the system that we have of government, industries and universities, is a good one. Congress, being the forum which will debate it out, is going to continue to make those decisions and continue to rely to a very large extent on information furnished by the Executive Branch and people like you who go up there and talk to them privately in their offices or testify openly.

I don't believe Congress is yet ready to set up a little group of experts that will tell them that everything that you and we propose to them doesn't make any sense and that they have a better way. Nor do I think that they are going to set up a little group of some kind that will exercise infinite wisdom and determine how the United States should allocate its resources.

I would welcome an expanded desire to make the system we have work. I'm saying this to open up any questions for you, if any of you have any desire to ask any question about any part of the space program.

Yes, sir?

MR. CLARENCE SPENGLE (from Honeywell): I was a little bit confused. You mentioned that there would be $35 billion allocated to NASA through fiscal '67.

MR. WEBB: I said that we started out in '61 with a plan to spend $35 billion over a 10-year period to develop all of the competence we required in every field and that we had already received about $22 billion of the 35; with about another 5 for fiscal '67 we'd be up to 27.

MR. SPENGLE: The lunar excursion is only taking part of this?

MR. WEBB: That is right; about 20. We would have done it under 20, really, if we hadn't been slowed up. About a billion dollars has been lopped off the recommended program in the Congress over the last 2 or 3 years. That's going to spread the program out a couple of years and make it cost maybe a couple billion more than we estimated. So it's probably going to run slightly over the $20 billion, but not an awful lot.

I would like to point out to you that very few of you have ever seen a program stated to run 10 years and spend $20 billion dollars and have it come out pretty much the way we said it would, in spite of the fact that a lot --

(Laughter.)

MR. WEBB: A lot of people said there aren't enough engineers, there aren't enough scientists, you'll never get this job done, and you didn't count up every job that had to be done and allocate it precisely. However, you know all of us in this program have had a lot of experience with American industry; and, we knew if we put this load on industry, they'd do the job. And they have. Furthermore, if we can make the flight to the Moon in, let us say, 11 or 12 or maybe even 10 of the Saturn V's, we'll have a few boosters and spacecraft left over to do something else with and it will be under the $20 billion; that is, up to that time.

Now this is quite an important thing and I should say that if we didn't rely on you for increases in reliability, we wouldn't be planning to put men on top of the fourth Saturn 1B and the third Saturn V. Our third Saturn V is scheduled to be launched that way, with men right on the nose.

So I don't think we've got to apologize to anybody for what you have done and NASA has done and the scientists in the universities have done.

I do think we must not get frozen into the precise pattern by which we got from 1958 or 1961 to now. We have to be as innovative in the future as we have been in the past, in my view.

Another question?

(No response.)

All right, we'll go eat.

(Thereupon, the meeting was recessed for lunch.)

COPY

January 14, 1966

Mr. John H. McAdoo
121 1941 Hall
Princeton University
Princeton, New Jersey

Dear Mr. McAdoo:

Mr. Harlan Anderson has advised me of your interest in summer employment with Digital Equipment Corporation.

We have not determined our summer employment requirements. However, we plan to make this decision during the first week of February.

If at that time we feel that we have a suitable opening, I will contact you regarding our plans.

Thank you for writing to us, and please do not hesitate to contact me if you have further questions.

Sincerely,

Robert T. Lassen
Personnel Manager

RTL/jfr

cc: H. E. Anderson

CONSULTANTS IN
RELIABILITY PROGRAMMING
QUALITY COST REDUCTION
QUALITY CONTROL SYSTEMS PLANNING
QUALITY & RELIABILITY ORGANIZATION PLANNING
DATA ANALYSIS, STATISTICAL ENGINEERING
VENDOR CONTROLS
SPECIFICATION & MANUAL WRITING
QUALITY & RELIABILITY MOTIVATION & TRAINING
EXECUTIVE DEVELOPMENT

rdi

RELIABILITY DYNAMICS INSTITUTE
15 Marian Road, West Acton, Massachusetts - COlonial 3-5519

January 31, 1966

Mr. Harold Anderson
Digital Equipment Corporation
Maynard, Massachusetts

Dear Andy:

In order to serve you better and to provide a broader range of services, RDI has the pleasure to announce that it will incorporate its services with those of Ernst and Ernst.

The new office will be:

Ernst and Ernst
1600 Equitable Building
120 Broadway
New York, N. Y.

phone: RE 2-7500

RDI in joining the Management Services Division of Ernst and Ernst will continue to maintain the personal, professional and friendly relationships which have characterized their relationships with you in the past and look forward to the opportunity of serving you again.

Sincerely,

RELIABILITY DYNAMICS INSTITUTE INC.

By:

Chet

C. Gadzinski
President

gp

H. Anderson

January 21, 1966

COPY

Mr. Terry L. Schmidt
Host, Third Design
Automation Workshop
The Boeing Company
P. O. Box 29100
New Orleans, Louisiana 70129

Dear Mr. Schmidt:

Your letter of January 13, 1966, to Mr. Harlan E. Anderson, has been referred to me for reply.

Digital Equipment Corporation is pleased to accept your kind invitation to send a delegate to the Third Annual Design Automation Workshop, to present a talk on our computer graphics equipment, May 16-19, in New Orleans, Louisiana.

The speaker will be the undersigned. Also in attendance will be Mr. John A. Jones, Small Computer Marketing Manager.

I will be looking forward to hearing from you in March regarding the details of agenda, registration, and accommodations.

Sincerely,

Michael A. Ford
Marketing Manager,
Graphic Arts

MAF:ejb

COPY

February 17, 1966

Mr. John H. McAdoo
121 1941 Hall
Princeton University
Princeton, New Jersey

Dear Mr. McAdoo:

Thank you for your interest in summer employment with DEC and for taking the time from your studies at Princeton to meet with Dave Denniston in our New Jersey office.

We have reviewed your background with the limited number of summer engineering openings which will be available in June and regret that we will not be able to offer employment to you.

Thank you again for the time you spent meeting with us. We wish you the best of luck in your future career endeavors.

Sincerely,

P. F. Chambers
Personnel Assistant

PFC/srb
cc: D. Denniston
H. Anderson ✓

HAncock 6-0033

Associated Industries of Massachusetts

2206 JOHN HANCOCK BUILDING • BOSTON 02116

ROBERT A. CHADBOURNE
EXECUTIVE VICE PRESIDENT

February 17, 1966

TO: Massachusetts Firms in the Computer Industry

The Associated Industries of Massachusetts is conducting a state-wide survey of the computer industry in Massachusetts to include the production of computers, computer components and computer services. The purpose of the study is to analyze the impact of the computer industry on the Massachusetts economy, to provide a service to companies in the computer industry and to provide a useful tool in promoting industrial development.

The results of this study will be published in a special section of the May 1966 issue of INDUSTRY Magazine and will include a Directory of company and product/service listings. Except for product/service listings, no individual company data will be shown and all statistical data will be summarized in state-wide totals.

Your participation in completing the attached questionnaire is greatly appreciated. Thank you for your cooperation and prompt reply.

Very truly yours,

C. Philip Gilmore

C. Philip Gilmore
Research Director

Extended to 25 march.

NOTE: Please return questionnaire not later than March 7, 1966.

Received on 14 march 1966
H. E. A.

ASSOCIATED INDUSTRIES OF MASSACHUSETTS
2206 JOHN HANCOCK BUILDING, BOSTON, MASSACHUSETTS 02116

COMPUTER SURVEY - MASSACHUSETTS
(Data requested applies to Massachusetts operations)

COMPANY: Digital Equipment Corporation

ADDRESS: Maynard, Massachusetts

EMPLOYMENT: (involving computer products/services only) 950.

COMPUTERS

1. Is your Company involved in the actual production of computers? x yes __ no

   a) If yes - type of computer:

   __ Analog
   x Digital
   x General Purpose
   __ Systems Control and Monitoring
   __ Hybrid (Analog-Digital)
   __ Special Purpose
   __ Other ____

   Name location where production work is done Maynard Employment 850

   b) Do you let subcontracts for certain components? x yes __ no

   If yes - name component(s) printed circuit boards

   c) Do you perform subcontract work for others? __ yes x no

   If yes - name component(s) ____

COMPONENTS

2. Is your Company involved in the production of computer components? x yes __ no (internal use only)

   and/or supplies? __ yes x no

   a) If yes - name component(s) hybrid integrated circuits, pulse transformers

   - name supplies --- ------

   Name location where production work is done ____ Employment __

   b) Do you let subcontracts for certain components? __ yes x no

   If yes - name component(s) and/or supplies ____

   c) Do you perform subcontract work for others? __ yes x no

   If yes - name component(s) ____

(Use additional sheets if necessary)

COMPUTER SURVEY (cont'd)

SERVICES

3. Does your Company offer computer services? __ yes x no

a) If yes - specify type of service ______________________________

and to whom:
__ Industry
__ Business
__ Educational Institutions
__ Other - specify ______________________________

Signed Harlan E Anderson

Please enclose product catalogs, sales promotion literature, press releases and any outstanding photographs showing computer (product-component) production or services or end use photos.

Please return not later than March 7, 1966 to:

C. Philip Gilmore
Research Director
Associated Industries of Massachusetts
2206 John Hancock Building
Boston, Massachusetts 02116

H. E. ANDERSON

3. no

LINC-8 brochure OK

PDP-8 brochure OK

Oceanography brochure OK

Physics brochure OK, copy of PDP-8 production photo in annual report, copy of Don Walton & Logic Lab, Arsenault at

DIGITAL EQUIPMENT CORPORATION

DP-8, Nangle at LINC-8 photo

LINC-8 press release motor + module photo

SPRING 6-1515 ORCHARD 0-1515

HUGHES AIRCRAFT COMPANY

INTERNATIONAL AIRPORT STATION
POST OFFICE BOX 90515
LOS ANGELES 9, CALIFORNIA

March 4, 1966

Mr. Harlan E. Anderson
Vice President
Digital Equipment Corporation
146 Main Street
Maynard, Massachusetts 01754

Dear Mr. Anderson:

The Hughes Space Systems Division has developed a special purpose computer which we thought might be of interest to Digital Equipment Corporation. Hughes is interested in finding a licensee to manufacture and sell the equipment.

Equipment was developed under Dr. Althaus and is called the System Effectiveness Simulator and Availability Computer (SESAC). The operation of up to thirty systems over long periods can be simulated. The equipment is applicable to systems that must be in an operating or ready condition for long periods, have random and steady failure rate, a probability of detecting failures when they occur and provision for repair of failed systems. The apparatus can be set up very quickly compared with the programming effort required for the typical computers currently used for such studies. It simulates months or years of experience in a few minutes. Variations in failure rate, probability of failure detection, repair time cycle, etc., can be set in. Trade-off studies involving a range of levels of the variable factors can be run to determine the optimum combinations. Studies can be made of such things as: (1) Percent of systems available, apparent and real, (2) queuing and workload for repair, (3) probability of getting a given number of systems into operation, or launched successfully, given a failure rate and repair cycle. A number of such studies have already been made with useful results.

Whereas existing computers solve mathematical equations, the SESAC puts a given number of systems through their paces for a given period of time. The results can be observed in terms of green, red, and amber lights, which leads to the discovery of such conditions as unstable repair workloads. Patent applications have been filed to cover (1) the general concept of the simulator and (2) the specific design and circuits used.

The SESAC has been used successfully to analyze a number of different space, missile and electronic systems. If interest develops, a demonstration could undoubtedly be arranged. With this letter are forwarded three photographs of the equipment and a paper covering one type of study for which it has been used.

If further information would be useful please let me know.

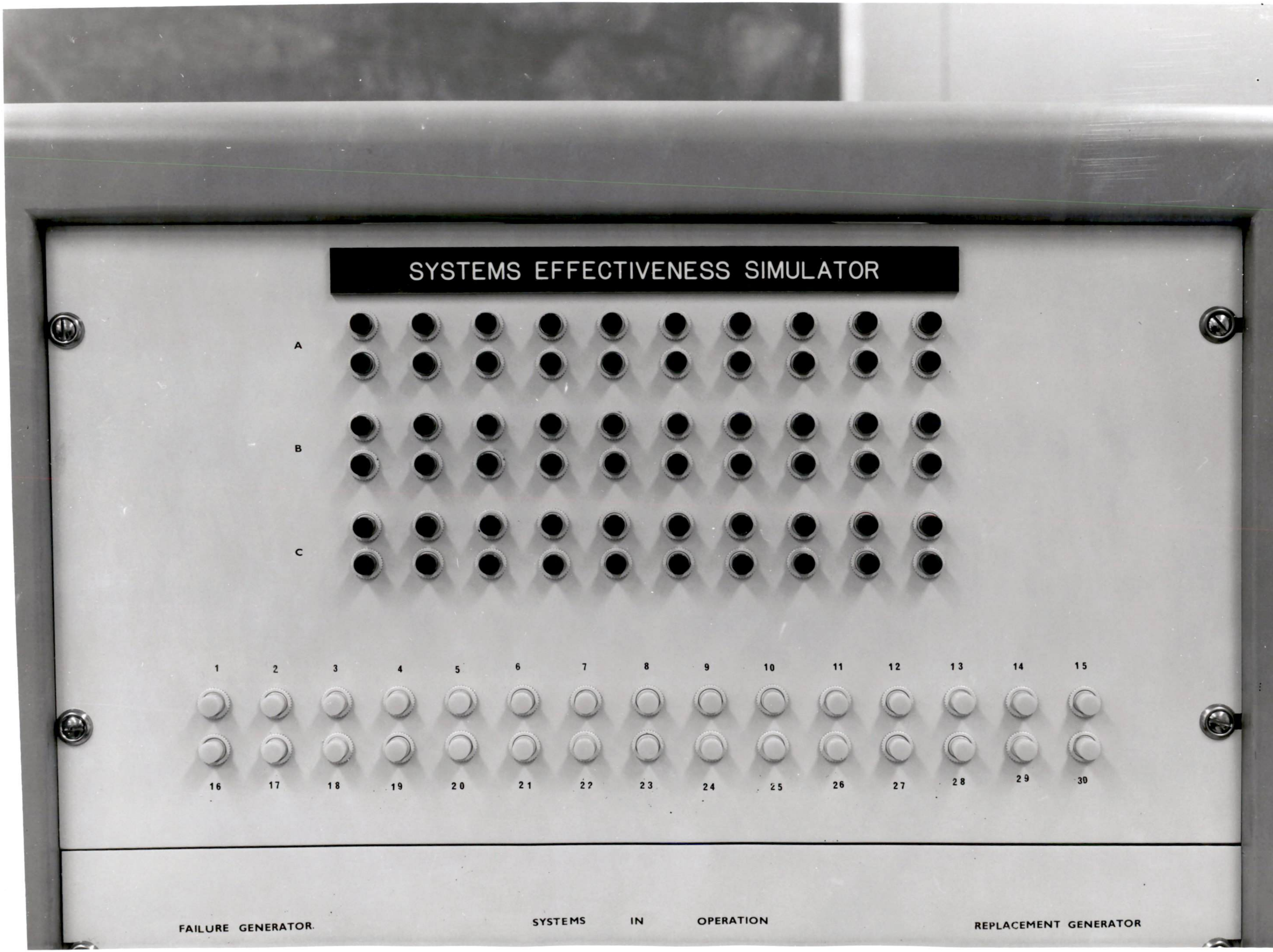
Very truly yours,

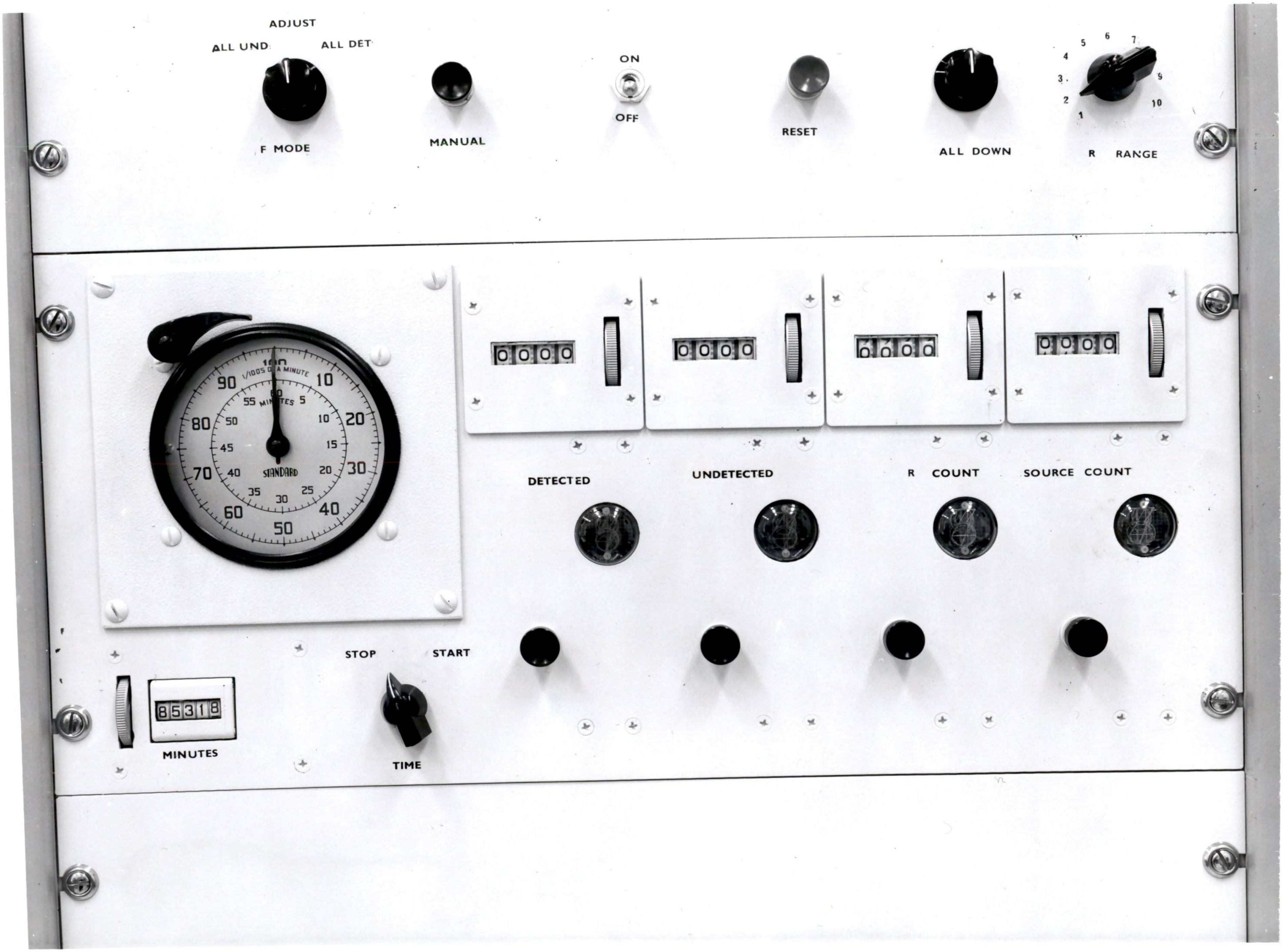
David Hill

David A. Hill
Associate Director of Licensing

DAH:amp
Encls.

cc: D. F. Doody


SYSTEMS EFFECTIVENESS SIMULATOR
A
B
C
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
FAILURE GENERATOR.
SYSTEMS IN OPERATION
REPLACEMENT GENERATOR



ADJUST
ALL UND
ALL DET
F MODE
MANUAL
ON
OFF
RESET
ALL DOWN
R RANGE
DETECTED
UNDETECTED
R COUNT
SOURCE COUNT
STOP
START
TIME
MINUTES
STANDARD


SYSTEMS EFFECTIVENESS SIMULATOR

A PRACTICAL RELIABILITY AND MAINTAINABILITY MODEL AND ITS APPLICATION

by

E. J. Althaus and H. D. Voegtlen

Hughes Aircraft Company
Culver City, California

To Be Presented At

11TH NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL

JANUARY 1965

A PRACTICAL RELIABILITY AND MAINTAINABILITY MODEL AND ITS APPLICATION

E.J. Althaus and H.D. Voegtlen
Hughes Aircraft Company
Culver City, California

INTRODUCTION

During the course of preparing numerous proposals, preliminary analysis reports and a few project analyses, a reliability and maintainability model has been developed that represents a satisfactory compromise between the complexities of exact Markov simulation and the crude availability formula approach. There is need for a model that includes features of a real system easily determined by present techniques of analysis that will provide a more realistic measure of performance than a probability of success for an arbitrary time length or a simple mean time to failure figure which does not adequately consider checkout and replacement. The present model has been applied to a system in development where it revealed that high operational availability can be easily attained. Lower values of MTBF and less than perfect field monitoring efficiency than may have been expected were found to be adequate. This paper presents the essential approach to the model development and the definition of terms and assumptions. A physical description of a system in fairly general terms for which the model is a representation is followed by an analysis of the self test checkout features of importance. A discussion of the mathematical elements, availability and readiness as seen by the model is included in a description of the model itself. Finally, a modified weapons system is briefly described to which the model is applied and the resulting reliability characteristics developed with a discussion of tradeoff possibilities made evident by the model.

APPROACH

In examining a number of systems in use, particularly weapons systems, it is important to note that a major element of effectiveness is the number of deployed systems which can be expected to perform their functions at any time. This we will call operational availability. This term encompasses all reliability and maintainability factors. Our purpose is to illustrate a multisystem model rather than a single system model. The failure and repair rate characteristics of each system will be assumed to be that of an exponential distribution. It has been shown frequently that with sizeable populations and with replacement this is a good assumption. For purposes of simplification we will deal with expected values, although computer simulation of the model can yield the range of value that would occur with any desired confidence. The model has been kept simple in order to provide insight into the general principles. More rigorous treatment can be readily applied by reference to the now rather vast literature on queues and renewal theory and on checkout statistics.[1,3]

Other sources of confusion in modeling are accuracy requirements. Because of the difficulty of assessing this effect, unnecessary details are often carried along. In order to avoid this, no greater than two significant figure accuracy is claimed for this model and it will probably be less. The parameters of interest are those most commonly evaluated such as MTBF, periodic maintenance interval, repair time, etc. It was necessary to develop the model in a form that would be easy to apply to a system under development whose parameters and configuration were changing rapidly without requiring too large an analysis staff. In addition, it was hoped that with only a few significant parameters, all persons concerned, even in detailed design, would have some idea of how these parameters would affect the system availability.

The unique feature of the model is the use and manner of determination of the undetected failure rate in the system. The model is applicable to those systems having integrated self test capability, where it is possible to determine during design whether the failure of a single element would be detected by the self test. Thus, in making the usual failure rate analysis, the elements, down to the parts level, were segregated into either detectable or non-detectable in the failed state. This permitted, for each system unit, a specification of both mean time to detected failure, MTDF, and mean time to undetected failure, MTUF, in addition to the usual MTBF.

DEFINITION - REQUIREMENTS

The model developed here is based on a fairly general system concept which, nevertheless, is sufficiently structured so that it can well represent a particular system. The essential characteristics are:

1. A continuous alert status for a number of systems in which some equipment in each system need not be operating.

2. An integral self test feature which frequently or continuously monitors the status of some portion of all equipments (replaceable modules).

3. A maintenance facility where systems are repaired either due to observed failures at self test or on a periodic basis.

4. Operational requirements such that the average number of good systems at any time is the characteristic to be achieved. This is made up of those systems with no apparent failures less those with undetected failures.

The concept of operational availability, A_o, is:

A_o - Operational availability: $A_o = R_r A_a$

A_a - Apparent availability: the number of systems in commission or with no apparent failures.

R_r - Readiness probability: the fraction of systems which have no undetected failures among those in commission.

Failures which may exist despite maintenance at a depot are not considered and also failures which may occur after attempted full use of the alert equipment, such as post missile launch failures, are not part of the model. Both of these may be handled in a straightforward manner independently of the present model. Following are definitions of additional symbols used in developing the model:

λ_i is the failure rate of the (i)th unit or $(MTBF)_i^{-1}$

$(\lambda d)_i$ is the failure rate of that portion of the (i)th unit in which a failure will result in detection by a self test.

τ_i is the average repair time for failures in the (i)th unit.

T - The time between periodic maintenance

μ - Mean repair rate for the system (to be derived).

DESCRIPTION OF SYSTEM STATES

The problem is treated like a stochastic process; however, it will not be necessary to use sophisticated Markov analysis. The steady state conditions can be derived from elementary considerations. Monte Carlo methods can be used to determine transient phenomena or to establish high confidence levels.

Figure (1) represents a flow diagram of the system in its various states. Systems with no failures leave the maintenance facility and enter the ready state. From this state they can go three ways: either to a state of undetected failure, detected failure, or to a periodic repair condition. Systems either in need of periodic repair or with detected failures enter a waiting queue before beginning repair. Systems with undetected failures remain in commission until a detected failure occurs or until the periodic repair interval is passed; then they go into the waiting queue. After a period of time it is assumed that the rates of entering and leaving all states are random in nature. Failures are poisson distributed and repair times are exponential.

The alert state is represented by those systems which either have no failures or in which one or more undetected failures exist. The rates of entering and leaving this two phase state are equal in the steady state condition.

CHECKOUT OPERATION

Checkout or self test is the means of continually monitoring the states of each system. Since this checkout is made frequently, the likelihood of statistical errors, which cause a failure to be overlooked which the checkout equipment can sense, (i.e. a detectable failure) is small and will be neglected. False failures due to statistical errors, operators or test equipment are also assumed negligible for the same reason. False failures due to design of the checkout equipment are repeatable and have the same effect as prime equipment failures and are so considered.2

The operation of the checkout is best described in the light of there being two areas in the system - one in which failures are observed as they occur and give rise to the detected failure rate, Λ_d, and one area in which they are not observed but do contribute to the repair time when a subsequent detected failure initiates a maintenance action. The detected failure rate is given by

$$\Lambda_d = \sum_i (\lambda d)_i \qquad (1)$$

and the total failure rate by

$$\Lambda = \sum_i \lambda_i \qquad (2)$$

The ratio Λ_d/Λ is referred to as the checkout efficiency. Note that here it can only be determined by analysis of both the checkout equipment and the prime equipment. This is done by augmenting the unit reliability stress analysis so that each part or group of parts has its failure rate classified under detectable and non-detectable categories. It is convenient to consider the i's to refer to replaceable modules.

Maintenance is accomplished in various ways. This model can accommodate several methods. One is that of one or more central facilities through which systems are passed upon the detection of a failure and all failures are removed. The equipment is restored to a state identical to its initial state. In a practical case a probability of a small residual number of failed systems exists and can be allowed for without compromising the model in any way. The model is still valid if repair crews travel to the various systems upon call for maintenance.

In the practical system complex upon which the application discussion to follow is based, a local maintenance facility is provided as well as a central maintenance facility. In order to avoid complication, the down time produced by the local maintenance facility is assumed negligible compared to that of the central maintenance facility and, in addition, there is no queueing at local maintenance. Therefore, detected failures corrected by the local facility are ruled out of the analysis for purposes of this paper. To further justify this assumption, it can be assumed that the type of failure corrected locally requires an order of magnitude less repair time than those handled in the central facility due to modular replacement, and that there are an equal amount of such failures to the former. Using the standard availability expression, the unavailability due to this effort is approximately 0.24% for the system described here.* If these factors were large, they could be included by extending the model to include a secondary loop.

APPARENT AVAILABILITY

The occurrence of failures in a random manner usually results in some waiting for maintenance as systems arrive in groups at a queue. Even if repair is a uniform cyclic process, a queue develops. Here we are dealing with a finite population with poisson arrivals and exponential repair times as described by P. M. Morse.[3] This theory has been applied to a number of systems by J. B. Heyne.[4] The curves for a 25 system population are reproduced as Figure (2) from Reference 4.

In order to use Figure (2) to determine availability, the queueing utilization factor, Λ_m/μ, as the abscissa is called, must be calculated for the system. Here μ is the reciprocal of the mean repair time. Mean repair time is computed by a weighted average of individual repair times. The weighting factors are the frequencies or failure rates. Let $1/\mu$ stand for the average repair time computed by

$$\frac{1}{\mu} = \frac{1}{\Lambda} \sum_i \lambda_i \tau_i \tag{3}$$

With no periodic maintenance the average rate Λ_m is equal to Λ_d and

$$\frac{\Lambda}{\mu}_m = \frac{\Lambda_d}{\mu} = \frac{\Lambda_d}{\Lambda}' \sum_i \lambda_i \tau_i \tag{4}$$

When periodic maintenance is involved, the queueing utility factor must include the effect of systems which do not return until reaching the end of the periodic interval. In the steady state the average number of systems leaving the repair facility equals the average number arriving in the queue during a long interval or

$$\Lambda_m = \Lambda_d + r_T \tag{5}$$

where r_T is the rate of return due to periodic need. Assuming the Λ_m has exponential characteristics after a long interval, r_T is proportional to Λm, since at time T a fraction of systems remain. The proportionality factor is that fraction of the systems which have not failed:

$$r_T = \Lambda_m e^{-\Lambda_d T} \tag{6}$$

and

$$\Lambda_m = \Lambda_d + \Lambda_m e^{-\Lambda_d T} \tag{7}$$

$$\Lambda_m = \frac{\Lambda_d}{1-e^{-\Lambda_d T}} \tag{8}$$

and we use $\frac{\Lambda m}{\mu}$ for the queueing utilization factor when periodic maintenance is in effect. An example of use of this is shown later in this paper.

READINESS PROBABILITY

Having developed the steady state or apparent availability, it is now necessary to consider those systems which have failed since leaving the repair facility, and in which some failures occur which are not detected until another detectable failure occurs.

Assume for the moment that there is no periodic repair policy. The probability of no failures in a system since it entered the alert population is

$$R(t) = e^{-\Lambda t} \tag{9}$$

The probability of a system not being replaced because of detected failures since it entered the alert population is $e^{-\Lambda dt}$. The conditional probability that a system is both in the population and has no undetected failures is

$$\frac{R(t)}{e^{-\Lambda_d t}} \tag{10}$$

which reduces to

$$R_u = e^{-(\Lambda - \Lambda_d)t} \tag{11}$$

R_u may be described as the reliability function of those systems which have survived checkout since entering the population of alert systems. Let $\Lambda - \Lambda_d = \Lambda_u$.

Let us consider the age x of systems at time t when t is very long so that no systems exist in the population which have not been replaced.

The age distribution of systems at any time is

$$R(x) = e^{-\Lambda_d x} \tag{12}$$

where x is time measured backwards from the present.

The value of R(x) corresponds to the fraction of systems which have ages greater than x. The fraction of systems which have ages between x and x + dx is the probability density

$$|dR(x)| = \Lambda_d e^{-\Lambda_d x} dx \tag{13}$$

---

* Unavailability is approximately MTR/MTBF; for the system to be described later, this is 2.4/1000 for the unavailability covered by the local facility.

Undetected failures can occur during x at rate Λ_u per system. Therefore, the fraction of systems which have ages between x and x + dx and have no undetected failures is found by the product of $R_u(x)$ and $|dR(x)|$.

$$|dR(x)| \; R_u(x) = \left[\Lambda_d e^{-\Lambda_d x}\right] \cdot \left[e^{-\Lambda_u x}\right] \; dx$$

$$= \Lambda_d e^{-\Lambda x} dx \qquad (14)$$

Expression (14) can be described as the conditional probability of the non-occurrence of an undetectable failure in a system of age x.

The reliability of the population in the steady state is the fraction of systems of all ages having no failure or,

$$R_r = \int_o^t \Lambda_d e^{-\Lambda x} dx \qquad (15)$$

$$R_r = \frac{\Lambda_d}{\Lambda}\left[1 - e^{-\Lambda t}\right] \qquad (16)$$

at $t \to \infty$ as is the case for no periodic maintenance and for steady state conditions

$$R_r = \frac{\Lambda_d}{\Lambda} \qquad (17)$$

This is a surprisingly simple result which means that the readiness is equal to the checkout efficiency with no periodic maintenance under steady state conditions. Of course, this is an average or expected value. The actual fraction of undetected failures among the alert system will fluctuate about this value in accordance with the characteristics of a poisson process.

Periodic Maintenance Case

In this case the rate of entering and leaving the population is increased to Λ_m as shown by (5) and (8).

Similarly for the age of system

$$dR(x) = -\Lambda_d e^{-\Lambda_d x} dx \qquad (18)$$

where x <T, the periodic interval, no system of age > T exists and in the steady state the fraction of systems of age exactly equal to T is negligible (this could be expressed by a δ function term, but has been omitted for reasons of facility in presentation).

In this case dR(x), the probability density of ages, is truncated at T and, thus, must have a normalization factor found by integrating:

$$\int_o^T dR(x) = \int_o^T \Lambda_d e^{-\Lambda_d x} dx = -\left(1 - d^{-\Lambda_d T}\right) \qquad (19)$$

The same result would have been found by carrying along a δ function term.

Now to find $\int_o^T R(x) R_u(x) dx$ as before

$$R_r(T) = \frac{\int_o^T \Lambda_d e^{-\Lambda x} dx}{1 - e^{-\Lambda_d T}} \qquad (20)$$

$$= \frac{\Lambda_d}{\Lambda} \; \frac{1 - e^{-\Lambda T}}{1 - e^{-\Lambda_d T}} \qquad (21)$$

The levels of readiness achieved by various values of T are shown in Figure (3) as a function of the dimensionless parameter ΛT.

OPERATIONAL AVAILABILITY

We have developed methods for computing both R_r and A_a so that the operational availability is easily computed from

$$A_o = R_r A_a \qquad (22)$$

The operational availability ideally is given as a system requirement and it would be desirable to find values of all other parameters which would yield A_o in a most economical manner. To this end, curves may be drawn which give parametric values of μT and $\frac{\mu}{\Lambda}$ for a number of values of A_o and of Λ_d/Λ. Figure (4) shows such a curve for a 25 system population. These curves do not require machine computation. Figure (4) is drawn based on the data of Figures (2) and (3) by an iterative process. Other means of describing the model relationship were examined and rejected in favor of that shown as giving most insight into means of achieving a desired availability within certain constraints.

Figure (4) shows curves for A_o value of .80 with checkout efficiency of 0.7 and 0.8. In the following section R_r and A_a for a specific weapon system will be evaluated and the curves will be used to illustrate tradeoff possibilities.

APPLICATION TO MODIFIED WEAPONS SYSTEM

Given a missile launching mobile weapon system consisting of the following major subsystems:

Operating Ground Equipment (OGE)
- Status Monitoring and Launch Control
- Communications and Command Control
- Launcher Platform/Vehicle (Power, Environmental Control, Ordnance, etc.)

Airborne Vehicle Equipment (AVE)
- Propulsion
- Guidance and Control
- Reentry and Warhead

The system remains in an alert status continuously, except for preventative and corrective maintenance, until countdown and missile launch is initiated. Reliability design objectives are shown in the table of Figure (5). System and subsystem reliability are shown in columns 1 and 2.

That portion of system reliability which is expected to be measurable is shown in columns 3 and 4. Test thoroughness and checkout efficiency, the ratio of detectable failure rate to the total rate, is shown in column 5.

The MTBF values apply to the functions performed while in the alert mode and to the degradation (due to alert mode environment and time) of non-operative equipment. Most of the OGE subsystems are operative during the alert mode (status monitoring, power generation and distribution, environmental controls, communications, safety controls, navigation for mobile systems, etc.); however, some elements of the OGE are dormant until countdown is initiated (countdown sequencing controls, enabling devices, missile leveling and erection mechanism, etc.)

On the other hand, most of the AVE subsystems are dormant during the alert mode (propulsion and flight control elements, staging equipment, one-shot devices, reentry maneuvering and targeting elements, the warhead, etc.); however, some equipment is operative (guidance computers, gyros, etc.) Both operative and dormant failure rates have been considered where appropriate.

The MTBF values do not reflect countdown, launch and flight failure rates--reliability numerics for this mode are expressed as probabilities. Furthermore, the MTBF reflects "system" operation. Thus, if redundancy is provided (for example, in communications or power elements), this MTBF represents the "equivalent" MTBF for the system. Thus, MTBF in this case pertains to the ability of the weapon system to remain in an alert status.

Repair time τ_i for each element of the system as given in Table 6 are based on design estimates. The method of estimating a subsystem or unit τ_i is identical to that illustrated for the whole system; namely, as an average of weighted repair times as described in Section VI. The value of 7.91 hours would be correct on an around-the-clock basis. However, in this case, it is assumed that there are only 8 working hours in a day so that MTBF is necessarily in calendar time or 3 times as long, or 23.8 hours.

$$\mu = \frac{1}{23.8} = 0.042 \text{ per hour} \tag{23}$$

or 42 repairs/1000 hrs.

The system specifications of Figure 5 are assumed to be the result of apportionment of a customer specified system MTBF. Additional constraints such as availability and periodic interval given by the customer were not developed by use of this model. The periodic interval given is 30 days or 720 hours.

Let us compute $\frac{\Lambda_m}{\mu}$ in order to determine A_a, the apparent availability. From (8)

$$\Lambda_m = \frac{\Lambda_d}{1-e^{-\Lambda_d T}} = \frac{0.700}{1-e^{-\frac{0.700(720)}{1000}}} \tag{24}$$

$$= 1.78/1000 \text{ hrs.}$$

The queueing utilization factor $\Lambda m/\mu$ is $\frac{1.78}{42}$ = 0.042. Referring to the curve of Figure (2), A_a is found to be 0.87.

The readiness probability R_r is, from equation (21)

$$R_r\,(T=720) = .70\,\frac{1-e^{-.72}}{1-e^{-(.72)(.70)}} = .915 \tag{25}$$

Then, from equation (22)

$$A_o = R_r A_o = (.915)(.87) = 0.795. \tag{26}$$

Thus, on the average nearly 80 percent or 20 of the 25 system will be both on alert and have no undetected failures which would interfere with the launching and performance of the missile. Failures occurring after launch and those existing in the equipment, but not removable at the maintenance facility, are the only effects that can degrade the reliability below this level.

The possibility of alternate system specifications which would also yield the same availability can be investigated by use of the curves of Figure (4). Let us compute the parameters needed -

$$\mu T = 720\;\frac{1}{23.8} = 30.2 \tag{27}$$

and

$$\frac{\mu}{\Lambda} = \frac{1000}{23.8} = 42 \tag{28}$$

These coordinates do not fall on the curve for $\Lambda_d/\mu = .7$ in Figure (4) because of the slight difference of A_o from 0.80. If μ is increased to 0.045 per hour from 0.042, the point H_o in Figure (4) will represent the situation which is not significantly different from that found by (27) and (28):

$$\mu T = 32 \tag{29}$$

$$\frac{\mu}{\Lambda} = 45 \tag{30}$$

Any other set of values of the three variables μ, T, and Λ which give a point on this curve will describe a system which will have A_o equal to .80. Examining Figure (4), it appears that an equivalent operational effectiveness of the system can be obtained by increasing the periodic maintenance interval by about a factor of 2, keeping μ/Λ the same, and making μ T equal to 68 and T to 64 days. This comes about because as T is increased the Λ_m will decrease allowing A_a to increase. We can be sure that R_r does not overcompensate for this improvement although it does decrease as T increases.

A considerably greater periodic interval is permissable when the checkout efficiency is increased. For example, with Λ_d/Λ equal to 0.8 and the same μ/Λ ratio μT is 163 and the periodic maintenance interval

$$T = (30 \text{ days}) \frac{163}{32} = 153 \text{ days} \tag{31}$$

with all other parameter held constant.

SIMULATOR

A film strip shown in connection with this paper as an illustration was made by using a simulator designed by one of the authors. This simulator has not been described in the literature as yet.[5] The device has a display panel which represents systems in the various states described in the present model by lights. It shows the life history in accelerated time of such a model using true random events generated by radioactive sources.

CONCLUSION

The modeling technique described here furnishes a powerful tool for system availability analysis. Detailed reliability and maintainability requirements based on the results will give assurance of optimizing operational effectiveness in the field by replacing vague and imperfect specifications and trading off between maintenance, logistics and reliability in a realistic manner with more insight into the long term effects.

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3. P.M. Morse, "Queues Inventories and Maintenance," p167-174, Wiley 1958.

4. J.B. Heyne, "Maximizing Machine Uptime," Hughes Technical Memorandum No. 613, July 1959, and R.H. Myers et al. Reliability Engineering for Electronic Systems, p. 60, Wiley 1964.

5. Article in preparation by E. J. Althaus.

SYSTEM FLOW DIAGRAM

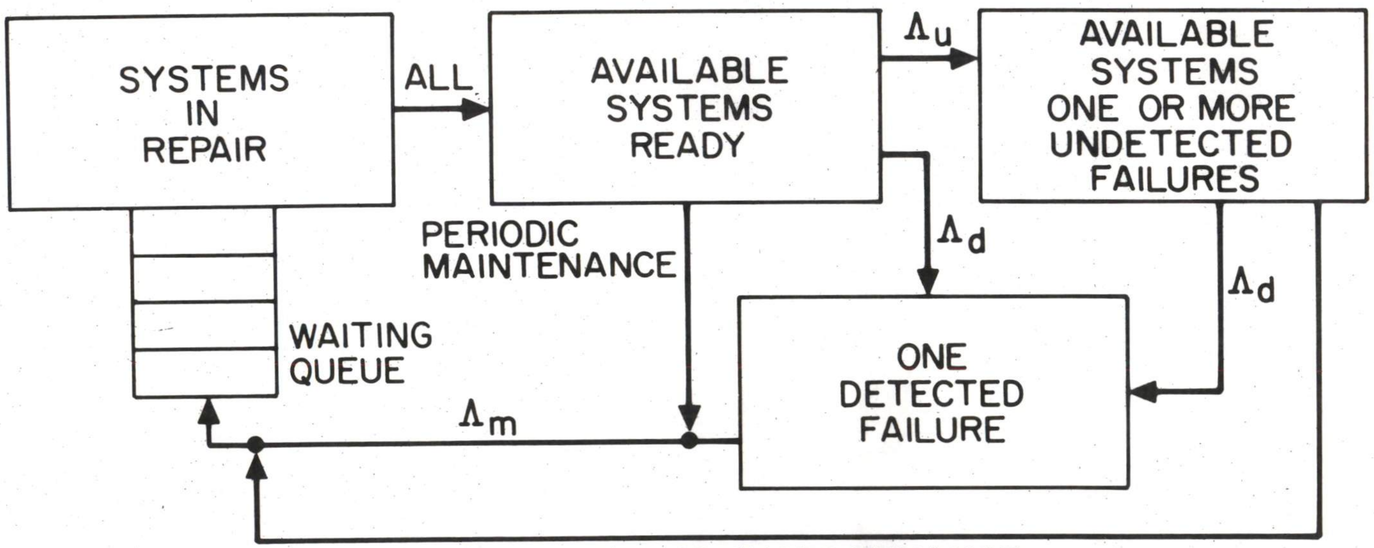

FIGURE I. SYSTEM FLOW DIAGRAM

QUEUING RELATIONSHIPS

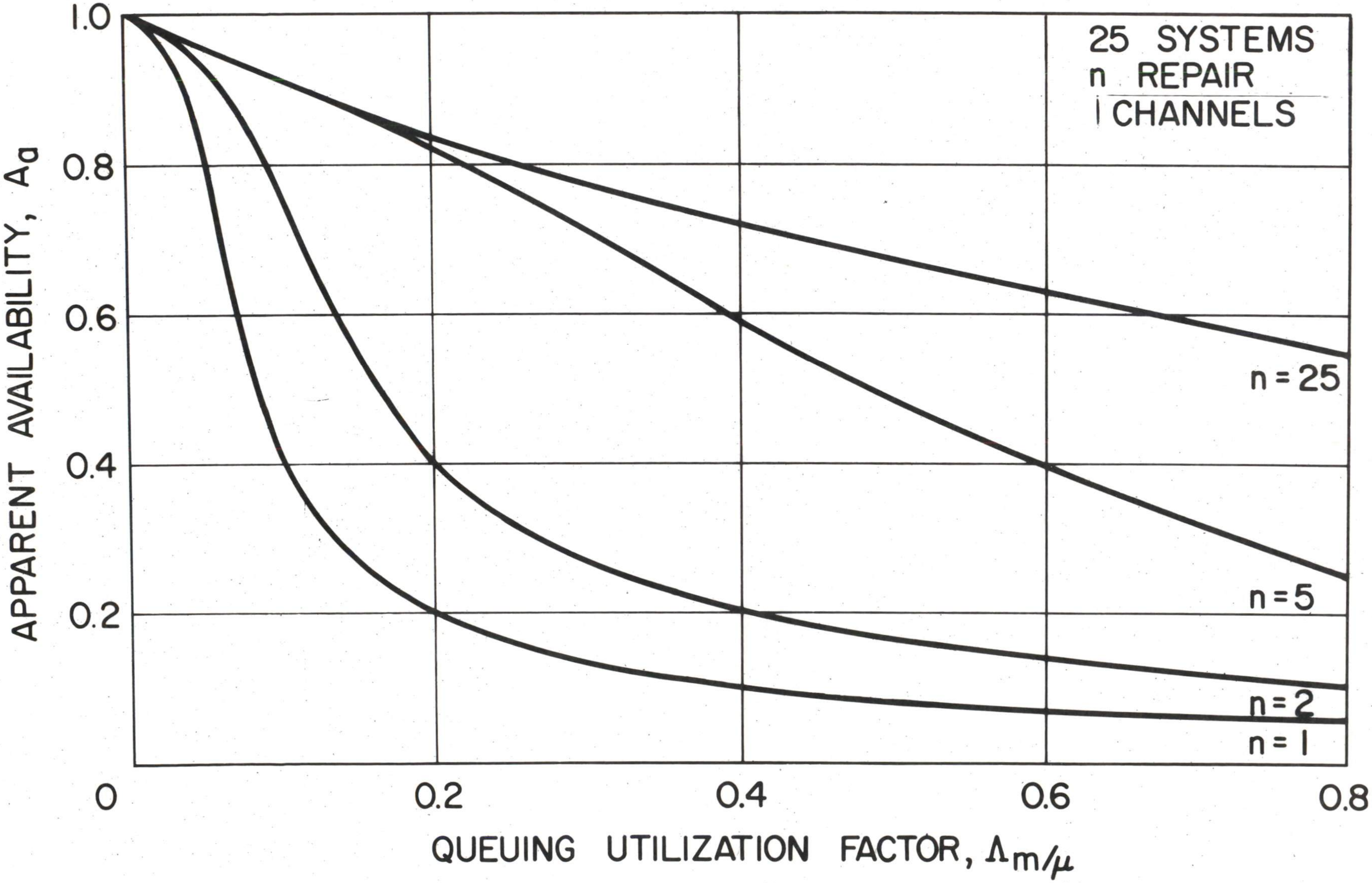

FIGURE 2. QUEUING RELATIONSHIPS

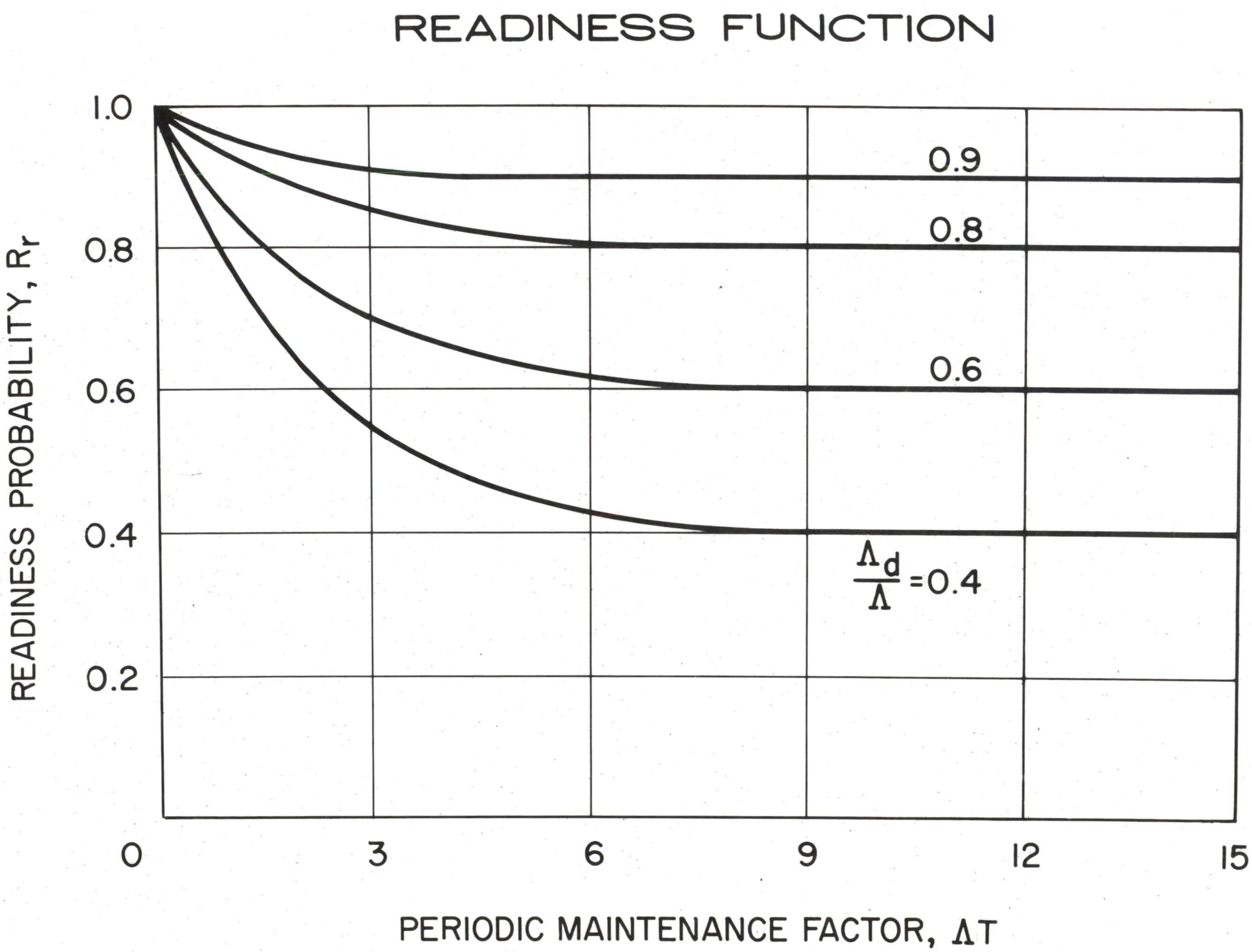

FIGURE 3. READINESS FUNCTION

OPERATIONAL AVAILABILITY CONTOURS

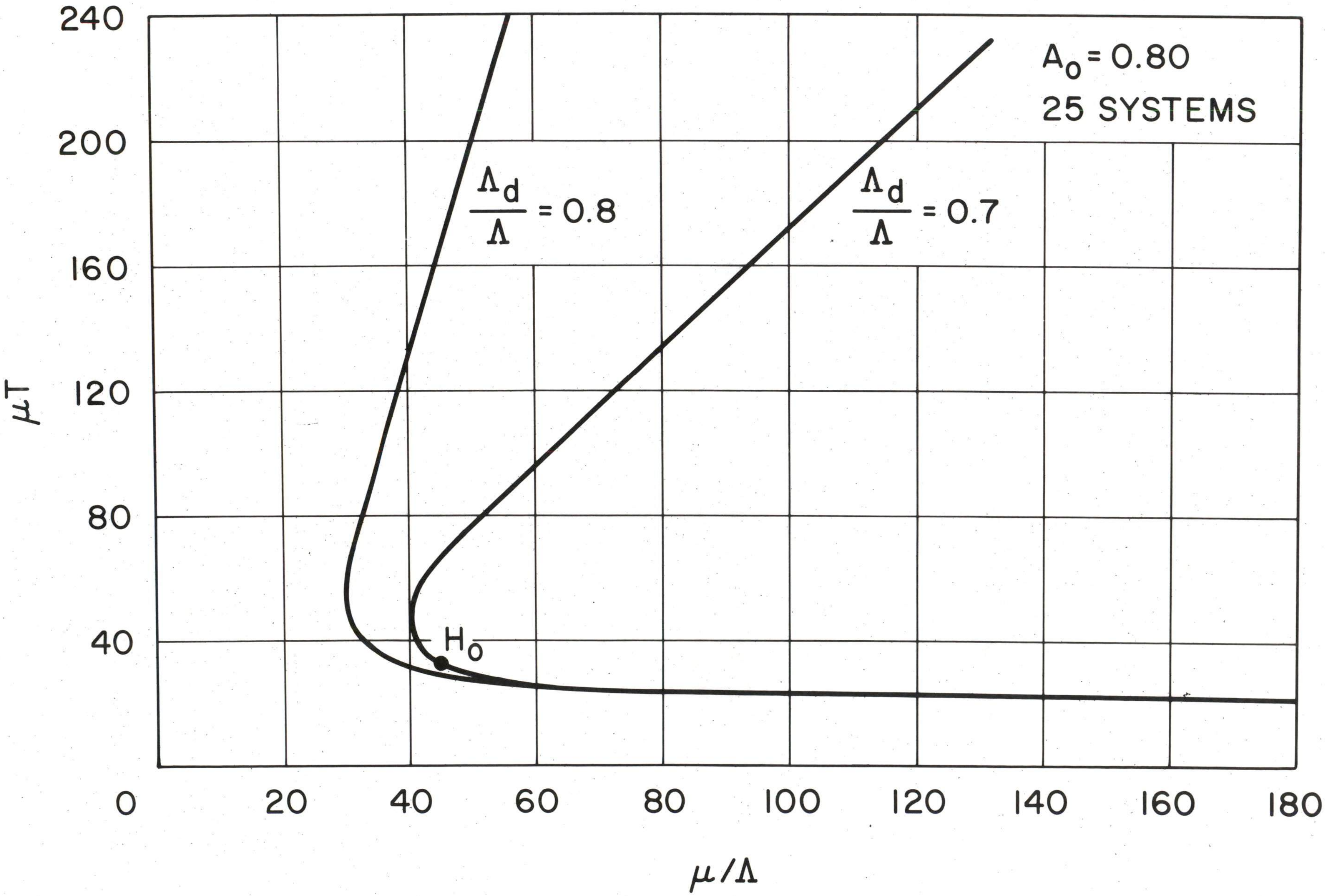

FIGURE 4. OPERATIONAL AVAILABILITY CONTOURS

FIGURE 5

DESIGN RELIABILITY OBJECTIVE

SYSTEM X

	(1) MTBF	(2) $\frac{\lambda_i}{1000\ hrs}$	(3) $MTBF_D$	(4) $\frac{(\lambda_d)_i}{1000\ hrs}$	(5) $\frac{(\lambda_d)_i}{\lambda_i}$
Operating Ground Equipment (OGE)	1,790	.558	2,000	.500	.90
Status Monitoring and Launch Control	40,000	.025	50,000	.020	.80
Communications and Command Control	2,500	.400	2,630	.380	.95
Launcher Platform/Vehicle (Power, Environmental Control, Ordnance, etc.)	7,500	.133	10,000	.100	.75
Airborne Vehicle Equipment (AVE)	2,260	.442	5,000	.200	.45
Propulsion	500,000	.002	1000,000	.001	.50
Guidance and Control	2,500	.400	5,140	.194	.49
Reentry and Warhead	25,000	.040	200,000	.005	.12
Weapon System	1,000	1.000	1,430	.700	.70

FIGURE 6

	$\frac{\lambda_i}{1000 \text{ hrs}}$	T_i (hours)	$\lambda_i T_i$
Operating Ground Equipment (OGE)			
Status Monitoring and Launch Control	.025	16	0.40
Communication/Command	.400	8	3.20
Launcher Platform	.133	4	0.53
Airborne Vehicle Equipment (AVE)			
Propulsion	.002	10	0.02
Guidance/Control	.400	9	3.60
Reentry/Warhead	.040	4	0.16
Totals	1.00	7.91	7.91

REPAIR TIME ESTIMATES

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copy sent to Bill Congleton 3/3/66

March 1, 1966

Mr. Harlan E. Anderson
Vice President
Digital Equipment Corporation
Maynard, Massachusetts

Dear Harlan:

You will recall that during the Fall Joint Computer Conference at Las Vegas, we discussed the opportunities for financing with American Research and Development Corporation. At that time I explained to you that we were negotiating with various groups of investors for the sale of common stock in our corporation. Finally, last week we completed an agreement with the Henry Phipps Estate, a New York investment group. This arrangement will provide us with the much needed working capital for the near future, and we will be able to accelerate our engineering work and greatly improve the services to our customers.

I want to thank you for your interest and help in this matter and I hope we have a long and prosperous business relationship.

Best personal regards.

Yours very truly,

Armin Miller
President

AM:lpg
cc: Mr. John Temple
Mr. Thomas Hamilton