FEDERAL SUPPORT AND STIMULATION OF INTERDISCIPLINARY RESEARCH IN UNIVERSITIES

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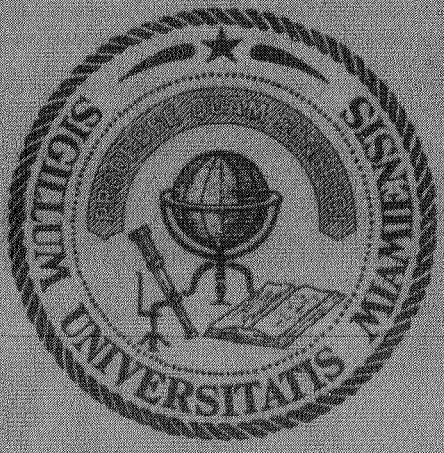

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FEDERAL SUPPORT AND STIMULATION OF INTERDISCIPLINARY RESEARCH IN UNIVERSITIES

SECTION I

Introduction

This report was written as the result of an attempt to determine what actions the various agencies of the Federal Government have been taking in stimulating and supporting interdisciplinary research. The study was sponsored by the National Aeronautics and Space Administration under Grant No. NASA-NGR-36-022-001. During the period in which the data were accumulated the principal investigator visited many Federal agencies, talked with many administrators of interdisciplinary research, gathering their thoughts. These thoughts he has attempted to distill into an organized pattern. Specifically, this report attempts several things.

1. It looks to the need for conducting interdisciplinary research in our present day society. It examines what interdisciplinary research is, how it has been conducted and who has been sponsoring it.
2. It looks to the methods so far used by the Federal agencies to support research, not necessarily confining itself to the subject of interdisciplinary research.
3. It examines in some detail the drawbacks, limitations, etc., of the various forms of support so far used. It

then considers how these various techniques of support could be directly applied to the support of multidisciplinary research.

4. It looks at the general limitations of conducting any type of interdisciplinary research program in the university, as the university now is structured.
5. It lists in tabular form the varied agencies of the Federal Government that are supporting interdisciplinary research, the means through which they are supporting it, the dollar amounts committed per year, and describes the general nature of each of the programs.
6. It reaches some conclusions concerning which techniques might be most appropriate for conducting and stimulating interdisciplinary research in the short run.

Naturally, in attempting to do these things there is great difficulty, for the nature of the programs is changing day by day. Further, because of the newness of these programs, or the recent advent of most of these programs, there is the likelihood that even in the period of time during which this survey was conducted the programs have changed in significant ways. For example, in at least three cases the administrator of the Federal agency's program has taken new employment in the period of time in which the data were collected. When the chief administrator of one of these programs leaves, or changes his assignment, the nature of the program may very well change, because of the newness of the program. And so, after all the data are accumulated, what has perhaps been accomplished is the

creation of a working paper rather than a more formal document. It is hoped that that, too, is a useful result.

SECTION II

What Is Interdisciplinary Research?

There are many definitions for interdisciplinary research. In this case, however, let us define interdisciplinary research as that research which is conducted by a mixture of investigators gathered both from the disciplines of the physical and social sciences. At this point in time it is becoming vital that such teams of investigators be formed. In previous times this need was not so evident. Why now and why interdisciplinary research? What is really needed is an understanding of the processes which lead to possible disasters. When a particular series of actions, each action motivated logically, can, when taken in series, lead to disaster, an understanding of the basic process and options is necessary. An example of a situation in which interdisciplinary research might be used might be the following--the case of a fire in a theater. In that situation each person is motivated by the instincts of self preservation--a quite logical motive, quite understandable and quite straightforward. When each person tries to save himself, the subsequent panic leads to death for many--death that would not have resulted except through the situation caused by the panic. Occasionally, in this situation a band leader has conducted his own interdisciplinary research by playing martial music, substituting another form of involve-

ment for the people who otherwise would have panicked, and has succeeded in saving many people who otherwise would have died. The process, though, is one where a series of logical actions on the part of each individual could lead to catastrophe. When the first man invented fire, or discovered the fact that fires could be lit, certainly pollution of the atmosphere was not a pressing problem. In our time, because of the power and resources available to a small group or small groups of individuals, a series of actions of the type above can lead quickly to disaster on a national scale. Perhaps not in the same vein, but certainly an interesting case of a process which has led to the destruction of a natural species, is the one involving the overfishing for haddock in the North Atlantic. Here, fishing companies from this country and other countries over the past several years have overfished the haddock supply, using the new techniques, the new boats, each company making a profit, each motivated in a logical fashion. The only problem that occurred, however, is that, as a result of this fishing, there exist virtually no haddock in the North Atlantic. The equilibrium rate of production has been overcome by depletion and now we are faced with a colossal problem if we are to reintroduce that breed of fish into its natural waters. A further example of need for interdisciplinary research occurs when we consider our transportation "system." This is not a system at all; it is rather a series or a group of inventions waiting for places to happen. An airplane is designed independently of methods for getting passengers from the airport to the

central city. Massive superhighways are built, even in cases where it is evident that the superhighway cannot be the solution to the long-term problem. In short, what is needed is a look at the varied features of all these problems from the point of view of the human environment, economics, science and any other insights which we can bring to bear upon the problem. This research will be called interdisciplinary research.

It is vital, of course, that the universities participate in interdisciplinary research, for they alone among the institutions of our society produce trained manpower for the future. In order that this manpower have an understanding of the problems to be faced, the universities must participate in the study of those problems. They must participate as researchers and as trainers. To do the research they must be supported financially and given entree to "where the action is." This is what the many agencies of the Federal Government are trying to accomplish.

The need for conducting interdisciplinary research has become evident in a general way to the public. Summing up thoughts of this type is the content of the following quotation from Congressman Daddario:

> A priority matter for national science policy has to do with multidisciplinary research on the problems of society. By this I mean research that combines the intellectual and informational resources of the life, physical, and social sciences and engineering. Multidisciplinary research holds out the hope for a better --note I did not say complete--understanding of the complex issues that perplex us today. We must further experiment with ways to marshall the interests and talents of our scientists and graduate students.

Dr. DuBridge has also phrased much the same thought:

> While we struggle with immediate and obvious problems requiring large monetary expenditures, we must try at the same time to mount research efforts in which scientists, social and political scientists, and engineers work together to seek basic causes, to develop new technologies, to invent new social and political instrumentalities, to identify and experiment with long range solutions. Unfortunately, there are not many research centers where such things can be done. There are very few trained people available. The methods and traditions of research which we take for granted in the natural sciences are not so highly developed in these new interdisciplinary areas.... If a few more great universities will initiate or accelerate their efforts in research and education in the urban and environmental fields, an enormous contribution would be made.

Recognizing the need, the Federal Government has attempted to stimulate interdisciplinary research in various ways. In the next section, all the ways that research has been supported will be discussed, and some comments made concerning the possible utility of each for the support of interdisciplinary activities.

SECTION III

Forms of Federal Support for Research

The complex programs and problems discussed previously are national in scope, so it is evident that the Federal and local governments have an abiding interest in their solutions. The interest is expressed in financial interaction between the government and the universities, and in this regard it must be recognized that it <u>does</u> matter <u>what</u> form the financial interaction takes place. In some cases it can indeed make the difference between progress in spite of the system or

progress because of the system. Because of the very nature of the problems, it is evident that no single funding technique will be appropriate for approaches to all problems for, as always, some problems are broader than others and in some understanding of certain features is more important than overall solutions. In short, all problems differ. Too, the appropriate means to attack a problem may vary with the state of maturity of the problem. An implication of this line of thought is that the funding technique used to stimulate solution to a given problem may need to change as the research and development efforts reach different stages in the problem solution cycle. Obviously, this could present administrative difficulties of an extreme type.

What is outlined below are the seven basic mechanisms by which the government has supported research in the past. In saying that there are seven basic mechanisms it must be recognized that some of these overlap--perhaps, in the words of Robert Benchley, we may say that these seven categories exist in the same spirit as that implied by the statement, "there are two kinds of people in the world--those that believe there are two kinds of people in the world and those that don't." Although the mechanisms of support do overlap, the seven categories listed below seem to describe the more general classes of support for research.

1. Block grants--mission oriented
2. Institutional grants--formula based
3. Project research--unsolicited and solicited

4. Use of agency on-site extensions
5. Use of non-profit "extensions"
6. Extensions of and involvement of national laboratory capabilities
7. Use of personnel through consultancies, when actually employed arrangements (WAE), etc.

Each of the above techniques has been developed in response to certain perceived needs. How appropriate each, or all, are to the studies of the broad problems of today is not at all well understood. In order to see some of the features which should be considered before an approach involving funding through any one of the seven above is undertaken, we should look at each of the types in detail and make some comment about success, drawbacks, and possibilities for them.

1. Block Grants--Mission Oriented

When this technique is used, a university is asked to develop a theme which is in consonance with its mission-oriented sponsor's aim. The central theme is carried forth by the individual elements contributed by faculty members, with the subsequent integration of the results by the investigators. Usually the integration into the theme has been performed at the university--generally by a committee. Funds flow from the agency to the university where they are dispersed through actions of the committee, based on the committee's judgment of the appropriateness of the research to the overall aims. In principle, this sort of granting technique insures the cooperation of the university as a whole and the cooperation of the

university with the sponsoring agency in pursuit and performance of appropriate mission-oriented research. All is not rosy, however. Problems arise both at the university and at the agency. At the university the lack of a real management structure becomes evident quite early in the game. In some cases, this has led to fragmentation in the distribution of funds, lack of overall educational involvement, communication difficulties with the agency in question and with the faculty itself, and various other difficulties recurring on a day-to-day and year-to-year frequency. On the agency side, problems of matching the agency mission to the output of the university are particularly difficult. The results supplied, if they are worthwhile, point toward future directions and are aimed at understanding the future problems and creating capacity to deal with future problems. On the other hand, the operational side of the agency must be concerned with day-to-day tasks. These tasks, in turn, have been frozen to some time in the past. It is not evident to the personnel in charge of the day-to-day operation of the agency how block grants contribute to <u>their</u> future success and they are sure that they could spend the funds more wisely--and indeed they could if all they were to perform were their day-to-day tasks. This unfortunately would leave the problem of creation of and provision for the future "mix" of competence and research results neglected. In view of this situation the middlemen, those men in the agency who are sponsoring the interdisciplinary research through allocation of agency funds, while at the same time defending their

use to the operational side of the agency itself, find themselves in an extremely difficult position. These positions are difficult in times of increasing budget, but in times of a static budget or a decreasing budget, as we have seen in the past few years, the pressures grow intolerable. As an example, within NASA the Sustaining University Program portion of NASA's budget has shrunk from a record high of $46 million per year to its present $9 million. This shrinkage has taken place in the face of perhaps the greatest overall success in the sponsoring of interdisciplinary research, accompanied by considerable success in attainment of mission-oriented goals. The problem is that when this type of research funding is used, it is very difficult to point to concrete results of the efforts, efforts that must be continued over several years to be successful.

Many agencies--NASA in the Sustaining University Program, DOD in Themis, and others--have attempted this approach and the results have proven in an absolute sense less than outstanding. It is possible that the universities were not ready for this type of funding. It is also possible that they are now. Perhaps the real problem to be faced must be more closely defined, and the time in which a response is expected be lengthened to correspond more to the typical delay times encountered in universities. What has occurred, however, is that this technique of funding has helped produce some university groups capable of undertaking and performing interdisciplinary research. Not enough groups, by any means, but some

that do provide a possible base for expansion and a possible means to study whether this technique can, in fact, succeed on a much broader scale than it has to the present time.

There are several other features to this granting procedure which should be considered. Some of these will be discussed later in looking at general limitations to the funding of interdisciplinary research, and some will be covered in the concluding section of the report. Perhaps the chief two factors, though, are the size of the grant compared to the cost of producing a single Ph. D.--for example, a typical number for the production cost of a Ph. D. is $75,000. It would not then be expected that block grants would make much of an impact on a university operating under such a price structure. Second, the question must be raised as to how much agency effort can be expended in monitoring a $100,000 grant. Certainly not an excessive amount of time can be spent on such a small expenditure and yet if a sufficient amount of time is <u>not</u> spent, the coupling process between the agency and the university and within the agency itself is certainly not an efficient one. More will be said of both these problems in later sections.

2. Institutional Grants--Formula Based

The reason for grants of this type is the fact that if a university undertakes research sponsored by an agency on a large scale, the individual grants and contracts awarded will not cover the total cost of the research performed by the university. Further, the grants and contracts will not allow the university to expand its ability to perform research in that

area. The institutional grant adds a certain amount of money to the university's award--perhaps matching the first $10,000 or so and some formula percentage of funds awarded over that. These funds are then transferred to the university with the understanding that they will be used in the general area of research which is of interest to the sponsoring agency. In the case of the NSF, the general area of research is science and so the use is rather broadly defined.

These funds are not, or have not been in the past, aimed at strengthening interdisciplinary research capabilities and so it is perhaps unfair to evaluate them in that regard. However, the developments leading to the Miller Bill, coupled with the need for interdisciplinary research, may make consideration of the process by which these funds could be used for interdisciplinary research more important in the future. If this is the case, to this point these grants suffer from three deficiencies when used to stimulate interdisciplinary research. First, in the awarding process no indication of what the funds will be used for is required. No theme is established except in the general sense referred to above. Second, at the moment there is quite clearly a crisis in the funding of higher education. In a climate such as this, institutional grants tend to be spread out through the general funds of the university. This is not altogether bad, since the spreading can be defended as a way to benefit the educational institution as a whole and its research activities on a broad basis. But as a direct stimulus for interdisciplinary research, this certainly misses

the mark. Third, where agencies are forced by Congress to impose a spending ceiling, as they have during the last two years, the funds which are not spent first are those contained in the institutional grant. The pressures on the university administrators are to continue to allow expenditures to those individuals who hold individual research project grants. Funds of a general nature are not spent in the face of this pressure.

3. Project Research--Unsolicited and Solicited

This technique represents perhaps the classic form of university participation in research programs. Usually a broad task is defined and announced by an agency, proposals are then received by the agency and an evaluation of each is made. Those successful in obtaining project support then carry on their projects individually, with the results being forwarded in the form of some kind of report (or publication) to the sponsoring agency. To this time, the main focus of such funding has not been toward stimulation of interdisciplinary research. A strong agency technical staff might be capable of performing the subsequent integration of results--an integration which leads into a coherent and cohesive program for interdisciplinary research. It is also possible that the integration process might be left at the university level. In either case problems can arise. The agency staff has to be flexible enough to realize that as research results become available, it is possible that the area of appropriate interest solicitation might have to change. The changing of focus of the research is not always easy to accomplish and sometimes

may lead to the pursuing of research which, when accomplished, will be worthless. If the research is sponsored by an rfp (request for proposal) route, problems with university response time arise, due to the nature of the university environment, university understanding of the rfp process and the way a university is operated. A university finds it difficult to meet deadlines, particularly if the deadlines occur in projects aimed at being interdisciplinary. The proposal lead time is frequently too short for the typical university to respond and the detailed checkpoints placed on various segments of an overall program do not recognize always the nature of the university operation, such as the use of graduate students to assist in research, etc. When graduate students are used and when other academic constraints are considered, the attainment of deadlines is difficult indeed. To some extent these factors are recognized in the unsolicited proposal technique. But when an interdisciplinary program has to be developed, it is more often than not developed by an after-the-fact assimilation and integration than in a conscious planning for interdisciplinary research.

As has been noted, if the integration of results is to take place at the agency level, a strong central agency staff is needed--a condition which might lead to active competition for agency funds between the agency staff and the solicited or unsolicited university contributors. Integration at the university implies a very deep understanding of agency intent, a condition difficult to attain when the development of interest

areas is carried on in semi-isolation from the university which is asked to perform the contributing research.

4. Use of Agency On-site Extensions

Various agencies have, from time to time, created what amounts to an extension on or near a university campus. The size of the extension has ranged from one professional staff member to a complete laboratory staffed by civil service personnel. The aim of the extension's activities is well defined and generally well integrated with the mission of its sponsoring agency. The agency on-site extension causes the intermingling of university staff and its graduate students with agency staff, in order that the resources of the university might be put to use in pursuit of the extension's mission. University personnel are used on a hired basis for varying periods of time--a summer, a year, a few months, for a seminar, etc. The results achieved are collected and packaged by the extension staff. In having a permanent staff at the on-site extension it is assured that there exists an understanding of what the mission of the agency is. In this way some of the problems of the ad hoc committee arrangement are overcome--the square wheel, for instance, is not continually reinvented in primitive form.

Considerable flexibility is possible under this plan. For example, employment procedures might involve direct payment to an individual, payment to the university for part of a faculty member's time, or the usual grant or contract administered at a local level. In practice, the techniques that have

been used have depended primarily upon the ingenuity of the local management in the performance of its assigned task. It should be noted, though, that the extension uses the university and does not enter into the university in a real sense.

Other difficulties can arise, too. What, in effect, is being attempted is the supplying of the management structure whose aim is carrying out interdisciplinary research, a management structure which it is supposed the university lacks. What might occur is that a conflict might take place between two management structures, neither one of which might be fully developed, and the site of which conflict might be the college campus. In view of this, strangely, there seems to be considerable support for the establishment of such organizations on college campuses by the faculty at those campuses, while at the same time the feeling exists in the agencies that this sort of structure might interfere with the academic organization. In short, the academic staffs are looking for leadership and direction, while the government is attempting not to supply that leadership in the fear that it will somehow corrupt the university participation.

There is also the tendency for organizations to grow without good reason for growth. This has been noted as a drawback to the implementation of the agency on-site extension and again the problem of "creative" monitoring by the central agency comes to the fore. Agency management must be capable of determining the difference between growth for growth's sake, or growth necessitated by greater understanding of the prob-

lems and ideas for possible solutions. As the on-site extension develops, most likely its activities will tend to spread beyond the mission of a single sponsoring agency. This means that the funding techniques used for such on-site extensions should recognize that there is a need for inter-agency cooperation, when the goal of the on-site extension is such that it overlaps more than one agency--as will be more and more the case. An example of this might be a unit designed to look at transportation problems in an urban environment. Surely NASA would be interested in the development of transportation systems in which airplanes are used. It is evident that the time between cities is inherently connected with the time that it takes for the airport to process airplanes--that is, the time per arrival or departure--and further that the processing of people from the urban areas through the airport interchange to the airplanes must be taken into account. To give serious consideration to this problem as a whole, the cooperation of several agencies should take place. This is a difficult state to achieve at best, and, as noted before, it is made increasingly difficult in times of static budgets.

What the academics see good about on-site extensions can be briefly stated as the lessening of pressures to change the university in a short period of time. In other words, this method could allow the university time to respond to the vital problems of the time without changing its structure. It is clear that not all about the university is bad; it is equally clear that not all about it is good, and that it must change.

What the real problem is is what changes are changes which are appropriate for the university to take over the long run versus those that are expedient for it to take over the short run? Using the agency on-site extension, effective approaches to this problem might be developed and where they prove effective and at the same time appropriate to the university structure itself they might be absorbed into that structure. In short, the agency on-site extension might allow a period of test to determine both the usefulness of the approach and the appropriateness to the university.

5. Use of Non-profit "Extensions"

A non-profit or not-for-profit extension located near a university or universities can function in much the same manner as an agency on-site extension. The chief difference is that the direct line of communication to agency interest no longer exists. However, the mission is defined; university resources are utilized; faculty, staff and students participate in the programs of the non-profit just as they might in the programs of the on-site agency extension. It is, though, more isolated from the central agency than the on-site agency extension. The insulation offered by the non-profit establishment may have good or bad effects. When the insulation leads to the ability to view problems in a broader perspective and over longer time periods, then this feature is a good one--provided, of course, that this is the sort of problem which has been delegated to the non-profit extension. When, however, the insulation interferes with the direct communication with

the agency, and with the universities, then the non-profit does not serve its purpose and actually causes additional problems.

Another drawback which may become evident as time passes is that the non-profit may actually compound the management problem. It can occur that an organization set up to supply management for the use of university resources toward an established goal may actually come in conflict with the academic process through lack of understanding of the academic environment, or through its recognized and avowed aim of bypassing direct involvement with the university itself. When that occurs, the arrangement is certainly not conducive to the performance of any mission, and all that happens is that "noise" is added to the system.

Thus, to sum up, the non-profit can potentially allow greater freedom to perform the mission due to its separation, but in its separation it may become less responsive to the agency mission. This need not necessarily be a deficiency in the technique, since frequently long-term and short-term missions differ and an agent acting in the long-term sense may actually be more responsive to the real needs of an agency than one pressured by day-to-day demands. To phrase it another way --it is the problem's solution that is important, not the agency's interpretation of the problem. Hopefully, of course, these two coincide, but it can occur that the ability to sit and analyze problems in long-term fashion can actually aid the performance of the mission-oriented agency when considered over a period of time.

6. Extensions and Involvement of National Laboratory Capabilities

The various national laboratories which now exist are certainly a potential resource in the development of means to cope with the new problems. Resident at the national laboratories is talent, equipment and resources which could be of great importance in their contributions to the efforts of the next ten years. There are, however, many problems inherent in the structure and history of the national laboratories which make their use very difficult.

First, national laboratories are usually funded primarily by a single agency and hence their mission is closely allied with that agency's mission. This is as it should be, but now to concentrate on broader problems which overlap individual agency responsibility requires means of coordination which do not exist at present. These have been referred to in previous sections. We can talk as much as we want, but unless it is realized that there is a joint responsibility for carrying out broad programs, those programs will not be carried out.

Second, national laboratories have usually been set up because the equipment and resources they possess are unique, generally too expensive in acquisition cost, too expensive in updating and upkeep for a single university to finance. They offer special facilities which may be used on demand by visitors. The visitors may make use of these facilities and receive support in a variety of ways. Their universities may send them to it. They may receive a grant or contract. They may

be employed on a part-time basis by the national laboratory. At any rate, the means for faculty interaction are many and varied. In order that the facilities may be used to their greatest utility, it is necessary that resident staff of high quality be maintained by the national laboratory. This staff, obviously, has interest in those areas which require the use and possession of the highly specialized equipment. In the face of this it is not at all evident that the analysis of the problems we will face in the next decade will require sophisticated specialized equipment of the type that has been accumulated at the national laboratories nor is it clear that the method of investigation will require the deep specialization that characterizes the fundamental research in the natural sciences. In short, the historic mission of the national laboratory has dictated its personnel requirements; requirements have resulted in the acquisition of staff; and the staff that has been acquired does not have interests and skills readily transferrable to investigations of the type we need.

Note, though, that this same argument can be applied to the capabilities and interests of the universities of today, and it does not imply at all that the national laboratories could not be of enormous use in the future. What it does imply is that methods akin to those necessary to stimulate changes in the university must also be employed in order to allow the resources of the national laboratories to bear. In the same sense that a university is an institution, so is a national laboratory and what is needed is a means and the de-

sire to change institutions.

Some laboratories have made considerable progress toward developing the capabilities to, and an interest in studying the broad problems of an interdisciplinary nature referred to above. Since 1961 it has been possible for the Atomic Energy Commission laboratories to conduct non-AEC-related research and development at its national laboratories. At present the Oak Ridge National Laboratory conducts 14% of its research under sponsorship of agencies other than the AEC. This laboratory is, however, an exception, even within the AEC structure, for the Argonne National Laboratory and the Brookhaven National Laboratory have less than 1% of their efforts funded by other than AEC sources.

7. Use of Personnel through Consultancies, WAE, etc.

This is perhaps the oldest form of administrative technique used when specific tasks must be performed. The use of consultants, the use of WAE (when actually employed) personnel, small contracts for individual services; all these techniques have been utilized to achieve the specific goals which have been defined by an agency. In general this technique is best used when there is internal agency competence which is capable of selecting a goal, performing research and integrating the results "purchased" from the individuals involved into the overall program. It does not work in cases where the goal is relatively undefined or where there is no good structure or ability at the agency level to assimilate the results. Further, the technique does not bring about large-scale inter-

change of information at a level deep enough to cause and allow constant reassessment of goals--a necessity for the large-scale, less well-defined and more complex problems of the future which must be solved. The mechanism is useful, but most likely it will achieve its maximum effects in conjunction with various other techniques discussed. It is further unlikely that this technique can be used to perform interdisciplinary research at a university or can be used indeed except as an ancillary to the performance of interdisciplinary research at the agency itself.

SECTION IV

General Limitations to the Stimulation of Interdisciplinary Research

The foregoing has been a brief discussion of the various administrative modes so far used by government to stimulate and support research in general considered in the framework of requirements now being generated for interdisciplinary research. Each technique blends into the other at some point and each has its region of applicability. A few words should be said about general problems inherent in the stimulation and administration of interdisciplinary research, independent of what particular administrative technique is used.

It has been recognized that the problems to be encountered in the next decade are problems which involve the participation of many disciplines. This fact connotes team approaches, or at least team coordination in the approach or

analysis must be used, if there is to be any hope of success. Just as the disciplines must overlap, it must be recognized that there will probably be agency overlap, since agencies themselves have grown along discipline-oriented lines. This requires a coordination of Federal agency approach. Coordination of approach is difficult in good budgetary times and is increasingly more difficult in times like the present.

An interdisciplinary effort cannot be planned or coordinated unless a goal is set. When goals are set, the goals can be accomplished by careful planning. It is clear that great haziness exists on what should be the priority of today's goals, and we find ourselves in a position where we have very little of the data necessary even to make informed opinions on this question. Goal setting need not always be global, but goal setting in at least some limited sense must be attempted. As long as the scope of goal setting is kept reasonably small, and the experiments and implementation reasonably small, we will at least generate the data on which to act. At the moment we have resources in depth in terms of the disciplinary researches undertaken in our universities. These resources do not exist in breadth. This is characteristic of the situation in the university, in the national laboratory and in the government. What is needed is a mechanism to bring these depth resources to bear, to finance the efforts necessary and to make use of the results. To do this requires a close coupling of management with problem analysis and since it is apparent that this coupling has not been successful in the past, we

should experiment, but with some idea of what we are experimenting to achieve.

Turning now to the somewhat more specific problems in sponsoring interdisciplinary research, first we should consider the administrative cost of monitoring at the agency level. If an agency is to monitor these interdisciplinary researches in a "creative" fashion, a task which is extremely difficult at best, but certainly necessary at this stage of development, then it must be able to devote its management talent to the monitoring process. To justify the monitoring of a grant of, say, $100,000 per year by a single monitor is extremely difficult. Administrative cost is too large compared to the size of the grant. Yet, in these early formative periods it is extremely necessary that close attention be paid to what the university is doing in relation to the mission-oriented agency needs, and to do this requires individual attention. The individual attention cannot be supplied if the monitoring person is required to oversee progress of twenty or thirty individual interdisciplinary grants.

The cost of "producing" a Ph. D. in the sciences is not universally agreed upon, but it certainly is in the range of $75,000 per Ph. D. With this fact in mind, it is evident that grants on the order of $100,000 to $200,000 per year can only serve a "tickler" function--they can only be superimposed on something already existing. While the focus of what is being done might be somewhat changed, deep changes will not take

place in the short run. If, however, the grant is maintained over a longer period of time, say five to ten years, the focusing effect that is caused through the grant will probably cause changes in the hiring policies and long-term interests of the university. Thus, over the longer run the university's focus can be changed; but in the short run it cannot. It is not evident, though, that grants of an extremely large size will have a conducive effect to university participation in interdisciplinary research, either. Largeness per se is not an easy way of assuring the desired effect. The reason for this is that very few universities can accept a large grant or contract in a "new" area and absorb the activity undertaken into the academic structure. Rather it is more likely that a unit to perform the research will be established <u>adjacent</u> to the university. If it is adjacent, it will most likely not involve faculty and students in an intimate way, but rather will develop resembling more a neighboring non-profit than an integral part of the university. In several cases where this has occurred there are very few joint appointments between the academic departments and the research unit. This is <u>not</u> a way to assure university cooperation in the achievement of interdisciplinary goals.

Actually to include interdisciplinary research in the academic structure, it is most likely necessary that new units in the university be created. These might be referred to as

"function-oriented" departments.[1] These departments (or units or centers or institutes), whatever they may be, have to possess academic power if they are to be successful. As Dr. Steinhart of the Office of Science and Technology has pointed out in his report on "Environmental Quality Programs" in universities, academic power is present only when the unit or center can

(1) participate in the reward structure for faculty through the award of tenure, promotion, hiring, etc.; and

(2) when the unit can actually sponsor courses and, perhaps, award degrees.

If these conditions cannot be satisfied, then it is very unlikely that the unit can participate effectively within the university as an agent for performing interdisciplinary research.

Further, academic structure is vertical in the sense that it is oriented along disciplinary lines. The problems of today are horizontal in that they require the coordination of the various disciplinary contributions. To effect a change in the academic structure in such a deep sense will require time, and will require the administration of the university to oppose at times the wishes of its senior faculty. To do this the university should and must understand in what direction it is proceeding and must accept the premise that the performance of and participation in interdisciplinary research activities

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(1) This concept has been proposed in a paper by E. Jantsch while at the Sloan School of Management (May, 1969).

actually represents the next stage in the evolution of the university. Naturally enough, this is not easy to accomplish and in budgetary times such as the ones we are passing through now, it is often that the theory of finite pie will motivate department chairmen and those within the university to actions which will assure that new units will not be established, on the theory that the new units will siphon away the resources which are in such short supply already.

The problem of meaningful evaluation of the effects and outputs of interdisciplinary grants has previously been mentioned. Not only does this involve the question of who is to do the evaluation, but it is also a question of how to evaluate a program rather than a project. One manifestation of this problem is determination of the relative value of having a good participant in a project located across the hall versus an excellent contributor 2000 miles away. A strict project review would point toward using the excellent contributor, while a program review might indicate the opposite. In either case, the hitherto firm basis on which proposals have been judged--that of excellence--has at least been challenged in the terms of programmatic research. Another question arises if indeed the agency dictates that the good investigator's contribution be eliminated and the excellent contributor does not succeed in coupling successfully to the interdisciplinary research. Is the project as funded the same project as proposed? Or is it a project that is lacking vital pieces in order to assure its success? A problem of the same type occurs

when some element of the proposed research does not fit within the mandate of the main agency's support. In this case the university is forced to seek support from some other agency, which may or may not be forthcoming. If it is forthcoming, it is still likely that this part or parts of the research proposed will be begun at times later than other parts and, indeed, that some parts may not be begun at all. How, then, can interdisciplinary research be evaluated if the results obtained are not those for the project originally proposed?

Finally, the problem of result utilization is a pressing one. The agency which sponsors interdisciplinary research is sponsoring it in a future sense. It is producing research results and manpower to be used in the next five years. The agency itself, however, is operating in real time and so there is a time gap between the sorts of research results obtained in the interdisciplinary research and the utilization of that result or those results by the agency itself. It is further evident that, if the problems attacked are really interdisciplinary in nature, not only the single agency sponsor should utilize the results, but the results should be widely known to all agencies with a potential mission in the given area. Means for accomplishing this aim do not exist.

Thus, it is clear that many approaches have been attempted and that there have been both specific limitations and general limitations to their success. Little quantitative data exists testifying to the success of the various attempts. Little experimentation has been undertaken to determine the range

of applicability of each approach in terms of agency character and competence, agency resources available for interdisciplinary research, and agency definition of problems. There is a need to develop these data if we wish to plan administrative and funding techniques appropriate to the problems. It is at best a heuristic feeling that certain problems can best be attacked by certain administrative techniques. We will not know which technique is appropriate until some investigation has been made of the historic development of the funding stimulation of interdisciplinary research. In short, what is vitally needed is a quantitative study of the effects of agency administrative structure and administrative approach on the stimulation and output of interdisciplinary research. It is probably true that the agencies themselves are no better structured to administer interdisciplinary research and make use of its results than the universities are to perform it. Until some measure can be applied, any use of the hitherto developed data will be extremely difficult.

SECTION V

Existing Interdisciplinary Research Support Programs

On the following chart (Figure 1) are listed the programs which are now sponsored by various agencies of the government, with aims directed toward support of interdisciplinary research. While this is not totally true in each case, particularly in the NSF's University Development and Departmental programs, it is true to a certain extent even there. In the

AGENCY	PROGRAM	FUNDING LEVEL (Millions of Dollars)
NSF	University Development	$20.0
	Departmental Development	8.0
	Sea Grant	6.0
	Planning and Policy	0.5
	IBP	1.0
	Interdisciplinary Research	6.0 (projected)
AEC	Nuclear Energy and Training	10.0 (total)
DoD	Themis	21.0
Commerce	State Technical Services	---
NIH	General Research Support (Formula)	56.0
	Health Science Advancement Award	5.0
NIDH	Dental Centers	2.0
HUD-DOT	University Research and Training Grants	2.4
DOT	High Speed Ground Transportation	0.4
Justice	National Institute of Law Enforcement	---
HUD	Urban Management Assistance Administration	4.0
Labor	Manpower Research	3.0
Interior	Office of Water Resources	---
	Federal Water Pollution Control	---
	Office of Saline Water	---
OE	Basic Research in Education Program	2.0
NASA	Sustaining University Program	5.5

Figure 1

following section each program will be discussed, the administrator responsible for the program will be named and his address indicated.

A. National Science Foundation

NSF-University Science Development Program

The director of institutional programs at the NSF is Howard Page (632-4342). Under Dr. Page the two programs--the University Science Development Program ("Center of Excellence") and the Departmental Science Development Program--are operated. These two programs have been in existence about five years. The "Center of Excellence" program had as its aim the upgrading of institutions not then ranked in the top twenty. These institutions, still excellent institutions, are aided by the funds made available by the Center of Excellence program to achieve distinction equivalent to that of the top twenty. The two programs--the Science Development Program and the Departmental Development Program--are funded at $20 million for this year for the Center of Excellence, and $8 million for the Departmental Science Program. Requests for FY 1970 are $30 million for the Center of Excellence, $10 million for the Departmental Science Program.

It is to be noted that these programs are not specifically aimed at the development of interdisciplinary research, but that in some cases the proposals which have been funded have been those aimed at the creation of interdisciplinary research units. The success which has been achieved to this point in developing interdisciplinary research units through

this approach has not been great.

The University Science Development Program has a stated objective to increase the number of strong academic centers in science, hence institutions already recognized as being outstanding in the sciences are not encouraged to apply. Many of the institutions which have applied have significant strength which could serve as the base for further advancement to a higher level performance.

The criteria stated for selection of grantees include:

(1) evidence of a carefully developed institutional plan for major upgrading of the science program over a five-year period;

(2) the presence of sufficient scientific and administrative strength to serve as the base for a development plan; and

(3) evidence of adequate financial resources to assure that the program, once started, may be maintained after the five-year period.

The Departmental Science Development program is intended to aid in improving the quality of research and educational activity in individual areas of science and engineering at institutions that are already engaged in such activities at the graduate level, but who have not moved into the top rank on the broad front. Science here includes biological sciences, engineering, mathematical, physical, social sciences and interdisciplinary areas formed by two or more of the fields above.

Specific provision is made in the program for cases when an interdisciplinary entity formed by the portions of two or more departments or fields want to submit a proposal they can. Proposals for developing or improving several departments, in contrast to a distinct interdisciplinary area, are also appropriate.

The proposals which are submitted may request support for up to three years of development planning. Construction in general is not allowed. The level of these grants tends to be about $200,000 per year, for a total of $600,000 over the three-year operation.

The criteria upon which proposals are judged are:

(1) evidence of a carefully developed plan for major upgrading of the department or area of science to a significant level of quality within a three to five year period;

(2) the presence of sufficient scientific strength in the department or area to serve as a base for the proposed development; and

(3) evidence of adequate financial resources to assure the desired program will be achieved and maintained after the developmental period.

NSF-National Sea Grant Program

This program is directed by Dr. Robert Abel (632-5944). His deputy is Harold Goodwin. This program was set up through an act of Congress that specifies three specific aims.

(1) "The Act should initiate and support programs at Sea Grant Colleges and other suitable institutes, laboratories and public or private agencies for the education of participants in the various fields relating to the development of marine resources with

(2) preference given to research aimed at practices, techniques and design of equipment applicable to the development of marine resources; and

(3) encouraging and developing programs consisting of instruction, practical demonstrations, publications and otherwise by Sea Grant Colleges and other suitable institutes, laboratories and other public or private agencies through marine advisory programs with the object of imparting useful information to persons currently employed or interested in the various fields related to the development of marine resources, the scientific community, and the general public."

The Sea Grant Program has two elements--the Sea Grant Institutional Support and the Sea Grant Project Support. Institutional support is focused on institutions engaged in marine resources programs that include research and educational advisory services. Such institutions should provide leadership, scientific and technological resources for marine activities within their regions. The Sea Grant Project Support has the purpose of aiding individual projects in marine resource development. These are in general single, well-defined research, study, educational, advisory or training activities expected to produce information, techniques, methods or systems applicable to marine resource exploitation.

Further, the Act defines a Sea Grant College as an institution of higher education which has major programs devoted to increasing the nationa's utilization of the world's marine resources. The NSF has the authority to designate, from time to time, certain Sea Grant Colleges.

There are several criteria cited for eligibility for Sea Grant institutional support. Among these are:

(1) a history of significant marine-related activities in research and education and demonstrable success of those activities;

(2) availability of the necessary facilities for conduct of a Sea Grant program, including laboratories, ships, docks, etc.;

(3) a capacity and an intention to adopt the Sea Grant program as a major goal as demonstrated, among other things, by the full commitment of responsible senior officials to the program;

(4) a staff recognized in the marine community for leadership and scholarship;

(5) ability to match the Federal contribution by providing at least one-third of the cost of Sea Grant activities;

(6) capacity for growth in the ability to plan and execute a complex program of high quality.

It is occasionally possible for a planning grant to be awarded in cases where regional or cooperative aspects of the plan require a preliminary study or conferences in order to develop background data. The grants are given after preliminary requests by the group planning to do the research.

The program is basically an applied program, and there are no Sea Grant Colleges as yet, but there are six institutions receiving institutional support this year. These include: Oregon State, $553,000; University of Rhode Island,

$477,000; University of Hawaii, $435,000; University of Wisconsin, $376,000; Texas A&M, $475,000; and the University of Washington, $220,000 (this for six months). Two other multidisciplinary projects are funded, one at Louisiana State University for $198,000 and one at Delaware for $311,000 (for two years). Various other grants run the total expenditures up to $6 million.

Congress has been requested for $10 million this year and there are expectations that this will be the funding level.

Grants are awarded only after an on-site visit to the university involved where conversations are carried on with the faculty, the deans, the president and even, occasionally, the state government. Since the program is in its early stages, only a year or so old, the data on evaluation are meager to this moment. The program funds are allocated on a year-by-year basis, but there is an intent expressed to fund over a three-year period.

The International Biological Program

This program was administered by Dr. Phillip Johnson (632-5854) until September 1, when Dr. Charles Cooper (on leave from the University of Michigan) took over the program (same phone number). The National Science Foundation is the lead agency in the International Biological Program and is charged with coordinating the activities of all the other agencies participating. The theme of the International Biological Program is the study of the biological basis of productivity and human welfare and the major part of the program

is in the area of ecosystems analysis. The program was first proposed in 1964, and there are 55 nations now participating. The National Academy of Sciences' Nation Research Council assists in planning the U. S. participation in the IBP. Proposals for grants for research projects under IBP may be submitted by colleges and universities and by academically-related non-profit research organizations. This program at NSF was funded at approximately $1 million this year. Next year the budget request is for $5 million. This year's funds were expended as follows:

Support of U. S. national committee	$ 125,000
Ecosystems analysis	
Grassland biome	451,000
Desert biome	20,200
Convergent and divergent evolution	100,100
Aerobiology	51,700
Upwelling	94,200
Biogeography of the sea	171,500
Total	$1,013,800

It should be noted that the biology funded under the program centers around ecology and man's adaption to it. It is not really across-the-board biology. The grasslands project involves about one hundred investigators, while the desert project is still in its planning phase. In both cases there will be and is a coordinator for the project--University of Colorado for the grasslands biome, University of California at Irvine for the desert--and in further planning other universities will act as the coordinators.

Proposals are reviewed by panels and the same experts are used to review individual projects as they do to review programs. The problem raised by this has been mentioned earlier in "General Limitations to the Stimulation of Interdisciplinary Research." They discuss the overall proposal with the investigators and suggest changes which, in principle, the principal investigator can ignore.

The IBP has a planned lifetime of five years, but the expectation is that the activities will continue in some form after that.

The University Science Planning and Policy Program

This program is directed by Dr. Charles Falk (632-5770).

For the purpose of the program the area of science policy is defined in terms of studies in which "an attempt to appraise the impact of research upon industrial development upon the general welfare" is made.

Activities eligible for support under the program take a variety of forms. There are grants which were awarded for research projects concerning science planning, science policy issues and the techniques and methodologies appropriate thereto. There is an attempt to make sure that the research is interdisciplinary in character and it is conducted by faculty members and graduate students working either individually or in groups.

The program aims at developing university ability to do research in the area of science planning or science policy. It

is in its initial stages. The funds are usually committed in two-year increments at about a $75,000-per-year operating level. There is, at the moment, an apparent lack of qualified institutions able to perform research of this type. At present grants are in operation at Harvard, MIT, University of Virginia, University of Illinois, Cornell University, Indiana University and Penn State. Typically--for instance at Penn State--the subject is state and local science planning; at Indiana University the subject is environmental problems; at the University of Virginia the area is the assessment of biomedical technology; and at MIT the area is political science.

Usually a pattern that is followed at all the institutions is first the conducting of a seminar aimed at attracting interested people and then the program develops from there. As is obvious, since the program is so new, assessment is difficult and the problem of judging interdisciplinary proposals both in the award and in the evaluation stage is a difficult one.

Interdisciplinary Research Relevant to Problems of Our Socity

This is a program which is new this year--as a matter of fact, it has not started as yet. The original budget request to Congress was $10 million; it has now been reduced to $6 million before final appropriations for the NSF have been enacted. The program director, or acting director at the moment, is Dr. Joel Snow, but responsibility for the program rests in Dr. Randall Robertson's, director of NSF's Research Division, office (632-4248).

It is anticipated that proposals will be funded for research in a wide variety of areas of public concern. Typically, problems might be of the following types:

(1) "cultural and social consequences of changes in technology;

(2) structure of the urban environment;

(3) environmental quality in modern society;

(4) national manpower needs and incentive structures;

(5) economic and social consequences of peace and war;

(6) technology and economic development;

(7) social implications of modern information handling techniques."

As an example of the interrelated aspects of the problem of environmental quality, the following has been noted by NSF:

"Considering air pollution, there are several factors which should be looked at. These are:

(1) physical and chemical features of air pollution, including the chemical composition of pollutants, photochemistry and photocatalysis of pollutants and the meteorological effects of mixing and deposition;

(2) consequences of pollution in man, animals and plants, including disease induced by pollutants, long-term systematic poisoning, economic costs and physical damage, impact on the quality of life;

(3) sources of pollutants, including automobiles and other transportation systems, power production and heavy industry, municipal sources including waste disposal; and

(4) economic and legal aspects of pollution, including the efficacy of burning laws, the enforcement of air quality standards, the balance of costs and the benefits of control."

In other words, what is desired is the combination of studies

undertaken by physical scientists and by social scientists to study the broad problems of the time.

It is anticipated that proposals will be discussed beforehand with the proposers and that the proposals will be submitted to and evaluated by an advisory panel. It is recognized that the panels in general are in for a stage of self-education.

B. The Atomic Energy Commission

Nuclear Energy and Training

This program is directed by Dr. Russell Poor (973-7758). His tital is Director of the Atomic Energy Commission's Division of Nuclear Energy and Training. The funding for this division has been fairly static over the past several years. One form of award consists of fellowships at approved institutions and traineeships in other approved programs. Typical of the requirements for the holder of one of the fellowships is the following statement:

> "During the first year, fellows are required to take at least one-half of their total course hourse in the following areas: radiation protection and dosimetry, nuclear radiation physics, radiobiology and statistics. At least one graduate course (or the equivalent) is required in each area. In addition, a seminar-type course devoted to current topics in health physics research and development is required. After the first-year fellow completes his academic course requirements, he is obligated to spend a summer in applied training at a national laboratory.
>
> To complete a balanced program, electives may be chosen from chemistry, biology, electronics, geology, meteorology, nuclear engineering, physics, mathematics, and appropriate industrial hygiene and sanitary engineering areas. The choice of electives requires the approval of the fellowship adviser.

> Some fellows may have to make up undergraduate deficiencies in order to take a course in a required area. In that event, the fellow is expected to take the prerequisite and the required course, respectively, at the first available opportunity.
>
> The plan of study for intermediate-year and terminal-year fellows, including thesis or dissertation topics, must also be consistent with the objectives of the fellowship program. Providing that the orientation is identifiable with the interests of health physics, thesis or dissertation topics are appropriate in such areas as atomic and nuclear physics, radiation biology (including radioecology), nuclear and/or radiochemistry, nuclear engineering and meteorology."

In addition, they support various non-profits like the Oak Ridge Associated Universities, part of the Argonne consortium and the Associated Universities (the operator of the Brookhaven Laboratory). They also are responsible for the matching grants program for science equipment for teaching nuclear science in universities.

There are, of course, other divisions in the Atomic Energy Commission that award contracts. Most of the research is supported in that way, of course. These contracts come from one of the below:

Division of Physical Research;

Division of Biology and Medicine;

Division of Peaceful Uses of Nuclear Explosives;

Division of Isotopes;

Division of Reactor Development Techniques.

C. Department of Defense

While DoD has long conducted materials and electronics programs which certainly are interdisciplinary in some sense,

it has only recently concerned itself with interdisciplinary research as defined in this paper. Its largest commitment is through Project Themis described below:

Themis

The man responsible for the Themis program until September 1 was Dr. Arvin Dougal (117-4197). The program is now run by Dr. S. Bennett Levin, whose title is Acting Assistant Director of the Themis program, Department of Defense. He has the same phone.

The Department of Defense initiated Project Themis in 1967 in an attempt to enhance and broaden the base of the nation's academic competence in science and engineering. In 1967 forty-one Themis awards were made; 1968 forty-three; in 1969 twenty-six, and it was planned that twenty-five were to be awarded in 1970. After that the program was to be phased out. Due to recent Congressional action, it appears that there will be no new starts this year and actually the number of continuations might be reduced.

Themis awards are generally made for programmatic research, in contrast to single-project type grants or contracts to individuals. In principle this makes possible coordinated multidisciplinary research by groups of faculty members and research associates, etc. The integration of the research is left to the university steering group.

The proposals which are funded are step funded three years in advance and they average about $200,000 per year in level. In general these proposals have subject areas lying

within the physical, engineering, environmental, biomedical and behavioral sciences. The aim of the program was to create new centers of scientific excellence which were regarded as essential to the nation's security.

The central office for Themis receives the proposals, assigns them for review to one of the branches of the military and then assures that the review will take place. For successful proposals, the usual monitoring technique is for the army to put responsibility in one of its labs, the navy to give it to the Office of Naval Research and the air force to sort of mix the procedure by either giving it to OSR (Office of Scientific Research) or to one of its field labs. Once the award has been made and monitors assigned, all future responsibility for funding is left to the designated DoD agency. The decision whether to continue funding is left to the particular monitoring agency in question. The central office for Themis does no evaluation itself, but it assures that evaluation takes place and the appropriate agency assigned responsibility.

As noted above, this program will be intentionally phased out after this year and there will be no new starts this year due to the Congressional budget action.

D. Department of Commerce

State Technical Services

The man who has day-to-day responsibility in the State Technical Services office is Russell Fitch (557-3185). This program has been in operation for several years and reached a

$6 million per year operating level. The $6 million in turn was matched by state funds on a 50-50 basis. Thus the operating level for the program on a national basis was $12 million per year, before this year. During the current year it was decided to ask for no appropriations for the program since there were carry-over funds on the order of $6 million. There has been no subsequent request to add funds to the program this year.

In order to evaluate the progress of the program and its overall approach, Arthur D. Little Company was asked to prepare a report on the value of the program to the nation. This report was submitted on August 26 and is presently being evaluated.

In general the program does not aim at exotic technology transfer, but operates more along a model in which an engineer in the field and a management type stationed at a university cooperate. The aim is to meet and match modern technology to small business. This operating scheme implies about a $35,000 to $40,000 total budget for each individual operation per year. It is evident that this program, if it continues, will continue in modified form. At the present time it is difficult to say what that form will be.

E. National Institutes of Health

General Research Support and
Health Science Advancement Awards

Dr. Carl Douglas, whose title is Associate Director for Program Development (496-5305), is in operating charge.

It is best to look at these two programs separately.

General Research Support falls into two categories: (1) general research support to health schools where formula grants totaling $48.2 million were awarded last year; and (2) general research support to biomedical sciences--these include schools like engineering, biology, etc.--a formula grant format totaling $7.5 million. To qualify for either of these two programs, the institution must be conducting research on the order of at least $100,000 per year sponsored by the National Institutes of Health. These programs resemble closely the National Science Foundation institutional grants and are not in any sense intended to stimulate interdisciplinary research directly. They are awarded on the idea that, when a university has a certain number of contracts and grants, it is recognized that there are other costs which are not covered directly by those contracts and grants and there is need for additional funds to cover those costs as well as to develop new competence in the fields of interest.

Turning now to the Health Sciences Advancement Awards, these have more interest in regard to interdisciplinary research activities. The program was established to assure long-term development of institutions carrying on research and research training. It was made possible by Public Law 86-798 enacted in 1960 which provides support not only for specific research and research training projects of individuals, but also provides for support of general research and research training programs of institutions.

The long-range goal of these Science Advancement Awards is to expand the ability to do research in the health sciences by increasing the number of distinguished biomedical research and research training centers within the country. The program is aimed at institutions that have substantial biomedical strength on which to build, and have the potential to become outstanding centers within a limited time span and within the amount of financial support available under this program. It is not intended that the Health Sciences Advancement Awards be a substitute for traditional project support, but rather that it be additive to it. The funds are awarded as the direct result of a proposal which is evaluated by a panel of peers. In many ways the format of the proposal resembles that of the National Science Foundation University Science Development Program.

It is urged that any applying institution consult with the staff of the General Research Support Branch of the National Institutes of Health before applying for one of these awards. After the proposal has been submitted, the review process normally involves a site visit, review and recommendation by the Health Sciences Advancement Award Review Committee, by the National Advisory Health Council, with final approval being given to the proposal by the Surgeon General.

At present the program is operated at a level of about $500,000 per year with five years' duration contemplated, so the total funding to an individual institution will be, over the five-year period, about $2.5 million. Awards were begun

in 1965, with the initial grants to the University of Virginia and Cornell. Subsequent awards have been made to eight more universities, including Purdue, Washington University in St. Louis, University of Colorado at Denver and Boulder, Rice, Duke, Kansas University at Lawrence and Kansas City and the University of Oregon at Eugene. About half of the awards are made to medical schools, the others to non-medical schools. The theme of the grants usually involves the building up of an area which does not have outstanding strength at an otherwise strong school. At Washington University it was decided to concentrate on genetics, for example. At Virginia funds were used to hire new department heads in a situation where several department heads were retiring at roughly the same time. They have always avoided supporting only a single department.

The program has been funded at a fairly steady level, rising from $1 million in 1965 to $4-$5 million this year and projected at the same level for next year. Originally it was hoped that the program would be at $40 million by now, but obviously in the present budget situation that was impossible.

Annual reports are required of all grantees during the budget period. Two months before the expiration of the yearly budget period the grantee is required to submit an interim narrative progress report, simultaneous with the annual request for the continuation of the grant. The reason for this is that the activities being carried out under the grant should be described and the progress related in detail and relative to the intended goals of the institutional program. During

the final year the interim narrative progress report is not requested, but a final narrative progress report is required within 90 days after the close of the project period.

Dental Research Institutes

The man in charge of this program is Dr. Clair Gardner (496-5315). This program was designed and instituted in response to a report by an advisory group on dental research. It was decided that it would be advisable for the National Institutes of Health to support the establishment and operation of several centers of research excellence in sciences relating to oral health. The idea behind this was to organize and coordinate interdisciplinary research in this area and to make possible the collection of the critical mass of people necessary to carry on interdisciplinary dental research.

There is no set format as to what the centers should look like. They could be organized units, centers, institutes or any other appropriate subdivision. They might be established at individual universities or in a consortium-type arrangement. It was hoped that the research institutes would build on existing institutional strength, but allow broadening of it to regions and to the nation. In order to describe the operation, it is probably best to include the requirements imposed upon an institution before it is selected.

1. "An explicit commitment by the university or parent institution to bring together scientists in collaborative research efforts relevant to understanding, prevention, and treatment of oral disease.

2. Provision by the Surgeon General of adequate supplementary facilities as well as stable program

support for each institute so that its categorical programs will supplement rather than deplete the strength of existing programs and educational resources within the sponsoring university.

3. An organizational structure within the university that would take full advantage of the opportunity to influence dental education through the sciences basic to oral health. If dentistry is to be saved from movement into pure technology, it is essential that these new research centers be available for training of individuals who represent the sources of future dental scientists.

4. The existence in the university of a strong program of research directly or indirectly related to dental health. There should be the demonstrated scientific competence and merit, and the presence of scientific leadership of high quality that would assure the institution's capacity to attract scientists who would be the essential foundation of the research effort. This would embrace the ability to draw into oral health oriented research young persons from other basic biomedical and physical science disciplines who are not now engaged in dental research and who may not now be aware of some of the challenging scientific problems in the field. Where there are relevant existing areas of special strength in the parent institution, these could be an important factor in defining the emphasis of an evolving organized dental research center. It would be desirable that this focus be in the main stream of the advance of contemporary research and so include dentistry in the research frontiers of the health related sciences.

5. The existence in the university of a strong program of graduate training in the biomedical sciences which is specifically responsive to the problems of dentistry. Although the dental research centers would not themselves offer graduate degrees independent of the university departments, nor necessarily be responsible for regular courses of instruction, they would serve importantly as active participants in the training of scientists with interests relevant to oral biology and dentistry.

6. A stable and continuing administrative structure in the university that provides assurance of long-term continuity of the organized research efforts relative to dental health. There should be a formal institutional commitment to make research relevant to dentistry and oral biology a stable

program of the institution, even though personnel might be subject to substantial turnover. The parent institution must have the capacity to guide the direction of the organized research unit so as to ensure that its categorical purpose will be preserved. For many institutions, this may be the most difficult requirement of all. It, therefore, is a particularly important element of administrative feasibility.

7. An administrative pattern of the university that provides freedom of motion of investigators so that they would not be bound to a categorical effort in which their interests might be transitory. The dental research institute thus requires a setting that would allow a scientist to enter it when his own interests appropriately bring him there, and to return to the institutional base of the university which is, in fact, the foundation of the efforts in all health related research.

8. The conduct of a dental research program that is sufficiently comprehensive to participate effectively in research and training beyond that identified strictly with clinical or applied dental problems. The dental research institutes should serve the general development of health related research capability in the university as well as the field of dentistry. For example, if the broad sphere of epidemiology and biometry were not adequately represented in a university, the dental research center could focus on such a development and so contribute to the overall health research capacity of the university as well as serve the categorical objectives of dental research."

It is intended that these dental research centers should operate at an annual budget of $3 to $5 million per year. It is further hoped that nine to twelve of these centers be established. One of the first set up is at North Carolina, specializing in the theme of growth and development as applied to dental research. The selection procedure is strict and thorough. Informal conversations, review by a study section, use of outside consultants, site visits, pre-proposals, interviews with the president, the vice-president, the admin-

istration of the university, the formation of an operating and a policy committee on the campus are all necessary prerequisites before the establishment of a dental research center. In addition, there is continuous monitoring of the progress as the grant period proceeds. It is expected that each of the centers will be funded for a five-year period, after which time the research will be supported by the institution and by other grants.

The five centers now funded, in various stages of development, are at the University of North Carolina, the University of Pennsylvania, the University of Michigan, the University of Washington and the University of Alabama. Other proposals which are pending run the number to a possible twelve.

The monitoring procedure on these grants is about as thorough as any developed for overseeing the performance of interdisciplinary research for the government. Such attention is made possible in part by the size of the grants--$3 to $5 million per year. This allows, of course, the assignment of a group of individuals who can closely follow progress made at each institution.

F. Department of Transportation and Housing and Urban Development

University Research and Training Grants

The administrator in nominal charge of this program is John Dupree (963-4206). (Actually at present there is no single person in charge of this particular program.) Under

this program grants may be made to public and private non-profit institutions of higher education that offer advanced training in some or all of the following fields: economics, social sciences, engineering, physical sciences, law, architecture, urban and regional planning, political science, business administration and public administration. Of particular interest is the research portion of the program. This program seems to be aimed rather directly at sponsoring interdisciplinary research in areas pertinent to urban transportation problems. In the evaluation procedure for programs to be sponsored by the Department of Transportation and HUD jointly, preference is given to the programs which involve more than one discipline. Examples include such topics as business management, law, economics, engineering, architecture and political science. The objectives of the program are to promote research in urban transportation problems, develop new approaches, train persons in the operation and management of transportation systems and induce states, localities and private industry to help in the solution of these problems.

There are several areas which have been delineated as appropriate for research. These are: "(1) design and functioning of urban transit systems; (2) design and functioning of urban roads and highways; (3) interrelationship between urban and interurban transportation; (4) role of transportation in urban planning; (5) public preference in transportation, both for users and non-users; (6) economic allocation of transportation resources; (7) the legal, financial, engineering and

aesthetic aspects of urban transportation; (8) urban growth problems as related to transportation; (9) the impact of transportation on the physical, economic and cultural isolation of disadvantaged groups; (10) problems of major activity centers; and (11) the problems of new transportation systems posed by the political and economic structure of city governments." The training part of the program offers graduate fellowships to those employed in managerial, technical and professional positions.

During the first year of operation this program was funded at $1.14 million, but this year--that is, fiscal 1970--it will be funded at $3 million. To this point it has been a joint Department of Transportation-Housing and Urban Development operation, but that may be changing so that it is sponsored completely by the Department of Transportation. During the first year grants were made to seven institutions of higher learning. This year there are nineteen universities funded. The following list (Figure 2) shows which universities these are and what the distribution of money is between the Department of Transportation and HUD.

In general, this program resembles very much the mission-oriented block grant programs described in previous sections. While it is too early to evaluate results of this program, it would seem that it is meeting with some fair success.

FY 1969 TRAINING PROGRAMS

(Combined Section 10 and 11)

No.	Grantee-Applicant	Funding UMTA	HUD	Total
1	Texas A&M	15,000		15,000
2	UCLA	75,000	125,000	200,000
3	Carnegie-Mellon University	125,000		125,000
4	University of Pittsburgh		125,000	125,000
5	University of California (Berkeley)	180,000		180,000
6	Syracuse University	50,000	100,000	150,000
7	University of Pennsylvania	163,000		163,000
8	Massachusetts Institute of Technology	160,000		160,000
9	Virginia Polytechnic Institute		40,000	40,000
10	Consortium of Universities of Washington Metropolitan Area	62,500	62,500	125,000
11	Florida State University	62,500	62,500	125,000
12	Polytechnic Institute of Brooklyn	65,000	65,000	130,000
13	University of Minnesota	75,000	75,000	150,000
14	University of Oklahoma	32,500	32,500	65,000
15	University of Washington	62,500	62,500	125,000
16	Georgia Institute of Technology	125,000		125,000
17	Illinois Institute of Technology	125,000		125,000
18	Northwestern University	125,000		125,000
19	University of Missouri (at Rolla)	75,000		75,000

Figure 2

G. Department of Transportation

Department of High Speed Ground Transportation

The administrator in charge of this program is Mr. Edward Ward (962-8533). This program is one in which the university decides upon a theme of research and then integrates several projects into that theme, applying results of the research to the needs of the Department of Transportation. At present MIT is supported at a level of $300,000 a year, the principal investigator being W. Seifert. With this $300,000 a year, twelve separate investigators are coordinated by Seifert. The funding period is for a year and at that time the proposal is reviewed with the opportunity for either party to eliminate any of the pieces on the basis of their relationship and contributions to the theme area.

In addition to the $300,000 per year grant at MIT, there has been in the past a $200,000 per year effort at Renssalear Polytechnic Institute and smaller grants to the University of Illinois and Carnegie-Mellon. In general the other support, that is on a project basis, is by the rfp route and not many universities have become involved.

The usual mode of operation is by the one-year contract with a report at the end of ten months, a one-month time to review the results by the Department of Transportation and another month to publish results and/or write a new proposal. This can, in some cases, lead to a two-month shut down in research which, after confidence is established between the Department of Transportation and the investigators, may be eliminated.

(In addition to this, a group in the Department of High Speed Ground Transportation has worked with the Langley NASA wind tunnel and has become involved there, predominantly in the aerodynamics of some of the transportation vehicles.)

In some senses the operation as run in this particular case resembles a sort of cross between the on-site agency extension and the mission-oriented block grant concepts. The general areas of research are developed by the Department of Transportation and the pieces are fitted into it by the university group.

H. The National Institute of Law Enforcement and Criminal Justice

The director of this unit is Dr. Henry Ruth (386-3306). This unit was started in October, 1968. Dr. Ruth has been directing it only since March of this year. During this fiscal year their budget was $3 million and almost none of this went to universities. Next year their budget request was for $20.9 million; a request that has been reduced by Congress to $7.5 million in one branch while the verdict is still out in the other.

Of some interest in interdisciplinary research is the means by which project Acorn was developed. Here awards were made of $5,000 each plus overhead. Fifty such awards were made, for a program total of perhaps $350,000. Investigators were asked to submit proposals to be judged and the proposals were judged by a panel of eighteen reviewers. Each proposal was reviewed by two reviewers chosen from the panel. They received many proposals of varying quality and some of these grants went

to universities. They also have twenty graduate fellowships which are awarded at selected schools in selected areas. If their present planning continues, they plan to institute three or more internships in Washington at the Institute.

Because of their uncertainty of budget between the $7.5 million and $20.9 million figure their program for next year is obviously quite undefined.

I. Housing and Urban Development

Urban Management Assistance Administration

The director of this division is Melvin Wachs, whose title is Director of the Community Development Training Division (755-6170). The thinking behind the development of this program is that there is an almost total lack of skilled people with a background capable of meeting and finding solutions to complex urban problems. What has been attempted is to get up such training programs. To accomplish this end programs have been set up to create new courses and curricula which eventually might lead to a degree. In order to do this, the Housing and Urban Development Department has, in a sense, designed a curriculum which will produce people who are equipped to tackle the problem. Subsequently, universities who are interested in offering this curriculum may do so. It may use its own staff, or may hire outside consultants, so experts in the field can be involved.

There is no funding to the university to do this. But, if the university does undertake to offer such curricula, the students will be supplied by the governmental units seeking

trained people. In addition students will be supplied not only by Federal and municipal governments, but through endorsement of the programs by professional associations. The university pays for the offering of these courses through a charge of $40 per semester hour credit fee. To date university participants have included Southern Illinois (the Edwardsville campus); University of Tulsa; University of Oklahoma; and the University of Michigan. The students for the program may be paid to take the program. In this way they can accumulate degree credits at a reduced, or at no, cost to themselves and become more expert in their chosen field. The program has been operated at the high school and college level and attempts are now being made to undertake a postdoctoral program.

This program does not attempt to sponsor interdisciplinary research, but does attempt to create what amounts to interdisciplinary curricula. As such it does not fall completely within the discussion of this paper.

J. Department of Labor

Office of Manpower Research

The man involved here is Sheridan Maitland (393-5368). Dr. Rosen is head of the Office of Manpower Research.

While manpower training in the Labor Department runs about $2 billion per year, research activities are funded at only about $2.6 million per year. The budget request for this year is for $6 million, but the outlook is not bright. The research is carried out through contracts on an unsolicited basis. Most of the work is done with universities. It is

possible, however, to work with profits, non-profits, individuals, etc., if the occasion presents itself. Usually, though, the research is funded as a project grant to a university. In addition to the $2.6 million there is an additional one million which may be spent in any one of three ways. The first of these is support of graduate students working on theses; support through this runs about $6,000 per year per student stipend plus college allowance. The second is the small research grant to postdoctoral scholars for innovative studies, development of research designs, and major studies of manpower problems. These grants range from $10,000 to $15,000 annual support and go to an investigator on a college faculty. There are nineteen research project grants active at the moment and forty-three dissertation grants of the type supporting graduate students. The third class of program, and one which is of the most interest to interdisciplinary research, is that involving institutional grants to develop new manpower research talent and long-term programs of research on local and regional manpower problems. These operate at about $75,000 annual level with an intent to continue each grant over a three-year period. Funds are awarded on the basis of a proposal from a principal investigator who integrates several pieces of research into a theme area. Proposals are judged by outside panels, and this year there are seven of these programs in existence. Holders of these programs include Atlanta University, Iowa State University, University of Maine, North Carolina

State University, Oklahoma State University, Temple, Virginia State and Virginia State at Norfolk. In the competition, the Office of Manpower Research received seventy or eighty proposals for the seven awards made. This year they hope to add an additional three programs at universities, for a total of ten.

In addition to this program the Manpower Research Office also gets transfer funds from the Social Security Administration, from OEO in connection with the work incentive program, to an amount of $1 million. These funds are used in the research phase of programs of interest to the Social Security Office and OEO.

K. Department of the Interior

There are several offices in the Department of the Interior which sponsor research which might be called of an interdisciplinary nature. While they do not have any interdisciplinary programs designated as such, various programs of the Office of Water Resources, the Federal Water Pollution Control and the Office of Saline Water do support interdisciplinary research. Plans are under way, however, to develop on a more formal basis the approach to interdisciplinary research.

In passing, one unique program which has been sponsored by the Fishery and Wildlife Section of the Department of the Interior involves the support of an individual, a senior investigator, who teaches on a university campus. This support is for $40,000 per year to the university, which supports the senior investigator and two graduate students. This program was started over forty-one years ago and, according to Interior,

over 5,000 people have been exposed to the problems of fisheries and wildlife through this program.

Interior is, in the future, going to face many problems requiring interdisciplinary research activities. Earlier in the paper the problem of the relative extinction of the haddock in the North Atlantic was referred to. Equally large are the problems involving the inland lakes and the source of fish which can thrive in those waters, and the general problem of establishing an equilibrium ecology in those areas. Formal plans for programs are, however, in a preliminary stage.

A good reference point for developing programs in the Department of the Interior is Dr. Gordon Everett, who is staff assistant to the Assistant Secretary of the Interior for Water Quality and Research, Department of the Interior. His phone number is 343-9495. For the three elements named above, people who understand the nature of the programs are: (1) Office of Water Resources Research, Dr. Gordon Everett; (2) for the Federal Water Pollution Control, Dr. David Stephan; and (3) for the Office of Saline Water, Dr. W. Sherman Gillam.

L. Office of Education

Basic Research in Education

The man responsible for this program is Dr. L. Goebel (963-4720).

This program is a relatively new one and runs abour $2 million per year. It is conducted out of the basic research section of the Office of Education. Grants under the program usually run at the $40,000 to $50,000 per year level, and the

aim of the program is to get various disciplines involved in conducting research in conjunction with the more traditional Education Departments. In particular, one of the programs interests is the biological side of learning, including psychometrics, etc. It is an attempt by the Office of Education to create interdisciplinary research activity, at least between the schools of education and the rest of the universities. Because of its newness, it is relatively difficult to evaluate the progress made, but it does appear to have solicited interest from many universities and, in some cases, programs showing promise.

M. The National Aeronautics and Space Administration Sustaining University Program--Research

The man in charge of the Sustaining University Program Research is Mr. Herbert Quinn (962-4366).

The Sustaining University Program research program has, in its history, made awards for multidisciplinary research to approximately fifty universities. These funds amounted to about 10% of the total research funds provided to universities by NASA. They were aimed at interesting and involving universities in the space-related sciences. They fall within the category of mission-oriented block grants, in which NASA requested the universities to define for NASA what activities in space-related research they would undertake. The proposals which were received were then evaluated by the NASA staff and, where the definition of space-related research coincided between the agency staff and the university personnel, multidis-

ciplinary research projects were funded. Typically, a committee was set up at a university and the committee decided on which particular projects contributed to the overall space-related theme as developed by the university.

These grants ran sometimes to quite large dollar figures, but were generally in the range of the $100,000 to $300,000 annual level. These funds were (and are) made available to the universities in a step-funding technique, so that the three-year period of support would be assured. The university committee was given total discretion in day-to-day control over how to spend the funds which NASA supplied. Their responsibility did include, though, writing a new proposal each year to assure three-year continuity, and in that proposal an account of how the funds for the previous year had been spent.

At one time the NASA Sustaining University Program research component was funded at a $15 million per year annual budget. It has now been reduced to $5.5 million per year with a consequent reduction in the number of universities taking part and in the size of grant being awarded. Evaluation of the research is performed internally by NASA personnel. This has led to previously-mentioned problems of evaluating multidisciplinary or interdisciplinary research aimed at five to ten years ahead by a staff which, by its very duties, must be concerned with the present day activities of the Space Administration. The fact that the program has decreased in size, though viewed from the point of view of the university community and the country as a whole it has had success, is an

example of the difficulties inherent in funding and evaluating interdisciplinary research. It has been very difficult to point to concrete results of the funding of the interdisciplinary research, except that at universities throughout the country there has been created a coordinating committee which understands what interdisciplinary research is, if not perhaps understanding how to implement it. Important research results have been achieved, some of whose implications are not as yet understood.

N, Others

There are undoubtedly many interdisciplinary programs of research which are not covered in the above list. It is to be noted that the programs of the Agriculture Department do not appear, although a good case can be made that agricultural research is certainly interdisciplinary. They have not been included because a specific program for causing interdisciplinary research is not in existence. This, perhaps, is a serious omission. In addition, the Agency for International Development carries on a program in interdisciplinary research. This centers on the problems of population, development and various other investigations appropriate to international consideration. At present they have interdisciplinary grants at seventeen universities supported at somewhere between $6 and $8 million per year total. The universities involved are Tufts, University of North Carolina, Johns Hopkins University, University of Michigan, Ohio State University, University of Illinois, University of Missouri, Kansas State University,

Penn State University, University of Tennessee, University of Arizona, University of Utah, University of Colorado, Southern Illinois University and the University of Rhode Island. The focus of these problems include the study of the development of democratic institutions, population problems, agriculture in India, water control problems, the economic development of Africa, the problems of Viet Nam, and fisheries. They, however, are not strictly speaking interdisciplinary research programs of the type discussed in this report.

SECTION VI

Conclusions and Recommendations

Interdisciplinary research involving joint efforts of physical and social scientists is a development in response to a relatively recently felt need. Its beginnings occurred perhaps less than ten years ago. With such a recent advent, it is not surprising that results so far have been less than outstanding. Many agencies have attempted to encourage this type of research in many ways. This report has succeeded only in scratching the surface of data available--data which exist, but which have not been compiled or analyzed. In spite of this, several conclusions can be drawn. These are listed and discussed below.

1. The number of institutions able to conduct interdisciplinary research is very small compared with the number of colleges and universities in the United States. Congressman Daddario, using data compiled by the staff of the

National Science Foundation, estimated that less than 50 universities were capable of these activities. Dr. John Steinhart, of the Office of Science and Technology, in conducting a study on Environmental Quality Programs in universities, has come to a similar conclusion. In his analysis he applied two criteria to determine which institutions were so equipped. These criteria were that the interdisciplinary units were in a position to

a) enter into the reward system (hiring, promotion, tenure, etc.) of the university and

b) offer courses, if not complete curricula.

These criteria are very realistic in that they strike to the heart of the question of where academic "power" resides in a university. (Parenthetically, he found one university with over 150 institutes, or centers, which leads to the suspicion that many of these exist mainly on paper and for the purpose of writing proposals and obtaining grants.) Steinhart points out that his two criteria are necessary, but certainly not sufficient conditions for the existence of the ability to perform interdisciplinary research.

2. Interdisciplinary research can occur only at institutions where the central administration clearly believes in it. The modes for conducting interdisciplinary research conflict with the organizational structure of the usual university, and so conflicts between it and that structure will occur. To allow the unit to function, the administration must offer strong backing and occasionally come into

conflict with its senior faculty and department heads.

3. The Federal agencies seeking to administer and stimulate interdisciplinary research are themselves discipline oriented. They have grown in this way and are administered by those whose training was in discipline-oriented colleges and universities. To effectively encourage and carry out interdisciplinary programs, this fact must be recognized and overcome.
4. Valuable experience with various approaches has been accumulated over the past ten years. Consistent standards of evaluation, both pre- and post, have not been developed. The problem of program evaluation versus project evaluation is a recurring and troublesome one.
5. Universities are changing rapidly. Very few could predict the nature or magnitude of the changes that have occurred over the last three years. The cries of "relevance" and the awareness of the need for study of "real world" problems are not unrelated. If we accept the premise that the development of means to consider such problems is the next state of evolution for the university (and government), then perhaps the time is right for rapid progress.
6. Truly interdisciplinary research requires more than one-agency coordination. This coordination must involve leadership roles, before the fact, for the various agencies--not just collecting results after the fact. No mechanism presently exists to accomplish this end. With the static funding of the past several years, it is unlikely that any

multiple agency funding and administration pattern will develop, unless it is consciously created. At present, large enough coordination problems exist within a single agency.

7. Certain variables have been experimented with by various agencies. Among these have been size of grant, duration of grant, modes of funding grants, monitoring and evaluation techniques, program definition and others. Effects of these variables in terms of results have not been analyzed.
8. Interdisciplinary research "uses" the results of basic research, but in itself may not be basic research. It cannot exist, then, in a vacuum from the usual discipline-oriented research. Possibly "function-oriented" departments will be established in recognition of this fact. Because of the differences between discipline-oriented research and interdisciplinary research, it could be that only universities of a certain critical size can be expected to undertake programs of the type under consideration.

With these general conclusions in mind, some recommendations for further activities in this area can be developed. Among these are:

1. Efforts should be made to define problems in a way that is understandable to the agency and to the university. It is not enough to say that we should develop programs in environmental quality. The time scale for solution, the

scope, the resources available as related to time available and scope are some of the administrative questions which must be considered. In addition, the problem must be studied in such a way as to allow prediction of the most appropriate means of matching administration, funding, and elements of university and government for achieving success. Enough data exist, in uncollected and unanalyzed form, to begin this work.

2. The process of identifying universities capable of responding to the demands of interdisciplinary research has been relatively haphazard. Dr. Steinhart has identified some necessary conditions. In Appendix A are listed some others. The need for deeper considerations of this type is evident and would be eminently valuable to both government and universities. For the government it would simplify the problem of choosing candidates for its programs. For the universities, it would allow internal evaluation of capabilities and show it the way to development of additional capabilities. Research toward this end is vitally needed.
3. The agencies must recognize their discipline-oriented make-up and accommodate to the needs of the next decade. Various industrial labs have developed the concepts of "matrix" management to a high degree. Implications of these techniques at the agency level should be considered.
4. For the short term (less than ten years), pursuit of interdisciplinary mission-oriented research, two techniques

seem most likely to result in success. Which is used depends on the various factors discussed above--particularly the need for problem definition and subsequent goal setting. When this has been done, the most likely routes are the two below.

(a) The first involves entering within the universities to establish and foster units which can carry out interdisciplinary research. These units must have the academic "muscle" which Dr. Steinhart suggests. They must further have a leader and the backing of the university administration. They must also be aware of the problem which is to be solved, the time scale in which it is to be solved, and the resources for solution which may be expected over the next few years. Given these conditions, it is entirely possible that good interdisciplinary research related to the real problems of our day can be carried out at the university. The problem lies only in the number of universities which are willing and able (or have the ability) to secure these conditions referred to above.

(b) The alternate approach, if the problem solution is vital and if the delay time necessitated by the development of appropriate numbers of groups at universities is excessive in terms of the solution time acceptable to society, involves the setting up, adjacent to universities, of agency on-site extensions or non-profit organizations. These on-site extensions or

non-profit organizations should again have a clearly defined problem to attack. They should function in such a way that they can utilize the resources of the university in terms of people, thoughts and at some times equipment, and integrate the results obtained, through use of their staff, into solutions of the problems which are their responsibility. In setting up such units it is evident that there must be a clear understanding of what these units will do with respect to the actual university itself. Hopefully, students can work there. Hopefully, faculty will be employed. But these agency on-site extensions or non-profits are certainly not substitutes for the educational institutions. They should not be thought of as degree-granting institutions in any sense. They should be thought of as ways to expose students to the real problems of the world. Students and faculty having seen these can then develop their talents in such a way that they can make approaches to the complex problems being faced by society today. Over the long run it would be hoped that the faculty and the students would trigger a diffusion process into the universities with the result that many, many more institutions would equip themselves to undertake programs of the sort so necessary in solving the problems of the future.

APPENDIX A*

Some General Considerations on Awarding Interdisciplinary Grants

In the process of deciding to whom to award grants structured as are the Multidisciplinary Grants (MDG) under the NASA Sustaining University Program it appears that there exists almost a check list of factors which could be used to determine whether a prospective program will prove successful. The answers to questions on this check list might also be used, if they were asked over a period of a few years, to evaluate progress much as a PERT chart is used. This questioning always would bear in mind that "success" here refers to success in responding to NASA's mission in an administrative sense.

In particular this success means that the university will undertake interdisciplinary research in a subject area or areas of interest to NASA. The check list could be extended and expanded. For example, it should be extended to critical scientific evaluation of both the work performed and its connection with what NASA plans to be undertaking in the future development of its mission. All that this check list hopes to determine, in a gross way, is the administrative and intellectual maturity at the time NASA awards a grant and as time proceeds subsequent to the grant. If the maturity does not exist, good work at a university which takes place in spite of a system, rather than because of it, tends to be done by separated

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* Appendix A is added as an operational guide to some of the factors affecting the university's ability to perform interdisciplinary research.

individuals rather than be interdisciplinary in nature. When the conditions are right, this use of individuals with a special competence makes sense, but it does not lead to collective efforts in interdisciplinary areas.

Below, the check list has been divided into four areas in which there is admittedly much overlap. They are:

(1) Financial

(2) Administrative

(3) Intellectual

(4) Administrative-intellectual

The specific factors all have an administrative cast, however. The categorizing is also quite arbitrary. While all the questions raised can be pursued to greater depth and expanded into new questions revealing finer structure, at the very least they provide a framework to derive a fair estimate of how a given college operates, with the expenditure of only a brief amount of time by the potential agency sponsor.

I. Financial

(1) What is the total grant budget of the division or divisions to which you will award the grant?

Answers to this question, when viewed in relation to the size of the proposed NASA commitment, will give data on how effective NASA money will be. Since the financial size of a typical NASA grant is of the order of $100,000-$200,000 per year, and since Pitzer, among others, has calculated the cost of producing one Ph. D. at $75,000, then the impact of NASA in

creating 'new' programs from scratch will not be large. Although a precise estimate of what funding technique should be used is impossible, perhaps a grant less than $100,000 per year would not serve NASA's purpose, if the "background" grants of the university amounted to less than $700,000 to $1,000,000.

To pursue this aspect further, if the "background" of grants is very large compared to NASA's contribution, then effects from NASA will probably not be easily identified except in terms of individual, specific contributions. This is the case at a large university. All this implies that there is an optimum size university at which a MDG can produce real and visible effects. Too small and the structure cannot handle it; too large and the results are smeared.

(2) Is there a research office established at the university as a separate entity? How does it relate to the financial side of the university and how does it relate to the academic?

If there is no coordinator, director or dean of (or for) research, this indicates either a lack of activity or a lack of interest in the undertaking of research in the university. Depending upon the university involvement and history, this position may be at the vice presidency for research and/or graduate studies level, or be an associate dean of the graduate school or have any of the titles above. What is important is that the position exists and that it be occupied, essentially full time, by someone. The existence, of course, relates directly to the implications of (1) above, except in those

cases where an administration has decided to "force feed" a university even where no immediate financial reason dictates.

There should be defined, at least, how the office operates with respect to the financial side, some coordination of policy, some feedback; and there should be some interaction on the academic side, perhaps an academic appointment, or some evidence that the office is held by one capable of being accepted by the university faculty as an equal. Otherwise, the office or unit is one akin to that of a bookkeeper and therefore cannot be effective in stimulating and carrying through on the "new" programs which NASA hopes to stimulate.

(3) Financial records of grant history, expenditures, etc., should exist in some form.

This may sound ridiculous, but in some universities no one knows who has a grant, what state of expenditure any grant is in, who gives a go-ahead to the proposer, who has to agree to the terms of a contract or grant, or other similar questions. Granting funds to such an institution carries obvious "high risk" features.

II. Administrative Factors

(1) Is there an individual in a unique spot who will administer the grant?

This individual should have the complete backing of the president. This individual should not be a committee, although he might well use a committee for advice. The individual also should not occupy an academic position which, in the

academic political scene, makes it difficult or impossible to operate effectively. For example, if the principal investigator of a grant is dean of a division, it is quite likely that he will have difficulty operating effectively, since in his day-to-day interchanges with other divisions much more, in an immediate sense, is at stake than in the administration of a $100,000-a-year grant. He might very well be tempted to use the grant to make his dealings with others easier, or at the very least not to make them more difficult. Depending on conditions a provost, or a department head, or in fact a man in any suitably defined position with relatively single responsibility for the grant, can be effective.

(2) If a grant is awarded, will it be run by a committee?

In view of the practicalities of the university structure, some sort of committee is necessary, undoubtedly. It can take several forms, however, It could be set up to run the grant, or it could be advisory to someone who is charged with actively operating the grant. The latter is much more likely to work operationally. It could be limited in size to five or six members, or it could run as high as 15 to 20. A small committee is indicative of a conscious choice of objectives, while a large one is not. In mission-oriented programs, a conscious choice must be made.

Further, large committees more likely will split allocations to smaller dollar amounts--a funding strategy not likely to produce collective, interdisciplinary efforts. It is important to know what is planned before a grant is awarded

since after dollars come, the funding technique may become trapped by tradition.

Lack of an answer as to what administrative structure would be used in the event a grant were to be awarded is a greater indictment of the academic structure than any of the above.

(3) What has the president of the institution said in public statements concerning the aim of the institution?

Much data is available on this point, ranging from statements indicating a concentration on undergraduate education to ideas about universities being, or not being, instruments of social change. Does the president say anything encouraging interdisciplinary research, or is he concentrating on building the strengths of individual departments? Some universities have demonstrated on their own commitments to interdisciplinary activities; others have not. It is unlikely that $100,000-$200,000 will change the aim of an institution, and so funds of this size can only be useful and effective where the institutional goal already parallels the NASA goal.

(4) How strong are the academic departments compared to other units?

For example, are there in existence Institutes or Centers which draw faculty from various departments under one roof? Lack of anything of this type indicates a strong departmental structure, one not likely to undertake interdisciplinary activities--or perhaps be able to. Ideally these institutes should be staffed with a good fraction of academic joint

appointments, or they come to resemble non-profits staffed by the "slave labor" of students without an intellectual involvement. Where no previous thinking has been done along interdisciplinary lines, the grant cannot hope to create an atmosphere of this type.

An extreme case of this may occur when even the departments themselves multiply. For example, at my own university, history has left us with three biology departments (Botany, Zoology and Physiology, and Microbiology). Other universities demonstrate this characteristic to even greater degree.

(5) Are there university research incentives?

These opportunities fall into such classes as small research funds for project research, summer research appointments and reduced load for new faculty. A rather strict interpretation in tenure regulations sometimes proves effective also.

The number of these opportunities available relative to outside support is also important, but very difficult to get at unless a special effort is made. A total financial commitment by the university of at least $1 to each $10 of outside funds would not seem unreasonable and might be minimal. Again, the existence of such opportunities to faculty is indicative of an attitude on the part of the administration.

(6) Is there a conscious plan for academic development?

At some universities the central administration has evaluated where it stands now, and how it plans to get from where it is to where it wants to be. The depth of detail

varies, but usually picking a developing area in which other universities are not active, but which is nonetheless important, and subsequently channeling resources into this area is an approach often used. If, on the other hand, no one has thought through the strategy aspects of development, it is evident that the potential pay-off on a grant of $100,000-$200,000 will not be high.

(7) How difficult is it for the university to produce an interdisciplinary proposal that makes sense?

Can the university pick an area which matches their skills, or does an outside agent have to almost select specific areas before they can identify them? Lack of ability to produce a broad proposal also is indicative of a department-centered power structure. Whatever the cause, if the university can't produce a working plan, define their problem area and accomplish this in a fairly short time, they are probably not able, or willing, to undertake interdisciplinary research activities which will be of benefit to a mission-oriented agency.

III. Intellectual

(1) What is the history of the Ph. D. granting program?

Starting a Ph. D. program is a difficult task at best. If many--say more than six or seven in the last four or five years--have been begun, it is very likely that the university is over committed at this time. Unless one of these degree programs is in an area of direct interest to NASA (say Bioen-

gineering) and in this way might automatically focus attention and efforts, NASA might better shy away from granting support other than on a project basis.

This check point bears much resemblance and connection to the question concerning the "background" grant support dealt with under I (1). It is, indeed, the academic side since Ph. D. programs, because of their expense, must inevitably be supported to a large extent from extra-university resources. It might be suspected that again the three classes of universities exist as described in I (1)--with the noted exception that this state of development, if it centers on a particular interdisciplinary area, might still be attractive for the type grant structure involved in the MDG.

(2) Does the academic personnel view the path of future development in the same way as the administration?

While not every faculty member will agree on where they want the university to go, of course, their story should be consistent with administration, or vice versa. The real thoughts are not easy to get at since there is always fear of the governmental representative, but by asking the correct questions much can be deduced. Such questions as, "If you had it to do again (or for the first time, for that matter), what would you do the same or differently?" This sort of question reduces feelings to a course of action and it becomes apparent quickly whether there is a total university orientation, rather than several diverse philosophies.

(3) Has there been rapid growth in research activities?

Bearing in mind the cautions cited in I (1), a faculty that has been expanding its research activities rapidly might be a good horse to back. The danger would be that the outstanding men might be overcommitted and shorthanded and hence that additional funding would be spread among those who think they would like to do research, rather than those who can. An analysis of who is doing what and how much of it is in order here.

(4) Is tenure considered seriously?

If there is an actual selection rather than a rubber stamping involved in the tenure evaluation, it is a good indication that the university has recognized a goal and is proceeding toward it.

(5) Does the university have any formal relationships with National Laboratories?

It turns out this is a relatively sophisticated requirement. It means, among other things, participation in "big" science and means, further, that the scientists on the university staff are accepted by the practitioners of "big" science. It also means that the thesis supervision problem, while a student is at a remote location, has been approached, considered and guidelines produced. It is also reasonable to expect that relationships with Federal centers might be more easily stimulated since no new academic pattern would be required.

IV. Administrative and Intellectual

(1) What are the hiring policies?

Do they attempt to hire at the assistant professor level generally? Can and do they sometimes make special attempts to lure promising people at higher ranks? What magnitude of funds do they use for hiring? Does the administration, above the departmental level, have any involvement in the hiring? Does the central administration merely "rubber stamp?"

An auxiliary question involves where the top administrators come from. If all the deans have been appointed after serving on the faculty for varying periods, a university preserving its past can be predicted. Change will come slowly and since MDG's require change in the traditional, the outlook for success is not high.

(2) Are there professional schools connected with the university?

While this is not a requirement, the existence of professional schools indicates a tradition of involvement with the community and its activities. A tradition of this sort brings university awareness of the type of problem which is emerging for the university to solve. If there are links, through joint appointments perhaps, between these schools and the college itself, this, too, is indicative of interest and promise.

Conclusion

While not all inclusive, this general listing has proved to be useful. The points noted have been examined at many universities and correllations with the evidence of "success" have been observed. It should be pointed out, though, that this is only administrative "success." Whether the product fit NASA's mission in a directly contributive way has not been answered in anywhere near the detail necessary. Whether this latter point can be determined is, in itself, a real question.