# DIVERSIFICATION AND THE AEROSPACE COMMUNITY





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## SUMMARY

This paper raises questions about the use of experience and knowledge of the aerospace community in some work for pressing, contemporary civil problems. It raises sequential and related issues of unemployment of professional scientists and engineers, operational and systematic definitions of civil problems, diversification of some of the work of aerospace people toward those problems, requirements for retraining, the issue of funding, and the possibly central question of need for national centers of excellence to manage and coordinate this work. Doubt is raised about the current "surplus" of professional people--being countered with the possibility of a future shortage. The principal goal of the paper is to provoke involved people to generate detailed and practical approaches for solutions--such approaches being based upon logical answers to issues such as are raised here.

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1/ Grateful acknowledgement is made of sound advice and contributions provided by Dr. Arnold M. Small, director of research, Institute of Aerospace Safety and Management, University of Southern California.

CONTENTS

## INTRODUCTION

We have all been reading daily articles in newspapers and magazines referring to the current problem of unemployment of scientists, engineers, and other technical people. Many of these articles present individual stories illustrating the extreme hardships being experienced, together with estimates of numbers of people who are out of work. They speak of highly trained professional people who have been laid off after years or decades of work in the aerospace community. Some of these people are working in gas stations, are being turned away by potential employers in the civil sector as "overly experienced," or are collecting unemployment checks--all the while worrying about how to make payments on houses, cars, and other obligations amassed during better times. Many references are made to cutbacks of funds for research and development work for the Department of Defense, NASA, and the Atomic Energy Commission. References are made to problems of colleges and universities, both in terms of funding and in placing their graduates in jobs.

Members of Congress worry about this problem daily. They are concerned with the problems of the people themselves, with the fact that their talents are not being used at the same time that contemporary civil problems are not being attacked, with effects upon the national economy, with the national investment in the brainpower represented, and with the concept of attempting to harness this brainpower for work on problems of the civil sector. The Congressional Record lists ideas advanced by MCs, to include comments about reasonably bounded civil problems and the issue of retraining aerospace people to work on some of those problems. They ask for answers to questions such as these:

How many scientists and engineers are unemployed? How many might become unemployed in the future?

How many companies have suffered from cutbacks of funds? How many of them have gone out of business as a result of such cutbacks?

What kinds of problems do we face in maintaining an R&D capability for DOD and NASA work?

How many existing aerospace organizations should survive?

What are examples of spinoffs from defense and space work that have been found useful in civil areas?

What firms are capable of conducting government R&D work in the civil sector?

How could aerospace people be used most effectively for work on civil problems:

Directly within their organizations?
In separate and special divisions of their organizations?
As separate cadres removed from their organizations?
In some other manner?

Is there a genuine surplus of trained professional people? What are possible effects upon the Country's scientific and technological posture if this were to lead to a cutback in training of future professionals?

This paper has been prepared in an attempt to bring together some current issues and ideas concerning diversification of aerospace work. It is hoped that some of its contents may stimulate thinking, provoke development of some effective, concrete, and timely ideas for solutions, and encourage more effective communication among affected parties. The expression "aerospace community" is used here in a very broad sense, to include people in colleges and universities, governments, the military, and in private industry. There is very little question that since World War II, research and development work such as that sponsored by the Department of Defense has involved many different people and organizations.

## THE PROBLEM

The problem is double-barreled: (1) How do we protect our investment in the brainpower located in the aerospace community, and (2) how do we use some of it to attack and to solve contemporary civil problems? Those questions are easily asked but they would seem to require amplification and expansion.

## UNEMPLOYMENT

For some time attempts have been made to assemble information about the aerospace cutback problem and to develop estimates of the extent of unemployment among defense workers and others involved in associated R&D work. People have hunted for estimates of (1) the number of scientists and engineers who are unemployed, (2) the number of supporting people also affected (technicians, factory workers, guards, secretaries), and (3) the number of people who are affected indirectly (community people offering goods and services to aerospace employees)--these, together with projections for the future. Available information appears to be spotty, of unknown reliability, inconsistent, and grim. Some tabulations indicate things like these:

- Employees of space projects numbered some 250,000 five years ago; now they number about 173,000. 2/
- In May 1970, unemployment among engineers was 29,000, as compared to 4,000 in May 1969--an increase of times-seven.
- Since 1970, 16,000 scientists and engineers of the aerospace community have become unemployed.
- The aerospace industry has laid off more than 10,000 people in electrical and electronic engineering alone.
- Los Angeles County had more than 20,000 unemployed scientists and engineers in September 1970. 2/
- The Department of Labor estimates that there are more than 208,000 unemployed professional and technical people--Nation-wide.
- Louis W. Thompson, writing in the Washington Post, Januray 3, 1971, notes:

  > [Employment in California's aerospace industry] reached a peak of 616,200 in December 1967, and has been in uninterrupted decline ever since. In 1970 alone, 84,000 jobs were lost in aerospace (75 percent of those in Southern California) and the decline is expected to continue into 1971, with some sources predicting a leveling-off at 400,000 employed in January 1972.

> This net loss of over 200,000 jobs is traceable to cutbacks by two governmental agencies--the Department of Defense and NASA--and to severe economic problems among the nation's air carriers.
>
> In Department of Defense contracts alone, California took a stunning blow, losing $1 billion in prime contract awards, from $6.8 billion in 1969 to $5.8 billion in 1970.
>
> .....
>
> "California's space exploration industry is in an extremely difficult position at the present time," California Senator Alan Cranston said recently. "Unless we have some firm national leadership of the kind President Kennedy provided in the early 1960s, the art of space exploration may die out and some California firms will suffer an economic disaster."

- Nationally, it has been estimated that 500,000 defense workers have lost their jobs since June 1968.
- Estimates have been cited that an additional 500,000 defense workers will lose their jobs by June 1971.
- Congressman John W. Davis, chairman of the House Subcommittee on Science, Research, and Development, is quoted in the Congressional Record, February 10, 1971, pp. H 633-634 as follows: "Turning to the national picture, the unemployment problem for scientists and engineers is projected to be no less serious. For example, aerospace related layoffs as of June 30, 1969, were 20,000. As of the same date last year, the number had jumped to 65,000. Present projections for June 30, 1972, are for 130,000--over a sixfold increase from 1969."

Notations such as the following are of equal interest:

- Of some 2,000,000 engineers, scientists, and technicians employed at the beginning of 1970, one quarter was involved in work generated by the Government. 2/
- Eighty-eight percent of all scientists working in space and atmospheric sciences have depended upon Federal programs for employment.
- Of all scientists and engineers in the aerospace industry, 44 percent are located on the Pacific coast, 24 percent are located in the New England and middle Atlantic States, with many of the rest being located in States such as Florida and Texas. 2/

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2/ These particular data were cited by Senator Edward M. Kennedy in the Congressional Record, December 7, 1970, pp. S19524-S19525.

- States whose economies are involved with defense and space work include: California, Connecticut, Florida, Georgia, Massachusetts, Missouri, Texas, and Washington.

It should be noted again that, taken as a whole, these data are sketchy and of unknown reliability. Apparent inconsistencies may be due in part to the terminology used. Note that the citations vary in referring to "engineers," "scientists and engineers," "employees of space projects," "professional and technical people," "engineers, scientists, and technicians," and "defense workers." A case could be made that the several citations refer to different categories of people but the categories are ambiguous. The basic ranges of figures, however, do not seem to disagree too sharply from those in other reports too numerous to list here. Those wanting additional information on this subject could contact the Aerospace Industries Association of America, Incorporated, 1725 De Sales Street, N.W., Washington, D.C. 20036.

Information concerning unemployment among support personnel in the aerospace community is not as easy to compile as some of the more dramatic figures we have noted. Estimates of numbers of people affected indirectly--those offering goods and services to people in the aerospace community--are conflicting. Estimates of the ratio of those affected indirectly to those affected directly seem to range from 1:1 through 20:1.

Further speculation about the numbers of unemployed people may not be warranted; the problem should be clear enough. Rather than dwell further on the negative side of the picture, let us consider some notions for doing something about the problem.

DIVERSIFICATION

For the last decade or even longer, various organizations have made excursions into diversified areas of work. With some exceptions, none of these has tended to make a major breakthrough from the standpoint of establishing a precedent for the diversification effort.

The Senate Committee Print, "National Economic Conversion Commission: Responses to Subcommittee Questionnaire," dated September 1970, describes the work of Senator Abraham Ribicoff, chairman of the Senate Subcommittee on Executive Reorganization and Government Research, in seeking opinions of industrial leaders, mayors of cities, and labor union leaders concerning Senate Bill S. 1286. The Bill, introduced in 1969 by Senator George McGovern, would establish a National Economic Conversion Commission for purposes of exploring ways of converting aerospace work to civil projects. It describes concern for avoiding a major economic crisis that might follow substantial cutbacks in defense spending after operations in southeast Asia are ended or an agreement is reached on limitation of strategic arms. The document gives complete letters written to Senator Ribicoff from various of the addressees. Answers describe some of the attempts at diversification and problems encountered in the efforts. The document is well worth reading and can be got from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price is 75¢.

Information from this and other sources seems to indicate that earlier and current efforts of the aerospace community to diversify are of historical interest only. Attempts to use off-the-shelf concepts and hardware would seem to fall in the same category. A review of such history may suggest problems and stimulate thinking but what is necessary is the launching of a brand new, organized and systematic effort.

I have spent some time talking with members of private industry, the academic community, and the Legislative and Executive branches of Government. The conversations have centered around identification of serious problems that must be solved and around questions that seem to bother members of the aerospace community the most. These conversations and joint thinking have led to generation of the following questions that appear to require answers:

1. What, in clear operational terms, are the definitions of specific civil problems in areas such as criminal justice, pollution, public transportation, safety, highway traffic, and housing?

If we want to address ourselves to the notion of diversified work, may we not begin with statements of those problems? Should not such statements involve bite-sized, but systematic, chunks that are manageable and that stand some practical chance of being solved? It is fine and good, for example, to talk about cleaning up the air. But how much cleaning do we want, and where, and by when? What are the human needs and how do we go about making necessary scientific measurements? The following, extracted from the Congressional Record, November 16, 1970, pp. E9561-E9564, while representing only one small problem from one area of civil problems, might be taken as an example of a defined and bounded effort.

Howard A. Tanner, assistant director of the Institute of Water Research, Michigan State University, is in the process of conducting an experiment, the results of which may suggest ways to combat water pollution of one type. He will channel about three million gallons of water per day into a sequential network of 5 artificial lakes--about 30 days being required for complete passage of water through the lakes. The water will be effluent from the East Lansing Sewage Plant--a typical primary and secondary processing plant. The effluent, while meeting standards concerning health and nuisance, still contains substantial amounts of nitrates and phosphates. As the water proceeds through the lakes, a series of recycling goes on. Aquatic plants placed in the lakes are expected to thrive on the nutrients in the water. They will remove nitrates and phosphates that, otherwise, would contribute to the increase of algae, slimes, and other undesirable plant growth. Later, having the approximate food value of alfalfa, the plants will be harvested and converted into food for livestock. In addition, two kinds of fish will grow in the lakes: a bass and bluegill combination and a channel catfish. In the second phase of recycling, the fish production estimate is some 800 to 1,600 pounds per acre (some 60 acres are involved in the experimental project). Some of the water from various of the lakes may be used for spray irrigation. It is expected that water arriving at the end of the series of artificial lakes will be of very high quality, being suitable for boating and fishing. With some further refinement, some of the water may be used for swimming. The project has been made possible by funds from grants. An estimated $2.4 million would be required for operation during the first 3 years. This is a very brief summary; those interested in more detail could refer to the issue of the Congressional Record cited or could contact Professor Tanner directly.

The vast majority of the civil problems involve human requirements. Therefore, both the definitions and the subsequent work must take those requirements into account. Effective interdisciplinary working teams concerned with both problem definition and the ultimate work itself would have to be composed of appropriate types of specialists, to include properly trained social and behavioral scientists who are versed in the literature and who know how to pinpoint human needs.

2. What manpower resources are available to do the work?

This may serve as a rhetorical question but it is raised to emphasize the thought that the aerospace community, as broadly as it has been defined here, is the one promising resource we have. Its people have been trained throughout a broad spectrum of disciplines such as biology and physiology, specialties of engineering, mathematics, medicine, physics, and the social and behavioral sciences.

3. What retraining of these people mught be required? For what phases of the work might retraining be required?

This subject has been discussed from time to time but I have not encountered thorough definitions of requirements. Some statements seem to imply that a complete retraining process is needed. Others may suggest that none is needed at all. Perhaps the answer lies somewhere between these extremes and would depend upon the problem contexts involved and upon the phases of work within those contexts. Various types of study and development teams exist within the aerospace community. Let us consider just one here: the interdisciplinary systems engineering team that has operated so successfully in the defense industry.

The interdisciplinary systems engineering team--seen at its best--is composed of specialists selected on the basis of appropriateness of their skills for the tasks at hand. It makes use of a process that begins by stating the problem or problems and continues working toward a solution or alternative solutions by keeping track of factors and events, together with their cross-effects and interactions. Each member of this kind of team has worked on other problems earlier and knows that even military systems, regardless of their similarities, are all different. He has, in fact, invented the expression "get smart", referring to the process of attempting to find out what is at stake in attempting to solve new and different problems.

Teams of this caliber might not require extensive retraining for problem definition phases of the work--again, depending upon the qualifications of the individual members. It might be that they would require retraining for later efforts involving hardware engineering. Suppose, for example, the team came from an airframe company and was concerned with development of a completely new type of high-speed rail transportation system. Its engineers might be behind the state of the art in designing railroad cars when compared to engineers who had worked for years in that field. On the other hand, is it possible that fresh ideas brought to bear by, say, aeronautical engineers might provide new solutions that had been obscured by earlier railroad traditions?

It should be noted well, however, that past experience has shown rather clearly that if study or design teams are composed of inappropriate or poorly trained members, their work will not be very good. A diversified systems engineering team improperly staffed or trained would likely make a hash of its work and could do a great deal of harm to the over-all diversification movement.

4. What kind of funding is required to attack the civil problems:
   - For systematic studies involving criteria and standards?
   - For empirical studies in the field?
   - For necessary laboratory research?
   - For hardware engineering?

Attempts to answer these kinds of questions in the absence of a definite problem context would be nearly meaningless. Consider the differences between a problem of selecting and training enforcement officers for police operations--people who would be paraprofessionals specialized in handling individual sets of problems, on the one hand,

and designing a semi-automatic freeway system, on the other. The problems are largely quite different. Hardware considerations (and costs) in the latter example would play a large role. In the former they would be relatively minor.

Even more important, these questions are dressed up with perhaps an artificial degree of respectability. They are far too orderly. In the real world we tend to respond more rapidly to questions of the degree to which a problem is pressing and the extent of solutions with which we will be satisified. Nevertheless, costs of work must be taken into account.

5. Where will the money come from?

This is perhaps a jackpot question. The answer would seem to lie with governments, but whether Federal, state, county, or city may depend upon many factors.

6. Will the money for work on civil problems, together with continuing funds for DOD and other Government programs, enable the aerospace community to survive?

This one becomes complicated immediately. We would need answers to other questions concerning how much money we are considering in each category, what parts of the aerospace community we want to survive, how well the civil problems are structured and analyzed, and the degree to which appropriate engineers and scientists are involved in interdisciplinary teams. In part, answers may depend upon a complex restructuring of our national goals.

7. How is the work on civil problems to be managed? Is there a requirement for national centers of excellence that would coordinate this work, disseminating information and preventing wasteful duplication of effort?

If it is true that earlier efforts of the aerospace community to diversify some of its work have been more or less random and disorganized in nature, these kinds of questions may be central to the whole problem. Spokesmen for some Government agencies have suggested that industry must come up with ideas for solutions to the diversification problem. Who knows whether or not industry has already done this? If there is one central set of questions voiced by the aerospace community, it is this:

> "Who is the customer? To whom do we propose to work on our ideas? We have developed what we believe to be a worthwhile approach to studying and/or solving thus-and-so. We have thought it out and the results of our thinking ought to be of interest to somebody. But to whom?"

This may be the principal stumbling block, elimination of which might tend to launch large scale solutions to the double problem of unemployment and lack of systematic work on the civil problems we all talk about. Many organizations in the aerospace community have been accustomed to dealing with one central customer: the Department of Defense. Work on civil problems could involve many customers: 50 States and who knows how many counties and municipalities? Would it not be possible to establish a number of national centers of excellence that could coordinate this work? Could they, with proper support, see to selection of working teams, funding, and--through dissemination of information--prevention of duplication of effort? In the latter function, for example, a community hunting for a solution to a specific problem could be informed that another, very similar community, appeared to have found a workable solution that should fall well within their budget limitations--one that they would do well to examine.

Such centers could keep themselves aware of what was going on throughout the total national effort. They could inform R&D teams of the locations of appropriate customers and/or inform the customers of appropriate R&D teams available. Within such a structure, competitive proposals for work could be submitted in the more or less standard manner.

Of course there would be many problems in establishing such centers of excellence. How should they be staffed? How could they provide for an effective balance of research and applied work--both carried out in a timely fashion? How would they go about solving funding problems? Exactly how could some sort of central management of coordinating activity be established that could, among other things, cross-feed information among various states and municipalities?

Some thought has been given to making use of the National Science Foundation to serve in such a role. Perhaps this is a correct approach. Could it be, however, that the NSF would find itself hampered and its work diluted by the addition of this task to its other roles, principally those of making significant contributions to the Country's effort for basic scientific research?

It would appear that the National Highway Traffic Safety Administration (formerly the National Highway Safety Bureau) of the Department of Transportation may be serving as such a center of excellence. But its efforts are restricted to only one set of current civil problems. It is not clear how work for diversification for other problems might be enabled. Some gross categories, within which bite-sized problems might be defined, include:

- o Urban and rural health facilities.
- o Educational facilities and environments.
- o Urban redesign to reduce population congestion.
- o Criminal justice and police operations.
- o Water-, air-, land-, and noise-pollution.
- o Low cost housing.
- o Mass transportation.
- o Air traffic control.
- o Management of airport ground operations.
- o Public communication systems.
- o Improved record-keeping and billing systems.
- o Improved nutrition and prevention of food contamination.
- o Efficient information and communication techniques enabling:
    - o employers to locate now-unknown manpower resources.
    - o job-seekers to locate now-unknown employers.
    - o identification of people really needing public aid--versus freeloaders.

- Adequate public power facilities--matched to population densities.
- Improved public recreation facilities.
- Reduction of depressed and poverty areas.
- Special facilities for education and communication techniques for improving race relationships.

While it would seem to make a great deal of sense that the centers of excellence operate on a national scale with, perhaps, each center's dealing with several related sets of problems, is it either necessary or desirable that all centers be located within governments, whether national or local? Would it be of interest to consider centers located in and of private industry and/or a university? When sufficient numbers of the civil problems have been defined clearly, would their relationships to the backgrounds and capabilities of such existing organizations point to straightforward efficiency of those organizations' serving as some of the centers?

## THE INDUSTRY-UNIVERSITY TEAM

Let us consider the concept of research and development teams involving both academia and private industry, such teams being proposed as likely candidates for carrying out some of the diversified work. Contributions that can be made by industry and by a university are complementary but slightly different. A company that has worked largely for DOD programs tends to provide a kind of vitality and rapid response that is not always characteristic of university research groups. Industry people have been trained to attack and solve problems in the face of uncertainties, in the absence of the kinds of hard data they would really like to have, and against stringent deadlines. Further, the industry people tend to be more highly qualified in matters having to do with systems engineering and hardware engineering.

The university people, on the other hand, generally provide a much more thoroughgoing expertise in research techniques: problem analysis, use of statistical tools such as multivariate analyses, and experimental designs that make use of proper controls that help to prevent confounding of effects of different factors in resulting data. Frequently, too, the university research people have amassed background information and data in much greater depth than could have been expected of industry. The university people simply have had more time to think problems through in detail and to develop concepts that are theoretically sound and are of great practical value for applied problems.

An R&D team involving a member of private industry and a university seems to be able to combine and coordinate these kinds of talents and to arrive at far more effective results in its work than could have been provided by either member in isolation. The industry people provide a more appropriate time factor for pressing problems, with an experienced eye for practical considerations. The university people, while also having an eye for the practical, can prevent the industry people from moving so rapidly that important considerations fall by the wayside. Teams of this sort have operated in the past and are operating right now. It is of much interest to observe the ways in which members of these two groups tend to educate each other. In recent times some of us have observed and worried about development of a hiatus between university work and the work of people "on the firing line." There is sometimes a question of the relevance of some academic work and a question of industry's not taking advantage of tremendous advances in theory that are being made by the university. Each, in its own way, may be tending to become obsolete. Such cooperative teams, however, would appear to be able to do much to close that kind of gap and to advance the effectiveness of both members. The benefits to be realized by the Country are too obvious to mention.

## U.S. STRENGTH IN SCIENCE AND TECHNOLOGY

The issue of survival of the aerospace community and of diversification may be one of the more complicated that the Nation must face. We have just considered some issues that suggest the magnitude of problems involved. There remain others that may have far reaching consequences. Among these is the question of maintaining the Country's posture and manpower capabilities in science, engineering, and technology. At this time we have not only the problem of unemployed professionals but the difficulties being experienced by recent graduates in finding jobs. For some time articles have addressed themselves to "surpluses" of professional people. We might wonder if there is a real surplus or if the current situation is only of transient nature. What would happen if the pendulum were to swing in the opposite direction before too long?

We have all heard and read reports that sons of unemployed professional people declare that under no circumstances would they elect to follow in their fathers' footsteps. "If, after 20 years of faithful service, Dad is laid off without warning, that is no kind of job for me!" What effect might this sort of reaction have upon our manpower resources 5, 10, or 20 years from now?

As the colleges and universities lose financial support and cannot locate their current graduates, will their necessary cutbacks in turning out qualified people provide a future national problem-- even a danger?

Dr. John D. Holmfeld, of the Congressional Research Service, has provided the following comparative figures, cited by Dr. John S. Foster, Jr. during the House hearings on the Department of Defense appropriation for Fiscal Year 1971. Holmfeld notes that they are apparently based upon a somewhat restrictive set of definitions because the absolute values are lower than those found in other tabulations. In any event, the relative values may speak for themselves.

Projection of Total Full-Time R&D Scientists and Engineers
(in thousands)

| | U.S. | U.S.S.R. |
|---|---|---|
| 1969 | 540 | 550 |
| 1971 (est.) | 570 | 610 |
| 1985 (est.) | 600 | 800 |

While we do not know how accurate these projections may turn out to be, they certainly provide grist for thought. Is it possible that our process of generating professional people and using them in work toward national goals tends to be cyclical rather than being based upon longer range thinking? Will a diversification effort tend to help both on a short range basis and in setting a precedent for future thinking? Would the diversification work indicate that, rather than having a surplus of professional people, we may even be heading toward a shortage? If indeed the civil sector problems are as numerous and demanding of of solutions as we are suggesting, may it not be that not only would available aerospace people be required but many new generations of scientists and engineers as well?

One factor that appears to be unrecognized is that some members of the aerospace community suffer not only from the crunch of financial cutbacks but from ennui of working within narrow scopes of the past. Many of the best of them are most anxious to be able to have a go at the civil problems. The very imagination that has enabled these people to work so successfully for defense and space projects could very well be unleashed with surprisingly successful and rewarding results for the people problems that we say are all around us and that we say we want to solve.

We might want to consider this: it would be a good bet that professional people working on diversified problems would not only retain their degree of readiness for reverting to defense and space work, the change of venue would likely sharpen their thinking and skills. Thus the diversification effort would serve a third purpose: one of preserving a well trained group that could serve in times of trouble.

## CLOSING REVIEW

Throughout the above we have been raising questions and thinking about the following:

1. What are we going to do about the professional unemployment situation?

2. What are operational definitions of contemporary civil problems?

3. Can we use aerospace professional people for work on the civil problems?

4. Do they need retraining?

5. What kind of funding is required for this work?

6. Where will the money come from?

7. Will that money, together with continued funding for defense and space work, enable the aerospace community to survive?

8. Do we need centers of excellence to manage the work, coordinating efforts on a national scale, seeing to funding, matching R&D teams and customers, and preventing duplication of effort?

9. What of the industry-university team concept?

10. Is there a real or a transient surplus of professional people?

I believe that this total set or problems is one of the most critical that is facing the Country at this time and that has far more implications than most of us seem to realize. I do not have the answers but suspect that some must be forthcoming and soon.