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# PRIVATE TECHNOLOGICAL INPUTS TO THE PUBLIC SYSTEM[1]

BY
HERMAN G. BERKMAN, PROFESSOR OF PLANNING
GRADUATE SCHOOL OF PUBLIC ADMINISTRATION, N.Y.U.

Debate wages on whether expenditure for aero-space activity generates inputs useful to the administration of public systems. Much of this debate relates primarily to the productivity of defense expenditure or expenditure for space exploration, and the question as to whether expenditure for such purposes might not better be re-allocated for <u>direct</u> research on such pressing problems as waste disposal, crime control, welfare administration, the war against poverty, and slum traffic control. This question is peripherally our concern here. For our thesis may be that spin-off from these directions though not made specifically for these purposes, indirectly generates technology and innovation useful in solving such public issues. Since the contracting system employing private research and development effort plays the role it does in these fields, we might well ask what can be the contribution of the private sector to these areas. This is a broad question. Research we are conducting suggests eleven areas of possible impact of space effort on the community.[2]

These remarks are confined to the area of innovation and change generated by the aero-space industry. It has generally been assumed that the greatest scientific and industrial revolution occurred at the end of the Middle Ages and that the greatest industrial changes occurred in the Eighteenth Century. But the world has gone through two more significant scientific revolutions. The first was from 1860 to the Second World War. It was in this period that the first great science-

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based industries rose. Since 1945, the world began perhaps as even greater revolution, however.

Evidence of this is the fact that in the period before the Second World War the percapita rate of increase in GNP in no country was more that 2.3%. In the post World War II period, the per capita rate of increase in most countries was as high as 8% though not in the United States where, however, per capita income was highest. On this basis, technological progress in the United States has not been as great as elsewhere. Yet despite rates of growth, an article in the New York Times points out that the $739.5 billion GNP of the United States more than equals the total combined GNP of the USSR's $333 billion, West Germany's $119.4 billion, U.K's $103.3 billion, Japan's $95.23 billion and France's $90.4 billion.[1] Further, the United States is assuming command of the future by its grip on "high technologies"--computers, microelectronics, space, communications, nuclear energy, air-craft. Eurpoe may be ahead in ground transportation, high voltage transmission of electric energy and on par with the United States in metallurgy, plastics, and synethetic fibers. It is behind in the manufacture of computers, computer controlled machine tools and jet aircraft, satellite communications, semiconductors, and microelectronics.

Among the factors accounting for differences in Eurpoean and United States technology, there is an hypothesis that these differences are due to management organization and emphasis on competition in the United States as compared with Europe. Hence, it is hypothisized that contributions of the private sector are obviously most important. Especially important are government supported research and development expenditures.

1 Dale Jr., Edwin L. "The U.S. Economic Giant Keeps Growing." The New York Times Magazine, March 19, 1967, 31, and "Technology Gap Upsets Europe." New York Times, March 12, 1967, p. 1

The "marriage" of the university, industry, and government, the Professor, product engineer, and government supervisor is a United States innovation of no small importance. This management revolution has enabled research toward user-oriented objectives. More relevant to our concern is it has enabled spin-off.in management and planning.

As we review research spending, we find that federal government support is highest in aircraft, missiles and in electrical equipment and communications. It is low in chemical, motor vehicle and transportation, machinary, scientific instruments and petroleum.. Interestingly enough the extent of research expenditure is in this order. The federal government is the major support for research expenditures in the United States. But it is industry which is undertaking with this support the major research burden, \$12.7 billion worth, as compared to \$2.4 billion being done by government itslef, \$1.7 billion by universities and \$.53 billion by independent labs.

There can, therefore, be no question that private industry is making a major contribution in these federally supported areas and that there has accumulated a vast amount of knowledge for sale.

Aerospace sales last year exceeded \$20 billion for the third successive year. Some evidently are buying this knowledge. Of small proportions but of extreme interest to us here are the sales made by the aerospace industries to the state of California aimed at solving major social problems.

The contribution of the System Development Corporation in reviewing urban information systems for the Department of Housing and Urban Development holds great promise. Major automated systems that have been used in metropolitan area planning and programming will be

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reviewed in this study. A report recommending standards for federal support of such systems will be made.

In New York, Governor Rockefeller has recommended the establishment of a central data bank to serve state and municipal governments and private agencies. He has also recommended the development of computer systems to enable the state to make effective use of modern technology. New York City is undertaking a major reorganization of local government in which a council composed of aero-space trained persons is being employed.

There are, therefore, many attempts being made to hire the knowledge gained from aero-space efforts. These efforts are important as showing spin-off capability in the face of the fact that 60% of the total research and development effort of the United States is channeled into space-military operations.

It is extremely important that spin-off generated from these sources be made available and its technology transferred as expeditiously as possible to civilian sectors. In the light of the problems facing our urban society and in the light of the high man-power absorbing area of government, it is all the more important that we search for potential spin-off of technique and technology contributions to government.

In these contexts, contributions by the aero-space industry to government is all the more meaningful.

It is also certainly true that following upon research and development expenditure in the aero-space sector, the impact of technological change has been among the greatest in this area. This is in contrast to direct

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research on water and land transit, machine tools or construction, health or education per se.

Now our basic problem appears to be that advances in the aero-space complex may be as much as a whole technological generation ahead of other private sectors and even more than this much ahead of advances in government. There is therefore some question as to whether any pay-off affording significant impact on governments can accrue to the existing generation.[1] Expediting technology transfer is a problem of no small importance. The technology is here, but agents of change are needed.

There is some hope that the process of adaptation to innovation can be expedited since a study by Frank Lynn of twenty major technological innovations during the past 60 to 70 years indicates that every step of technological development and diffussion has accelerated. Thus:

1. The average time span between the initial discovery of a new innovation and recognition of commerical potential decreased from 30 years in the 1880-1919 period to 16 years for the post World War I period to 9 years for the post World War II period.

2. The time required to translate a basic technical discovery into a commercial product or process decreased from 7 to 5 years during the 60-70 year time period.

3. The rate of diffusion for technological innovation introduced during the post World War II period was twice the rate for post World War I innovation and four times the rate for innovation introduced during the early part of the current century.

Our question assuming expeditious transfer, might be, particularly in the light of the need for better administration, what can governments learn from the aero-space industry insofar as management techniques and technology is concerned. In some quarters it might almost be treason to

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[1] Boulding, Kenneth. "Is Scarcity Dead." The Public Interest No.5, Fall, 1966, p. 38.

qualify any statements we might make as to the extent of contribution by the private sector. We Americans take such pride in our capitalist system, we are fiercely protective of the institutions which have evolved to protect private property, the profit incentive, and private enterprize.

Yet we all surely must accept that we are living in a mixed economy, though the enterprize portion must continue to dominate, if indeed it can be distinguished.

On a broad generalized and conceptual level, distinctions between public and private administrative systems and the management components thereof cannot be identified easily. It may be when we get to the nuts and bolts of planning, organizing, staffing, coordinating, budgeting, and information processing both for within the organization and relating to the publics served our problems become sticky. Perhaps most sticky are the problems of the detailed decision-making segments of an organization, the management component.

To understand potential contributions of the private sector it is relevant to note that replacing a behavioral, environmental, structural emphasis in governmental management and administration is a systems emphasis.[1] As McLuhan notes, there is a replacement and consequent clash between the "linear, sequential, professional, individualistic, mechanical technology by the new instantaneous, totally involving, amaturistic xerographic, mass, electronic technology. The whole landscape of social organization is changing as new instantaneous information--retrieval systems make possible communication flows heretofore considered fantastic."[2]

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[1] Henderson, Keith. Emerging Synthesis in American Public Administration, New York: Asia Publishing House, 1967.

The study of communication and its passage from one point to another is what has come to be known as systems analysis. Aerospace industry knowledge of communication technology and that industry's methods for attacking problems applied by analogy to governmental administration and problem solving ostensibly holds great promise in an electronic-communications oriented urban society.

The need for organization of decision making information in this world to resolve environmental land based socio-economic problems is a task for which such industries should be admirably suited. Organization based upon information flow to and from decision centers is the chief characteristic of systems design with which this industry is so familiar. But such capability is no more important than the experience the industry has had in mission or program-oriented procedures for attaining the objectives with which it has been charged. This experience with dealing in organized, bounded and complex wholes has provided a bank of knowledge of systems which by analogy can prove important.

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[2] McLuhan, Marshall. The Medium is the Message. New York: Random House, 1967.

Assembling or combining jobs, personnel and other resources forming a complex unitary working organization with the tools-the electronic devices-this industry has also developed would seem to hold promise.

These methods of attack imply planning, method, order, arrangement. They are opposite to the view that everything depends on everything else. This industry is used to working with hierarchies of systems, each a sub-set so organized as to constitute a component contributing to the whole. In any organization, a systems approach involves the understanding that no part can be considered in isolation from the overall objectives of the whole of which it is a contributing part, an awareness of the big-picture. The city itself is a system which requires management.[3]

Similarly many governmental programs which require information systems that must precede management systems constitute identificable entities. Thus, Elliot Lumbard, special assistant to Governor Rockefeller has said:

> "For systems purposes justice must be regarded as one area, as a unit, concerned with protection of the persons and property of the public. Unfortunately, however, many tend to think of criminal justice in fragmented and compartmentialized ways, with separate approaches for each of the six broad functional groupings that are really part of the one whole...Yet they exist for one purpose, it is one defendent who goes through them successively. It is true that the governmental structure for administrative criminal justice is a rigid legacy of history and intensely difficulty to change. The whole fabric of our criminal justice structure is tightly woven into our government and the life and law of our people. We have terrific difficulty in breaking free into new approaches. But systems analysis need not be restricted. They have a new chance to cut across all lines and concern themselves with function alone with an operational approach that utilizes and services the government structure as it exists."

3 Berkman, Herman G. "Planning Information Systems and Electronic Data Processing." Paper before the SDC-University of Ga. Conference On ADP In Local Government, March 30, 1965.

Thus we are able to identify a new field for study with new methods of attack--systems engineering to control and develop public systems.

The California waste disposal systems study and transportation, and criminal investigation and information studies are also examples of public systems.

The management of such public systems involves planning, organizing and controlling. These in turn depend upon information flow and communication for decision-making. Hence, information flow and communication are vital to a systems approach to so managing systems. as to solve problems.

System analysis, system design and system management depend on analogy which is expressed in models, perhaps applicable to many different systems. In macrocosmic terms there may be no distinction between private and public enterprizes. There are a number of subfields that have developed with which this industry has worked which help form models useful to a systems approach applicable equally to the private and public sector:

(a) Cybernetics, the science of communication and control.

(b) Operations research, the application of mathematical modeling to researching operations and programs.

(c) Information theory dealing with the mathematical modeling of probability distributions for clearing channels of communication of random noise.

(d) Organization theory.

All these are inter-disciplinary. A frame must bind them together. This frame is the system.

The development of systems theory involved picking out of these fields such common phenomena as to provide a general model common to these phenomena.

When these models are applied to the structuring of a hierachy of levels of complexity, a more general theory of systems becomes possible. This is a major area of private contribution to the public sector. There are procedures for identifying and studying any phenomena as a system which the aero-space industry has developed to a fine art:[1]

1. Ascertain the static structure or general frame, the anatomy or geography of the phenomena so as to ascertain the parameters of relevancy.

2. Ascertain the simplest dynamics of the system, that is the predetermined and necessary changes. This is the clockwork of the system.

3. Ascertain the control mechanisms which govern the system, i.e., the cybernetics of the system.

In studying the control mechanisms, the thermostats in the system must be identified. Describing the transmission and interpretation of information will help locate these thermostats. The emerging homeostatis model is the cybernetic or control system. To the extent a system is a thermostats, it is closed-loop system. It may be that an emerging system especially in public management will be an open-system, which can be identified and described. Such a system may be self-maintaining, with its own reproduction structure. The system thus identified must be related to the external world of which it is a part.

Thus it is well known that purposes of government change with the enviornment. Machinery for achieving these objectives, however, also change with the environment. The relations of any system nested in an

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1. Boulding,Kenneth, "General Systems Theory: The Skeleton of Science," Management Science, April, 1966, 197-208.

environment constitute the ecology within which the system occurs.[1] An approach of this type of studying the political basis of administration reveals several interesting components. Such an approach reveals that transfer mechanisms for communicating with this world must then be studied. In systems involving human actors, such as the man-in-space program, specific characteristics involve increased mobility, technological behavior, and self-awareness and multi-dimensional feedback. Human actors , of course, play as important and even more important roles in urban and public systems.

In such systems there can be identified specialized information receptors which increase enormously the intake of information, specialized data organizers or processors which provide the images. The images in systems involving humans are extremely important. For it is not the specific stimulus to which behavior then responds but to image or patterns recognized. The problem here is that prediction of behavior of these systems involves the intervention of this image between stimulus and response. The mechanism involves some type of screening process which the behaviorial sciences study.

In systems involving human actors such considerations as we have noted as to image creation, pattern recognition, and motive means that ... important to our concerns is the human being as a system, a subject also studied by the aero-space industry.

And now we come to the problem perhaps most difficult of all, the relationship of the individual human system to the social system, i.e., social organization.

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[1] Gaus, John M. Reflections on Public Administration, Birmingham: University of Alabama Press, 1947, p. 1-20.

Social organization, itself, can be considered a system independent of the human system to which it is of course related. It is here that we can begin using the term public system as describing a very special animal with which the industry has not yet had to cope.

Even with all these points of contact to the study of systems in public management, there will always be "unescapables, unknowables and absolutes" which exhibit symbiotic structure and relationship. Hence, public problem solving involves man-machine interactions where the physical environment and the"hard" tools of modern civilization constitute the machine part. But it involves more importantly the human environment. This the industry has seen less of than would be necessary for success.

Public management as a system is open in the sense that there is maintained a dynamic equilibrium as the system is influenced by, and influences, its environment, and the space ship earth is more complex than others. Such problems as encountered in the aero-space program have led to a great deal of insight into environment creation with man at the "button." But more insight is needed into man-to-man interaction. Yet the aero-space success story is sufficiently significant to have induced President Johnson in his budget message to the new 90th Congress of January 24 to urge programs for assisting state and local governments in the application of such procedures as have been successful in the aero-space sector for management of their programs.

Of particular concern now is the establishment of sound planning, programming, and budget systems requiring data and information systems.

For PPBS requires that agencies:

1. Make explicit objectives of programs and focus on identifying fundamental objectives and then relate all activities to these regardless of organizational placement.
2. Set out specific proposed plans of work to attain these objectives within a time horizon.
3. Analyze and compare the probable costs and benefits of these plans against those of alternate methods of accomplishing the same results.

Hence, PPBS involves identification of governmental objectives, explicit systematic identification of alternate ways to carry out objectives, estimates of total cost implications of each alternative and estimates of expected results of each alternative. This configuration of a number of different concepts into a package and their systematic application as a package in government is new.

In these areas, the private sector motivated by the necessity for showing profits and for generally assuring corporate growth, has had vast experience. Contributions involve knowledge of systems analysis, systems engineering, and systems management each a specific field.[1]

We are now subjecting the administrative and management component to identifiable, observable and measureable processes. Formalism, structure, explicit measurement, precision and subjective probability analysis are supplementing intuition and judgement. Obviously, computers are instruments enabling this type of information revolution for providing more effective decision results.

It is not unreasonable to ask whether transfer of these techniques and experiences involving quantitative methods can not be used for sound public administration, whether the findings of the behavorial sciences being increasingly employed in the private sector cannot be of use in governing.

1 Black, Guy. "The Application of Systems Analysis to Govt. Operations." Washington, D.C.: National Institute of Pub. Affairs,

Our question is to what extent can these developments in techniques and technology in the private sector be transferred to public systems.

We are faced here with three problems. Public apathy and lack of understanding as to the magnitude and severity of the problems with which we are faced is the first. Means of information transfer is a second. The aero-space groupd can play important roles as agents of transfer.

However, there is a fourth question as fundmental as the means of desseminating information and experience on the utilization of these techniqus and technologies..

That question is: How different is the management environment of a public system as compared to the private?

Insofar as the dissemination problem is concerned, it seems to me contribution and transfer in several areas should be possible:

1. Experience with mathematical models, techniques, and method of attack including knowledge of statistical techniques. Standards of reliability analysis can have profound effects on our everyday life.

2. Knowledge of psychological impacts and reactions of man-machine systems.

3. Computer capability and technology.

4. Knowledge of the physical universe and many of the elements necessary for maintaining life in that universe.

5. Knowledge of systems techniques involving:[1]
   (a) Establishing mission requirements.

   (b) Separating a system into identifiable components and sub-systems.

   (c) Deriving general system requirements.

   (d) Analyzing to identify optimum combination of subsystems.

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[1] Rogers, W.L. "Aero-space Systems Technology and the Creation of Environment." Paper presented at AIP Conference, Portland, Oregon, August 14-18, 1966.

(e) Establishing design and operational criteria.

(f) Testing to determine that objectives have been met.

(g) Manufacturing, assembling and operating the system.

6. A particularly important area will be those programmed decision-making areas where the decisions are routine and repetitive in the public sector.

With comments concerning possible transfer noted, we must now turn to problem areas. Firstly, major governmental decision-making for the most part may be non-programmed in that it is complex, non-repetitive, and unique. Where non-programmed information processing is involved, experience in the private sector is of a more limited utility.

More importantly non-programmed decision-making occurs in a management enviornment. The executive climate or management environment affords the climate within which ideas and people can encourage and expedite new concepts which have merit; that climate must be one where such concepts become challanges not crises, where substantial numbers of officials must be informed in some detail about new ideas, where active involvement, participation and cooperation at every stage of potential use can be encouraged.

This is not only because there are deep-rooted fears and points of resistance which must be clarified, understood, and eliminated, but also because before an efficient system should be computerized, existing administrative systems and procedures, information, and communication channels and networks have to be examined in great detail before they are concretized into expensive hardware and software packages.

The environment within which the public systems engineer must operate is not only the physical environment within which the aero-space systems engineer works for the most part. It is an environment of man-made law and regulation. The public environment differs from the private sector in several ways, some of which can be enumerated as follows:

1. Governments live close to constituents. They are visible. Accontability to the public is more important. Thus one time initially high expenditure on a system, for example, which must be spread over a number of years finds it difficult to compete for public funds of a more immediate payoff, both for program and patronage. For introducing new technology planning becomes difficult as elected support changes direction.
2. Due to the nature of the electoral process, with respect to policy making positions there is perhaps less understanding of the software-hardware requirements in the public than in the private sectors. Indeed the knowledge of technical specialization required in the field is more than can be expected of the public electing these officials. Such specialized knowledge leads to an electorate, a public, unsympathetic and indeed perhaps even hostile to expenditure for installations and sophisticated technique.
3. The problem of civil liberties is an especially difficult one in public work. Problems of disclosure on types of information which only public power can generate cannot be compared to the voluntary association which characterizes the private sector.
4. Security experience in aero-space may be applicable to some degree. But a political system has been built to assure maximum freedome from outside invasion and a moral system has developed in response which is resistant to change. An enterprise economy may depend upon this protection.

5. Public power places a particular responsibility on the public systems engineer as does public purpose.
6. Federal, state, and local laws, administrative regulations, and judicial decisions constitute the guts constraining and indeed delimiting the system. These change and as such must be studied as open systems. Federalism is the larger system within which other systems nest. Not only are centers of political power different from where they should be in terms of system design and management, but organization, funding, personnel, and programming are subject to these legal constraints. Thus constrained, aero-space technology should learn from public administration.
7. Lack of environmental standards on which to base design results not only from our lack of knowledge of the physical environment but also from the nature of public purpose. Efficiency and cost may have to be tempered as decision rules. Localness, responsiveness and accessibility rather than efficiency or economy may characterize public purpose.
8. Social objectives are difficult to identity. If decision rules are difficult to ascertain in public systems the identification of objectives in public systems are even more complex. Social welfare functions are difficult to ascertain, if ascertainable at all. Here again there are those who claim individual private welfare function maximinization may mean such impairment of freedom as to change the quality of life.
9. Lack of pertinent data systems impede study.

10. Lack of generalized analytic models for many public situations remain to be developed. Specifically, over simplification can be a major pitfall. The range of alternative systems is unknown.. Known variations technically available may be less than technically feasible in the light of vested interest and financing possiblities.

11. Political systems are built to develop mechanisms for building and maintaining political power. Job generation and expenditure allocation are as much subject to these constraints as to other decision rules.

12. Sub-systems may be the way to analyze public systems, but sub-optimination may not be relevant. Some time ago, the term satisfising solutions was coined. How meaningful this is in managing complex systems is questionable. Incrementalism, not planning, may be the only way to cope with complex public systems. If so, the planning, normative, prescriptive aspects of system analysis design and management may be impossible. If so, of what use are half-way measures where no criteria are available for judging a total system in terms of its sub-models.

13. Costs and efficiency may be necessary to assure the success of a business. Upon use of new management techniques may depend the business itself, not so in government. Resistance to change is greater in government. Tradition protects.

Despite these difficulties, contribution can and will be made though painstakingly slowly. It is perhaps best this be so in the light of the disorganization which is likely to ensue upon effectuation of possible recommendations. Indeed if such does not develop, the job would not have been worth-while. A change in the quality of our lives is what we are seeking. But extensive social disruption is dangerous; instability vs. rule of law to enable adequate private decision-making are at stake.

Because of these characteristics, the aero-space systems engineer cannot do the job himself. But by working with other emerging specialized personnel on an interdisciplinary team we can mitigate disruption. To work in public systems, the industry will have to work with those experienced in public administration, urban and regional planning, and housing, lawyers trained in constitutional and administrative law, social workers and community organizers, experts in public personnel administration and public finance, both on the local and national levels.

This teamwork the systems analyst is used to. For the systems analysts does not define or identify problems on his own. Problem identification is a team effort and the first step in systems engineering. Model construction and application depend on proper system and variable identification. Here the systems engineer must work with the social science specialists not excluding them in the search for alternative models, in establishing feasibility of and ultimately in learning the management of the system. He is a new member of the public team.

Yet we must face the fact also that Public Systems Engineering may be a form of social engineering inimical to democratic institutions and values.[1] For the aero-space technologist has been specifically trained to exclude from consideration the "non-mathematisizeable, the non-measurable, the human consideration" and values in complex social systems. He will include them only if we know more about how to subject these to measurement.[2] Measurement of human dimensions which create and condition system dynamics so far have not been as sufficiently studied in terms of mathematically treatable n-dimensional spaces. Jargon differences will not overcome real problems. Lack of familiarity with political, administrative, social, and economic institutions as they impact the public sector will not only render the public systems engineer ineffective, but can be disastrous. Needed is not only the wedding of the computer with operations research and system analysis. More necessary for advance in public problem solving is the living together of the family formed, the team which must be wielded together.

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1 Hoos, Ida. Review of the New Utopians by Robert Boguslaw, 1966.

2 Churchman, C. West. Prediction and Optimal Design, N.Y. Prentise Hall, 1961.

In a paper presented in this same city on December 28, 1967, Professor Wilensky of the University of California, Berkeley, pointed out that when there is an inability to muster the intelligence needed for successful pursuit of organizational goals, when relevent information is not in the system as a result of the lack of appropriate searching procedures, we have a case of "intelligence failure." But "when information is in the system but the intended recipient is not in a position to act upon it because he is clearly constrainted by forces beyond his control," we cannot refer to this as intelligence failure." It may really be a power failure.

Hence, as he puts it, "competent organization of the intelligence function cannot substitute for political judgement and administrative leadership." The direction and effectiveness of policy reasonable standards for judging performance of administrative leaders--are affected by intelligence. But more important perhaps are those who can grasp the limitations as well as the contributions of men of knowledge. This lesson the system engineer may learn through living with the public administrator.

Status, power, promotion, opportunity are elements in system management. Employment of on-line administrators in designing and managing from firing line knowledge may remove the cost of specialization in intelligence. The system expert may be parochial as an information producer. His distance from the user results in power failure. Lack of user input and danger from user separation no less account for power failure than the failure to provide due regard for such elements as hierarchy, specialization, centralization, occupational ideology which constitute barriers to information flow and use. The flesh of this skeleton, the public administrator, can help the system designer fill to avoid system failure.

We will need the aero-space specialist but he must be retooled. He must be trained to work with a new type of team. The emerging profession will be the public systems analyst for the training of whom University curricula will have to be developed and financed. Research in public systems will have to be developed using aero-space industry, university and government talent working in public systems laboratories. Action in these areas is necessary now.