Systems Analysis and the Fire Department: Problems in Design

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Systems analysis can be used to solve fire department operations problems if certain pitfalls are recognized.

During the past five or six years I have watched with considerable interest the courtship between systems analysis groups and various fire protection and land management agencies — an interest heightened because I am working with a Forest Service research team seeking to apply systems analysis to problems of forest fire control. Systems groups have contracted with fire departments and forestry agencies at Federal, state, and local levels on studies ranging from an evaluation of fire damage to an evaluation of the feasibility of an automated dispatch system. The courtship usually starts with a statement to the effect that a nation that can send men to the moon and back should be able to speed up transportation of men to fires, or that in a nation that can detect hostile missiles it should be possible to detect fires before major damage has been done. The spectacular innovations in defense and in space have led many to conclude that the abilities and techniques of the research and development establishment — particularly the systems approach — can solve the transportation and crime crises, air and water pollution, and most of the other social ills, including fire damage.

Although the proponents of systems analysis make a strong case, and despite the fact that the systems approach is applicable in defense and space, where human behavior is not a principal ingredient, more and more systems analysts are discovering that the assumptions, rules, and courses of action that appear so successful in many other applications cannot automatically be transplanted into the civil economy.[1]

The purpose of this paper is to point out some of the problem areas in applying systems analysis to fire protection and to suggest some solutions.

One definition of systems analysis goes as follows: "A system is a set of elements organized to perform a set of designated functions in order to achieve desired results."[2] Perhaps more important is the use of the systems approach. It is a style of analysis in which we examine all the interrelationships in a system and consider the over-all problem and objectives. It proceeds by analyzing the quantitative aspect of the human activity, the operation, by developing mathematical models that represent some of the interrelations between those aspects and by using the model to predict the reactions of the operation to various possible changes in external or internal influences. Those predictions are then available to the decision maker to help him to choose between alternative policies and plans.

Ideally, the systems approach should be a disciplined, systematic attack on problems, begun by determining what something is intended to do. A systems engineer would not merely build houses; he would attempt to obtain the best possible shelter and related subsystems of water, sewerage, heating, power, transportation, and fire protection. In that case the analyst would consider the fire system as a subsystem of a larger community system.

Systems analysis further requires clearcut relationship between need and design; that achievement be related to purpose.

[1] I. R. Hoos, "A Realistic Look at the Systems Approach to Social Problems," *Datamation*, Vol. 15, No. 2 (1969), pp. 223–228.

[2] J. M. English, *Cost Effectiveness: Economic Evaluation of Engineered Systems* (New York: John Wiley and Sons, Inc., 1968).

What would be the problems in applying systems analysis to a fire department? I shall offer some answers in terms of the rural fire department. What is said, however, may apply equally well to municipal or urban fire departments. I have selected rural fire departments for two reasons: First, that is where our expertise lies — we are conducting our research in that area; and, second, considerable systems work is already being done or has been started in urban areas — some of it specifically aimed at urban fire problems — while comparatively little is now aimed at the rural department.[3, 4, 5] Arbitrarily defined, a rural department is any fire protection agency whose responsibility includes suppression of fires that occur primarily in rural or wildland vegetation — grass, brush, crops, or forests. Consequently, I am including both the small volunteer fire department and the 20,000-man United States Forest Service.

ACCORDING TO ONE APPROACH to systems analysis, there are two essential parts of system design: the *exterior,* or that portion concerned with requirements of the system and its environment — the sociopolitical "real world" within which the system must operate — and the *interior,* or the portion concerned with design choices relative to equipment, procedures, and people — that is, the system itself. The design choices are the definitive means for meeting the stated objectives within the constraints of the exterior design, and they constitute the solution.

Before an analyst can effectively design the system itself, he should be intimately familiar with the exterior. When he has not examined the exterior there is a tendency to build what can be built and then seek out a problem for which the system at hand is a solution.[6] Here is where our systems group and, we think, other groups have made errors.

Public versus private good. Almost every activity for national defense can be considered a public good — i.e., one that is enjoyed in common; we have national defense for all, or we have it for none. This may or may not be true with other activities. Education, for example, is a combination of public and private good. A fire protection agency can be considered in a like vein. Some organizations, such as the United States Forest Service and some of the state agencies, provide protection from the general fund, their philosophy being that all the people will reap the benefits of good conservation. On the other hand, where fire protection is inequitably distributed or based on a special tax, such as a timber tax, fire protection becomes largely a private good. The inevitable result is a greater interaction between public decision and individual interests, an inherent difference that makes decisions in nondefense or civil programs more politically sensitive.

The chief of one major urban fire department has stated:

> The fire practitioner does not enjoy the controlled experiment or planned experimentation that the researcher expects . . . his solutions in prevention and suppression are frequently politically and economically restrained.[7]

On the other hand, an author contends:

> Despite the pessimistic views that are sometimes expressed, there is every reason to believe that more and better analysis would influence policy makers. Pork-barrel aims, local pressures by log-rolling, empire-building — in short, political considerations both good and bad — are obviously powerful forces, often decisive ones, in the shaping of decisions at all levels. Yet one reason that these forces are so powerful is that decision makers are rarely presented with analysis in terms of economic criteria.[8]

Objectives and Measure of Effectiveness. The problems of fire control agencies often defy definition as to objective philosophy and scope. Achieving a sound goal in policy is far from easy. For example, one's definition of a good fire control system depends on point of view and ideology. The system looks very different to the administrator, the owner of a summer home, the urban dweller, and the subsistence rancher with a long history of woods-burning.

Management has the job of selecting goals, but the systems analyst who does not know what those goals are has little chance of meeting management needs.

Early in the system development stage the analyst must begin to formulate quantitative measures of effectiveness (MOE) for the operation, to gage the output that management wants to maximize (or minimize). The determination of appropriate MOE is often complicated because the manager has never tried to formulate his standards in quantitative terms. It is further complicated in functionally divided organizations, in which each group may have its own set of objectives.

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[3] P. M. Morse, *Operations Research for Public Systems* (Cambridge, Mass.: MIT Press, 1967).

[4] G. M. Parks, "Analytical Models for Attack and Control of Wildland Fires," *Management Science,* Vol. 10, No. 4 (1964), pp. 760–766.

[5] Harold S. Weitz, "A Model for the Simulation of the Fire Services of an Urban Community," FIRE JOURNAL, Vol. 63, No. 1 (January 1969), pp. 48–55.

[6] A. C. Block, M. A. Broner, and E. L Peterson, "What's Going on Here? The Manager's Guide to Systems Analysis," *Management Revue* (December 1967), pp. 4–14.

[7] J. S. Billheimer, "Comments on the Western States Combustion Institute Meeting," *Fire Research Abstracts and Reviews,* Vol. 10, No. 2, pp. 210–215.

[8] R. N. McKean, *Efficiency in Government through Systems Analysis* (New York: John Wiley and Sons, Inc., 1958).

For example, a shop foreman may be so obsessed with preventive maintenance that an undue amount of fire apparatus is kept out of service in the repair shop. As a further complication, the MOE and even the objective may change during an analysis.

Political Subdivision. A problem that may or may not confront the fire control agency is that of splintered and overlapping political jurisdictions, which the systems analyst may have to contend with.[9] Large protection areas, such as national forests or public domain, usually are not divided. But there is a bewildering array of city, county, and fire districts whose boundaries almost no one, except possibly the respective fire chiefs, understands. An area may be so subdivided, under so many political authorities, that there is no one in a responsible position to talk with the systems analyst.

Willingness to Innovate. If systems analysis is to be successful in fire control organizations, management must be willing to accept new ideas and technological innovations. But, mindful of their limited budgets and public purse strings, public officials have traditionally tended to ignore or resist innovation. Equally critical here may be the inherent resistance of individuals to "change." The manager must somehow integrate the new tools or techniques into his present modus operandi, and that process involves careful learning, planning, teaching, and physical change. In some cases the result is a major upheaval. The administrator, with his staff, can help minimize such an upheaval. First he must conclude that he has a problem that requires systems analysis. Next he must convince his staff of the importance of the analysis, so that each member will be willing to assist in gathering data. Finally, both he and his staff must be willing to listen to the results of the analysis, and, if they agree with the findings, to act in accordance with the recommendations.

In-house Capability. There is an urgent need for management to educate some staff members who can speak the language of the systems analysts. Communications problems can arise during formulation, design, development, and – if it has ever been achieved – implementation. No plan or recommendation for action is worth much until it has been put into practice. And the putting into practice usually requires ingenuity and a thorough understanding of what is important and what is peripheral.

The manager can make the systems parts relevant to one another and avoid misunderstanding if he organizes a small group in his own staff to work closely with the systems group and eventually to monitor the implementation of the study. When the system goes into operation, people will be in a position to operate it or to train operators.

Models and Data. The Department of Defense and its agencies have a highly developed tradition of planning. The heritage of over 20 years of systematic analysis of national security problems has few counterparts. By contrast, civil programs lack mathematical models and good data. Since the late 1950's considerable effort has been directed toward the development and application of urban planning models, but they are not yet sufficiently developed for routine use, such as predicting the growth and functioning of an urban system. While models have not as yet played a decisive role in civil planning, they have proved useful in formulating ideas and in guiding decision makers. Planning models have shown their value in aiding our understanding of the effects of planning decisions. Probably their greatest contribution lies in educating their makers on the nature and relationship of the phenomena; but education is an evolutionary process. Scarcely has a planning model become operational before it is recognized as a clumsy effort, and work on its successor is begun.

Data are needed for developing models, but they must be collected for a specific purpose. In starting his analysis after the preliminary discussions with participants at all levels, and after the initial observation of the activity, the systems analyst must begin to formulate his model of the operation, to postulate the important factors and their dependence on one another. His first data-gathering, then, must help him check out the model to see whether his guesses are correct; it need be only extensive enough and accurate enough to show whether he is on the right track. If the assumed model does appear to be right, then his next data-gathering and analysis job should be designed to improve the model and to estimate the variability of the various components.

Yet data collected laboriously and habitually over a period of many years may prove to be useless to a systems analyst. Why? The data may be inaccurate, partly because of unrealistic requirements or standards. For example, if the fire boss says that the "getaway" time is two minutes, the fire crew gets away from the station in "two minutes," no matter how long it takes. Data may be useless because they have been collected to satisfy particular financial and legal requirements – which rarely coincide with the needs of the systems analyst.

Level of Financing. Used to operating in an environment of "megabucks," systems analysts usually react with disbelief when they first encounter the limited finances of most non-Defense agencies. An organization that is hard pressed to buy enough paint for its buildings will not be very receptive to expensive hardware or systems. The contract proposals for fire control

[9] Sumner Myers, "How to Sell New Ideas to the Cities," *Harvard Business Review* (July-August 1968), pp. 111–118.

systems analysis that I have seen during the past five years show that in 75 to 80 per cent of the cases the systems group greatly overestimated the financial resources of the agency they hoped to deal with. Even when resources have been relatively large, financing has been a problem.

I have seen several proposals held up to ridicule and the systems group discredited in the eyes of a fire agency because the proposed system was far too elaborate and expensive – e.g., rocket systems for delivery of fire-retardant materials. Any systems group planning to work with a rural agency should do considerable homework to acquire some "feel" for what the agency can afford before submitting a proposal. The systems analyst would be wise to forget everything about the level of financing he worked under in previous military or defense contracting.

Ivory Towerism. Working in an environment in which he has no previous experience, the analyst finds it very easy to imagine that he is gifted with clairvoyance denied specialists in the subject area, so that he brands present practices as fragmentary and duplicatory, or even condemns anything now being done by the operating agency. Another difficulty lies in the use of unjustified "simplifying assumptions" – which can produce an unworkable solution. For example, a study on the optimum location of fire stations used the assumption that only one fire would occur in the agency's protection jurisdiction at any given time.[10] That seemed a valid assumption for the particular agency, but it would be unworkable for a department frequently confronted with multiple lightning fires.

Another problem frequently encountered by the systems analyst fresh from the military environment is that civil agencies rarely display a military-like command structure, with well-defined decision points. Half a dozen people may have to approve or review a budget decision that may not be final until they agree.

On the other hand, under emergency conditions an otherwise "snail's pace" fire agency can suddenly operate with speed and efficiency. The analyst must recognize and account for such radical change of pace.

The Nonproblem. Both research and management have been guilty of wasting effort on problems that either never did exist or were not subject to solution within the framework of the study. There is a need for mutual establishment of requirements and research goals and of analytical procedures to measure the worth of any study. The president of one of the nation's major aerospace firms states that a new system usually starts with a couple of military and industry people getting together to discuss common problems; by far the largest part of his business comes from requirements established by the Department of Defense or NASA. Another aerospace executive goes on to say, "We try to foresee the requirements that the military is going to have three years off. We work with their requirements people and therefore get new business."

It is obvious, then, that the fire control agency and the systems group are going to have to develop close associations with their counterparts. Some of our less successful ventures have resulted from a study started independently by ourselves or by the using agency, with no effort at joint identification of the problem. A study aimed at developing a guidance and lighting system for night helicopter operations is a case in point. We developed the system at the request of the agency, but to my knowledge no one has used it. The reason is that all the pilot's flying time (which is determined by fatigue and safety considerations) has been used up on higher-priority daytime operations.

One almost universal rule is that the participants in an operation cannot give an outsider a balanced picture of the operation as a whole. Each person, even the manager, magnifies his part and distorts those of the others. Even more misleading is the natural tendency to remember the unusual and to forget the habitual, with the result that the analyst is likely to wind up trying to correct what happens once a month instead of working to improve what happens every day. The best safeguard is for the analyst to see for himself what the participant does as well as what he says he does.

EVERY SYSTEMS STUDY DEMANDS close and constant involvement between individuals expert in relevant disciplines. Every major problem today, whether it be civil or military, foreign or domestic, including every problem of fire protection, is multifaceted in nature. Economic, political, and social rationality must all contribute to developing a viable, workable model. Precisely because of his central role, the systems analyst should possess a deep and sensitive understanding of the social matter with which he is engaged.

On the other hand, the results of research lie in the actions of the agency's administrator. In a very real sense, the results depend on partnership of effort between the practitioner and the researcher. In general, that partnership works most smoothly if the administrator has his own systems team continually studying the system under his control and anticipating the issues he will have to decide in the near future. This is now the case in military and corporate staffs, and perhaps it will eventually be the case in many fire protection agencies. △

[10] J. M. Hogg, "The Siting of Fire Stations," *Operational Research Quarterly* (Pergamon Press), Vol. 19 (1968), pp. 278–287.