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Technological Progress as it Affects the Fire Service of the Future

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FOREWORD

This publication is essentially a reproduction of a presentation given at the Fire Management Institute, University of Southern California, on December 10, 1962. The audience was comprised of Fire Chiefs and Captains of fire departments in the Southern California area.

TECHNOLOGICAL PROGRESS AS IT AFFECTS THE FIRE SERVICE OF THE FUTURE

I. INTRODUCTION

The purpose of this report is to bring to the attention of fire service personnel some of the potential effects of our rapidly evolving technology upon the fire service. Technology is here defined as applied science; that is, the application of scientific knowledge, methods, and/or research to the real life world.

If one were pressed to describe today's society in a single word, a logical choice and perhaps the most relevant one would be "change" (see References 1 and 2). Technological changes are occurring everywhere about us at an ever increasing rate. Until the turn of the twentieth century, invention was essentially dependent upon the motivation and capability of individuals functioning largely on their own. In the last several years and particularly since the mid-forties, as the result of cold-war pressures and the efforts to supply the needs of a swiftly increasing population, there has arisen an industry of discovery. Expenditures on research in this country have increased from about half a billion to over ten billion dollars annually since the beginning of World War II. Large scale organizations and considerable resources are now devoted to discovery and invention. Technological change is being forced with a consequent effect upon nearly all areas of our economic and social life.

There is more to technological change than scientific advancement alone. Science yields knowledge and power of action and indicates what can be done to solve problems; technology, while critically dependent upon science and discovery, is a complex economic and social process which is influenced by a range of decisions by business enterprises, labor organizations and workers, military and other governmental or government-sponsored agencies, the education system, the family unit, and by the values, motivations, and interests of society in general. Further, technological progress does not bestow its benefits without cost. On the one hand, it reshapes the physical environment of human beings, and provides improved living standards and increased cultural opportunities. On the other, it raises many problems and issues for which solutions are not necessarily immediately available, problems relating to employment, organization, management, education, training, collective bargining, and other elements of our social and economic life. These are major topics for discussion in themselves and necessarily will only be mentioned here. However, one hypothetical example in a fire service context might be given to illustrate the point. Suppose that an extinguishing agent were discovered which would enable a single firefighter to suppress immediately any fire within a radius of fifty feet of himself. This would call for changes in firefighting tactics, manpower allocations, fire station and equipment distribution, training, budgeting, and a host of other factors which could not be neglected. Thus, the overall configuration of the fire service would be altered as a result of this type of change.

Section II will discuss some of the important implications of technological progress as it relates to the fire service. Section III includes two illustrations of the potential application of present technology to areas of concern to the fire service. The last section reiterates the major points upon which the writer feels attention should be focused.

II. TECHNOLOGY AND THE FIRE SERVICE

A prime objective of this presentation is to submit that the time is at hand for fire service administrators to decide how actively they wish to participate in seeking to influence the impact of the rapidly advancing technology upon the fire service. There are several ways in which this participation could proceed. For example, fire departments, particularly the larger departments, might develop an internal competence for assessing the technological state-of-the-art as it relates and could be applied to the fire service. Among other things, this would entail selecting and training uniformed personnel to assume this function. As a second alternative, this competence might be utilized on an as-needed basis through an associated unit created for this purpose within a governmental complex. For example, in a municipality this unit could be made available to various departments and bureaus under the direction of the city's administrative head. Third, assistance might be sought inside (example, National Fire Protection Association) and/or outside the fire service on a consulting basis. In particular, there are several agencies outside the fire service (example, University of Southern California, Los Angeles) from which assistance might be gained. Fourth, fire service administrators might well consider blending the foregoing alternatives to obtain the most for their money and efforts. There is still another alternative, namely, taking no action whatever. Selection of this alternative, either directly or indirectly by neglecting the issue, is to be avoided since it would reduce the fire service's influence upon its own destiny. The point in question, then, is how to proceed, not whether or not to act.

III. APPLICATIONS OF CURRENT TECHNOLOGY

The two examples included in this section will be examined to see more concretely what technology has to offer the fire service today. These illustrations represent only a limited sampling of the types of contributions that might be made. Further, they emphasize the methodological aspects of technology since the writer feels himself more competent to speak in this context.

Terms such as "systems approach," "systems concept," and "systems engineering" are frequently used in today's technology. The two examples presented in this section are embedded in systems philosophy, so a general definition of a "system" should be attempted. For our purposes, a system is defined as a configuration of man and/or machines functioning together to carry out a common objective(s). Thus, a fire department with its personnel, fire apparatus and other components is regarded as a system under this definition.

Modern man-machine systems typically go through a design and development phase, are analyzed and modified as time and economic factors permit, and eventually are considered to be mature. During the design, development and modification cycles, optimal trade-offs are sought between man and machine for producing the most efficient system feasible.

Operational fire departments necessarily do not have the opportunity of progressing through a design and development phase and all too often find themselves forced to modify their operations on a daily basis. The first illustration suggests an approach for reducing the number of recurring problems through the utilization of system analytical methodology. This example has been taken from the Conference on Los Angeles Mountain Areas and Disaster, held on April 17, 1962, at the University of California, Los Angeles (see Reference 3).

A. SYSTEM ANALYSIS EXAMPLE

1. Technology and the Threat

Major fires such as the Bel-Air disaster which occurred within the environs of Los Angeles during November, 1961, indicate the need for a concerted research and development effort in the area of fire prevention and suppression at both the national and local levels. A relatively high percentage of the national budget and creative brain power is being utilized for developing and maintaining our national defense against an external threat. The conflagration, one of our most formidable enemies from within, must be attacked similarly. In the interim, the fire service might well investigate the broader scope of technological achievements so that it can reap some of the fruits of nationally supported multi-million dollar research at a relatively small cost. With this in mind, it is suggested that a methodology currently employed in improving military operations be utilized by the fire service for enhancing its overall effectiveness.

2. Military and Fire Department Systems Similarities

As has been pointed out by Schneider (see Reference 4), there are striking similarities in the problems faced by military air defense systems and fire departments. The air defense system planners design their system in the light of the potential threat. There must be provisions for detecting, identifying, intercepting and destroying hostile targets. This implies adequate sensing (radars), data transmission (man and communications hardware), data processing (man and computers), and intercept and kill (manned interceptor and missile) capabilities to destroy the enemy.

A fire department's threat is comprised of the combustible materials within its area of responsibility and the potential sources for igniting them. Like the air defense system, a fire department must have threat sensing, data transmission and processing, intercept, and suppression capabilities. Both configurations are complex man-machine systems which must react quickly to the threat; both seek to deter the threat; both are intimately concerned with threat evaluation, command and control, manning, hardware, procedures, and logistics requirements. Neither is required to combat the major disaster on a day-to-day basis although the threat of a catastrophe continuously exists. This latter consideration poses problems in maintaining operational proficiency and a high preparedness level for the innumerable contingencies which arise during major emergencies. Important training implications, therefore, derive from this infrequency of exposure to the real-life environment of a major disaster.

3. Systems Concept

The systems concept is central to the suggested method of analysis. This approach takes into consideration the components, that is, the men and machines comprising a system. It also is concerned with the organization of and interactions among the components, and the procedures under which the components function. It serves to keep one aware of the overall goals of the system while examining details, to prevent one from "losing sight of the forest for the trees."

In analyzing a system in which the threat is an extremely important parameter, one can start logically at the top by defining the goals of the system relative to the threat, first broadly and then in detail. System performance criteria are derived from these objectives. These function as bases for investigating the system from the top downward. Components, component organization, component interactions, and operational procedures are examined to determine if and how they are contributing to fulfilling the system's goals. Existing problems are brought into focus for resolution. There are techniques falling within the province of operations research, systems engineering and human factors for attacking the detailed aspects of this type of analysis. A discussion of these techniques is beyond the scope of this report. It should be mentioned, however, that the services of a professional inter-disciplinary team are required for effectively employing these techniques.

4. Applicability to Fire Service

This section contains an example of the application of the systems concept to the analysis of a fire department. Figure 1 outlines some of the parameters which would be considered in the analysis. The listing is not exhaustive and is intended only to define some of the broad categories for examination; i.e., the fire department's objectives; system requirements; environmental factors; hardware; human factors; and maintenance, operation and control. Thus, men, machines, the dynamic processes which make the system operate, system maintenance, and the external factors influencing the system are encompassed. Not shown in Figure 1, although equally important, are the multitude of interactions within, between and among the categories. For example, human factors interact with hardware when equipment is "human engineered," that is, when equipment is

Objective of Fire Department

To decrease the loss of life and property by fire to a minimum consistent with budgetary constraints

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System Requirements and Characteristics

General examples: (1) Fire prevention and suppression capability; (2) capability for quickly abating the conflagration threat; (3) high command and control capability, which is critically dependent upon adequate communications.

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Environmental Factors

Factors operating upon but external to the fire department, such as:

1. Fire hazard
2. Water supply
3. Taxpayer attitudes
4. Cooperating agencies (police, civil defense, etc.)

Human Factors

Factors which enable the system to utilize man's flexibility, decision-making capability and ideational processes. Human factors considerations include:

1. Selection of personnel
2. Training
3. Performance evaluation
4. Safety

Hardware Factors

Mission of hardware is to extend human capabilities. Examples of fire department hardware are:

1. Fire engines
2. Communications hardware
3. Hand tools
4. Protective equipment

Maintenance, Operation, and Control Factors

Factors which enable the system to function, such as:

1. Operational procedures
2. Hardware maintenance
3. Administrative control
4. Logistics

Figure 1. SELECTED FACTORS WHICH CONTRIBUTE TO FIRE DEPARTMENT PERFORMANCE

designed in the light of the human operator's needs. A more specific example is the human factors-hardware-maintenance interaction which occurs when a radio technician repairs communications hardware. Still another example is the distribution requirements of fire stations relative to the threat, and the subsequent manning requirements stemming from consideration of these factors as they integrate with each other.

These are the types of parameters with which the systems analyst concerns himself. It is to be emphasized that there can be, and usually are, multiple solutions to specific problem areas. It remains for the systems analyst to choose that configuration of solutions to the various specific problems which yields the largest payoff.

5. <u>Value of the Systems Concept to the Fire Service</u>

The systems approach offers the following benefits to fire departments:

a. Manpower, equipments, operations, and procedures are considered as a unified whole as they relate to carrying out departmental objectives. Sound bases are provided thereby for: specifying qualitative and quantitative manpower requirements, specifying equipment requirements, and improving operations and procedures.

b. External environmental conditions are evaluated relative to their effect upon departmental objectives.

c. Long-range planning is facilitated.

d. Budget requests can be justified in logical detail.

e. Research and development needs are brought into focus.

f. Project priorities can be established in logical sequence.

g. Human factors considerations are viewed in appropriate perspective. Personnel and training requirements are defined in the light of actual system requirements.

h. Iterative aspects of systems approach keep department dynamic and up-to-date.

These considerations are not necessarily being overlooked by the fire service at the present time. Fire departments, however, are required to provide a continuous service to the public from the time they first become operational. They are subject to the conventional budgetary constraints and austerity programs imposed upon governmental agencies. In consequence, the tendency is to concentrate upon the specific day-to-day problems. The combination of these factors invites organizational appendages, created to resolve specific problems. In contrast, the systems approach would enable a fire department to minimize this type of problem-solving behavior and to anticipate and plan for the future. It would also offer a high degree of assurance to taxpayers and fire departments that maximal fire service protection per tax dollar was being afforded for a given degree of conflagration risk.

B. SYSTEM TRAINING EXAMPLE

The second example is concerned with system training and has been chosen for illustration because of its contributions to the effective performance of military defense systems which, again, are much like fire department systems.

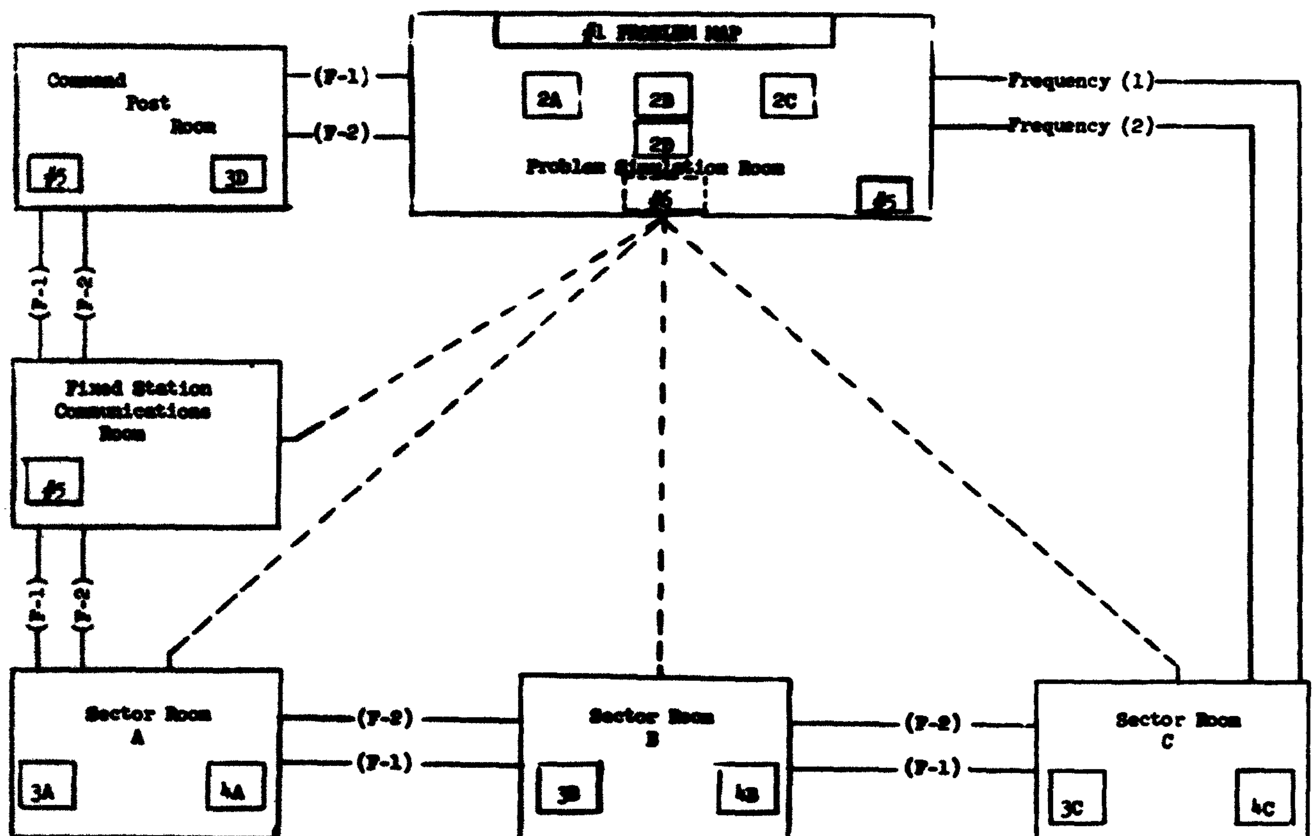
System training of fire departments for conflagrations has as a primary goal the exercising of participating units (fire companies, command post personnel, line chiefs, etc.) as a unified whole so that they will better learn to work together as a system. This is accomplished by providing the units called upon to operate in a conflagration with the opportunity to function as a team, to learn system skills, and to adapt readily to a simulated large fire presented under controlled conditions. Although emphasis is on unit interactions because of their importance in system operation, the development of component skills is not precluded as an adjunct to this type of training.

A specific example of system training is provided in an exercise presently being formulated for a large municipal fire department. The purpose of the initial exercise is to provide limited system (subsystem) training largely at the command post level under simulated conflagrant conditions. The exercise will include three fire sectors (battalion chief's level), command post (deputy or assistant chief's level), and various other services such as land-based communications, supply and maintenance, and police support. No operational equipment will be employed, and the exercise will be conducted under one roof. A three-sector fire is regarded as being sufficiently large for the initial run although plans are to simulate a much larger fire in the future.

The specific objective of the first experience is to provide an opportunity for command post-sector-auxiliary services interactions and decision-making during a simulated brush fire where human participants are taxed to a much higher degree than in most day-to-day fire suppression situations.

A simplified illustration of the simulation facilities is given in Figure 2. A three-sector fire problem is planned in advance of the exercise. Pertinent information such as the fire and fire company locations is shown on the problem map (1) which depicts the three sectors and their surrounding territory. Three of the four closed-circuit television cameras (2A, B, C) are focused on sectors A, B and C, respectively, so that each sector commander sees only his sector during the exercise. The fourth TV camera (2D) encompasses the entire fire area for utilization by the fire commander when he makes a simulated helicopter flight. Two-frequency radio communications are simulated by conference-tied telephone lines (7) so that actual radio communications can be approximated. Additional radio channels can be simulated in a similar manner although these are not shown in Figure 2. Two-way communications lines (8) are established so that fire companies and other agencies (utilities, police, etc.) can be simulated. Simulation of fixed-station communications is effected in a separate room; this facility is a participating operational element in the problem. Detailed sector maps (4A, B, C) of a sector commander's area are supplied at his facility. Maps (5) encompassing the entire area involved are provided to the command post, problem simulation room, and the fixed-station communications room.

A battalion-level chief is dispatched to the simulated brush fire to initiate the problem run. His sector TV receiver (3) in conjunction with information given him by simulation facility (6) via simulation lines (8), provides him with information upon which to base his decisions. As the fire increases in magnitude (this has been pre-planned), additional assistance is required, the command post is established, and sectors are created. The overall display (1), segments of which are communicated to the appropriate sectors via TV, and the simulation facility (6) provide basic information about the fire which can be transposed to the local detail maps (4) at the sectors. A prime purpose of the TV displays is to coordinate the problem so that unrealistic obstacles (such as conflicting information about the location of the fire) are not imposed; any conflicts which arise will be the result of the way the problem is handled by the participants, not because the displays are incorrect. The local maps and other aids such as photographs supply greater detail about specific locations. The intent is to provide the various commanders with the same general core of information available to them at an actual fire. A second important purpose of the TV display is to facilitate the presentation of a dynamic problem. This is accomplished through a problem formulator who employs the TV system as a means of communicating problem changes to the participants.



Legend:
1 - Problem Map of Overall Area
2 - Television Cameras
3 - Television Receivers
4 - Sector Maps
5 - Overall Area Maps
6 - Associated Services and Fire Company Simulation Area

——— Radio Simulation Lines (7)
- - - - Associated Services and Fire Company Simulation Telephone Lines (8)

Figure 2. SIMPLIFIED ILLUSTRATION OF SYSTEM TRAINING SIMULATION FACILITIES

The problem formulator, an expert on brush fires, is located in the problem simulation room. He modifies the problem map (1) as the fire develops by reacting to parameters such as the general fire plan, terrain, decisions made, and a host of other pertinent factors. He can modify the problem to reflect the results of actions taken or phenomena occurring on a moment-to-moment basis. His activities are coordinated with the simulation facilities (6). Coordinated outputs via TV cameras (2) and simulation lines (8) are thereby given to the sector commanders. It remains for the sector commanders to apprise the command post of the status of the fire, equipment and personnel falling within their sphere of responsibility. The personnel in the problem simulation room can monitor all communications taking place among the units being exercised. Thus, during problem time, sector commanders and personnel working with the command post have the opportunity of making sector and command-level decisions, of interacting with each other, and of functioning together as a team.

Because the fire problem is dynamic, it is important that participant behavior be observed and recorded accurately. Observers are stationed at each operational position to observe and record performance in correct time sequence. Photographs can be taken of the problem map (1) at designated intervals and later related to actions taken during the exercise.

A critique (debriefing) is held after the conclusion of the problem. The participants gather to discuss the various aspects of the system's performance during the training mission. The rationale underlying debriefing has been stated as follows: 1) Operational personnel will be greatly benefited in their learning by gaining knowledge of what has occurred; and 2) solutions to operational problems are facilitated by discussion among the personnel immediately involved.

The foregoing general description of system training as applied to a large, municipal fire department is intended to show how a current methodology might be employed to advantage for exercising those important aspects of a system which are infrequently employed. These include the decision-making, interactive, and procedural functions which are so critical during large fires.

IV. CONCLUDING REMARKS

This presentation has attempted to point out some of the implications of the rapidly advancing technology for the fire service. In particular, it has been suggested that those who would control the destiny of the fire service might well consider this wellspring of information and experience for its potential application. There is little doubt that this will be done in the future! The questions are, by whom and to what degree? The time is at hand for present and future fire administrative officers to focus their attention upon all aspects of the technological state-of-the-art if they would hope to continue to be as influential as they are at present.

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