LONG RANGE PLANNING - THE FIRE SCENARIO APPROACH

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Introduction

The Federal Fire Prevention and Control Act of 1974 appreciably broadened the mission of the Center for Fire Research at the National Bureau of Standards. New subjects include fires in the transportation and use of combustibles, design concepts for improved fire safety in structures, biological and physiological effects of toxic substances arising from unwanted fire, the traumatic effects of fire on its victims, improved methods of first aid for fire victims, characteristics of arsonists, and studies of the stress encountered by firefighters. In response to this mandate the Center staff set out to develop a long range research plan showing how we proposed to carry out our responsibilities. The result is an administrative report titled "Reducing the Nation's Fire Losses - The Research Plan," now a public document available on request from the Center.

The conceptual approach was simple:

1. List and classify fire losses
2. Define suitable ways to intervene to prevent losses
3. Define the technical content of each way
4. Define what research is needed
5. Define the necessary resources

6. Lay out milestones

7. Estimate the impact on fire losses if research succeeds and is used.

To classify fire losses requires a set of coordinates to define each loss. The Center chose six such coordinates: losses, occupancy, time, ignition source, spreading agent, and direct cause of loss. For each, a set of descriptors was established using in many cases those of NFPA. A fire incident described by these coordinates is termed a fire scenario. Figure 1 highlights one such scenario: a death at home at night caused by a fire in furnishings started by smoking materials and producing toxic gases as the direct cause of the loss. There are 5040 such scenarios. Senior staff at the Center selected those few that were felt to account for most fire losses. By clustering, a final group of fourteen scenarios were picked. These are listed in Table 2 and are discussed in greater detail later. Verification against statistically valid fire data was next to impossible because data in a suitable form did not exist. However, the NFPA had data on about 11,000 fire fatalities in its Fire Incident Data Organization (FIDO) system. These were queried by computer and the results agreed remarkably well with the Center's list. It was not possible to work with all six coordinates used in this plan; only four were available in the FIDO system. The results have been published by Clarke, of the Center, and Ottoson of NFPA in the May 1976 issue of Fire Journal. The highlights are as follows. First, fatalities were broken down into occupancies and adjusted by adding data on fires originating in apparel (Table 1). If one assumes most apparel fires occur at home then we have over 80% of fire deaths occurring in residences. Each category was further subdivided. For example, of the 72% of fatalities occurring in residences over half of these are in furnishings and most of these furnishings fires are caused by smoking. The authors estimated that 13% of all fire fatalities were caused by smoking and upholstered furniture. A special computer evaluation of this has just shown that the number is closer to 15%.

Next is the question of how to intervene in each scenario. The fault tree analysis used by the NFPA Committee on Safety to Life was reduced to four alternatives: ignition control, control of fire spread and growth, fire suppression and detection, and measures for escape, refuge, and protection. Each of the four intervention strategies was further divided into substrategies;

- ignition control
    - ° materials selection
    - ° controlling design and use of ignition sources
    - ° human behavior

- control fire spread and growth
    - ° materials selection
    - ° passive design concepts
    - ° active design concepts

- fire suppression and detection
    - ° automatic detection devices and systems
    - ° automatic suppression devices and systems

- measures for escape, refuge, and protection
    - ° detection, alarm, and communication
    - ° means of escape and refuge
    - ° anticipating human response to stress
    - ° protection by materials

Altogether there are twelve substrategies. Then we constructed a matrix of substrategies versus scenarios and checked those boxes for which we believed there was a match (Table 2). For the top scenario we found all but one of the possible ways to intervene had some relevance. For example, we can control materials used to make upholstered furniture to improve resistance to ignition, we can control the cigarette so that it goes out if not puffed, we can add smoke alarms, we can design smoke barriers, we can conceive of smoke control systems in the home, we can educate people, and so on. On the other hand, fires in automobiles and the apparel fire caused by spilling flammable liquids on one's clothing offered relatively few options. Next we took the objectives and subdivisions thereof (strategies and substrategies) and wrote out, year by year, the principal research tasks, milestones, and dollars required. In so doing only those tasks were selected which logically fall in the public sector, which are research undertakings, and which come under the Center's legislative mandate. The result is a set of tables containing a listing of planned accomplishments and required funds suitable for both program presentation and for management control, once approved.

Finally, the impact of the work was estimated. We assumed that successful research would be used fully by standards and codes groups and by industry. This is, of course, crucial. The results of this assessment are in Table 3 and show a reduction of almost 50% of fire losses by the target year of 1995. The entries are not independent. The savings from suppression strategies including fire detection, would be much higher if a variety of hazards had not already been eliminated under the efforts of ignition and spread and growth control, for example. Such factors as half lives for buildings and furnishings, time required to push a new proposal through the standards process, and time to obtain a code change, were taken into account.

The plan calls for funding to rise to about $10,000,000 a year for the Center for the base case and about $18,000,000 for a more innovative

case. At the $10,000,000 level this represents an increase above current funding of about 70%--the Center is now operating at about the $6,000,000 level. (The funds for grants formerly handled by the NSF RANN group are not included in either number.)

What is the Center's program under this plan? As you know from your program, we are not discussing the NBS program this week with the exception of one or two of our grants. In the moment or two remaining I shall simply review our organization chart (Figure 2). The Center is organized in three parts--the Fire Science and Fire Safety Engineering divisions headed by Bob Levine and Irwin Benjamin respectively, and a new unit, the Office for Extramural Research. I have designated Clayton Huggett to head this unit. With the transfer of the NSF RANN fire grants program to the Center, we will have next year about one third of our activity in grants and contracts. This work will be complementary to our in-house program and monitored by members of the individual programs. Clayton Huggett's job will be that of a general overseer working with the nine Program Chiefs and the two Division Chiefs in a sort of management matrix.

The Fire Science Division has four programs. The effort on hazard analysis, headed by Ben Buchbinder, includes collection of in-depth case histories of fire incidents with laboratory analysis of samples from the scene, and the development of a methodology of hazard assessment. This work provides a basis for new research projects for other groups in the Center. Our fire research library comes under this program. The chemistry group is headed by Clayton Huggett (he'll have two responsibilities for a while). This program covers reactions in the condensed and gas phases, effect of retardants and inhibitors, chemistry of flash fires, and general combustion chemistry. Last year we separated from chemistry the toxicology program and designated Merritt Birky to head this group. He is working on the analysis of fire gases and the response of animals to the toxins contained in the gases. He uses a large proportion of grants to accomplish his objectives. John Rockett is Chief of the Physics and Dynamics group with projects on modeling fires in enclosures, physics of smoke particles, smoldering combustion, and ignition phenomena. This group has been built up considerably over the past three years.

The Fire Safety Engineering Division is organized along the lines of our intervention strategies. Jim Winger is Chief of the Products group and is primarily concerned with reducing ignitions. Examples are work for CPSC on upholstered furniture and apparel standards. The groups on Furnishings under Sandy Davis and Construction under Dan Gross deal with controlling the spread and growth of fire. Mr. Davis seeks means of measuring and predicting fire hazard from furnishings, given a sustained ignition. Mr. Gross has the same objective for materials of construction and structures. Sample results are the flooring radiant panel test for carpeting in nursing home and hospital corridors, test results and

recommendations to HUD on plastic pipe (DWV) and on interiors of mobile homes. Dick Custer is Chief of our work on fire detection and suppression. Results of our work on detectors are now the basis of UL's method of certifying smoke detectors. We have done a lot of work on tracing smoke movement in large buildings thereby facilitating the design of smoke control systems. We are now running full-scale room-corridor studies of the flow of heat and gases from a fire in a bed in a hospital configuration. This work is being done for a project under the Design Concepts group headed by Bud Nelson. Bud and his group are developing a broad comprehensive set of design guides and operating procedures of interest to HEW. These ideas range from hardware recommendations to ways of educating supervisors and staff as to the best way to react to a fire. We hope to secure additional funding to extend this to residential fires.

This has been a brief glimpse of the program plan and present activities. We have descriptive literature available on request from my office. We would be pleased to share this with you.

Thank you.

TABLE 1

U.S. Fire Deaths*

Type of Fire	%
Residential	72
Apparel	14
Transportation (excluding aircraft)	4
Industrial	3
Institutional	2
Public Assembly	2
Others	3
TOTAL	100

*Source: NFPA/NBS Joint Project

Table 2 Matrix of Intervention Strategies and the Fourteen Clustered Scenarios

Intervention strategies / Scenarios	Ignition control			Control of fire spread			Detection/suppression/ fire control		Direct measures for people protection			
	Material selection	Controlling design	Behavior	Material selection	Passive design concepts	Active design concepts	Automatic detection devices and systems	Automatic fire suppression devices and systems	Detection alarm, and communication	Means of escape and rescue	Human response to emergency stresses	Protection by materials
Death and injuries/residence/night/ smoking, lighters, matches/ furnishings/smoke and gas	√	√	√	√	√	√	√	√	√	√	√	
Death and injuries/residence/day/ heating and cooking surface/apparel/ heat and flame	√	√	√	√							√	√
Death and injuries/independent/day/ lighters or matches/apparel/heat and flame	√	√	√	√							√	√
Property/commercial and industrial/ night/arson/flammable fluids/heat and flame		√	√	√	√	√	√	√				
Death/institutional/night/lighters or matches/furnishings/smoke and gas	√	√	√	√	√	√	√	√	√	√		√
Death/transportation/day/other/ flammable fluids/heat and flame	√	√	√		√							
Death/residence/night/electrical/ furnishings and structural/heat and flame/smoke and gas	√	√	√	√	√	√	√	√	√	√	√	
Death and injuries/residence/night/ smoking, lighters and matches/ furnishings/heat and flame	√	√	√	√	√	√	√	√	√	√	√	√
Death/commerical/day/flame/ flammable fluid/heat and flame	√	√	√	√	√	√	√	√	√	√		
Property/industrial/day/flame/ flammable fluids/heat and flame		√	√	√	√	√	√	√				
Death/industrial/day/arson/ flammable fluids/heat and flame		√	√	√	√	√	√	√				
Property/industrial/night/flame/ flammable fluids/heat and flame		√	√	√	√	√	√	√				
Deaths and injuries/independent/ day/flammable fluid/apparel/heat and flame		√	√									√
Property/residence/day/heating and cooking/fini and furnishings/ heat and flame	√	√	√	√	√	√	√	√	√		√	

TABLE 3

Estimate of Impact on Fire Losses from Fully-Utilized Research Results from this Plan - By 1995

Research Strategy	% Reduction of Losses
Ignition control	19
Control of fire spread & growth	9
Detection and automatic suppression	12
Protection by design	7
TOTAL	47

Elements of Fire Scenario and Specific Loss Paths

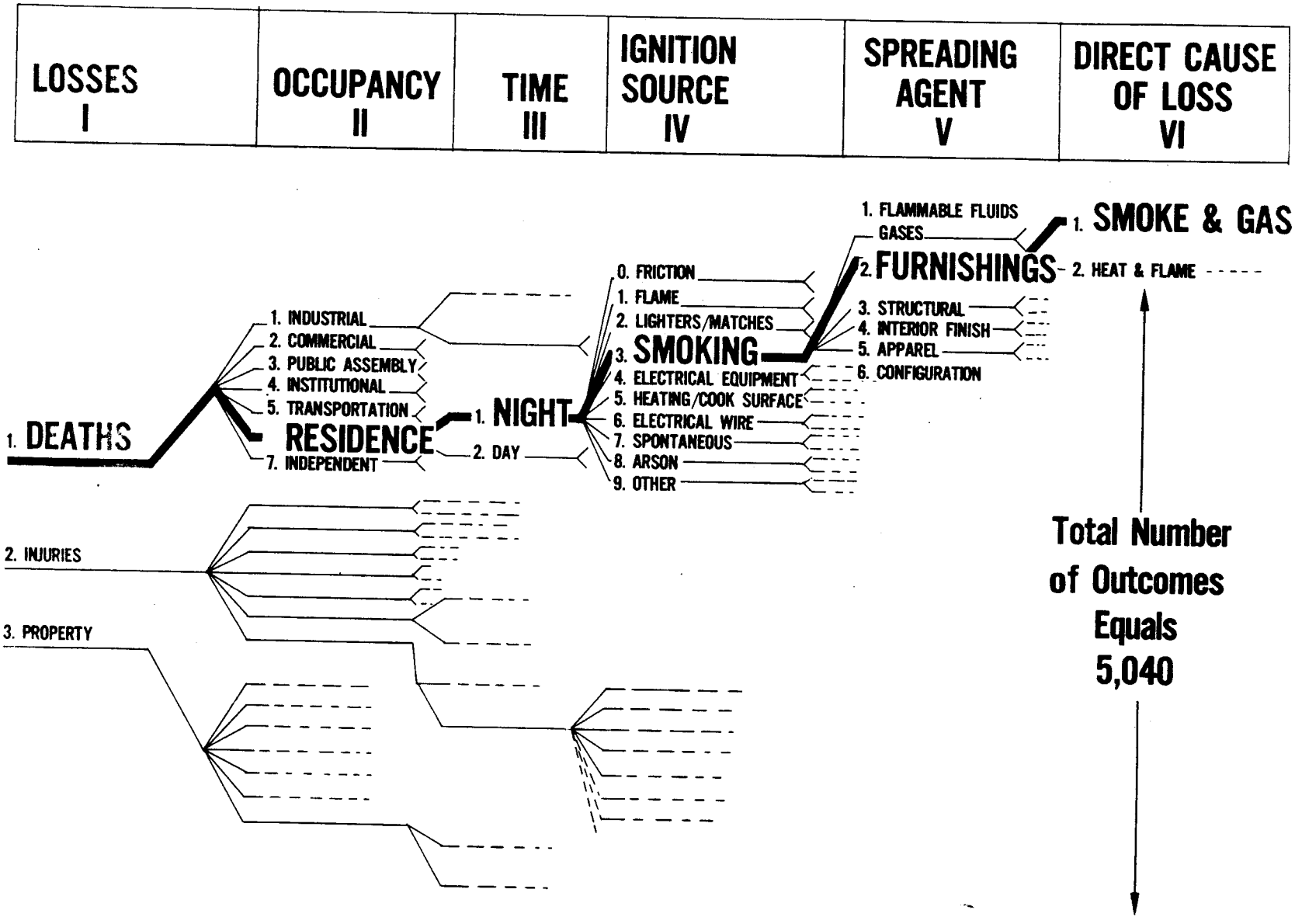

Figure 1

CENTER FOR FIRE RESEARCH

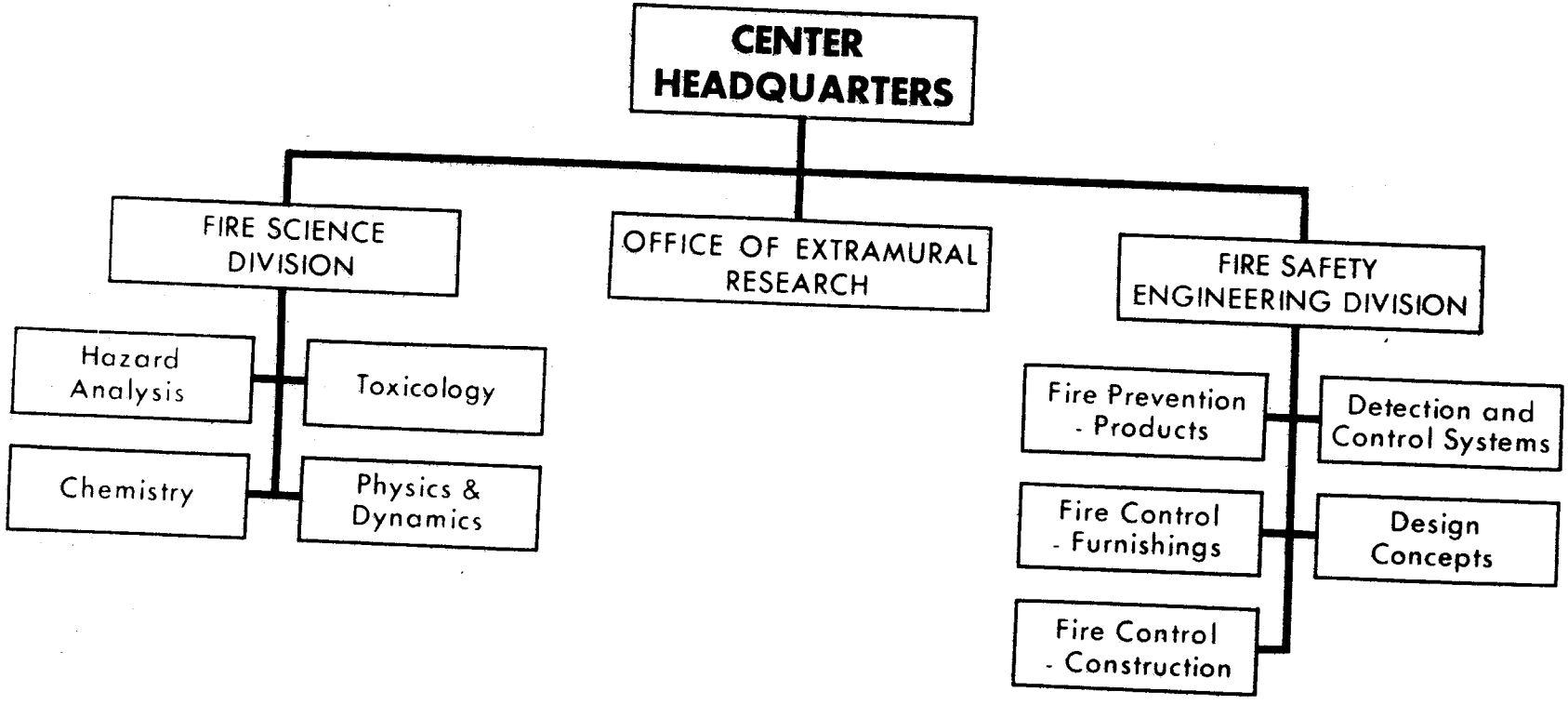

Figure 2