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Fire Risk Assessment for Telecommunications Central Offices

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Abstract

From a fire protection standpoint, telecommunications equipment facilities present a unique set of conditions. Although life safety hazards are minimal in such facilities, a fire that would be considered small in most other industrial settings can have a devastating impact on the community such facilities serve. This paper describes the development of a method that systematically assesses the fire risk associated with individual, discrete spaces in telecommunications facilities by measuring and reporting fire risk values for life safety and network integrity. The method, called the Central Office Fire Risk Assessment (COFRA) methodology, may be implemented manually or integrated into a computer-based program. It is unique in that it measures business interruption fire risk, uses decision tables extensively, and develops and treats subparameters.

Introduction

Historically, public telecommunications networks have been designed in such a way that they must be controlled by equipment centrally located in buildings called central offices or telephone exchanges. One consequence of this network architecture has been the concentration of risk: A fire or other disaster in a central office will have an enormous impact on the network. Fortunately, the record of fires in telecommunications facilities and central offices over the past 100 years has been exceptionally good. A 1993 study for the U.S. Federal Communications Commission[1] showed that a total of 189 fires occurred in U.S. telecommunications facilities over a five-year study period, and no injuries were reported. On average, 38 incidents occurred per year, and only 8 of these interrupted telecommunications service. The effects of these fires on service lasted from several minutes to, in one case, several weeks.

What's important about telecommunications fires is that the quantities of materials burned and the area of burn damage have been very small. In the most significant telecommunications fire in recent U.S. history, the Hinsdale, Illinois fire of May, 1988, the fire burned in densely packed cable trays for over three hours, but only about a 30 × 40 foot area of cable trays burned.[2] (The nonthermal damage was considerably more extensive than the thermal damage.) The fire disrupted local phone service for some 38,000 customers in the immediate area, had varying degrees of impact on more than a half a million residents and business customers in the surrounding communities, and shut down many critical communications operations, including the Federal Aviation Administration (FAA) air traffic control center serving Chicago's O'Hare Airport, one of the busiest in the nation. It took 2½ days to restore full service to the FAA control center, 15 days to restore full customer service, and more than 30 days to restore full operations in the facility. Though, by most measures, this was a small fire, the impact it and similiar fires have had on the community are of concern to industry leaders, regulators, and telecommunications service users.

Recognizing that traditional telecommunications facilities present very little life safety hazard, industry leaders have sought a means to quantify fire risk to life safety and network interruption. While many methods have been developed to measure fire risk against life safety,[3] none of the methods identified were designed to quantify business interruption risk.

This paper describes the process by which a system to evaluate fire risk in telecommunications central office facilities was developed. The process integrates technical information to the extent possible, but it depends, to a large extent, on subjective judgment. This judgment will vary among different groups of telecommunications facilities. The final product of this work is customized for use by Bellcore's client companies, the Regional Bell Operating Companies: Ameritech, Bell Atlantic, Southern Bell, U.S. West, Southwestern Bell, and Pacific Telesis. Details of the development process are presented here for public verification and to assist others who may wish to create similar fire risk assessment systems. Additional information on the underlying principles and applying them to fire risk evaluations of telecommunications facilities may be found in papers presented at the Fifth International Symposium on Fire Safety Science.[4,5]

The COFRA Methodology

The Central Office Fire Risk Assessment (COFRA) approaches risk hierarchically using a numerical grading scheme that is similar, in some respects, to other methods developed for unique occupancies, including health care facilities,[6,7] office buildings, and prisons.[8] The COFRA process allows identification of the discrete components and elements that affect fire safety, and it derives the impact of each of these without requiring a direct and explicit analysis of that impact.

However, there are several significant differences between COFRA and other methods due to the fact that the COFRA methodology addresses the risk to network integrity as well as occupant life safety. Whereas other systems of this type measure risk relative to benchmark requirements or to explicit regulations, such those in NFPA 101, *Life Safety Code* or in one of the model building codes, the COFRA method addresses network integrity as well as life safety and provides other measures in addition to code equivalency.

The methodology provides a tool for separately evaluating the fire risk to personnel safety and network integrity in an existing or proposed central office space. No mechanism in this methodology allows for combining the separate and distinct fire risks for network integrity and life safety, which are treated and evaluated as separate and discrete risks. However, this methodology can be used alone as a means to identify and prioritize fire risk levels in a specific facility or throughout an entire inventory of facilities. It can be readily merged with a "critical areas" analysis or routine cost-benefit methods to incorporate fire risk assessments into broader risk frameworks for central office operations. The methodology can also be used to optimize strategies for improving the relative risk associated with a central office space. It facilitates evaluation of alternate designs and allows assessment of multiple design candidates relative to policy issues and implementation costs.

The general COFRA methodology, its use of decision tables, and various other development particulars are discussed in several previous papers and are outlined here only in a broad form. Additional details about the method are available in the referenced materials.[9,10,11]

COFRA Structure

The COFRA methodology is designed to address the elements that affect fire risk in a facility's environment. In the context of this work, fire risk is a measure of the relative exposure risk that may result from certain hazards, and it is used to compare one facility to another and to established corporate standards. The elements were identified through a hierarchical process linking the elements directly to a fire safety policy statement. The hierarchy developed for this methodology consisted of six fire safety elements: policy; objectives; strategies; parameters; subparameters, as necessary; and survey items, as illustrated in Figure 1.

The general procedure used in developing the COFRA is illustrated in Figure 2. The first steps involve identifying the hierarchy's elements. The top-level element is a fire safety policy that specifies, in broad terms, what one is trying to accomplish. Once this is established, the lower level elements are determined, and, in this case, they include the objectives or specific fire safety goals that need to be met to establish policy, the strategies or independent fire safety alternatives that contribute to meeting the objectives, and the parameters of each strategy. The next steps are calculating the weights of each parameter, developing the subparameters, and determining the specific survey items for measuring each parameter and subparameter. Subsequently, determinations must be made about the relationships between subparameters, parameters, parameter weights, and the parameter grades that lead to the fire risk value.

Fire Safety Objectives

The fire safety objectives developed for the COFRA include:

• Providing life safety by protecting people from all hazards associated with fire insults.

• Protecting against loss of or damage to telecommunications equipment due to any fire or related insult.
• Preventing service interruption by protecting equipment from fire and related hazards.
• Preventing the impact of facility damage on people, service, and equipment.

Fire Safety Strategies

At the third level of the hierarchy, the fire safety strategies that were selected include:
• Preventing ignition,
• Controlling fire growth, and
• Managing and/or protecting the exposed people and equipment.

Each strategy is an independent alternative that can contribute to achieving the stated fire safety objectives. For example, if ignition can be prevented, all four of the fire safety objectives are met.

Parameters

The fourth level in the hierarchy consists of the individual features in a facility that represent measurable components of its fire risk. Each feature, referred to as a fire safety parameter, contributes, to some degree, to achieving the fire safety

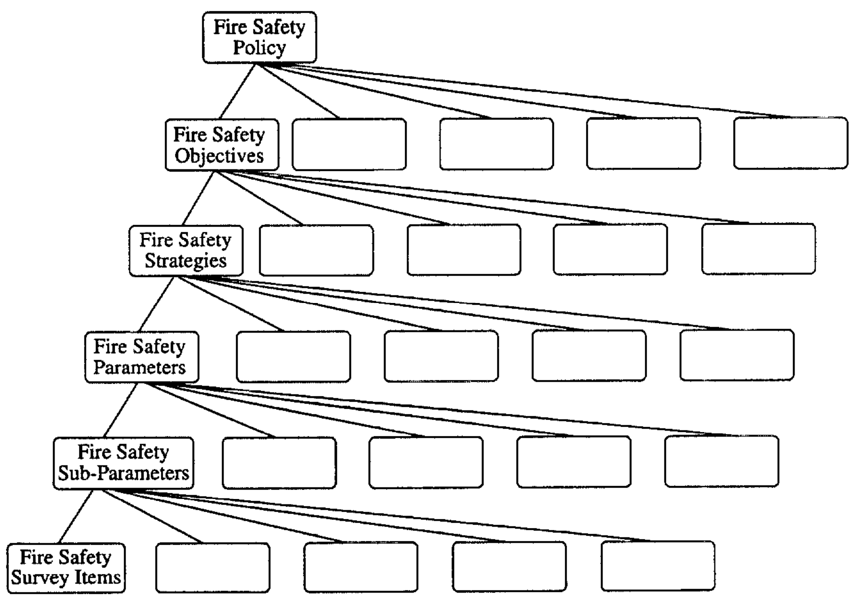

Figure 1. COFRA element hierarchy.

strategies, objectives, and policy. A total of 17 safety parameters that help measure the features that influence the level of fire risk in central office space were identified and grouped under four headings: facility, contents, fire protection, and occupants. The same 17 parameters are used for evaluating both life safety and network integrity. However, the relative weight, or impact, of each parameter on the overall fire safety policy, as determined by the process described below, is quite different for network integrity than it is for life safety. Table 1 provides a list of the COFRA parameters and describes each one.

Calculating Parameter Weights

In order to relate the relative importance of each fire safety parameter to the fire risk policy established as the top level in the risk hierarchy, the relative importance of the objectives, strategies, and individual parameters were determined based on available technical information and analytical methods, and refined through the use of a Delphi process[12] initiated within the COFRA project group. The result was a series of matrices in which each element was assigned a value between 0 and 5 to represent its relative importance in the risk hierarchy to the next level above.

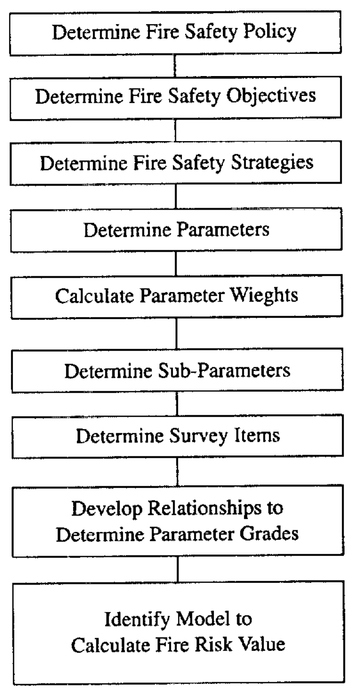

Figure 2. General COFRA development process.

TABLE 1
Fire Safety Parameters

Facility	Construction: Combustibility and fire endurance of load bearing structural assemblies; number of floors Height: Floor that space is on Compartmentation: Extent to which floor areas are divided by fire resistive walls and partitions Building Services: Electrical and mechanical equipment including HVAC, power, and other utilities
Contents	Cables: Amount and type of cables and cabling practices, e.g., mining Equipment: Amount and type of switching equipment Ordinary Combustibles: Amount and type of ordinary and not otherwise classified combustible contents, including interior finish Special Hazards: Building contents posing a higher than average degree of hazard such as storage or use of flammable liquids or use of high-heat producing appliances
Fire Protection	Smoke Control: Equipment, systems, and protocols for limiting spread of toxic and corrosive fire products Alarm: Equipment and systems for transmitting an alarm of fire Detection: Equipment and systems for detecting fires Fixed Suppression: Equipment and systems for automatic or semi-automatic application of water, halon, CO_2, or similar agent, to a fire Fire Department: Capability and effectiveness of fire department to respond to an emergency fire situation and implement mitigation and rescue Egress System: Number, capacity, accessibility, and reliability of emergency exits and areas of refuge Power Down: Shutting off electrical service so as to de-energize equipment
Occupants	Personnel: Capability and effectiveness of occupants to react to emergency fire situation Management: Fire safety policies, enforcement, and attitudes

Matrix Interactions

Matrix multiplication was used to relate the relative importance of each fire safety parameter to the fire risk policy. This two-step process involved calculating the strategy-to-policy vector and the parameter-to-policy vector.

Figure 3 illustrates the matrix interactions used to determine the importance of each of the parameters. The objectives-to-policy vector and strategies-to-objectives matrix were combined using matrix multiplication to derive the strategy-to-policy vector. The resulting strategies-to-policy vector was then combined with the parameters-to-strategies matrix to derive the parameters-to-policy vector. This vector provides the relative weight of each parameter in terms of its importance to the fire safety policy. The weights are then multiplied by individual parameter grades and summed to provide measures of relative risk for the space being evaluated.

Subparameters

In a number of instances, a parameter could be further broken down into subparameters. This made developing survey items easier in some cases, while in other cases, the parameter was better expressed and measured as a function of its components.

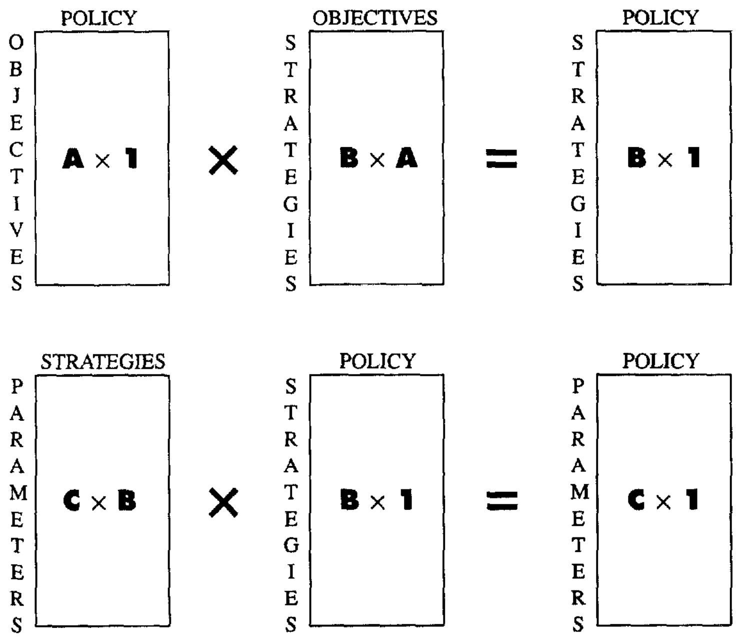

Figure 3. COFRA matrix interactions.

Survey Items

Survey items are the measurable building and space attributes that make it possible to calculate parameter grades. Most parameter grades are determined by using a list of several survey items. In some cases, the survey items are used to determine values for subparameters that are, in turn, used to develop the parameter grades. In a number of cases, a survey item is a constituent part of more than one parameter.

Cable type, for example, is a survey item determined by the predominant age of the cable in the facility: the value N, for "new," is assigned when more than 80% of the cable was installed after 1983, the value V, for "vintage," is assigned when more than 80% of the cable was installed before 1970, and the value M, for "mixed," is assigned when any other percentage of cable was installed.

Members of the COFRA project group developed survey items by subjectively analyzing the parameters and subparameters using their experienced judgment. They chose survey items that contributed significantly to the effectiveness of their respective parameters or subparameters and that were directly measurable. Survey items were defined in sufficient detail to support these traits, and they were described in detail to support the decision-table logic that produces parameter grades from the answers to survey questions. The descriptions were designed to be sufficiently explicit and illustrative so that people with no fire protection background could conduct the survey, since, in actual practice, site personnel who operate the telecommunications network often conduct the surveys.

In the COFRA, multiple use of survey items is the principle way in which parameter interaction is represented. Parameters that are recognized as significantly interdependent will have this interdependence accounted for through one or more common survey items. For example, the survey item "staffing" affects the parameter grades for the parameters "personnel," "alarm," "smoke control," and "fixed suppression."

Parameter Grades

An essential feature of the COFRA methodology is the grading of fire safety parameters. For each identified parameter, a relative importance is determined and generalized for all cases. The importance of each parameter will vary from facility to facility depending on the degree to which parameters exist or occur in a space. The parameter grades are a measure of these levels of danger or security.

Parameter grades are determined separately for network integrity and life safety, and one set of conditions in a facility may result in a different level of danger or security for each. Note that the examples provided in the following sections represent a network integrity evaluation only, and not the life safety evaluation.

Parameters are defined as components of fire-risk that can be determined quantitatively by direct or indirect measurement or estimation. The parameters represent factors that account for an acceptably large portion of the total fire risk in a space. In most cases, the parameters are not directly measurable. This is especially true when limited information about a building is readily available.

To facilitate the grading, parameters are partitioned into measurable constituent parts. In most cases, these parts are directly measurable survey items. Subparameters are defined as intermediate components of a parameter with a grade or assessment based on one or more survey item. Thus, determining parameter grades depends on those facility features identified as survey items.

Decision Tables

A series of decision tables was developed to assign a grade to each parameter. Some of these were quite simple, having only three decision rules. In other instances, the tables were long and complex. For example, the decision table for the cables parameter has 84 rules.

Decision tables may reference other decision tables, allowing problems to be divided into logical segments and providing for a multilevel structure in decision analysis. The subparameter level appears in several of the fire safety parameters. For example, the equipment parameter has nine decision tables, one for each of six types of equipment and three to describe equipment vulnerability. This unusual level of detail is discussed later in this paper. Five other parameters also have multiple decision tables. An example of a decision table for the special hazards parameter is shown in Table 2. The table shows the decision rules as the vertical columns numbered one through eight.

The extensive use of decision tables in developing parameter grades is discussed in NFPA 101A, *Alternative Approaches to Life Safety*,[8] and will not be detailed here. In some cases, the subparameter grades are input to another decision table that produces the parameter grade.

Subparameter Development

The relationship between a parameter and its subparameters is one of the most complex and challenging aspects of the COFRA. In the simplest case, a single subparameter yields a subparameter value, which is derived from a decision table. That value, in turn, is input into the decision table to determine the grade for the "parent" parameter. In the most complex case, multiple subparameters are interdependent and must be analyzed before the parameter grade can be developed. Three different processes were used to develop weights and values for each subparameter that, in turn, are used to determine the grade for the parent parameter. Figure 4 illustrates the process generically.

Two approaches were used to derive subparameter weights based on the complexity of the subparameter groupings: the analytic hierarchy process (AHP), and a multiattribute decision (MAD) process.

TABLE 2
Special Hazards Decision Table

Survey Items	Decision Rules 1	2	3	4	5	6	7	8
Hazards (Y, N)	N	Y	Y	Y	Y	Y	Y	Y
Separation from Exits (Y, N)	–	Y	Y	Y	N	N	N	N
Equipment in Space* (N, O)	–	N	O	O	N	N	O	O
Containment (Y, N)	–	–	Y	N	Y	N	Y	N
Parameter Grade	0	1	3	5	1	1	3	5

* from the "equipment parameter": N = None; O = any other

Analytical Hierarchy Process

In the AHP, the relative importance of each subparameter is determined by setting up a square matrix and making pairwise comparisons. Each possible pair of subparameters is examined, and a subjective determination made as to which is more important and to what extent. The degree of preference is assigned on a scale of one to nine.

For n subparameters, there will be $n(n-1)/2$ such comparisons. The diagonal of the matrix is, by definition, composed of ones, since each subparameter is of equal importance when compared with itself. Values on symmetrically opposite sides of the diagonal are reciprocals. That is, if a subparameter A is n times as important as subparameter B, then subparameter B is $1/n$ times as important as subparameter A.

Weights of the relative importance of each subparameter can then be calculated from the matrix using any of a number of methods for determining weights. The most well known and most supported by commercial software is the eigenvalue method.[13] In the COFRA project, calculations of subparameter weights were produced with the computer program HIPRE 3+.[14]

Applying the AHP

The cables parameter represents the amount and type of cable and cabling practices, for example, the extent and frequency with which inactive cables are removed, an industry practice called "cable mining." The decision tables that address this parameter include six subparameters: ignition sources, transfer processes, fuel (cable) ignitability, flame spread, corrosivity, and smoke production. Weights for these subparameters were derived using the AHP process.

The relative importance of each of these subparameters was determined by setting up a square matrix and making pairwise comparisons. (See Figure 5.) From each possible pair of subparameters, the more important one was determined. The extent to which a subparameter was preferred was also determined, and a value was assigned to each on a scale of one to nine. The relative importance of each subparameter was then calculated from the matrix. The resulting weights for the cable subparameters, calculated by the eigenvalue method, are shown in Table 3. These results are then used to determine the parameter grade for the cables parameter as the scalar product of the subparameter weights and the subparameter values.

For example, consider a central office space with mixed cable types, cable mining, moderate mixing of power and communication cables, high cable load, and unimproved smoke production cable with no polyethylene insulation. These conditions correspond to the survey items shown in Table 4. Using the cables decision table (see Table 5), the survey item values indicate that decision rules 9, 21, and 28 apply. The decision rules produce numeric grades for the six cable subparameters listed in Table 6. Four of the subparameter values were produced from decision rule 9, and one value each were produced from decision rules 21 and 28.

Weighting these subparameter values (Table 6) by the calculated subparameter

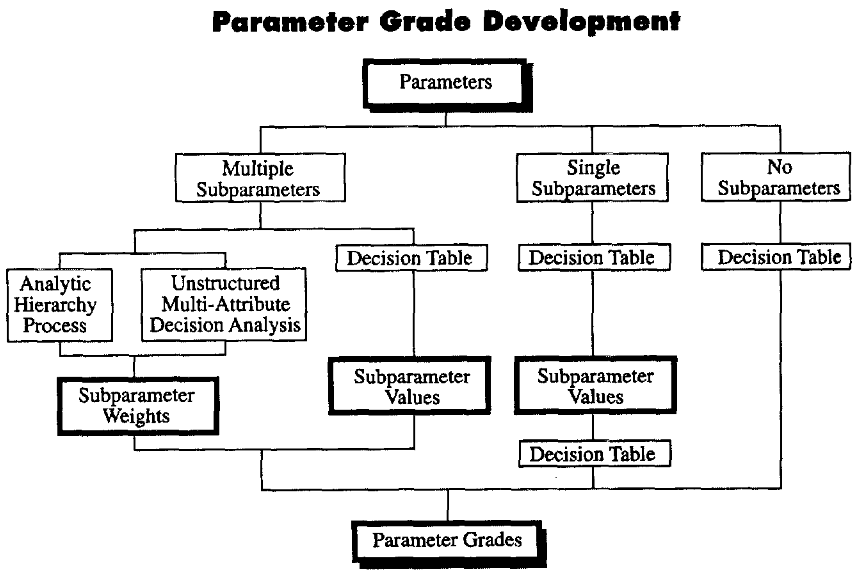

Figure 4. Parameter grade development.

TABLE 3
Subparameter Weights for Cables Parameter

Sources	0.054
Interactions	0.058
Ignitability	0.136
Flame Spread	0.369
Corrosivity	0.360
Particulates	0.022

TABLE 4
Example Values of Cables Survey Items

Cable type	M
Mining	Y
Load	H
Smoke limited	N
Mixing	M
Polyethylene jacket	N

weights (Table 3), and summing the results produces the cables parameter grade, giving us:

$$(4 \times 0.054) + (3 \times 0.058) + (2 \times 0.136) + (4 \times 0.369) + (5 \times 0.360) + (5 \times 0.022) = 4$$

The MAD Process

The MAD process used to determine other subparameter weights varied according to subparameter complexity. For instance, the ordinary combustibles parameter has only two subparameters, ignition and fire growth, and the project team developed weights for these using their experienced judgment. In contrast, the "equipment" parameter is the most complex in the COFRA. It deals with six different types of equipment that may be present in a CO space: computers (Comp), batteries (Bat), other power (OP), switching (SW), transmission (TR), and dis-

TABLE 5
Excerpts from Cables Decision Table

Survey Items		Decision Rules 9	21	28	
	...	9	21	28	...
1. Cable Type (N, M, V)		M			
2. Mining (Y, N)		Y			
3. Load (N, L, M, H)		H		H	
4. Smoke Limited (Y, N)				N	
5. Mixing (Y, N)			M		
6. Polyethylene Jacket (Y, N)		N	N	N	
Subparameters		**Decision Rules**			
	...	9	21	28	...
Sources (1, 2, 3)*		4			
Interactions (5)			3		
Ignitability (1, 3, 6)		2			
Flame Spread (1, 3, 6)		4			
Corrosivity (1, 3)		5			
Smoke Production (3, 4)				5	

* Numbers in parenthesis indicate survey items that apply to that specific subparameter.

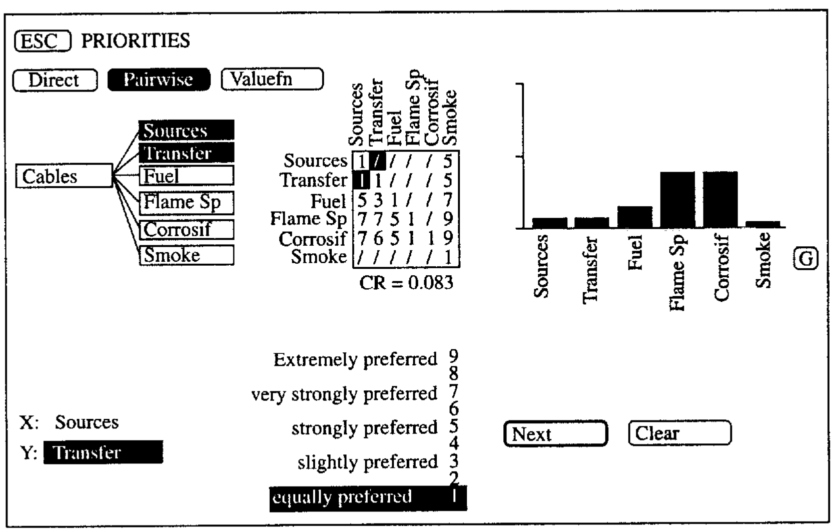

Figure 5. Analytical hierarchy process for cables parameter.

TABLE 6
Example Subparameter Values for Cables Parameter

Sources	4
Interactions	3
Ignitability	2
Flame Spread	4
Corrosivity	5
Particulates	5

tributing frames (MDF). There may be more than one type of equipment present and there may be multiple switching systems and distributing frames with different characteristics. In addition, the vulnerability of CO equipment to a fire incident is of critical importance to network integrity. The equipment parameter was further broken down into three subparameters: ignition, fire growth, and vulnerability.

The relative importance of each subparameter will vary according to equipment type. This is represented by a matrix of subparameters by equipment types. The cells in this matrix represent values from an integer scale of importance ranging from one for the least important to nine for the most important. Using experience and judgment, the relative importance of each subparameter was evaluated for each equipment type. The results are shown in Table 7.

Conversion of the relative importance of the subparameters to subparameter weights was accomplished by normalizing the values in Table 7. Each value in the table was divided by the highest sum of the values of all the equipment types. Sums of the relative subparameter importance values for each type of equipment are 15, 8, 11, 15, 15, and 16, respectively. Dividing each value by the highest sum, 16, gives the results shown in Table 8.

Applying the MAD

Equipment vulnerability is considered to be a function of the direct effects of heat and smoke as well as the secondary effects of suppression agents. In turn, these secondary effects depend on the type of suppression system that's in place and its susceptibility to damage from suppression agents. Figure 6 summarizes the process of deriving a grade for the equipment vulnerability subparameter from survey items associated with the equipment and fixed suppression parameters.

TABLE 7
Relative Subparameter Importance by Type of Equipment

	Comp	Bat	OP	SW	TR	MDF
Ignition	2	2	6	2	2	3
Fire Growth	4	3	2	4	4	9
Vulnerability	9	3	3	9	9	4

A separate set of decision tables was developed to produce a grade for equipment vulnerability. The first table generates grades for suppression damage susceptibility and fire and smoke damage vulnerability based on survey items that identify the relevant equipment characteristics in the space as well as equipment type and age.

The second table considers survey items that characterize the suppression system in terms of its ability to cause secondary equipment damage: type, valve, and actuation. These survey items are evaluated in the fixed suppression parameter. The output is referred to as a suppression damage threat. This threat, together with the suppression damage susceptibility from the first decision table, produces a value for suppression damage vulnerability in the third decision table.

When two types of equipment are installed in the same space, their responses

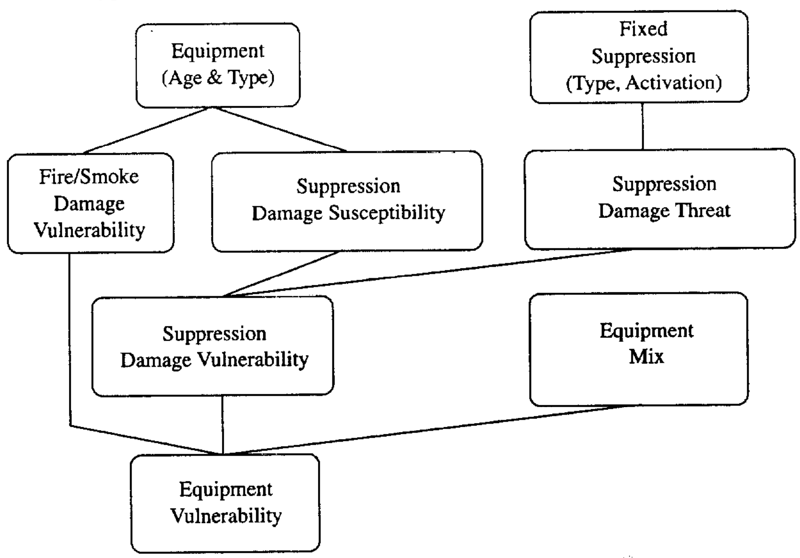

Figure 6. Equipment vulnerability subparameter.

TABLE 8
Subparameter Weights for Equipment Parameter

	Comp	Bat	OP	SW	TR	MDF
Ignition	0.125	0.125	0.375	0.125	0.125	0.188
Fire Growth	0.25	0.188	0.125	0.25	0.25	0.563
Vulnerability	0.563	0.188	0.188	0.563	0.563	0.25

to fire may affect each other adversely. Such combinations are considered in determining a value for equipment mix. A final table combines equipment mix with suppression damage vulnerability and fire and smoke damage vulnerability to generate a grade for the equipment vulnerability subparameter.

Subparameter Values

The subparameter values are determined from one or more decision tables. The survey items and subparameter interdependencies are used to select the appropriate rules from the proper decision tables. The subparameter values are combined with subparameter weights as scalar products to produce a parameter grade.

Fire Risk Value

The two basic components of the fire risk value are the parameter weights and the parameter grades. The risk score is the scalar product of the parameter weights and the parameter grades. Table 9 shows the table that combines the parameter weights determined for the facilities targeted in this study with the parameter grades derived from the survey and the various subparameter routines described earlier.

Computer Program

A series of calculation tables was developed to help users perform risk calculations manually. The complexity of the process, however, makes manual calculation cumbersome. Fortunately, the process can be readily mechanized for computer calculation. The project team considered several potential mechanization methods that were not part of the original scope of the project. These included options for recording and encoding the survey data, including: manual survey forms, hand-held computers (laptop or palmtop computers) and personal digital assistants; and options for entering collected data into a desktop computer, including: manual data entry, automatic form readers or scanners, and standard data links for hand-held and palm-top computers.

TABLE 9
COFRA Calculation Table

Risk Parameter	Life Safety Grade* (A)	Life Safety Weight (B)	Life Safety Score (A × B)	Network Integrity Grade* (C)	Network Integrity Weight (D)	Network Integrity Score (C × D)
Construction		4.8			3.7	
Height		4.6			3.0	
Compartmentation		6.4			5.7	
Building services		4.2			6.3	
Cables		2.8			7.3	
Equipment		2.3			9.2	
Ordinary combustibles		6.9			6.4	
Special hazards		8.9			7.4	
Detection		8.5			7.2	
Alarm		8.3			5.8	
Smoke control		6.2			6.2	
Fixed suppression		5.3			5.7	
Fire department		6.6			5.2	
Egress		5.4			1.1	
Power down		2.4			4.4	
Personnel		8.3			8.6	
Management		8.1			6.8	
			Σ=			Σ=
			Life Safety Score (Σ (A × B)) =			
			Network Integrity Score (Σ(C × D)) =			

* from decision tables

For the initial implementation of the COFRA program, manual survey forms and manual data entry were selected. Subsequent to this project, Bellcore undertook the development of a Windows™-based program to accomplish the needed calculations on a personal computer. Survey data is recorded manually, and the program uses a prompting format to guide input. This program was distributed for evaluation to Bellcore's owners, the Regional Bell Operating Companies: Ameritech, Bell Atlantic, Southern Bell, U.S. West, Southwestern Bell, and Pacific Telesis. After two years, users were polled and a second version of the program was developed. Improvements in the COFRA-2 program included the following:

• The program was revised so that it can operate under the two current Windows operating system platforms, Windows 3.1 and Windows 95.

• Significant improvements were made to the user interface, data entry, and

TABLE 10
Building Scores Calculated by the COFRA-2 Program for a Hypothetical Facility

Case	Smoke Detection System	
	Aspirating Type System	Spot-Type System
Base case	15.0	19.5
Base case plus preaction sprinkler system throughout	15.9	21.6
Base case plus automatic smoke control system throughout (no sprinklers)	2.0	5.4
Base case plus manual smoke control system throughout (no sprinklers)	13.8	20.3
Base case plus improved compartmentation and provision of separate HVAC systems for each functional area of the facility (no sprinklers)	2.6	2.8
Base case plus a prepared emergency power disconnect procedure	3.7	6.0

output interfaces so that they are more intuitive, reflecting current trends in software design.

• Algorithms were added to permit direct comparison between two or more configurations of fire safety parameters, allowing users to view the impact of actual or proposed facility changes on the fire safety score, either on screen or on hard copy. This feature allows rapid assessment of alternative approaches, facilitating development of the most cost-effective solution to a facility with a deficient score.

• An algorithm was developed and implemented to permit analysis of the fire safety score for an entire central office facility, as opposed to the score for a single space within a facility.

• The fire safety impact of several major new equipment design and usage trends in the telecommunications industry since release of COFRA-1 were incorporated into the program. The most significant of these changes involve co-located equipment, (i.e., the presence of telecommunications equipment owned and operated by another company in the same room or space as the network equipment); and the use of Valve Regulated Lead Acid (VRLA) batteries.

• Several of the decision table grades or subparameter weights were modified to reflect recent changes in network architecture and usage.

The program will be detailed further in an article currently being prepared for publication in a future issue of the *NFPA Journal.*

Applying the COFRA-2 Program

Consider a typical dial office constructed of fire resistive Type I construction in a community with a good fire department. The office has a basement with two separate areas, a cable vault, and a power room that contains the standby generator and the DC power plant. The ground floor has two areas separated by one-hour fire rated construction, a main distributing frame room, and a toll or transmission equipment room. The second floor has a single area housing a digital switching system. Automatic smoke detection is provided throughout the building, and a HVAC system serves all areas of the facility through a common duct system. The building has no automatic fire suppression system and no prepared emergency power disconnect procedure.

Using the COFRA-2 program to measure the facility's relative risk, it is possible to consider a wide range of alternative protection schemes. Table 10 illustrates the building scores derived for the 12 cases described in the table. Note that lower scores represent an increase in safety, or, conversely, a decrease in risk. A facility manager need only compare the calculated values with the corporation's risk management guidelines to score the facility. If the facility is deemed deficient, this analysis, coupled with cost data, will permit the rapid selection of the most cost-effective risk-reduction strategies.

At first glance, the values shown may appear counter to conventional wisdom. However, considering the fact that nonthermal damage has accounted for some 90% of the damage in telecommunications facility fires, any fire that grows large enough to activate a sprinkler system has already produced enough smoke to destroy all the equipment in the compartment. When one considers that the principal fire safety objective in these often unstaffed facilities is maintenance of network integrity, the risk scores calculated become clearer.

Summary

A method has been developed for systematically assessing the fire risk associated with individual and discrete spaces in telecommunications facilities. Called the Central Office Fire Risk Assessment (COFRA) methodology, it is designed to for manual implementation or for integration into a computer-based program. The fire risk to network integrity and personnel safety is measured and reported on an individual-space basis.

The basic framework of the COFRA methodology is a numerical grading system similar to evaluation schemes developed for other unique occupancies, such as health care facilities and office buildings. However, the COFRA method incorporates explicit evaluation of the fire risk to network integrity as well as personnel safety. Other similar systems are typically limited to evaluating life safety.

The methodology integrates current technical knowledge and analytical methods with expert judgment to provide the user with a rational, consistent means to evaluate the relative fire risk in a central office space. The user, who may be unfamiliar with fire hazard analysis and fire modeling techniques, surveys a space in terms of readily available information about its structure, contents, and fire safety systems, and performs a series of table look-ups and simple calculations to determine the relative risk. Expert judgment was used to compensate for uncertainties in the analytical methods used to calculate fire risk. These elements were integrated into the COFRA through a Delphi process involving members of the COFRA project group. The system is designed to permit modifications as technical knowledge in this area advances.

The basic method provides an evaluation of 17 different parameters determined to be of significant importance to fire risk in central office facilities. Results can be used to rank the fire risk in any critical space or facility. In addition, the relative change in risk can be evaluated for proposed fire safety improvements, which, in conjunction with cost analysis data, can provide a benefit-cost basis for decision making.

The final product of this work is a custom system developed for Bellcore and the Regional Bell Operating Companies that uses a set of subjective decisions. This paper describes the process by which that system was developed so that others can produce comparable systems for similar fire risk assessment applications. Initial experience with the system has resulted in several refinements.[15]

The methodology has several limitations. First, the parameter assignments are derived from consideration of five primary fire scenarios. While it was determined that these scenarios represent the majority of historical fire incidents in central office facilities, they do not represent the universe of such incidents. Second, the results are expressed in terms of a relative risk index based on an arbitrary numerical scale. Such results should not be interpreted as a measure of total or absolute fire safety. Third, relative risk is determined separately for life safety and network integrity; these separate grades are not intended to be combined to provide an aggregate measure of risk. And, finally, the methodology is only partially supported by quantified technical knowledge and analyses. The professional judgment of experts embedded in a balanced peer-consensus group along with external review bridges these gaps.

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