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ALARM 1.0
Decision Support Software for Cost-Effective Compliance with Fire Safety Codes

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Abstract

ALARM, *A*lternative *L*ife Safety *A*nalysis for *R*etrofit Cost *M*inimization, is a personal computer software tool that helps building managers and fire safety officers achieve cost-effective compliance with the widely-used *Life Safety Code*. This first version of *ALARM* supports analysis of health care occupancies. Through use of an equivalency provision in the code, *ALARM* implements a goal-oriented, or performance-based approach to code compliance. *ALARM* generates a set of alternative code compliance strategies and their estimated costs. These strategies offer decision support by providing a set of alternatives from which to select the most appropriate code compliance strategy based on both cost and design considerations. The software offers an integrated code compliance optimizer, full-screen data editor, and file manager. The optimization method used in *ALARM* has been field tested in nearly 100 hospitals since 1981. Cost savings have been found to average between 30 and 35 percent of the cost of prescriptive compliance strategies. *ALARM* could be tailored to other building occupancies in the future.

Key words: building codes; cost minimization; economic analysis; fire safety; health care facilities; hospitals; life safety codes; linear programming; optimization.

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Getting Started

System Requirements

ALARM runs on an MS-DOS™ personal computer with a 386 or higher microprocessor, a numeric coprocessor, at least one high density floppy diskette drive (3.5" or 5.25"), and MS-DOS™ Version 5.0 or higher. At least 525 kilobytes of conventional memory must be available for running executable programs. A printer is preferred but not required.

If the optimizer does not run on your system, you may not have enough free extended memory (XMS). If none of your other programs need expanded memory (EMS), you can free more extended memory by adding the NOEMS option to your CONFIG.SYS command that loads the EMM386 device driver and rebooting. If any of your other programs need expanded memory, limit the amount (e.g., to 2 megabytes) with the memory option of the EMM386 device driver command. Refer to your MS-DOS documentation for the correct syntax for adding options to the EMM386 device driver command.

Installing *ALARM*

ALARM must first be installed on your hard drive and then run from there. From your hard drive (e.g., drive C), make the directory to which *ALARM* will be installed by typing **MD\ALARM** and pressing ←┘ . Then go to the new directory by typing **CD\ALARM** and pressing ←┘ . Next, insert the distribution disk into any floppy drive (e.g., drive A), type **COPY A:*.*** and press ←┘ . All the *ALARM* program and data files will be copied to the new \ALARM directory on your C drive.

The *ALARM* distribution diskette contains these files:

ALARM.EXE	-	Main executable program
OPTIM.EXE	-	Code compliance optimizer, accessed from within ALARM.EXE
OPTIM.DAT	-	Data file with FSES table values, prescriptive compliance solutions, Design Class definitions, and retrofit unit cost data
RETROFIT.DBF	-	Data file with retrofit information
DESQUAL.DBF	-	Data file with Design Qualifier information
HELP.DBF	-	On-line help file
HELP.DBT	-	On-line help file
SAMPLE.LRM	-	Sample building data file

Starting *ALARM*

To start *ALARM*, go to the directory in which it is installed by typing **CD\ALARM** and pressing ←┘ . Then type **ALARM** and press ←┘ .

Contents

1. Background and Introduction

ALARM, *A*lternative *L*ife Safety *A*nalysis for *R*etrofit Cost *M*inimization, is a software tool that helps building managers and fire safety officers achieve cost-effective compliance with the *Life Safety Code*.[1] The Life Safety Code is a widely-used, voluntary code developed by the National Fire Protection Association (NFPA) for identifying the minimum level of fire safety in buildings. The basic code is prescriptive, since it requires specific solutions for fire safety. For example, it might require a minimum fire retardancy rating for interior finishes and the presence of manual fire alarms. However, the *Life Safety Code* has a provision allowing for **alternative code compliance** through a goal-oriented, or performance-based, fire safety code. Through use of an equivalency concept, performance-based codes determine how **combinations** of fire safety features can achieve a level of fire safety equivalent to that required by prescriptive codes.

Health care is the first building occupancy for which an equivalency system was developed. The system was developed in the late 1970's at the National Institute of Standards and Technology (then National Bureau of Standards), through support from the U.S. Public Health Service.[2] The NFPA subsequently adopted the equivalency system into the Life Safety Code in 1981.[3] This performance-based code, or Firesafety Evaluation System (FSES), has been modified and updated several times, most recently in 1994.[4] *ALARM* currently supports only health care occupancies.

The FSES is a measuring system for equivalency. It compares the level of safety provided by alternative combinations of fire safety features with the level of safety that exactly conforms to the prescriptive code. If the safety level is at least as high as the prescriptive level, equivalency (and therefore code compliance) has been achieved.

The FSES is applied on a zone-by-zone basis. Zones are building spaces separated by floors, horizontal exits, or smoke barriers. Each zone may trade off 13 fire safety features, such as emergency movement routes, smoke detection, and sprinklering. The zone is assigned points for each fire safety feature corresponding to its level of safety in that zone. Point totals earned across the fire safety features are then compared with point requirements for the following four safety redundancy features: containment, extinguishment, people movement, and general safety. If point totals meet or exceed point requirements for all four safety redundancy requirements, that zone

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[1]National Fire Protection Association, NFPA 101, *Life Safety Code*, 1994 edition, Quincy, MA, 1994.

[2]H.E. Nelson and A.J. Shibe, *A System for Fire Safety Evaluation of Health Care Facilities*, National Bureau of Standards, NBSIR 78-1555, Washington, D.C., 1980.

[3]National Fire Protection Association, *Code for Safety to Life from Fire in Buildings and Structures*, NFPA 101-1981, Appendix C, Quincy, MA, 1981.

[4]National Fire Protection Association, "Firesafety Evaluation System for Health Care Occupancies," NFPA 101A, *Alternative Approaches to Life Safety*, 1994 edition, Quincy, MA, 1994.

has achieved equivalency. Each zone must achieve equivalency for the building as a whole to achieve equivalency.

Since point requirements are established only for total scores across all fire safety features, tradeoffs among the 13 fire safety features are possible. For example, in exchange for more widespread automatic sprinklering, less smoke control may be permitted. These potential tradeoffs generate the opportunity for savings in complying with fire codes. Less expensive fire safety features may be substituted for more expensive ones, all the while maintaining an acceptable level of fire safety. With many zones to analyze, and 13 fire safety features each with up to 7 levels of fire safety, the problem quickly becomes unwieldy and difficult to optimize. An economic optimization method, implemented in a software tool, is needed.

An optimization method for this kind of problem was originally developed by Chapman and Hall and applied to the 1981 edition of the FSES for health care occupancies through the software, *F*ire *S*afety *E*valuation *S*ystem *C*ost *M*inimizer (*FSESCM*).[5] The method is an application of the mathematical technique known as linear programming. This approach efficiently evaluates all possible code compliance solutions. The general idea is to balance improvements in fire safety scores with the costs necessary to achieve them. In this way, the least-cost means of achieving code compliance can be identified.

In addition to generating the least-cost solution, *FSESCM* offers two important features. It generates design-equivalent solutions for every zone, used for matching common compliance strategies across zones. For benchmarking purposes, it also reports the prescriptive solution cost for each zone and for the building as a whole.

Since the 1981 edition of the FSES for health care occupancies was adopted, important changes in the FSES, fire safety technology for buildings, and construction costs have occurred, and *FSESCM* has been extensively field tested. In response, the optimization software and supporting data have been updated. In addition, significant changes have occurred in computer hardware and software development tools that encourage user-friendly interactive software. To take advantage of these advancements, an interactive environment for the updated optimization software has been built and integrated into a new software tool for reducing code compliance costs, *ALARM*.

The U.S. Public Health Service has successfully applied *ALARM*, and its predecessor *FSESCM*, to nearly 100 military, public, and private hospitals over the past nine years. The cost savings have been substantial. Savings from the performance-based solutions average between 30 and 35 percent of the cost of the prescriptive solutions. Field experience also indicates the size of hospital to which *ALARM* can be successfully applied. In 1993, *ALARM* was applied to the largest hospital yet, the 60-zone, 62,710 m^2 (675,000 ft^2) Wright-Patterson Air Force base hospital in Ohio.

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[5]For an extended discussion of FSESCM and the underlying optimization method, see R.E. Chapman and W.G. Hall, *User's Manual for the Fire Safety Evaluation System Cost Minimizer Computer Program*, National Bureau of Standards, NBSIR 83-2797, Washington, D.C., 1983; R.E. Chapman and W.G. Hall, *Programmer's Manual for the Fire Safety Evaluation System Cost Minimizer Computer Program*, National Bureau of Standards, NBSIR 83-2749, Washington, D.C., 1983; and R.E. Chapman, "Assessing the Costs of Fire Protection in Health Care Facilities," *Fire Safety Journal*, Vol. 9, No. 2, 1985, pp. 221-231.

2. Updating the Code Compliance Optimizer and Supporting Data

ALARM's code compliance optimizer incorporates relevant changes that have taken place in the FSES, fire safety technology for buildings, and construction costs, as well as changes based on extensive field experience. These changes are discussed in this section.

The 1994 edition of the FSES for health care occupancies contains several types of changes that are incorporated into *ALARM*. First, point values assigned to several of the fire safety levels, or states, have been changed. Second, several footnotes have been added to two of the FSES tables. In general, the footnotes change point values under certain design scenarios. Many of them reflect interdependencies among the fire safety features. To implement the new footnotes, several "Design Qualifiers" were added to the data entry requirements. There are now a total of 10 Design Qualifiers, each one being specific to a given fire safety feature. In general, the Design Qualifiers further define a zone's fire safety status or potential retrofits.

For each zone, *ALARM* reports the prescriptive solution and generates its cost for benchmarking purposes. *ALARM* implements an updated set of prescriptive solutions, compatible with the 1994 *Life Safety Code* (NFPA 101) and the 1994 *Alternative Approaches to Life Safety* (NFPA 101A), which contains the FSES for health care occupancies. The updated set of prescriptive solutions was derived by the developers of the FSES in NIST's Building and Fire Research Laboratory by applying the prescriptive code to the framework of the FSES.

In minimizing code compliance costs, *ALARM* generates automatic cost estimates for all possible fire safety states for the 13 fire safety features. These automatic cost estimates are based on an *ALARM* catalog of potential retrofits for every fire safety feature, *ALARM* retrofit unit cost estimates, and user-provided retrofit quantity estimates. The list of potential retrofits and the unit cost estimates remain fixed from hospital to hospital, whereas the quantity estimates vary.

The catalog of potential retrofits has been modified and updated based on changes in fire safety technology for buildings and extensive field experience. The updated catalog of retrofits for each fire safety feature is contained in appendix A.

Unit construction cost estimates corresponding to each potential retrofit and fire safety state were collected by the U.S. Public Health Service. The costs reflect U.S. average 1991 prices, and include both labor and materials costs. These costs are reported in appendix A, along with the revised cost algorithms for computing retrofit costs based on the unit cost and retrofit quantity data.

In general, the cost algorithms sum retrofit costs across all potential retrofits for a given fire safety feature. Due to provisions in the 1994 *Life Safety Code*, however, some potential retrofits are not required or are simplified if the entire facility is sprinklered. For example, in the presence of sprinklering, new corridor partitions need extend only to the ceiling (instead of the slab), and windows need not be replaced. *ALARM* implements these code provisions by eliminating or

adjusting costs for all applicable retrofits in the presence of sprinklering. Appendix A highlights the retrofits to which these cost adjustments apply.

ALARM offers two features for modifying the default automatic cost estimates, one of which applies across-the-board to all retrofits, and the other which applies to individual retrofits. To modify by the same percentage amount the automatic cost estimates for all retrofits, *ALARM* offers a "Construction Cost Modifier" feature. This feature permits location- and time-specific cost changes to all default unit costs. Location-specific data are typically reported separately for labor and materials costs, reflecting differences in the labor and materials markets due to regional effects. For such location-specific changes, *ALARM* offers the "Labor Cost Differential" and "Material Cost Differential." Time-specific data are typically reported for labor and materials costs combined. For such time-specific changes, such as general price inflation since mid-1991, *ALARM* offers the "Cost Growth Factor."[6] To modify an individual retrofit cost, or to include a retrofit not on the retrofit list, the "Added Cost" feature is available at every fire safety state.

ALARM generates design-compatible solutions for every zone, used for matching common compliance strategies across zones. These design-compatible solutions are based on a prespecified list of "Design Classes." Each Design Class defines a fixed set of solution states for key fire safety features. After generating the feasible Design Class solutions for every zone, *ALARM* reports a series of compliance strategies for the entire building, one for each feasible Design Class. Within each of these building-wide compliance strategies, key design variables are held constant as defined by the Design Classes. The U.S. Public Health Service updated the list of Design Classes based on its extensive field experience. The new list of Design Classes is given in exhibit 1.

[6]There are many data sources available for obtaining values for the construction cost modifiers. For example, general price inflation data may be obtained from the latest issue of U.S. Department of Commerce, *Survey of Current Business*, Washington, D.C. Location-specific labor and materials cost differentials may be obtained from the latest edition of R.S. Means Company, Inc., *Means Facilities Cost Data*, Kingston, MA.

Exhibit 1. *ALARM* Design Classes

Fire Safety Feature					
Construction	Hazardous Areas	Zone Dimensions	Emergency Movement Routes	Smoke Detection and Alarm	Automatic Sprinklers
INPUT	NO DEF	NO DED	W/O H*E	INPUT	INPUT
INPUT	NO DEF	NO DED	H*EXIT	INPUT	INPUT
INPUT	NO DEF	DED*30	W/0 H*E	INPUT	INPUT
INPUT	NO DEF	DED*30	H*EXIT	INPUT	INPUT
INPUT	NO DEF	NO DED	INPUT	CORDOR	INPUT
INPUT	NO DEF	DED*30	INPUT	CORDOR	INPUT
INPUT	NO DEF	NO DED	INPUT	ROOMS	INPUT
INPUT	NO DEF	DED*30	INPUT	ROOMS	INPUT
INPUT	NO DEF	NO DED	INPUT	CORHAB	INPUT
INPUT	NO DEF	DED*30	INPUT	CORHAB	INPUT
INPUT	NO DEF	NO DED	INPUT	TTLZON	INPUT
INPUT	NO DEF	DED*30	INPUT	TTLZON	INPUT
INPUT	NO DEF	NO DED	INPUT	INPUT	CORHAB
INPUT	NO DEF	DED*30	INPUT	INPUT	CORHAB
INPUT	NO DEF	NO DED	INPUT	INPUT	TTLBLD
INPUT	NO DEF	INPUT	INPUT	INPUT	TTLBLD
INPUT	SGL IN	DED*30	INPUT	INPUT	TTLBLD
INPUT	SGL IN	NO DED	INPUT	INPUT	TTLBLD
INPUT	SGL IN	INPUT	H*EXIT	INPUT	TTLBLD
INPUT	SGL IN	INPUT	W/0 H*E	INPUT	TTLBLD

KEY

INPUT	Input State (initial fire safety state)
NO DEF	No Deficiencies
SGL IN	Single Deficiency in Zone
NO DED	No Dead Ends
DED*30	Dead End 30-50 Feet in Length
W/0 H*E	Without Horizontal Exits
H*EXIT	With Horizontal Exits
CORDOR	Corridors Only
ROOMS	Rooms Only
CORHAB	Corridors and Habitable Spaces
TTLZON	Total Space in Zone
TTLBLD	Entire Building

3. *ALARM* Software Features

ALARM takes advantage of current personal computer software and hardware configurations which allow easier, faster, and more reliable data entry, program execution, and report writing. The software is significantly redesigned to include a menu-driven interface with seamless passing of data between processes and context-sensitive help at every screen. It offers an integrated file manager, full-screen data editor, and code compliance optimizer, each of which is discussed below.

3.1 File Manager

The *ALARM* file manager lists all building data files available in the current directory. These are data files that have been created using the *ALARM* data editor, each of which holds the data necessary for running the optimizer for an entire building. The *ALARM* distribution diskette includes a sample building data file which will be listed in the file manager as SAMPLE.

The file manager is the command center from which the user can perform a number of file operations on any building data file. These file operations may be explored using the data file SAMPLE. The major file operations are editing building data files (including creating them), and running the optimizer on them. Each of these is discussed in detail below. Other file operations available in the file manager include copying, renaming, deleting, and printing building data files.

3.2 Data Editor

The *ALARM* data editor is used to enter data on the hospital building under study. The editor displays on-screen prompts and complete data validation routines to facilitate the creating and editing of error-free data files. Data files serve as direct input to the optimizer. To facilitate the data entry process, a data collection form was developed that closely mirrors the layout of the *ALARM* editor. The data collection form is given in appendix B.

Data must be entered on the building as a whole, on each zone in the building, and on each fire safety feature within each zone. Building information consists of general information, a building qualifier, construction cost modifiers, and a zone listing. General information includes the name and address of the building. The building qualifier simply asks whether the building is new, existing without sprinklering, or existing with sprinklering. This response is used to determine the FSES mandatory point requirements. The construction cost modifiers, as noted above, are used to modify by the same percentage amount the automatic cost estimates for all retrofits. This feature permits time- and location- specific cost changes to all default unit costs. The zone listing simply gives the name, identification number, and floor number of every zone in the building.

The zone listing, also known as the zone browser, is used to select zones for which to enter zone and fire safety feature information. Zone and fire safety feature information must be entered for all zones.

Zone information consists of occupancy risk factors and other information. The occupancy risk factors are five risk parameters that the FSES uses to determine the point value of the general safety requirement for each zone. They include FSES table values for patient mobility, patient density, zone location, ratio of patients to attendants, and average patient age. For ease of data entry, the set of possible values for each risk parameter is listed on this data entry screen. Other zone information consists of basic information on the zone required by FSES table footnotes.

Fire safety feature information must be entered for each fire safety feature and consists of its input state, retrofit quantities, and any applicable Design Qualifiers. Added cost data is optional. All the information is entered through the fire safety feature browser, which lists all 13 fire safety features. The input states are entered directly in the browser, and reflect the zone's current fire safety states for the 13 fire safety features. A fire safety feature's input state defines its lowest fire safety state and therefore the set of states for which retrofit quantities are relevant. The help for the fire safety feature browser defines the available input state choices by listing and defining fire safety states for all fire safety features.

Once the input state is entered, the remaining data may be entered for the fire safety feature by selecting that feature from the browser. If applicable, Design Qualifier data, used to further define a zone's fire safety status or potential retrofits, is entered first. For example, one Design Qualifier for the Automatic Sprinklers fire safety feature asks whether asbestos must be removed as part of the sprinkler installation. After any applicable Design Qualifiers, the retrofit quantities are entered. Retrofit quantities are particular to retrofit and fire safety state. They give the amount of the retrofit required in that zone to achieve the corresponding fire safety state. Units in which retrofit quantities must be entered are displayed on this data entry screen. It is important to enter quantity data in these units to be compatible with the built-in unit cost data.

ALARM offers a means by which any fire safety state may be precluded from all the solutions generated by the optimizer for a zone. To preclude a fire safety state, simply enter a -1 for all retrofit quantities for that state. It is important to include as many states as possible, however, since precluding states eliminates possible zone solutions, which in turn can limit possible building solutions. By default, *ALARM* rules out 5 out of the total of 56 fire safety states across the 13 fire safety features. These states are precluded because it is difficult to provide automatic cost estimates that realistically allocate costs to a single zone. Therefore, the *ALARM* editor sets default retrofit quantities for these states at -1.[7]

Finally, the "Added Cost" feature is available at every fire safety state. It offers a convenient way to modify an individual retrofit cost or to include costs for a retrofit not on the retrofit list. Note that if the added cost feature is used to modify an individual retrofit cost, a zero should be entered for that retrofit's quantity data. Further note that if for any reason a reduction in cost is warranted, a negative "Added Cost" value may be entered.

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[7]If the user can provide reasonable cost estimates for any of these states, they may be included by first entering a 0 for all retrofit quantities for the state, and then entering the total state cost as the "Added Cost" for that state.

3.3 Code Compliance Optimizer

The *ALARM* code compliance optimizer generates a set of alternative code compliance strategies and their estimated costs. The code compliance strategies each satisfy a set of predefined design specifications for the entire building. They offer decision support by providing a set of alternatives from which to select the most appropriate compliance strategy based on both cost and design considerations. For benchmarking purposes, the optimizer also reports the prescriptive solution cost for each zone and for the building as a whole.

The optimizer is run from the *ALARM* file manager after selecting a building data file to use as input. Once the optimizer has finished, the user is returned to the file manager. The optimization results are stored in the file OPTIM.RPT. If an error message appears when attempting to run the optimizer, the system on which *ALARM* is running may not have enough free extended memory. In this case, refer to "Getting Started" for possible solutions.

The file OPTIM.RPT consists of key FSES tables, zone reports, and building summary reports. The contents of OPTIM.RPT are listed in exhibit 2. The FSES tables are reproduced for informational purposes. There are three zone reports. The "Input Summary" reports the zone's occupancy risk factors and the input state, prescriptive compliance state, and retrofit quantities for each fire safety feature. The "Summary of Estimated Retrofit Costs" reports the total retrofit costs for each fire safety state and the prescriptive compliance cost for the zone as a whole. The "Fire Zone Summary Report" lists all code compliance strategies generated by the optimizer for the zone. Each strategy is identified by its solution states for the 13 fire safety features. The total compliance cost for each strategy is also reported. Finally, this report gives the number of surplus points earned by each strategy for the four safety redundancy requirements.

Exhibit 2. Contents of Optimization Report

I. FSES Tables
- A. Occupancy Risk Factors
- B. Mandatory Safety Requirements
- C. Parameter Values (Fire Safety Feature Point Values)

II. Zone Reports
- A. Input Summary
- B. Summary of Estimated Retrofit Costs
- C. Fire Zone Summary Report

III. Building Summary Reports
(one for each possible design class and one for the prescriptive solution)

The "Building Summary Reports" match common compliance strategies across all zones in the building. There are up to 21 such reports, one for each of the 20 Design Classes listed in exhibit 1 and one for the prescriptive design solution, and they are sorted by total compliance cost. Each identifies the least-cost compliance strategy that satisfies that Design Class for each zone in the building. If any zone cannot achieve code compliance under a given Design Class, then that Design Class is not represented in the building summary reports.

The Building Summary Reports provide a set of alternatives from which to select the most appropriate compliance strategy based on both cost and design considerations. If for any reason the Design Classes represented in the Building Summary Reports do not satisfy design requirements for a particular building, the user may select a customized set of solutions from the individual Fire Zone Summary Reports.[8]

[8]In creating customized building solutions, special attention must be paid to solutions for which the automatic sprinkler fire safety feature is in the total building state (labeled TTLBLD), meaning the entire building is sprinklered. This state is unique since it is defined relative to the entire building. Therefore, in combining solutions across zones, solutions containing the total building sprinklering state may only be combined with other solutions also in the total building state. Note that *ALARM* automatically handles this issue in generating the predefined building summary reports for the design classes.

4. Future Directions

This first version of *ALARM* is designed with built-in flexibility for efficiently making changes for future versions of the software. A new version of the software is needed when a new edition of the FSES for health care occupancies is adopted, and when retrofit cost estimates become so outdated that across-the-board inflation adjustments are no longer realistic. A new version of *ALARM* is also needed to permit the productivity enhancements inherent in networking applications and on-site data entry technology. A network version of *ALARM* would permit many users to edit the same building data file simultaneously. On-site data entry would be possible through a laptop and ultimately a pen-based version of the software. On-site data entry would improve productivity because building data is currently developed in two stages: notes are made on building blueprints on site, then back at the office they are translated into data for entry into *ALARM*. A pen-based computing application would load digitized blueprints into a hand-held computer. Notes made on these digitized blueprints would automatically be converted into the necessary building data.

With the success of the FSES for health care occupancies, performance-based codes have been developed for other occupancies such as business occupancies, board and care facilities, and detention and correctional facilities. The *ALARM* methodology for reducing code compliance costs is equally applicable to these and even other occupancies as more FSES systems are developed. Software tools tailored to these occupancies could be developed in the future.

Appendix A. Unit Cost Data and Cost Algorithms for Computing Retrofit Costs[9]

Building Safety Feature #1: Construction

Retrofits

(a) Spray columns with fire-resistive fiber linear feet
(b) Spray beams with fire-resistive fiber linear feet
(c) Spray decking with fire-resistive fiber square feet

States and Algorithms for Cost of Transition from Input State:

1. Unprotected (N/A)

2. Protected

$$\sum_{a}^{c} UnitCost * RetrofitQuantity$$

3. Fire Resistive

$$\sum_{a}^{c} UnitCost * RetrofitQuantity$$

Per Unit Cost Data used in the algorithms:

Labor Costs

State	(a)	(b)	(c)
2) Combustible Woodframe Protected	6.00	4.00	2.00
3) Combustible Ordinary Unprotected	6.00	4.00	2.00
4) Combustible Ordinary Protected	6.00	4.00	2.00
5) Non-combustible Unprotected	6.00	4.00	2.00
6) Non-combustible Protected	6.00	4.00	2.00
7) Non-combustible Fire Resistive	9.00	5.00	3.00

[9]Unit cost data were collected by the U.S. Public Health Service from R.S. Means Company, Inc., Means Facilities Cost Data 1992, 7th annual edition, Kingston, MA, 1992. Cost data reported in *Means Facilities Cost Data 1992*, and reproduced here, are denominated in customary units. Since U.S. construction materials are widely available only in these units, it is impractical to denominate cost data in metric units.

BSF 1 - Continued

Material Costs

States	(a)	(b)	(c)
2) Combustible Woodframe Protected	6.00	5.00	1.00
3) Combustible Ordinary Unprotected	6.00	5.00	1.00
4) Combustible Ordinary Protected	6.00	5.00	1.00
5) Non-combustible Unprotected	6.00	5.00	1.00
6) Non-combustible Protected	6.00	5.00	1.00
7)Non-combustible Fire Resistive	7.00	6.00	2.00

Building Safety Feature #2: Interior Finish [Corridors and Exits]

Retrofits

(a) Install drywall on paneling — square feet
(b) Coat walls with retardant — square feet
Not necessary with comprehensive sprinklers. Program adjusts costs.
(c) Install fire-resistive acoustical mylar ceiling tiles — square feet
Not necessary with comprehensive sprinklers. Program adjusts costs.
(d) Install fire-resistive carpeting — square feet

States and Algorithms for Cost of Transition from Input State

1. Class C (N/A)

2. Class B

$$\sum_{a}^{d} UnitCost * RetrofitQuantity$$

3. Class A

$$\sum_{a}^{d} UnitCost * RetrofitQuantity$$

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)	(d)
2) Class B	4.00	1.00	2.00	1.00
3) Class A	4.00	1.00	2.00	1.00

Material Costs

State	(a)	(b)	(c)	(d)
2) Class B	1.00	2.00	1.00	3.00
3) Class A	1.00	2.00	1.00	3.00

Building Safety Feature #3: Interior Finish [Rooms]

Retrofits

(a) Install drywall on paneling — square feet
(b) Coat walls with retardant — square feet
Not necessary with comprehensive sprinklers.
Program adjusts costs.
(c) Install fire-resistive acoustical mylar ceiling tiles — square feet
Not necessary with comprehensive sprinklers.
Program adjusts costs.

States and Algorithms for Cost of Transition from Input State:

1. Class C (N/A)

2. Class B

$$\sum_{a}^{c} UnitCost * RetrofitQuantity$$

3. Class A

$$\sum_{a}^{c} UnitCost * RetrofitQuantity$$

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)
2) Class B	4.00	1.00	2.00
3) Class A	4.00	1.00	2.00

Material Costs

State	(a)	(b)	(c)
2) Class B	1.00	2.00	1.00
3) Class A	1.00	3.00	1.00

Building Safety Feature #4: Corridor Partitions/Walls

Retrofits

(a)	Install partition slab-to-slab	linear feet
	To ceiling with comprehensive sprinklers.	
	Program adjusts costs.	
(b)	Extend existing partition to slab	linear feet
	Not necessary with comprehensive sprinklers.	
	Program adjusts costs.	
(c)	Replace windows (glass only)	square feet
	Not necessary with comprehensive sprinklers.	
	Program adjusts costs.	
(d)	Replace windows (glass and frames)	number
	Not necessary with comprehensive sprinklers.	
	Program adjusts costs.	
(e)	Replace windows (glass and frames)	square feet
(f)	Sheath existing (<1/3 hour) partition	linear feet
(g)	Sheath existing (1/3-1 hour) partition	linear feet

States and Algorithms for Cost of Transition from Input State

1. None or Incomplete (N/A)

2. Less than 20 minutes fire resistance

$$\sum_{a}^{g} UnitCost * RetrofitQuantity$$

3. Greater than or equal to 20 minutes but less than 1 hour

$$\sum_{a}^{g} UnitCost * RetrofitQuantity$$

4. Greater than or equal to 1 hour

$$\sum_{a}^{g} UnitCost * RetrofitQuantity$$

BSF 4 - Continued

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)	(d)	(e)	(f)	(g)
2) <1/3 Hr	32.00	14.00	4.00	70.00	4.00	4.00	4.00
3) >1/3<1.0 Hr	32.00	14.00	4.00	70.00	4.00	4.00	4.00
4) ≥1.0 Hr	51.00	22.00	4.00	70.00	4.00	4.00	4.00

Material Costs

State	(a)	(b)	(c)	(d)	(e)	(f)	(g)
2) <1/3 Hr	14.00	5.00	8.00	635.00	38.00	1.00	1.00
3) >1/3<1.0 Hr	14.00	5.00	8.00	635.00	38.00	1.00	1.00
4) ≥1.0 Hr	22.00	7.00	8.00	635.00	38.00	1.00	1.00

Building Safety Feature #5: Doors to Corridor

Retrofits

(a)	Replace doors and frames (single)	number
(b)	Replace doors and frames (double)	number
(c)	Replace doors (single)	number
(d)	Replace doors (double)	number
(e)	Replace latch	number
(f)	Replace view panel	number
(g)	Install closers (mechanical)	number
(h)	Install closers (automatic/electronic)	number

States and Algorithms for Cost of Transition from Input State

1. None (N/A)

2. Less than 20 minutes with mechanical closer

$$\sum_{a}^{h} UnitCost * RetrofitQuantity$$

3. Greater than or equal to 20 minutes with mechanical closer

$$\sum_{a}^{h} UnitCost * RetrofitQuantity$$

4. Greater than or equal to 20 minutes with automatic closer

Automatic cost estimates not feasible

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
2) <20 Min. FR	60.00	120.00	33.00	66.00	36.00	30.00	38.00	44.00
3) >20 Min. FR	60.00	120.00	33.00	66.00	36.00	30.00	38.00	44.00
4) >20 Min. AC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

BSF 5 - Continued

Material Costs

State	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
2) <20 Min. FR	459.00	918.00	220.00	440.00	96.00	65.00	113.00	392.00
3) >20 Min. FR	609.00	1218.00	220.00	440.00	96.00	65.00	113.00	392.00
4) >20 Min. AC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Building Safety Feature #6: Zone Dimensions

Design Qualifiers

(1) What is the longest dimension of this zone? (length)
(2) Can a new smoke partition be installed to subdivide the fire zone? (Y/N)

Retrofits

(a)	Create a cross connection to a parallel corridor	linear feet
(b)	Install interior stairway	number of stories
(c)	Install exterior stairway	number of stories
(d)	Install smoke partition	number
(e)	Install partition slab-to-slab *To ceiling with comprehensive sprinklers. Program adjusts costs.*	linear feet
(f)	Extend existing partition to slab *Not necessary with comprehensive sprinklers. Program adjusts costs.*	linear feet
(g)	Install smoke dampers	number

States and Algorithms for Cost of Transition from Input State

1. Dead end more than 100 feet (DED100) (N/A)

2. Dead end 50-100 feet (DED*50)

$$\sum_{a}^{c} UnitCost * RetrofitQuantity$$

3. Dead end 30-50 feet (DED*30)

$$\sum_{a}^{c} UnitCost * RetrofitQuantity$$

4. No dead ends greater than 30 feet and zone length is greater than 150 feet (NO+150)

$$\sum_{a}^{g} UnitCost * RetrofitQuantity$$

BSF 6 - Continued

5. No dead ends greater than 30 feet and zone length is between 100 feet and 150 feet (NO+100)

$$\sum_{a}^{g} UnitCost * RetrofitQuantity$$

6. No dead ends greater than 30 feet and zone length is less than 100 feet (NO-100)

$$\sum_{a}^{g} UnitCost * RetrofitQuantity$$

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)	(d)	(e)	(f)	(g)
2) DED*50	106.00	12817.80	11536.02	592.00	51.00	22.00	50.00
3) DED*30	106.00	12817.80	11536.02	592.00	51.00	22.00	50.00
4) NO+150	106.00	12817.80	11536.02	592.00	51.00	22.00	50.00
5) NO+100	106.00	12817.80	11536.02	592.00	51.00	22.00	50.00
6) NO-100	106.00	12817.80	11536.02	592.00	51.00	22.00	50.00

Material Costs

State	(a)	(b)	(c)	(d)	(e)	(f)	(g)
2) DED*50	44.00	8545.20	14099.58	2135.00	22.00	7.00	241.00
3) DED*30	44.00	8545.20	14099.58	2135.00	22.00	7.00	241.00
4) NO+150	44.00	8545.20	14099.58	2135.00	22.00	7.00	241.00
5) NO+100	44.00	8545.20	14099.58	2135.00	22.00	7.00	241.00
6) NO-100	44.00	8545.20	14099.58	2135.00	22.00	7.00	241.00

Building Safety Feature #7: Vertical Openings

Retrofits

(a)	Frame and sheath (create) enclosure	square feet
(b)	Sheath existing enclosure	square feet
(c)	Install doors and frames	number
(d)	Install doors only	number

States and Algorithms for Cost of Transition from Input State

1. Open 4 or more floors (N/A)

2. Open 2 or 3 floors

$$\sum_{a}^{d} UnitCost * RetrofitQuantity$$

3. Enclosed with indicated fire resistance:
   1) <1 Hr 2) ≥2 Hrs and <2 Hrs 3) ≥2 Hrs

$$\sum_{a}^{d} UnitCost * RetrofitQuantity$$

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)	(d)
2) Open 2 or 3 floors	51.00	4.00	272.00	173.00
Enclosed with fire resistance of:				
3) <1 Hr	51.00	4.00	272.00	173.00
4) ≥1 Hr<2 Hr	51.00	4.00	272.00	173.00
5) ≥2 Hr	51.00	4.00	272.00	173.00

BSF 7 - Continued

Material Costs

State	(a)	(b)	(c)	(d)
2) Open 2 or 3 floors	23.00	2.00	635.00	404.00
Enclosed with fire resistance of:				
3) <1 Hr	23.00	2.00	635.00	404.00
4) ≥1 Hr<2 Hr	23.00	2.00	635.00	404.00
5) ≥2 Hr	23.00	2.00	635.00	404.00

Building Safety Feature #8: Hazardous Areas

Design Qualifier

Is asbestos removal necessary for sprinklering? (Y/N)

Retrofits

(a)	Upgrade enclosure	square feet
(b)	Install new doors	number
(c)	Install sprinklers	square feet

States and Algorithms for Cost of Transition from Input State:

1. Double Deficiency in Zone (N/A)

2. Double Deficiency Outside Zone
   This state is always inadmissible since retrofit quantities apply to another zone

3. Single Deficiency in Zone
   Eliminate the deficiency that is least expensive to eliminate--either upgrade enclosure/doors OR install sprinklers, where

   *Encl/Doors Cost = (Encl Sq Ft * Unit Cost) + (No. Doors * Unit Cost)*

   For sprinklering <2000 sq ft of building without asbestos removal, or <5000 sq ft with asbestos removal:
   *Cost = Maximum Unit Cost * Retrofit Quantity*
   For sprinklering >233,000 sq ft of building without asbestos removal, or >11,893 sq ft with asbestos removal:
   *Cost = Minimum Unit Cost * Retrofit Quantity*
   For sprinklering, >2000 sq ft and <233,000 sq ft of building without asbestos removal, or >5000 sq ft and <11,893 sq ft with asbestos removal, Unit Cost is derived by interpolating between minimum and maximum unit costs
   *Cost = Interpolated Unit Cost * Retrofit Quantity*

4. Single Deficiency in Adjacent Zone
   This state is always inadmissible since retrofit quantities apply to another zone

5. No Deficiency
   *Cost = (Encl Sq Ft * Unit Cost) + (No. Doors * Unit Cost) + Sprinkler Cost, where*
   Sprinkler Cost is computed as in State 3 above

BSF 8 - Continued

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	EXPOSED No Asbestos Removal Max	EXPOSED No Asbestos Removal Min	EXPOSED Asbestos Removal Max	EXPOSED Asbestos Removal Min
2) Double Def. outside Zone	N/A	N/A	N/A	N/A	N/A	N/A
3) Single Deficiency in Zone	22.00	316.00	1.47	1.13	6.26	4.48
4) Single Def. adjacent Zone	N/A	N/A	N/A	N/A	N/A	N/A
5) No Deficiency	22.00	316.00	1.47	1.13	6.26	4.18

Material Costs

State	(a)	(b)	EXPOSED No Asbestos Removal Max	EXPOSED No Asbestos Removal Min	EXPOSED Asbestos Removal Max	EXPOSED Asbestos Removal Min
2) Single Def. outside Zone	N/A	N/A	N/A	N/A	N/A	N/A
3) Single Deficiency in Zone	8.00	1027.00	0.83	0.75	3.13	2.09
4) Single Def. adjacent Zone	N/A	N/A	N/A	N/A	N/A	N/A
5) No deficiency	8.00	1027.00	0.83	0.75	3.13	2.09

Building Safety Feature #9: Smoke Control

Retrofits

(a)	Install a new smoke partition	number
(b)	Install smoke doors only	number
(c)	Install partition slab-to-slab *To ceiling with comprehensive sprinklers. Program adjusts costs.*	linear feet
(d)	Extend existing partition to slab *Not necessary with comprehensive sprinklers. Program adjusts costs.*	linear feet
(e)	Install smoke dampers	number
(f)	Install duct smoke detectors	number

States and Algorithms for Cost of Transition from Input State

1. No Control (N/A)

2. Smoke Partition

$$\sum_{a}^{f} UnitCost * RetrofitQuantity$$

3. Mechanical Assisted Systems (by Zone)
Automatic cost estimates not feasible

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)	(d)	(e)	(f)
2) Smoke Partition	592.00	66.00	32.00	14.00	50.00	38.00
3) Mechanically Assisted Systems by Zone	N/A	N/A	N/A	N/A	N/A	N/A

Material Costs

State	(a)	(b)	(c)	(d)	(e)	(f)
2) Smk. Part.	2135.00	440.00	14.00	5.00	241.00	67.00
3) Mechanically Assisted Systems by Zone	N/A	N/A	N/A	N/A	N/A	N/A

Building Safety Feature #10: Emergency Movement Routes

Retrofits

(a)	Install interior stairway	number of stories
(b)	Install exterior stairway	number of stories
(c)	Install emergency light	number
(d)	Install horizontal exit	number
(e)	Install horizontal exit doors only	number
(f)	Install partition slab-to-slab	linear feet
	To ceiling with comprehensive sprinklers. Program adjusts costs.	
(g)	Extend existing partition to slab	linear feet
	Not necessary with comprehensive sprinklers. Program adjusts costs.	
(h)	Install smoke dampers	number

States and Algorithms for Cost of Transition from Input State

1. Less than 2 Routes (N/A)

2. Multiple Routes
   deficient capacity
   without horizontal exit(s)
   with horizontal exit(s)

$$\sum_{a}^{h} UnitCost * RetrofitQuantity$$

3. Multiple Routes with Direct Exit(s)
   Automatic cost estimates not feasible

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Multiple Routes								
2) def. cap.	12817.80	11536.02	59.00	592.00	66.00	51.00	22.00	50.00
3) w/o HE(s)	12817.80	11536.02	59.00	592.00	66.00	51.00	22.00	50.00
4) w/ HE(s)	12817.80	11536.02	59.00	592.00	66.00	51.00	22.00	50.00
5)dir. ex.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

BSF 10 - Continued

Material Costs

State	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Mult. Rtes								
2) def. cap.	8545.20	14099.58	431.00	2535.00	880.00	44.00	14.00	241.00
3) w/o HE(s)	8545.20	14099.58	431.00	2535.00	880.00	44.00	14.00	241.00
4) w/ HE(s)	8545.20	14099.58	431.00	2535.00	880.00	44.00	14.00	241.00
5) dir. ex.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Building Safety Feature #11: Manual Fire Alarm

Retrofits

(a)	Install/replace a 12-zone control panel only	number
(b)	Install additional pull stations	number
(c)	New/additional connections to the fire department	number

States and Algorithms for Cost of Transition from Input State

1. No Manual Fire Alarm (N/A)

2. Manual Fire Alarm without Fire Department Connection

$$\sum_{a}^{c} UnitCost * RetrofitQuantity$$

3. Manual Fire Alarm with Fire Department Connection

$$\sum_{a}^{c} UnitCost * RetrofitQuantity$$

Per Unit Cost Data used in the algorithms

Labor Costs

State	(a)	(b)	(c)
2) Manual Fire Alarm w/o Fire Dept. Connection	1225.00	65.00	1275.00
3) Manual Fire Alarm with Fire Dept. Connection	1225.00	65.00	1275.00

Material Costs

State	(a)	(b)	(c)
2) Manual Fire Alarm w/o Fire Dept.Connection	3475.00	240.00	2425.00
3) Manual Fire Alarm with Fire Dept.Connection	3475.00	240.00	2425.00

Building Safety Feature #12: Smoke Detection and Alarm

Retrofit

Install smoke detectors	number

Retrofit Quantities to determine the number of Smoke Detectors needed

(1)	Corridor Only	
	(a) Length of corridor	linear feet
	(b) Number of patient rooms	number
	(c) Common areas	square feet
	(d) Number of nonpatient rooms	number
	(e) Number of bathrooms and closets	number
(2)	Rooms Only	
	(a) Length of corridor	linear feet
	(b) Number of patient rooms	number
	(c) Common areas	square feet
	(d) Number of nonpatient rooms	number
	(e) Number of bathrooms and closets	number
(3)	Corridor and Habitable Space	
	(a) Length of corridor	linear feet
	(b) Number of patient rooms	number
	(c) Common areas	square feet
	(d) Number of nonpatient rooms	number
	(e) Number of bathrooms and closets	number
(4)	Total Space in Zone	
	(a) Length of corridor	linear feet
	(b) Number of patient rooms	number
	(c) Common areas	square feet
	(d) Number of nonpatient rooms	number
	(e) Number of bathrooms and closets	number

BSF 12 - Continued

States and Algorithms for Cost of Transition from Input State

1. None (N/A)

2. Corridor Only
*Cost = (Corridor Length/30) * Unit Cost*

3. Rooms Only
*Cost = Patient Rooms * Unit Cost*
EXCEPTIONS:
If Input State = 1 [NONE] and No patients rooms in zone:
*Cost = Nonpatient Rooms * Unit Cost*
If Input State = 2 [Corridors Only]:
Cost = infinity

4. Corridors and Habitable Spaces
*Cost = [(Corridor Length/30) + Patient Rooms + (Common Area/900) + Nonpatient Rooms] * Unit Cost*

5. Total Space in Zone
*Cost = [(Corridor Length/30) + Patient Rooms + (Common Area/900) + Nonpatient Rooms + (Baths & Closets)/2] * Unit Cost*

Per Unit Cost Data used in the algorithms

Labor Costs

State	Unit Cost ($/Detector)
2) Corridor only	100.00
3) Rooms only	100.00
4) Corridors & habitable spaces	100.00
5) Total space in Zone	100.00

Material Costs

State	Unit Cost ($/Detector)
2) Corridor only	100.00
3) Rooms only	100.00
4) Corridors & habitable spaces	100.00
5) Total space in Zone	100.00

Building Safety Feature #13: Automatic Sprinklers

Design Qualifiers

(1) Potential Retrofit (1=Exposed Automatic Sprinklers, 2= Concealed Automatic Sprinklers)
(2) Water Supply (1 = Adequate, 2 = Inadequate)
(3) Is asbestos removal necessary? (Y/N)
(4) Are quick-response now used in the entire zone? (Y/N)
(5) Are quick-response sprinklers planned in the entire zone? (Y/N)
(6) Are corridors and exits in this zone now sprinklered? (Y/N)
(7) Are all rooms in this zone now sprinklered? (Y/N)

Retrofit

Install automatic sprinklers	square feet

Retrofit Quantities

(1) Corridors and Habitable Spaces:
Zone floor area less area of bathrooms, closets, elevators, and hazardous areas — square feet
(2) Entire Building:
Zone floor area less area of hazardous areas — square feet

States and Algorithms for Cost of Transition from Input State

1. None (N/A)

2. Sprinklering
Corridors and Habitable Spaces
Entire Building
For concealed sprinklering, <2000 sq ft of building without asbestos removal, or <5000 sq ft with asbestos removal:
*Cost = Maximum Unit Cost * Retrofit Quantity*
For concealed sprinklering, >233,000 sq ft of building without asbestos removal, or >11,893 sq ft with asbestos removal:
*Cost = Minimum Unit Cost * Retrofit Quantity*
For concealed sprinklering, >2000 sq ft and <233,000 sq ft of building without asbestos removal, or >5000 sq ft and <11,893 sq ft with asbestos removal, Unit Cost is derived by interpolating between minimum and maximum unit costs
*Cost = Interpolated Unit Cost * Retrofit Quantity*

*Exposed Cost = 0.625 * Concealed Cost*

BSF 13 - Continued

Per Unit Cost Data used in the algorithms

Labor Costs	CONCEALED No Asb. Remove		CONCEALED Asb. Remove	
State	Max	Min	Max	Min
2) Corridor and Habitable Space	2.35	1.80	10.02	6.69
3) Entire Building	2.35	1.80	10.02	6.69

Material Costs	CONCEALED No Asb. Remove		CONCEALED Asb. Remove	
State	Max	Min	Max	Min
2) Corridor and Habitable Space	1.32	1.20	5.01	3.34
3) Entire Building	1.32	1.20	5.01	3.34

Appendix B. Data Collection Form

ALARM

Alternative Life Safety Analysis for Retrofit Cost Minimization

DATA COLLECTION FORM

Stephen F. Weber
Barbara C. Lippiatt
Brian E. Harper
Office of Applied Economics
Computing and Applied Mathematics Laboratory
National Institute of Standards and Technology

Sponsor: Bureau of Health Resources Development
Health Resources and Services Administration
Public Health Service
U.S. Department of Health and Human Services

How To Use This Form

The ALARM Data Form collects all data required to run the ALARM code compliance optimizer. To facilitate the data entry process, the form's layout closely mirrors that of the ALARM data editor. The data form is divided into two sections.

The first section records general building information and lists the building's zones. For each zone, enter a UNIQUE (not repeated) zone number, the zone's floor number, and a brief (60 or fewer characters) description. Only one copy of this section is needed for each building.

The second section records general information for each zone, as well as retrofit quantities, design qualifiers, and additional costs for each of the zone's Building Safety Features (BSFs). On the Zone Information page, the Occupancy Risk Parameter Factors may be determined using table 3-1 of the *FSES for Health Care Occupancies*; enter the column number corresponding to the risk status for each Risk Parameter. In the "Input State" column, enter the current state of the zone with respect to each Building Safety Feature. State definitions may be found on the individual BSF data entry forms. On these forms, enter the retrofit quantities (not the costs) required for the zone to achieve the corresponding state. Retrofit quantities must be entered for all states higher than the input state. If a state is unattainable due to impracticality of design, enter "-1" for each of its retrofit quantities. Additional costs may be entered if desired for the input state and above. A separate copy of this section must be filled out for EACH zone listed in the first section.

B U I L D I N G I N F O R M A T I O N

GENERAL INFORMATION:

Facility Name: _____

Building Name: _____

Contact: _____

Address: _____

City, State, Zip Code: _____

Telephone: _____

BUILDING QUALIFIER: ___

1 = New Building
2 = Existing Building, Not Fully Sprinklered
3 = Existing Building, Fully Sprinklered

CONSTRUCTION COST MODIFIERS:

Cost Growth Factor: _._
(Mid-1991 = 1.00)

Labor Cost Differential: _._
(U.S. Average = 1.00)

Material Cost Differential: _._
(U.S. Average = 1.00)

Number of Zones:

Zone Floor Description

Zone Floor Description

ZONE INFORMATION

Building: _____

Zone: _____ **Floor:** _____

Zone Description: _____

_____

OCCUPANCY RISK PARAMETER FACTORS:

Patient Mobility: ____ Number of Patients on Floor: ____

Patient Density: ____ Patient Sleeping Rooms in Zone: ____ (Y/N)

Zone Location: ____

Ratio of Patients to Attendants: ____

Patient Average Age: ____

Building Safety Feature	Input State	Highest State
1. Construction	_____	7
2. Interior finish corr and exit	_____	3
3. Interior finish rooms	_____	3
4. Corridor partitions and walls	_____	4
5. Doors to corridor	_____	4
6. Zone dimensions	_____	6
7. Vertical openings	_____	5
8. Hazardous areas	_____	5
9. Smoke control	_____	3
10. Emergency movement routes	_____	5
11. Manual fire alarm	_____	3
12. Smoke detection and alarm	_____	5
13. Automatic sprinklers	_____	3

BUILDING SAFETY FEATURE NO. 1
Construction

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit **State**

	(2) C*WF*P	(3) C*OR*U	(4) C*OR*P	(5) NCOM*U	(6) NCOM*P	(7) NCOM*R	
Spray columns with fire-resistive fiber	_____	_____	_____	_____	_____	_____	length
Spray beams with fire-resistive fiber	_____	_____	_____	_____	_____	_____	length
Spray decking with fire-resistive fiber	_____	_____	_____	_____	_____	_____	area
(1) C*WF*U Added Cost:	_____	_____	_____	_____	_____	_____	$

State	Definition
(1) C*WF*U:	Combustible Woodframe Unprotected
(2) C*WF*P:	Combustible Woodframe Protected
(3) C*OR*U:	Combustible Ordinary Unprotected
(4) C*OR*P:	Combustible Ordinary Protected
(5) NCOM*U:	Non-combustible Unprotected
(6) NCOM*P:	Non-combustible Protected
(7) NCOM*R:	Non-combustible Fire Resistive

BUILDING SAFETY FEATURE NO. 2
Interior Finish
(Corridors and Exits)

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit		State		
	(2) BBBB	(3) AAAA	
Install drywall on paneling	_____	_____	area
Coat walls with retardant	_____	_____	area
Install fire-resistive acoustical mylar ceiling tiles	_____	_____	area
Install fire-resistive carpeting	_____	_____	area
(1) CCCC			
Added Cost:	_____	_____	_____ $

State	Definition
(1) CCCC :	Class C
(2) BBBB :	Class B
(3) AAAA :	Class A

Building Safety Feature NO. 3
Interior Finish
(Rooms)

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit **State**

	(2) BBBB	(3) AAAA	
Install drywall on paneling	_____	_____	area
Coat walls with retardant	_____	_____	area
Install fire-resistive acoustical mylar ceiling tiles	_____	_____	area
(1) CCCC			
Added Cost: _____	_____	_____	$

State	Definition
(1) CCCC :	Class C
(2) BBBB :	Class B
(3) AAAA :	Class A

BUILDING SAFETY FEATURE NO. 4
Corridor Partitions/Walls

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit	State (2) LT1/3H	State (3) 1/3-1H	State (4) GE 1HR	
Install partition slab-to-slab	_____	_____	_____	length
Extend existing partition to slab	_____	_____	_____	length
Replace windows (glass only)	_____	_____	_____	area
Replace windows (glass and frames)	_____	_____	_____	number
Replace windows (glass and frames)	_____	_____	_____	area
Sheath existing (<1/3 hour) partition	_____	_____	_____	length
Sheath existing (1/3-1 hour) partition	_____	_____	_____	length
(1) NON/IN Added Cost:	_____	_____	_____	$

State	Definition
(1) NON/IN:	None or Incomplete
(2) LT1/3H:	Less than 20 minutes fire resistance
(3) 1/3-1H:	Greater than or equal to 20 minutes but less than 1 hour
(4) GE 1HR:	Greater than or equal to 1 hour

BUILDING SAFETY FEATURE NO. 5
Doors to Corridor

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit			**State**	
	(2) LT 20M	(3) GE 20M	(4) GE20AC	
Replace doors and frames (single)	_____	_____	-1	number
Replace doors and frames (double)	_____	_____	-1	number
Replace doors (single)	_____	_____	-1	number
Replace doors (double)	_____	_____	-1	number
Replace latch	_____	_____	-1	number
Replace view panel	_____	_____	-1	number
Install closers (mechanical)	_____	_____	-1	number
Install closers (automatic/electronic)	_____	_____	-1	number
(1) NODOOR Added Cost:	_____	_____	_____	$

State	Definition
(1) NODOOR:	No doors
(2) LT 20M:	Less than 20 minutes with mechanical closer
(3) GE 20M:	Greater than or equal to 20 minutes with mechanical closer
(4) GE20AC:	Greater than or equal to 20 minutes with automatic closer

BUILDING SAFETY FEATURE NO. 6
Zone Dimensions

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit	(2) DED*50	(3) DED*30	State (4) NO+150	(5) NO+100	(6) NO-100	
Create a cross connection to a parallel corridor	_____	_____	_____	_____	_____	length
Install interior stairway	_____	_____	_____	_____	_____	number of stories
Install exterior stairway	_____	_____	_____	_____	_____	number of stories
Install smoke partition	_____	_____	_____	_____	_____	number
Install partition slab-to-slab	_____	_____	_____	_____	_____	length
Extend existing partition to slab	_____	_____	_____	_____	_____	length
Install smoke dampers	_____	_____	_____	_____	_____	number
(1) DED100 Added Cost:	_____	_____	_____	_____	_____	$

State	Definition
(1) DED100:	Dead end more than 100 feet
(2) DED*50:	Dead end 50-100 feet
(3) DED*30:	Dead end 30-50 feet
No dead ends > than 30 feet & zone length is:	
(4) NO+150:	Greater than 150 feet
(5) NO+100:	Between 100 feet and 150 feet
(6) NO-100:	Less than 100 feet

BSF 6 DESIGN QUALIFIERS

What is the longest dimension of this zone? (length) _____

Can a new smoke partition be installed to subdivide the fire zone? (Y/N) ___

BUILDING SAFETY FEATURE NO. 7
Vertical Openings

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit **State**

	(2) OP*2-3	(3) ENC-1H	(4) ENC-2H	(5) ENC+2H	
Frame and sheath (create) enclosure	_____	_____	_____	_____	area
Sheath existing enclosure	_____	_____	_____	_____	area
Install doors and frames	_____	_____	_____	_____	number
Install doors only	_____	_____	_____	_____	number
(1) OP*GE4 Added Cost:	_____	_____	_____	_____	$

State	Definition
(1) OP*GE4:	Open 4 or more floors
(2) OP*2-3:	Open 2 or 3 floors
Enclosed with indicated fire resistance:	
(3) ENC-1H:	Less than 1 hour
(4) ENC-2H:	Greater than or equal to 1 hour but less than 2 hours
(5) ENC+2H:	Greater than or equal to 2 hours

BUILDING SAFETY FEATURE NO. 8

Hazardous Areas

Building: _____

Zone: ___ **Floor:** ___

Input State: ___

Retrofit **State**

	(2) DBLOUT	(3) SGL IN	(4) SGLOUT	(5) NO DEF	
Upgrade enclosure	-1		-1		area
Install new doors	-1		-1		number
Install sprinklers	-1		-1		area
(1) DBL IN Added Cost:					$

(1) DBL IN: Double deficiency in zone
(2) DBLOUT: Double deficiency outside zone
(3) SGL IN: Single deficiency in zone
(4) SGLOUT: Single deficiency in adjacent zone
(5) NO DEF: No deficiency

BSF 8 DESIGN QUALIFIER

Is asbestos removal necessary for sprinklering? (Y/N) ___

BUILDING SAFETY FEATURE NO. 9
Smoke Control

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit	State (2) PARTTN	State (3) MECZON	
Install a new smoke partition	_____	-1	number
Install smoke doors only	_____	-1	number
Install partition slab-to-slab	_____	-1	length
Extend existing partition to slab	_____	-1	length
Install smoke dampers	_____	-1	number
Install duct smoke detectors	_____	-1	number
(1) NO CTL Added Cost:	_____	_____	$

State	Definition
(1) NO CTL:	No Control
(2) PARTTN:	Smoke Partition
(3) MECZON:	Mechanical Assisted Systems (by Zone)

BUILDING SAFETY FEATURE NO. 10
Emergency Movement Routes

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit **State**

	(2) DEFCAP	(3) W/OH*E	(4) H*EXIT	(5) DIRECT	
Install interior stairway	_____	_____	_____	-1	number of stories
Install exterior stairway	_____	_____	_____	-1	number of stories
Install emergency light	_____	_____	_____	-1	number
Install horizontal exit	_____	_____	_____	-1	number
Install horizontal exit doors only	_____	_____	_____	-1	number
Install partition slab-to-slab	_____	_____	_____	-1	length
Extend existing partition to slab	_____	_____	_____	-1	length
Install smoke dampers	_____	_____	_____	-1	number
(1) LT2RTS Added Cost:	_____	_____	_____	_____	$

State	Definition
(1) LT2RTS:	Less than 2 routes
Multiple Routes:	
(2) DEFCAP:	Deficient Capacity
(3) W/OH*E:	Without Horizontal Exits
(4) H*EXIT:	With Horizontal Exits
(5) DIRECT:	With Direct Exits

BUILDING SAFETY FEATURE NO. 11
Manual Fire Alarm

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit	**State** (2) W/OCON	(3) FD CON	
Install/replace a 12-zone control panel only	_____	_____	number
Install additional pull stations	_____	_____	number
New/additional connections to the fire department	_____	_____	number
Added Cost: (1) NO ALR	_____	_____	$

State	**Definition**
(1) NO ALR:	No manual fire alarm
(2) W/OCON:	Manual fire alarm without fire department connection
(3) FD CON:	Manual fire alarm with fire department connection

BUILDING SAFETY FEATURE NO. 12
Smoke Detection and Alarm

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit **State**

	(2) CORDOR	(3) ROOMS	(4) CORHAB	(5) TTLZON	
Length of corridor	_____	_____	_____	_____	length
Number of patient rooms	_____	_____	_____	_____	number
Area of common areas	_____	_____	_____	_____	area
Number of nonpatient rooms	_____	_____	_____	_____	number
Number of bathrooms and closets	_____	_____	_____	_____	number
(1) NONE Added Cost: _____	_____	_____	_____	_____	$

State	Definition
(1) NONE :	None
(2) CORDOR:	Corridor only
(3) ROOMS :	Rooms only
(4) CORHAB:	Corridors and habitable spaces
(5) TTLZON:	Total Space in Zone

BUILDING SAFETY FEATURE NO. 13
Automatic Sprinklers

Building: _____
Zone: ___ **Floor:** ___
Input State: ___

Retrofit		State	
	(2) CORHAB	(3) TTLBLD	
Zone floor area	_____	_____	area
(1) NONE			
Added Cost: _____	_____	_____	$

State	Definition
(1) NONE :	None
(2) CORHAB:	Corridors and Habitable Spaces
(3) TTLBLD:	Entire Building

BSF 13 DESIGN QUALIFIERS

Potential Retrofit (1=Exposed Automatic Sprinklers, 2=Concealed Automatic Sprinklers) ___
Water Supply (1=Adequate, 2=Inadequate) ___
Is asbestos removal necessary? (Y/N) ___
Are quick-response sprinklers now used in the entire zone? ___
Are quick-response sprinklers planned for the entire zone? ___
Are corridors and exits in this zone now sprinklered? ___
Are all rooms in this zone now sprinklered? ___