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FIRECAM™ System Model Documentation

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ABSTRACT

This document describes the FiRECAM™ system model as well as each of the individual submodels. The submodel linkages and interactions are described along with a summary of their respective results. Additional sections of this report also describe the FiRECAM™ input files and its contents, and the output data produced by a FiRECAM™ run.

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1. INTRODUCTION

1.1 FiRECAM™ Description

FiRECAM™ (Fire Risk Evaluation and Cost Assessment Model) is a computer model that is being developed at the National Research Council of Canada. The model can be used to assess both fire risks to life and protection costs and expected losses in a building. A general description of the model has been published previously [1]. This report describes the interaction and data flow among the individual models of FiRECAM™.

In its current implementation, FiRECAM™ is a standard Microsoft Windows® compatible graphical user interface (GUI) software package making use of a mouse, pull-down menus and dialogue boxes.

The software was developed using standard commercial program development tools and language libraries. For this release, FiRECAM™ was coded using commercially-available graphical interface software to handle the user input and reporting tasks.

FiRECAM™ uses six design fires in the compartment of fire origin, and the subsequent fire and smoke spread, to evaluate life risks and protection costs for apartment and office buildings. The six design fires, representing the wide spectrum of possible fire types, are:

1. Smouldering fire with the fire compartment entrance door open,
2. Smouldering fire with the fire compartment entrance door closed,
3. Flaming non-flashover fire with the fire compartment entrance door open,
4. Flaming non-flashover fire with the fire compartment entrance door closed,
5. Flashover fire with the fire compartment entrance door open,
6. Flashover fire with the fire compartment entrance door closed.

The probability of occurrence of each design fire, given that a fire has occurred, is based on statistical data. For example, in Canada, statistics show that 24% of all office fires reach flashover and become fully-developed fires, 54% are flaming fires that do not reach flashover and the remaining 22% are smouldering fires that do not reach the flaming stage [2]. If sprinklers are installed, the model assumes that some of the flashover and non-flashover fires, depending on the reliability and effectiveness of the sprinkler system, are rendered non-lethal [3].

FiRECAM™ evaluates the cumulative effect of all probable fire scenarios that could occur in the building during the life of the building. For example, in an office building, a fire scenario could be one resulting from one design fire in any one of the floors in the building. The number of fire scenarios, therefore, is the product of the number of design fires and the number of floors in the building.

In the case of an apartment building, the scenarios with occupants awake and occupants asleep are treated separately.

FiRECAM™ consists of a number of submodels that simulate the dynamic interaction of fire growth, smoke spread, occupant response and fire department intervention. For each fire scenario, the model calculates the expected number of deaths and fire losses. These values are then combined at the end with the probabilities of occurrence for the fire scenarios to obtain the following two decision-making parameters:

1. **E**xpected **R**isk to **L**ife **(ERL)**, defined as the expected number of deaths over the design life of a building, divided by the population of the building and the design life of the building.

2. **Fire Cost Expectation (FCE)**, defined as the expected total fire cost which includes the capital costs of the passive and active fire protection systems, the maintenance cost of the active fire protection systems and the expected losses as a result of all probable fire spread in the building.

1.2 Computer System Requirements

The present release of FiRECAM™ requires the following system configuration:

- 80286 or newer CPU running Microsoft Windows® 3.1 or newer.
- 8 to 16 MB of RAM (16 MB recommended).
- Hard disk with approximately 15 MB free space.
- Math coprocessor strongly recommended for 286 and 386 CPU.
- Mouse compatible with Microsoft Windows®.

2. FiRECAM™ MODELS

This section gives a brief description of the individual FiRECAM™ models and their linkages; e.g., interaction with the other models of FiRECAM™.

FiRECAM™ consists of fifteen interconnected models. The results of each model are stored in temporary files which are then used by other models to compute their respective outputs.

Table 2-1 lists the models used in FiRECAM™ and their purposes.

2.1 Model Naming Convention

In this document, frequent references will be made to the abbreviated names of the individual FiRECAM™ models. For reference, Table 2-1 below lists the description of a model, and its abbreviation. These model short names are used to derive the base names of any temporary files produced by each model, and any sections of the final output databases.

Table 2-1. FiRECAM™ model description and abbreviations

Model Name	Short Name	Section	Page	Purpose
Building Evaluation Model	**BEVM**	**3.1**	**9**	Computes correction factors for ignition potential, risk and other fire characteristics.
Fire Department Response Model	**FDRM**	**3.2**	**11**	Computes the response, setup, and intervention times of a fire department, as well as the probabilities of intervention.
Economic Model	**ECMD**	**3.3**	**13**	Computes building structural and contents costs, as well as costs for passive and active fire protection and suppression systems.
Boundary Element Failure Model	**BEFM**	**3.4**	**15**	Computes probabilities of failure of a wall or floor element.

Table 2-1. FiRECAM™ model description and abbreviations (Cont.)

Design Fire Model	**DFMD**	**3.5**	**18**	Calculates the rate of fire occurrence and the probability of occurrence of a fire scenario.
Fire Growth Model	**FGMD**	**3.6**	**20**	Models the growth of a fire in a compartment and calculates temperature and toxic gas concentrations as a function of time.
Fire Department Action Model	**FDAM**	**3.7**	**22**	Computes the intervention times and probabilities. In addition, calculates extinguishment and rescue effectiveness.
Occupant Response Model	**OCRM**	**3.8**	**26**	Computes occupant response and evacuation probabilities as well as probabilities of no occupant response.
Smoke Movement Model	**SMMD**	**3.9**	**31**	Computes the smoke hazard based on the temperature and concentration of toxic gases throughout the building as a function of time. In addition, this model computes the critical time that the stairs cannot be used by the occupants to evacuate.
Evacuation Model	**EVMD**	**3.10**	**34**	Simulates the evacuation of a building, given a floor of fire origin, building population and evacuation destinations.
Fire Spread Model	**FSPM**	**3.11**	**36**	Computes the probabilities of fire spread using the boundary failure probabilities from the Boundary Element Failure Model.
Expected Number Of Deaths Model	**ENDM**	**3.12**	**38**	Computes the expected number of deaths in a building given the number of trapped occupants and fire and smoke hazards.
Expected Risk To Life Model	**ERLM**	**3.13**	**40**	Computes the total expected risk to life of a building, based on the expected deaths from all given fire scenarios.
Property Loss Model	**PLMD**	**3.14**	**41**	Computes the expected economic losses to a building structure and contents given fire and smoke spread, and sensitivity to water.
Fire Cost Expectation Model	**FCED**	**3.15**	**43**	Computes the total fire cost expectation of a building, based on the property losses from all given fire scenarios.

2.2 Model Temporary File Naming Convention

During its execution, FiRECAM™ creates and uses temporary files to pass parameters and data between its individual models. When a model creates a temporary file, it uses the following naming convention:

`$$$$[model name].[1 to 3 digit extension indicating file #]`

A prefix consisting of four dollar signs; i.e. `'$$$$'` is followed by a four-letter model name. The file extension indicates the number of the file; it is used to distinguish multiple temporary files created by the same model. For example:

The Fire Growth Model **(FGMD)** creates two temporary files:

The first file is named	**`$$$$FGMD.0`**	for file # **0**
The second file is named	**`$$$$FGMD.1`**	for file # **1**

The Smoke Movement Model **(SMMD)** also creates two temporary files:

The first file is named	**`$$$$SMMD.0`**	for file # **0**
The second file is named	**`$$$$SMMD.1`**	for file # **1**

The Design Fire Model **(DFMD)** creates a single temporary file:

Its file is named	**`$$$$DFMD.0`**	for file # **0**

FiRECAM™ uses a zero-based file numbering convention. The first temporary file required by a model is numbered `0`, The second file is numbered `1`, and so on.

2.3 Location of Temporary Files

By default, FiRECAM™ creates all temporary files in the Windows **TEMP** directory[1]. FiRECAM™ does allow the user to specify the program's main directory as an alternative. All temporary files are deleted at the end of a FiRECAM™ run.

An available user option allows FiRECAM™ to create a debugging dump file that will contain all the contents of the temporary files created during a run[2].

2.4 Temporary File Contents and Structure

All temporary files created by FiRECAM™ are written out as ASCII text files, in a table (rows and columns) format. The general structure of a temporary file is as follows:

---

[1] The Windows **TEMP** directory is a special disk subdirectory used by Windows for storing its (and its applications') temporary files. By convention, any Windows program (such as FiRECAM™) uses this directory. It is usually set by an environment variable called **TEMP** in the system's startup files (**AUTOEXEC.BAT** and **CONFIG.SYS**). For more information, please consult Microsoft Windows® documentation.

[2] At the end of each scenario, FiRECAM™ will scan all the temporary files created by each model, and concatenate the contents into a single dump file.

Table 2-2. FiRECAM™ general temporary file layout

Column 1 Brief description of variable	Column 2 Data	...	Column N Data
Row 1 Description	Column 1 Row 1 Data	...	Column N Row 1 Data
Row 2 Description . . .	Column 1 Row 2 Data . . .	... . . .	Column N Row 2 Data . . .
Row M Description	Column 1 Row M Data		Column N Row M Data

For example, The Building Evaluation Model **(BEVM)** produces a single data column output file as shown below:

```
Fire_RateFactor        , 1
FlashFireFactor        , 1
NonflFireFactor        , 1
SmldrFireFactor        , 1
BarrFailFactor         , 1
SupprManFactor         , 1
SupprAutFactor         , 1
```

and a multiple-column data file is created by the Smoke Movement Model **(SMMD)**.

```
ProbSmokeSpreadFL/DO11   , 1            .6841847      4.732645E-02   6.930804E-04
ProbSmokeSpreadFL/DO12   , 4.951338E-02 4.571532E-02  5.690721E-03   4.951338E-02
ProbSmokeSpreadFL/DO13   , 4.474533E-03 6.536565E-03  0              4.474533E-03
ProbSmokeSpreadFL/DO21   , 4.474533E-03 6.536565E-03  0              4.474533E-03
ProbSmokeSpreadFL/DO22   , 1            .6841847      4.732645E-02   6.930804E-04
ProbSmokeSpreadFL/DO23   , 4.474533E-03 6.536565E-03  0              4.474533E-03
ProbSmokeSpreadFL/DO11   , 4.474533E-03 6.536565E-03  0              4.474533E-03
ProbSmokeSpreadFL/DO22   , 4.474533E-03 6.536565E-03  0              4.474533E-03
ProbSmokeSpreadFL/DO33   , 4.474533E-03 6.536565E-03  0              4.474533E-03
```

2.5 Model Execution and Linkage

FiRECAM™ executes its models, in a predetermined order, so models requiring data from previous models will have these results available as needed. The order in which the FiRECAM™ models execute during a run is dictated by the following conditions:

- Some models are fire scenario (and fire origin floor) independent[3]. Therefore, they may be executed once per FiRECAM™ run to reduce computation time. If such models are also model independent, they can also run at the beginning of FiRECAM™ and create a single copy of their respective temporary files. Examples of such models are **BEVM**, **FDRM**, and **ECMD**.
- Some models execute on a per fire scenario basis only. For example, **FGMD** runs once per fire scenario only. The results of this model are then stored in its temporary files.
- Some models execute on a per fire scenario basis, but may internally generate calculations for a fire occurring on each floor of the building. For example, **SMMD** will compute the smoke

[3] Here, model independent means no other models are required to run in order to produce intermediate results that may be required for this model; i.e. this model requires no intermediate files.

hazard data throughout the building for a fire occurring on Floor 1, then on Floor 2, and so forth. These results are then stored on a per floor basis for each fire origin floor.

Table 2-1 lists the scenarios and occupant states for which each FiRECAM™ executes.

Table 2-1. FiRECAM™ model scenario execution list

Scenario	BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Run Once Only[4]	•	•	•	•											•
FL/DO - Flashover fire, fire origin compartment door open					•	•	•	•	•	•	•	•	•	•	
FL/DC - Flashover fire, fire origin compartment door closed					•	•	•	•	•	•	•	•	•	•	
NF/DO - Non-flashover fire, fire origin compartment door open					•	•	•	•	•	•	•	•	•	•	
NF/DC - Non-flashover fire, fire origin compartment door closed					•	•	•	•	•	•	•	•	•	•	
SM/DO - Smouldering fire, fire origin compartment door open					•	•	•	•	•	•	•	•	•	•	
SM/DC - Smouldering fire, fire origin compartment door closed					•	•	•	•	•	•	•	•	•	•	
Occupants Awake[5]					•	•	•	•	•	•		•	•	•	
Occupants Asleep					•		•	•		•		•	•		
Each Fire Origin Floor[6]				•					•	•	•	•			

Figure 2-1 shows the actual order of model execution. Independent models are run only once at the beginning to conserve computation time, and the Design Fire Model **(DFMD)** executes as the first of the scenario dependent models. **DFMD** then produces the fire occurrence probability results used by other models whose calculations are then used by other models. At the end of all the fire scenarios' calculations, two small models, **ERLM** and **FCED**, calculate the final results of the run.

Figure 2-2 shows the order in which FiRECAM™ executes each of its models, but also shows the order of the temporary files created by each model. The arrows represent the data linkages and flow between the models. In general, the models at the end of the execution order use intermediate results of previous models. For example, the Expected Risk to Life Model **(ERLM)** requires data from the Expected Number of Deaths Model **(ENDM)** and the Design Fire Model **(DFMD)**. It then produces a final expected risk to life report.

[4] Some models are scenario independent, therefore their output is computed once only.
[5] For office occupancy buildings, occupants are always assumed to be awake; occupants asleep scenario is not run.
[6] Fire floor calculations are done internally.

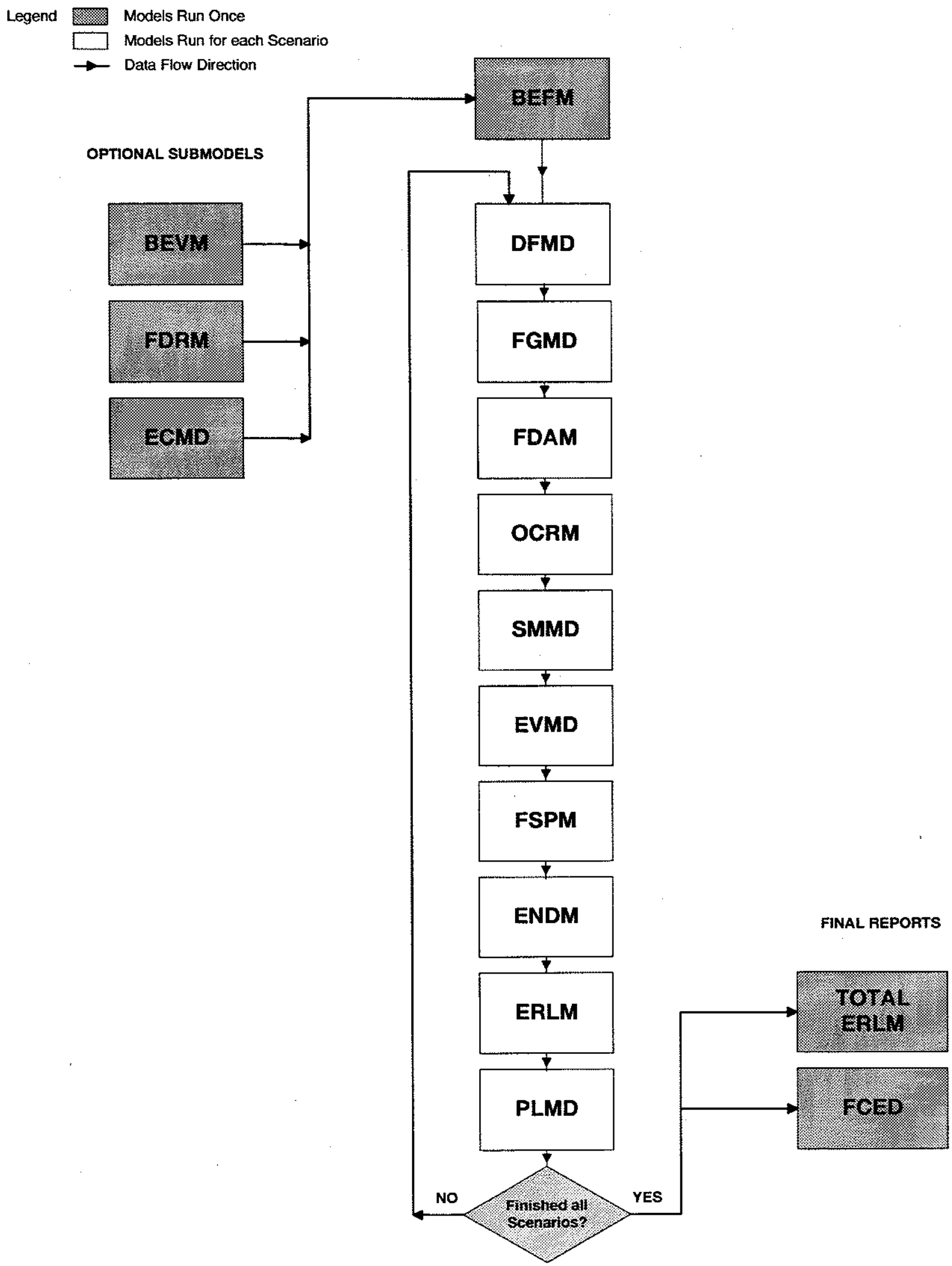

Figure 2-1. FiRECAM™ model execution sequence

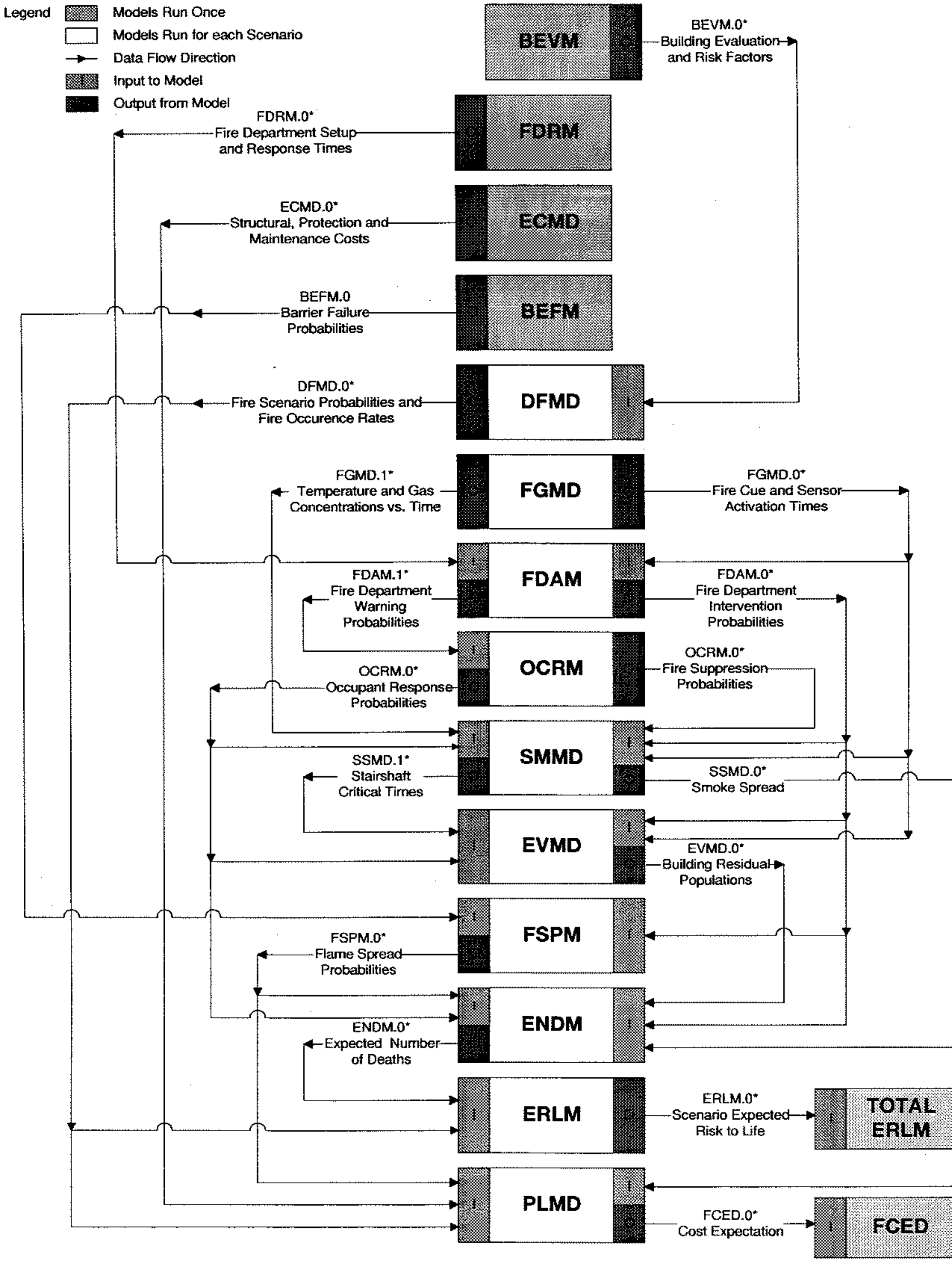

Figure 2-2. FiRECAM™ model data flow paths

3. FiRECAM™ MODEL DESCRIPTIONS

This section of the report will describe the individual FiRECAM™ models.

3.1 BEVM - Building Evaluation Model

This is an optional model that can be run to evaluate the fire characteristics of a building if the building is considered to be not a typical building where normal fire statistics can be applied. Based on the types and quantity of combustibles in the building and the separation of the combustibles from potential ignition sources and the maintenance of fire suppression systems (if they are installed), the model calculates the factors that can be used to correct the statistical values of the probability of fire starts, the probability of various design fires that may develop and the reliability of the fire suppression systems. These factors are used later in the Design Fire Model **(DFMD)** to correct the normal statistical values.

Objectives	This model evaluates the fire characteristics of a building.
Main input	Building layout Installed protection systems Building management and occupant characteristics Building fuel sources, quantities and flammability information Building risk of explosion and risk of collapse factors Construction materials Contents characteristics
Main output	Factors which are used to adjust the following probabilities, computed by the Design Fire Model **(DFMD)**. • Rate of fire occurrence • Probability of flashover fire occurrence • Probability of non-flashover fire occurrence • Probability of smouldering fire occurrence • Probability of manual suppression • Probability of automatic suppression • Probability of barrier failure
Comments	This model is executed once at the beginning of FiRECAM™. The temporary output file(s) for this model are created once, and used throughout the execution of FiRECAM™. The files are then deleted at the end of a FiRECAM™ run.

Table 3-1. Contents of Building Evaluation Model (BEVM) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	File Row	File Col	Models Using This Output
Factor used to adjust probability of fire start rate	BEVM.0	Fire_RateFactor	Single	-	1	2	DFMD
Factor used to adjust probability of flashover fire	BEVM.0	FlashFireFactor	Single	-	2	2	DFMD
Factor used to adjust probability of non-flashover fire	BEVM.0	NonflFireFactor	Single	-	3	2	DFMD
Factor used to adjust probability of smouldering fire	BEVM.0	SmldrFireFactor	Single	-	4	2	DFMD
Factor used to adjust probability of barrier failure	BEVM.0	BarrFailFactor	Single	-	5	2	Not Used
Factor used to adjust probability of manual suppression	BEVM.0	SupprManFactor	Single	-	6	2	Not Used
Factor used to adjust probability of automatic suppression	BEVM.0	SupprAutFactor	Single	-	7	2	Not Used

Listing 3-1. Example output file: BEVM.0

```
Fire_RateFactor          , 1
FlashFireFactor          , 1
NonflFireFactor          , 1
SmldrFireFactor          , 1
BarrFailFactor           , 1
SupprManFactor           , 1
SupprAutFactor           , 1
```

3.2 FDRM - Fire Department Response Model

This is an optional model that evaluates the fire department response characteristics to a building where normal response statistics can not be applied. Considering the characteristics of the fire department and the distance to the building, the model calculates the response time to the building. The computed response time is used later in the Fire Department Action Model **(FDAM)** instead of the normal statistical value.

Objectives	This model calculates the response of a fire department to a fire site
Methodology	The response time is computed by adding the dispatch, preparation and setup times
Main input	Fire department characteristics Distance between the fire department and the building
Main output	Fire department response and setup time
Comments	This model is executed once at the beginning of FiRECAM™. The temporary output file(s) for this model are created once, and used throughout the execution of FiRECAM™. The files are then deleted at the end of a FiRECAM™ run.

Table 3-2. Contents of Fire Department Response Model (FDRM) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Time of fire department dispatch	FDRM.0	DispatchTime	Single	sec	1	2	-
Time of fire department preparation	FDRM.0	PreparationTime	Single	sec	2	2	-
Time of fire department travel	FDRM.0	Travel Time	Single	sec	3	2	-
Time of fire department setup	FDRM.0	SetupTime	Single	sec	4	2	FDAM
Time of fire department response	FDRM.0	ResponseTime	Single	sec	5	2	FDAM

Listing 3-2. Example output file: FDRM.0

```
DispatchTime            , 50
PreparationTime         , 70
TravelTime              , 300
SetupTime               , 300
ResponseTime            , 420
```

3.3 ECMD - Economic Model

This model calculates the building construction cost and the capital and maintenance costs of the fire protection systems. It also calculates the replacement costs of building contents and the restoration costs of building elements as a result of smoke, fire and water damage. These costs are used later in the Property Loss Model **(PLMD)** to calculate the expected fire losses for each fire scenario, and in the Fire Cost Expectation Model **(FCED)** to calculate the total fire cost expectation.

Objectives	This model calculate the capital costs of structural building components and fire protection systems. In addition, It also calculates the annual costs of replacement, maintenance, and organizational activities
Methodology	This model retrieves cost data from the costs database by using the building layout and types of fire protection systems installed. It then sums the costs of components in the building (including structural components, fire protection systems, and organizational systems), as well as maintenance and organizational activities
Main input	Building layout Itemized capital and annual costs of components and activities Alarm and detection system characteristics Fire suppression system characteristics Passive system characteristics Smoke control system characteristics Emergency & organizational system characteristics Economic factors
Main output	Total capital cost per floor Total annual cost per floor Basic construction cost per floor FRR incremental cost per floor Construction cost per floor Annual maintenance costs Annual organizational costs Annual replacement costs Present worth of total annual costs Active protection systems capital costs Detection and alarm system capital costs Automatic suppression system capital costs Manual suppression system capital costs Smoke control system capital costs Emergency system capital costs Organizational system capital costs Capital cost of compartment of fire origin Capital cost of floor of fire origin Capital cost of each of the other floors
Comments	This model is executed once at the beginning of FiRECAM™. The temporary output file(s) for this model are created once, and used throughout the execution of FiRECAM™. The files are then deleted at the end of a FiRECAM™ run.

Table 3-3. Contents of Economic Model (ECMD) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Basic structure capital cost for compartment of fire origin	ECMD.0	BasicStructureCostCO*N*[7]	Single	$	1	2	PLMD
Basic structure capital cost for fire origin floor excluding compartment of fire origin	ECMD.0	BasicStructureCostFO*N*	Single	$	2	2	PLMD
Basic structure capital cost for entire floor	ECMD.0	BasicStructureCostOF*N*	Single	$	3	2	PLMD
Capital cost for fire protection systems	ECMD.0	CapCostProtection*N*	Single	$	4	2	PLMD
Annual cost for fire protection systems	ECMD.0	AnnlCostProtection*N*	Single	$	5	2	PLMD

Listing 3-3. Example output file: ECMD.0

```
BasicStructureCostCO1      , 170347
BasicStructureCostFO1      , 528512.5
BasicStructureCostOF1      , 698859.5
CapCostProtection1         , 36575.25
AnnlCostProtection1        , 0
     .                     .
     .                     .
     .                     .
BasicStructureCostCON      , 45134.68
BasicStructureCostFON      , 653724.8
BasicStructureCostOFN      , 698859.5
CapCostProtectionN         , 36575.25
AnnlCostProtectionN        , 0
```

[7] ***N*** is used to indicate the fire origin floor number.

3.4 BEFM - Boundary Element Failure Model

This model calculates the probability of failure of the boundary elements (such as walls, floors and doors) in the building when exposed to a design flashover fire that could occur in the building. The characteristics of the design flashover fire are obtained from the Fire Growth Model **(FGMD)**. The failure probability values are used later in the Fire Spread Model **(FSPM)** to calculate the probability of fire spread from the compartment of fire origin to every location in the building.

Objectives	This model calculates the probability of failure of boundary elements of construction when these boundaries are subjected to fully developed fires.
Methodology	This model is based on the normalized heat load concept. It compares the heat attack in the fire resistance rating test on the boundary element with the heat attack in a real fire to estimate the probability of failure of the element. The heat attack in real fires is computed based on the fire load, the area of the compartment and the ventilation openings.
Main input	Fire Resistance rating of the boundary elements Type of construction Fire load in building Building geometry
Main output	Probability of failure of boundary elements.
Comments	This model is executed once at the beginning of FiRECAM™. The temporary output file(s) for this model are created once, and used throughout the execution of FiRECAM. The files are then deleted at the end of a FiRECAM™ run.

Table 3-4. Contents of Boundary Failure Model (BEFM) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Fire Spread Probabilities							
Probability of fire spread from apartment to apartment above	BEFM.0	ApartmentApartmentUp *N*[7]	Single	-	6	2	FSPM
Probability of fire spread from apartment to apartment below	BEFM.0	ApartmentApartmentDown*N*	Single	-	7	2	FSPM
Probability of fire spread from apartment to corridor	BEFM.0	ApartmentCorridor *N*	Single	-	8	2	FSPM
Probability of fire spread from apartment to ducts	BEFM.0	ApartmentDuctsHorizontal*N*	Single	-	9	2	FSPM
Probability of fire spread from ducts to apartment	BEFM.0	ApartmentDuctsHorizontal*N*	Single	-	10	2	FSPM
Probability of fire spread from apartment to balcony-void	BEFM.0	ApartmentBalcony-Void*N*	Single	-	11	2	FSPM
Probability of fire spread from corridor to stairwell	BEFM.0	CorridorStairwell*N*	Single	-	12	2	FSPM
Probability of fire spread from corridor to elevator	BEFM.0	CorridorElevator*N*	Single	-	13	2	FSPM
Probability of fire spread from apartment to apartment horizontal	BEFM.0	ApartApartHorizontal *N*	Single	-	14	2	FSPM

Listing 3-4. Example output file: BEFM.0

```
ApartmentApartmentUp1       , 5.000223E-02
ApartmentApartmentDown1     , 6.670985E-09
ApartmentCorridor1          , 0.990001
ApartmentDuctsHorizontal1 , 1.003965E-04
ApartmentDuctsHorizontal1 , 0.0001
ApartmentBalcony-Void1      , 0.9900014
CorridorStairwell1          , 0.1000905
CorridorElevator1           , 0.1000901
ApartApartHorizontal2       , 0.1000902
ApartmentApartmentUp2       , 5.000223E-02
ApartmentApartmentDown2     , 6.670985E-09
ApartmentCorridor2          , 0.990001
ApartmentDuctsHorizontal2 , 1.003965E-04
ApartmentDuctsHorizontal2 , 0.0001
ApartmentBalcony-Void2      , 0.9900014
CorridorStairwell2          , 0.1000905
CorridorElevator2           , 0.1000901
ApartApartHorizontal2       , 0.1000902
        .
        .
        .
ApartmentApartmentUpN       , 5.000223E-02
ApartmentApartmentDownN     , 6.670985E-09
ApartmentCorridorN          , 0.990001
ApartmentDuctsHorizontalN , 1.003965E-04
ApartmentDuctsHorizontalN , 0.0001
ApartmentBalcony-VoidN      , 0.9900014
CorridorStairwellN          , 0.1000905
CorridorElevatorN           , 0.1000901
ApartApartHorizontalN       , 0.1000902
```

3.5 DFMD - Design Fire Model

This model calculates the probability of a fire scenario occurrence. The six fire scenarios, representing the spectrum of possible fire types, are:

- Smouldering fire with the fire compartment entrance door open,
- Smouldering fire with the fire compartment entrance door closed,
- Flaming non-flashover fire with the fire compartment entrance door open,
- Flaming non-flashover fire with the fire compartment entrance door closed,
- Flashover fire with the fire compartment entrance door open,
- Flashover fire with the fire compartment entrance door closed.

The probability of occurrence of each design fire, given that a fire has occurred, is based on statistical data. If sprinklers are installed, the model assumes that some of the flashover and non-flashover fires, depending on the reliability and effectiveness of the sprinkler system, are rendered non-lethal.

Objectives	This model computes the rates of fire occurrences, and the probabilities of the fire types being one of the following: • Flashover • Non-flashover • Smouldering
Methodology	Fire occurrence and type probabilities are read from the Statistics section of the Expert Data Input, which are obtained from studies. Fire occurrence and probabilities are adjusted by the output of the Building Evaluation Model **(BEVM).** If sprinklers are installed, flashover and non-flashover occurrence probabilities are adjusted downward to reflect the probability of suppression by the sprinklers.
Main input	Statistical values for fire occurrences and probabilities of fire type Building Evaluation fire rate and occurrence factors Presence of sprinkler systems in building
Main output	Adjusted rates of fire occurrences and probabilities of fire type: • Rate of fire occurrence • Probability of flashover fire occurrence • Probability of non-flashover fire occurrence • Probability of smouldering fire occurrence
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-5. Contents of Design Fire Model (DFMD) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Adjusted rate of fire occurrence	DFMD.0	FireStartRate	Single	-			ERLM PLMD
Adjusted probability of flashover fires	*DFMD.0*	*ProbFlashFire*	*Single*	-			ERLM PLMD
Adjusted probability of non-flashover fires	DFMD.0	ProbNonFlFire	Single	-			ERLM PLMD
Probability of smouldering fires	DFMD.0	ProbSmldrFire	Single	-			ERLM PLMD
Adjusted rate of fire occurrence for apartment buildings for occupants *awake or asleep*	DFMD.0	PartFireStartRate	Single	-			ERLM PLMD

Listing 3-5. Example output file: DFMD.0

```
FireStartRate          , .00768
ProbFlashFire          , .242
ProbNonFlFire          , .535
ProbSmldrFire          , .223
PartFireStartRate      , .00768
```

3.6 FGMD - Fire Growth Model

The fire growth model predicts the development of the six design fires in the compartment of fire origin. Details of the fire growth model for apartment buildings are described in a previous paper [4]. The model calculates the burning rate, room temperature and the production and concentration of toxic gases as a function of time. With these calculations, the model determines the time of occurrence of five important events:

- Time of fire cue,
- Time of smoke detector activation,
- Time of heat detector or sprinkler activation,
- Time of fire flashover,
- Time of fire burnout.

The first three detection times are used later in the Occupant Response Model **(OCRM)** and Evacuation Model **(EVMD)** to calculate the response and evacuation of the occupants from the building. The flashover time is used in the Fire Department Action Model **(FDAM)** to calculate the effectiveness of fire fighting and rescue efforts. The burnout time is used in the Smoke Movement Model **(SMMD)** to calculate the maximum smoke hazard that the occupants could be subjected to. The model also calculates the mass flow rate, the temperature and the concentrations of CO and CO_2 in the hot gases leaving the fire compartment. This latter information is used in the Smoke Movement Model to calculate the spread of smoke to different parts of the building as a function of time.

Objectives	This model calculates the fire development in the compartment of fire origin. The model then computes the temperature, CO and CO_2 concentration with time in that compartment as well as the flow of hot gases out of the compartment. Determines the timing occurrence of the different states of the fire development process.
Methodology	This model is a one zone model. Fire growth is computed based on the combustion of a representative fuel: • Polyurethane foam for residential buildings • Wood cribs for office buildings
Main input	Compartment dimensions, fire load and openings Type of design fire
Main output	Temperature, CO, CO_2 and mass flow rate of hot gases leaving the compartment of fire. Times of occurrence of a number of states of fire growth
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-6. Contents of Fire Growth Model (FGMD) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Fire Cue Times							
Time of cue	FGMD.0	TimeCue	Single	sec	1	2	FDAM EVMD
Time of activation of smoke alarm	FGMD.0	TimeActivateSmoke Alarm	Single	sec	2	2	FDAM EVMD
Time of activation of sprinklers	FGMD.0	TimeActivateSprinkl ers	Single	sec	3	2	FDAM EVMD
Time of flashover	FGMD.0	TimeFlashover	Single	sec	4	2	FDAM EVMD
Time of burnout	FGMD.0	TimeBurnout	Single	sec	5	2	FDAM SMMD
Time Frame Duration							
Beginning of time frame 1	FGMD.0	BeginTimeFrame1	Single	sec	6	2	FDAM SMMD EVMD
Beginning of time frame 2	FGMD.0	BeginTimeFrame2	Single	sec	7	2	FDAM SMMD EVMD
Beginning of time frame 3	FGMD.0	BeginTimeFrame3	Single	sec	8	2	FDAM SMMD EVMD
Beginning of time frame 4	FGMD.0	BeginTimeFrame4	Single	sec	9	2	FDAM SMMD EVMD
Beginning of time frame 5	FGMD.0	BeginTimeFrame5	Single	sec	10	2	FDAM SMMD EVMD
Beginning of time frame 6	FGMD.0	BeginTimeFrame6	Single	sec	11	2	FDAM SMMD EVMD
Begin of time frame 7	FGMD.0	BeginTimeFrame7	Single	sec	12	2	FDAM SMMD EVMD
Beginning of time frame 8	FGMD.0	BeginTimeFrame8	Single	sec	13	2	FDAM SMMD EVMD
Beginning of time frame 9	FGMD.0	BeginTimeFrame9	Single	sec	14	2	FDAM SMMD EVMD
Beginning of time frame 10	FGMD.0	BeginTimeFrame10	Single	sec	15	2	FDAM SMMD EVMD

Table 3-7. Contents of Fire Growth Model (FGMD) file #1

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Fire Growth Data File Time Steps							
Time limit of fire growth	FGMD.1		Long	sec	1	1	SMMD
Time step of fire growth	FGMD.1		Long	sec	1	2	SMMD
# Rows in fire growth file	FGMD.1		Long	-	1	3	SMMD
Fire Growth Data File Temperature and Gas Concentrations Vs. Time							
Room Temperature	FGMD.1		Single	°K	2......	1	SMMD
Mass flow rate of fire gases	FGMD.1		Single	kg/min	2......	2	SMMD
CO concentration	FGMD.1		Single	%	2......	3	SMMD
CO_2 concentration	FGMD.1		Single	%	2......	4	SMMD

Listing 3-6. Example output file: FGMD.0

```
TimeCue                          , 85.1999
TimeActivateSmokeAlarm           , 121.2
TimeActivateSprinklers           , 235.2
TimeFlashover                    , 888.015
TimeBurnout                      , 3396.99
BeginTimeFrame1                  , 103.2
BeginTimeFrame2                  , 121.2
BeginTimeFrame3                  , 178.2
BeginTimeFrame4                  , 235.2
BeginTimeFrame5                  , 535.2
BeginTimeFrame6                  , 835.2
BeginTimeFrame7                  , 1135.2
BeginTimeFrame8                  , 1435.2
BeginTimeFrame9                  , 1735.2
BeginTimeFrame10                 , 2035.2
```

Listing 3-7. Example output file: FGMD.1

```
3600          3             1200
293.091       .0346544      7.54996E-06     7.54984E-04
   .             .             .               .
   .             .             .               .
   .             .             .               .
293.091       .0346544      7.54996E-06     7.54984E-04
```

3.7 FDAM - Fire Department Action Model

This model calculates the effectiveness of fire fighting and rescue efforts, based on the time of arrival of the fire department, the time of flashover from the Fire Growth Model **(FGMD)** and the fire fighting resources that have arrived at the scene. The rescue effectiveness value is used later in the Evacuation Model **(EVMD)** to reduce the number of occupants who are trapped in the building and the fire fighting effectiveness in the Fire Spread Model **(FSPM)** to reduce the probability of fire spread. The time of arrival is also used later in the Smoke Movement Model **(SMMD)** to evaluate the smoke hazard conditions to the occupants at the time of arrival of the fire department.

Objectives	This model calculates the probability of fire department arrival at the fire site and the expected time of fire department action. It also calculates the impact of fire department action on the fire spread and smoke hazard probabilities in the building as well as the rescue effort.
Methodology	Uses the probabilities of fire detection at the different states of fire development and probabilities of calling the fire department at those states to find the overall probability of notification. The probability of notification is assumed to be equal to the probability of arrival. The expected time of action is computed by adding the notification time, the response time, the travel time and the setup time. The impact on the fire spread and smoke hazard probabilities is computed using the fire fighting effectiveness probabilities computed by the firefighters effectiveness model.
Main input	Notification, response and setup times of the fire department Probability of calling fire department by building occupants Direct connection to fire department
Main output	Probability of fire department arrival Expected time of arrival Fire fighting effectiveness in terms of intervention and extinguishment probabilities Rescue effectiveness
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-8. Contents of Fire Department Action Model (FDAM) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Fire Department Notification, Intervention and Extinguishment Factors							
Time of fire department notification	FDAM.0	TimeNotification	Single	sec	1	2	-
Time of fire department intervention	FDAM.0	TimeIntervention	Single	sec	2	2	SMMD EVMD FSPM
Probability of fire department intervention	FDAM.0	ProbIntervention	Single	-	3	2	SMMD FSPM ENDM
Combined probability of fire department extinguishment	FDAM.0	ProbExtinguish	Single	-	4	2	FSPM
Rescue effectiveness of the fire department	FDAM.0	RescueEffectFactor	Single	-	5	2	ENDM

Table 3-9. Contents of Fire Department Action Model (FDAM) file #1

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Fire Department Intervention Probabilities							
Probabilities of fire department intervention for time frame 1	FDAM.1	FdIntervProbs*Scenario*TimeFrame1[8]	Single	-	1	2	OCRM
Probabilities of fire department intervention for time frame 2	FDAM.1	FdIntervProbs*Scenario*TimeFrame2	Single	-	2	2	OCRM
Probabilities of fire department intervention for time frame 3	FDAM.1	FdIntervProbs*Scenario*TimeFrame3	Single	-	3	2	OCRM
Probabilities of fire department intervention for time frame 4	FDAM.1	FdIntervProbs*Scenario*TimeFrame4	Single	-	4	2	OCRM
Probabilities of fire department intervention for time frame 5	FDAM.1	FdIntervProbs*Scenario*TimeFrame5	Single	-	5	2	OCRM
Probabilities of fire department intervention for time frame 6	FDAM.1	FdIntervProbs*Scenario*TimeFrame6	Single	-	6	2	OCRM
Probabilities of fire department intervention for time frame 7	FDAM.1	FdIntervProbs*Scenario*TimeFrame7	Single	-	7	2	OCRM
Probabilities of fire department intervention for time frame 8	FDAM.1	FdIntervProbs*Scenario*TimeFrame8	Single	-	8	2	OCRM
Probabilities of fire department intervention for time frame 9	FDAM.1	FdIntervProbs*Scenario*TimeFrame9	Single	-	9	2	OCRM
Probabilities of fire department intervention for time frame 10	FDAM.1	FdIntervProbs*Scenario*TimeFrame10	Single	-	10	2	OCRM

[8] *Scenario* is one of the following: **FL/DO, FL/DC, NF/DO, NF/DC, SM/DO, SM/DC**

Listing 3-8. Example output file: FDAM.0

```
TimeNotification                  , 183.6487
TimeIntervention                  , 903.6487
ProbIntervention                  , .5858566
ProbExtinguish                    , .5272708
RescueEffectFactor                , .828
```

Listing 3-9. Example output file: FDAM.1

```
FdIntervProbsFL/DOTimeFrame1           , 0
FdIntervProbsFL/DOTimeFrame2           , 0
FdIntervProbsFL/DOTimeFrame3           , 0
FdIntervProbsFL/DOTimeFrame4           , 0
FdIntervProbsFL/DOTimeFrame5           , 0
FdIntervProbsFL/DOTimeFrame6           , 0
FdIntervProbsFL/DOTimeFrame7           , .1632423
FdIntervProbsFL/DOTimeFrame8           , .3078205
FdIntervProbsFL/DOTimeFrame9           , .0161176
FdIntervProbsFL/DOTimeFrame10          , 1.007017E-02
```

3.8 OCRM - Occupant Response Model

This model calculates the probability of occupant response at different locations in the building and at the 3 detection times (fire cue, smoke detector, heat detector/sprinkler activation). Details of this model are described in a previous publication [5]. The probability of response is calculated based on warnings received from fire cues, local alarms, central alarms, voice alarms, warnings from others and from fire fighters. The response probability values are used later in the Evacuation Model **(EVMD)** to calculate the percentage of the occupants who would respond and evacuate at the ten different time frames.

Objectives	This model calculates the probability building occupants will decide to evacuate the building.
Methodology	The response probabilities are calculated from the probabilities of detection and fire cues at ten time frames.
Main input	Building layout and installed protection systems Installed protection system components Protection system sensor activation probabilities and reliability Occupant perception probabilities for ten time frames Occupant action probabilities for ten time frames
Main output	Occupant response and evacuation probabilities for ten time frames Probabilities of no occupant response Probability of manual suppression by occupants
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-10. Contents of Occupant Response Model (OCRM) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Occupants in Compartment of Fire (OCF)							
Conditional evacuation probability for time frame 1	OCRM.0	ProbEvac*Scenario*OCFTimeFrame1[8]	Single	-	1	2	EVMD
Conditional evacuation probability for time frame 2	OCRM.0	ProbEvac*Scenario*OCFTimeFrame2	Single	-	2	2	EVMD
Conditional evacuation probability for time frame 3	OCRM.0	ProbEvac*Scenario*OCFTimeFrame3	Single	-	3	2	EVMD
Conditional evacuation probability for time frame 4	OCRM.0	ProbEvac*Scenario*OCFTimeFrame4	Single	-	4	2	EVMD
Conditional evacuation probability for time frame 5	OCRM.0	ProbEvac*Scenario*OCFTimeFrame5	Single	-	5	2	EVMD
Conditional evacuation probability for time frame 6	OCRM.0	ProbEvac*Scenario*OCFTimeFrame6	Single	-	6	2	EVMD ENDM
Conditional evacuation probability for time frame 7	OCRM.0	ProbEvac*Scenario*OCFTimeFrame6	Single	-	7	2	EVMD ENDM
Conditional evacuation probability for time frame 8	OCRM.0	ProbEvac*Scenario*OCFTimeFrame6	Single	-	8	2	EVMD ENDM
Conditional evacuation probability for time frame 9	OCRM.0	ProbEvac*Scenario*OCFTimeFrame6	Single	-	9	2	EVMD ENDM
Conditional evacuation probability for time frame 10	OCRM.0	ProbEvac*Scenario*OCFTimeFrame6	Single	-	10	2	EVMD ENDM

Table 3-10. Contents of Occupant Response Model (OCRM) file #0 (Cont.)

Occupants on Level of Fire (OLF)							
Conditional evacuation probability for time frame 1	OCRM.0	ProbEvac*Scenario*OLFTimeFrame1[8]	Single	-	11	2	EVMD
Conditional evacuation probability for time frame 2	OCRM.0	ProbEvac*Scenario*OLFTimeFrame2	Single	-	12	2	EVMD
Conditional evacuation probability for time frame 3	OCRM.0	ProbEvac*Scenario*OLFTimeFrame3	Single	-	13	2	EVMD
Conditional evacuation probability for time frame 4	OCRM.0	ProbEvac*Scenario*OLFTimeFrame4	Single	-	14	2	EVMD
Conditional evacuation probability for time frame 5	OCRM.0	ProbEvac*Scenario*OLFTimeFrame5	Single	-	15	2	EVMD
Conditional evacuation probability for time frame 6	OCRM.0	ProbEvac*Scenario*OLFTimeFrame6	Single	-	16	2	EVMD ENDM
Conditional evacuation probability for time frame 7	OCRM.0	ProbEvac*Scenario*OLFTimeFrame6	Single	-	17	2	EVMD ENDM
Conditional evacuation probability for time frame 8	OCRM.0	ProbEvac*Scenario*OLFTimeFrame6	Single	-	18	2	EVMD ENDM
Conditional evacuation probability for time frame 9	OCRM.0	ProbEvac*Scenario*OLFTimeFrame6	Single	-	19	2	EVMD ENDM
Conditional evacuation probability for time frame 10	OCRM.0	ProbEvac*Scenario*OLFTimeFrame6	Single	-	20	2	EVMD ENDM

Table 3-10. Contents of Occupant Response Model (OCRM) file #0 (Cont.)

Occupants on Other Levels (OOL)							
Conditional evacuation probability for time frame 1	OCRM.0	ProbEvacScenarioOOLTimeFrame1[8]	Single	-	21	2	SMMD EVMD
Conditional evacuation probability for time frame 2	OCRM.0	ProbEvacScenarioOOLTimeFrame2	Single	-	22	2	SMMD EVMD
Conditional evacuation probability for time frame 3	OCRM.0	ProbEvacScenarioOOLTimeFrame3	Single	-	23	2	SMMD EVMD
Conditional evacuation probability for time frame 4	OCRM.0	ProbEvacScenarioOOLTimeFrame4	Single	-	24	2	SMMD EVMD
Conditional evacuation probability for time frame 5	OCRM.0	ProbEvacScenarioOOLTimeFrame5	Single	-	25	2	SMMD EVMD
Conditional evacuation probability for time frame 6	OCRM.0	ProbEvacScenarioOOLTimeFrame6	Single	-	26	2	SMMD EVMD
Conditional evacuation probability for time frame 7	OCRM.0	ProbEvacScenarioOOLTimeFrame6	Single	-	27	2	SMMD EVMD
Conditional evacuation probability for time frame 8	OCRM.0	ProbEvacScenarioOOLTimeFrame6	Single	-	28	2	SMMD EVMD
Conditional evacuation probability for time frame 9	OCRM.0	ProbEvacScenarioOOLTimeFrame6	Single	-	29	2	SMMD EVMD
Conditional evacuation probability for time frame 10	OCRM.0	ProbEvacScenarioOOLTimeFrame6	Single	-	30	2	SMMD EVMD
Smouldering Fire Extinguishment Probabilities							
Smouldering fire suppression probability	OCRM.0	TotalPSMFSupprScenario	Single	-	31	2	SMMD

Listing 3-10. Example output file: OCRM.0

```
ProbEvacFL/DOOCFTimeFrame1          , 0
ProbEvacFL/DOOCFTimeFrame2          , 0
ProbEvacFL/DOOCFTimeFrame3          , .496
ProbEvacFL/DOOCFTimeFrame4          , .2542
ProbEvacFL/DOOCFTimeFrame5          , .2286732
ProbEvacFL/DOOCFTimeFrame6          , 7.576702E-03
ProbEvacFL/DOOCFTimeFrame7          , 0
ProbEvacFL/DOOCFTimeFrame8          , 0
ProbEvacFL/DOOCFTimeFrame9          , 0
ProbEvacFL/DOOCFTimeFrame10         , 1.355004E-02
ProbEvacFL/DOOLFTimeFrame1          , 0
ProbEvacFL/DOOLFTimeFrame2          , 0
ProbEvacFL/DOOLFTimeFrame3          , .1
ProbEvacFL/DOOLFTimeFrame4          , .20592
ProbEvacFL/DOOLFTimeFrame5          , .6068931
ProbEvacFL/DOOLFTimeFrame6          , 3.150436E-02
ProbEvacFL/DOOLFTimeFrame7          , 1.977104E-02
ProbEvacFL/DOOLFTimeFrame8          , .0164777
ProbEvacFL/DOOLFTimeFrame9          , 6.018719E-03
ProbEvacFL/DOOLFTimeFrame10         , .0134151
ProbEvacFL/DOOOLTimeFrame1          , 0
ProbEvacFL/DOOOLTimeFrame2          , 0
ProbEvacFL/DOOOLTimeFrame3          , .1
ProbEvacFL/DOOOLTimeFrame4          , .18648
ProbEvacFL/DOOOLTimeFrame5          , .6199761
ProbEvacFL/DOOOLTimeFrame6          , .032911
ProbEvacFL/DOOOLTimeFrame7          , 2.130515E-02
ProbEvacFL/DOOOLTimeFrame8          , 1.796712E-02
ProbEvacFL/DOOOLTimeFrame9          , 6.586296E-03
ProbEvacFL/DOOOLTimeFrame10         , 1.477432E-02
TotalPSMFSupprFL/DO                 , 1
```

3.9 SMMD - Smoke Movement Model

The smoke movement model calculates the spread of smoke and toxic gases to different parts of the building as a function of time. Details of this model are described in a previous publication [6]. The model also calculates the critical time that the stairs become untenable. This is the time that the remaining occupants, who have not evacuated the building, cannot use the stairs to evacuate and are considered trapped in the building. This critical time is used later in the Evacuation Model to calculate the time available for evacuation.

This model also calculates the smoke hazard (probability of incapacitation due to toxic gases) at every location in the building at the time of arrival of the fire department, obtained from the Fire Department Action Model **(FDAM)**. If there is no fire department response, this model calculates the smoke hazard at the time of burnout in the compartment of fire origin, obtained from the Fire Growth Model **(FGMD)**. The smoke hazard is based on the dosage and temperature of the toxic gases that the occupants are exposed to. The smoke hazard values are used later in the Expected Number of Deaths Model **(ENDM)** to evaluate the expected number of deaths at every location in the building, and in the Property Loss Model **(PLMD)** to evaluate the replacement costs of building contents due to smoke damage.

Objectives	This model calculates movement of hot gases from the compartment of fire origin to other locations in the building. Determines temperature, CO and CO_2 concentrations in the building with time. Computes the smoke hazard probabilities in the building based on the concentrations of CO and CO_2 and temperature at different locations in the building. Estimates time that the stairs become critical and occupants cannot use them for evacuation.
Methodology	Use buoyancy and stack effect forces to compute movement of hot gases from the fire compartment to other locations in the building with time. From mass, energy and species conservation equations find the temperature and CO and CO_2 concentrations at every location with time. All compartments on each floor, other than the compartment of fire origin, are grouped into one compartment. The FID values are computed using Steckler's equations [6]. The critical time when the stairs become critical is computed based on the effect of temperature and toxic gases on occupants from the top floor leaving through the stairs. Smoke hazard probabilities are computed using the concentrations of toxic gases and the temperature rise in the building. These are computed at two reference times; the time of fire brigade arrival and the burnout time. These include hazard from toxic gases (FID) and hazard from temperature.
Main input	Building geometric dimensions Number of compartments per floor Flow and properties of hot gases from the fire compartment
Main output	Probabilities of smoke hazard Time that stairs become critical
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-11. Contents of Smoke Spread Model (SMMD) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Smoke Spread Probabilities							
Probability of smoke spread from Fire Origin Compartment to Fire Origin Compartment	SMMD.0	`ProbSmokeSpreadScenarioMN`[7,8,9]	Single	-	all	2	ENDM PLMD
Probability of smoke spread from Fire Origin Compartment to Corridors	SMMD.0		Single	-	all	3	ENDM PLMD
Probability of smoke spread from Fire Origin Compartment to Stairwells	SMMD.0		Single	-	all	4	ENDM PLMD
Probability of smoke spread from Fire Origin Compartment to other Compartment on fire floor	SMMD.0		Single	-	all	5	ENDM PLMD

Table 3-12. Contents of Smoke Spread Model (SMMD) file #1

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Critical time	SMMD.1	`TimeCriticalScenarioN`[7,8]	Single	sec	all	2	SMMD

Listing 3-11. Example output file: SMMD.0

```
TimeCriticalFL/DO1          , 1077
TimeCriticalFL/DO2          , 1038
        .                     .
        .                     .
        .                     .
TimeCriticalFL/DON          , 732
```

Listing 3-12. Example output file: SMMD.1

```
ProbSmokeSpreadFL/DO11    , 1            0.6841847    4.732645E-02 6.930804E-04
ProbSmokeSpreadFL/DO12    , 4.951338E-02 4.571532E-02 5.690721E-03 4.951338E-02
                                .            .            .            .
                                .            .            .            .
                                .            .            .            .
ProbSmokeSpreadFL/DO1N    , 4.474533E-03 6.536565E-03 0            4.474533E-03
ProbSmokeSpreadFL/DO21    , 4.474533E-03 6.536565E-03 0            4.474533E-03
ProbSmokeSpreadFL/DO22    , 1            0.6841847    4.732645E-02 6.930804E-04
                                .            .            .            .
                                .            .            .            .
                                .            .            .            .
ProbSmokeSpreadFL/DO2N    , 4.474533E-03 6.536565E-03 0            4.474533E-03
                                .            .            .            .
                                .            .            .            .
                                .            .            .            .
                                .            .            .            .
                                .            .            .            .
                                .            .            .            .
ProbSmokeSpreadFL/DON1    , 4.474533E-03 6.536565E-03 0            4.474533E-03
ProbSmokeSpreadFL/DON2    , 4.474533E-03 6.536565E-03 0            4.474533E-03
                                .            .            .            .
                                .            .            .            .
                                .            .            .            .
ProbSmokeSpreadFL/DONN    , 4.474533E-03 6.536565E-03 0            4.474533E-03
```

3.10 EVMD - Evacuation Model

This is a time-dependent, deterministic model that calculates the egress of the occupants from the building. Based on the probability of response at ten time frames computed by the Occupant Response Model **(OCRM)** and the critical time of the stairs from the Smoke Movement Model **(SMMD)**, the model calculates the number of occupants who can evacuate the building and those who are considered trapped in the building. The number of occupants who are trapped in the building is reduced by the effectiveness of the rescue efforts of the fire department. The residual population in every location of the building is used later in the Expected Number of Deaths Model **(ENDM)** to calculate the expected number of deaths.

Objectives	This model calculates the residual population in the building when the stairs become critical and occupants cannot use them for evacuation.
Methodology	The model computes the movement of occupants through the stairs and out of the building. For this calculation it assumes a certain specified floor evacuation sequence. The flow of occupants through the stairs is computed using empirically derived occupant flow equations. The time available for the occupants to evacuate is obtained from the Fire Growth Model (**FGMD**) and the Smoke Movement (**SMMD**) models. Occupants who are unable to exit the building remain trapped inside the building and they are subjected to the probabilities of death at their location. These occupants are called the residual population.
Main input	Number of floors in the building Number of occupants per floor in the building Number and dimensions of exit routes Time available for occupant evacuation Condition of occupants, awake or asleep
Main output	Residual population in the building at the time that the stairs become critical.
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-13. Contents of Evacuation Model (EVMD) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Fire Origin Floor	EVMD.0	FireFloor*ScenarioN*[7,8]	Integer	-	1	2	-
Elapsed Time	EVMD.0	ElapsedTime	Float	sec	2	2	-
People on each floor	EVMD.0	PeopleinFloor*N*[7]	Integer	-	3......*N*	2	ENDM
People in the stairs	EVMD.0	PeopleinStairs	Integer	-	*N*+1	2	ENDM
People exited	EVMD.0	PeopleatExits	Integer	-	*N*+2	2	-

Listing 3-13. Example output file: EVMD.0

```
FireFloorFL/DO1          , 1
ElapsedTime              , 1077
PeopleinFloor1           , 0
PeopleinFloor2           , 0
      .                    .
      .                    .
      .                    .
PeopleinFloorN           , 0
PeopleinStairs           , 0
PeopleatExits            , 660
FireFloorFL/DO2          , 2
ElapsedTime              , 1038
PeopleinFloor1           , 0
PeopleinFloor2           , 0
      .                    .
      .                    .
      .                    .
PeopleinFloorN           , 0
PeopleinStairs           , 0
PeopleatExits            , 660
FireFloorFL/DON          , 3
ElapsedTime              , 999
PeopleinFloor1           , 1
PeopleinFloor2           , 0
      .                    .
      .                    .
      .                    .
PeopleinFloorN           , 0
PeopleinStairs           , 0
Exited                   , 659
```

3.11 FSPM - Fire Spread Model

The Fire Spread Model **(FSPM)** calculates the probability of fire spread to every location in the building based on:

- Probability of failure of the boundary elements obtained from the Boundary Element Failure Model **(BEFM), and**
- Fire fighting effectiveness obtained from the Fire Department Action Model **(FDAM)**.

The model is non-time-dependent where the probability of fire spread to every location in a building is assumed to occur at the time of fire burnout in the compartment of fire origin. This is a conservative approach since fire spread to all locations in a building is usually a slow process; much slower than the time it takes for the fire to burn out in the compartment of fire origin. The fire spread probability values are used later in the Expected Number of Deaths Model **(ENDM)** to evaluate the probability of life loss at every location in the building, and in the Property Loss Model **(PLMD)** to evaluate the replacement costs of building contents and restoration costs of building elements.

Objectives	This model computes the fire spread probabilities in the building based on the probabilities of barrier failures for each possible barrier and location.
Methodology	This model represents the building compartments, corridors, stairwells and shafts as a directed graph. A recursive graph searching routine is used to find all the possible paths from a fire source location to other locations in the building, while computing their respective probabilities. Once all the possible routes are found, the probabilities are combined to yield a probability of fire spread from a source to a destination. All compartments on each floor other than the compartment of fire origin are grouped into one compartment.
Main input	Building geometric dimensions Barrier failure probabilities from **BEFM**
Main output	Probabilities of fire spread from the compartment of fire origin to: • Corridors • Stairwells • Other compartments for each floor, given that a fire occurs on a particular floor.
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-14. Contents of Fire Spread Model (`FSPM`) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Probability of fire spread from Fire Origin Compartment to Fire Origin Compartment	FSPM.0	ProbFireSpread*ScenarioMN*[7,8,9]	Single	-	all	2	ENDM PLMD
Probability of fire spread from Fire Origin Compartment to Corridors	FSPM.0	(Not Used)	Single	-	all	3	ENDM PLMD
Probability of fire spread from Fire Origin Compartment to Stairwells	FSPM.0	(Not Used)	Single	-	all	4	ENDM PLMD
Probability of fire spread from Fire Origin Compartment to other Compartment on fire floor	FSPM.0	(Not Used)	Single	-	all	5	ENDM PLMD

Listing 3-14. Example output file: BEVM.0

```
ProbFireSpreadFL/DO11     , 1            0.6841847    4.732645E-02 6.930804E-04
ProbFireSpreadFL/DO12     , 4.951338E-02 4.571532E-02 5.690721E-03 4.951338E-02
                                 .            .            .            .
                                 .            .            .            .
                                 .            .            .            .
ProbFireSpreadFL/DO1N     , 4.474533E-03 6.536565E-03 0            4.474533E-03
ProbFireSpreadFL/DO21     , 4.474533E-03 6.536565E-03 0            4.474533E-03
ProbFireSpreadFL/DO22     , 1            0.6841847    4.732645E-02 6.930804E-04
                                 .            .            .            .
                                 .            .            .            .
                                 .            .            .            .
ProbFireSpreadFL/DO2N     , 4.474533E-03 6.536565E-03 0            4.474533E-03
                                 .            .            .            .
                                 .            .            .            .
                                 .            .            .            .
                                 .            .            .            .
                                 .            .            .            .
                                 .            .            .            .
ProbFireSpreadFL/DON1     , 4.474533E-03 6.536565E-03 0            4.474533E-03
ProbFireSpreadFL/DON2     , 4.474533E-03 6.536565E-03 0            4.474533E-03
                                 .            .            .            .
                                 .            .            .            .
                                 .            .            .            .
ProbFireSpreadFL/DONN     , 4.474533E-03 6.536565E-03 0            4474533E-03
```

[9] ***M*** is used to indicate the affected floor number.

3.12 ENDM - Expected Number of Deaths Model

This model calculates the probability of life loss in every location in the building, based on the smoke hazard values obtained from the Smoke Movement Model **(SMMD)** and the fire spread values obtained from the Fire Spread Model **(FSPM)**. In this model, the probability of life loss is reduced if there is a refuge area nearby, such as a balcony, which the occupants can use to avoid the hazard. The model then calculates the expected number of deaths for the fire scenario being considered, based on the residual population obtained from the Evacuation Model **(EVMD)** and the life loss probability values. The expected number of deaths is used in the Expected Risk to Life Model **(ERLM)** to calculate the total expected risk to life.

Objectives	This model calculates the expected number of occupants that may die from the effects of toxic gases and heat.
Methodology	Calculate the number of people that will die using: • The smoke hazard and probabilities of fire spread • The residual population in the building.
Main input	Smoke hazard and probabilities of fire spread Residual population in the building
Main output	Expected number of deaths
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-15. Contents of Expected Number of Deaths Model (ENDM) file #0

Description	File Name and Number	Variable Tag Name	Units	Data Type	Row	Col	Models Using This Output
Expected number of deaths	ENDM.0	ExpectedDeaths*Scenario* $N^{7,8}$	-	Float	all	2	ERLM

Listing 3-15. Example output file: ENDM.0

```
ExpectedDeathsFL/DO/AW1          , .147396
ExpectedDeathsFL/DO/AW2          , .1459403
     .                                 .
     .                                 .
     .                                 .
ExpectedDeathsFL/DO/AWN          , .6340529
```

3.13 ERLM - Expected Risk to Life Model

This model calculates the overall expected risk to life **(ERL)** by using the expected number of deaths in the building for each fire scenario, obtained from the Expected Number of Deaths Model **(ENDM)**, and the fire rates and probability of occurrence of each scenario, obtained from the Design Fire Model **(DFMD)**. The **ERL** is the expected number of deaths over the design life of a building, divided by the total population of the building and the design life of the building.

This model actually consists of two parts:

- The first part calculates the Expected **R**isk to Life **($ERL_{Scenario}$)** for a particular fire scenario. The expected risk values for each scenario are stored in a temporary file for further totalling by the second part of **ERLM**.
- The second part calculates the total Expected **R**isk to **L**ife **(ERL)** of a building at the end of FiRECAM™ by reading the **$ERL_{Scenario}$** values for each scenario from the first part, and multiplying them by the probability of occurrence of the fire scenario in question. Finally, the sum of these **ERL** and scenario probabilities is the total **ERL** for the building; i.e.

$$\mathbf{ERL} = \sum \mathbf{ERL}_{Scenario} \times \mathbf{Prob}_{Scenario}$$

Objectives	This model calculates the expected risk-to-life for the building. The total risk to life **(ERL)** is the sum of all the expected risks for each fire scenario.
Methodology	Calculates the expected risk-to-life for the building using • The expected number of deaths for each fire scenario • Population of building • Rate of fire occurrences • The probabilities of occurrence of each scenario.
Main input	ERLM Part 1: • Building construction type • Total population of building • Population for each floor in the building • Expected number of deaths for each scenario • Rate of fire occurrences ERLM Part 2: • Expected risk from each scenario from Part 1 • Probabilities of each scenario occurring
Main output	Expected risk-to-life.
Comments	The first part of this model is executed for each fire scenario to calculate a partial ERL value for this fire scenario. The second part of this model is executed once at the end of FiRECAM™, to calculate final expected risk results.

Table 3-16. Contents of Expected Risk to Life Model (ERLM) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Expected risk to life	ERLM.0	ExpectedRisk*Scenario*[8]	Float	-	1	2	ERLM

Listing 3-16. Example output file: ERLM.0

```
ExpectedRiskFL/DO/AW        , 8.310699E-06
ExpectedRiskFL/DO/AS        , 8.310699E-06
ExpectedRiskFL/DC/AW        , 8.310699E-06
ExpectedRiskFL/DC/AS        , 8.310699E-06
ExpectedRiskNF/DO/AW        , 8.310699E-06
ExpectedRiskNF/DO/AS        , 8.310699E-06
ExpectedRiskNF/DC/AW        , 8.310699E-06
ExpectedRiskNF/DC/AS        , 8.310699E-06
ExpectedRiskSN/DO/AW        , 8.310699E-06
ExpectedRiskSM/DO/AS        , 8.310699E-06
ExpectedRiskSM/DC/AW        , 8.310699E-06
ExpectedRiskSM/DC/AS        , 8.310699E-06
```

3.14 PLMD - Property Loss Model

This model calculates the replacement costs of building contents and restoration costs of building elements for the fire scenario being considered, based on smoke spread values from the Smoke Movement Model **(SMMD)**, fire spread probabilities from the Fire Spread Model **(FSPM)** and replacement and restoration unit costs from the Economic Model **(ECMD)**. The fire losses are used later in the Fire Cost Expectation Model **(FCED)** to calculate the total expected fire cost.

Objectives	This model calculates the costs of heat, smoke, and water damage for a building structure and its contents. These costs are calculated for a specific scenario occurring on each floor of the specified building.
Methodology	The probabilities of damage due to heat, smoke, and water are calculated for the type of fire scenario (flashover, flaming, or smouldering fire). These are calculated for each level of the building design. The total cost of damage due to smoke and fire is evaluated for each of the three fire types. This is done by multiplying these probabilities by the costs of the structure and the contents, and summing over each location and over each damage type,
Main input	Scenario characteristics Building layout characteristics Structural and building system capital costs from the Economic Model **(ECMD)** Value of contents Sensitivity of building structure and contents to smoke and water. Smoke spread probabilities from the Smoke Movement Model **(SMMD)** Fire spread probabilities from the Fire Spread Model **(FSPM)**
Main output	Loss to structural components for occurrence of each fire scenario Loss to contents for occurrence of each fire scenario
Comments	This model is executed for each fire scenario in FiRECAM™. The temporary output file(s) for this model are created at the beginning of this model's execution. Files existing from previous scenarios are overwritten.

Table 3-17. Contents of Property Loss Model (PLMD) file #0

Description	File Name and Number	Variable Tag Name	Data Type	Units	Row	Col	Models Using This Output
Losses per Floor		CostLossesPerFloor*ScenarioMN*[7,8,9]	Float				
Value of Losses per Floor			Float				

Listing 3-17. Example output file: PLMD.0

```
CostLossesPerFloorFL/DO11        , 654641.4     952291.1
CostLossesPerFloorFL/DO12        , 698487       933993.3
CostLossesPerFloorFL/DO13        , 698842.8     934000
CostLossesPerFloorFL/DO14        , 698748       933999.4
CostLossesAllFloorsFL/DO1        , 2750719      3754284
CostLossesPerFloorFL/DO21        , 698134.7     933975.3
CostLossesPerFloorFL/DO22        , 644086.8     953023.4
CostLossesPerFloorFL/DO23        , 698799.2     933999.8
CostLossesPerFloorFL/DO24        , 698841       934000
CostLossesAllFloorsFL/DO2        , 2739862      3754999
CostLossesPerFloorFL/DO31        , 698831.8     933999.9
CostLossesPerFloorFL/DO32        , 698775.7     933999.7
CostLossesPerFloorFL/DO33        , 645662.9     955098.4
CostLossesPerFloorFL/DO34        , 698459.2     933992.4
CostLossesAllFloorsFL/DO3        , 2741730      3757091
CostLossesPerFloorFL/DO41        , 698642.7     933997.8
CostLossesPerFloorFL/DO42        , 698831.8     933999.9
CostLossesPerFloorFL/DO43        , 698168.3     933977.5
CostLossesPerFloorFL/DO44        , 645652.1     955098.4
CostLossesAllFloorsFL/DO4        , 2741295      3757074
```

3.15 FCED - Fire Cost Expectation Model

This model calculates the total fire cost expectation **(FCE)** by using the capital and maintenance costs for the fire protection systems, obtained from the Economic Model **(ECMD),** the expected fire losses for each fire scenario, obtained from the Property Loss Model **(PLMD)** and the probability of occurrence of each scenario, obtained from the Design Fire Model **(DFMD). FCE** is the expected total fire cost which includes the capital cost for the passive and active fire protection systems, the maintenance costs for the active fire protection systems and the expected losses resulting from all probable fires in the building.

Objectives	This model calculates the Fire Cost Expectation of fire-related damage and protection systems for a specified building design.
Methodology	For a particular fire scenario, a probable cost of damage due to fire is calculated by multiplying the losses from fire damage by the probability of occurrence of that scenario, and summing for all scenarios expected over the life of the building. This value is added to the cost of protection systems and the annual costs associated with the building and protection system design, and normalized by the cost of the building structure and contents to obtain the Fire Cost Expectation **(FCE).**
Main input	Building layout Capital cost of building structure Capital cost of building contents Capital cost of protection systems in building Annual cost for protection systems in building Probability of occurrence for each scenario on each floor Rate of fire occurrence Value of probable property losses for occurrence of each scenario on each floor
Main output	Fire Cost Expectation Annual cost of property loss for building Annual cost of protection systems in building Capital cost of protection systems in building Capital cost of structure in building Cost of contents in building
Comments	This model is executed once at the end of FiRECAM™, to calculate final cost expectation results. This model produces no temporary files.

4. FiRECAM™ USER INPUT DATA

This section describes the layout and contents of a FiRECAM™ input file. A FiRECAM™ input document file is organized as a hierarchical data structure which contains all the necessary information to describe a building and its characteristics. The FiRECAM™ input document contains:

- Building geometric and construction data, including dimensions and materials.
- Installed fire protection and suppression systems.
- Climate and location.
- Economic data.
- Occupant characteristics and distribution.
- Fire growth and control information.
- Statistical (Expert) data

Each of these sections is defined as a single user defined object. Table 4-1 lists each section of the Document data structure, and Figure 4-1 shows the hierarchical layout of a FiRECAM™ main Document.

Table 4-1. Major structural elements of the `Document :: DOCUMENT_DATA_TYPE` data structure

FiRECAM™ INPUT DATA STRUCTURE		
VARIABLE TYPE	**VARIABLE DESCRIPTION**	**VARIABLE NAME**
RUN_TYPE	Run Control Data	Document.**RunControl**
FIREGROWTH_TYPE	Fire Growth Data	Document.**FireGrowth**
CLIMATE_TYPE	Climate and Weather Data	Document.**Climate**
ECONOMOC_TYPE	Economic and Fire Cost Calculation Data	Document.**Economic**
OCCUPANTS_TYPE	Building Occupant Data	Document.**Occupants**
GEOMETRIC_TYPE	Building Geometric Data	Document.**Geometry**
PROTECTION_TYPE	Fire Protection Systems Data	Document.**Protect**
FLOOR_TYPE	Individual Building Floor Geometric Data	Document.**Floors()**
EVALUATION_TYPE	Building Evaluation and Risk Factor Data	Document.**Evaluation**
DOCUMENT_DBASEDATA_TYPE	Statistical and Cost (Expert) Data	Document.**Stat**[10]

[10] The **DOCUMENT_DBASEDATA_TYPE** is described in "FiRECAM™ Expert Data" starting at Page 61.

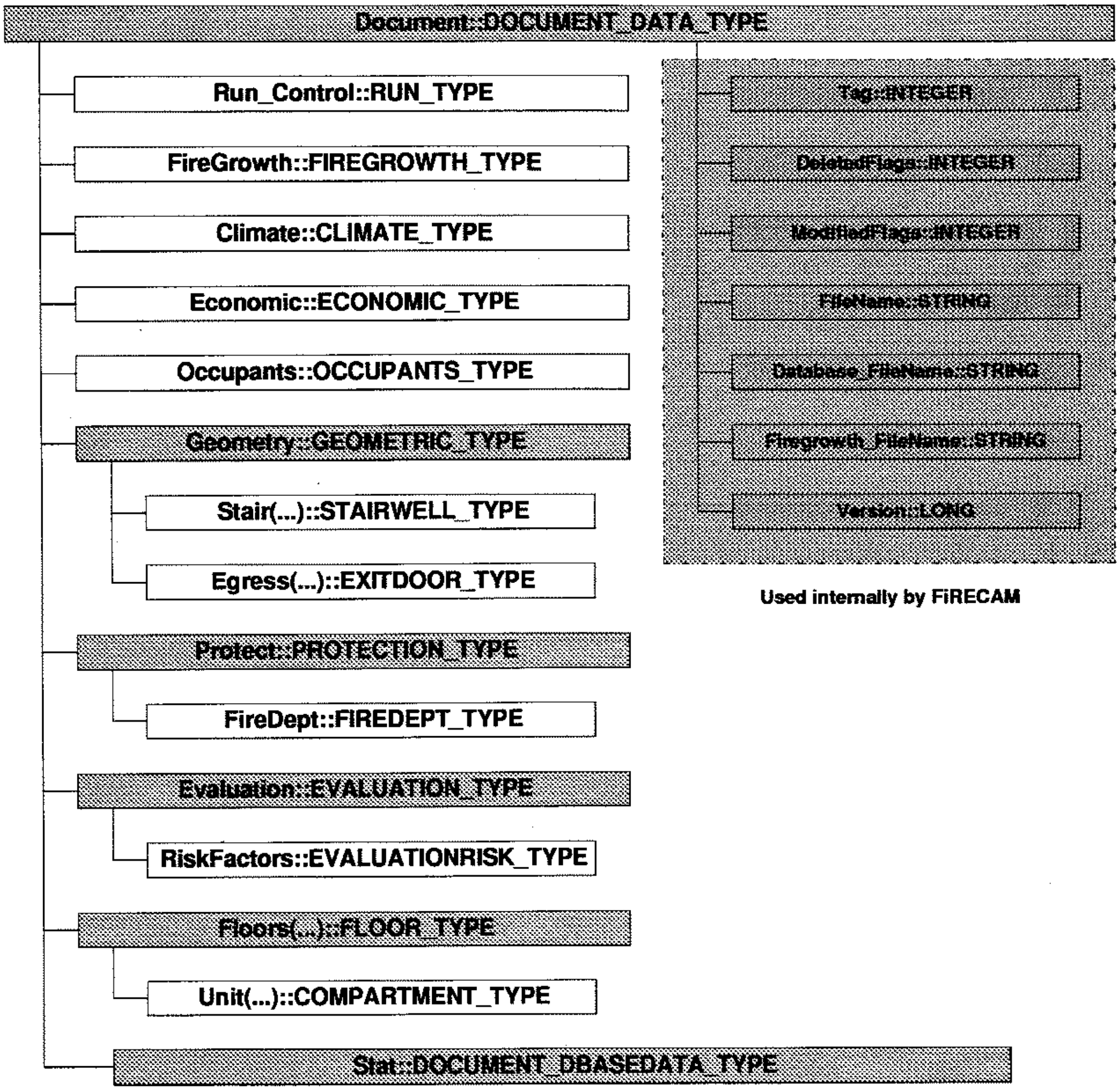

Figure 4-1. Layout of a FiRECAM™ input document: User input data sections

4.1 FiRECAM™ Document Section Variable Structure

This section describes the internal structure and elements of each section contained in the `Document::DOCUMENT_DATA_TYPE` document data structure.

Table 4-2 through Table 4-15 list the elements of each section.

The `RunControl::RUN_TYPE` input section contains the data used to control the execution of FiRECAM™, such as display units, file names and dates, and descriptions of the case study.

Some of the listed elements are unused, but are included for documentation and for future FiRECAM™ enhancements.

Table 4-2. Contents of `RunControl::RUN_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
RunControl :: RUN_TYPE			**BEVM**	**FDRM**	**ECMD**	**BEFM**	**DFMD**	**FGMD**	**FDAM**	**OCRM**	**SMMD**	**EVMD**	**FSPM**	**ENDM**	**ERLM**	**PLMD**	**FCED**
Run control data																	
.FileDate	File Creation Date	String					•										
.Author[11]	File Author	String															
.Description[11]	File Description	String															
.File_Name[12]	Reserved	String															
.Auxl_Name[12]	Reserved	String															
.ModelExecutionFlags	Model Run Flags	Integer	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
. ModelOutputFlags[11]	Model Output Flags	Integer															
.ModelScenarioFlags[11]	Model Scenario Flags	Integer															

The `FireGrowth::FIREGROWTH_TYPE` input section describes the data used to control the fire growth processes in FiRECAM™, such as:

- Fire origin compartment
- Fire origin floors; which floor to ignore or use
- Location of fire growth data file(s)
- Fire duration.

The Fire Growth **(FGMD)** model uses these entries to control the location and duration of the compartment fire(s).

[11] Although these input items are not used in any FiRECAM models, they are included for documentation purposes.
[12] These fields are reserved for future use

Table 4-3. Contents of `FireGrowth::FIREGROWTH_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
FireGrowth :: FIREGROWTH_TYPE			**BEVM**	**FDRM**	**ECMD**	**BEFM**	**DFMD**	**FGMD**	**FDAM**	**OCRM**	**SMMD**	**EVMD**	**FSPM**	**ENDM**	**ERLM**	**PLMD**	**FCED**
Fire growth data																	
.FireFloors	Fire floor	Integer						•									
.FireOrigins	Fire origin	Integer						•									
.FireFloorMask	True/False string used to indicate fire origin floors	String						•									
.FGDataSource	Location of fire growth file: default, use external or calculate new data	Integer						•									
.FGDuration()	Fire duration in minutes for each scenario	String						•									
.FGDataFile	Fire growth data file name	String						•									

The `Geometry::GEOMETRIC_TYPE` input section describes the geometric layout and dimensions of the building. In general, the following data falls in this category:

- Number of floors in the building and their dimensions
- Number of stairwells, elevators and service ducts
- Construction materials

Table 4-4. Contents of `Geometry::GEOMETRIC_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Geometry :: GEOMETRIC_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Building geometric data																	
.Nfloors	Number of floors above ground, including ground floor	Integer	•		•	•	•		•	•		•	•	•	•	•	
.Occupancy	Building occupancy Type	Integer	•		•	•	•		•	•		•			•	•	
.Layout	Building layout (Good, medium, poor)	Integer															
.Constr_type	Building construction type	Integer	•				•										
.Age	Building age (years)	Single	•														
.Life	Building design life (years)	Single			•										•		
.Floor_height	Height between floors (m)	Single				•				•		•					
.Floor_length	Floor length for a given floor (m)	Single			•							•					
.Floor_width	Floor width for a given floor (m)	Single			•	•						•					
Shaft and elevators																	
.Shafts	Number of elevators	Integer			•								•				
.FireElevs	Number of fire rated elevators	Integer															
.Ducts	Number of service ducts	Integer			•												
.Chutes	Number of garbage chutes	Integer			•												
.Balconies	Number of balconies	Integer			•												
Construction materials																	
.Matl_building	Building material type; 0 concrete, 1 steel, 2 wood frame	Integer			•												
.Matl_floor	Material for floors	Integer			•	•											
.Matl_aptwall	Material for inter-apt walls	Integer			•	•											
.Matl_ductwall	Material for service duct walls	Integer			•	•											
.Matl_balcwall	Material for exterior walls	Integer			•	•											
Smoke and water sensitivity																	
.Sens_smoke()	Sensitivity of building contents to smoke	Integer														•	
.Sens_water()	Sensitivity of building contents to water	Integer														•	

The `Geometry.Stair()::STAIRWELL_TYPE` input section describes the number, location, dimensions and occupant load factors of the stairwells in the building. This data is used by the Smoke Movement **(SMMD)** model to compute the concentrations of toxic gases, and to evaluate different escape routes for the Evacuation **(EVMD)** model.

Table 4-5. Contents of `Geometry.Stair()::STAIRWELL_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Geometry.Stair() :: STAIRWELL_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Building stairwell data																	
.StairWells	Number of stairwells used for evacuation	Integer			•						•	•	•				
.stairs_outside	Are stairs open to the outside ?	Integer									•						
.stair_tread	Tread of stair steps (m)	Single															
.stair_riser	Riser of stair steps (m)	Single															
.stair_depth	Depth of each stairwell (m)	Single									•	•					
.stair_width	Width of each stairwell (m)	Single									•	•					
.ID()	Stair location	Integer										•					
.Weight()	Stair load factor used in evacuation	Single										•					

The **`Geometry.Egress()::EXITDOOR_TYPE`** input section describes the number, location and occupant load factor of all the exit doors of the building. This data is used to evaluate different escape routes for the Evacuation **(EVMD)** model.

Table 4-6. Contents of `Geometry.Egress()::EXITDOOR_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Geometry.Egress() :: EXITDOOR_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Building exit door data																	
.Nexits	Number of exit doors	Integer										•					
.ID()	Exit location	Integer										•					
.Weight()	Exit load factor used in evacuation	Single										•					

The **`Protect::PROTECTION_TYPE`** input section describes the passive and active protection systems installed in the building. In general, the following data falls in this category:

- Fire resistance ratings in minutes
- Type of installed active fire protection system (if any)
- Number and location of detectors
- Sprinkler system description
- Manual suppression systems
- Smoke control and emergency planning

Table 4-7. Contents of `Protect::PROTECTION_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Protect :: PROTECTION_TYPE			**BEVM**	**FDRM**	**ECMD**	**BEFM**	**DFMD**	**FGMD**	**FDAM**	**OCRM**	**SMMD**	**EVMD**	**FSPM**	**ENDM**	**ERLM**	**PLMD**	**FCED**
Fire protection systems																	
.Passive_frr()	Passive fire resistance ratings	Integer		•		•											
Active protection systems																	
.System_type	Protection system Low Word - System type High Word - Central system type	Integer		•					•	•							
.Voice	Voice installed	Integer		•													
.Auto_callup	Connection to fire department	Integer		•					•								
.Nmini_horns	Mini-horns per floor	Integer		•													
.Nspeakers	Speakers per floor	Integer		•					•	•							
.Npull_bars	Manual pull-bar installed	Integer		•						•							
.Ntelephones	Emergency telephones per floor	Integer		•													
Smoke and heat detectors																	
.Nsmkdet_comp	Number of Smoke detectors installed in each compartment	Integer		•					•								
.Nsmkdet_corrs	Number of Smoke detectors installed in each corridor	Integer		•					•								
.Nsmkdet_stairs	Number of Smoke detectors installed in each stairwell	Integer		•					•								
.Nsmkdet_elev	Number of Smoke detectors installed in each elevator shaft	Integer		•					•								
.Nsmkdet_srvc	Number of Smoke detectors installed in each service duct	Integer		•					•								
.Nsmkdet_chute	Number of Smoke detectors installed in each garbage chute	Integer		•					•								
.Nsmkdet_HVAC	Number of Smoke detectors installed in all building HVAC ducts	Integer		•					•								
.Nheatdet_comp	Number of Thermal detectors installed in each compartment	Integer		•					•								
.Nheatdet_corrs	Number of Thermal detectors installed in each corridor	Integer		•					•								
.Nheatdet_stairs	Number of Thermal detectors installed in each stairwell	Integer		•					•								
.Nheatdet_elev	Number of Thermal detectors installed in each elevator shaft	Integer		•					•								
.Nheatdet_srvc	Number of Thermal detectors installed in each service shaft	Integer		•					•								

Table 4-7. Contents of `Protect::PROTECTION_TYPE` data section (Cont.)

.Nheatdet_chute	Number of Thermal detectors installed in each garbage chute	Integer		•					•								
.Nheatdet_HVAC	Number of Thermal detectors installed in all building HVAC ducts	Integer		•					•								
Automatic suppression																	
.Sprinklers	Sprinkler system type - full or partial coverage	Integer					•										
.Spk_connect	Sprinklers connected to central system	Integer					•										
.Nspkler_heads	Sprinkler heads per floor	Integer			•												
.Flow_switch	Flow switch & supervised valve in compartments	Integer			•												
.Nbooster_pumps	Sprinkler system booster pumps in building	Integer			•												
.Other_suppress	Other type of suppression System	Integer			•												
.Other_compts	Other suppression system components	Integer			•												
.Nstandpipe_risers	Number of standpipe risers per floor	Integer			•												
.Nstandpipe_recess	Number of fire hose cabinets per floor	Integer			•				•								
.Nstandpipe_pumps	Number of standpipe booster pumps in building	Integer			•												
.Nservice_elevs	Number of fire department service elevators in building	Integer			•												
.Npriv_hydrants	Number of private fire hydrants serving building	Integer			•												
Manual suppression																	
.Nexting_A	Type A extinguishers	Integer			•												
.Nexting_B	Type B extinguishers	Integer			•												
.Nexting_C	Type C extinguishers	Integer			•												
.Nexting_ABC	Type ABC extinguishers	Integer			•												
Smoke control systems																	
.Sp_installed	Stair shaft pressurization installed?	Integer															
.Sv_installed	Elevator shaft pressurization installed?	Integer															
.Nexhaust_shafts	Smoke exhaust vents per floor	Integer			•				•								
.Nexhaust_fans	Smoke exhaust fans in building	Integer			•												
.Nmax_opendoors	Maximum open doors for effective stair pressurization	Integer															

Table 4-7. Contents of `Protect::PROTECTION_TYPE` data section (Cont.)

Emergency, planning and inspection																	
.ngenerators	Number of emergency generators in building	Integer			•												
.nexit_lights	Number of emergency light fixtures per floor	Integer			•												
.nexit_signs	Number of exit signs per floor	Integer			•												
.orgopt_emerplan	Emergency & safety plan	Integer			•												
.nposted_emrplan	Posted emergency procedures per floor	Integer			•												
.nposted_floorplan	Posted floor plans per floor	Integer			•												
.ntrainees_exting	Trainees in manual extinguishment	Integer			•												
.ntrainees_evac	Trainees for evacuation and drills	Integer			•												
.inspection	Maintenance & inspection	Integer			•												
.system_monitor	Alarm system monitoring	Integer			•												
.annual_inspect	Annual Inspection	Integer			•												
.annual_drills	Annual evacuation drills	Integer			•												
.inc_repcosts	Include cost of replacement parts	Integer			•												

The `Protect.FireDept::FIREDEPT_TYPE` input section describes the characteristics of the fire department under study. The fire department is described using the following entries:

- Percentage of full-time, part-time and volunteers
- Communication systems
- Crew sizes and equipment
- Distances and layout of routes
- Hazard conditions

Table 4-8. Contents of `Protect.FireDept::FIREDEPT_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Protect.FireDept :: FIREDEPT_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Fire department data																	
.PerFullTime	% full-time	Integer							•								
.PerPartTime	% part-time	Integer							•								
.PerVolunteers	% volunteers	Integer							•								
.Communication	Communication systems (1: PA System) (2: Central alarm)	Integer		•													
.NotifyFFs	Notification of firefighters not in station (1: Page system) (2: Special phone) (3:PA System)	Integer		•													
.CallsPerDay	Number of calls per day	Integer		•													
.CallsConcur	Number of concurrent calls per day	Integer		•													
Crew and equipment																	
.CrewSize	Crew size	Integer							•					•			
.AvailOfBackURes	Availability of backup resources	Integer							•								
.EqNumOfEngines	Number of engines	Integer															
.EqNumOfAerials	Number of aerials	Integer															
.EqNumOfTankers	Number of tankers	Integer															
.EqNumOfCFRveh	Number of CFR vehicles	Integer															
.EqNumOfOtherVeh	Number of other vehicles	Integer															
.SpeEquipHoseDiam	Fire engine's hose diameter	Integer															
.SpeEquipLadderSize	Ladder size	Integer															
Firefighter experience and availability																	
.YearsOfExp	Years of experience	Integer		•													
.TrainFreq	Training frequency	Integer		•													
.LocalKnow	Local knowledge	Integer		•													
.Availability	Availability	Integer		•													
.PhysFitness	Physical fitness	Integer		•													
.EquipCond	Condition of firefighters' equipment	Integer		•													
Notification and travel conditions																	
.FDNotification	Fire department notification	Integer		•													
.DistOfPrimaryRoute	Distance of primary route [km]	Single		•													
.ProbOfPrimNotAvail	Probability of primary route not being available	Single		•													
.PrimStrArr	Primary: Street Arrangement	Integer		•													

Table 4-8. Contents of `Protect.FireDept::FIREDEPT_TYPE` data section (Cont.)

.PrimFreqOfCI	Primary: Frequency of curves and intersections	Integer		•													
.PrimTrafVol	Primary: Traffic Volume	Integer		•													
.DistOfAlternative	Distance of alternative route [km]	Single		•													
.AlterStrArr	Alternative: Street Arrangement	Integer		•													
.AlterFreqOfCI	Alternative: Frequency of Curves and Intersections	Integer		•													
.AlterTrafVol	Alternative: Traffic Volume	Integer		•													
.DistPublicRdToBld	Distance of building from public road [km]	Single		•													
Setup and hazards																	
.SetupTime	Setup time (sec)	Single		•													
.ProbAdeqWaterSupp	Adequate water supplies	Integer		•													
.PotentForExplos	Potential for explosion	Integer		•													
.RelOfHazMater	Potential for release of hazardous material	Integer		•													
.ProbBldCollapse	Probability of building Collapse	Integer		•													

The `Occupants::OCCUPANT_TYPE` input section describes the characteristics of the building occupants.

Table 4-9. Contents of `Occupants::OCCUPANT_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Occupants :: OCCUPANT_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Occupant data																	
.Occ()	Occupants habits	Integer	•														
.EvacPattern	Evacuation pattern- random or sequential	Integer										•					
.EvacTarget	Evacuation destination - exits or refuge floors	Integer										•					

The `Evaluation::EVALUATION_TYPE` input section describes some characteristics which are used to evaluate a building in terms of its occupant habits and management.

Table 4-10. Contents of `Evaluation::EVALUATION_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Evaluation :: EVALUATION_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Building evaluation and management																	
.Mng()	Management	Integer	•														
.Cmp()	Compartment	Integer	•														
.Spe()	Special Measures	Integer	•														

The `Evaluation.RiskFactors::EVALUATIONRISK_TYPE` input section describes some of the building characteristics which affect the occupant hazards, ignition sources, risk factors and danger potentials in the building under study.

Table 4-11. Contents of `Evaluation.RiskFactors::EVALUATIONRISK_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Evaluation.RiskFactors :: EVALUATIONRISK_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Building risk factors																	
.Heat()	Heat-energy sources risk factors - 6 items	Integer	•														
.Separ()	Separation Between Fuel and Heat Sources - 5 items	Integer	•														
.Inter()	Cause of Interaction - 13 items	Integer	•														
.Fuel()	Fuel Sources - 7 items	Integer	•														

The `Economic::ECONOMIC_TYPE` input section lists some flags used to control the behaviour of the Economic **(ECMD)** model. These flags control if the replacement costs are be included in the calculated losses, and if a basic or an fully itemized calculation of capital costs is computed.

Table 4-12. Contents of `Economic::ECONOMIC_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Economic :: ECONOMIC_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Economic data																	
.Use_basic_cost	Use basic construction capital cost	Integer			•												
.Inc_repcosts	Include replacement cost	Integer			•												

The `Climate::CLIMATE_TYPE` input section describes the location of the building and its climate data.

Table 4-13. Contents of `Climate::CLIMATE_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Climate :: CLIMATE_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Climate and location data																	
.CityName	Selected location	String					•										
.MonthMax()	Max temperature for each month (°C)	Single									•						
.MonthMin()	Min temperature for each month (°C)	Single									•						
.Air_temp	Indoor air temperature of the building (°C)	Single									•						

The `Floor()::FLOOR_TYPE` input section describes the layout for each floor of the building.

Table 4-14. Contents of `Floor()::FLOOR_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Floor() :: FLOOR_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Building floor layout																	
.Concept	Floor concept (Floor Layout Type) 1=Open, 2=Hybrid, 3=Divided	Integer			•						•	•				•	
.IsFireFloor	Is this floor considered as a fire origin floor ?	Integer			•						•	•					
.Refuge_balcs	Floor characteristics flags • Bit 0 : Is this floor a refuge floor ? • Bit 1 : Does it have balconies ?	Integer			•						•	•					
.FloorsEqual	Are all floors are of equal height and width ?	Integer			•												
.Floor_area	Floor area for THIS floor (m2) (if different from building value)	Single			•						•				•	•	
.Floor_length	Floor length for THIS floor (m) (if different from building value)	Single			•	•						•					
.Floor_width	Floor width for THIS floor (m) (if different from building value)	Single			•	•						•					
.Floor_height	Floor height for THIS floor (m) (if different from building value)	Single				•					•	•					
.Perc_Open	% of Open Area for hybrid floor (%)	Single										•				•	
Corridor layout																	
.Cor_width	Corridor width (m)	Single				•						•					
.Cor_length	Corridor length (m)	Single			•							•					
.Cor_area	Corridor area (m2)	Single			•							•					
.Cor_open	Are corridors partially open to outside?	Integer														•	
Compartments and doors																	
.Compartments	Number of compartments per floor	Integer			•						•	•	•		•	•	
.FireCompt	Fire origin compartment	Integer			•						•	•	•		•	•	
.columns	Number of columns per floor	Integer			•												
.wdiv_length	Length of one dividing wall (m)	Single			•						•						

Table 4-14. Contents of `Floor()::FLOOR_TYPE` data section (Cont.)

.cdiv_length	Length of corridor dividing wall(m)	Single			•												
.door_height	Height of compartment exit door (m)	Single									•						
.door_width	Width of compartment exit door (m)	Single									•						
.win_area	Non-fire rated window area (ventilation area)(m2)	Single			•								•				
.balc_area	Balcony glazing area (m2)	Single			•												
.win_height	Window height (ventilation height) (m)	Single											•				
Grid coordinates for occupant positions																	
.NumGrid		Integer										•					
.NumGridRows		Integer										•					
.NumGridCols		Integer										•					
Occupants																	
.SpecifiedOccLoad	Specifies whether to use a default occupant load, OR user specified load	Integer										•					
.People		Integer										•					
.FCPeople	People in fire origin compartment	Integer										•					
.MaxFloorPeople	Maximum population of typical floors	Integer										•					
.MaxCmptPeople	Population of typical floors	Integer										•					
.SpecFloorPeople	User specified population of typical floors	Integer										•					
.MinOccFloorArea	Minimum allowable floor area per occupant	Single										•					
Occupant composition																	
.PctMen	% Men	Integer									•	•					
.PctSeniorChildren	% Seniors and children	Integer									•	•					
.Families	% Family groups	Integer									•	•					
.PctDisabled	% Disabled persons	Integer										•					

The `Floor().Unit()::COMPARTMENT_TYPE` input section describes the dimensions and population of each compartment on a particular floor of the building.

Table 4-15. Contents of `Floor().Unit()::COMPARTMENT_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Floor().Unit() :: COMPARTMENT_TYPE			**BEVM**	**FDRM**	**ECMD**	**BEFM**	**DFMD**	**FGMD**	**FDAM**	**OCRM**	**SMMD**	**EVMD**	**FSPM**	**ENDM**	**ERLM**	**PLMD**	**FCED**
Building compartment layout																	
.Unit().Cmpt_Length	Compartment length (m)	Single															
.Unit().Cmpt_Width	Compartment width (m)	Single															
.Unit().Cmpt_Area	Compartment area (m2	Single															
.Unit().People	Occupants in compartment	Integer															

5. FiRECAM™ EXPERT DATA

This section describes the layout and contents of the Expert Data (Statistical and Cost) section of a FiRECAM™ input document. The FiRECAM™ expert section contains:

- Fire department characteristics and equipment factors.
- Fire occurrence rates and fire type occurrence probabilities.
- Occupant response and travel speed data.
- Numerical tolerance and iteration control for fire spread.
- Installed fire protection and suppression systems reliability factors.
- Cost data for building contents, construction and installed fire protection systems.

Table 5-1. Major structural elements of the `Stat::DOCUMENT_DBASEDATA_TYPE` data structure

FiRECAM™ EXPERT DATA STRUCTURE		
TYPE	**VARIABLE DESCRIPTION**	**VARIABLE NAME**
FDSTATISTICS_TYPE	Fire Department Statistics	Document.**Stat.DeptStatistics**
FIRESTATISTICS_TYPE	Fire Occurrence Statistical Data	Document.**Stat.FireStatistics**
OCCPTSTSTISTICS_TYPE	Occupant Statistical Data	Document.**Stat.OccptStatistics**
STATISTICS_TYPE	General Statistical Data	Document.**Stat.Statistics**
NUMERICAL_TYPE	Numerical and Iteration Control (Tolerance) Data	Document.**Stat.Numerical**
COST_TYPE	Cost and Economic Data	Document.**Stat.Costs**

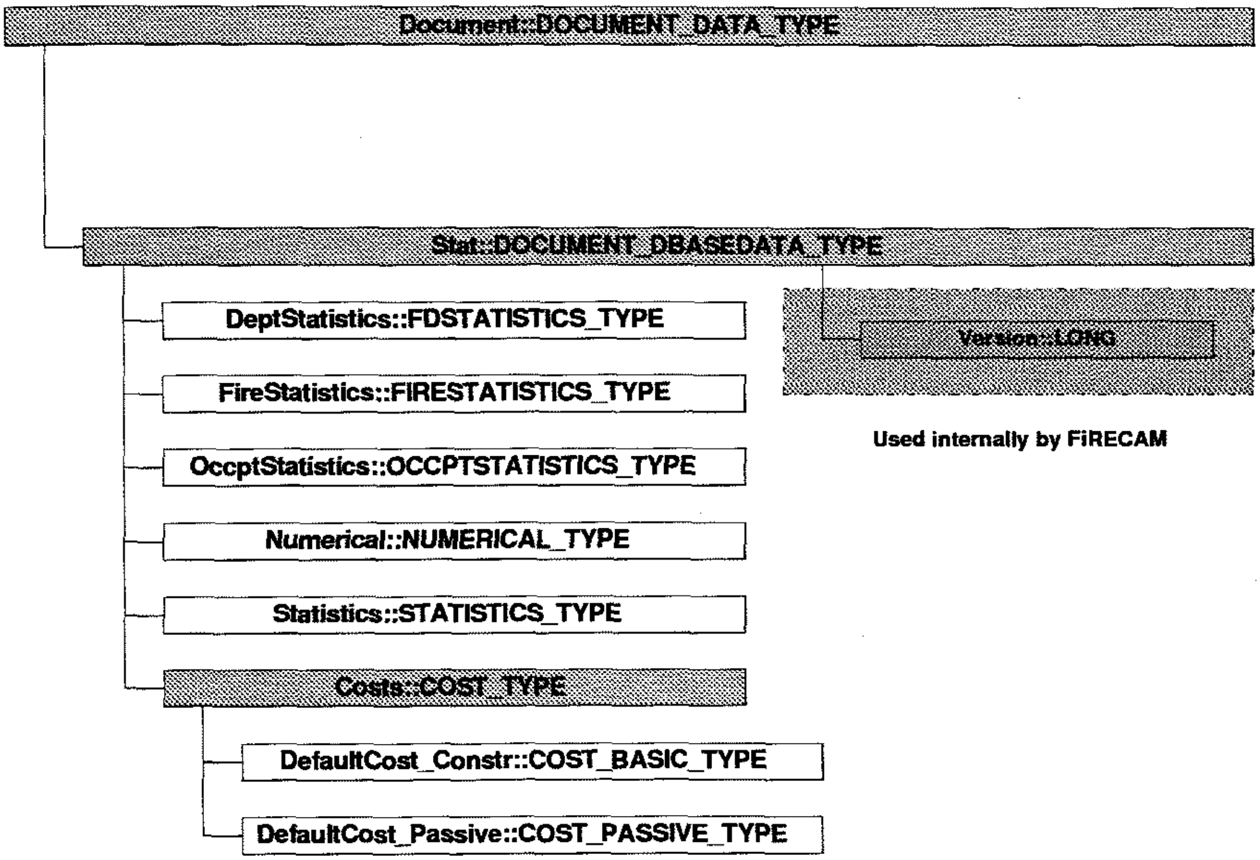

Figure 5-1. Layout of A FiRECAM™ Document: Expert Input Data Sections

5.1 FiRECAM™ Document Section Variable Structure

This section of the report describes the internal structure and elements of each section contained in the `Document.Stat::DOCUMENT_DBASEDATA_TYPE` document data structure.

Table 5-2 through Table 5-9 list the elements of each section.

The `DeptStatistics::FDSTATISTICS_TYPE` input section lists the factors used to compute the fire department's response time.

These entries are used by the Fire Department Response **(FDRM)** and Fire Department Action **(FDAM)** models.

Table 5-2. Contents of `DeptStatistics::FDSTATISTICS_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
DeptStatistics :: FDSTATISTICS_TYPE			**BEVM**	**FDRM**	**ECMD**	**BEFM**	**DFMD**	**FGMD**	**FDAM**	**OCRM**	**SMMD**	**EVMD**	**FSPM**	**ENDM**	**ERLM**	**PLMD**	**FCED**
Fire department response data																	
.Time_dispatch	Dispatch time of fire department (sec)	Single		•													
.Time_preparation	Preparation time of fire department (sec)	Single		•													
.Time_response	Response time of fire department (sec)	Single															
.Time_travel	Travel time to a fire site (sec)	Single		•													
.Time_setup	Setup time of fire department (sec)	Single		•													
Notification data																	
.FDNotif()	Fire department notification: Auto alarm, 911 centre, Public phone	Single		•													
.NotifyFF()	Notification of absent firefighters	Single		•													
.CommSys()	Communication Systems: PA system, central alarm, public phone	Single		•													
Dispatch data																	
.FFExper_d()	FF Experience: two or more years, less than two years, novice	Single		•													
.FFTrain_d()	FF training frequency: high, medium, low	Single		•													
.FFLKnow_d()	FF local knowledge: very good, good, poor	Single		•													
.FFAvail_d()	FF availability: high, medium, low	Single		•													
.RatioFactor_d		Single		•													
Preparation data																	
.FFExper_p()	FF Experience: two or more years, less than two years, novice	Single		•													
.FFTrain_p()	FF training frequency: high, medium, low	Single		•													
.FFLKnow_p()	FF local knowledge: very good, good, poor	Single		•													

Table 5-2. Contents of `DeptStatistics::FDSTATISTICS_TYPE` data section (Cont.)

.FFAvail_p()	FF availability: high, medium, low	Single		•													
.RatioFactor_p		Single		•													
Hazard data for dispatching and preparation																	
.PotExpl_d()	Building potential for explosion: low, medium, high	Single		•													
.Collaps_d()	Building potential for collapse: low, medium, high	Single		•													
.RelHazm_d()	Building potential for release of hazardous material: low, medium, high	Single		•													
.PotExpl_p()	Building potential for explosion: low, medium, high	Single		•													
.Collaps_p()	Building potential for collapse: low, medium, high	Single		•													
.RelHazm_p()	Building potential for release of hazardous material: low, medium, high	Single		•													
Travel and route condition data																	
.FFExper_t()	FF experience: two or more years, less than two years, novice	Single		•													
.StrArra()	Street arrangement: wide, average, narrow	Single		•													
.FFLKnow_t()	FF local knowledge: very good, good, poor	Single		•													
.CurvInt()	Frequency of curves and Intersections: low, medium, high	Single		•													
.TrafVol()	Traffic volume: low, medium, high	Single		•													
.RoadBuildFactor		Single		•													
Crew data																	
.MinCrewSize	Minimum required crew size	Integer							•								
.DeltaF	Person differential	Single							•								
.FullTimeFactor	Full time factors	Single							•								
.PartTimeFactor	Part time factors	Single							•								
.VolunteersFactor	Volunteer factors	Single							•								
.BldHeight()	Building height factors	Single							•								
.BackUpRes()	Availability of Backup Resources: good, medium, poor	Single							•								
.PhysicFit()	Physical Fitness: good, medium, poor	Single							•								
.CondEquip()	Condition of Firefighters' Equipment: good, medium, poor	Single							•								

Table 5-2. Contents of `DeptStatistics::FDSTATISTICS_TYPE` data section (Cont.)

Equipment data																	
.FDconnect()	Fire department connection	Single							•								
.CentAlarm()	Central alarm	Single							•								
.Sprinkler()	Sprinkler system	Single							•								
.SmokeCont()	Smoke control system	Single							•								
.CommSyste()	Communication system	Single							•								
.EmerPower()	Emergency power	Single							•								
.EmerLight()	Emergency lighting	Single							•								
.FireElev()	Firefighter elevator	Single							•								
.HoseCabin()	Hose cabinets	Single							•								
.PortFireE()	Portable fire equipment	Single							•								

The `FireStatistics::FIRESTATISTICS_TYPE` input section describes the rates and probabilities of fire occurrence. This section contains entries for the following values:

- Rate of fire occurrences
- Probabilities of a particular fire type occurring.

These entries are used by the Design Fire **(DFMD)** model to compute rates and probabilities of fire scenario occurrences.

Table 5-3. Contents of `FireStatistics::FIRESTATISTICS_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
FireStatistics :: FIRESTATISTICS_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Natural probabilities of fire occurrence																	
.FlashFire	Probability of flashover fires	Single	•				•										
.NonflFire	Probability of non-flashover fires	Single	•				•										
.SmldrFire	Probability of smouldering fires	Single	•				•										
Probability of fire starts																	
.FSRate_office	Rate of fire starts for office buildings	Single					•										
.FSRate_aptaw	Rate of fire starts for apartment buildings when occupants are awake	Single					•										
.FSRate_aptas	Rate of fire starts for apartment buildings when occupants are asleep	Single					•										

The `OccptStatistics::OCCPTSTATISTICS_TYPE` input section describes the characteristics of the building occupants.

- Probabilities of perception to different events
- Probabilities of performing an action
- Travel speeds for emergency and normal conditions

These values are used by the Occupant Response Model **(OCRM)** and Evacuation Model **(EVMD)** to simulate the response and evacuation of the building occupants.

Table 5-4. Contents of `OccptStatistics::OCCPTSTATISTICS_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
OccptStatistics :: OCCPTSTATISTICS_TYPE			**BEVM**	**FDRM**	**ECMD**	**BEFM**	**DFMD**	**FGMD**	**FDAM**	**OCRM**	**SMMD**	**EVMD**	**FSPM**	**ENDM**	**ERLM**	**PLMD**	**FCED**
Probabilities of perception																	
.PrbPerception()	Probabilities of perception	Single								•							
Probabilities of action																	
.PrbAction()	Probabilities of action	Single								•							
Interpretation time delays (sec) for 3 levels																	
.InterpretTimeDelay()	Interpretation time delays (sec)	Single								•							
Probability of calling fire department																	
.ProbCallFD()	Probability of calling fire department	Single							•	•							
Occupant speeds																	
.Speed()	Occupant speeds	Single									•	•					

The `Statistics::STATISTICS_TYPE` input section contains data relating to the reliability of installed fire protection and smoke control systems. Entries are listed for:

- Detector activation probabilities
- Sprinkler system reliability and effectiveness
- Smoke control system effectiveness
- Probabilities of doors being left open.

These entries are used by the Occupant Response **(OCRM)** and Fire Department Action **(FDAM)** models to compute the probability of an alarm system being activated, and by the Smoke Movement **(SMMD)** model to compute the smoke hazard probabilities.

Table 5-5. Contents of `Statistics::STATISTICS_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Statistics :: STATISTICS_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Sensor operation probability																	
.prb_local_act	Local smoke detector activation probability	Single							•	•							
.prb_smoke_act	Smoke detector (of a central system) activation probability	Single							•	•							
.prb_heatd_act	Heat detector (of a central system) activation probability	Single							•	•							
.sys_reliability	Central alarm system (control panel) reliability	Single							•	•							
Sprinkler reliability																	
.spk_reliability	Reliability of automatic sprinkler system	Single					•		•	•							
.spk_effect	Effectiveness of automatic sprinkler system	Single					•										
Smoke control																	
.pfsmoke	Probability that smoke ventilation system is working	Single															
.pfstair	Probability that stair pressurization system is working	Single															
Probability of doors being left open or closed																	
.stw_dooropen	Probability of door leading from corridor to stair shaft on any floor being open	Single				•					•						
.frc_dooropen	Probability of door from fire compartment to corridor on any floor being open	Single				•					•				•		
.oth_dooropen	Probability of door leading from non-fire compartment to corridor on any floor being open	Single									•						
Probability of barrier failures																	
.bfp_ososu	Failure probability between open stairs to open stairs (up)	Single											•				
.bfp_ososd	Failure probability between open stairs to open stairs (down)	Single											•				

The `Numerical::NUMERICAL_TYPE` input section contains data which controls the behaviour of the Boundary Element **(BEVM)** and the Fire Spread **(FSPM)** models. The first section contains correction factors and fire load statistical data used by **BEVM**. The second section contains entries for the tolerance factors used by **FSPM** to control its maximum path lengths.

Table 5-6. Contents of `Numerical::NUMERICAL_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Numerical :: NUMERICAL_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Fuel statistics data for barrier failure calculations																	
.stdev_fire	Standard deviation / mean fire rating for the construction element	Single				•											
.mean_inertia	Average thermal inertia value of building materials	Single				•											
.stdev_dens	Standard deviation / mean of the inventory fire load density	Single				•											
.mean_dens	Inventory mean load fire density	Single				•											
Correction data for barrier failure calculations																	
.wffactor	Correction for walls and floors made of gypsum board	Single				•											
.iofactor	Correction for inadvertent openings in walls and floors	Single				•											
Numerical control for fire spread																	
.Accuracy	Tolerance limit for probability of fire spread calculations	Single											•				
.Maxp_length	Maximum path length for fire spread calculations	Integer											•				

The `Costs::COST_TYPE` input contains entries for the following cost categories:

- Interest and prime rates
- Building contents
- Active fire protection and emergency planning costs
- Periodic (maintenance) and replacement costs

These cost entries are used by the Economic **(ECMD)** model to compute the active fire protection capital costs and replacement costs for a building.

Table 5-7. Contents of `Costs::COST_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Costs :: COST_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Interest and prime rates																	
.PrimeRate	Prime interest rate	Single			•												
.InflationRate	Inflation Rate	Single			•												
Content and capital costs																	
.DefaultCost_Contents()	Default value for cost of contents of the building	Single														•	
Active fire protection capital costs																	
.DefaultCost_AlarmSys()	Default value for cost of the central alarm system	Single			•												
.DefaultCost_Sprinklers()	Default value for cost of the sprinkler system	Single			•												
.DefaultCost_Extinguish()	Default value for manual extinguishers	Single			•												
.DefaultCost_SmkControl()	Default value for cost of smoke control systems	Single			•												
.DefaultCost_Emergency()	Default value for cost of emergency systems and training	Single			•												
Periodical and replacement costs																	
.Def_ActiveFPACEntry()		Single			•												
.Def_FPACPeriodEntry()		Single			•												

The `Costs.DefaultCost_Constr()::COST_BASIC_TYPE` input section describes basic construction costs of a building. The `DefaultCost_Passive()` structure is actually an array of cost values for each of the following types of occupancy and building material:

- Construction — 1 - Apartment; 2 - Office
- Material — 1 - Concrete; 2 - Wood; 3 - Steel

These cost entries are used by the Economic **(ECMD)** model to compute the total construction capital costs for a building.

Table 5-8. Contents of `Costs.DefaultCost_Constr()::COST_BASIC_TYPE` data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE															
Costs.DefaultCost_Constr() :: COST_BASIC_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Basic construction capital costs																		
.Basic_frame	Basic frame cost in compartments per m2 floor area	Single			•												
.Basic_exterior	Basic exterior wall cost per m length per floor	Single			•												
.Basic_interior	Basic interior wall cost per m length per floor	Single			•												
.Basic_corridor	Basic corridor wall cost per m length per floor	Single			•												
.Basic_floor	Basic floor/ceiling cost per m2 floor area	Single			•												
.Basic_column	Basic column cost per column for building	Single			•												
.Basic_balcony	Basic cost of balcony per balcony	Single			•												
.Basic_stairshaft	Basic stair shaft cost per floor served	Single			•												
.Basic_staircase	Basic staircase cost per floor served	Single			•												
.Basic_elevator1	Basic elevator shaft cost per floor for # floors <= 6	Single			•												
.Basic_elevator2	Basic elevator shaft cost per floor for # floors > 6 and <=20	Single			•												
.Basic_elevator3	Basic elevator shaft cost per floor for # floors > 20	Single			•												
.Basic_elevcar	Basic elevator car cost per elevator	Single			•												
.Basic_shaft	Basic service shaft cost per floor	Single			•												
Interior capital costs																		
.Interior_door	Basic compartment door cost per door	Single			•												
.Interior_strdoor	Basic stair door cost per door	Single			•												
.Interior_evldoor	Basic elevator door cost per door	Single			•												
.Interior_glazing	Basic window cost per m2 area	Single			•												

The **Costs.DefaultCost_Passive()::COST_PASSIVE_TYPE** input section lists the costs associated with the addition of passive fire protection (fire resistance ratings) to the construction of the building. The **DefaultCost_Passive()** structure is actually an array of cost values for each of the following types of occupancy, building material and FRR value:

- Construction — 1 - Apartment; 2 - Office
- Material — 1 - Concrete; 2 - Wood; 3 - Steel
- FRR — 1 - FRR 0.5 hr; 2 - FRR 1.0 hr; 3 - FRR 1.5 hr; 4 - FRR 2.0 hr; 5 - FRR 3.0 hr; 6 - FRR 4.0 hr

These cost entries are used by the Economic **(ECMD)** model to compute the total fire protection capital costs for a building.

Table 5-9. Contents of Costs.DefaultCost_Passive()::COST_PASSIVE_TYPE data section

VARIABLE NAME	VARIABLE DESCRIPTION	TYPE	SUBMODELS USING THIS VARIABLE														
Costs.DefaultCost_Passive() :: COST_PASSIVE_TYPE			BEVM	FDRM	ECMD	BEFM	DFMD	FGMD	FDAM	OCRM	SMMD	EVMD	FSPM	ENDM	ERLM	PLMD	FCED
Passive fire protection capital costs																	
.Cost_frame	Basic building frame	Single			•												
.Cost_extwal	Exterior wall	Single			•												
.Cost_fstop	Fire stop at door	Single			•												
.Cost_intwall	Interior wall	Single			•												
.Cost_corrwall	Corridor wall	Single			•												
.Cost_flrceil	Floor/ceiling assemblies	Single			•												
.Cost_column	Columns	Single			•												
.Cost_stairshaft	Stair shafts	Single			•												
.Cost_staircase	Staircase	Single			•												
.Cost_shaft	Service ducts/shafts	Single			•												
.Cost_cdoor	Compartment door	Single			•												
.Cost_sdoor	Stair doors	Single			•												
.Cost_glaze	Balcony windows and glazing	Single			•												

6. FiRECAM™ OUTPUT FILE

This section of the report describes the final output files created by FiRECAM™.

6.1 FiRECAM™ Output Database Structure

For its final results, FiRECAM™ creates a Microsoft Access 2.0 compatible database file containing a set of database tables and SQL (Structured Query Language) queries[13]. Each model produces two tables that are used to store results of the model's calculations:

- a *Primary Table* which generally contains the model's main output in short format, and
- a *Secondary Table* which provides some additional detail on the contents of the Primary Table

In addition, FiRECAM™ uses SQL queries. These queries are used to extract a small part of a table to aid in viewing or displaying data.

Table 6-1 below summarizes the list of tables created by FiRECAM™ and their naming convention. The convention for a table name is

`[Database name].[Model name]`	for Primary Tables
`[Database name].[Model name]_SEC`	for Secondary Tables

Figure 6-1 shows the hierarchical structure of a FiRECAM™ output database, complete with primary tables **`(PRIMARY_TABLE)`** and secondary tables **`(SECONDARY_TABLE)`**.

[13] For more information on database tables and stored queries, please consult the Microsoft Access 2.0 User's Guide.

Table 6-1. FiRECAM™ output database - Primary and secondary tables

FiRECAM™ OUTPUT DATABASE STRUCTURE			
MODEL	**MODEL NAME**	**PRIMARY TABLE NAME**	**SECONDARY TABLE NAME**
Building Evaluation Model	BEVM	Database.**BEVM**	(Not Used)
Fire Department Response Model	FDRM	Database.**FDEM**	Database.**FDEM_SEC**
Economic Model	**ECMD**	Database.**ECMD**	(Not Used)
Boundary Element Failure Model	**BEFM**	(Not Used)	(Not Used)
Design Fire Model	**DFMD**	Database.**DFMD**	(Not Used)
Fire Growth Model	**FGMD**	Database.**FGMD**	Database.**FGMD_SEC**
Fire Department Action Model	**FDAM**	(Not Used)	(Not Used)
Occupant Response Model	**OCRM**	Database.**OCRM**	Database.**OCRM_SEC**
Smoke Spread Model	**SMMD**	Database.**SMMD**	Database.**SMMD_SEC**
Evacuation Model	**EVMD**	Database.**EVMD**	Database.**EVMD_SEC**
Fire Spread Model	**FSPM**	Database.**FSPM**	Database.**FSPM_SEC**
Expected Number Of Deaths Model	**ENDM**	Database.**ENDM**	(Not Used)
Expected Risk To Life Model	**ERLM**	Database.**ERLM**	(Not Used)
Property Loss Model	**PLMD**	Database.**PLMD**	(Not Used)
Fire Cost Expectation Model	**FCED**	Database.**FCED**	(Not Used)

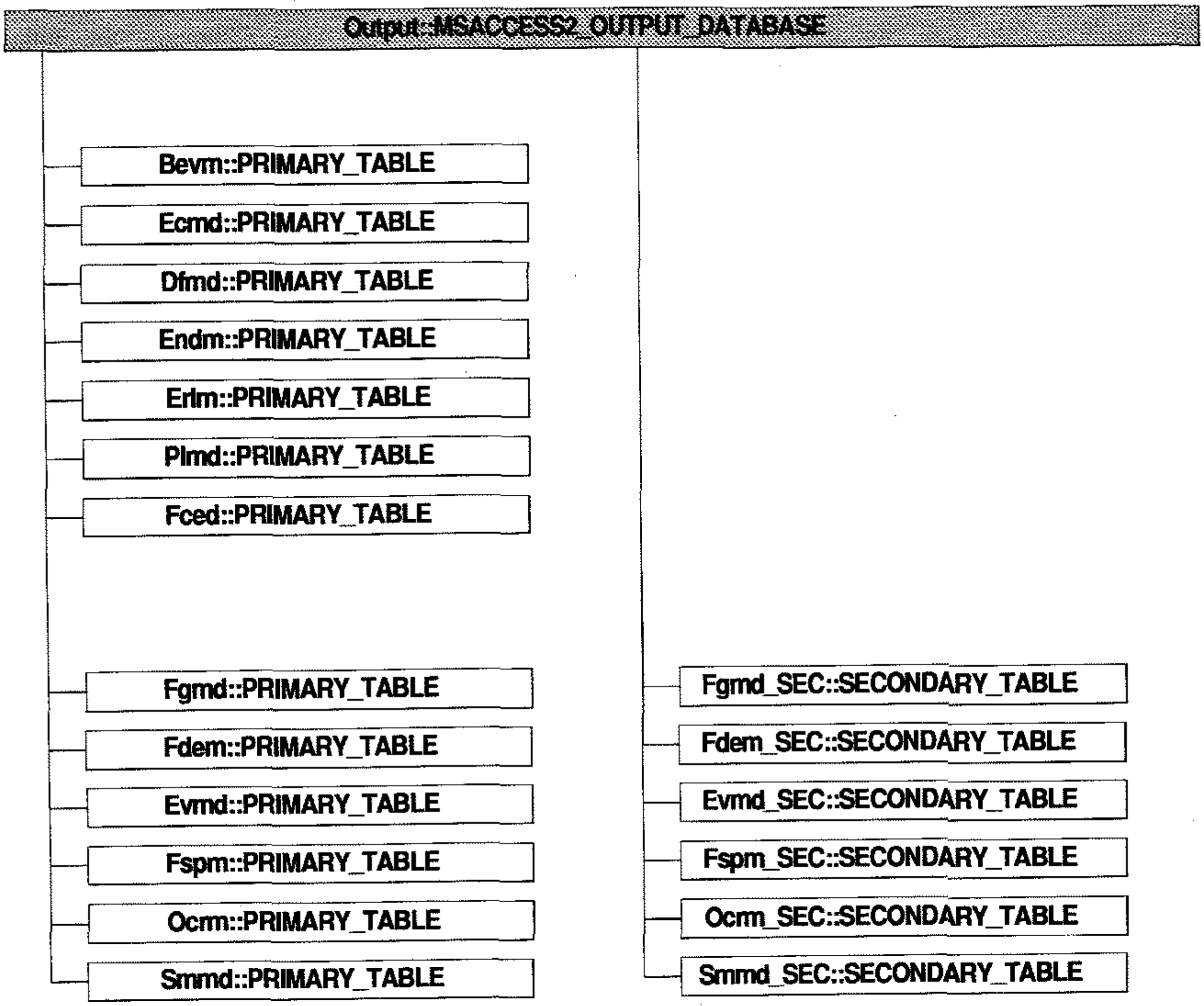

Figure 6-1. Layout of a FiRECAM™ output database - Primary and Secondary tables

6.2 FiRECAM™ Output Database Table Structure

This section describes the layout and contents of the Access® database tables created by each FiRECAM™ model.

6.2.1 BEVM - Building Evaluation Model

The Building Evaluation Model creates a Primary Table only. The Primary Table lists the descriptions, initial values and adjusted values for:

- Ignition Factor
- Flashover Factor
- Flaming Factor
- Smouldering Factor
- Barrier Failure Factor

- Manual Suppression Factor
- Auto Suppression Factor
- Flashover Fire Rate
- Flaming Fire Rate
- Smouldering Fire Rate

for a particular building design.

Table 6-2 lists the data fields in the Primary Table.

Table 6-2. Database table field contents for Building Evaluation Model (BEVM) primary table

BEVM		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table BEVM		
Component Description	Description of fire component	Text
Initial Fire Statistics	Initial value	Single
Adjusted Fire Statistics	Value adjusted by BEVM	Single

6.2.2 FDRM - Fire Department Response Model

The Fire Department Response Model creates both Primary and Secondary Tables. The Primary Table contains the descriptions and computed values for:

- Fire Department Dispatch Time
- Fire Department Preparation Time
- Fire Department Travel Time
- Fire Department Setup Time

which are only computed once.

The Secondary Table lists the values for the Fire Department Action Model **(FDAM)**[14] on a per fire scenario basis. The following values are computed and stored:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Occupant Location
- Fire Department Notification Time
- Fire Department Intervention Time
- Fire Department Intervention Probability

[14] In general, each model creates its own tables. Exceptions to this rule will be noted, as when a model will use one of its *parent model's* tables to store its results. For example, the Fire Department Response Model **(FDRM)** can be considered a *parent* of the Fire Department Action Model **(FDAM)**, since the parent's results are required and used by the second model.

- Fire Department Fire Fighting Effectiveness
- Fire Department Rescue Effectiveness

Table 6-3 lists the fields in the Primary and Secondary Tables.

Table 6-3. Database table field contents for Fire Department Response Model (FDRM) primary and secondary tables

FDEM		
Table FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table FDEM		
Department Setup Times	Description of fire department times	Text
Value	Time values in sec.	Single
Secondary Table FDEM_SEC (used by FDAM)		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Occupant Location	Location of occupants: OCF,OLF, OOL	Integer
Notif Time	Fire department notification time (sec)	Single
Interv Time	Fire department intervention time (sec)	Single
Interv Prob	Fire department intervention probability	Single
Exting Prob	Fire department extinguishment probability	Single

6.2.3 ECMD - Economic Model

The Economic Model creates a Primary table only. The contents of the primary table are the descriptions and the cost values for the following components:

- Capital Cost of Basic Construction per Floor
- Capital Cost of Fire Resistance per Floor
- Capital Cost of FRR and Basic Construction per Floor
- Capital Cost of Alarm & Detection systems per Floor
- Capital Cost of Auto. Suppression systems per Floor
- Capital Cost of Man. Suppression systems per Floor
- Capital Cost of Smoke Control systems per Floor
- Capital Cost of Emergency systems per Floor
- Capital Cost of Organizational systems per Floor
- Capital Cost of Active Protection systems per Floor

- Total Capital Cost per Floor
- Annual Cost of Maintenance per Floor
- Annual Cost of Organizational Systems per Floor
- Annual Cost of Component Replacement per Floor
- Total Annual Cost per Floor
- Present Worth of Total Annual Cost per Floor

Table 6-4 lists the fields in the Primary Table.

Table 6-4. Database table field contents for Economic Model (ECMD) primary table

ECMD		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table ECMD		
Component Description	Description of cost component	Text
Value	Value of cost associated with component	Currency

6.2.4 BEFM - Boundary Element Failure Model

The Boundary Element Model creates no tables. Its calculations are passed to the Fire Spread Model **(FSPM)**, where they are written to the primary table created by **FSPM**. For a description of the layout and contents of this table, see Table 6-10.

6.2.5 DFMD - Design Fire Model

The Design Fire Model creates a Primary Table only. The Primary Table is for documentation purposes, and includes detailed list of the following building parameters:

- Date of Run
- File Name
- City Name
- Building Geometric and Layout Data
- Building Materials
- Installed Protection Systems

Table 6-5 lists the fields in the Primary Table.

Table 6-5. Database table field contents for Design Fire Model (DFMD) primary table

DFMD		
FIELD NAME	**DESCRIPTION**	**TYPE**
Table DFMD		
Component Description	General building comments and description for a particular item	Text
Category	Category of building description item	Integer
Value	Value of building description item	Text

6.2.6 FGMD - Fire Growth Model

The Fire Growth Model creates both Primary and Secondary Tables. The contents of the primary table are the values for:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Occupant Location
- Cue Time
- Detector Time
- Sprinkler Activation Time
- Flashover Time
- Burnout Time

computed on a per fire scenario basis. The Secondary Table lists the following values computed by the fire growth and combustion a function of time:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Elapsed Time
- Mass Flow Rate of Combustion Gases
- % CO Concentration
- % CO_2 Concentration
- Room Temperature in ° Kelvin

Table 6-6 lists the fields in the Primary and Secondary Tables.

Table 6-6. Database table field contents for Fire Growth Model (FGMD) primary and secondary tables

FGMD		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table FGMD_SEC		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Occupant Location	Location of occupants: OCF,OLF, OOL	Integer
Cue	Time of occupant perception and response to fire cues.	Single
Detector	Time of smoke detector activation	Single
Sprinkler	Time of sprinkler system activation	Single
Flashover	Time of fire flashover	Single
Burnout	Time of fire burnout	Single
Secondary Table FGMD_SEC		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Elapsed Time	Fire burn time in sec.	Single
Room Temp	Room temperature in °Kelvin	Single
Burn Rate	Burn rate in kg/min	Single
% CO	% CO concentration	Single
% CO_2	% CO_2 concentration	Single

6.2.7 FDAM - Fire Department Action Model

The Fire Department Action Model creates no tables of its own.[14] The results of **FDAM**'s computations are stored in the secondary table created by the Fire Department Model **(FDRM)**. For a description of this table's layout and contents, see 3.2, "FDRM - Fire Department Response Model".

6.2.8 OCRM - Occupant Response Model

The Occupant Response Model creates Primary and Secondary Tables. The contents of the primary table are the values for the occupant response probabilities for ten time frames computed on a per fire scenario basis:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Occupant Location
- Occupant Evacuation Probability for Time Frame I
- Occupant Evacuation Probability for Time Frame II
- Occupant Evacuation Probability for Time Frame III
- Occupant Evacuation Probability for Time Frame IV
- Occupant Evacuation Probability for Time Frame V
- Occupant Evacuation Probability for Time Frame VI
- Occupant Evacuation Probability for Time Frame VII
- Occupant Evacuation Probability for Time Frame VIII
- Occupant Evacuation Probability for Time Frame IX
- Probability of No Response

The Secondary Table lists the probabilities that occupants will not attempt to suppress a fire for each fire scenario. These probabilities are computed for smouldering fires only. It is assumed that flashover and non-flashover fire are not suppressed by the occupants. The Secondary Table's contents are:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Occupant Location
- Probability of occupants not suppressing a smouldering fire

Table 6-7 lists the fields in the Primary and Secondary Tables.

Table 6-7. Database table field contents for Occupant Response Model (OCRM) primary and secondary tables

OCRM		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table OCRM		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Occupant Location	Location of occupants: OCF,OLF, OOL	Integer
Frame I	Probability of occupants beginning evacuation at Time Frame I	Single
Frame II	Probability of occupants beginning evacuation at Time Frame II	Single
Frame III	Probability of occupants beginning evacuation at Time Frame III	Single
Frame IV	Probability of occupants beginning evacuation at Time Frame IV	Single
Frame V	Probability of occupants beginning evacuation at Time Frame V	Single
Frame VI	Probability of occupants beginning evacuation at Time Frame VI	Single
Frame VII	Probability of occupants beginning evacuation at Time Frame VII	Single
Frame VIII	Probability of occupants beginning evacuation at Time Frame VIII	Single
Frame IX	Probability of occupants beginning evacuation at Time Frame IX	Single
No Response	Probability of occupants not responding	Single
Secondary Table OCRM_SEC		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Occupant Location	Location of occupants: OCF,OLF, OOL	Integer
Suppression Probability	Probability of occupants not suppressing a smouldering fire	Single

6.2.9 SMMD - Smoke Movement Model

The Smoke Movement Model creates both Primary and Secondary Tables. The contents of the primary table are computed on a per fire scenario and fire floor basis:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Occupant Location
- Fire Floor
- Travel Time
- Critical Time - Time at which Stairwells are Untenable

The Secondary Table contains the actual smoke hazard probabilities for each location in the building on a per scenario and fire floor basis. The hazard probabilities are the result of combining toxic gas concentration dosage hazards and temperature hazards into a single probability of life hazard at the time of fire department arrival. If the fire department arrives after fire burnout, the fire burnout time is used.

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Probability of smoke hazard to compartments
- Probability of smoke hazard to corridors
- Probability of smoke hazard to stairs
- Probability of smoke hazard to non fire origin compartments on fire floor

Table 6-8 lists the fields in the Primary and Secondary Tables.

Table 6-8. Database table field contents for Smoke Movement Model (SMMD) primary and secondary tables

SMMD		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table SMMD		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Occupant Location	Location of occupants: *OCF,OLF, OOL*	Integer
Travel Time	Time required for occupants to travel in stairwells	Single
Critical Time	Time at which stairwells become hazardous due to temperature and toxic gases.	Single
Secondary Table SMMD_SEC		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Pss Compts	Probability of smoke spread from compartments on 'Fire Floor' to compartments on 'Floor'	Single
Pss Corr	Probability of smoke spread from compartments on 'Fire Floor' to corridors on 'Floor'	Single
Pss Strs	Probability of smoke spread from compartments on 'Fire Floor' to stairs on 'Floor'	Single
Pss NFCompts	Probability of smoke spread from compartments on 'Fire Floor' to compartments on same floor	Single

6.2.10 EVMD - Evacuation Model

The Evacuation Model creates both Primary and Secondary Tables. The contents of the primary table are the following computed for each fire scenario and fire floor:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor

- Elapsed Time
- State - Which State the Fire Reached
- Occupants Still in Building
- Occupants Still in Stairs
- Occupants Exited
- Occupants Still on Floors on a per Floor Basis

The Secondary Table lists the actual occupant movement as a function of time, for each time step of the evacuation simulation. The following quantities are listed:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Elapsed Time
- Occupants Still in Building
- Occupants Still in Stairs
- Occupants Exited
- Occupants Still in Floors on a per Floor Basis

Table 6-9 *lists the fields in the Primary and Secondary* Tables.

Table 6-9. Database table field contents for Evacuation Model (EVMD) primary and secondary tables

EVMD		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table EVMD		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	*Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'*	Integer
Elapsed Time	Elapsed time in sec.	Single
Time Frame	Time frame number and description	Text
Building	Number of occupants located in building at 'Time'	Integer
Stairs	Number of occupants located in stairs at 'Time'	Integer
Exited	Number of exited occupants at 'Time'	Integer

Table 6-9. Database table field contents for Evacuation Model (EVMD) primary and secondary tables (Cont.)

Floor 1	Number of occupants located on Floor 1 at 'Time'	Integer
Floor 2	. Number of occupants located on Floor 2 at 'Time'	Integer
.	.	Integer
.	.	Integer
Floor *N*	Number of occupants located on Floor *N* at 'Time'	Integer
Secondary Table EVMD_SEC		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Time	Elapsed time in sec.	Single
Building	Number of occupants located in building at 'Time'	Integer
Stairs	Number of occupants located in stairs at 'Time'	Integer
Exited	Number of exited occupants at 'Time'	Integer
Floor 1	Number of occupants located on Floor 1 at 'Time'	Integer
Floor 2	Number of occupants located on Floor 2 at 'Time'	Integer
.	.	Integer
.	.	Integer
Floor *N*	Number of occupants located on Floor *N* at 'Time'	Integer

6.2.11 FSPM - Fire Spread Model

The Fire Spread Model creates both Primary and Secondary Tables. The contents of the Primary Table are the results of the Boundary Failure Model **(BEFM)** [14]:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor

- Probability of Fire Spread from Apartment to Apartment above
- Probability of Fire Spread from Apartment to Apartment below
- Probability of Fire Spread from Apartment to Corridor
- Probability of Fire Spread from Apartment to Ducts
- Probability of Fire Spread from Ducts to Apartment
- Probability of Fire Spread from Apartment to Balcony-void
- Probability of Fire Spread from Corridor to Stairwell
- Probability of Fire Spread from Corridor to Elevator
- Probability of Fire Spread from Apartment to Apartment horizontal

computed for each floor. The Secondary Table contains the actual fire spread probabilities for each location in the building on a per scenario and fire floor basis. These results are computed by the Fire Spread Model (FSPM)[14].

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Probability of Fire Spread to Compartments
- Probability of Fire Spread to Corridors
- Probability of Fire Spread to Stairs
- Probability of Fire Spread to Non-fire Origin Compartments

Table 6-10 lists the fields in the Primary and Secondary Tables.

Table 6-10. Database table field contents for Fire Spread Model (FSPM) primary and secondary tables

FSPM		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table FSPM (computed by BEFM)		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Compartment to Compartment up	Barrier failure probability - Compartment to Compartment up	Integer
Compartment to Compartment down	Barrier failure probability - Compartment to Compartment down	Single
Compartment to Corridor same floor	Barrier failure probability - Compartment to Corridor same floor	Single
Compartment to Ducts	Barrier failure probability - Compartment to Ducts	Single

Table 6-10. Database table field contents for Fire Spread Model (FSPM) primary and secondary tables (Cont.)

Ducts to Compartment	Barrier failure probability - Ducts to Compartment	Single
Corridor to Stairwell, same floor	Barrier failure probability - Corridor to Stairwell, same floor	Single
Corridor to Elevator	Barrier failure probability - Corridor to Elevator	Single
Compartment to Compartment same floor	Barrier failure probability - Compartment to Compartment same floor	Single
Open Stairs to Open Stairs up	Barrier failure probability - Open Stairs to Open Stairs up	Single
Open Stairs to Open Stairs down	Barrier failure probability - Open Stairs to Open Stairs down	Single
Secondary Table FSPM_SEC (computed by FSPM)		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Pfs Compts	Probability of fire spread from compartments on 'Fire Floor' to compartments on 'Floor'	Single
Pfs Corrs	Probability of fire spread from compartments on 'Fire Floor' to corridors on 'Floor'	Single
Pfs Strs	Probability of fire spread from compartments on 'Fire Floor' to stairs on 'Floor'	Single
Pfs NFCompts	Probability of fire spread from compartments on 'Fire Floor' to compartments on same floor	Single

6.2.12 ENDM - Expected Number of Deaths Model

The Expected Number of Deaths Model creates a Primary Table only. The contents of the table lists the detailed results of the intermediate calculations on a per floor basis. These intermediate death totals are added to yield a total expected number of deaths for a fire occurring on a particular floor. The following items are listed:

- Scenario/Door State
- Fire Floor
- Location
- Floor Population
- Stair Population
- Floor Death Probability
- Stair Death Probability
- Floor Deaths
- Stair Deaths

Table 6-11 lists the fields in the Primary Table.

Table 6-11. Database table field contents for Expected Number Of Deaths Model (ENDM) primary table

ENDM		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table ENDM		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Floor Pop	Number of occupants trapped in compartments	Single
Stair Pop	Number of occupants trapped in stairwells	Single
Floor Death Prob	Probability of death for occupants trapped in compartments	Single
Stair Death Prob	Probability of death for occupants trapped in stairwells	Single
Floor Deaths	Expected deaths for occupants trapped in compartments	Single
Stair Deaths	Expected deaths for occupants trapped in stairwells	Single

6.2.13 ERLM - Expected Risk to Life Model

The Expected Risk to Life Model creates a Primary Table only. The contents of the primary table are the following, computed on a per fire scenario and fire floor basis:

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Risk to Life
- Life Hazard
- % Contribution

Table 6-12 lists the fields in the Primary Table.

Table 6-12. Database table field contents for Expected Risk To Life Model (ERLM) primary table

ERLM		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table ERLM		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Risk to Life	Expected risk to life	Single
Life Hazard	Life hazard : risk to life multiplied by the probability of a particular scenario occurring	Single
% Contribution	Contribution of this particular scenario's ERL to the total value of the ERL for the building.	Single

6.2.14 PLMD - Property Loss Model

The Property Loss Model creates a Primary Table only. The values are computed on a per fire scenario and fire floor basis. The Secondary Table contains additional information per floor given that a fire occurs on a particular floor, computed on a per fire scenario and fire floor basis.

- Scenario/Door State
- Occupant State
- Fire Origin Floor
- Fire Destination Floor
- Cost of Structure Loss ($)
- Cost of Content Loss ($)

Table 6-13 lists the fields in the Primary Table.

Table 6-13. Database table field contents for Property Loss Model (PLMD) primary table

PLMD		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table PLMD		
Fire Scenario/Door State	Fire scenario and fire compartment door open/closed state	Integer
Occupant State	Occupant state: awake or asleep	Integer
Fire Origin Floor	Floor on which the fire occurs	Integer
Destination Floor	Building floor for which these results are computed, given that a fire occurs on 'Fire Origin Floor'	Integer
Cost of Structure Loss	Cost of loss to building structure for floor 'Destination Floor', given that a fire occurs on 'Fire Floor'	Currency
Cost of Contents Loss	Cost of loss to building contents for floor 'Destination Floor', given that a fire occurs on 'Fire Floor'	Currency

6.2.15 FCED - Fire Cost Expectation Model

The Fire Cost Expectation Model creates a Primary Table only. The contents of the primary table are the descriptions and the final values for the following cost components:

- Annual Cost of Property Loss
- Annual Cost of Protection Systems
- Capital Cost of Protection Systems
- Capital Cost of Structure
- Cost of Building Contents
- Fire Cost Expectation

Table 6-14 lists the fields in the Primary Table.

Table 6-14. Database table field contents for Fire Cost Expectation Model (FCED) primary table

FCED		
FIELD NAME	**DESCRIPTION**	**TYPE**
Primary Table FCED		
Cost Component	Description of cost component	Text
Value	Value of cost component	Currency

6.3 FiRECAM™ Output Database SQL Queries

This section describes the contents of the database queries used by each FiRECAM model.

In addition to the tables, FiRECAM™ also use **Structured Query Language (SQL)** queries. These queries are used to extract a portion of a table. An example might be to extract a model's data in a table for a single scenario and fire floor. To illustrate, the Secondary Table of the Smoke Movement **(SMMD)** model stores all the smoke hazard probabilities of each fire scenario and each fire origin floor as a single list. A SQL query is used to extract the probabilities for a particular floor and fire scenario. Table 6-15 lists the queries used by FiRECAM™ along with their purpose.

Future releases of FiRECAM™ will make more extensive use of SQL queries to extract subsections of information from each model's tables. In addition, queries will be used extensively for reporting purposes.

Table 6-15. FiRECAM™ output database - SQL queries

FIRECAM™ OUTPUT DATA SQL QUERIES		
MODEL	**PURPOSE**	**SQL STATEMENT**
BUILDING EVALUATION MODEL	(Not Used)	`(Not Used)`
FIRE DEPARTMENT RESPONSE MODEL	(Not Used)	`(Not Used)`
ECONOMIC MODEL	(Not Used)	`(Not Used)`
Boundary Element Failure Model	(Not Used)	`(Not Used)`
DESIGN FIRE MODEL	(Not Used)	`(Not Used)`
Fire Growth Model	Select all records for the specified : • Fire Scenario • Occupant State • Fire Origin Floor	SELECT [Elapsed Time], [Mass Flow Rate], [% CO], [% CO2], [Temp C] FROM Fgmd_SEC WHERE Scenario/Door State]= ***'Scenario'***[8] AND [Occupant State] = ***'OcState'*** AND [Fire Origin Floor] = ***'Floor'*** ORDER BY [Elapsed Time];
Fire Department Action Model	(Not Used)	`(Not Used)`
Occupant Response Model	(Not Used)	`(Not Used)`

Table 6-15. FiRECAM™ output database - SQL queries (Cont.)

Smoke Spread Model	Select all records for the specified : • Fire Scenario • Occupant State • Fire Origin Floor	SELECT [Destination Floor], [Pss Cmpts], [Pss Corr], [Pss Strs], [Pss NFCmpts] FROM Smmd_SEC WHERE Scenario/Door State]= '*Scenario*'[8] AND [Occupant State] = '*OcState*' AND [Fire Origin Floor] = '*Floor*';
Evacuation Model	Select all records for the specified : • Fire Scenario • Occupant State • Fire Origin Floor	SELECT [Elapsed Time], [Building], [Stairs], [Exited] FROM Evmd_SEC WHERE [Scenario/Door State]= '*Scenario*'[8] AND [Fire Floor]= '*Floor*';
Fire Spread Model	Select all records for the specified : • Fire Scenario • Occupant State • Fire Origin Floor	SELECT [Destination Floor], [Pfs Cmpts], [Pfs Corr], [Pfs Strs], [Pfs NFCmpts] FROM Fspm_SEC WHERE Scenario/Door State]= '*Scenario*'[8] AND [Occupant State] = '*OcState*' AND [Fire Origin Floor] = '*Floor*';
Expected Number Of Deaths Model	(Not Used)	(Not Used)
Expected Risk To Life Model	(Not Used)	(Not Used)
Property Loss Model	(Not Used)	(Not Used)
Fire Cost Expectation Model	(Not Used)	(Not Used)

7. REFERENCES

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