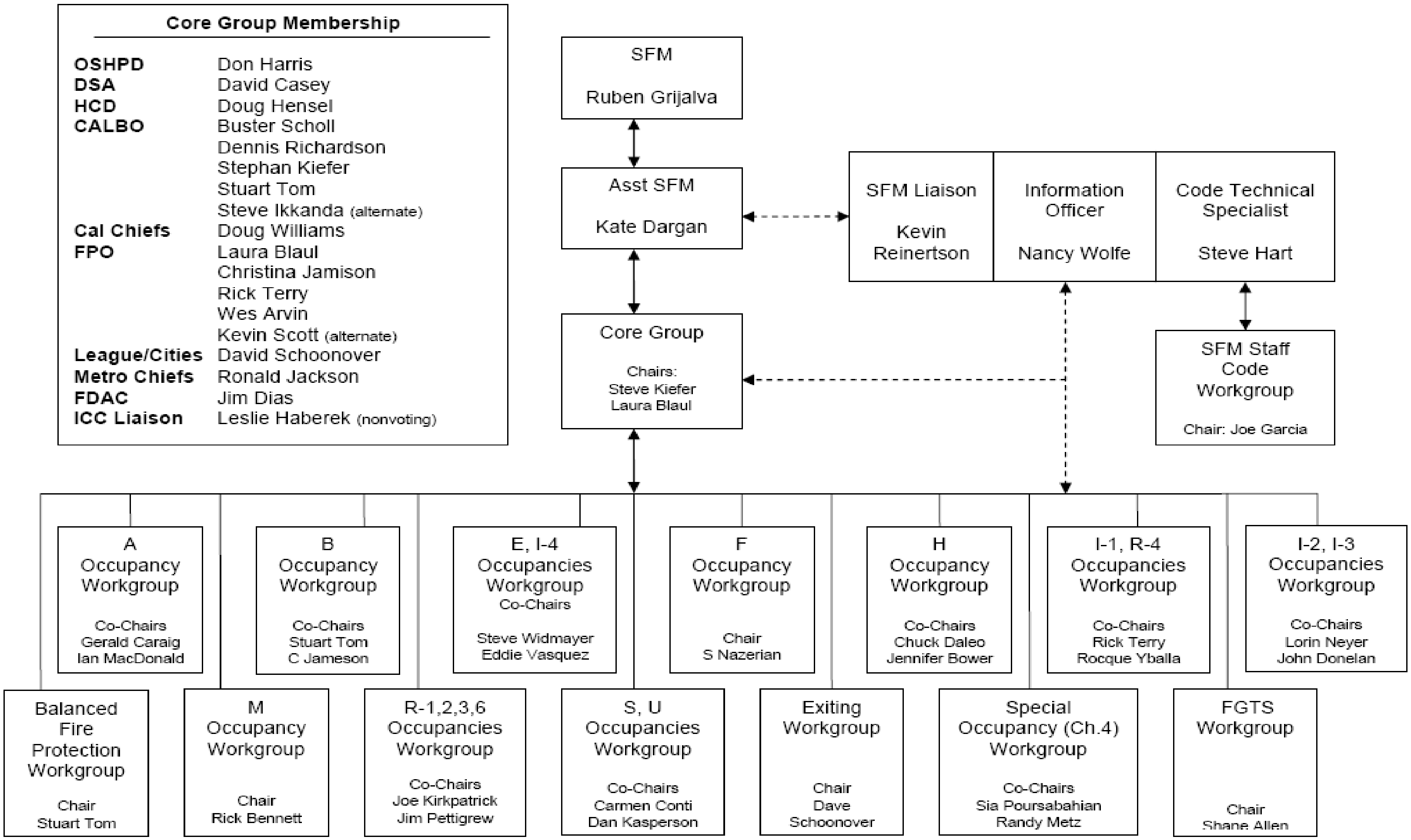
Appendix A

SFM Code Adoption Project Organization

03/01/06



Appendix B

SFM Code Adoption Project **Calendar of Events**		
September 2005	1	Establish project goals; assemble Core Group and Workgroup members; identify process
	6	Core Group Kickoff
	16	Initial Workgroup meeting (Irvine)
	21	Initial Workgroup meeting (Sacramento)
January 2006	5	Deadline for workgroups to submit first recommendation drafts
	9-11	Core Group review of Workgroup recommendations (Sacramento)0
	20	SFM Code Adoption Stakeholders meeting (Sacramento)
	24	Core Group Conference Call
	31	SFM Staff Workgroup meeting (Sacramento)
February 2006	1	SFM Staff Workgroup (continues)
		First draft of SFM's CBC/CFC "monograph" to be posted on website
	7	Core Group Conference Call
	10	Final date for Workgroups to submit recommendations
	13-14	Core Group/Workgroup Leaders meet to review/comment on Workgroup recommendations (SFM - Sacramento)
	21	Core Group Conference call
	22	SFM Code Adoption Stakeholders meeting (OCFA - Irvine)
	23	Core Group/Workgroup Leaders meet to review/comment on Workgroup recommendations (OCFA - Irvine)
March 2006	1	SFM posts final draft monograph of recommendations to website
	2-3	SFM to present monograph to CALBO Annual meeting
	7	Core Group Conference Call
	17	Core Group meeting to review "final package" of Workgroup recommendations (Buellton)
	21	Core Group Conference Call
	24	SFM Code Adoption Stakeholders meeting (San Jose)
April 2006	1	Final package to Chief Grijalva with Core Group recommendations; package includes identification of critical elements (e.g., height/area tables, area separations, Group L Occupancies, Group R, Division 3 Occupancies including residential care facilities, etc.)
	18	Core Group Conference Call
May 2006	2	Core Group Conference Call
	15	SFM submits proposed package to California Building Standards Commission

Appendix C

Reliability of Automatic Sprinkler Systems

William E. Koffel, P.E.

Revised January 2006[1]

Whether one is preparing a performance design or working with a prescriptive code, the reliability of fire protection systems and features must be considered. Budnick[2] explains that reliability includes both operational reliability and performance reliability. The operational reliability is a measure of the probability that a system or component will operate as intended when needed. The performance reliability is a measure of the adequacy of the system once it has operated. While critical for all fire protection features and systems, this paper will focus on the reliability of automatic sprinkler systems, in particular the operational reliability.

When the original paper on this subject was prepared by this same author, critics immediately claimed that the data was manipulated and the operational reliability of sprinkler systems was being represented as being too low. However, many of the critics failed to consider the aspects of uncertainty addressed in the paper. Since that time, NFPA has released two additional reports, the latter of which specifically confirms that the operational reliability of sprinkler systems, as reported in the original paper, accurately represented the data upon which the paper was based. The recent NFPA reports utilize more current data which cannot be combined with the original data due to differences in the reporting system. The more recent NFPA reports are included in this revised paper.

Past Studies

Table 1 provides a list of previous studies in which the reliability of automatic sprinkler systems has been documented. The scope, breadth, and reporting periods of the various studies vary significantly. One must also carefully review the scope of each study.

Table 1

Reference	Reliability of Success	Comments
Marryat[3]	99.5	Inspection, testing, and maintenance exceeded normal expectations and higher pressures
Maybee[4]	99.4	Inspection, testing, and maintenance exceeded normal expectations.

[1] There are two primary differences between this paper and earlier papers. The first is that this paper, along with the paper dated September 2005, updates the original paper using data provided in the August 2005 NFPA report (referenced later in the paper). The second change, which is a change between the September 2005 paper and this paper, is the overall reliability number for automatic sprinklers systems as reported by the current NFPA data was changed from 91% to 89%. This change occurred after discussions with Dr. Hall in which he suggested that the more correct number to use would be 89%. The 89% number is calculated using an operational reliability of 93% and a performance reliability of 96% as reported in the August 2005 NFPA report.

[2] Budnick, Edward K. , P.E., "Automatic Sprinkler System Reliability," *Fire Protection Engineering*, Society of Fire Protection Engineers, Winter 2001

[3] Marryat, H. W., *Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886 – 1986,* Australia Fire Protection Association, Melbourne, Australia.

Powers[5]	98.8	Office buildings only in New York City
Powers[6]	98.4	Other than office buildings in New York City
Finucane et al.[7]	96.9 – 97.9	
Milne[8]	96.6/97.6/89.2	
NFPA[9]	88.2 – 98.2	Data provided for individual occupancies – total for all occupancies was 96.2%.
Linder[10]	96	
Richardson[11]	96	
Miller[12]	95.8	
Powers[13]	95.8	Low rise buildings in New York City
US Navy[14]	95.7	1964 – 1977
Smith[15]	95	UK data
Miller[16]	94.8	
Budnick[17]	92.2/94.6/97.1	Values are lower in commercial uses (excludes institutional and residential)
Kook[18]	87.6	Limited data base
Ramachandran[19]	87	Increases to 94 percent if estimate number of fires not reported is included and based upon 33% of fires not reported to fire brigade.
Factory Mutual[20]	86.1	1970 – 1977
Miller[21]	86	Commercial uses (excludes institutional and residential)

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[4] Maybee, W. W. “Summary of Fire Protection Programs in the U.S. Department of Energy—Calendar Year 1987,” U.S. Department of Energy, Frederick, MD, August 1988.
[5] Powers, R. W. “Sprinkler Experience in High-Rise Buildings (1969-1979),” *SFPE Technology Report 79-1*, Society of Fire Protection Engineers, Boston, MA, 1979.
[6] Powers, R. W., ibid
[7] Finucane, M, and Pickney, D. “Reliability of Fire Protection and Detection Systems,” United Kingdom Atomic Energy Authority, University of Edinburgh, Scotland.
[8] Milne, W. D., “Automatic Sprinkler Protection Record, “*Factors in Special Fire Risk Analysis*, Chapter 9, pp. 73-89.
[9] NFPA. “Automatic Sprinkler Performance Tables, 1970 Edition,” *Fire Journal*, July 1970, pp. 35-39.
[10] Linder, K. W. “Field Probability of Fire Detection Systems,” Balanced Design Concepts Workshop, NISTIR 5264, R.W. Bukowski (ed.), Building and Fire Research Laboratory, National Institute of Standards and Technology, September 1993.
[11] Richardson, J. K. “The Reliability of Automatic Sprinkler Systems,” *Canadian Building Digest*, Vol. 238, July 1985.
[12] Miller, M. J. “Reliability of Fire Protection Systems,” *Loss Prevention ACEP Technical Manual 8*, 1974.
[13] Power, R. W., ibid.
[14] Kelly, Kevin J. “Trade Ups”, *Sprinkler Quarterly*, Summer 2003
[15] Smith, Frank. “How Successful are Sprinklers,” *SFPE Bulletin*, Vol. 83-2, April 1983, pp 23-25.
[16] Miller, M. J., ibid.
[17] Budnick, Edward J., ibid.
[18] Kook, K. W. “Exterior Fire Propagation in a High-Rise Building,” Master’s Thesis, Worcester Polytechnic Institute, Worcester, MA, November 1990.
[19] Ramachandran, Ganapathy. “The Economics of Fire Protection,” New York: E & FN Spon, 1998.
[20] Kelly, Kevin J., ibid.
[21] Miller, M. J., ibid.

Oregon State Fire Marshal[22]	85.8	1970 – 1978
Taylor[23]	81.3	Limited data base

Operational Reliability

Table 1 includes both domestic and international estimates regarding the reliability of sprinklers. Many of the studies include limited data bases and are based upon experience over 15 years ago. A review of more recent fire experience in the United States indicates that the reliability of automatic sprinkler systems, while still good, may not be as high as reported by several of the studies in Table 1. In an NFPA report[24], Rohr provides considerable data regarding the fire experience in the United States in buildings protected with automatic sprinklers.

The NFPA data over a ten year reporting period regarding the operational reliability of automatic sprinkler systems can be summarized as indicated in Table 2.

Table 2

Property Use	Estimated Number of Fires with Sprinklers Present (1989-1998)	% of Fires With Sprinklers Where Sprinklers Operated
Public Assembly	30,000	73.9%
Educational	11,700	79.6%
Health Care and Correctional Facilities	41,900	80.0%
All Residential	87,500	84.6%
One- and two- family dwellings	16,900	80.0%
Apartments	50,000	87.6%
Hotels and Motels	12,900	82.7%
Department Stores	28,700	84.9%
Offices	10,700	80.6%
Industrial Facilities	4,100	85.9%
Manufacturing Facilities	49,800	91.1%
Storage Properties	9,000	84.0%
Total All Uses	273,400	83.6%

NFPA provided an update on the original report using both the original data reported in Table 2 and data for a period of one year (1999). Due to differences in the reporting system, the two data sets should not be combined. Table 3 summarizes the data as reported by NFPA using 1999 data.

Table 3

Property Use	Estimated Number of Fires with Sprinklers Present (1999)	% of Fires With Sprinklers Where Sprinklers Operated
Public Assembly	4,200	70.2%
Educational	1,810	76.2%
Health Care and Correctional	3,980	80.5%

[22] Kelly, Kevin J., ibid.
[23] Taylor, K. T. "Office Building Fires…A Case for Automatic Fire Protection," *Fire Journal*, 84(1), January/February 1990, pp. 52-54.
[24] Rohr, Kimberly, "U.S. Experience With Sprinklers," National Fire Protection Association, September 2001

Facilities		
All Residential	15,871	86.3%
One- and two- family dwellings	6,620	81.8%
Apartments	8,770	89.2%
Hotels and Motels	1,650	90.4%
Stores and Offices	5,000	
Department Stores	930	88.3%
Offices	1,520	81.1%
Industrial Facilities	500	88.3%
Manufacturing Facilities	5,910	90.7%
Storage Properties	1,690	84.5%
Other	1,300	
Total All Uses	41,480	78.8%

Although the 1999 data would indicate that the operational reliability of automatic sprinkler systems has decreased slightly from the previous ten year data base, the decrease may not be statistically significant since the data base is substantially smaller.

As with any data collection system, there are some limitations regarding the accuracy of the data. While identified as a limitation in some of the studies reported in Table 1, it should be noted that the Estimated Number of Fires with Sprinklers Present in Tables 2 and 3 do not include fires which were too small to operate a sprinkler. For example, if the incident report indicated that the fire was too small to operate a sprinkler, that data point is not included in Tables 2 and 3.

The data in Tables 2 and 3 do not include fires that are not reported to fire departments. The data does not discern whether the systems have been properly designed, installed, and maintained which would obviously increase the operational reliability of automatic sprinkler systems. Also not included is the type of sprinkler system provided and as such, it is not clear that sprinklers were present in the area of origin for all the reported fires. For example, it is possible that sprinklers were present in the building and the incident report may indicate the presence of sprinklers. However, the area of origin may not be in an area where sprinklers were present and there is no way to discern this from the data. Using an older data base, a separate NFPA report[7] indicated that fires originated in an area that was not sprinklered in partially sprinklered buildings constitute 7.8% of the sprinkler system failures.

In the August 2005 report[25], NFPA utilizes information available in the new data system to better document the fires that occur within an area where sprinklers are not present. The adjusted data in the August 2005 report deletes all data in which sprinklers were reported as not being present in the area of fire origin from the data base if sprinklers did not operate and if sprinklers operated but were not effective. The information contained in the report does not allow one to determine if this may result in overestimating sprinkler system reliability. For example, if a fire occurs in an area in which sprinklers are not present and the reference standard does not require sprinklers to be present, the incident may be eliminated from the analysis based upon the entry that sprinklers were not in the area of fire origin. This is different than the issue where the only selected areas of a building are protected and the fire occurs in a space that was not intended to be protected by automatic sprinklers.

Unfortunately the August 2005 NFPA report does not provide the same level of data as provided in previous reports. Instead, the report merely provides percentage values for the time period 1999-2002. Therefore, Table 4 does not contain the number of incidents as provided in the previous tables. The first column of percentages in Table 4, labeled “Nonadjusted,” is provided for comparison with Tables 2 and 3. The second column of percentages in Table 4, labeled “Adjusted,” provides the data as “corrected” by NFPA.

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[25] Rohr, Kimberly and John R. Hall, Jr, “U.S. Experience With Sprinklers and Other Fire Extinguishing Equipment,” National Fire Protection Association, August 2005.

Where data is not provided in Table 4, the information is not provided in the August 2005 report but was provided in one of the previous reports.

Table 4

Property Use	Nonadjusted Data (1999-2002) - % of Fires With Sprinklers Where Sprinklers Operated	Adjusted Data (1999-2002) - % of Fires With Sprinklers Where Sprinklers Operated
Public Assembly	65%	90%
Educational	74%	93%
Health Care and Correctional Facilities	80%	95%
All Residential	88%	97%
One- and two- family dwellings		94%
Apartments		98%
Hotels and Motels		96%
Stores and Offices	81%	91%
Department Stores		
Offices		
Industrial Facilities		
Manufacturing Facilities	88%	93%
Storage Properties	82%	86%
Other		
Total All Uses	82%	93%

Again, the operational reliability of automatic sprinkler systems as reported by the non-adjusted data is lower than what was reported in the original paper by this author.

Performance Reliability

Performance reliability is not easily determined using NFPA fire data. Some of the studies cited in Table 1 use the number of sprinklers operating as a means of evaluating performance reliability. In a performance-based design, the ultimate evaluation may be whether the outcome is consistent with the expected performance as documented during the design process.

It is understood that most automatic sprinkler systems are designed to control a fire but not necessarily to completely extinguish the fire. The NFPA fire data supports the concept that sprinkler systems can control fires but do not necessarily result in complete extinguishment. Table 5 indicates the percentage of fires where sprinklers are present and that are reported as being extinguished by an automatic suppression system. Note that the data includes the fires reported to be extinguished by all types of automatic suppression systems and not only those extinguished by automatic sprinkler systems. However, since automatic extinguishing systems other than sprinkler systems constitute only a tiny fraction of protected areas, it is reasonable to assume that the overall automatic extinguishing system data can be interpreted as a relatively accurate indication of sprinkler system data.

The data in Table 5 has not been updated to include the periods from 1999 through 2002. Instead, the August 2005 report indicates that when sprinkler systems operate they are effective in 96% of the incidents. Assuming the validity of the data entry used to generate this value, the August 2005 report would be a better means to measure performance reliability than the data in Table 5.

Table 5

Property Use	Estimated Number of Fires with Sprinklers Present (1989-1998)	Estimated Number of Fires reported to be Extinguished by an Automatic Suppression System (1989-1998)	Percent of Fires Extinguished by System
Public Assembly	30,000	8,000	26.7%
Educational	11,700	1,000	8.5%
Health Care and Correctional Facilities	41,900	5,000	11.9%
All Residential	87,500	17,000	19.4%
One- and two- family dwellings	16,900	3,000	17.8%
Apartments	50,000	10,000	20.0%
Hotels and Motels	12,900	2,000	15.5%
Department Stores	28,700	6,000	20.9%
Offices	10,700	2,000	18.7%
Industrial Facilities	4,100	1,000	24.4%
Manufacturing Facilities	49,800	13,000	26.1%
Storage Properties	9,000	3,000	33.3%
Total All Uses	273,400	53,000	19.4%

While property loss and life loss are greatly reduced in buildings protected with an automatic sprinkler system, the sprinkler system alone is not providing the entire increased protection.

Summary

While NFPA fire data clearly demonstrates that property loss and life loss are reduced in buildings protected throughout with an automatic sprinkler system, the same data has indicated in the past that sprinklers fail to operate 1 in every 6 fires that are large enough to activate a sprinkler. The nonadjusted data in the more recent studies indicates that the operational reliability of automatic sprinkler systems may be decreasing. However, improvements in the data collection system enable a better evaluation of the data and based upon the August 2005 NFPA report, the operational reliability of sprinkler systems may be as high as 93%.

It has been stated that unreported fires may increase the reliability of automatic sprinkler systems. However, no data has been presented to support that claim. It is common in the U.S. that current building and fire codes require the water flow alarm from an automatic sprinkler system to automatically transmit an alarm to an alarm receiving facility. This should have the effect of increasing the percentage of fires reported to fire departments in buildings protected with an automatic sprinkler system.

The original paper indicated that the uncertainty in the data could result in an operational reliability of sprinkler systems in the area of 90%. In subsequent presentations regarding the paper, this is the value that the author has used. This is the same value that is proposed to be used for sprinkler system reliability for life safety purposes in a British Standard.[26] The same British standard proposes a value of 80% for automatic sprinkler system reliability when considering property protection.

The NFPA data indicates that the commonly stated reliability of automatic sprinkler systems in the range of 96% (fails once in every 25 fires) is overstating the reliability of sprinkler systems unless there are assurances that the preventive maintenance on the system is substantially better than that on the average system in a building in which a fire has occurred. When combining the operational effectiveness and performance effectiveness data as published in the August 2005 NFPA report, the overall reliability of automatic sprinkler systems is 89%. This value is extremely close to the 90% value previously proposed by this author and the value proposed by the British Standard.

The paper was commissioned by the Alliance for Fire and Smoke Containment and Control, Inc.

William E. Koffel, P.E., is President of Koffel Associates, Inc., a fire protection engineering and code consulting firm with offices in Maryland and Connecticut. Mr. Koffel has a B.S. in Fire Protection Engineering and he has over 26 years of experience as a practicing fire protection engineer. Mr. Koffel participates actively in the model code development processes of the International Code Council and the National Fire Protection Association and has served on numerous committees within each process.
He has previous experience with the Maryland State Fire Marshal's Office and has been a volunteer firefighter.

[26] **BSI PD7974-7 (2003) –***Application of fire safety engineering principles to the design of buildings – probabilistic risk assessment*

Appendix D

Ten Largest Private Nonresidential Permitted Construction Projects in California: 2005

Number	Description	City County	Value
1	Pharmaceutical Manufacturing Facility	Vacaville Solano County	$200.0 million
2	Private Museum Building	San Francisco San Francisco County	$130.0 million
3	Office Development	Irvine Orange County	$54.8 million
4	Hotel	Westlake Village Los Angeles County	$52.0 million
5	Private Music School Building	Los Angeles Los Angeles County	$51.5 million
6	Office Development	San Diego San Diego County	$47.7 million
7	Office Development	Irvine Orange County	$47.1 million
8	Office Building	Modesto Stanislaus County	$46.4 million
9	Office Development	Irvine Orange County	$45.2 million
10	Office Development	Irvine Orange County	$45.1 million
		Total*	$719.8 million

*Note: Total for Nonresidential Permitted Construction in California was **$14.389 billion**

Reference: Construction Industry Research Board, 2006. "Building Permit Summary: California Cities and Countries Data for Calendar Year 2005." Burbank, California.

Appendix E

How will the changes to the 2006 **International Building Code** proposed by the California Office of the State Fire Marshal [OSFM] effect R-2 building costs?

With regard to multi-family buildings constructed specifically, while only a portion of R2's would be regulated by the proposed OSFM regulations, a concern exists that local jurisdictions might also adopt and apply those regulations. What then, would be the fiscal impact on projects built according to the proposed OSFM regulations - as compared to current building costs as under the current California Building Code?

To answer this, we have evaluated current allowances for Type V-1 hour buildings for R-2 (R-1 in the 2001 CBC) uses and compared those with the proposed, IBC based CBC with OSFM amendments.

Under the existing CBC, the basic area allowed for Type V-1 hour buildings for R-2 (R-1 in the 2001 CBC) is 10,500 square feet with a basic height allowance of three stories for un-sprinklered buildings. An increase can be made to four stories for such buildings if an appropriate automatic sprinkler system is used. The maximum building area allowed under the existing CBC (utilizing all of the allowable area increases permitted in the code) for this construction type and occupancy is 42,000 square feet and four stories, or 84,000 square feet for a three story building.

If the proposal from the Office of the State fire Marshal is adopted, in the parlance of the IBC code, Type V-A buildings will correspond to the existing Type V- 1 hour fire endurance rated holdings. Following the logic above and allowing for height increase or area increases, the largest possible building under the proposals being discussed will be 96,000 ft.^{2} (for a three-story building), an increase of 12,000 ft.^{2} - approximately a 14% increase in total area over what is currently allowed.

Likewise, under the provisions of the existing CBC vs. the proposed CBC with OSFM amendments, the largest possible 4 Story building of this type allowed under the proposals being considered will be 48,000 ft.^{2}, an increase of 6,000 ft.^{2} This will also provide an approximately 14% increase for the new code with proposed amendments in total area over what is currently allowed under the existing CBC .

As such, construction of either these large three or four-story apartment buildings, under the provisions of the 2006 IBC subject to the SFM H&A amendments will end up costing roughly equal or less than the same building built under the existing California Building code on a per square foot basis for the following reasons:

- The proposed new regulations allow for increases in the range of 13-14% in allowable area beyond what is *currently* allowed by the CBC.
- The proposed new regulations will not require any additional fire resistive building construction elements.
- The proposed new regulations will not require any fire safety features not currently required by the California Building Code.
- Dependent on design of included areas, costs per square foot to construct projects under the proposed code will be reduced over those associated with the current California Building Code and economy of scale issues suggest a corresponding reduction in cost per square foot based on the larger permissible areas.