AAIS

AAIS FLAMES: A White Paper for Insurance Carriers and Regulators

Reimagining fire severity and mitigation assessment through the development of AAIS's new Fire Loss and Mitigation Evaluation Score (FLAMES) methodology

AAIS FLAMES
Fire Loss and Mitigation Evaluation Score

Contents at a Glance

Disclaimer: Notes and References to the figures used can be found on pages 9-10.

AAIS

AAIS FLAMES: A White Paper for Insurance Carriers and Regulators

The AAIS Fire Loss and Mitigation Evaluation Score (FLAMES) is a data-driven, predictive model developed to help insurers more accurately quantify expected fire severity at the ZIP code level. Legacy approaches, including AAIS's legacy approach, were based on assumptions of the drivers of fire loss that tend to prioritize the location of insured properties relative to fire protection resources and infrastructure. What is missing from legacy models is sufficient stratification in exposure based upon the public fire protection resources available. While much has changed in fire protection and insurance, the methods for assessing public fire protection have not kept pace.

Executive Summary

AAIS spent the past several years consulting with leading subject matter experts to understand the changing nature of fire risk and fire mitigation efforts nationwide. Using these insights, we developed a methodology to redefine our public fire protection classifications to differentiate expected loss experience.

Several key principles guided us in the development of the FLAMES model. Chief among these was the modeling framework should be flexible, scalable, and tunable to get the most appropriate fit consistent with regional variations, regulatory requirements, and, importantly, the drivers of fire loss.

Breaking away from historical precedence, the AAIS FLAMES approach is not intended to serve as an evaluation or performance assessment of local fire departments. Moreover, the FLAMES approach also does not focus the analysis or rating upon areas within or outside of fire department response boundaries. Instead, the FLAMES approach assigns a score for each ZIP code and line of business, which makes it easier to integrate into established underwriting workflows. While fire departments may not typically be concerned with what occurs in the portions of ZIP codes outside their jurisdictional boundaries, the FLAMES methodology takes a more holistic and outcome-focused approach that may indirectly encourage fire departments to prioritize collaboration and coordination with their neighbors in both fire response and mitigation efforts.

The AAIS FLAMES approach represents a significant improvement in how the insurance industry measures and manages fire risk. This approach will be expanded and refined based upon intricacies of the individual lines of business, access to improved data about mitigation efforts, and feedback from AAIS Members, regulators, and fire service thought leaders alike. The new FLAMES methodology is exactly the sort of modern, transparent, flexible, and responsive approach expected from a modern advisory service organization like AAIS.

P&C Insurance and Fire Service Developed Hand in Hand

Source: www.mercermuseum.org

The history of the property and casualty (P&C) insurance industry is linked to the history of fire protection. From the Great Fire of London in 1666 to Benjamin Franklin and the Philadelphia Contributionship (for the Insurance of Houses from Loss by Fire) in 1752, fire departments were originally organized and funded by insurance companies as a loss prevention strategy and member benefit.

The provision of local fire protection and insuring properties against fire losses often went 'Hand in Hand,' as captured in the iconic fire mark.[i] Since that time, the insurance industry and the fire protection industry have evolved, but what has not changed is how significant fire losses continue to impact the P&C insurance industry.

Still a significant and often overlooked peril

Non-catastrophic losses from fires consistently account for a significant portion of insured losses (see Figure 2). Given the significant wildfire losses during the 2017, 2018, and 2020 wildfire seasons, one might assume that catastrophic losses from wildfires dwarf non-catastrophic structure fire losses annually. However, the vast majority of fire-related annual insured losses during the past decade came from non-catastrophic fire losses.[ii] While non-catastrophic losses from fires may be easily overlooked in the modern environment, they remain a considerable driver of loss to the industry that must be addressed.

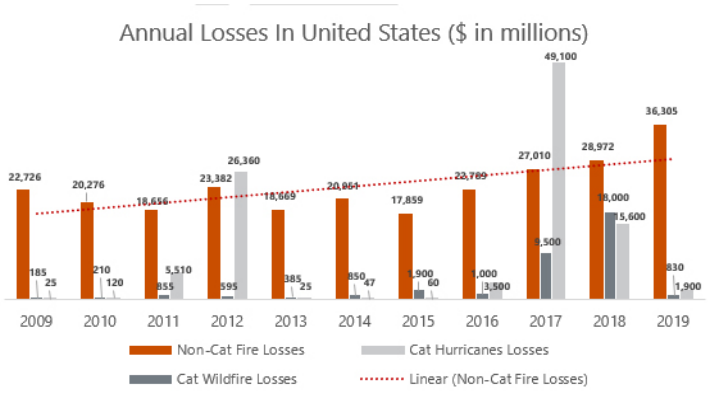
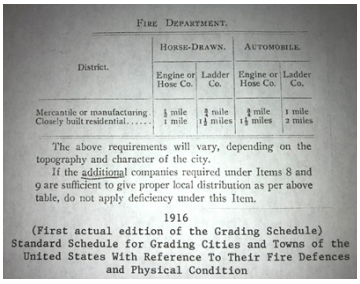


Figure 2: Data sourced from Insurance Information Institute and MunichRe NatCatSERVICE

Historic Approaches to Evaluating Public Fire Protection

A fundamental feature in assessing property fire risk is the quantification of the impact of public fire protection resources. Public firefighting capabilities vary by geographic area and are influenced by a wide variety of factors, including water supply, firefighter training, firefighting equipment, and radio system capabilities.[iii] However, it is less clear how these fire service-oriented input measures translate into improved outcomes like reduced claims experience.[iv]

Given that non-catastrophic fire losses remain a considerable and ongoing source of loss, it is instructive to revisit historical approaches and assumptions about assessing the impact of public fire protection on fire risk.



FIRE DEPARTMENT.

District.	Horse-Drawn.		Automobile.	
	Engine or Hose Co.	Ladder Co.	Engine or Hose Co.	Ladder Co.
Mercantile or manufacturing	¼ mile	⅜ mile	⅜ mile	1 mile
Closely built residential.....	1 mile	1½ miles	1½ miles	2 miles

The above requirements will vary, depending on the topography and character of the city.

If the additional companies required under Items 8 and 9 are sufficient to give proper local distribution as per above table, do not apply deficiency under this Item.

1916

(First actual edition of the Grading Schedule)

Standard Schedule for Grading Cities and Towns of the United States With Reference To Their Fire Defences and Physical Condition

Figure 3: Research and materials provided by NBFU historian Ed Tochterman, Jr., September 17, 2020

The location and distribution of fire stations and fire hydrants in a community has long been a primary focus in measuring public fire protection. Knowing the location of fire stations and how far a property is from a fire station[v], is a factor in most legacy public fire protection (PFP) models. However, assumptions about the relevance of distances from fire stations can be traced to historical, colloquial knowledge about how far horses could pull a steam fire apparatus before tiring[vi], originally codified by the National Bureau of Fire Underwriters in the early 1900s.

[1] Bruce Hensler, Crucible of Fire, Page 8 | [2] Insurance Information Institute data, Page 8
[3] Fire Department Table, Page 8 | [4] Public Protection Class scale, Page 8 | [5] Geographic Information Systems, Page 8
[6] The Standard Grading Schedule for Grading Cities and Towns, Page 8

Many of these legacy assumptions were further refined by the RAND Corporation in seminal studies in New York City in the late 1960s and early 1970s.[vii] Assumptions that fire apparatus typically travel at 35 miles per hour, regardless of time of day, congestion, or road configuration can be traced to this period as well.

Many of the dominant approaches in the industry focus on measuring the fire protection capabilities within the geographic boundaries of an individual fire department. This legacy approach ignores variation in capabilities and claims severity across communities, especially when a single fire protection jurisdiction can cover less than one square mile, or in other cases more than one thousand square miles. Moreover, using fire department boundaries as the primary geographic unit of measure can make it difficult to integrate into carriers' internal programs and processes.

The legacy AAIS public fire protection classification program, while directionally accurate, was also overly simplistic being based on the distance to the nearest fire hydrant and fire station to assign broad public fire protection classifications—Protected, Partially Protected, and Unprotected. This approach was quite coarse for risk selection used by insurers since the vast majority of homeowners' exposure fall within the best-rated public fire protection class.

Expansion of Fire Risk Data Sources

The types and amount of data available from fire departments, local communities, and other sources continue to expand. Meanwhile, insurance carriers are developing more sophisticated pricing strategies based on an expansive and growing list of data sources and advanced modeling techniques. It is imperative that fire risk is not excluded from these efforts. With the increased availability of additional data, it is instructive to revisit many of the methodological approaches and assumptions to identify opportunities for greater insights and differentiation about the fire risks to properties. The increasingly complex web of information available about properties and communities include data such as:

- Detailed and dynamic data about fire department response and emergency operations,
- Expanded use of fire protection system sensors and remote status monitoring capabilities,
- Data about inspection, testing, and maintenance (ITM) activities of fire protection and alarm systems,
- Smart building sensors and connected device controls,
- Improved insights in to building permits and construction practices,
- Occupant behavioral and building usage patterns,
- Detailed information about fire code enforcement, violations, and compliance in commercial properties,
- Information about community risk reduction and other organized mitigation activities in residential properties, and a growing list of other data sources.

What the insurance industry needs is a fresh approach that effectively leverages these evolving data sources to dynamically respond to and account for this increasingly complex and changing environment.

Learning from Transformations in Auto Insurance

Assessing fire risk and fire protection is too complex for the rudimentary models of the past. This is not a novel insight exclusive to the fire peril, as other insurance subsets have already begun the journey to modern risk assessment. For example, auto insurers have long realized that traditional univariate actuarial techniques do not provide sufficiently granular understanding of the nuances of auto claims experience to operate in the highly competitive area of personal auto. Auto insurers adopted complex multivariate models to make sense of the newly available data about crashes, claims, driver behavior, repair costs, vehicle telemetry, road conditions, and travel patterns. This multivariate approach has transformed auto underwriting and specifically how auto insurers calculate their risk.

[7] The Fires (2010), Page 9

Today, many auto lines carriers use Generalized Linear Models (GLMs) to process and analyze large numbers of complex variables. The advantage to multivariate analyses like GLM approaches is that they consider the interactions between multiple variables.[viii] A key point when using a GLM approach is that the actuary or analyst remains the one evaluating both the fit of the model and the appropriateness of the variables. The advantages of GLMs in terms of their transparency, their predictiveness, and their widespread acceptance by regulators make them ideally suited to apply to the fire peril.

Introducing FLAMES

Traditional approaches to assessing fire risk start with the assumption that simply measuring the composition, proximity, and response capabilities of local fire service resources are sufficient to explain differences in losses, but this basic assessment no longer provides an accurate picture. AAIS has developed a modern, objective, and evidence-based approach for assessing fire risk and severity that **began with the premise that a modern and transparent methodology should be able to explain variance in fire severity at a consistent and easily interpretable geographic aggregation**.

Fire risk variation does not follow political or fire department boundaries. Fires affect communities; and communities—not political or jurisdictional boundaries—are the best way to understand fire risk. **AAIS evaluates public fire protection at the ZIP code level**, which is consistent and simple to integrate into underwriting workflows. The total geographic footprint of a ZIP code varies with population density. ZIP codes in populated urban and suburban areas cover small geographic areas. Conversely, in rural areas with smaller population density, the ZIP codes cover larger areas. Since populated areas have higher insured exposure, using ZIP codes varies the resolution in a way that is most relevant to fire exposure.

By not focusing on fire department boundaries in evaluating fire risk, more insight can be gleaned into the distribution, coordination, and cooperation of fire protection resources within and across communities. Many fire departments cover and protect multiple ZIP codes. By using ZIP codes, carriers will have a much more nuanced understanding of differences in expected claims severity in large cities that might otherwise have a single or split rating. Similarly, many ZIP codes will likely be covered by two or more neighboring fire departments, which will often highlight—positively or negatively—the amount of coordination and cooperation among the different agencies towards the common goal of reducing fire risk.

We call this new ZIP code-focused predictive modeling approach **AAIS Fire Loss and Mitigation Evaluation Score** or **AAIS FLAMES**. The data we have currently incorporated, the methodology we selected, and the flexibility of the approach were designed to quantify variance in both expected fire claims severity and the impact of mitigation efforts to reduce fire loss at the ZIP code level. We refer to this as an "approach" deliberately. **This approach to quantify fire risk will continue to expand and adapt as new, more predictive data sources and technology become available and as we incorporate additional lines of business where the fire problem may be fundamentally different.**

Developing the FLAMES Model

AAIS spent the past several years consulting with leading subject matter experts to understand the changing nature of fire risk and fire mitigation efforts nationwide. Using these insights, we developed a new methodology to redefine our public fire protection classifications to differentiate expected loss experience. Underlying this analysis is a wealth of public and third-party data that encompasses fire-fighting capabilities and the environments where they are employed. To objectively assess the public fire protection impact on insured losses, we have built a predictive model which we transformed into a scoring algorithm to create distinct FLAMES classes.

Several key principles guided us in the development of the FLAMES model. Chief among them is the need to build a data-driven, analytical solution that is acceptable to regulators and other industry professionals. Another key principle was that the approach should be flexible, scalable, and tunable to get the most appropriate fit consistent with regional variations, regulatory requirements, and, importantly, the drivers of loss.

[8] A Practitioner's Guide to Generalized Linear Models: A CAS Study Note. 3rd Ed., Page 9

Initially, the FLAMES model has been approved as part of the Homeowners By-Peril program for Florida effective January 2021. In the coming years, AAIS will be expanding and filing FLAMES in other states and programs. Unlike other industry approaches that utilize a single grading criteria and model across all lines of business, the FLAMES approach will be specifically tuned and validated for each program, since fire claim experience will be different.

The Data Utilized Currently

Another foundational development principal of building the FLAMES predictive model, was that no assumption were made about the drivers of fire claims severity. AAIS cast a wide net to include data sets that could be relevant to public fire protection and then systematically narrowed the focus as the model was refined to maximize accuracy. The initial countrywide FLAMES model focuses on homeowners policies. This model was refined to the specific requirements of the Florida homeowners market.

The two foundational datasets we used were such as nationwide fire incident data from fire departments from the National Fire Incident Reporting System (NFIRS) and carrier claims data covering five accident years. Additional data sets investigated during model development included weather, crime, economic activity, fire stations, traffic patterns, fire hydrants, and vacancy rates. The model also considered aggregate building stock characteristics such as average number of stories, age of buildings, and population density in a geographic area.

The Methodology for Feature Selection

The computational framework of FLAMES is a generalized linear model (GLM). The GLM was selected for its general acceptance by ratemaking actuaries and regulators, and for its ability to predict and explain the prediction through a host of diagnostics and statistical tests. Other more advanced algorithms were reviewed for the classification, but the lack of transparency in those models led us to exclude them from direct inclusion in the initial FLAMES rollout.

For additional transparency, the final GLM was transformed into a scorecard. This transformation rescales the GLM model while still preserving the relationships among selected features and creates a set of indicated points. The scorecard was then applied to all ZIP codes. From these scored ZIP codes, with class 5 capped at a 1.200 factor to minimize impact, the breakpoints were then selected to create classes which contain roughly the same exposures on a country wide basis.

Results Modeling Severity

When evaluating damage ratios for homeowners policies—in terms of the average ground-up ultimate loss to total insured value (TIV)—the FLAMES approach shows clear lift over the existing public fire protection classifications (Figure 4).

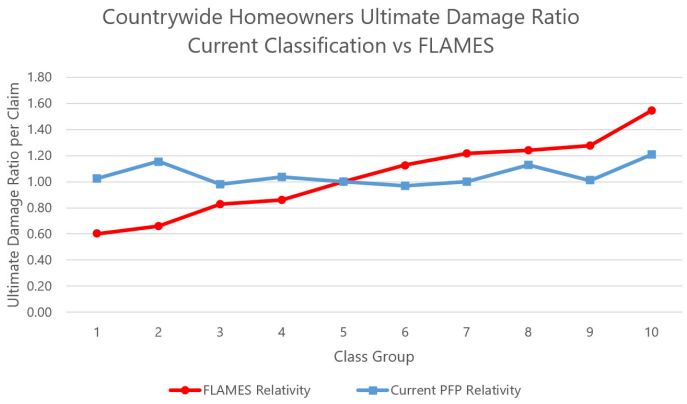


Figure 4: Damage ratios are defined as the average group up ultimate loss only amount per $1000 of TIV. Current PFP classes have been mapped to the scale of 1 to 10 for comparison. FLAMES damage ratio bins represent the deciles of the FLAMES predictions.

Why Focus on Severity?

Economic loss from fire is a persistent and growing threat to the profitability of insurance carriers. AAIS Members have shared their challenges in differentiating fire loss claims experience using legacy public fire protection rating approaches.[ix]

Typical public fire protection assessment approaches that focus upon the number of resources available within a community—the number of trained firefighters, the number of stations, the number of fire apparatus, the number of fire hydrants—evaluate the impact of these resources on claim severity. These resources are almost exclusively focused on responding to a fire that is underway. If a fire has already begun (in an insured property), a loss has already occurred at some level—the question is simply how much of a loss it will be.

[9] The III Insurance Fact Book, Page 9

By bringing fire claim severity to the foreground, it cements a key outcome measure for the fire protection practitioners. This may encourage practitioners to identify innovative and evidence-based ways to reduce claim severity from fire losses, business disruption, and extra expenses via a renewed focus on loss-reduction practices.

Next Steps for FLAMES

FLAMES represents a clear departure from established legacy approaches, including AAIS's legacy public fire protection model. The FLAMES model is still being refined and refinement will continue through the lifecycle of the approach. AAIS employs an Agile product development approach to rapidly develop new features and services in iterations to ensure they are fit-for-purpose, provide value to our Members, and are responsive to end-user requirements. FLAMES will continue to grow and improve based upon industry feedback, changes in the data available, and user input.

Fire Frequency and Mitigation Efforts

In terms of fire frequency, the number of incidents year over year has experienced a decline over the past four decades in the U.S. However, the National Fire Protection Association (NFPA) highlights that fire frequency, based on fire incident reports from fire departments, has leveled out for the past two decades after significant decreases in the period from 1978 to 1998—especially when focused on structure fires (Figure 5).

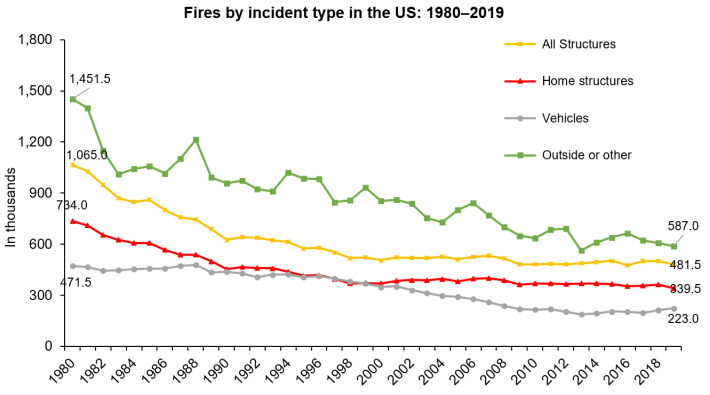


Figure 5: Source - NFPA Fire Loss in the United States 2020: https://www.nfpa.org/News-and-Research/Data-research-and-tools/US-Fire-Problem/Fire-loss-in-the-United-States

While the frequency of structure fires across the United States has remained stagnant[x] over the past two decades, it is less clear which communities are actively engaged in evidence-based fire prevention activities—often known in the fire service as "Community Risk Reduction"—and how much these risk mitigation activities translate into reduced frequency of fires.

Fire Department Outcomes Not Inputs

The AAIS FLAMES approach is not intended to serve as a performance assessment of local fire departments. Nor is the intention to create a checklist and grading scheme of emergency response input measures that fire departments can use to evaluate their performance or derive a score. The FLAMES approach is more focused on outcome measures of losses from fires, which marks a significant and perhaps uncomfortable change in how fire departments think about evaluating performance.

The FLAMES approach also does not focus the analysis or rating upon areas within or outside of fire department response boundaries. FLAMES assigns a score for each ZIP code and line of business. Fire departments are primarily concerned with what occurs within their jurisdictional boundaries and may be puzzled by the reliance upon ZIP codes that may include areas beyond their immediate control. AAIS takes a more holistic view that may indirectly encourage fire departments to prioritize collaboration and coordination in both response and mitigation efforts.

As AAIS continues to expand FLAMES in the coming years, we will focus on developing an innovative approach for quantifying fire service mitigation efforts to quantify the variance in fire frequency. The most pressing data need is granular information about mitigation efforts by fire departments, third-party life safety system contractors, and other interested parties who actively are working to mitigate risk in communities and protected properties to better quantify, evaluate, and validate data about fire mitigation efforts across all policy lines.

[10] Residential Fires, Page 9

AAIS has built relationships throughout the fire protection industry and has begun discussions with industry experts and thought leaders about how to standardize, consolidate, and validate this type of mitigation data. Measuring a fire department's ability to prevent and mitigate fire losses is an important outcome measure that has been missing from the modern fire service. Getting away from legacy, input and output-based checklist approaches will free the fire service to identify innovative, coordinated, and evidence-based service delivery and risk reduction strategies to achieve improved fire loss outcomes.

Conclusion

Fire remains a persistent peril that threatens the long-term profitability of the P&C insurance industry. While much has changed in fire protection and insurance, the methods for assessing public fire protection largely have not kept pace. What is needed is a modern approach that utilizes the latest analytical methodologies and the most predictive datasets to provide the insurance industry with robust risk decision making insights. FLAMES does exactly this.

Legacy approaches, including the program created by AAIS, were based on historical analyses and assumptions of the drivers of fire loss that tend to prioritize the location of insured properties relative to fire protection resources and infrastructure. The question is not whether it is possible to find evidence to validate whether these historical rules of thumb still have any empirical basis; the question is, do simplistic heuristics and intuitive models sufficiently differentiate exposures to fire loss to help modern carriers to make good fire risk decisions? What is typically missing from these models are sufficient variation in claim experience to quantify exposures.

AAIS has developed a countrywide model for homeowners policies and will be expanding to additional lines of business. The FLAMES approach explains variation in expected claims severity. AAIS is beginning to develop and validate data about mitigation efforts to begin to expand and explain variation in expected claims frequency. AAIS invites input and feedback from its Member companies on the current approach, the product roadmap, and for opportunities to evaluate the approach against your internal claims experience.

Getting a better understanding of the impact of fires remain a considerable challenge and opportunity to help carriers remain competitive. The fire peril continues to evolve and so too should the methodologies the insurance industry uses to quantify those changes. The AAIS FLAMES approach represents a significant shift from traditional legacy approaches that were based upon a number of intuitive measures and historical assumptions that rarely changed. The new FLAMES rating methodology is exactly the sort of modern, transparent, flexible, and responsive approach expected from a modern advisory service organization like AAIS.

Notes and References

i History is replete with folklore about the early fire departments, after responding to a cry of FIRE, checking the branded 'fire mark' plaque affixed to the building on fire and leaving—without putting out the fire—if it was not insured by their sponsor (Bruce Hensler, Crucible of Fire: Nineteenth-Century Urban Fires and the Making of the Modern Fire Service, 2011).

ii. According to Insurance Information Institute data, non-cat fire losses by year averaged $26.9 billion from 2010 to 2019 (https://www.iii.org/table-archive/20575). Whereas catastrophic wildfire losses averaged $5.2 billion for the same period and the significant wildfire losses in 2018 were estimated at $25.4 billion. (https://www.iii.org/table-archive/21420)

Year	Non-cat Fire Loss Estimates	Wildfire Loss Estimates
2010	$20,486,000,000	$80,000,000
2011	$19,511,000,000	$1,922,000,000
2012	$23,977,000,000	$1,112,000,000
2013	$19,054,000,000	$620,000,000
2014	$21,801,000,000	$1,700,000,000
2015	$19,759,000,000	$4,400,000,000
2016	$23,789,000,000	$1,200,000,000
2017	$36,510,000,000	$14,300,000,000
2018	$46,972,000,000	$25,400,000,000
2019	$37,135,000,000	$1,300,000,000
10-year avg	$26,899,400,000	$5,223,400,000

iii. This approach also considers the 'divergence' between the highest and lowest scoring measures and adjusts the scores for departments that have high divergence between variables. https://www.isomitigation.com/ppc/fsrs/items-considered-in-the-fsrs/

iv. It is worth noting that the ISO Fire Suppression Rating Schedule now considers mitigation efforts to some degree through the opportunity to gain up to 5.5 bonus points for those departments that have adopted a fire code, have certified inspectors, educators, investigators, and plans review personnel, and can provide evidence of having programs in place for each.

Community risk reduction activities and personnel were included in the 2014 revision of the Insurance Services Office: Fire Suppression Rating Schedule and total 5.5 possible points. This amounts to 105.5 possible points and the Public Protection Class scale are awarded on the basis of 100 points, leading to the opportunity to earn up to 5.5 bonus or extra credit points. Despite the inclusion of extra credits for fire prevention inputs the focus remains squarely upon rating "Fire Suppression" capabilities of a fire department not the impact on fire claims. https://www.isomitigation.com/ppc/fsrs/items-considered-in-the-fsrs/

v. As part of assessing the distribution and concentration of fire stations advisory organizations, and by extensions fire departments, traditionally would map a concentric circle or series of concentric circles (akin to a Venn diagram) with each of the fire stations in the center to determine how much of the community or especially the central business district fell within the area that fire station was assumed to be able to appropriately cover. As fire departments moved from horse-drawn apparatus to motor drawn apparatus the distances a fire station could be assumed to adequately cover expanded. Concentric circles that tended to use distance "as the crow flies" were eventually abandoned and some approaches used a "diamond method" for areas where roads were based on a planned grid. Modern approaches use advanced GIS (Geographic Information Systems) mapping technology to measure "response polygons" where a polygon is created based upon how far a vehicle could travel in a set distance or set amount of time at the posted speed limit from a specific location—in this case a fire station. The most modern approaches take into consideration actual drive times based upon data about average or fractal observed speeds for each road segment to give a more realistic picture of how far a vehicle could travel in any direction taking into account traffic congestion at different times of day, traffic control devices, and other factors that may limit or impact travel times at certain times or days of the week. Ultimately, the goal is the same, to identify areas that are anticipated to be beyond the distance that can be assumed to be reasonably covered by units based at fixed facilities to ensure timely responses to emergency calls for service.

vi. The origin of the defined distance measures likely pre-dates the founding of the National Bureau of Fire Underwriters which incorporated this measure in "The Standard Grading Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions" originally published in 1916 according to Ed Tochterman who is the unofficial historian and one of the last surviving employees of the NBFU. The measurement of concentric circles, later a diamond, around fire stations used to originally were originally based upon knowledge of how

far a team of horses could pull a steam powered fire engine before tiring. Ed Tochterman noted that in 1912 the NFBU made a clear distinction in distance guidelines between distances for horse-drawn fire apparatus and motor-driven fire apparatus (personal correspondence 9/17/20). Separately, Chief Ronny J. Coleman, retired California State Fire Marshal and renown fire service historian, has noted that after the Civil War many full-time fire departments "adopted the idea that they should have no longer than a five-minute response time. Considering that the horses that were in service were team horses, i.e. draft animals, a five-minute response translated into about 1.5 miles in distance at a full gallop" (Personal correspondence, 9/17/20). These concentric circles were intended to ensure a sufficient concentration of fire stations so that no area would be beyond a distance that the horse drawn equipment could cover. This is further discussed in Bruce Hensler's history of the urban fire service (2011).

[vii] These studies (available here: www.rand.org/topics/fire-protection.html) looked at various aspects of unit deployment, unit response times, and ultimately were used to justify the re-deployment of units to account for reduced staffing and allocations. In The Fires (2010), author Joe Flood detailed the unintended consequences of these studies and assumptions upon which they were based had devastating effects on particular communities, especially the low income portions of the Bronx. Perhaps the least appreciated portion of the RAND studies were the computer technology and approaches developed decades ahead of their time for dynamically recommending the re-location of fire apparatus to fill gaps in coverage. Most current assumptions of fire protection coverage assume that fire apparatus are primarily located at and likely to respond from their fire station, but given increasing call volume, over lapping calls, mutual aid agreements, many time units may not be situated at their home station when a call comes in or the apparatus that is normally closest might not be the closest available unit. Most public fire protection models do not typically account for dynamic deployment and movement of fire apparatus. The genesis of these computer based dynamic deployment systems can be traced to RAND's 1972 report: An Algorithm for the Dynamic Relocation of Fire Companies and their 1975 report: An On-Line Program for Relocating Fire-Fighting Resources.

[viii] Source: Anderson, D., Feldblum, S., Modlin, C., Schirmacher, D., Schirmacher, E., and Thandi, N (2007) A Practitioner's Guide to Generalized Linaer Models: A CAS Study Note. 3rd Ed.

[ix] The III Insurance Fact Book (2020, pg 112) notes that 2013-2017 weighted average of homeowner claims severity was $68,322 for fire and lightening losses and compared with a combined $30,503 for all other perils.

[X] There were 734,000 residential fires in 1980 and 369,500 in 1998, a 50% reduction. In 2018 across the US there were 363,000 residential fires, less than a .01% reduction in that 20-year period.