

# **RESEARCH IN THE DEVELOPMENT OF DEPLOYMENT STANDARDS: WHY CAN'T WE ANSWER 'BIG QUESTIONS' IN THE FIRE SERVICE?**

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## **1.0 Introduction**

Some authors have argued that a profession must define the 'Big Questions' facing their discipline.[1] These Big Questions need to be discussed, researched, and ultimately answered. In the fire service, we have struggled with one set of questions for over three decades – what is the appropriate level of staffing necessary for effective fire ground operations and how quickly do we need to deliver it? That makes one of our Big Questions fire service deployment. While we have certainly discussed this question over the years, have we researched and answered it?

The focus of this paper is to provide an assessment of the current state of deployment research in the fire service. To do so, an evaluation of the research used to answer questions of staffing and response times in the development of NFPA 1710 was conducted. The paper then discusses problems found with current research efforts and recommends further efforts that will enhance the development of future deployment standards.

## **2.0 Research used to support NFPA 1710: A critique**

The development and subsequent adoption of NFPA 1710 was a contentious process. Various interest groups lobbied their respective positions strongly during the development of the standard. And while not the first attempt to develop a comprehensive deployment standard – the first efforts happened at least ten years earlier - the ultimate adoption of 1710 resulted only after major constituency groups argued the standard was based on strong scientific evidence.[2,3,4] To evaluate that claim, and determine if current research meets the needs of the fire service in deployment issues, a critique was performed on the major studies cited by proponents.

The IAFC encouraged its members to review major studies used to support NFPA 1710. Citing 30 years of study, research testing and validation, the IAFC encouraged members to “ read for yourself and make your own conclusions.”[5] Accordingly, this paper reviewed the available appendix material obtained through the IAFC website, focusing on that which was purported to be ‘research’ appropriate for use in supporting adoption of the standard. Several of the documents were quickly identified as excerpts from organizational tools, for example copies of a particular agency’s deployment efforts, etc. However after reviewing all the appendix materials, only four documents were identified by proponents as original studies on deployment issues. These four documents, examined here, are 1) “Safe Fire Fighting Staffing: Critical Considerations” by the IAFF; 2) “Shaping the Future of Fire Ground Staffing and Delivery Systems within a Comprehensive Fire Safety Effectiveness Model” by the Ontario Fire Marshal; 3) “Dallas Fire Department Staffing Level Study” and 4) Phoenix Fire Department FIREDAP Program.

To perform a systematic review of these four studies, a critique derived from methodologies applied elsewhere was used here.[6] The four studies were evaluated to see if they 1) employed original data; 2) provided a comparison to other systems; 3) provided sufficient information to replicate the study and 4) if appropriate statistical analysis was used. The review of a study’s appropriateness also assessed if any methodological problems were identified. Employing this approach, the following studies were reviewed.

## **2.1 IAFF's Safe Fire Fighter Staffing**

This 1993 document's stated purpose is to provide "the most up-to-date and comprehensive review of the facts, statistics, and issues surrounding fire fighter staffing." [7] In doing so, Chapter 2 of the report does provide a literature review of other works, most related to the issue of firefighter staffing. Brief synopsis of various reports, studies and industry recommendations are presented, but not in a systematic approach such as a meta analysis or critical review. The document was apparently developed to provide IAFF members a position paper on the topic of firefighter staffing for use when discussing issues with elected officials. As such, it appears to be more a lobbying tool rather than an objective review of scientific studies.

Most importantly, the IAFF study contains no original data on staffing or other deployment issues. Accordingly, it provides no primary evidence to support any position, for or against, with regard to fire service staffing and deployment.

## **2.2 Ontario Fire Marshal's Fire Ground Staffing Project**

The Ontario project was undertaken to identify and quantify various factors that impact fire safety effectiveness. Seen as a holistic approach, the project included a fire ground effectiveness sub-model that was comprised of eleven factors, including fire ground staffing and response times. The project, begun in 1991, sought to first develop a theoretical construct and then validate the variables identified. As such, this document clearly stated that the findings reported in the 1993 report were preliminary. The report further stated that "final conclusions and recommendations on the issue of staffing, for the targeted fire, will follow a thorough validation process." [8] The project paper clearly identified the preliminary nature of both the recommendations and what additional actions were contemplated to validate the earlier theoretical constructs. Further actions were to include a detailed design document, data collection through field studies and data analysis. As such, similar to the IAFF report, the Ontario study offered no original data by which to judge its veracity. However, since the report indicated further validation was to have been done, a follow-up with the Ontario Fire Marshal's Office was undertaken. Unfortunately, since its release in 1993, no further work has been done on the fire ground effectiveness sub-model, including any work on staffing levels or response times. [9] As the project appears abandoned, or at least on hold since 1993, this document also fails to provide any original data related to issues of fire service deployment.

## **2.3 Phoenix Fire Department Evaluation System (FIREMAP)**

With its origins from a 1991 Urban Fire Forum project to evaluate the effectiveness of fire services, the Phoenix FIREMAP project was expected to achieve many of the goals stated by the Ontario Fire Marshal's Office. However the initial phases, as summarized in the 1992 FIREMAP report cited by the IAFC, falls short of providing any substantive data. The initial FIREMAP report stated as its goals the development and validation of a task analysis for a single-family structure fire. After defining appropriate tasks for units and personnel, the project was intended to design and build props that could simulate critical tasks. [10] The initial work did provide some original data, however of the three evolutions where any original data (task completion times) were reported, only the final evolution reported all the data associated with fire ground actions. The other two evolutions provided only limited data on certain aspects. Therefore, the usefulness of data from only a single evolution does not lend itself to any meaningful conclusions. However, the report did indicate an intent to finalize the task analysis components and then experiment with variations in staffing, response variables, etc. [11] Similar to the Ontario Fire Marshal's project, an attempt was made to determine if any further substantive progress was made beyond that found in the documents cited to support NFPA 1710.

A 1998 article updating the status of the FIREMAP project indicated future efforts of the project would seek to assess the impact that "varying response times, staffing, and other components" would have on service delivery. [12] The article also stated that a partnership with the Industrial Engineering Department at Oklahoma State University would provide an engineering perspective to the questions of staffing and response times. Unfortunately, similar to the Ontario study, the future intent of the FIREMAP project has not yet materialized. Expectations that Oklahoma State University's Industrial Engineering Department would conduct further research were premature. Recent inquiries indicate no funding exists, and therefore no additional work has been undertaken on FIREMAP. [13]

## 2.4 Dallas Fire Department Staffing Level Study

The Dallas study, completed in 1984, is likely the most comprehensive studies related to fire service staffing ever conducted. Its conclusions stated that a minimum of four firefighters should be assigned to each engine company and that a minimum of five firefighters were justified for ladder companies when assigned to handle an apartment building fire. Unlike studies discussed earlier, the Dallas Study employed the use of external consultants to design the study, supervise the collection of data and perform the analysis used as a basis for the study's conclusions. While fire department staff were closely involved, the study's authors sought to conduct a methodologically sound study. For example, precautions were taken to have the study evolutions performed by a representative cross-section of the department, thereby limiting bias.[14]

The Dallas study provided a significant amount of original data on the subject of company staffing levels. Utilizing three scenarios and one full-scale fire test, the study authors provided a strong accounting of the tasks conducted by each firefighter, included original data, and provided in the study's appendix their statistical analysis of the results. Accordingly, this study met three of the four criteria outlined earlier. The study does fall short by not providing any comparison between the Dallas Fire Department and comparable fire agencies. Accordingly, the ability to generalize the findings from this single report is limited.

Several interesting issues were identified when reviewing the original data from one of the evolutions, in particular the private residence evolution. The first issue involved the first due engine's critical task of a "straight lay 5-inch hose to provide a permanent water supply." [15] At a staffing level of three personnel, the average time for task completion was 62 seconds. For the four person evolution the average hydrant connection time and arrival at front of house was 48 seconds. Finally, for the five person staffing level the evolution only took an average of 38 seconds.[16] The report indicates that irrespective of the staffing level involved, this task would only require two individuals – the hydrant firefighter and the pump operator. Yet, somehow when there are more firefighters riding on the first engine, the task was performed more quickly. Management theorists have described unusual findings such as these before. Where no other obvious explanation exists for why two firefighters perform more quickly when more personnel are riding on the truck, one may wish to consider what Juran has called conscious errors. "This is a deliberate distortion of the sensed data, for a variety of (usually) self-serving human purposes: reduction of workload, avoidance of unpleasant tasks, self-aggrandizement, fear of being punished as the bearer of bad news." [17] Therefore, the finding in this study may be indicative of other factors not identified in the study impacting this critical task, or perhaps some type of bias in performance and/or data collection. Such bias would not be unprecedented.[18]

A second problem identified was in the analysis of data, specifically the statistical significance between various levels of staffing. As reported in Appendix G of the Dallas report, the statistical significance between staffing levels was, in many instances, not significant. Most research of this nature would require a statistical significance sufficient to provide a 95% confidence level. Yet, the data reported in the Dallas Study for the single-family evolutions only had three of 10 comparisons with sufficient statistical significance to support the conclusions. For example, the executive summary highlights that a three-person crew was unable to complete a search during the private residential evolution while the four person staffing level performed satisfactory. Yet, the data in Appendix F and Appendix G indicates that such differences were not statistically significant. The calculated significance was only at a 70% confidence level, well below that typically required.[19]

There was an additional methodological problem that should be considered when reviewing the Dallas study - a concern with the Hawthorne Effect. While the study authors took precautions to minimize selection bias in the fire companies chosen for conducting the various evolutions, there is no discussion within the report suggesting the purpose of the study was shielded from study participants. Discussion of this study in a series of articles published in Fire Command magazine suggests that department personnel were involved in the development of the study and in the direct data collection phase.[20] Therefore, it is reasonable to assume that participating firefighters knew the intended purpose of the study and the implications their relative performance would have on the final conclusions.

## **2.5 Summary of Research Used to Justify NFPA 1710**

The preceding review of four major studies used to justify NFPA 1710 reflects a paucity of rigorous information that could be used to support proponents assertions. Three of the four studies provided no original data that could be considered to meet any appropriate definition of scientific rigor. The one remaining study appeared to meet most of the criteria outlined. However, the Dallas Study is limited in its ability to be generalized, provided no discussion of the statistical significance in its data analysis and may have suffered from a Hawthorne Effect where fire personnel were influenced by the scope and nature of the study. Notwithstanding this critique, the Dallas Study would be well suited for replication in other jurisdictions where the concerns raised here could be addressed.

In summary, there is only one study that partially meets the scientific rigor needed to justify the staffing requirements called for in NFPA 1710. There is no data to support the response time requirements outlined in NFPA 1710. The other cited references do not support, one way or the other, the appropriateness of the standards contained in NFPA 1710.

## **3.0 Current Research Efforts**

The focus of this paper relates to the Big Questions of deployment in fire rescue services. As such, it is important to examine the efforts currently devoted to research in the field of fire fighting, and also that currently underway in the field of emergency medical services. Of course, any discussion of research must also consider the funding devoted to such efforts. Accordingly, these discussions of fire and EMS research will also consider the level of funding being provided today.

### **3.1 USFA's Fire Research Agenda**

The US Fire Administration is the nation's leading proponent of fire service research. While the task is distributed among multiple agencies, the glue for the underlying research structure is the US Fire Administration. This concept was outlined in a recent report submitted to Congress by the US Fire Administration on the National Fire Research Agenda.[21] The research agenda was developed through several methods, including workshops designed to define the needs of the fire service, needs identified by consensus standards-making committees and other "constituent research needs as those are made known to the USFA." [22]

Working in concert with the National Institute of Standards and Technology (NIST), the US Fire Administration held several workshops designed to gather input on the needs of the fire service and the research needs in the fire community. In October 1999, the USFA and NIST held two workshops. The first, held in San Antonio, sought to identify needs of the fire service. Areas addressed included fire fighting operations, health & safety, large fire incidents, fire mitigation and communications & information technology.[23] The second workshop, intended to specifically discuss fire research needs, was held in Emmitsburg, Maryland. In this second workshop, participants acknowledged the difficulty in applying current research to operational needs of fire departments. In particular, these workshops concluded that it was not possible to correlate response times to affects on loss of life and property, and also that response time requirements "are based on 'rules of thumb' for fire growth and not based on research.[24,25] Overall, workshop participants believed that the fire service does not have input into selecting fire research areas. They recommended that a mechanism needs to be developed that allows the selection, awarding, and tracking of fire related research.[26] Importantly, participants recognized that better research was needed to develop and support policy positions taken by the nation's fire service.

The USFA's Fire Research Agenda provides a glimpse into the types of research presently being supported from a national perspective. While most of the projects funded for 2000 and 2001 have some relevance for today's fire service, none are related to the recently debated questions on deployment.[27] This is reflected in the efforts of the Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology. Three of the four main research areas at the laboratory focus on the quality of building construction and their constituent materials. Only one research area, Fire Loss Reduction, provides a direct

effort to improve, among other items, firefighter effectiveness.[28] Again, none of BFRL's current research efforts explore issues related to fire service deployment.

It was interesting to note that the US Fire Administration Research Agenda is guided partially by the "needs identified by the committees of national consensus standards-making organizations." [29] This approach is particularly troubling when consensus organizations assert existing research is appropriate for the support of new standards such as NFPA 1710 when in fact, no such research exists.

Considering the significant costs associated with the provision of fire rescue services, current funding levels are extremely small. According to the USFA report, funding for fire research in 1999 was \$500,000 and expanded in FY2000 to \$2 million. For FY2001, this figure was expected to reach a total of \$3.1million and increased further yet to \$3.25 in FY2002. These increases, while significant, are still insufficient for the fire service's needs.

### **3.2 EMS Research Agenda**

In December of 2001, the National Highway Traffic Safety Administration published their National EMS Research Agenda.[30] This report cited several issues of concern on the current efforts in EMS research, including an insufficient number of researchers to explore EMS issues, not enough collaboration in conducting research and inadequate funding. However, while some of these same failures can be seen in the current fire research efforts, there are significant differences in the scope and quality of research between fire operations and pre-hospital emergency care.

The development of pre-hospital emergency care, and the creation of EMS systems in the United States, was rooted deeply in the efforts to reduce the adverse effects from out-of-hospital cardiac arrest. Therefore studies used to justify the creation of EMS systems, and those used to explore its efficacy today, have been nurtured by mainstream medicine and fostered by the stringent standards typically applied to scientific medical research. There is an ever growing collection of studies employing appropriate research methodologies being published in peer-reviewed journals. While this approach meets the highest standard we as society have developed for conducting scientific research - such a process is not being done for fire service research. The EMS Research Agenda report further concludes the federal support for EMS research is extremely poor. The report found that only 3.8% of studies on EMS received some support from the United States Public Health Service.

## **4.0 Future Directions for Fire Research**

Recognizing the current status of fire related research, considering the recommendations derived from the USFA workshops and drawing from the recommendations of the EMS Research Agenda, the following recommendations for improvement to the fire service's research needs can be summarized in the following components; funding, national research review board, peer-review forum and development of critical thinkers in the fire service. The following recommendations attempt to follow the logical progression in the creation and use of fire research.

### **4.1 Funding**

If we are unable to research the Big Questions in our field, than we are doomed to muddle through in our delivery of fire rescue services. There would be little need to create standards within the fire service if supporting evidence does not exist to support them. The lack of a rational basis for standards will simply make one arbitrary over another. To meet the goals to which most professions aspire, we must conduct basic research – and to do so will require appropriate funding.

What then would be an appropriate level of funding for research? Some guidance may be found in the National Highway Traffic Safety Administration's EMS Research Agenda. Their recommendations call for funding at a level equal to 1% of the annual expenditures for EMS – that translates to funding for EMS research at \$50 million per year, a level well above that being spent on fire related research. It could be

argued that a similar level in the fire service may also be reasonable. If one were to limit the analysis to only those costs associated with funding career fire departments, 1% research funding would represent \$200 million for fire research.[31] However, it is unlikely that support for that magnitude of increase over current funding levels could not be obtained. Another approach may be to allocate a percentage of Assistance to Fire Fighters Grant Program funds to research, thereby both assisting local fire agencies through new information and assisting in the identification of effective programs. A 10% allocation of grant funds to support research would increase the current research efforts by ten-fold and still provide over \$320 million to local fire departments. Regardless if a proper amount or not, almost any appropriate research funding goal must exceed the \$3 million being expended today.

With the recent success of the Assistance to Fire Fighters Grant Program, and the existing role the USFA takes in fire related research, it seems the funding and coordination of fire service research is best suited for placement under the existing federal structure. The United States Fire Administration should work with constituency groups to seek greatly increased levels of funding for fire related research. Regardless of the political or policy perspectives each group may express, all groups would benefit from an improved fire research effort, especially when the research would be related to operational questions.

## **4.2 National Fire Research Board**

A national fire research board should be created to provide a necessary level of coordination in fire related research. Originally proposed at the Fire Research Needs Workshop in 1999[32], this process would afford a sharper linkage between Big Questions in the field and those research projects we fund. Research is often funded based on the strength of the research institution or researcher. A proper model should allocate funding to answer specific questions and then seek proposals from those interested in working on such projects. Therefore, the board would need to articulate Big Questions for the fire service and then seek researchers interested in answering those questions. To first define Big Questions, the board would need representation from major constituency groups, but with an emphasis on individual members who could bring a relevant research perspective to the discussion. Membership should include public officials (non-fire service), chief fire officers, labor officials and existing researchers.

Current fire service research efforts are limited, and therefore so are current facilities conducting the research. Efforts should be made to seek, and fund, existing academic institutions with interest in a wide range of research areas, including the fire service, public administration, operations research, ergonomics and others. Efforts should also be made to tap into existing research capabilities of the National Fire Protection Association, National Institute of Standards and Technology and the National Highway Traffic Safety Administration. There is little doubt that if research funding is made available, there will be no problem in identifying existing research institutions to perform the work.

## **4.3 Peer-Review Forum**

Assuming the fire service can identify funding, define the questions and have the research conducted, what will we do with it? A major problem we have in the fire service is the lack of a well-structured process for wide dissemination of research, and then the subsequent debate on what the research means. Such a structure requires some type of peer-reviewed forum.

Previously there has been a proposal for the National Fire Academy to undertake the creation of a peer-reviewed journal for the fire service.[33] Since many obstacles exist in the creation of a new journal, it may be more advantageous that existing publications accommodate this need. For example, the NFPA has several journals that may be appropriate. Fire Technology is a quarterly publication of the NFPA that is peer-reviewed. While the publication is a cross-disciplinary journal seeking articles in a wide range of fields, the content often reflects a focus on more traditional engineering topics. Perhaps this is related to the failure of the fire service to conduct studies on operational issues that are appropriate for peer-review publications. The second publication is NFPA Journal. While not peer-reviewed, its readership is much higher and has greater acceptance within the fire service. A special section of the NFPA Journal could be dedicated to articles disseminating research findings and following the rigors of peer-reviewed research. Regardless of the

approach taken, a wide dissemination of research findings and a forum for continued debate on these research issues will greatly benefit both the posing and answering of Big Questions in the fire service.

Recent efforts of The Institution of Fire Engineers have provided one forum for discussion of important questions in the fire service. Yet, while deployment issues have been Big Questions for three decades, it was not until 1999 that the first fire service deployment conference took place. At many fire service conferences occurring each year, there is little opportunity to participate or attend programs related specifically to fire related research. This appears to be a missed opportunity for both researchers and chief fire officers.

#### **4.4 Critical Thinking**

The final component needed to complete the process is the application of relevant and valid fire related research. All the prior steps are useless if we do not have fire researchers, and especially fire officers, who are critical thinkers. Too often chief officers have had to confront issues raised by their personnel based on articles in trade publications written by experienced firefighters and fire officers. These articles typically do not represent research, but rather insights based on anecdotal experiences or organizational case studies. While these may be useful in moderation, our entire body of knowledge should not be based solely on this approach. The posture taken by fire personnel in many organizations seems to be if it was published in a trade magazine, it must be right. We have failed as chief officers if our personnel are unable to appropriately question the information they receive. Perhaps our paramilitary structure and insistence that firefighters should never question what they are told on the fire ground has been transplanted into the firehouse where they never question what is read in a magazine or book. A critical mind is important to identifying weaknesses in our operations and finding improvements in what we provide.

If we desire to overcome the natural resistance to critical thinking, we need to provide the tools. Education is the key. The Fire and Emergency Service Higher Education Conference in June 2001 outlined components for the development of a fire related bachelor's degree.[34] This included recommendations for development of critical thinking skills and particularly courses in research design and statistical techniques. These findings compliment research examining undergraduate programs in the fire service. A study of fire service educational programs found, among other items, that lack of funding for research, lack of incentives for firefighters to earn advanced degrees and the failure to identify quality instructors all hindered the academic potential of fire service educational programs.[35]

The use of formal education, while important, is not the only manner in which we can develop critical thinking skills. Fire Service conferences should provide educational tracks designed to assist chief fire officers in the development of critical thinking skills. These efforts would not only help in digesting fire related research, but also in a multitude of other areas, including budgeting, public administration and human resources.

#### **5.0 Conclusion**

There are several conclusions that can be drawn from the foregoing discussion. Of secondary importance is that there is no data, one way or the other, to support any position on precise staffing or response time requirements as outlined in NFPA 1710. There is simply no good research to provide the necessary support. This is not a criticism of NFPA 1710 as much as it is a criticism of the fire service. The primary conclusion that should be drawn from this paper is that we have failed to provide a mechanism to answer the Big Questions in our field. In the vacuum that remains, pseudo-science has been inserted to justify recently adopted standards.

The author generally agrees that more firefighters are better, and that more rapid response to emergency incidents results in generally better outcomes. Yet, the creation of a definitive benchmark on a single variable (i.e. 3 vs. 4 firefighter on an engine or 3:59 response time vs. 4:01 response time) to measure performance may be an elusive dream. Firefighters and fire officers understand that there are a large number of variables that impact our effectiveness in fighting fires. Yet, the impact that certain variables have over others, and the

interplay between these variables, are still poorly understood. Without sufficient research, we are unable to identify where we can make the biggest impact in the future.

It has been argued here that a Big Question facing the fire service relates to staffing and response time issues. Considering the potential impact these two issues alone may have for the average taxpayer, it is almost incomprehensible that no relevant research efforts are being made in this area. Close examination should indicate that a national effort to 1) define the Big Questions, 2) secure funding to conduct research on these questions and 3) provide a forum for discussion must precede our attempts to answer the Big Questions before us.

The recommendations from this paper will likely generate debate on the future of fire research. In that debate, some may argue that our Big Questions may not lend themselves to being answered. That is a position the author himself believes may be true. Yet, we will never know if the Big Questions on deployment can be answered unless we attempt to properly research these important issues. As of yet, we have not attempted to do so.

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- 23 United States. Department of Commerce. National Institute of standards and Technology. (1999). Fire Service Needs Workshop Proceedings. NISTIR 6538.
- 24 United States. Department of Commerce. National Institute of standards and Technology. (1999). Fire Research Needs Workshop Proceedings. NISTIR 6539. (page 10.)
- 25 United States. Department of Commerce. National Institute of standards and Technology. (1999). Fire Service Needs Workshop Proceedings. NISTIR 6538. (p. 14)
- 26 Surprisingly, there were no participants from either the IAFF or IAFC in this workshop. See United States. Department of Commerce. National Institute of standards and Technology. (1999). Fire Research Needs Workshop Proceedings. NISTIR 6539.
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Bruce Moeller, Ph.D., MIFireE, has been a career fire chief since 1992 and is currently serving in Sunrise, Florida. The department provides a full range of fire, EMS and specialized services to its 86,000 residents and the 25 million visitors who come to the City each year. Moeller began his fire service career as a firefighter and paramedic in the Chicago area before moving to South Florida where he was Fire Chief/Director for Broward County Fire-Rescue serving almost 750,000 residents.

In addition to his fire service career, Moeller's formal education includes a MPA from Northern Illinois University and a Ph.D. in Public Administration from Florida Atlantic University. Dr. Moeller has taught graduate courses in organizational behavior and management for St. Thomas University in Miami and currently is an adjunct professor teaching labor relations at Florida Atlantic University. His research interests include performance measurement and organizational behavior.