# 6 Primary Findings

## 6.1 Fire Versus EMS Response

The most fundamental comparison made was between fire responses and EMS responses. We looked at

- *Alarm handling time*, a function of emergency dispatchers in the PSAP/Communication Center addressed by the NFPA 1221 standard.
- *Turnout time*, a function of fire and EMS crews within the ERF addressed by the NFPA 1710 standard.
- We bridged the two and looked at *mobilization time* overall to assess just how quickly the fire service, represented by our participant sample, actually "puts the rubber to the road" when the call for emergency aid is received.
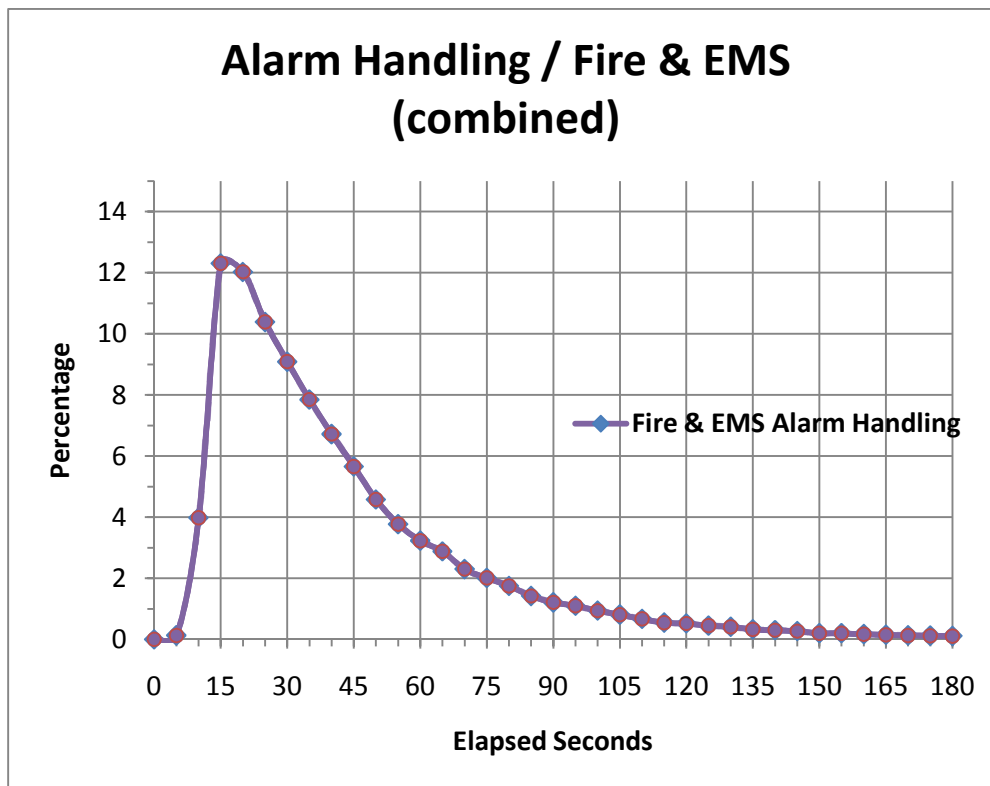
**Alarm Handling Time**



**Figure 3. Alarm Handling / Fire & EMS (combined)**

*Benchmarks and Criteria*

*Both NFPA 1221 and NFPA 1710 use similar metrics to establish Call Processing Times and Turnout Times. The first part of the metric is the benchmark: a specified length of elapsed time. The second is the criteria: the percentage of responses within a sampling period that must occur at or below the benchmark time to achieve compliance with the standard.*

*For instance, part of the standard for Call Processing requires that 90% of all responses (criterion) must be processed within 60 seconds (benchmark). Compliance with the standard can be measured in two ways:*

1. *Benchmark Compliance: What actual percentage of responses occurred at or below the benchmark time?*
2. *Criteria Compliance: How many seconds were actually required before the required percentge of responses occurred?*

*Tables throughout this document show the relevant NFPA benchmarks and criteria compared with the corresponding compliances recorded in the data.*

*Example: Widget Production Table*



As stated previously, *alarm handling time* represents the elapsed time from the time a call for assistance is received at a PSAP, or "Alarm Time" (i.e., *Call intake;* when a 9-1-1 phone call is answered, when an automatic alarm is acknowledged, etc.), until appropriate ERUs are dispatched, or "Dispatch Time."

The findings of this study have been compared to the current NFPA 1221 standard, which sets two benchmark times with specific compliance criteria for Alarm handling:

- 90% of all emergency calls must be processed within 60 seconds or less.
- 99% of all emergency calls must be processed within 90 seconds or less.

The standard makes no *alarm handling time* distinction between fire and EMS, but there are potentially significant differences in the nature of information, the amount of information, and the level of detail needed to accurately process Fire and EMS calls to warrant separate analyses. It could be argued that

EMS responses, although they account for 84% of all emergency responses in this study, are more likely to be triaged into less emergent response priority categories than fire responses, which have traditionally been categorized as emergencies. EMS has widely embraced call triage through standard *emergency medical dispatch* (EMD) protocols since the mid-1990s, which could result in reduced processing times through formalization of the EMS call-taking process.
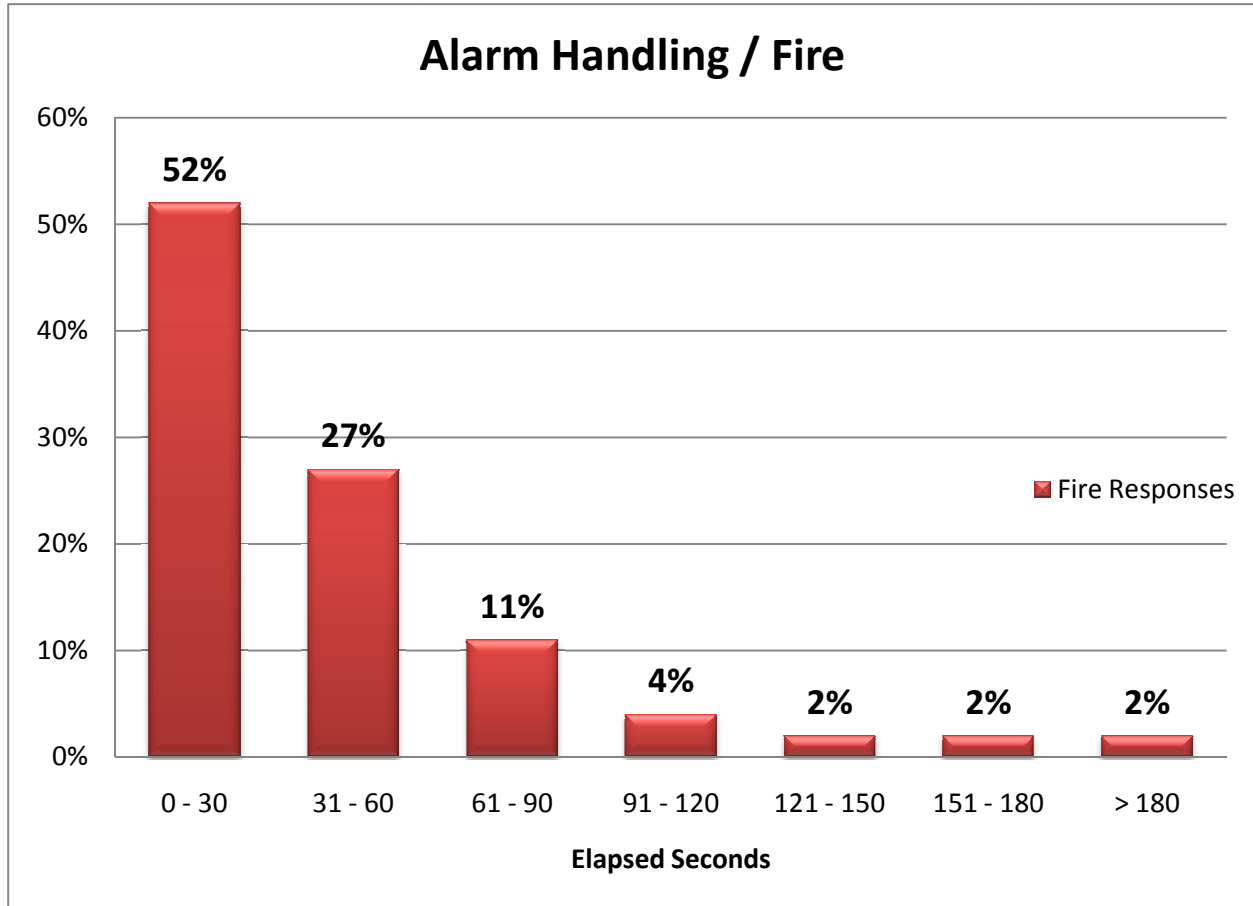
*Fire*



**Figure 4. Percent of Fire Alarms Handled over Time**

In the initial analysis, we examined 22,564 fire response records and noted that 79% of all alarm handling for those observed responses was accomplished in 60 seconds or less with half of them accomplished in 29 seconds (median) or less (Table 2). This performance is well below the criterion set by NFPA 1221 for the 60 second benchmark. The mean average of 56 seconds is very close to the NFPA benchmark. Only 90% of the responses were processed in 90 seconds or less, the second NFPA 1221 benchmark, as opposed to the 99% in 90 seconds or less required by that standard.

| Fire Calls n = 22,564 | NFPA 1221 Benchmark Criteria | Observed Compliance | Median Mean Max |
|---|---|---|---|
| **Alarm Handling** | 60 seconds 90 % | 79% 92 seconds | 29 56 |
| | 90 seconds 99% | 90% 315 seconds | 3946 |

Table 2. Alarm Handling Time / Fire[14]

Regarding the time required to reach the criteria level required by the standard, it took 92 seconds to process 90% of all fire response calls and 315 seconds – over 5 minutes – to process 99% of all fire calls.

The maximum processing time for fire response was a matter of concern at well over an hour – clearly well beyond a typically acceptable processing time for an emergency call but nonetheless not inconceivable in a group of over 22,000 responses. The last 1% of all responses analyzed ranged from over 315 to 3,946 seconds to process; 99% of the responses required only 8% of the observed range of values. It is likely that the processing times recorded in this extreme upper range represent grossly atypical responses, documentation errors, routine calls erroneously categorized as emergent, or some other form of data artifact. Several methods for filtering out these extreme outliers were considered but rejected as moot, since it was determined that they had very little statistical impact on the overall analysis. (see Appendix, Raw Versus Filtered Data)

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[14] The confusing appearance of 90% at both 90 and 92 seconds is an artifact of rounding. At 90 seconds, 89.72% of all calls have been processed. It takes 92 seconds to reach 90.15% of all calls processed.
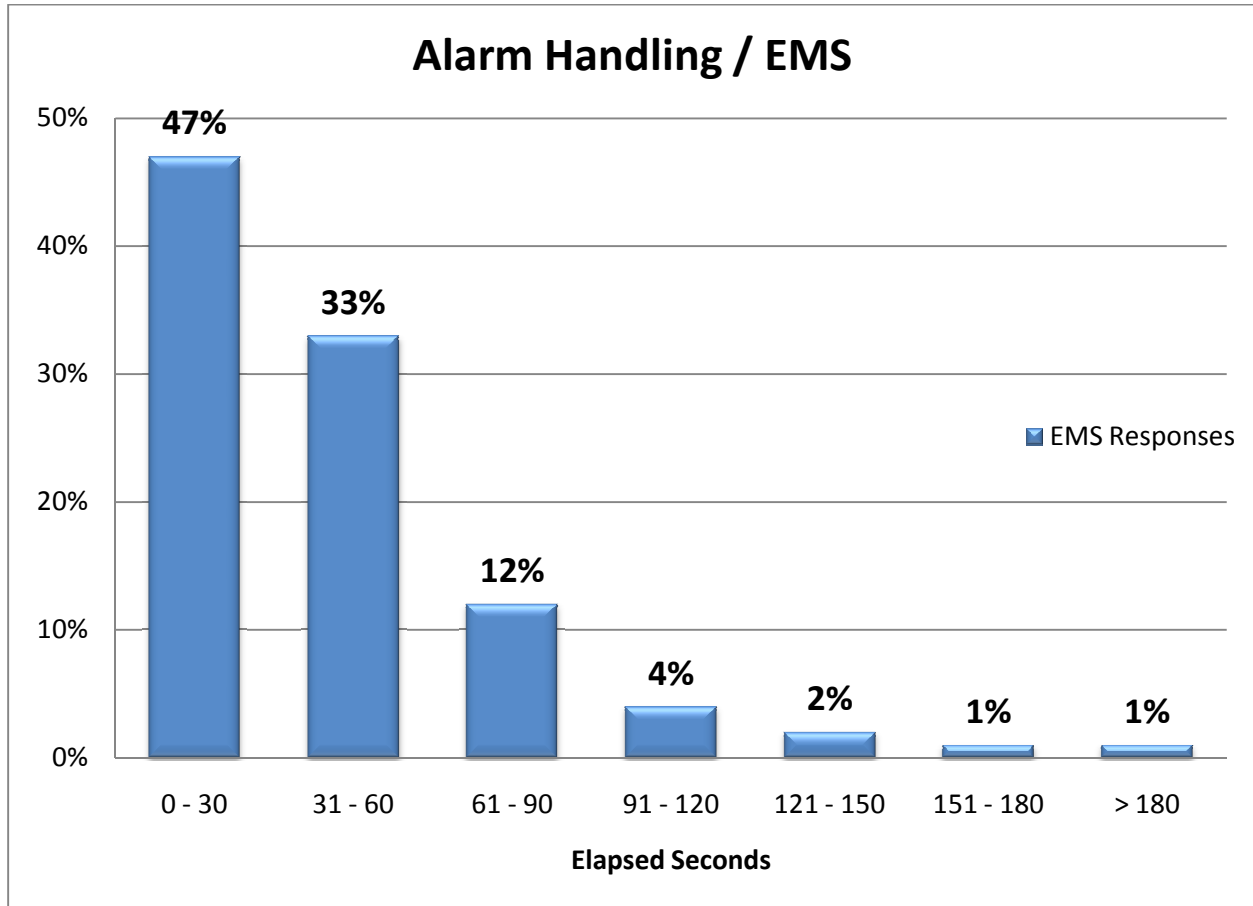
*EMS*

**Alarm Handling / EMS**



**Figure 5. Percent of EMS Alarms Handled over Time**

Looking once more at the time that was actually needed to achieve the criteria required by the standard, it can be noted that it took 84 seconds to process 90% of all EMS response calls and 182 seconds – about 3 minutes – to process 99% of all EMS calls.

| EMS Calls n = 115,206 | NFPA 1221 Benchmark Criteria | Observed Compliance | Median Mean Max |
|---|---|---|---|
| **Alarm Handling** | 60 seconds 90 % | 80% 84 seconds | 32 44 3565 |
| | 90 seconds 99% | 92% 182 seconds | |

**Table 3. Alarm Handling Time / EMS**

The maximum processing time for an EMS response was slightly less than an hour. The time to process the last 1% of the responses analyzed ranged between 182 and 3,565 seconds (59.4 minutes) to process: That 1% of the responses accounted for 95% of the observed range of values. It is likely that many of these *alarm handling times* represent the same type of artifacts presumed to be present in the fire response data and they were again found to have very little statistical impact on the overall analysis. (see Appendix, Raw Versus Filtered Data)

### Discussion Points

In the initial *alarm handling time* analysis, the fire and EMS responses were similar overall with respect to the current NFPA benchmarks. At the 60-second benchmark, about 80% of all observed responses were processed, and nearly 90% of all observed responses were processed at the 90-second benchmark. Alarm handling for fire responses does show a more skewed distribution of calls requiring more time to process than did the EMS responses. This distribution suggests that there may be a small qualitative difference between processing fire and EMS responses.
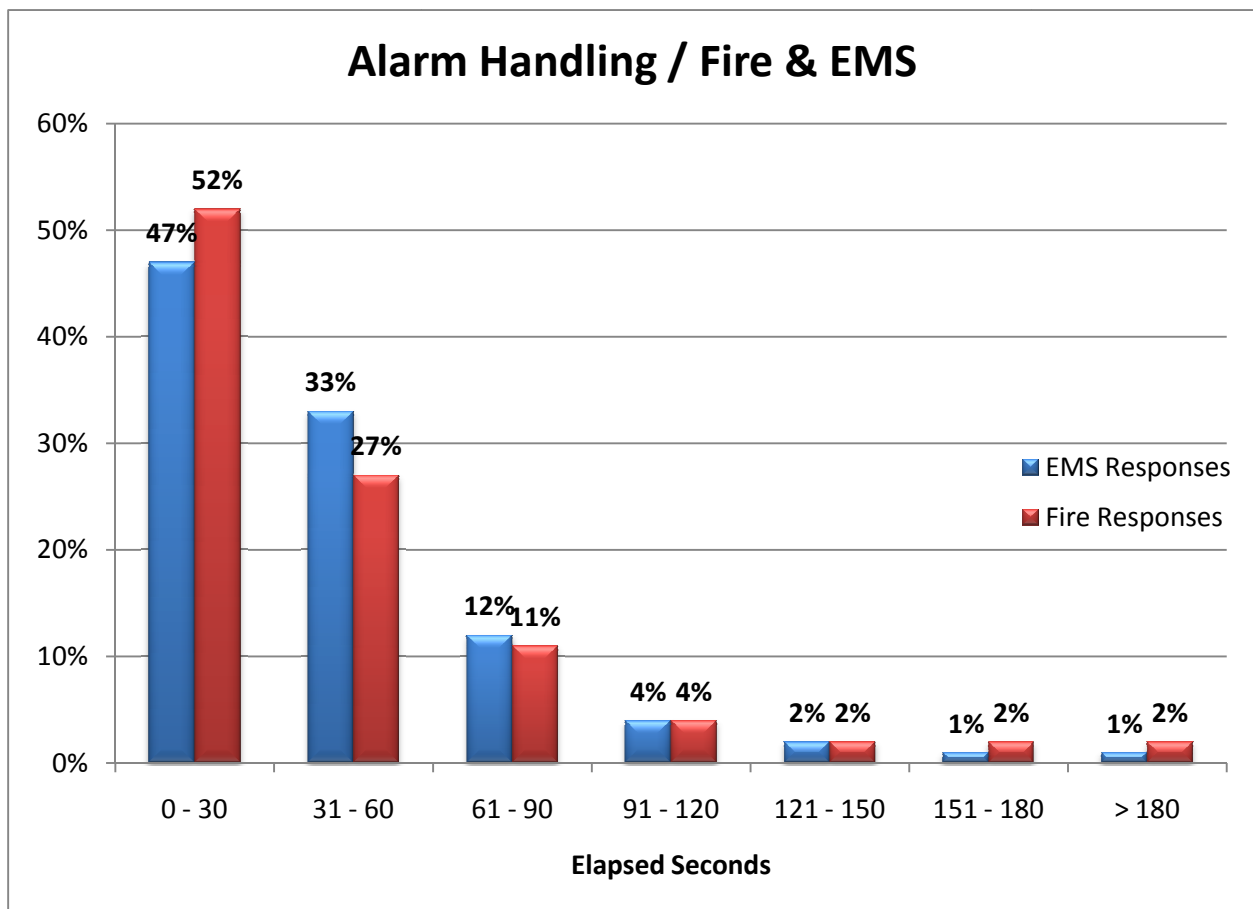


**Figure 6. Comparative Percent of Fire & EMS Calls Handled over Time**

## The Cumulative Distribution Function (CDF)

*CDFs in this document illustrate graphically the distribution of response data for alarm handling, turnout, and mobilization times.  Starting at the lower left corner at 0% and 0 seconds, a plot line representing the cumulative percentage of observed responses completed, shown on the vertical axis, is plotted against time elapsed to complete that percentage of responses, shown on the horizontal axis.   The line rises quickly through the median average, 50% of observed responses, and eventually passes through the various benchmark criteria that may be noted on the graph.  The line "flattens out" quickly after the majority of responses have been completed and trails off in a long "tail" to the right as the last outliers are completed.*

### CDF Plot of a Normal Distribution
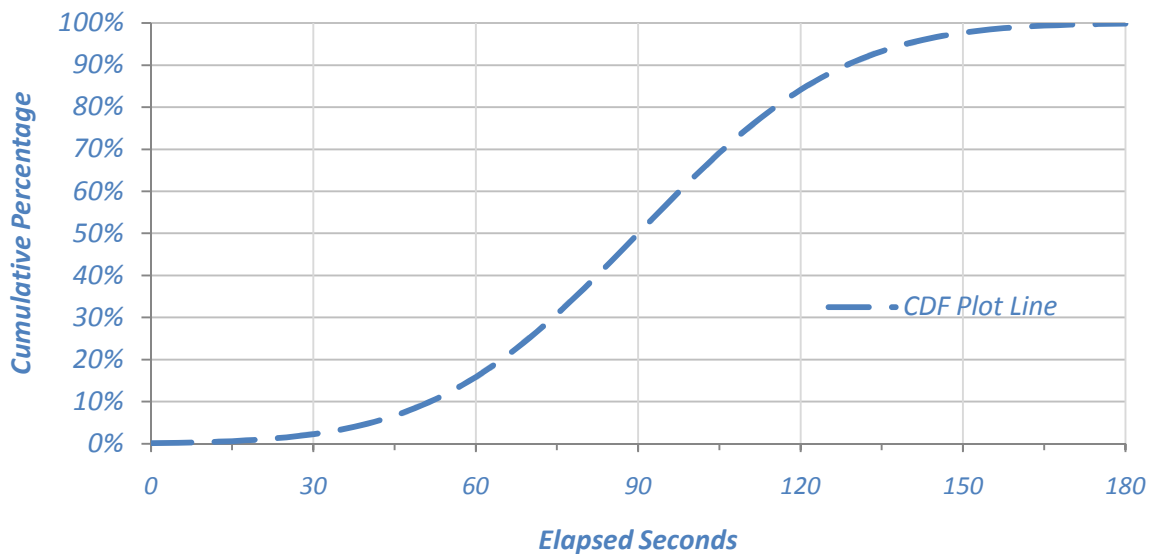


*Using the above CDF plot of a normal distribution with a median value of 90 seconds, for example, the percentage of trials completed in 120 seconds or less can be determined.  Starting at 120 seconds on the elapsed time x-axis, a vertical line would be drawn upward until it intersects the CDF plot.  From there, a horizontal line is drawn to the left.  The value at the point where that line intersects the cumulative percentage y-axis shows the percentage of trials completed in 120 seconds or less.  In our example, for an elapsed time of 120 seconds, about 85% of the trials are completed in 120 seconds or less.*

*Conversely, to answer the question of how long it would take to complete a certain percentage of calls, a similar process is followed in reverse.  For example, in order to determine the time it would take to complete 90% of all trials, one would start of the y-axis at the 90% mark.  A horizontal line would be drawn from this point to the right until the line intersects with the CDF plot.  From this point of intersection, a vertical line is drawn down to the x-axis.  The elapsed time read off the x-axis at this point is the answer.  For our example, to process 90% of the calls, requires a call processing time of about 130 seconds.*

The previous edition of NFPA 1221 required a more stringent 95% compliance time at the 60 second benchmark. With an 81% observed compliance rate at 60 seconds, 95% compliance would not be reached until ~106 seconds (Figure 7). From the graph it can be seen that the cumulative distribution function crosses the 90% mark very near to its upper inflection point. This is the point where the function begins to flatten faster than it rises. This point is arguably a more significant feature of the distribution to observe in terms of benchmark compliance than the 95% mark.

Combining both fire and EMS alarm handling times into a single cumulative distribution function graph illustrates the sharp difference between the previous 95% compliance criterion and present 90% criterion. By the time the function achieves 90% at around 83 seconds, it has reached its inflection point and is beginning to flatten more quickly than it rises. Beyond the 95% mark the graph is flattening very quickly, which explains the lengthy time to compliance at the 99% criterion.
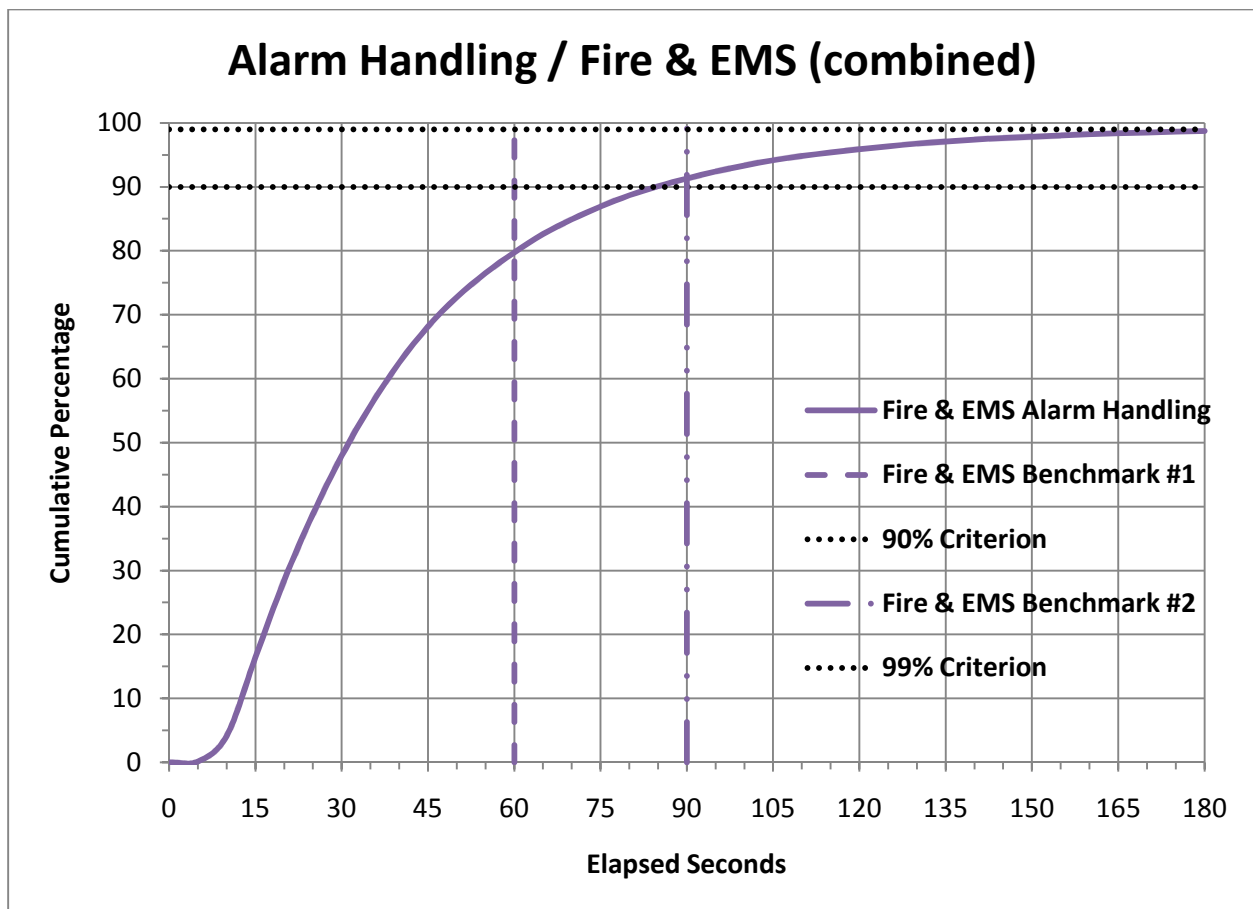


**Figure 7. CDF Fire & EMS (combined) Alarm Handling Time**
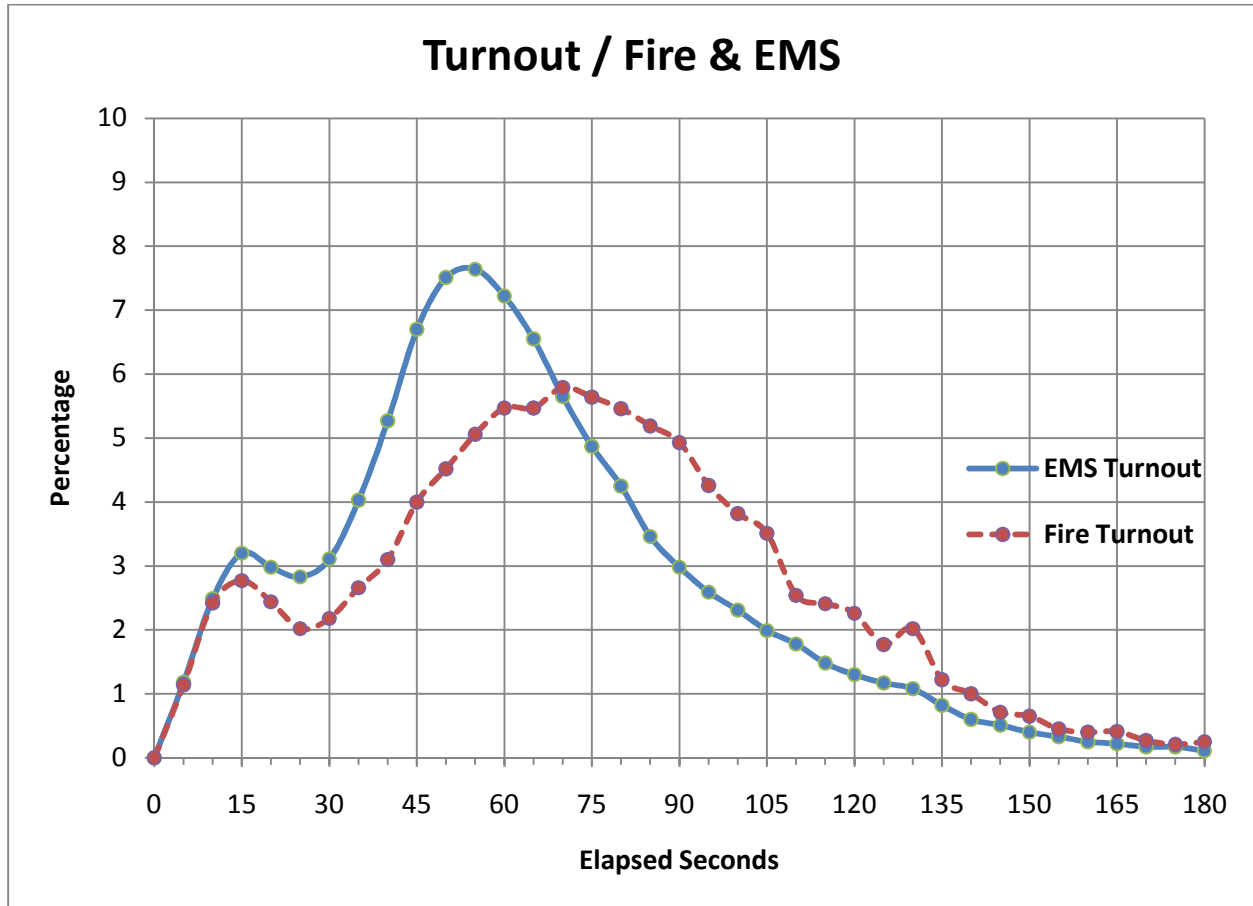
## Turnout Time



**Figure 8. Turnout / Fire & EMS**

Turnout Time represents the elapsed time from the moment a call is dispatched, or "Dispatch Time" (i.e., when the call processer/dispatcher initiates an alert message to the assigned ERU.), until the assigned ERU(s) is physically en route, or "En route Time." The current NFPA 1710 standard sets separate benchmark times for fire and EMS responses with the same compliance criteria for Turnout:

- 90% of all emergency responses to fire calls must turnout within 80 seconds or less.
- 90% of all emergency responses to EMS calls must turnout within 60 seconds or less.

Alarm handling is primarily a data-gathering operation, while turnout can be characterized primarily as a set of physical tasks. The typical tasks common to all turnouts from the ERF can reasonably be summarized as:

- Notification of the alarm
- Gathering critical response information
- Disengagement from tasks in process

- Travel within the ERF to the ERU
- Donning PPE
- Mounting the ERU and securing seatbelts
- Opening ERF bay doors
- Starting the ERU
- Signaling "en route"

For turnouts that originate outside of the ERF, when an ERU is already "on the air," the task list is considerably shorter:

- Notification of the alarm
- Gathering critical response information
- Signaling "en route"

The data contains turnout times for responses both from the ERU and "on the air" starts. The small peak in the response distributions shared by fire and EMS, about 15 seconds, is presumed to be representative of "on the air responses," while the much larger peaks represent normal responses from the ERU.

The NFPA 1710 standard makes a significant distinction between fire and EMS turnout time based on the slightly different tasks required as part of the turnout process. A response to a typical fire emergency requires donning structural firefighting PPE prior to mounting the ERU, whereas a response to a typical EMS call does not necessitate such extensive PPE[15]. Benchmarks for fire responses must accommodate additional turnout time to ensure that firefighters can safely don PPE before mounting the ERU. This permits seatbelts to be worn while en route in the interest of firefighter safety.

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[15]"…This is believed to be due to the fact that dressing in structural firefighting protective clothing prior to boarding the fire apparatus takes more time…. Because fire fighters do not need to dress in structural firefighting protective clothing for EMS responses, the extra 20 seconds of turnout time was not felt to be necessary for these responses." (NFPA 1710 ROC 2009, 1710-5)
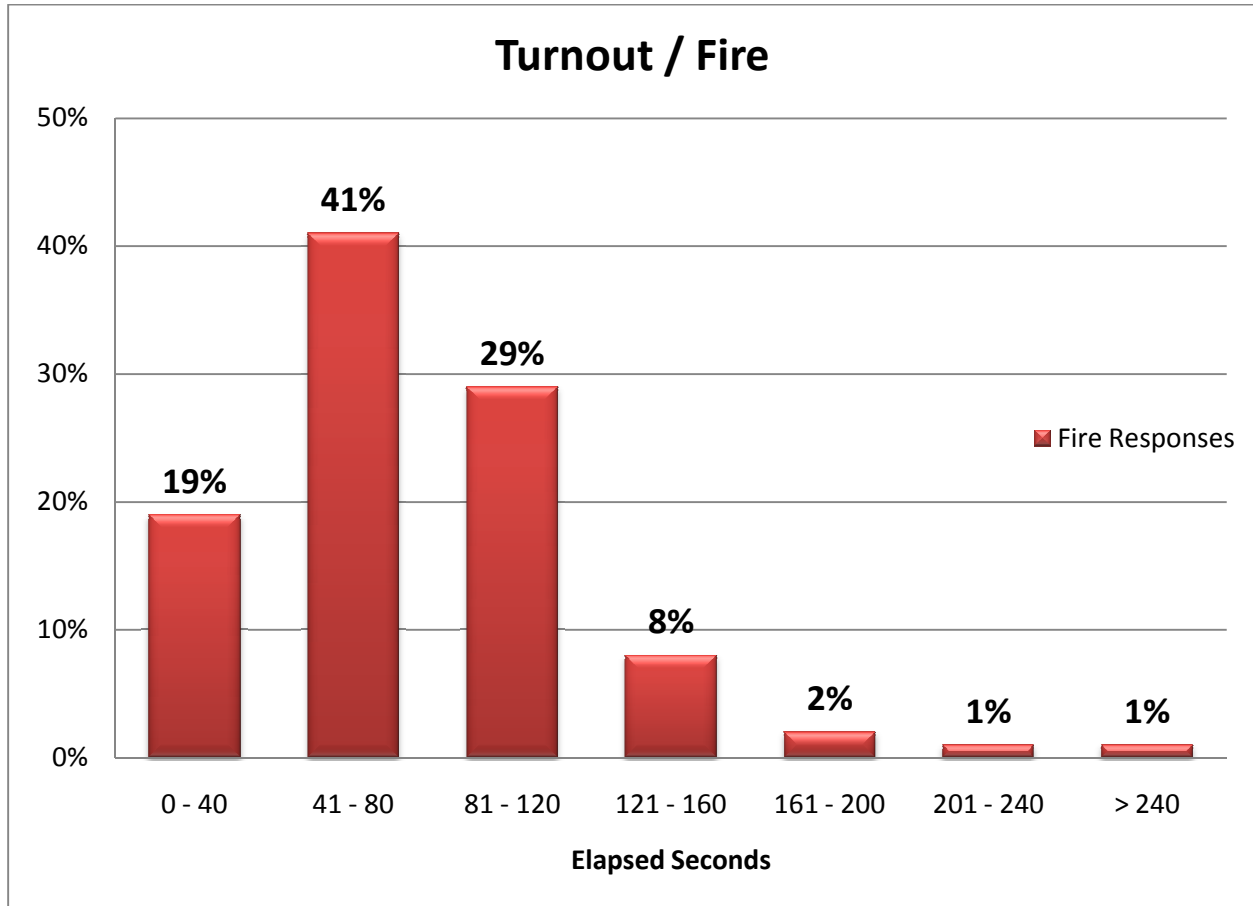
*Fire*



**Turnout / Fire**

Figure 9. Percent of Fire Turnouts Completed over Time

Analyzing a set of 22,564 fire response records (Figure 12), we noted that only 60% of all recorded turnouts were accomplished in 80 seconds or less with half of them accomplished in 71 seconds (median) or less. This result is a well below the performance criterion set by NFPA 1710 for fire responses. The mean average of 75 seconds is very close to the NFPA benchmark.

| Fire Calls n = 22,564 | NFPA 1710 Benchmark Criteria | Observed Compliance | Median Mean Max |
|---|---|---|---|
| **Turnout** | 80 seconds 90 % | 60% 123 seconds | 71 75 2629 |

Table 4. Turnout Time / Fire

*Fire*

Looking at the time actually needed to reach the criteria required by the standard, it can be noted that it took 123 seconds to reach the 90% criterion for reported fire call responses – over one and one-half times the time allotted by the standard benchmark.

The maximum reported turnout time for fire response ranged up to 45 minutes. The extreme outliers within this range presumably contain some mixture of atypical actual turnout times and documentation artifacts. As with alarm handling, it was determined that the extreme outliers, representing 1% of the data and 95% of the range of reported values, had very little statistical impact on the overall analysis.

*EMS*
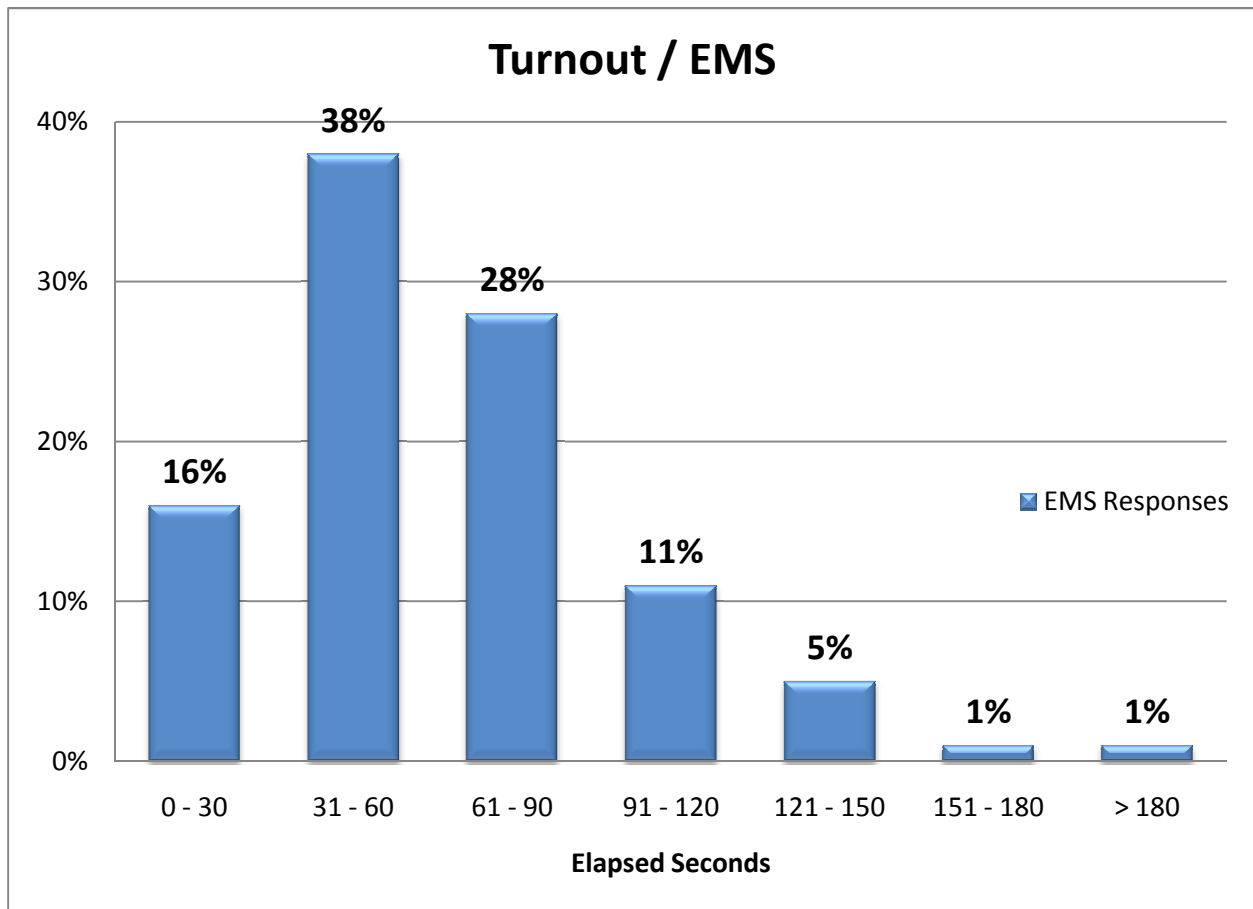


**Figure 10. Percent of EMS Turnouts Completed**

Analysis of 115,206 EMS response records, summarized in Table 5, shows only 54% of all recorded turnouts were accomplished in the more stringent 60 seconds or less required for EMS with half of them accomplished in 58 seconds (median) or less. This is below the performance criterion set by NFPA 1710 for EMS call responses. Once again, the weighted average of 63 seconds (mean) is very close to the NFPA benchmark.

Looking at the time required to reach the compliance criteria set by the standard, it is noted that it took 109 seconds to account for 90% of turnouts to EMS call responses – over one and two-thirds times the time allotted by the standard benchmark.

| EMS Calls n = 115,206 | NFPA 1710 Benchmark Criteria | Observed Compliance | Median Mean Max |
|---|---|---|---|
| **Turnout** | 60 seconds 90 % | 54% 109 seconds | 58 63 3112 |

**Table 5. Turnout Time / EMS**

The maximum reported turnout time for EMS response was nearly 52 minutes.  As was observed with fire call response turnout, it was determined that the outliers, representing 1% of the data and 96% of the range of reported values, had very little statistical impact on the overall analysis.

### *Discussion Points*

In the overall *turnout time* analysis, we found the recorded fire and EMS responses were generally consistent with the benchmarks set for each in the NFPA 1710 standard.  The recorded fire response turnouts required, on average, 12 seconds longer than EMS response turnouts with 54-60% of all recorded responses recording turnout times at or below the appropriate standard benchmark.  Turnout times for both fire and EMS responses required 43-49 seconds beyond the standard benchmarks to reach the 90% criterion.  This result suggests that the standard may be underestimating the time it takes to complete the baseline turnout tasks common to both fire and EMS responses in establishing the benchmark. Section 6.3 Firefighter Crew Proficiency in Baseline Turnout Exercise, examines the ideal baseline time-to-task measurement for fire call responses.

The previous edition of NFPA 1710 did not set a separate benchmark for fire and EMS responses.  In that version, all responses shared a common 60-second benchmark.  Less than 40% of the recorded fire call responses showed turnout times of 60 seconds or less (Figure 12. CDF Fire & EMS Turnout Time).   From the graph it can be seen that the cumulative distribution function crosses the 60 second mark early in its rise.  This is well below its upper inflection point.  An arguably more significant point to observe in terms of fire response turnout benchmark compliance may be the apparent inflection point around 120 seconds, which corresponds closely with the 90% mark.

Likewise, in terms of EMS response turnout, benchmark compliance suggested in Figure 12 may be at the apparent inflection point at 110 seconds, corresponding closely with the 90% mark.
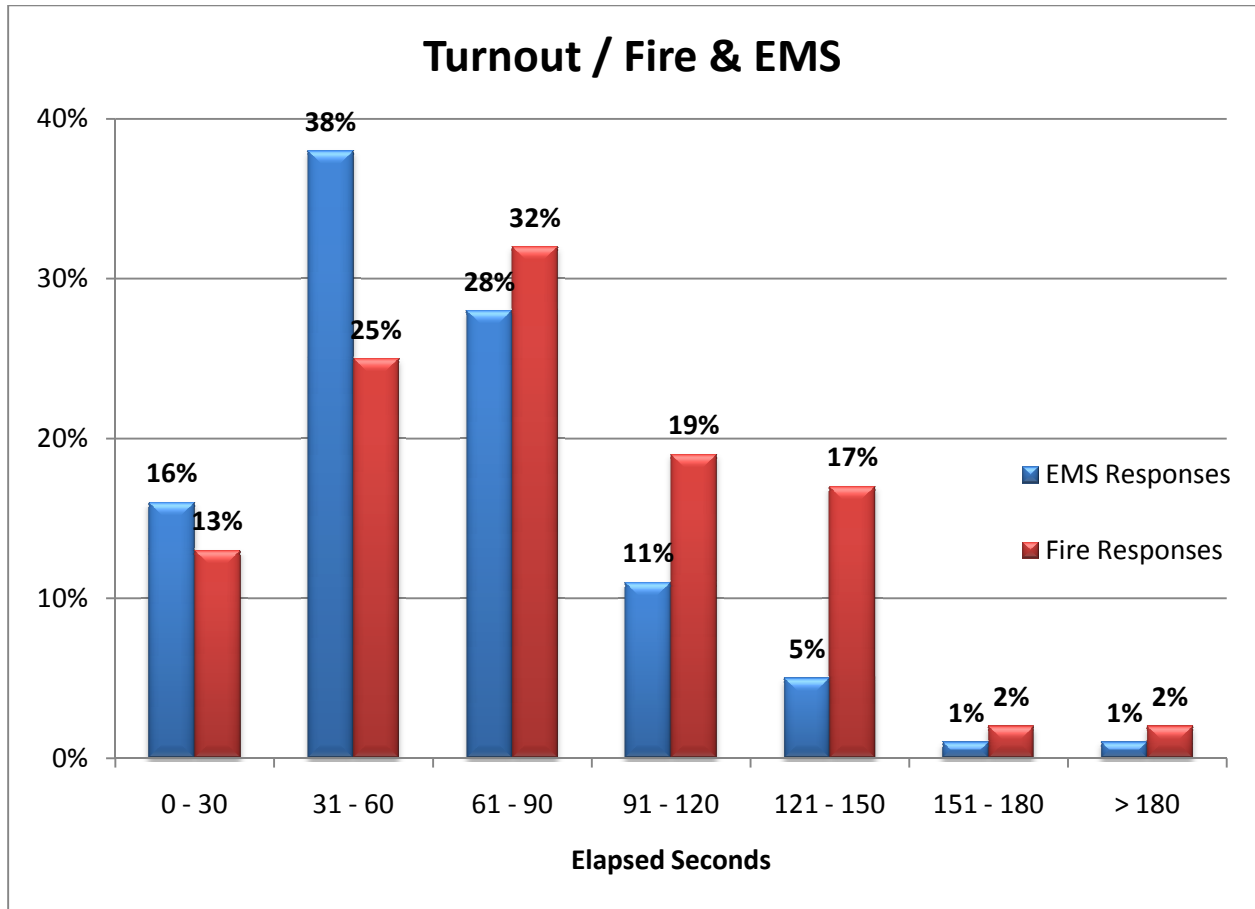
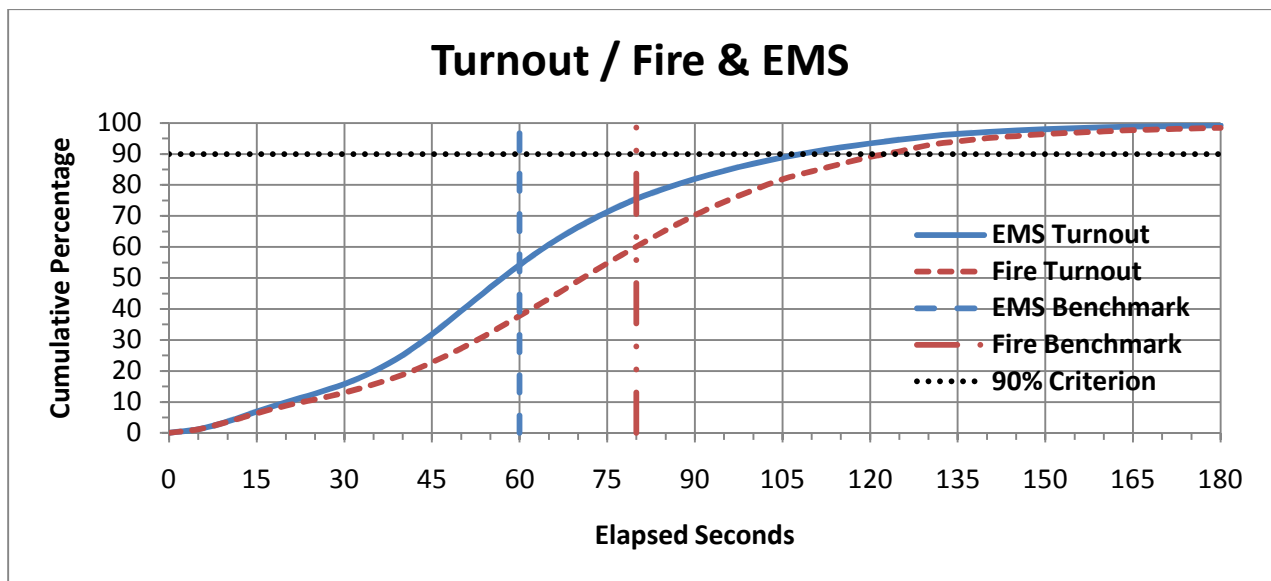**Figure 11. Comparative Percent of Fire & EMS Turnout Completed over Time**

**Figure 12. CDF Fire & EMS Turnout Time**
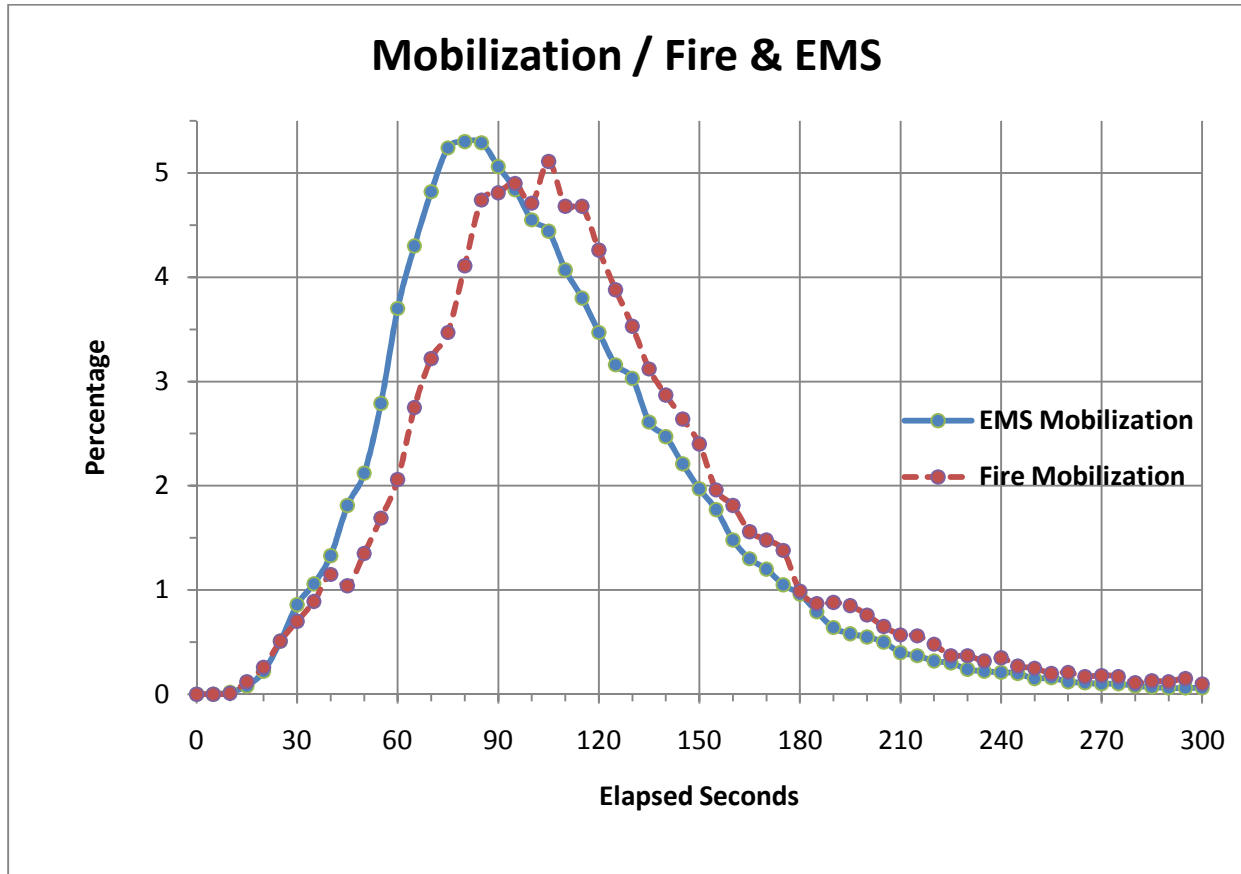
**Mobilization Time**



**Figure 13. Mobilization / Fire & EMS**

*Mobilization time* brings together the complete process of receiving the call for aid at "Alarm Time;" determining and assigning appropriate ERUs at "Dispatch Time;"and getting those ERUs on the road to the scene of the emergency at "En route Time."  Combining performance criteria in NFPA 1221 and NFPA 1710 standards yields implicit fire and EMS benchmark times with a common performance criterion:

- 81% of all emergency responses to fire calls must turnout within 140 seconds or less.
- 81% of all emergency responses to EMS calls must turnout within 120 seconds or less.

As we have seen, the compliance rates for *alarm handling time* and *turnout time* were not observed in practice to be as high as their respective standards required.  However, the combined rates have the advantage of a lower standard that is implied by the statistical combination of the performance criteria in the NFPA 1221 and NFPA 1710 standards.
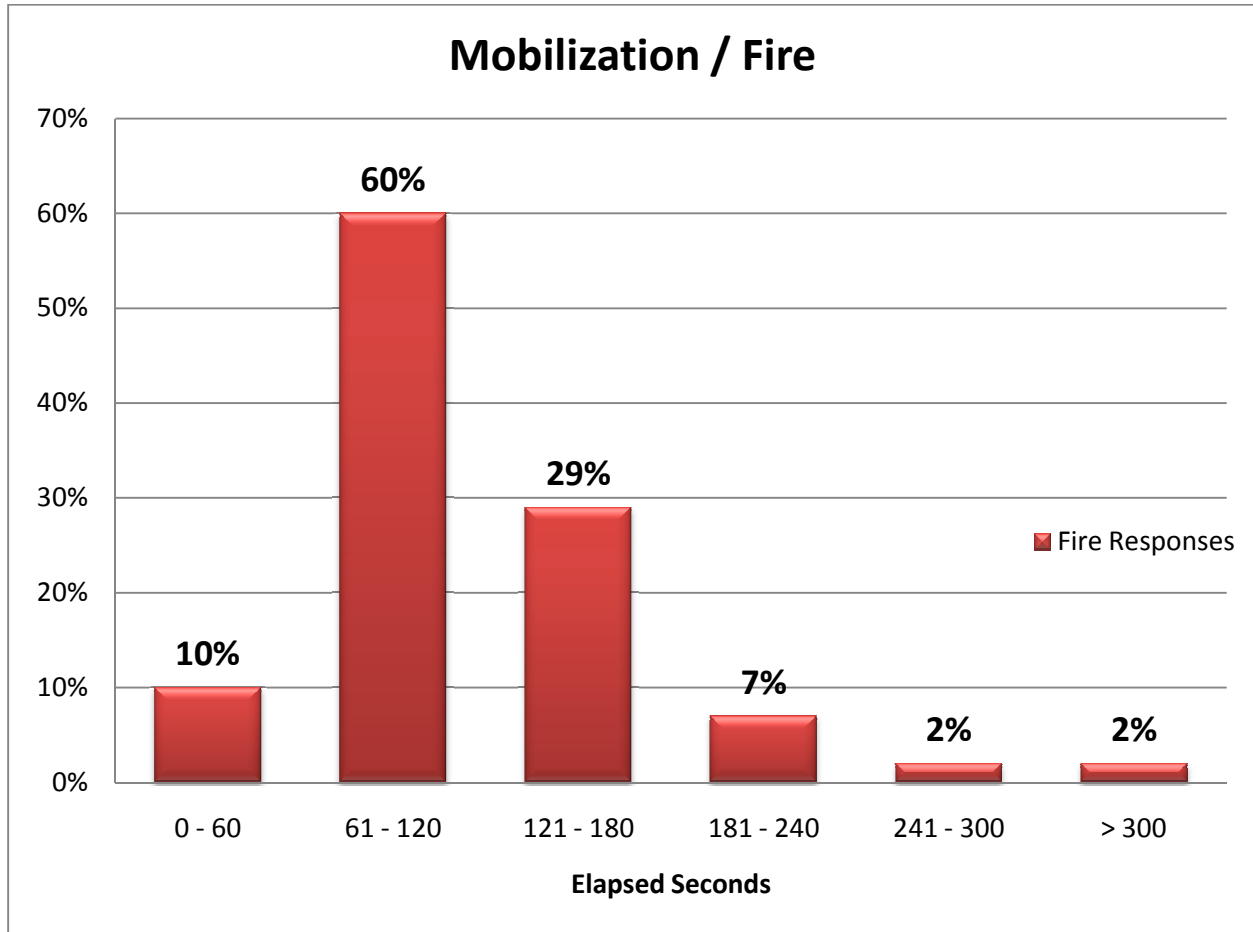
*Fire*

## Mobilization / Fire



**Figure 14. Percent of Fire Mobilizations Completed over Time**

More than 22,500 records for recorded *mobilization times* for fire responses (Table 6) show a benchmark compliance rate of 75%. Half of the recorded mobilizations turnouts (median) were completed in 108 seconds or less. This is only 6% below the implied mobilization for fire call responses. The weighted average of 130 seconds (mean) is only 10 seconds below the implied benchmark.

| Fire Calls n = 22,564 | Implicit Benchmark Criteria | Observed Compliance | Median Mean Max |
|---|---|---|---|
| **Mobilization** | 140 seconds 81 % | 75% 154 seconds | 108 130 5966 |

**Table 6. Mobilization Time / Fire**

Looking at how much time was actually needed to reach the performance criterion required by the standard, it is noted that it took 154 seconds to reach the 81% criterion for reported fire call responses – only 14 seconds longer than the time allotted by the implied benchmark.

The maximum reported mobilization time for fire response was over one and one-half hours. This is likely the result of extreme outliers in both *alarm handling times* and *turnout times.* Although the effects of these extreme outliers continue to show themselves in the uppermost cumulative percentages, they remain statistically insignificant overall.
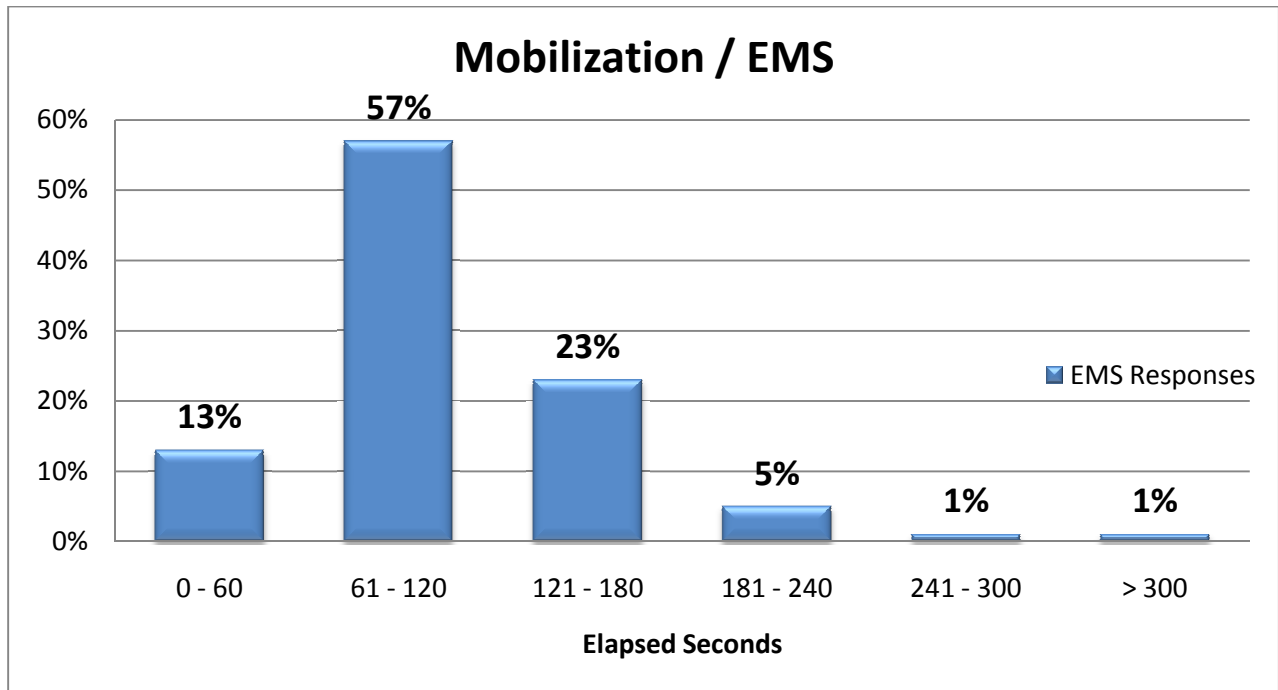
*EMS*



**Figure 15. Percent of EMS Mobilizations Completed over Time**

More than 115,000 records for EMS response *mobilization times* (Table 7) show a benchmark compliance rate of 70%. Half of the recorded mobilizations turnouts (median) were completed in 107 seconds or less (only one second less than fire responses). This result is 11% below our implied mobilization criterion for fire call responses, which places EMS responses slightly below the fire responses in overall mobilization criterion compliance. Note that the weighted average of 107 seconds (mean) is only 13 seconds below the implied benchmark.

Looking at how much time was actually needed to achieve the performance criteria required by the standard, it is noted that it took 141 seconds to reach the 81% criterion for reported fire call responses – 21 seconds longer than the time allotted by the implied benchmark.

| EMS Calls n = 115,206 | Implicit Benchmark Criteria | Observed Compliance | Median Mean Max |
|---|---|---|---|
| **Mobilization** | 120 seconds 81 % | 70% 141 seconds | 96 107 3615 |

**Table 7 Mobilization Time / EMS**

The maximum reported mobilization time for EMS response ranged to just over one hour.  As seen previously with fire responses, this is the result of extreme outliers in both alarm handling and turnout times.  Although the effects of these outliers continue to show themselves in the uppermost cumulative percentages, they remain statistically insignificant overall.

### Discussion Points

With respect to a hypothetical 90% criterion equivalent to that imposed on *alarm handling time* and *turnout time*, an additional 30+ seconds would be required beyond the current benchmarks for both Fire (187 seconds required) and EMS (167 seconds required).   Cumulative distribution functions for both fire and EMS mobilization show similar curves for fire and EMS (Figure 17), with fire responses showing a longer "tail."  This may indicate a more common pairing of both longer than average *alarm handling times* and longer than average *turnout times*.
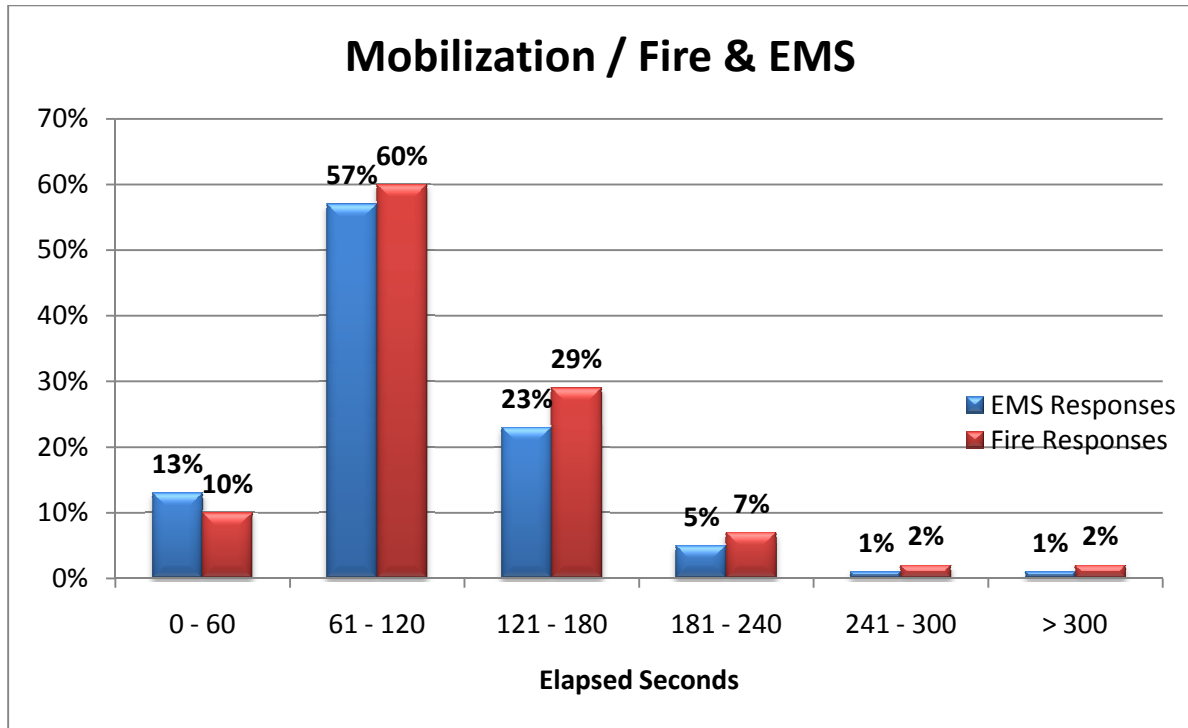
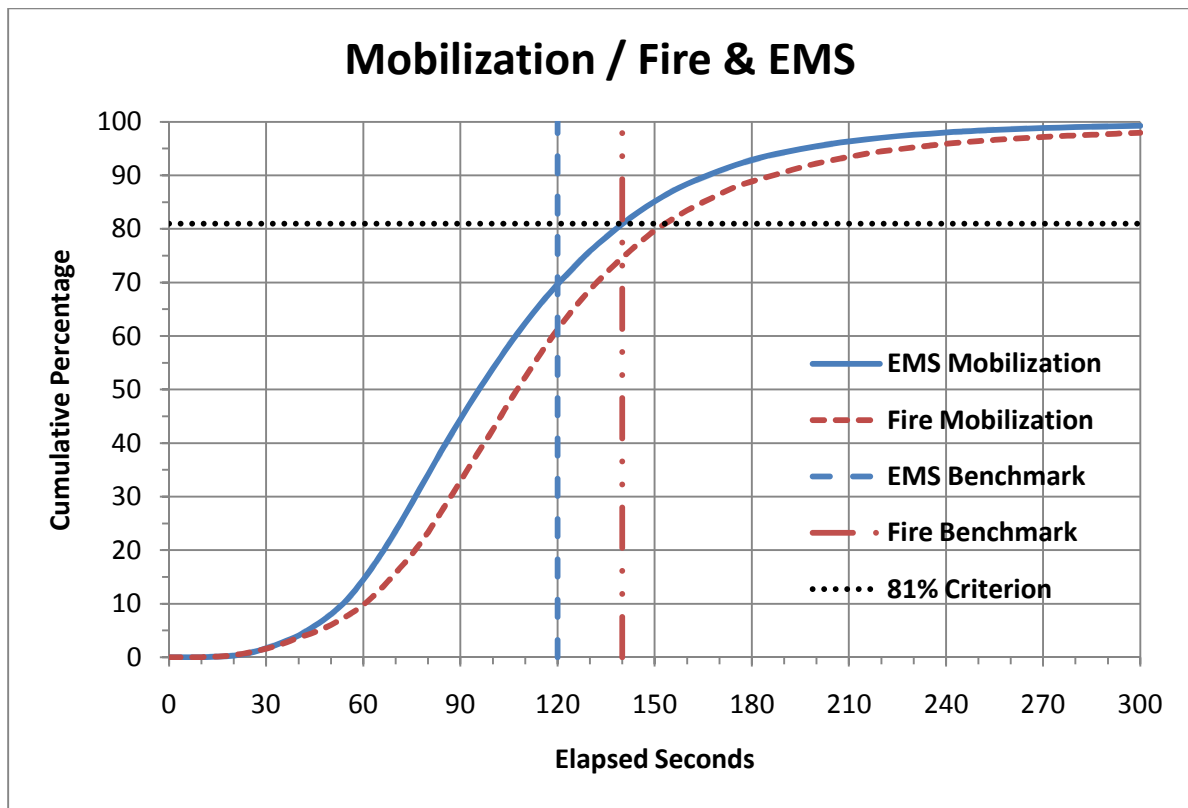**Figure 16. Comparative Percent of Fire & EMS Mobilization Completed over Time**



**Figure 17. CDF Fire & EMS Mobilization Time**