MTFC Project Proposal 2025-26

Team Name	Team 6 - How 'Bout Them Apples
Team ID #	23918
Short Title for Proposal	Faster to the Flame: Shortening Firefighter Response Time
Topic Category	Healthcare or Injuries

MTFC Project Proposal Template Use Notes:

- *Note that the topic for the Project Proposal is the **team's choice** (i.e., it is **NOT** intended that you use the 2025-26 Scenario Quest corn farming for your project proposal topic)*
- *Refer to the official MTFC Project Proposal Prompts 2025-26 for the 15 prompts and scoring instructions.*
- *The use of this template is OPTIONAL.*
    - *It is provided as an optional resource for teams to keep their Project Proposal response organized. Teams who wish to use this template should make a copy in order to edit.*
- *The final version of the team's MTFC Project Proposal should be downloaded as a PDF or Word document to submit on the ICS Dashboard. A single file will be submitted.*
- *Additional resources (including the Actuarial Process Guide) can be found on the Modeling the Future Challenge website: https://www.mtfchallenge.org/resources/*
- *Please direct any questions to challenge@mtfchallenge.org.*

Part 1: Project Definition *(Team's Topic)*

These prompts can be found on page 3 of the MTFC Project Proposal Prompts 2025-26. Additional information on Project Definition can be found in ***Step 1: Project Definition*** in the Actuarial Process Guide.

Team Responses:

#1: Identify the topic

- Response: Our project investigates how to reduce firefighter emergency response times in urban and suburban areas. As cities grow and traffic congestion increases, response times have lengthened, putting lives and property at risk. Faster response times are strongly associated with lower fatality rates, smaller burned areas, and reduced economic loss. This issue affects homeowners, communities, and local governments across the country. Improving response efficiency can directly improve survival outcomes and reduce long-term financial and infrastructural costs.

#2: Identify potential risks

- Response: Key risks include increased fatalities and injuries due to delayed rescues, greater property loss as fire spreads before firefighters arrive, and elevated risk of responder vehicle accidents while attempting to travel at high speeds. By reducing response times, we can have fewer deaths, lower medical severity, and smaller fire damage (in both a monetary and sentimental sense). However, if response times continue to grow along with cities, delays could continue or worsen, resulting in more civilian and firefighter deaths, rapid fire spread, and millions of dollars in preventable property damage.

#3: Identify a behavior change risk mitigation strategy

- Response: We have a public education campaign encouraging drivers' education programs to help student drivers learn to consistently pull over and create a “fire lane” when sirens are heard with both instruction and practice. This primarily impacts individual drivers and can decrease delays caused by motorists reacting too slowly or incorrectly.

#4: Identify a modifying outcomes risk mitigation strategy

- Response: A highly effective modifying-outcomes strategy is strategically building or relocating fire stations based on optimal coverage modeling. By reducing the distance between stations and homes, this strategy directly shortens travel time and decreases fire spread before arrival. This would primarily impact city governments and fire departments responsible for infrastructure planning.

#5: Identify an insurance risk mitigation strategy

- Response: Insurance companies could offer discounted premiums to municipalities meeting specific response-time benchmarks, incentivizing departments to adopt improvements. This impacts local governments who manage fire department operations and budgets.

#6: Identify driving research questions for your topic

- Response: How does response time vary across different neighborhoods, and what factors contribute most to delays? How does increased response time affect expected injury severity and property damage? What improvements would most efficiently reduce response times? How long do households have before they are unsafe for firefighters to get in? What is the spread of fire departments throughout cities and towns? How long can people survive in homes once fire starts before permanent injury or death?

Part 2: Data Identification & Assessment *(Team's Topic)*

These prompts can be found on page 4 of the MTFC Project Proposal Prompts 2025-26. Additional information on Data Identification and Assessment can be found in ***Step 2: Data Identification & Assessment*** in the Actuarial Process Guide.

Team Responses:

#7: Identifying the type of data you hope to find

- Response: Ideal datasets would include precise timestamped incident records showing dispatch time, travel time, and arrival time for each fire call, along with location, distance traveled, and approximate road way conditions. The perfect data would also report occupant injuries, property damage estimates, and fire progression indicators such as square footage burned. We hope to find five to ten years of geographically detailed historical data to observe trends and model risk.

#8: Identify potential data sources for your topic

- Response:

- NFIRS (National Fire Incident Reporting System) — yearly public data releases (PDR) from the U.S. Fire Administration. This is the closest thing to a nationwide incident-level dataset; it often contains timestamps we can use to compute response intervals. Useful for aggregate U.S. analyses. We can calculate median response times, create heatmaps of incident locations, and analyze frequencies of response delays.
- NFPA research & national reports — NFPA publishes summaries and profiles of fire-department activity, which are great for benchmarks and descriptive statistics. We can build national trend charts, compare regions, and extract descriptive statistics on injuries and property losses.
- City / county open data portals — many large cities publish detailed response-time datasets (dispatch, arrival, travel, etc.). Examples: FDNY monthly response times (NYC), San Francisco EMSA response times, Tempe fire response dashboards. These are often the cleanest, most granular sources for urban comparisons.
- Peer-reviewed studies and papers — there's academic work comparing rural vs urban prehospital and fire response times that we can cite for methodology and expected effect sizes (e.g., recent studies describing rural EMS/fire response differences). These are useful for framing and validating results.

Part 3: Mathematical Modeling *(Team's Topic)*

These prompts can be found on page 5 of the MTFC Project Proposal Prompts 2025-26. Additional information on Mathematical Modeling can be found in ***Step 3: Mathematical Modeling*** in the Actuarial Process Guide.

Team Responses:

#9: Modeling research on your topic

- Response: Our research revealed three categories of modeling relevant to emergency response: fire station facility location optimization, dynamic dispatch/relocation mdoels, and GIS/machine-learning-based travel-time prediction. Many published papers provide formulas and methods for maximizing coverage or minimizing travel time. The facility-location models were the most helpful because they matched our project goals and used approachable optimization techniquees. Some methods, such as distributionally robust optimization and spatial survival analysis, use advance concepts that were beyond our current skill level. These papers help clarify which modeling approaches are feasible.

Static siting / facility-location models

1.Location optimization of urban fire stations:
https://www.sciencedirect.com/science/article/abs/pii/S0198971517305525 ScienceDirect
2.Location Optimization of Urban Fire Stations Considering the Backup Coverage:
https://www.ncbi.nlm.nih.gov/articles/PMC9819386/ PMC
3.Distributionally robust optimization for fire station location under uncertainties;
https://www.nature.com/articles/s41598-022-08887-6 Nature4
4.A Hierarchical Multi-Objective Programming Approach to Planning Locations for Macro and Micro Fire Stations- https://arxiv.org/abs/2106.08098 arXiv
5.Estimating Fire Response Times and Planning Optimal Routes Using GIS and Machine Learning – https://www.mdpi.com/2673-7418/5/4/58 MDPI
6.Multi-objective fire station siting based on non-linear fuzzy optimization
https://papers.ssrn.com/sol3/Delivery.cfm/55afbdc6-b858-4d46-b7b8-07084eefn&mirid=1 SSRN

Dynamic relocation / dispatch / simulation models

7. An Algorithm for the Dynamic Relocation of Fire Companies
https://pubsonline.informs.org/doi/10.1287/opre.22.2.249 INFORMS PubsOnline+1
8. Simulation-based Optimization of Resource Placement and Emergency Response – https://web.engr.oregonstate.edu/~afern/papers/iaai09.pdf Oregon State University Engineering
9. Dynamic Floating Stations Model for Emergency Medical Services with a Consideration of Traffic Data https://www.mdpi.com/2220-9964/9/5/336 MDPI
10. Real-time optimization for relocation and dispatching of Emergency Medical Services
https://www.sciencedirect.com/science/article/abs/pii/S0360835223008471 ScienceDirect

Coverage / access / travel-time prediction models

11. Spatial Modelling of Emergency Service Response Times https://arxiv.org/abs/1503.07709 arXiv
12. Estimating effective coverage rate of fire-station services based on online map APIs
https://www.sciencedirect.com/science/article/abs/pii/S0379711220300503 ScienceDirect
13. FSLens: A Visual Analytics Approach to Evaluating and Optimizing the Spatial Layout of Fire Stations https://arxiv.org/abs/2307.12227 arXiv

#10: Goals of a mathematical model in the project phase

- Response: Our mathematical model should estimate how various factors, such as distance, traffic patterns, and station placement, affect response times and associated risks. Ideally, it will quantify both the likelihood of delayed arrival and the severity of resulting outcomes such as property loss or injury. The model could also simulate how changes like adding stations or improving drivers ed courses modify risk over time. Optimization or regression-based analysis appears most helpful, since these approaches directly compare alternative strategies. This odel will guide which mitigation strategy provides the greatest risk reduction.

#11: Assumption development

- Response:
  - The emergency response times are primarily influenced by distance, traffic conditions, roads, and infrastructure. We assume that the firefighters are well-trained and equip to respond as well as that the equipment is up to par.
  - Population density and traffic will continue to grow just has it has in recent years which make it harder to respond.
  - Because it will take time to implement and emergency response teams will need time to adjust to our new changes, we expect the time period to be 5-10 years.
  - We expect our data to improve over this time period, decreasing the number of fires across cities, along with how much damage fires are able to inflict onto houses. The increase in lights that show whether or not a firetruck is behind them will also decrease the amount of time it takes to get firefights to the scene.
  - This rate of change will be different from the historical rate of change because as we are changing the variables that are responsible for fires across cities, firefighters are able to take more action, and less damage is able to get inflicted in comparison to past years.

Part 4: Risk Analysis *(Team's Topic)*

These prompts can be found on page 6 of the MTFC Project Proposal Prompts 2025-26. Additional information on conducting a Risk Analysis can be found in ***Step 4: Risk Analysis*** in the Actuarial Process Guide.

Team Responses:

#12: Goals for mitigation strategy

- Response: If no interventions occur, response times are likely to increase in congested or growing areas, leading to higher rates or severe property damage and fire-related injuries. Our mitigation strategies aim to reverse this trajectory by enabling faster arrival and reducing both the likelihood and severity of losses. The goal is to ensure more households fall within safe response-time thresholds.

Part 5: Recommendations *(Team's Topic)*

These prompts can be found on page 7 of the MTFC Project Proposal Prompts 2025-26. Additional information on making Recommendations can be found in ***Step 5: Recommendations*** in the Actuarial Process Guide.

Team Responses:

#13: Recommendation differences between mitigation strategies

- Response: I believe that cost and effectiveness will be huge factors for us. We have ideas that are very widespread, with some being more expensive but less to put in place (optimizing fire department placement) and some being less expensive but a larger quantity (the drivers ed course). Complexity will also matter. Evaluating these trade-offs will help prioritize the strategy that yields the largest risk reduction per dollar.

#14: Audience for recommendations

- Response: The state/federal agencies are the one potential audience for our recommendations because they are the people responsible for creating and adjusting the curriculum of driving education. Also, they are also financially responsible for handling the cars, federal aid, and issued tests for passing these tests to ensure safety out on the roads.

#15: Goals for situation improvement

- Response: The best-case scenario would be to eliminate the unpredictable and time sensitive challenges that slow down firefighter response and route times, allowing the fighters to have the best chance of saving lives and reduce damages. As there are multiple, uncontrollable factors when dealing with firefighter routes, we planned to implement infrastructure that is more fire resistant, create better understanding of the roads to make way for fire trucks, and insurance premiums to influence firefighters to improve on areas such as speed. The goal is to maximize efficiency of responses times— limiting delays and limiting damage— so that firefighters can reach emergencies as quickly and safely as possible.