Charlotte Fire Department

Sven Dugojevic, Carl Niedner

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LEVRUM
DATA TECHNOLOGIES

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Executive Summary

The objectives of this study are:

1. Validate the prior study
2. Develop datasets for light, moderate, and aggressive growth scenarios for 2025-2029.
3. Provide a written report and digital archive.

1. Methodology

Code 3 Strategist version 2.10.0.7478 was used in this study. Code 3 Strategist is a simulation software that allows a user to input a set of incidents and simulate the hypothetical performance of their fire department. The simulation software takes into consideration:

Update with final C3S version

1. Station location
2. Apparatus types and staffing requirements
3. Personnel
4. Dispatch rules

The software is capable of assigning a single, or multiple, apparatus staffed with personnel to an incident based on the department's dispatch rules. Apparatus and personnel are taken out of service while they are simulated as responding and working on scene, while the simulator continues to dispatch apparatus and personnel that are available for any subsequent 911 calls. The framework and rules are set by the user and the accuracy, or how closely the simulator resembles real life, is determined by these rules and how predictably the department is able to follow its written policies.

In complex systems, it is very common for a simulator to deviate from reality within an acceptable margin. Causes of these deviations can be:

1. Pursuing absolute perfection in simulator performance, replicating real-life scenarios, eventually yields diminishing returns. Once researchers attain a level of proficiency deemed 'good enough,' allocating time to explore other study domains becomes a more productive endeavor.
2. Company officers often have to make small adjustments to a conventional response plan in order to better fit the current needs. For example:
    - A company officer may elect to divert to a 911 call they are closer to while they are traveling to or from training.
    - A company officer may elect to assign themselves to an incident based on call notes to replace or assist another unit if they are closer.

The goal of Code 3 Strategist is to mimic department policy as it is intended to be executed in a perfect world. It is up to the user to interpret the results and make inferences from the results, while taking into account potential deviations from the real world. The workflow and system methodology of Code 3 Strategist is drawn below.

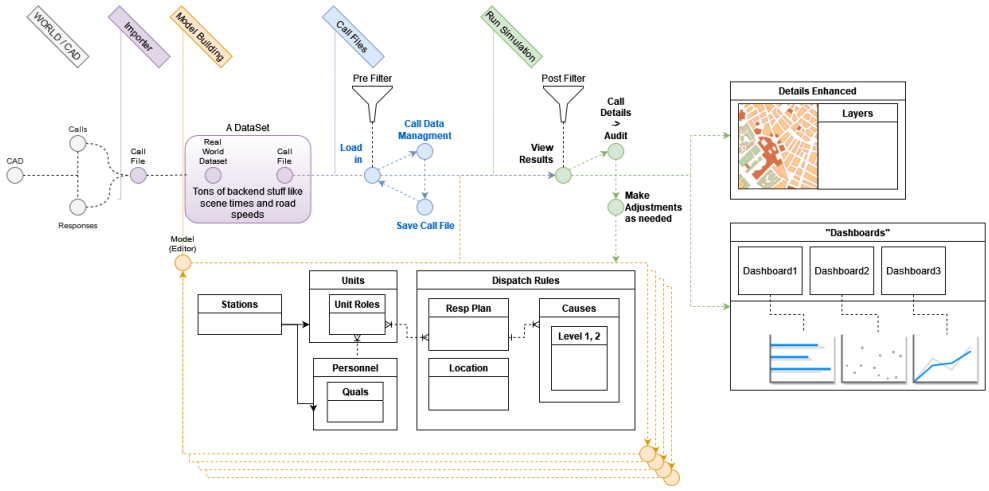

Figure 1.1: Visual representation of the logic and workflow with Code 3 Strategist.

1.1 Zoning Shapefiles

Two primary shapefiles were retrieved from the Charlotte Data Portal[1] to classify the different regions used for growth modeling. The 2040 Zoning data source* provided a comprehensive list of zoning labels that served as the initial foundation for building a complete list of zoning labels used in this study. From this starting point, additional labels were extrapolated from the current Zoning dataset* to further enhance the shapefile layers, particularly for multifamily and residential areas.

maps showing different zoning areas

One of the main challenges of this study was developing a method to classify or label defined regions consistently across current and future zoning maps. This consistency allows us to describe regions with similar characteristics, such as a 'Neighborhood.' By analyzing how the Neighborhood label changes in shape and size in the 2040 zoning map, we can predict future 911 calls by adjusting the typical 911 call volume found in a Neighborhood zone for expected growth over time. This process is repeated for all identified labels.

The translation of current labels[2] to new labels required significant assistance from the Charlotte Planning Department. The zoning labels that exist in 2024, referred to as zoning descriptions, did not align with the labeling system used in 2021 to create the 2040 Future zoning labels. Fortunately, the Planning Department was able to recover the classification system* used in 2021 to generate the 2040 zoning plan. This data "crosswalk" is not publicly available, and any future requests for this data will need to be directed to the Charlotte Planning Department.

*https://data.charlottenc.gov/datasets/charlotte::charlotte-future-2040-policy-map-4/explore

*https://data.charlottenc.gov/datasets/charlotte::zoning-1/about

*the classification system was a shapefile with an attribute table of shape (11951, 2)

1.1.1 Handling data discrepencies

Ask Carl to help write out strategy for incomplete data. This would be a good place to discuss the many to many relationship of the tables used for zoning

1.2 Future Growth Modeling

With the assistance of Miriam McManus, we shifted our approach to predicting 911 calls. Every 911 call, whether real or simulated, includes three essential components: the nature of the call, the location, and the time it occurred. The nature of the call specifies a particular issue, such as a breathing problem, which can be further generalized as a medical issue. Predicting call types at this level of specificity, based on historical data, led to an overestimation of working structure fires due to the high incidence of low-acuity fire calls being grouped similarly. To address this issue, we adopted a different approach to categorizing the nature of 911 calls.

Instead of predicting specific "nature codes" based on historical data, we generalize 911 calls into broader categories. This methodology helps produce more accurate and meaningful predictions. The generalized categories are as follows:

Call Type	**Response Level**
Medical Call	Single Resource response
Fire Incidents Hazmat Incidents Motor Vehicle Accidents (MVA)	Single engine company response Double engine company or two heavy asset responses Three or more company responses (large structure fires or major incidents)

Table 1.1: Generalized 911 Call Types and Response Levels

By categorizing 911 calls in this manner, we can create more accurate and manageable predictions for future call volumes and types.

2. Deployment and Coverage Analysis

2.1 Ressource Allocation

1. ~~Resource and apparatus allocation chart~~
2. resource map

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2.2 Deployment

Station	Apparatus	Staffing Details
Future Airport	N/A	No Engine or Ladder
Station 1	E01, L01	6 Firefighters, 2 Engineers, 3 Captains, 1 Battalion Chief
Station 2	E02, L02	4 Firefighters, 2 Engineers, 2 Captains
Station 3	E03, TW03	4 Firefighters, 2 Engineers, 2 Captains
Station 4	E04, L04	4 Firefighters, 2 Engineers, 2 Captains
Station 5	E05	2 Firefighters, 1 Engineer, 1 Captain
Station 6	E06	2 Firefighters, 1 Engineer, 1 Captain
Station 7	E07	2 Firefighters, 1 Engineer, 1 Captain
Station 8	E08	2 Firefighters, 1 Engineer, 1 Captain
Station 9	E09	2 Firefighters, 1 Engineer, 1 Captain
Station 10	E10, R10	5 Firefighters, 2 Engineers, 2 Captains, 1 Battalion Chief
Station 11	E11, R11	5 Firefighters, 2 Engineers, 2 Captains
Station 12	E12	2 Firefighters, 1 Engineer, 1 Captain
Station 13	L13, E13	4 Firefighters, 2 Engineers, 2 Captains
Station 14	E14	2 Firefighters, 1 Engineer, 1 Captain
Station 15	E15	2 Firefighters, 1 Engineer, 1 Captain
Station 16	E16, L16	4 Firefighters, 2 Engineers, 2 Captains
Station 17	E17	3 Firefighters, 1 Blaze FF, 1 Blaze Company Officer, 1 Blaze Engineer, 1 Captain
Station 18	E18, TW18	3 Firefighters, 2 Engineers, 2 Captains
Station 19	E19	2 Firefighters, 1 Engineer, 1 Captain
Station 20	E20	2 Firefighters, 1 Engineer, 1 Captain, 1 Battalion Chief

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Table 2.1 – *Continued from previous page*

Station	Apparatus	Staffing Details
Station 21	E21	2 Firefighters, 1 Engineer, 1 Captain
Station 22	E22	2 Firefighters, 1 Engineer, 1 Captain
Station 23	L23, E23	4 Firefighters, 2 Engineers, 2 Captains
Station 24	L24, E24	4 Firefighters, 2 Engineers, 2 Captains
Station 25	E25	2 Firefighters, 1 Engineer, 1 Captain, 1 Battalion Chief
Station 26	L26, E26	4 Firefighters, 2 Engineers, 2 Captains
Station 27	L27, E27	4 Firefighters, 2 Engineers, 2 Captains, 1 Battalion Chief
Station 28	E28, L28	4 Firefighters, 2 Engineers, 2 Captains
Station 29	E29	2 Firefighters, 1 Engineer, 1 Captain
Station 30	E30	2 Firefighters, 1 Engineer, 1 Captain
Station 31	E31, L31	4 Firefighters, 2 Engineers, 2 Captains
Station 32	L32, E32	4 Firefighters, 2 Engineers, 2 Captains
Station 33	L33, E33	4 Firefighters, 2 Engineers, 2 Captains
Station 34	E34	2 Firefighters, 1 Engineer, 1 Captain
Station 35	E35	2 Firefighters, 1 Engineer, 1 Captain
Station 36	E36	2 Firefighters, 1 Engineer, 1 Captain
Station 37	E37	2 Firefighters, 1 Engineer, 1 Captain
Station 38	E38	2 Firefighters, 1 Engineer, 1 Captain
Station 39	E39	2 Firefighters, 1 Engineer, 1 Captain, 1 Battalion Chief
Station 40	L40, E40	4 Firefighters, 2 Engineers, 2 Captains
Station 41	E41	2 Firefighters, 1 Engineer, 1 Captain, 2 Blaze Firefighters, 3 Blaze Engineers, 2 Blaze Company Officers
Station 42	E42, E65	3 Firefighters, 2 Engineers, 2 Captains, 1 Battalion Chief
Station 43	E43	2 Firefighters, 1 Engineer, 1 Captain

Table 2.2: Staffing and Apparatus Allocation for Fire Stations

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Start	End	Description
March 2020	September 2020	Temporary drop in calls due to COVID-19 and changed dispatch protocols between County MEDIC and CFD.
January 2022	ongoing	County MEDIC stopped dispatching CFD on certain calls. Noticeable shift in Psych and Trauma calls, and potentially other EMS calls.
April 2023	ongoing	County MEDIC stopped dispatching CFD on additional calls, leading to noticeable shifts across most EMS calls, effective from April 21, 2023.
March 2020	ongoing	Changes in population dynamics and locations have occurred, such as the relocation of an uptown homeless camp to hotels in South and West Charlotte during COVID-19. This has led to shifts in call locations and population characteristics, particularly income, in affected areas. Affordable low-income areas are moving further from the city center, while formerly affordable neighborhoods are being replaced by luxury residential developments, resulting in different types and volumes of calls. These changes may add complexity to the analysis of geospatial call trends.

Table 2.3: Timeline of Changes in Call Volume and Dispatch Protocols

3. Call Volume Analysis

3.1 Validation of Historical Predictions

3.1.1 Predicted vs. Actual Call Volumes

1. Overview of 2018 predictions for 2018-2023.
2. Comparison of predicted total incidents vs. actual incidents.
3. Breakdown by incident types (fire, EMS, hazardous materials, etc.).

3.1.2 Temporal Analysis

1. Predicted vs. actual incidents by time of day, day of week, month, etc.
2. Identify any significant deviations and possible reasons.

3.1.3 Geospatial Comparison

1. Predicted vs. actual incident distribution maps.
2. Analysis of high and low density areas.
3. Discussion on how predictions matched real-world geographic trends.

3.2 Adjustments and Learnings

3.2.1 Methodology Adjustments

1. Recommendations for improving prediction accuracy.
2. Adjustments to be made in the future growth scenario models.

3.2.2 Study Insights

1. Key insights from the prediction vs. reality comparison.
2. Identifying external factors influencing deviations (e.g., COVID-19, policy changes).

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Is 2018 - 2023 the right date?

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4. Projected Growth and Call Volume

Incident Statistics:

1. Total number of incidents
2. Incident types (fire, EMS, hazardous materials, etc.)
3. Areas of highest growth
4. High and low projections
5. Ensure clear labeling and correlation with call volumes.
6. Include detailed growth rate models.

5. Conclusion

1. Summarize the findings,
2. implications for CFD,
3. any further research needed.
4. Final thoughts and next steps

Glossary of Terms

- **AOR or Area of Responsibility**: a geographical area for which one fire station is primarily responsible. Generally, a station's AOR corresponds approximately to the area in which it is closest by street distance or travel time. AORs are also sometimes called "first due areas" or "still alarm areas."
- **Call File**: a digital file containing essential information about a collection of emergency incidents or calls, including each incident's dispatch date/time, type, location, and other parameters.
- **Initial Response Time or IRT**: the elapsed time between the initial dispatch of an incident to the arrival of the first unit at the scene of the incident.
- **Model**: a digital representation of one potential way of organizing a fire agency, including station locations, staffing, apparatus placement, scheduling, dispatch policies, and other variables. Models typically include a "base model" (encoding the deployment and behavior of the current operational model) and the subsequent study items are altered from the base model to create new deployments.
- **Response Time**: the time between a unit's notification (dispatch) of an incident and its arrival at the scene of the incident.
- **Scenario**: a digital collection of incidents designed to represent a possible future state of workload demand. Scenarios are typically generated by a statistical modeling process involving historical data, observed growth rates, and general and detailed development plans.
- **Simulation**: the process of performing detailed prediction of the behavior of a model or models, in response to a set of incidents (scenario or call file), at the level of individual staff members and apparatus on individual incidents.
- **Travel Time**: the time between a unit's departure enroute to an incident and its arrival at the scene of the incident.
- **Turnout Time**: the time between a unit's notification (dispatch) of an incident and its departure enroute to the incident.

References

[1] City of Charlotte. Charlotte data portal. https://data.charlottenc.gov/, 2024. Accessed: 2024-06-05.

[2] Charlotte Urban Design. Article 15: Use regulations - section 15.2 global use matrix, 2024. Accessed: 2024-06-16.