Securing of Golden Time for Emergency Vehicles, by Identifying and Mitigating Obstacles and Causes of Delay through Big Data Analysis

The initial response, specifically the prompt dispatch of fire trucks and ambulances, is crucial to dealing with large-scale disasters involving considerable losses of lives and property. In Daejeon, however, it is a challenge to ensure emergency vehicle arrival during the Golden Time for optimal emergency response, due to the increasing traffic volume as well as the numerous vehicles left illegally unattended in alleyways and narrow streets. According to an analysis by the Daejeon Fire Headquarters in 2017, the average emergency vehicle dispatch coverage rates (the proportions of areas where fire fighters or emergency service teams can arrive within 5 minutes) were quite low, at 20% for fire engines and 31% for ambulances.

In response, recognizing the urgent need to resolve the issues involved in delayed dispatches of emergency vehicles and to establish plans to bolster safety measures for areas prone to fires and other disasters, Daejeon Metropolitan City began to implement improvements and strengthen safety measures using cutting-edge technologies including big data and AI. Since then the city has achieved meaningful outcomes in dramatically shortening the arrival times of emergency vehicles, and protecting more lives and property thereby, through identifying areas where delays are persistent, and working to resolve their causes, via big data analysis of the GPS data of emergency vehicles such as fire engines and ambulances.

Progress

July 2017	●	Began big data analysis using GPS location data of emergency vehicles
April 2018	●	Analyzed traffic flows for optimization of emergency vehicle dispatch systems
May 2018	●	Identified vulnerable areas through time frame-based dispatch coverage rate analysis

Major Programs

Analysis of Factors Affecting Emergency Vehicle Dispatches

From August 2016 to January 2017, in collaboration with other agencies, Daejeon Metropolitan City employed diverse algorithms to thoroughly analyze the various factors that could affect the dispatches of fire engines and ambulances

- It analyzed 30 million cases of GPS data of ambulances to generate location coordinates at 10-second intervals, and analyzed the pager numbers of 210 vehicles dispatched to various disasters, the administrative jurisdictions of fire stations, the 119 Safety Centers under the fire stations, and the vehicle type data
- It also analyzed the intelligent transportation system (ITS, nodelink.its.go.kr), in order to arrive at more accurate and reliable results
- The analysis was carried out based on 110,000 cases of road location data as well as 9,000 cases of road characteristics data, categorized in terms of roadway names, road IDs, road numbers, lane information, etc.

Analysis of Vehicle Routing for Optimization of Emergency Dispatches

Machine learning-based analysis of routing data identified seven vulnerable areas and 800 chronically congested spots which emergency vehicles could not reach within 5 minutes

- The analysis identified the optimal routes for avoiding congested sections and dispatching emergency vehicles to promptly arrive at the vulnerable areas
- The results of analysis showed that using the most expeditious routes between the centers and the destinations is more efficient than focusing on the shortest direct distances between them (Even if its total distance between the two points is longer than the shortest direct distance, the more efficient route, which avoids obstacles such as traffic lights or left-turn signals, should be used)
- Drawing on the data, an emergency service team can be more promptly dispatched from a center from which it can arrive at the site most rapidly
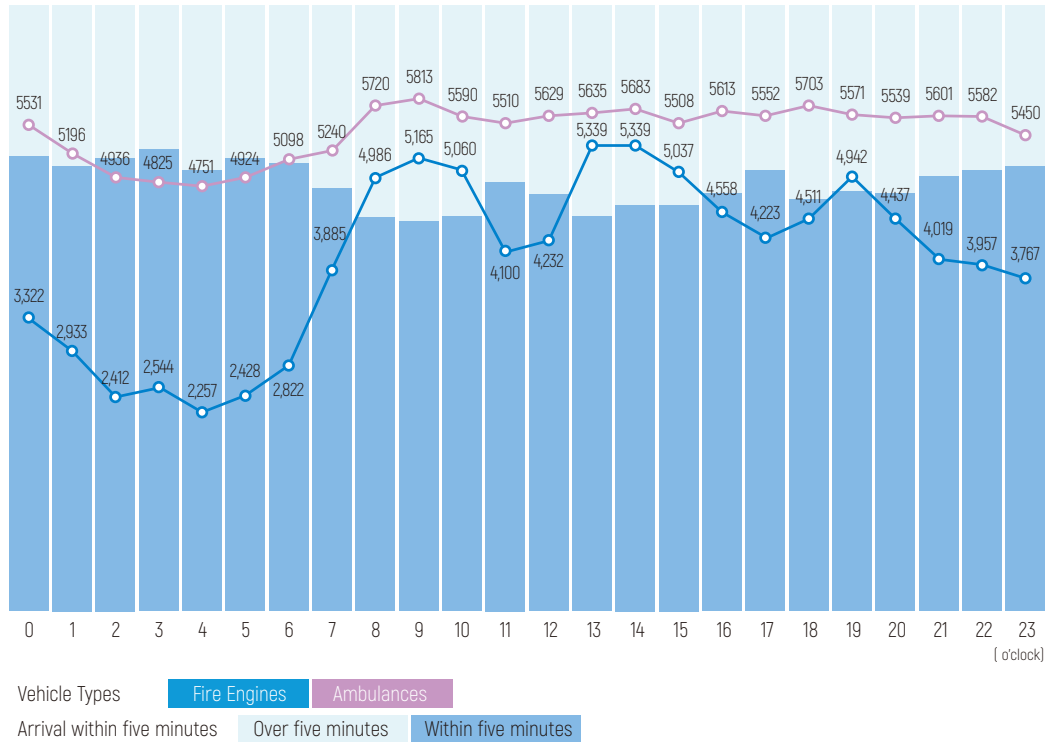
Shortest Routes for
Emergency Dispatch

Identified Vulnerable Times and Areas through Time Frame-based Coverage Analysis

Through a multifaceted analysis and approach, the dispatch coverage rate differences by time frame of fire engines and ambulances were identified, as well as their vulnerable areas and times, leading to the achievement of enhanced dispatch coverage rates

- While the dispatch coverage rate for fire engines amounts to 60% in the time frame from midnight to 7 am, when traffic is light, it is only 10% between 1 and 2 pm when the volume of traffic is relatively high. The vulnerable hours for ambulances are from 8 to 10 am, when the coverage rate is only 25%
- Additional analysis was undertaken to come up with a more accurate approach to reinforce safety measures for the region
- A shortest route algorithm was adopted, based on the average speed of ambulances, and simulations were carried out on designating centers to dispatch rescue teams in cases of emergencies and avoiding routes subject to delays. This resulted in a twofold increase in the overall dispatch coverage rate, from 31% to 60%

Numbers of arrivals within five minutes and dispatch coverage rates, by time frame

Ambulances (line, over/within five minutes values):
5531, 5196, 4936, 4825, 4751, 4924, 5098, 5240, 5720, 5813, 5590, 5510, 5629, 5635, 5683, 5508, 5613, 5552, 5703, 5571, 5539, 5601, 5582, 5450

Fire Engines (line values):
3,322, 2,933, 2,412, 2,544, 2,257, 2,428, 2,822, 3,885, 4,986, 5,165, 5,060, 4,100, 4,232, 5,339, 5,339, 5,037, 4,558, 4,223, 4,511, 4,942, 4,437, 4,019, 3,957, 3,767

Time frame (o'clock): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 (o'clock)

Vehicle Types: Fire Engines | Ambulances
Arrival within five minutes: Over five minutes | Within five minutes

Major Achievements

Established Transportation Policies for Emergency Vehicles and Enhanced Fire Fighting Response System, Using Big Data Modeling

Installed left-turn signals on roads near emergency centers; Implemented traffic signal control system giving priority to fire trucks; Installed hose-reel fire hydrants in areas difficult for fire trucks to access

Before modeling	After modeling
- Sections causing chronic delays for emergency vehicles. - Low dispatch coverage rates - Vulnerable areas	- Shortened arrival times of emergency vehicles - Vulnerable areas and times identified - Proactive responses to congested areas (causes of delays eliminated, and safety measures reinforced)

Significant Reductions in Response Times of Emergency Vehicles, Thanks to Decision-making based on Machine Learning Algorithms or AI Data

Proportion of dispatches to fires recording response times less than 7 minutes: Increase of 9.9%, from 72.2% in 2017 to 80.0% in 2021

*Comparisons with rates in Gwangju, which has traffic conditions similar to Daejeon, and nationwide: Gwangju (77.4%), National Average (65.9%)

*While the analysis was based on the 5-minute dispatch coverage rate widely used in academic research, a response time of seven minutes was used here for a more realistic reflection of fire suppression practices

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