Research Title:

Queueing-Based and Data-Driven Design of Emergency Transportation Services

Primary Investigator:

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This report presents the outcomes of a three-year study aimed at improving emergency transportation services through operations research and data-driven modeling. The work produced two manuscripts. The first establishes, from over 20 million incident records covering fire services in Toronto, San Francisco and London and emergency medical services in San Francisco, that these systems operate under light traffic with statistical stationarity, and proves that the range of utilizations over which tractable infinite-server approximations remain accurate widens with fleet size. An accompanying optimization analysis shows that meeting response-time standards drives systems into this regime even when fleet size is explicitly minimized, establishing low utilization as a design outcome rather than an inefficiency. The second develops a calibration-free queueing framework in which the dispatch protocol – which vehicle types respond to each incident, in what hierarchical order and in what numbers – enters the model as data rather than as a fitted parameter, so prospective protocol changes can be evaluated without recalibration or new data collection. Applied to 720,844 Toronto Fire Services incidents, it quantifies how group dispatch amplifies fleet workload and how targeted protocol changes can extend the system's demand-growth capacity without fleet expansion. Together the two studies advance smart transportation by supporting optimized resource utilization and reduced response times, contribute to the vision of "zero externalities", and demonstrate the value of interdisciplinary collaboration between operations research and emergency management.