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Fleet Management some Myths and Realities

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ABSTRACT *Presents a review of the research to-date in the two basic components of dynamic incident handling namely real-time fleet management systems and travel time prediction methods. More specifically, the first part of the chapter presents the main characteristics of a fleet management system and underlines the need for real¬time fleet management when dynamic incident handling is required. The main features as well as current work in the area are presented. The second part of the chapter reviews .current methods for travel-time prediction, which comprise an important part for accurate and effective incident detection. Various surveillance devices and travel time estimation techniques are presented, followed by their characteristics. Emphasis is given to Automatic Vehicle Location (AVL) devices (used for data collection) as well as to the non-parametric regression method (used for data processing). As real-time management and dynamic routing of freight fleets lies in the area of Operations Research (OR), there is also a section that identifies this issue in OR terms. The section focuses on vehicle routing problems that are time dependent and occur mainly in urban settings and are described as Dynamic Vehicle Routing Problems (DVRP). Finally, the chapter ends with a brief concluding summary.*

INTRODUCTION
Fleet Management Systems enable the real-time monitoring of various parameters such as vehicle location and velocity, field data (e.g. load temperature) and so on in order to detect bottlenecks in delivery execution and minimize operational costs. These systems are%pecialized software packages that are aimed specifically at fleet operations (Lapcrte and Crainic, 2000). The architecture of such system is depicted in figure 2.1 and comprises of three main components:

1. On-board telematic equipment: It consists of a set of microelectronic devices that are responsible to process all the data received either by the positioning satellites or by the on-board sensors and transmit them through a mobile network at the control centre.

Control centre: It consists of an application that manages all the data transmitted by the on-board equipment. The route planner is abie to know in real-time the position of each vehicle and collect any necessary information concerning the execution of each delivery schedule.

Mobile & Satellite Communication systems: Communications consist of two parts: a) The mobile access terrestrial network (e.g. GSM), which is responsible for the wireless interconnection of the control centre with the onboard devices, and b) the positioning system (e.g. GPS), which is responsible for vehicle tracking.

Functionalities of fleet management systems
Fleet management systems enable freight carriers to monitor their fleet through vector maps to improve delivery network performance (Gruhn et a/., 2003). Ideally, the dispatching centre knows in which state the vehicle and the driver are at any given point in time. Within a reaf-life setting the positioning information is transmitted at fixed intervals and an interpolation scheme is employed in order to estimate the positions of the vehicles. The main functions covered by such systems are (Rushton etal.,2000):

Fleet administration and costing; This feature provides detailed information relating to vehicle and fleet costs. It assists the logistics manager by providing analysis and information concerning individual vehicle and overall fleet profitability. Features include vehicle and driver cost analysis as well as overall fleet costs. Telematic logger analysis and a posteriori reports: Information from telematic logger recordings can provide the input data for an analysis of driver/vehicle performance. A number of systems are available that can read these charts and produce a posteriori reports on rest time, driving time and break time, as well as details of legal infringements.

Maintenance scheduling: This includes the monitoring of the service life of vehicles in a fleet and the scheduling of routine and non-routine maintenance and repairs. Typical features include service history, maintenance schedule reports and workshop cost analysis.

Review of current flee t management systems
Existing fleet management systems use mobile and positioning technologies for monitoring the execution of a delivery schedule. Monitoring systems are mainly used for fleet surveillance purposes. Indeed, such systems are able to collect and process, in real-time, various data transmitted by the vehicles (e.g. geographical coordinates, vehicle's velocity, load temperature and so on), so as to create a-posteriori reports that include information concerning the daily route of each truck.

In the literature, there are mainly two cases where monitor systems are engaged, in the first case, these systems are implemented in real-life distribution networks so as to compare the performance of delivery execution prior and after the system use. The results in the literature show that the use of such systems reduce the cost of the delivery process as the route planner is able to identify problematic customers {i.e. customers with increased service times) as well as roads with high traffic congestion. In the second case, researchers use monitoring systems so as to assess the performance of initial routing algorithms that have implemented in order to construct the optimal route that each vehicle should follow. Thus, in the second case, monitoring systems are used just for collecting data that can help a researcher to investigate whether the proposed algorithms reduce significantly the operation cost of the fleet. Table 2.1 shows a series of papers that deals with either case.

Although the use of such systems supports better utilization and management of the delivery fleet, they are not typically designed to address unforeseen events in a systemic fashion. This is due to the disturbances that are intrinsic especially in urban environments and arise from traffic congestion, weather conditions, vehicle breakdowns, and other unpredictable

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events as noted above (Psaraftis, 1995; Savelsbergh and Sol, 1998). The following section discusses the main characteristics of real-time fleet-management systems that can cope with information that is revealed in a dynamic manner and can also manage unexpected events.
Real-time Fleet Management Systems

Main system components
The aforementioned systems are used mainly for monitoring purposes and are not designed to handle an unexpected event during delivery execution in a systemic manner. However, the last decades, research focused in real-time fleet management that are able to manage a series of events such as new customer requests. Usually such systems try to fulfil two main objectives: The first objective is the minimization of delays, which are unavoidable in a dynamic situation; the second is the minimization of cost, which is assumed to be proportional to the total duration of all tours.

The basic components that real-time fleet management systems incorporate are shown in figure 2.2. As it can be seen in such systems apart from the fleet monitoring process there is usu&Uy an event management mechanism that handles in a dynamic manner unexpected events such as traffic congestion, vehicle breakdowns and new customer requests. Incident detection is usually made through travel time prediction methods and incident handling (i.e. vehicle rerouting) is made through routing algorithms. Both issues are discussed later in detail in sections 2.4 and 2.5 respectively.

Review of current real-time fleet management systems
Current real-time fleet management systems can be categorized according to the type of real-time information they process. Table 2.2 shows a list of research work in the area of real-time fleet management.

Available work addresses cases wtiere a new customer request appears and must be fulfilled in a specific time period. Initially the systems that appeared in the previous decade (Goetschalckx ,1998; Powel, 1990, Savelsbergh & Sol, 1997; Slater, 2002; Gans & Ryzing 1999) although they can cope with new customer requests they assume that travel times throughout the day are constant or exploit simple procedures to adjusVthem like multiplier factors associated with different periods of the day. However, these assumptions are weak approximations of the real-world conditions where travel times are subject to more subtle variations over time. These variations may resuit from predictable events (e.g. congestion during peak hours) or from unpredictable events like accidents, mechanical failures and others. Therefore, Background review in fleet management systems and travel time prediction methods the optimal solution to a formulation of an urban freight delivery problem that assumes constant travel times may be suboptima! or even infeasible (Ichoua., 2003).

Kim et al. (2003) was the first to introduce real-time traffic information in such a system. They examine its value to optimal vehicle routing in a non-stationary stochastic network by developing a systemic approach for determining driver attendance time, optimal departure times and optimal routing policies under stochastically changing traffic flow. Ichoua et al. (2003) presented a real-time fleet management model based on time-dependent travel speeds. An experimental evaluation of the proposed model is performed in a static and a dynamic setting, using a parallel tabu search heuristic and the results show that the time-dependent model provides substantial improvements over a model based on fixed travel times. Fleischmann et al. (2004b) presented a dynamic routing system that dispatches a fleet of vehicles according to customer orders arriving at random during the planning period. The system disposes of online information of travel times from a traffic management centre. Taniguchi and Shimamoto (2004) presented also an intelligent transportation system based dynamic vehicle routing and scheduling with variable travel times. Results indicated that the total cost decreased by implementing the dynamic vehicle routing and scheduling model with the real-time information based on variable travel times compared with that of the forecast model (i.e. the latter provides forecasted travel times based on historical data). Finally, Hanghani & Jung (2004) presented a systemic approach to address the dynamic vehicle routing problem with time-dependent travel times. They also present a genetic algorithm to solve the problem. The latter is a pick-up or delivery vehicle routing problem with soft time windows in which they consider multiple vehicles with different capacities, realtime service requests, and real-time variations in travel times between demand nodes. Dynamic travel times are obtained by on-board terminals. However, incidents include also travel time and service time delays and vehicle breakdowns that have not been tackled by any of the aforementioned system. This research gap makes the need for real-time incident handling systems.

The need for real-time incident handling systems
As mentioned in Section 1.3 (Chapter 1) there are three main sources of incidents in urban freight deliveries: a) incidents originating from the clients served, b) incidents from the road infrastructure and environment and c) incidents that arise from delivery vehicles. Current work have dealt with a certain case of incident handling (i.e. customer requests), and thus there is still a lack of modelling approaches that represent more closely general real-life conditions such as vehicle breakdowns as well as travel time and service time delays caused by traffic congestion, rain, or no available unloading area in the customer's site.

This thesis enhances dynamic incident handling in urban freight distributions by proposing a real-time fleet management system that addresses the aforementioned issues. The system incorporates a travel time prediction mechanism to monitor the execution of the delivery plan, detects possible deviations from the delivery schedule (caused by time delays and vehicle breakdowns), and recommends intelligent rerouting interventions through real-time algorithms.

CONCLUSION
Such a system makes use mainly of real-time information in order to handle unexpected events. Time-dependent information can be based on traffic management centres or on information extracted by vehicle position monitoring. The latter facilitated by recent advances in mobile and satellite communication technologies. Indeed, a combination of satellite iocation identification systems, using the Global Positioning System (GPS), and terrestrial mobile communication systems, such as General Packet Radio Service (GPRS) or Terrestrial Trunked radio (TETRA), may enable freight carriers to dynamically handle unexpected events (Gruhn et al., 2003). In addition to real-time information, in such a system effective travel time prediction is of great importance for accurate real-time management of trucks and incident detection. The following section describes the concept of travel time estimation and reviews current methods for travel time prediction.