# PhD Open Days

## Optimizing Emergency Medical Service Systems

PHD PROGRAMME IN ENGINEERING AND MANAGEMENT

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## Motivation

**Public Health |** The Emergency Medical Services (EMS) capacity to efficiently respond to emergency calls can be crucial for a patient recovery success;

**Increasing demand for EMS |** The number of calls made to the Portuguese Emergency Medical Services (INEM) has been increasing. CODU, INEM's center for orientation of urgent patients, received 1368141 calls in 2017, more 11% than in 2012, yielding an average of 3748 call per day;

## Case Study

When an emergency call is made, and it is the case of a medical emergency, it is forwarded to the dispatch (CODU), managed by INEM. CODU is responsible for answering and triaging the call, in order to dispatch the right resource

If the patient is considered as a non-urgent case, the caller might be forwarded to a 24h medical assistance line (Saúde 24), to the center of antivenin information (CIAV) or to the center of psychological help and crisis intervention (CAPIC)

If a patient is considered to be an urgent case, an emergency vehicle is dispatched. INEM's emergency vehicles include both road and air transport. Depending on the priority assigned to the patient, a different vehicle may be dispatched.

- Medical Emergency Ambulance (AEM)
- Immediate Life Support Ambulance (SIV)
- Inter-hospital Pediatric Transport (TIP)
- Medical Emergency Motorcycle (MEM)
- Medical Emergency and Reanimation Vehicles (VMER)
- Mobile unit of Psychological Emergency Intervention (UMIPE)
- Helicopter

FIGURE1: EMS system workflow

## Objectives

**Develop decision support systems to improve the efficiency of INEM**
To do so, the synergy between three research fields is required: demand forecast, vehicle location and relocation, and personnel scheduling;

**Develop a model to derive patterns and predict demand for EMS**
A model to derive patterns and predict demand for EMS on multiple time horizons (hourly, daily, weekly, monthly and yearly) will be developed to serve as input for the decision support tool;

**Develop a tool for ambulance location planning and relocation**
For the vehicle location and relocation work phase, two optimization models will be developed. First a multi-objective model for the location of ambulances, and then a dynamic optimization model for the relocation of ambulances to respond to shifts in demand. Finally, there is the objective to combine both models creating a single tool enabling planning and reaction to disruptions.

**Multi-objective algorithm for personnel scheduling**
A multi-objective algorithm will be developed that considers social factors, preferences and demand constraints for personnel scheduling.

## Methodology

This work aims to improve the efficiency of the EMS systems by planning and optimizing resources. To accomplish that, three planning levels are defined for EMS: strategic, tactical and operational, differing on the time horizon. In this work, three groups of problems will be addressed in the scope of those levels, while exploring their integration: demand forecast, vehicle location and relocation, and workforce management. This is mapped in Figure 2.
In a strategic decision level calls will be forecasted for one or several years, enabling the decisions on the number of vehicles and TEPH. On a tactical level a more specific forecast can be done, considering for instance call priority and geographic location, within a weekly to monthly horizon. This forecast can be used to determine ambulance location and shift and staff planning. At last, operational data allows local ambulance decisions, for instance which vehicle dispatching and relocation, as well as staff scheduling and rescheduling.

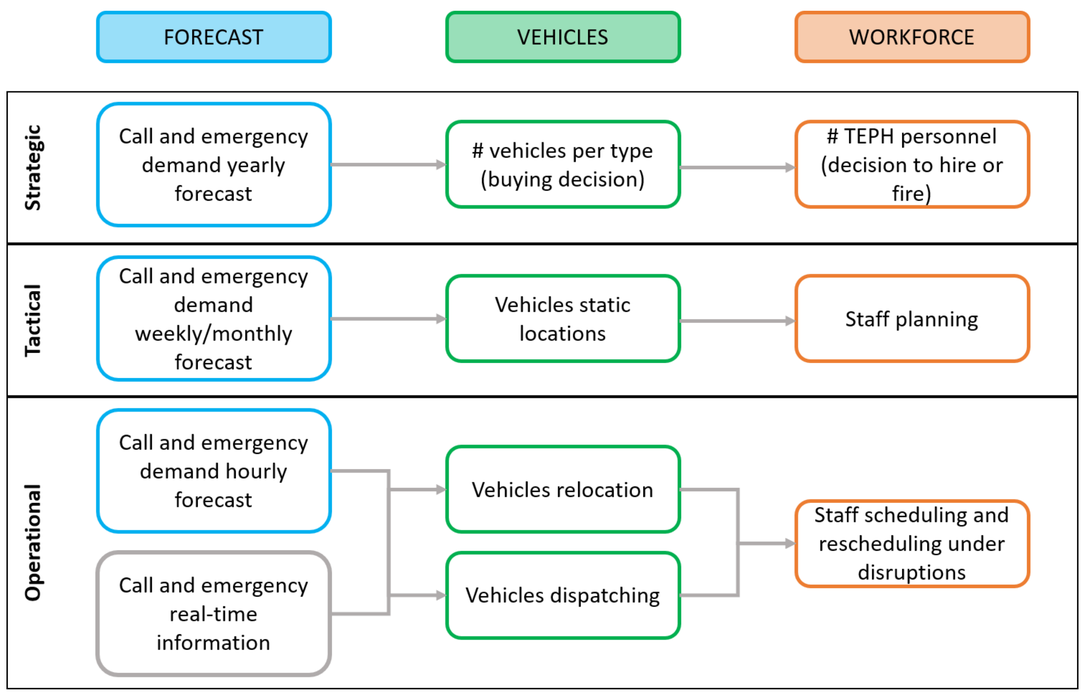


FIGURE2: Decision levels and interdependence between planning problems