Kansas City Operations Analysis

Demand analysis

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This document is the first of three analyses on Kansas City (Missouri) ambulance services operations. From data provided by the Metropolitan Ambulance Service Trust (MAST), we analyze historical demand in order to extrapolate future demand. In this short paper, we share our observations and explain our methodology. The resulting demand curves will be used as a basis for schedule analysis.

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Introduction

The objective of this analysis is to review the demand for ambulance services of Kansas City Missouri. This analysis is based on data supplied by the Metropolitan Ambulance Service Trust (MAST). The analysis is limited to data manipulation to establish trends. All comments that are made are based on observed data behavior.

This analysis approaches demand at three levels: annual, monthly and daily. This systemic approach is used to establish trends which then allow us to construct a real demand curve. The most challenging aspect of demand analysis is to distribute demand in the most realistic way possible. This is particularly difficult in emergency medical services because of the non repetitive nature of call demand which while having general similarities will, for multiple reasons (e.g.; climatic, major event, pandemic, etc), not be the same. The challenge then lies in removing the artifact in order to smooth out the demand curve into useful data.

This analysis is part one of three: demand, deployment, schedules. The three analyses together have as an objective to establish the possible improvements to the system design. It is worth noting that all data analysis are limited to what they are, as such, human behavior, specific need and wants are not covered. This is a scientific approach to EMS with science being defined as “science is a mathematical imposition on nature” A. Einstein

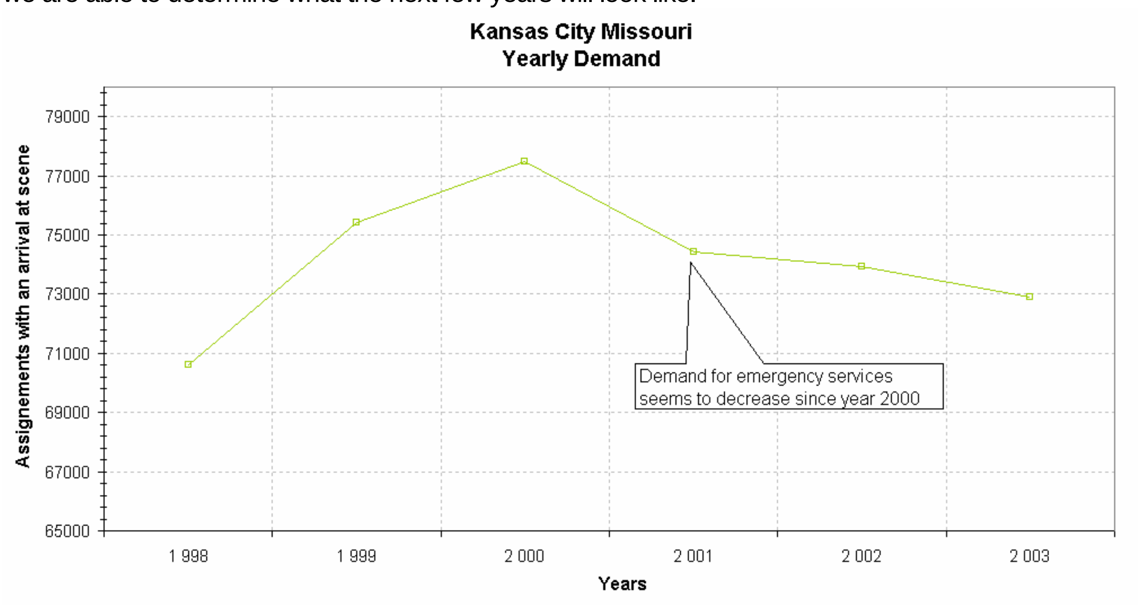
General outline and methodology

The approach that was used in this document was a empirical approach. Thus historical data is used to establish trends, we use these trends to create quality forecasts, the forecasted data is then used to establish real demand. It is important to note that if only historical data is used then the demand that one is working with is passed its prime at the moment of application. This is likened to using a map to see where you have been instead of where you are going. Our objective is to give an overall portrait of the system demand thus allowing the reader to have the full map with the best route possible.

Demand in this document is defined as vehicles assigned that arrive on scene. This definition is possible because there is no significant vehicle assignments that do not arrive on scene.

Yearly demand

Yearly demand is used to establish gross trends, the methodology used is the total amount of annual demand plotted over several years, this allows us to establish the life cycle of the demand for ambulance services and situate the demand in one of three categories: upward trend (increasing demand), downward trend (decreasing demand), or flat trend (demand is stable). It is worth noting that with five years we cannot establish a full life cycle of a service but we are able to determine what the next few years will look like.

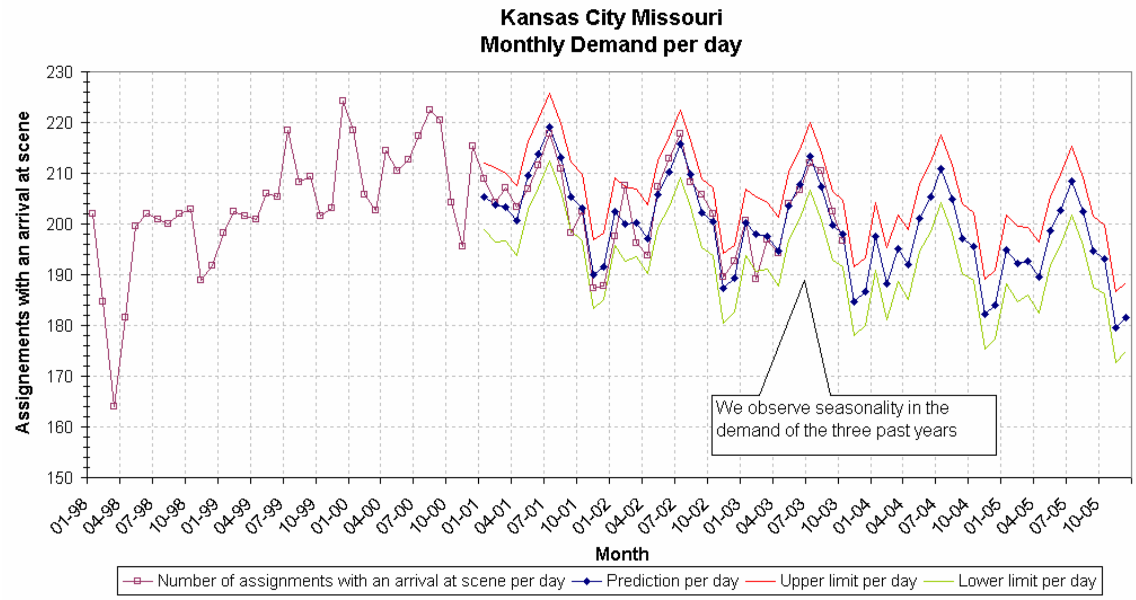


- Figure 1 – Kansas City Missouri yearly demand

In Figure 1, we can observe a significant increase in demand can be observed from 1998 to 2000 approximately 9,1% with the majority of the increase coming in the first year (8%). In the last two years the decrease in demand has been, 0.7 % and 1.4% respectively on top of which over a five year cycle we can observe a 2,7 % increase which allows us to determine that the relative value of the demand is stable. Note that the increase leading to the year 2000 can be explained by the millennium phenomenon.

Yearly demand established as a monthly value

Monthly demand is used to establish seasonal consumption patterns that take into account demographic rifts based on vacation patterns, industrial holidays, etc. This allows for the general behavior of the ambulance system throughout the year. Monthly demand is established as the average assignments with arrival on scene per day for a given month.

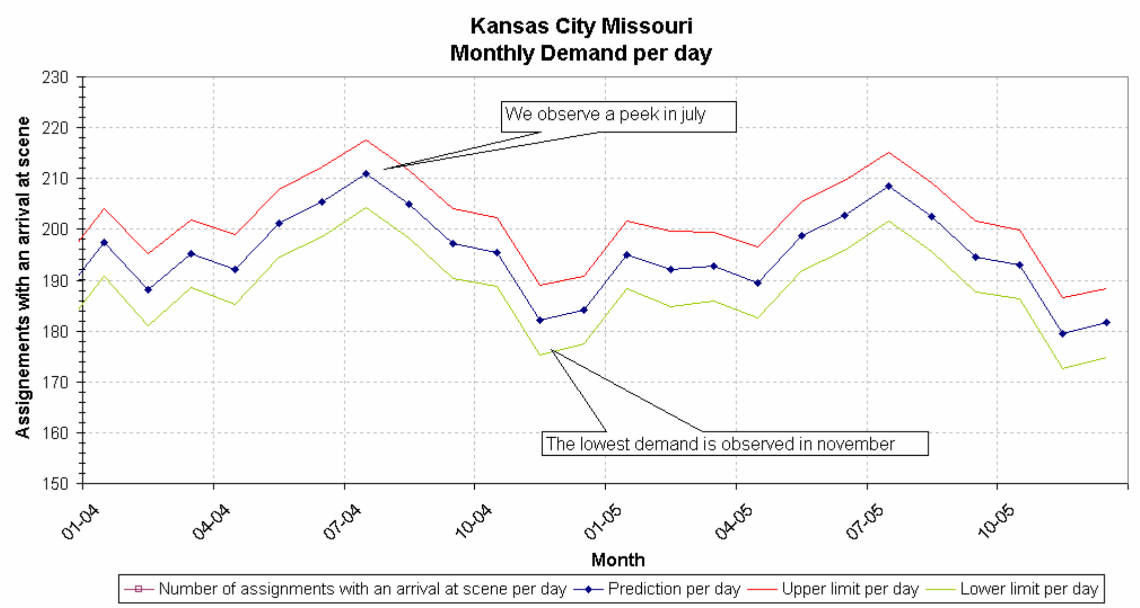


• Figure 2 - Kansas City Missouri monthly demand per day

This graph not only plots the historical monthly demand but uses a forecasting method to plot the demand until 2005. The limits of the forecast are established using the average and the standard deviation of the past three year. We use the Winter's method to do the forecast (Winston 1994).

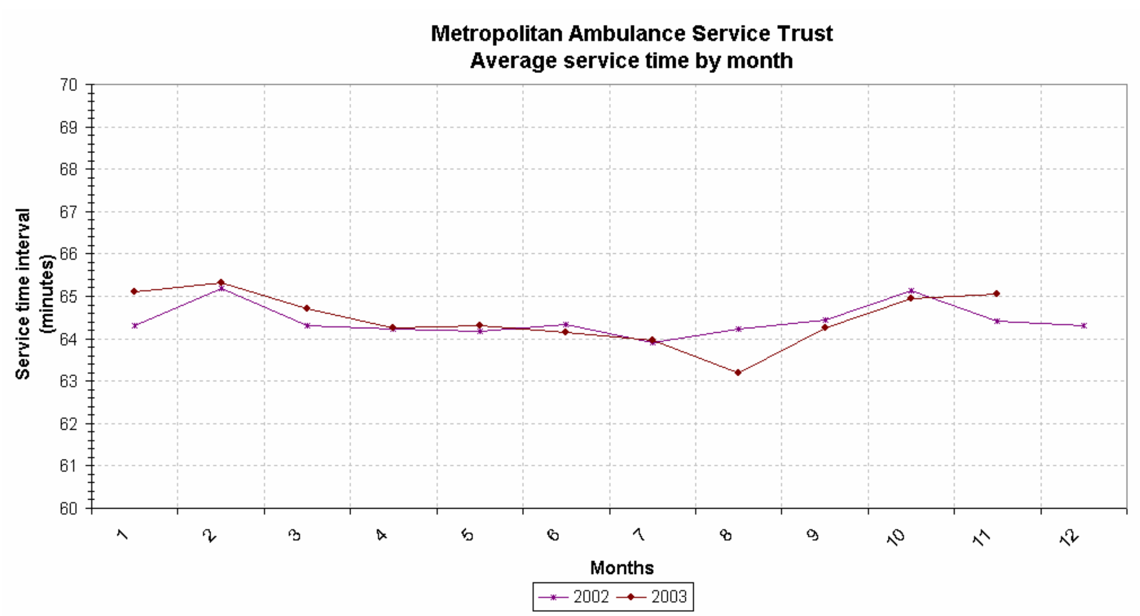
Monthly demand

Using the projected demand we can clearly observe seasonality. July is the highest month for the Kansas City Missouri (KCMO) operation and November the lowest demand month. It is possible to cut a year in two parts. The high demand is from May to October and the low demand from November to April.



• Figure 3 - Kansas City Missouri monthly demand per day

There is a clearly observable difference in demand from the high to the low season. The gap is situated at 16 assignments per day on the average for 2003 (or 7.5%). While it is a note worthy shift in demand the fact that the high season is situated in the summer months means that the increase in demand may not necessarily translate into increase needs for paramedics due to the fact that in general time on task in the summer is shorter This is seen in the graph below where we can observe a two minute shift of consumption from the lowest month to the highest month.

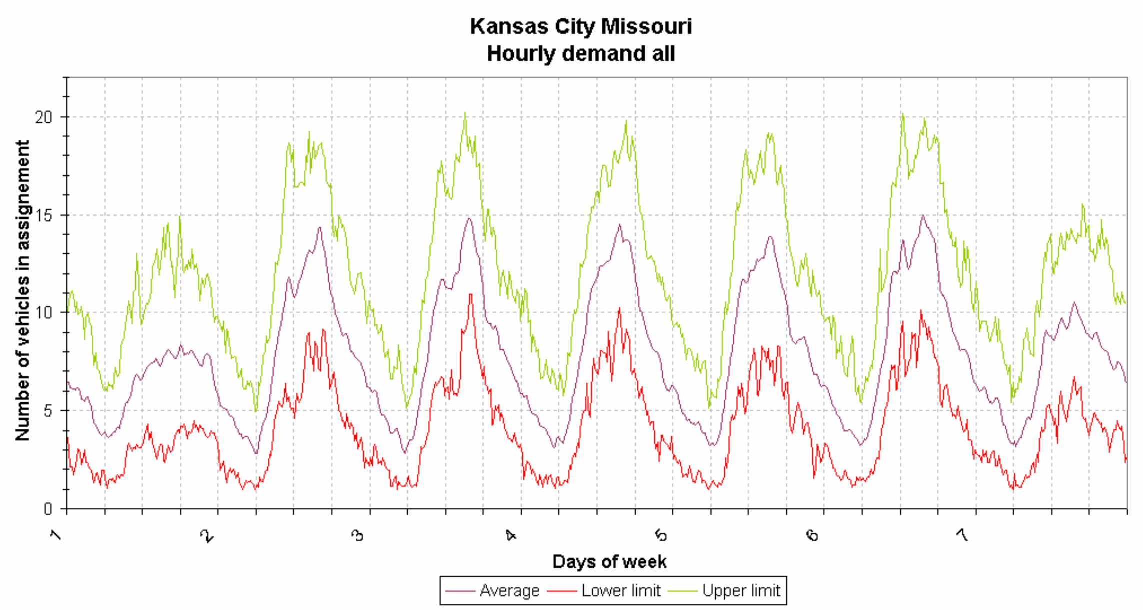


• Figure 4 - Metropolitan ambulance service trust average service time by month

This correlation will be explored more closely in the construction of schedules.

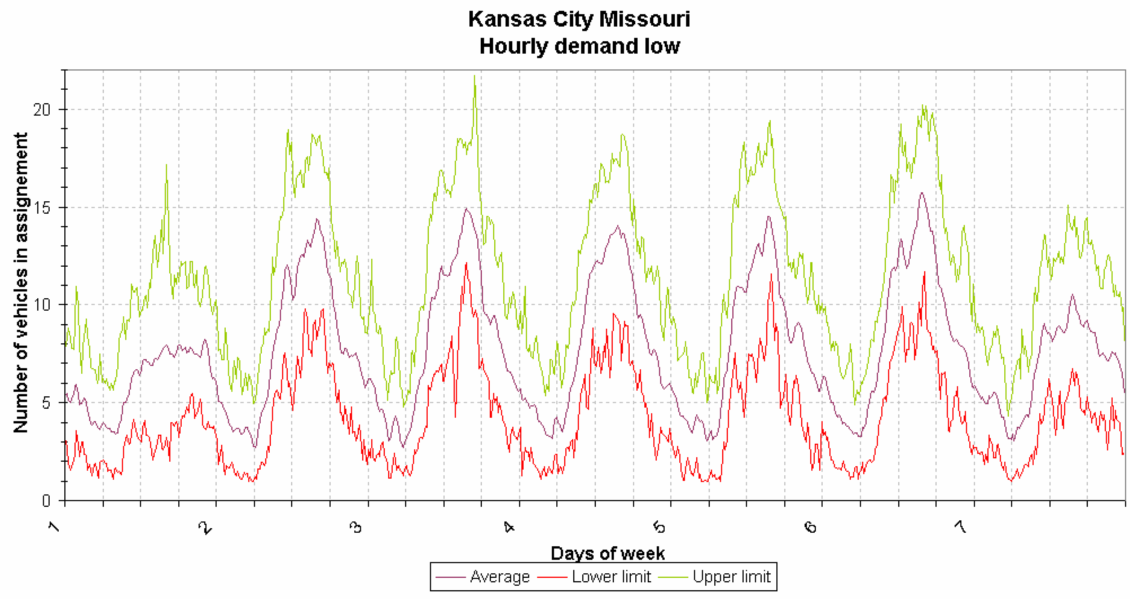
Hourly demand

Hourly demand is defined as the distribution of the demand over a 24 hour period for every day of the week. The same descriptive values apply for all the graphs: the upper limit covers 95 % of the days, the lower limit covers 5 % of the days and the other line is the average. The graph starts day one as a Sunday and day seven as a Saturday we can thus observe that there are two distinct demand weekdays and weekends. This being true there is little difference between the days of the week and that is also true for the two days in the weekend.

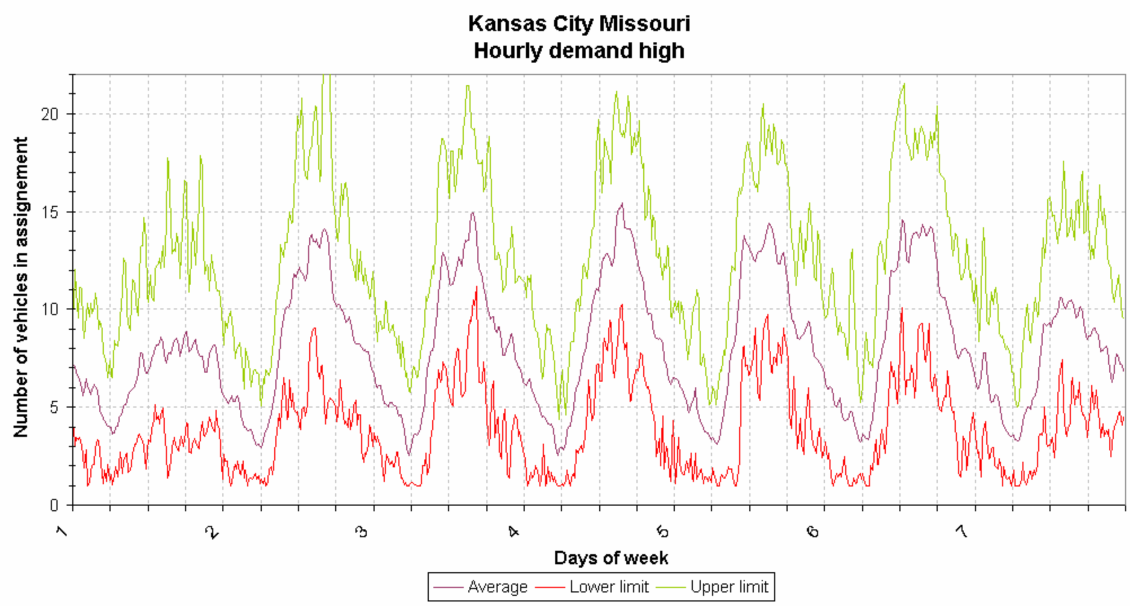


• Figure 5 - Kansas City Missouri hourly demand for one year

A certain number of observations can be made between high and low season on the hourly demand as we analyze the data. We can see that the significant change in demand is situated at the upper and lower limits but when we use the average high and low seasons hourly demand curves (9) we observe little change.



• Figure 6 - Kansas City Missouri hourly demand for low demand months



• Figure 7 - Kansas City Missouri hourly demand for high demand months

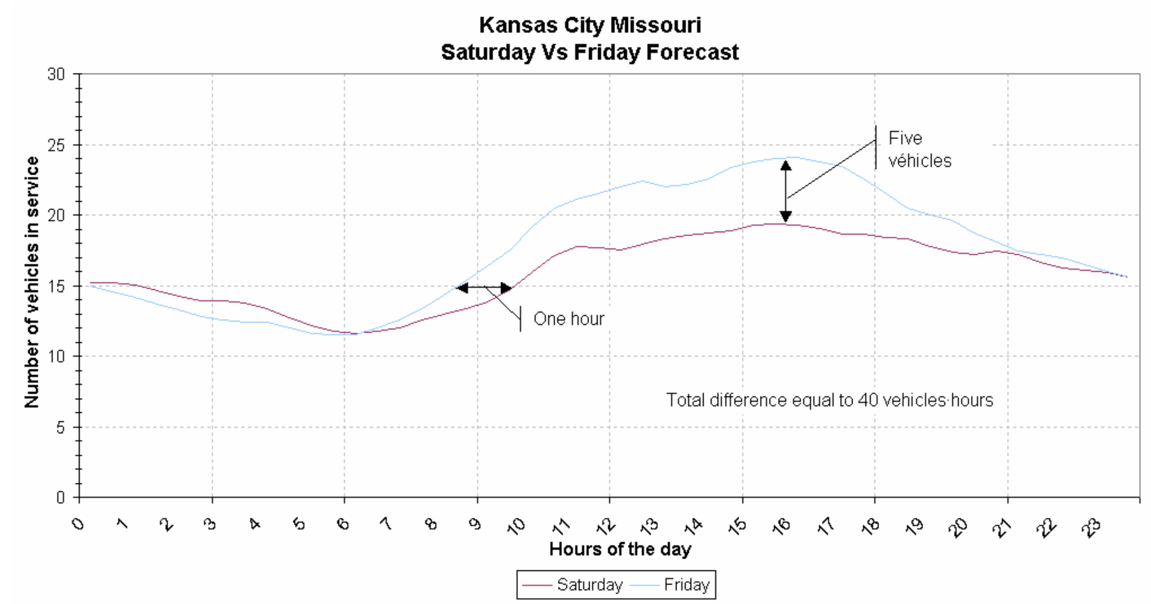
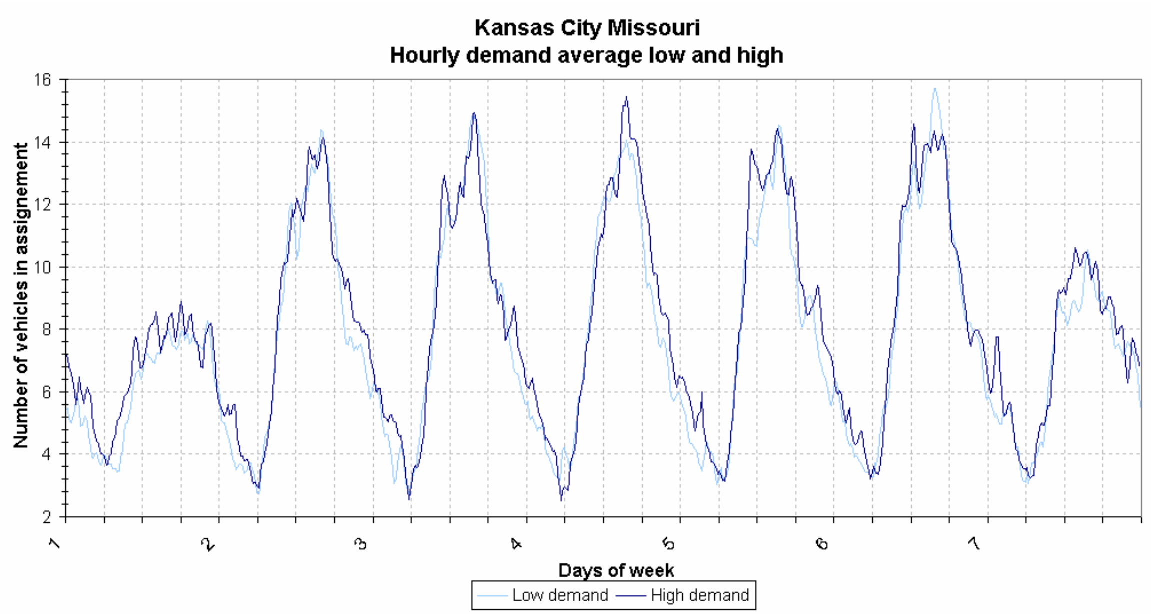


Figure 8 - Kansas City Missouri hourly demand comparison between a Friday and a Saturday

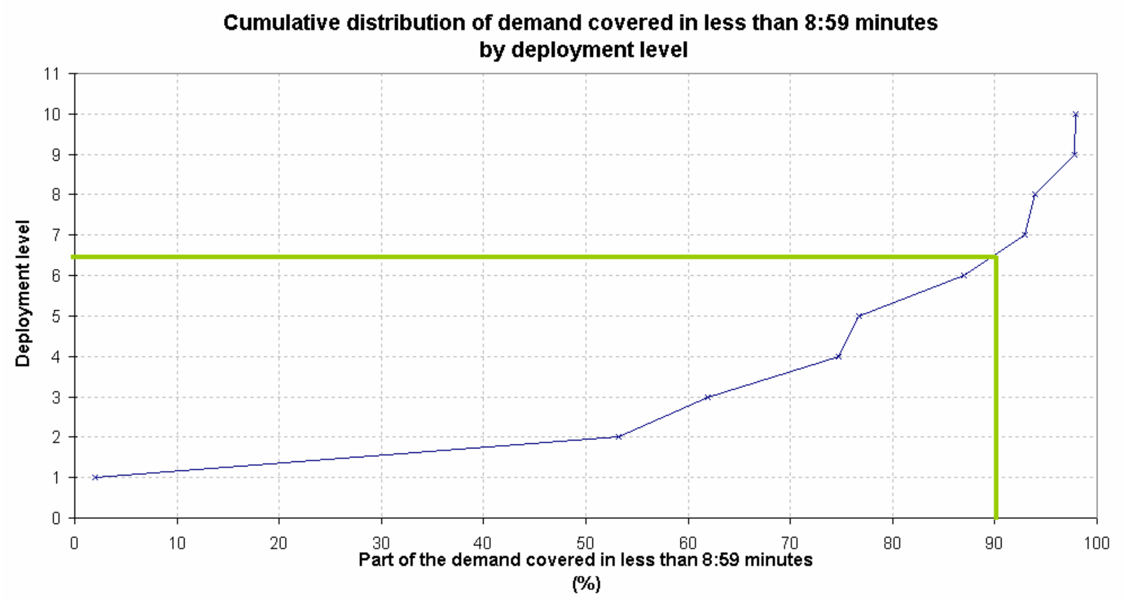
As can be observed the shift in demand from weekday to week end is approximately five vehicles per hour this is equivalent to forty hours a day less consumption from weekend to weekday



• Figure 9 - Kansas City Missouri hourly demand average for high and low demand months

Stand-by coverage

A major component of response time in roving deployment otherwise known as street corner deployment is the systems ability to cover specific stand-bye. As such using a GIS analysis (further developed in the second part of the project) we are able to determine the required amount of ambulances that must be available on specific street corners to yield the desired response times. As can be observed in Figure , with 7 ambulances on stand-by we can respect the 8:59 minute objective in response time 90% of the time.



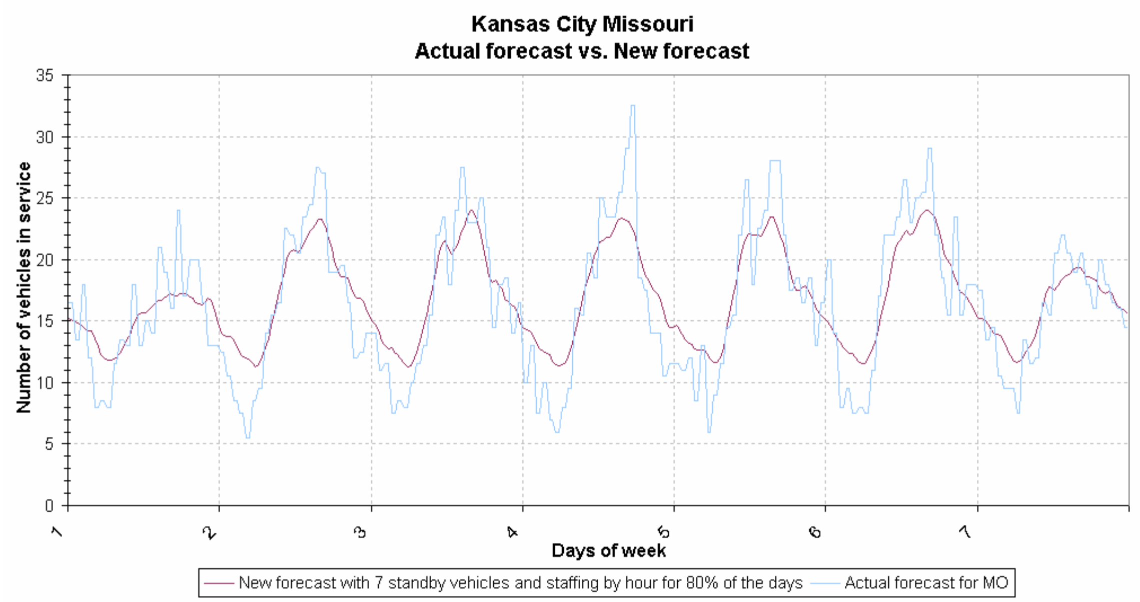
- Figure 10 - Cumulative distribution of demand covered in less than 8:59 minutes by deployment level

This graph does not address the amount of ambulances that must be available in order to cover the seven stand-by points. This is easy to understand that ambulances that are clustered together do not yield the same response times as properly distributed ambulance. This is the difference between trying to pick up a ball with a closed fist rather than an open hand it is obvious that while you have the same amount of fingers you do not attain the same result.

Prior to the construction of schedules the amount of vehicles necessary to cover desired stand-bys will be established

Hourly demand for planning

Using all the prior data we are able to remove the artifact of the demand curve as seen between the difference of the analysis done by the service today and that which is constructed using a smoothing method. When all the different trends are incorporated into one analysis it has the effect of shaving the extremes off of the demand. If we compare the two demand curves we notice that the new demand curve has a usable rhythm. Interpreting data is similar to interpreting cardiac rhythms on a monitor, the first step is to remove the artifact so as to have a usable rhythm, we then convert this rhythm into a usable schedule. The demand that is demonstrated below is a demand that is constructed with 7 ambulances on stand-by and 80% of the days covered by this demand. It is obvious that the more days that are covered the more the system cost is high. During schedule analysis, we will have to come back here and take decisions about the number of ambulances on standby and about the percent of the days covered. Those are management decisions that are dependent of the client wishes



• Figure 11 - Kansas City Missouri actual forecast compare to our forecast with standby level 7 and demand satisfaction for 80% of the days

Conclusion

Using a scientific approach to Demand and incorporating recognized trending techniques we where able to establish a demand curve that has a repetitive pattern and is more likely to protect against the absence of available ambulances to respond to life threatening calls . In general, the Kansas City (Missouri) ambulance service is living through a flat demand cycle. This should remain true for the next couple of years based on the data analyzed. We can also state that while there is a shift in demand due to seasonality, that it is somewhat offset by the decreased time on task. It is also clear that there is not significant enough difference between the days of the week to adjust to the specific days, it is possible to have two demands weekday and weekend Finally, before constructing the schedules, certain decisions must be made but we can state that a singular annual schedule can appropriately follow the demand.

References

Spaite D., Benoit R., Brown D., et al., 1995. *Uniform Prehospital Data Elements and Definitions : A Report From the Uniform Prehospital Emergency Medical Services Data Conference*. Annals of emergency medicine 25, 525-534.

Winston W., 1994. *Operations research: applications and algorithms*. Duxbury Press.