
Kansas City Operations Analysis

Schedule analysis

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This document is the third of three analyses performed on the ambulance services operations of the Metropolitan Ambulance Service Trust (MAST). From data provided MAST, we analyze historical needs for ambulance units to create schedules for paramedics. In this short paper, we share our observations about the actual schedules and create new schedules base on the need for units that was established in the first two reports.

Kansas City Operations Analysis

Schedule analysis

Introduction

Schedule analysis is the conjunction of system need and the ability of individuals to deliver the services the system needs. As seen in the two previous sections, the system has specific needs and to this we must design an ambulance operation schedule that is both cost effective and viable from the perspective of the personnel who must staff the ambulances.

This analysis uses the system norms, the descriptive value of a schedule, the ergonomics of a schedule and the cost in hours of a schedule to propose ambulance operational schedules that meet the optimal conjuncture of these four points. It must be understood that what are proposed are scenarios or options. It goes without saying that schedules need to be negotiated with the personnel that are going to live them in order to assure that the selected schedule is allows an acceptable quality of life for the personnel who will staff it.

This report is the third of three analysis. The first was demand analysis, the second a geographic deployment analysis. The sum of the three give an overall appreciation of the system design from a third party's point of view. This remains a theoretical analysis serves as a factual foundation for future discussions.

System Norms

As defined by contractual obligations the system is designed as follows

Territory	Objective (operational standards)
Kansas City, Missouri	A response time 8 minutes 59 seconds in 90% of priority 1 calls
Sub sections	A response time of 8 minutes 59 seconds in 85% of priority 1 calls

As was evaluated in the geographic deployment analysis, the system response is adequate on both accounts. It was determined that in theory with 7 vehicles on stand-by the system is able to achieve the desired response time. It was also determined that in reality it takes anywhere from 11 to 18 vehicles on duty to attain the same level of response. As such all schedules scenarios were constructed using 7 and 11 vehicles.

What is a Schedule

A schedule is composed of multiple work shifts that start at a predetermined hour and finish at fixed hours. All shifts have predetermined length of times awarded to them.

- Each shift has a predetermined lunch break within one hour of the median hour of the shift.
- Each Lunch break is 40 minutes in duration, during which time the ambulance crews are not available for calls.
- Shifts starts are staggered through out the twenty-four hour period (taking into consideration the ergonomics of a schedule), to allow for territorial coverage and shift break coverage.
- All hours in a shift do not have the same value as shifts have an end-of-shift close-out period of 15 minutes during which time the crew is not available for response.

A schedule is optimal when it covers the demand curve at the desired level and while respecting the non-availability of the shifts.

Ergonomics comments about schedules

This section presents general comments about shift work ergonomics. These will be the guidelines used to help us increase the quality of the schedules for Kansas City. It is important to understand that virtue is good to know but is not always (possibly never) possible to apply to 24/7 operations. The following comments are broken down into three sections: comments regarding the sequence of shifts, comments regarding the duration and distribution of working time and comments regarding the position of working time (start/stop of shifts).

Comments regarding the sequence of shifts

Consecutive shifts

It is important to note that early morning shifts in succession have similar effect to night shifts, that is, to cause sleep deficit accumulation. On the other hand, evening shifts have the effect of reducing social contacts for the workers.

To reduce problems with circadian rhythms and to reduce sleep deficit accumulation, we recommend that an organization avoid more than three night, morning or evening shifts in succession. It is obvious that this recommendation is almost impossible to respect in the delivery of ambulance services. A special attention will be placed on night shifts because night work is known to be difficult for the team. It is also important to pay attention to an aging work force because they seem to be less tolerant of night work.

Days-off

It is well known that a single work day between days off is not appreciated by shift workers. This causes a disruption of useful leisure time. This is well respected by the actual schedules. The patterns that will be used to build the schedule will adhere to that rule.

Comments regarding the duration and distribution of work time

Consecutive work days

It is recommended that schedules entail a maximum of seven consecutive work days. This is well respected by the actual schedules. We will continue to respect this rule

Duration of a shift

Shifts that are longer than 8 hours can increase the accumulation of fatigue, accidents and can potentially have long-term health effects. For that reason, we will use a mix of 12 hour and 8 hours shifts in our schedules.

Time off between two shifts

Between two shifts, there should be adequate resting time (>11 hours). For this reason, the 12 hours shift is the longest acceptable shift type.

Comments regarding the position of working time

Start of morning shift

Morning shifts have an optimal starting time and may not start too early (i.e. 6:30 h is better than 6:00h, 6:00 h is better than 5:00 and so on). Starting too early has the effect of reducing sleep.

End of evening shift

Evening shifts have an optimal terminating time as such shifts should not end too late. (i.e. 22:00 h is better than 23:00 h, 23:00 h is better than 24:00 h, and so on). Ending too late has the effect of reducing sleep and social contact.

End of night shift

Night shifts should end as early as possible. This stands up to intuitive logic and is defended by our natural desire to sleep during the night hours so the schedules used will end as early as possible.

Work on weekend

Schedules should comprise some form of week-end down time. Employees need this time to have some form of family life. In most unionized environments, we can observe that senior worker appreciate schedules with two weekends off. This has the adverse effect of having schedules that work every week-end. These schedules are necessarily staffed by more junior employees, who probably really need weekends off because they are more subject to having family responsibilities. Moreover, days off during the week are good for employers because they decrease absenteeism due to weekday activities (for example dentist or physician appointments). Actually, 42 of the schedule blocks utilized by MAST (of 86, or 50%) do not offer any weekends off to the employees assigned those schedule blocks. The schedules that will be proposed will try to correct that problem.

Schedules scenarios

What we will be doing is supplying a comparison between multiple scenarios and the actual schedules. This will allow the reader to determine which is the optimal scenario--considering existing constraints. It is important to note that there are hundreds of permutations and that only some are looked at in this analysis.

The structure of the comparison is to :

- demonstrate the shift in the demand curve,
- compare the cost and efficiency of the schedule,
- demonstrate the attributes of the proposed schedule.

The three schedules that are supplied are

- Equivalent costing schedules
- Ideal response time schedules
- 10minutes 59 seconds for priority 1 schedules

Using demand in schedules

In order to make apple-to-apple comparisons in schedules we must first understand which demand curve we are using. As stated in the demand analysis, the new demand curve is a more realistic demand. It uses a trended technique that cuts out the peaks and valleys of the demand. This allows for a less fragile demand. We will be using this graph as the basis of our comparison so what we will do is adjust the demand curve to the desired result and then superimpose new schedules on it. This will allow the reader to visually discern the advantages and disadvantages to each schedule.

Current Kansas City Missouri Schedules

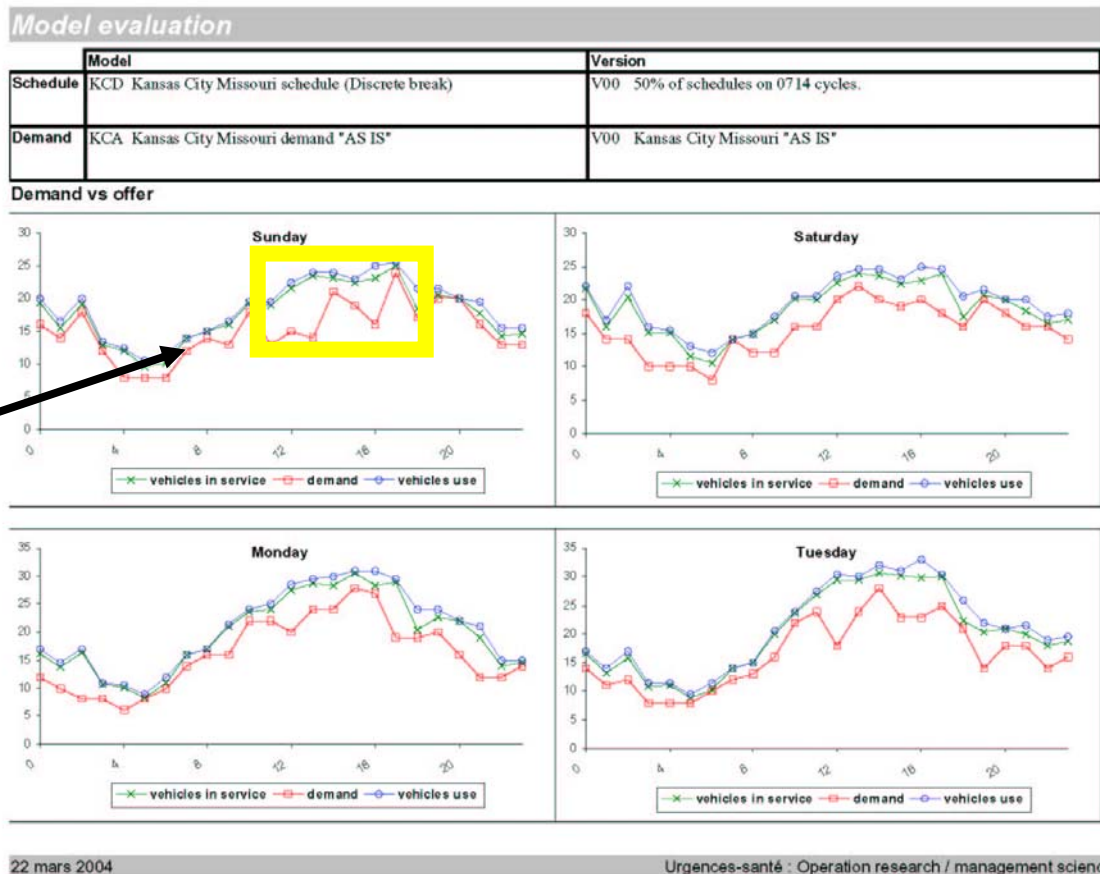
The current, Kansas City Missouri schedules have 86 shifts (80 ALS and 6 BLS).

Shift type	Number of shifts	Days work	Comments
08:30	12	10 work day on 14	2 power car
10:30	23	8 work day on 14	6 BLS

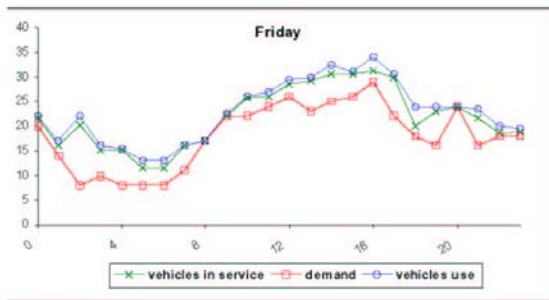
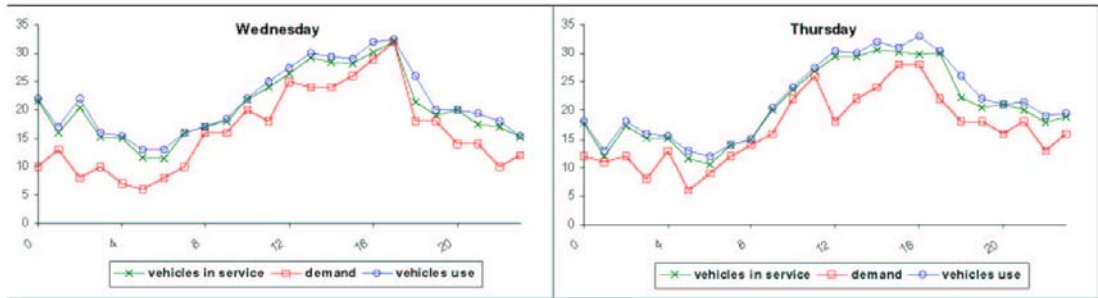
12:00	48	7 work day on 14	
KCI Car	3	5 work day on 14	??

Roughly, we can calculate that those schedule consume 173,827 Unit-hours. If we multiply those hours by 2, we obtain 347,654 man-hours. This will be the basis for comparison with other schedules.

Scenario 1: Actual demand cover with 8 and 12 hours shifts



When making schedule comparisons it is important to talk about schedule inefficiencies as seen here. A schedule's inefficiency is any vehicle in service that is not being used to cover the demand. As can be seen when compared with current demand curve, these schedules have 22% inefficiency (one out of every 4 unit hours is wasted).



Summary

Vehicles-hours:	179 484
Men-hours:	358 969
Schedules total:	186
Vehicles number:	37

Shifts starts by type

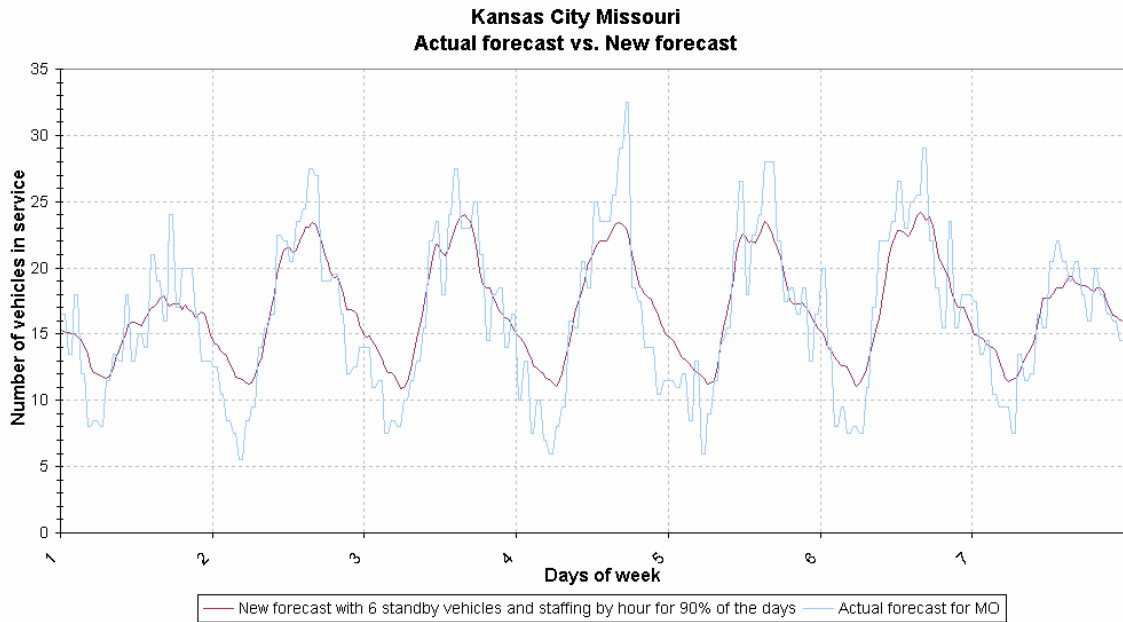
cycle	050	055	060	065	070	075	080	085	090	095	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	Total	
414															1																									5
714			4	6	6		2			2	6															2	2		6	2				4			2	2	46	
1014			2		2				6		2	4	4	4				4		2	2								4	2				2	2	2		42		
Totaux	0	0	6	6	8	0	2	0	6	2	6	4	4	4	1	0	0	4	0	2	2	0	0	0	0	2	2	0	6	9	2	1	0	0	6	2	2	2	93	

Scenario 0: Equivalent territorial coverage.

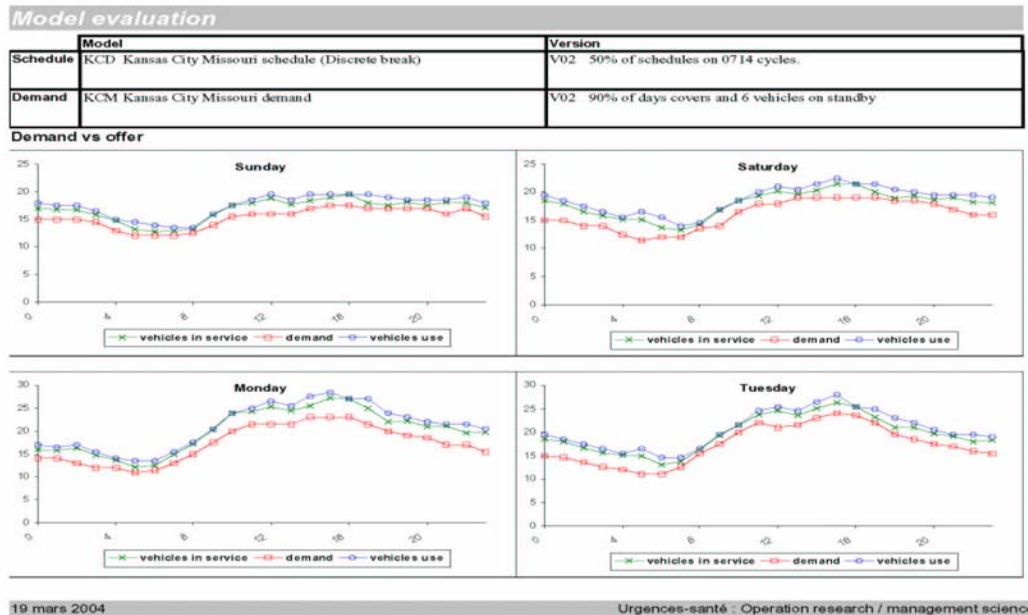
The first comparison is creating schedules with the same cost per schedules as the actual Kansas City schedules. The blue line represents the Kansas City Missouri demand data as it is currently being applied. It is a pure demand model, and as we can see a better distribution of the demand at the same cost will protect against rupture.

By applying a schedule optimization technique we can calculate the most efficient schedules possible for the same cost.

6 vehicles on stand by



This first comparison is to find what schedule options are available at similar cost. What we can determine is that for 3,000 unit hours less per year, we can yield 5,000 more service hours a year.



As seen in the schedules we have only 16% inefficiency versus the 22% inefficiency of the actual schedule. This is mainly because of its smoothness. Thus, for less money we can get superior performance and still maintain ergonomic (worker friendly) schedules.

See appendix 1 for schedule details.

This scenario considers full demand coverage without policy change. It allows for all calls to be covered at the 90th percentile including low priorities

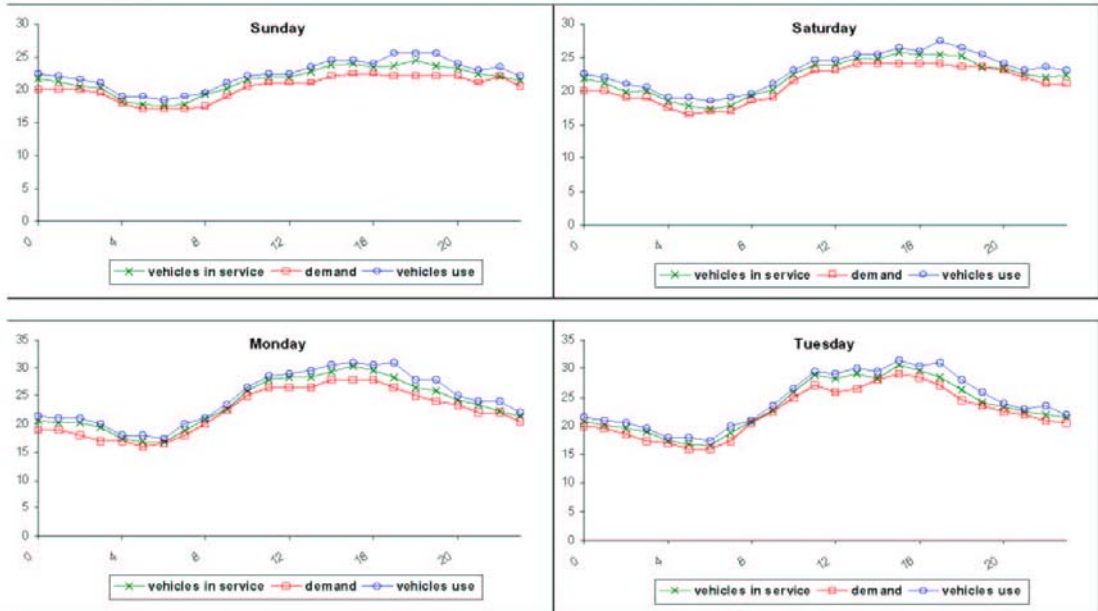
It is a scenario that cost 34,000 unit hours more per year.

This type of schedule may be seasonally useful but has little annual use.

Model evaluation

	Model	Version
Schedule	KCD Kansas City Missouri schedule (Discrete break)	V03 50% of schedules on 0714 cycles. Pareil à V01 mais optimisé à 4% au lieu de 7%
Demand	KCM Kansas City Missouri demand	V01 90% of days covers and 11 vehicles on standby (response in less than 9 minutes)

Demand vs offer

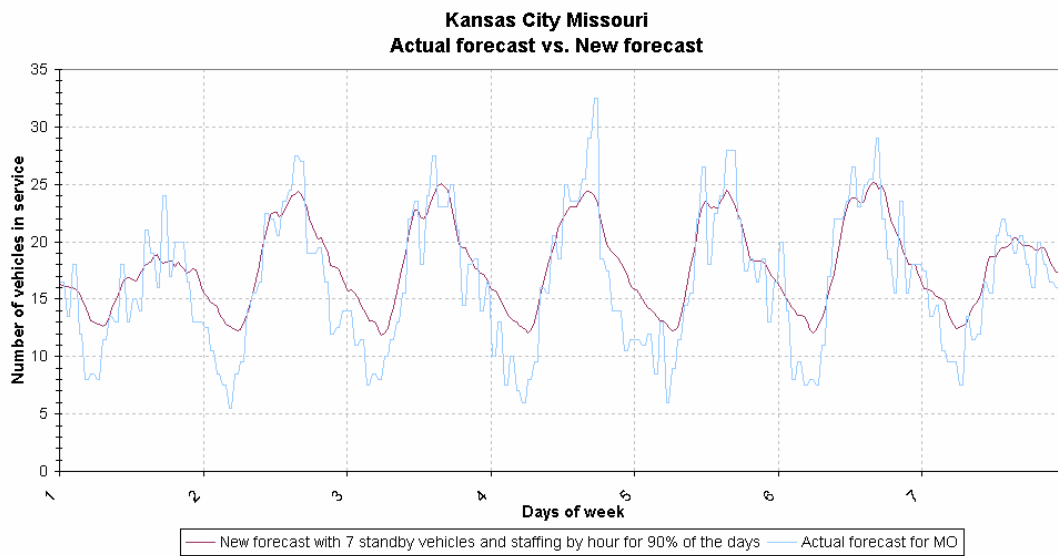


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Scenario 4: 7 vehicles in stand by

7 vehicles on stand by



This is the optimal theoretical schedule. This schedule is based on a 90th percentile on all performance standards, this is not to say that it can be applied as is, but it can yield the 90th percentile system response similar to 11 vehicles on stand-by with significantly less cost. It is a scenario that would require policy and procedure change, but one can visualize the last improvement on the fragility of the current schedules while covering almost the equivalent in peak time.

Schedules scenarios						
Scenarios		0	1	2	3	4
Schedules model	Actual	KCD	KCD	KCD	KCD	KCD
Schedules version	Actual	V02	V00	V03	V07	V05
Demand						
<i>Standby vehicles</i>	0	6	0	11	5	7
<i>Proportion of days cover</i>	?	90%	?	90%	90%	90%
<i>Demand (vehicles hours/week)</i>	2 743	2 833	2 743	3 672	2 664	3 003
<i>Demande (thousand of vehicles hours/year)</i>	143	148	143	191	139	157
Work						
<i>Paid hours (vehicles hours/week)</i>	3 334	3 282	3 442	3 986	3 057	3 376
<i>Paid hours (thousand of vehicles hours/year)</i>	174	171	179	208	159	176
Payroll						
0414	0	3	5	2	3	2
0514	3	0	0	0	0	0
0714	48	52	46	84	50	64
0814	23	0	0	0	0	0
1014	12	32	42	17	28	22
<i>Full time employee on payroll</i>	172	168	176	202	156	172
<i>Part time employee for week-end</i>	0	6	10	4	6	4
Total number of employee	172	174	186	206	162	176
Vehicles						
<i>Minimum number of vehicles</i>	65	32	37	37	34	32
Evaluation						
<i>Differentiel (vehicles hours/week)</i>	0	-51	108	653	-277	43
<i>Differentiel (thousand of vehicles hours/year)</i>	0	-3	6	34	-14	2
<i>Schedule inefficiency</i>	22%	16%	25%	9%	15%	12%
<i>Total cost (million of dollars)</i>	12 168	11 981	12 564	14 550	11 156	12 324
Parameters						
<i>vehicles cost per year (k\$)</i>	100.00 \$					
<i>paramedic average salary per hour</i>	35.00 \$					

Conclusion

In the schedule analysis we can conclude that due to the inefficiency in the demand curve that is currently applied, compounded with the fact that schedules are 22% inefficient, with a decrease in cost of 3,000 unit hours per year the system can increase coverage equivalent to 5,000 unit hours per year. This will correct some of the system deficiencies but even against a theoretical model the system will not respond optimally.

For 2,000 unit hours more per year we can yield 14,000 hours more of service. This is the theoretical threshold of the system, which allows for the vast majority of calls to be answered appropriately while at the same time allowing for ergonomic schedules. To properly maximize these schedules, changes in policy are necessary.

For 34,000 additional unit hours per year, the proposed schedules yield 48,000 additional service hours, which allows for full call coverage at the 90th percentile and with change in policy.

If the desired effect is to reduce the performance standard to 10:59, 90th percentile it can be done at a cost saving's of 14,000 unit hours per year.

- All our schedules have the advantage of being ergonomic.
- Our demand curve can be covered by "schedules" more efficiently than the one actually in use at KCMO. This is mainly because of its smoothness. For the actual demand curve, 22 % of the total hours are lost instead of an average of 13% with the new forecast.
- Eliminating the "walk time" at the end of shift can decrease costs by 4%.
- Our scenario requires fewer ambulances than those done with the demand curve currently in use.