Maximize Operational Efficiencies Through Accurate Deployment of Your Resources

The use of analytic models and tools in the planning and implementation of resources in an Emergency Medical Services (EMS) system allows for greater understanding of the interactions between various performance measures. The end goal of such models is to facilitate the effective and cost-efficient allocation of resources. Although the "science" behind matching supply with demand in EMS has been around for several decades, the tools for doing the analysis in a timely manner have only recently become available.

The History of High-Performance Emergency Medical Services

Research conducted during the 1970's to improve the efficiency of the Nation's EMS system concluded the following; that statistically, EMS demand was highly predictable and as a result, could be responded to with standard production model economics and systems/industrial engineering approaches and techniques. The legitimacy of the findings was enhanced in that the research also integrated the reality of the unique economic challenges of the EMS industry.

In the 1980's, select EMS organizations who continued to be challenged with significant systems problems, decided to rework their operational basis around this research. What resulted after a period of time was the first ever high-performance EMS system (HPEMS). Subsequent to the 1980's, additional systems began to utilize the concepts derived from the research in their own deployment methodology. These real life models have become the foundation of today's modern HPEMS systems.

Economics 101: Products, Supply and Demand

Economics is primarily focused on the issues associated with the production, distribution, and consumption of goods and services. The foundation of this field of study, of course, is the issues of Supply and Demand. Supply is basically the amount of something that is available to be consumed. Conversely, Demand is the quantity of some "thing", whether a product or service, that is wanted at any particular time. A common example of this that most of us are very familiar with is the fluctuation in domestic fuel prices associated with OPEC's changes in the production rate of crude oil. As less oil is available to be consumed, prices escalate, as more oil is available for consumption, fuel prices drop. Regardless of the business model, in a perfect world, equilibrium is reached when supply equals demand.

These same concepts apply within EMS. At any one time of the day there is a certain demand for services (calls) and at that same point in time, there is a particular level of supply (vehicles available to respond). The research conducted in the 1970's was unique in that it recognized the similarities between what occurs within EMS relative to supply and demand, and hence, basic economic theory could be applied to understanding how best to get supply to meet demand. To fully understand the relationship however, another very important factor must be taken into account.

Static versus Temporal

Getting supply to equal demand, in itself, is a relatively straightforward exercise if two things occur; the demand is predictable, and the demand changes very little as a function of time. As discussed above, the research conducted in the 1970's concluded the demand for EMS services was statistically predictable. With that solved, the issue at hand now is; how does supply and demand in EMS vary on an hourly basis. To answer the question we must explore the meaning of the terms Static and Temporal.

Things that are Static experience very little change and in most cases do not change at all. An example of something that is static is a building, such as the local library, that never moves and short of being torn down will always occupy the same place in town. Another example would be how fire protection is planned for. Although many cities and towns have some level of growth associated with them, the vast majority of the buildings are static in that their number and location is unchanging. As such, Fire Departments base their fire response and locate their stations around these static objects.

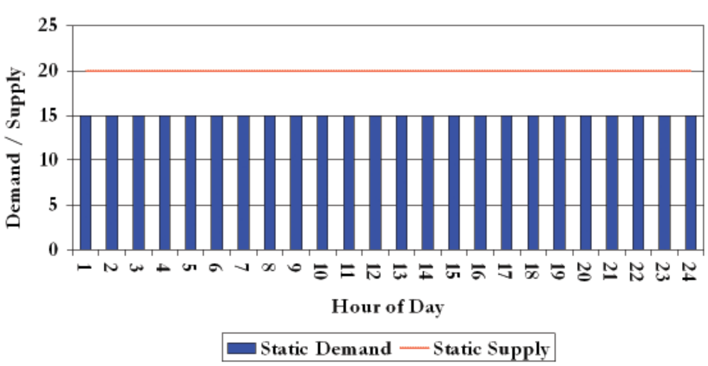
Temporal on the other hand is how things change as time changes. Something we are all too familiar is the issue of rush-hour traffic. Since most people to need to be at work at generally the same time every day and pretty much leave at the same time of day, traffic on the road network is temporal in that it is busy (high demand for road services) in the morning and evening and much less busy (low demand for road services) during the middle of the day or evening. Probably the best example of temporal is the weather where the weather not only changes winter to summer but also can change dramatically through a particular day.

What makes Static and Temporal particularly interesting in the study of Supply and Demand is that both Supply and Demand can be either Static or Temporal. Briefly, they are described as follows:

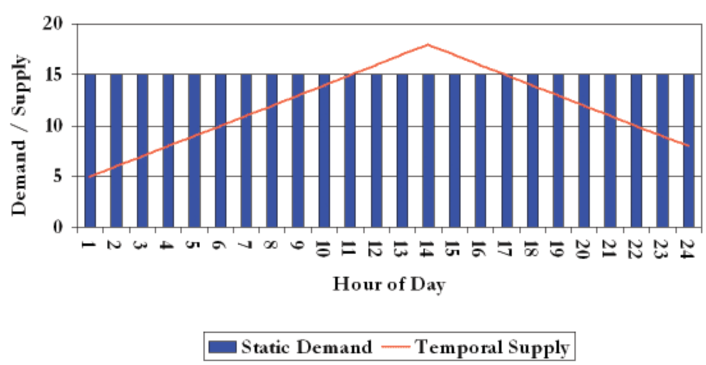
- Static Demand - Unchanging requirements on supply
- Static Supply - Unchanging resources to meet demand
- Temporal Demand - Changing requirements on supply
- Temporal Supply - Changing resources to meet demand

The illustrations below show what the various combinations of Supply/Demand and Static/Temporal look like for the 24 hours of a particular day

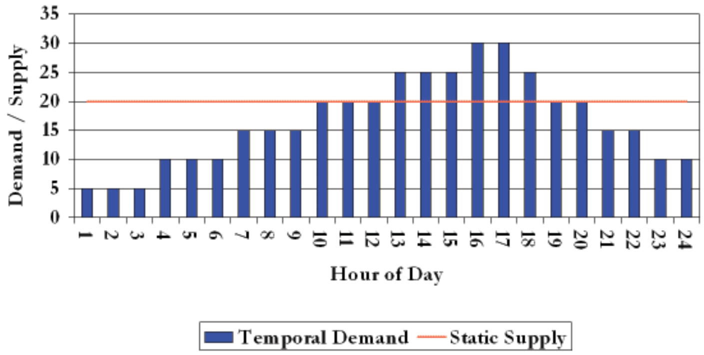
Static Demand & Static Supply



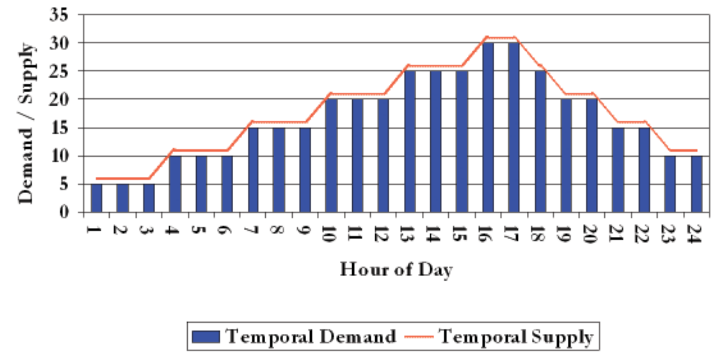
Static Demand & Temporal Supply



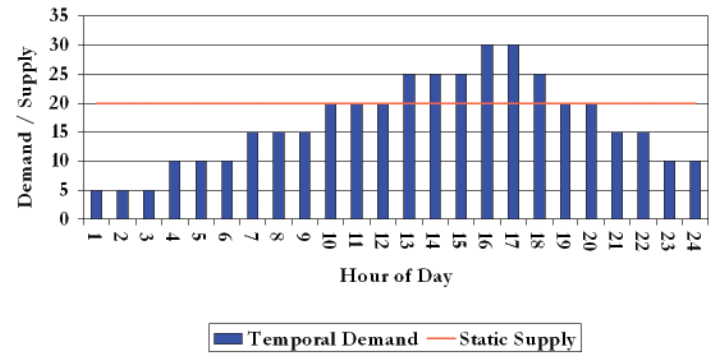
Temporal Demand & Static Supply



Temporal Demand & Temporal Supply

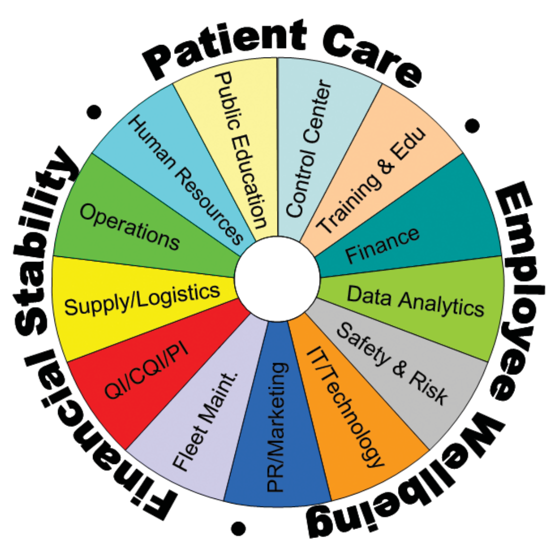


When examining the relevance to EMS of the illustrations above one very important conclusion must be reached. The primary mission of EMS is to provide exceptional medical care to people. And people move from place to place, therefore demand varies by time of day (TOD) and day of week (DOW), hence the important conclusion is that EMS demand is temporal. As such, the optimum relationship of supply to demand for EMS is shown in chart 4, where the two meet. Unfortunately, many times the actual relationship practiced by organizations is that of chart 3, or some variant of that. The pitfalls of that will be discussed later. The epiphany is that EMS systems, in order to meet their changing demands, should vary their supply of ambulances in a manner such that patient care needs are met, the financial stability of the organization is shored, and the well-being of employees is cared for.



Is EMS a Service Industry or a Production Industry?

EMS is a production industry that provides its customers with a level of quality service as an end result of a quality product. So what widgets (or products) do high-performance EMS systems produce? A quality unit hour is the answer. A quality unit hour is an ambulance that is available to the EMS System for one hour that responds to properly triaged calls for service, is produced within a CQI environment that uses modern technology to collect and assess accurate data, is fully staffed, fully trained, fully maintained, fully stocked, properly placed in location and time, properly funded and safely operates within an educated population.



The Quality Unit Hour Concept
Section I - EMS Prodcution Model Theory, II.e.ii.

The EMS Widget: The Quality Unit Hour

A production industry that makes widgets produces and distributes (supply) their goods based on consumer consumption (demand) for their product. They use *analytical tools* to determine how many widgets to make, and where they need to be, in order to meet the needs of the consumer. Good EMS Systems do the same thing. Volumetric demand tells us how many UH's are needed by TOD and DOW and uses a temporal demand analysis. Geospatial demand tells us where UH's are needed by TOD and DOW and uses a geographic demand analysis. So what is actually being predicted here?

Human behavior patterns are quite predictable. These patterns vary by time of day and day of week. EMS systems only need to look at the calls generated by their patients based on their patterns of behavior. From this data, they can predict (based on history) where their population will be and how much service they will need for that hour of that day.

To provide a quality unit hour, an EMS system should utilize different methods, tools and measurements to help determine product quality, quantity and distribution of their goods to the market place. A production schedule is used to determine how many widgets to make based on an analysis of demand for their product. And actual production is used to determine how many widgets were actually produced (or made) by the factory according to the production schedule. Lost production is used to determine how many widgets were actually produced based on the production schedule are lost due to poor product quality.

Actual Production - Lost Production = Effective Production
Or, what is available at the end of the day for consumption after production limitations and quality controls have been applied. Distribution plans are used to determine where the new quality widgets will be geographically sent (shipped) based on customer orders. So how do these concepts apply to HPEMS?

Production Schedules — HPEMS systems (as most do) use a schedule to determine how many QUH's they need to produce by hour of day and day of week based on a temporal demand analysis.

Actual Production — The ability of HPEMS systems to fill their schedule determines how many QUH's are produced by the system.

Lost Production — once QUH's are produced, they may or may not be available to the EMS system for a variety of reasons (lost UH's). These lost UH's are not available to the system for consumption by patients.

Effective Production = Actual Production - Lost Production
Or, what is available at the end of the day to respond to calls after production limitations (inability to fill the schedule) and lost production (lost UH's) are applied. Distribution plans are used to determine where QUH's need to be placed within the EMS system in order to respond to calls within response time limitations based on the geographical demand analysis.

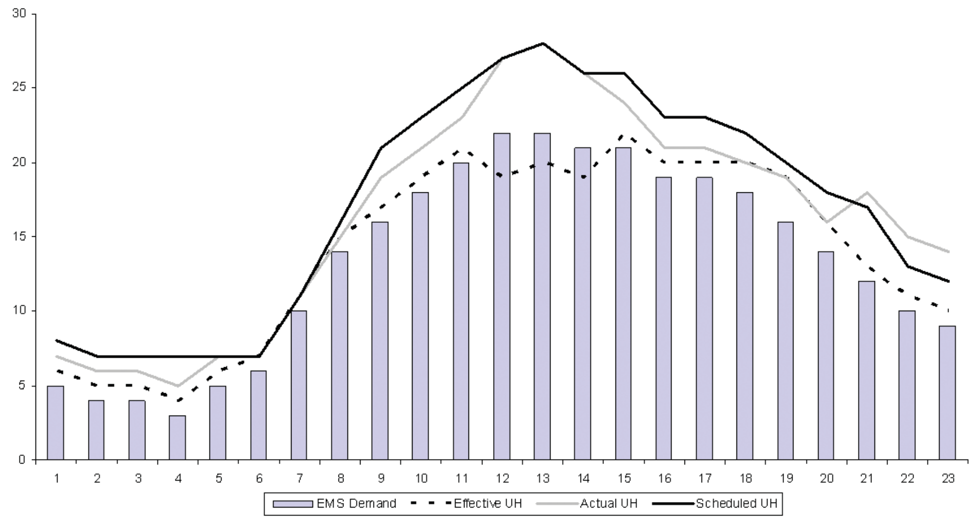
Understanding Production Model Theory

A unit hour is a time-based "product" where quality is directly affected by any system breakdown or failure that takes time away from the unit hour's ability to work in the EMS system. There are also several types of Unit hours; Schedules Unit Hours, Actual Unit Hours, Lost Unit Hours and Effective Unit Hours...

Types of Unit Hours and Measurements

- Static SUH: Scheduled Unit Hours (production schedule)
  - The QUH scheduled for deployment
- Static AUH: Actual Unit Hours (actual production)
  - What on the schedule was able to be filled
- Static LUH: Lost Unit Hours (lost production)
  - What UH were paid for but lost due to various reasons
- Static EUH: Effective Unit Hours (effective production)
  - Static AUH minus LUH = EUH

When plotted, as a function of call demand, the typical relationship between the different types of unit hours is shown in the following graph



The most important take-away from the graph is that Effective Unit Hours will always be less than Actual Unit Hours, which will be less than Scheduled Unit Hours. Much of this is driven by the issues of Effectiveness and Efficiency. Effectiveness is a measure of how close did a particular activity come to reaching the desired outcome. Efficiency is a measure of cost in terms of energy, cost, and time. In other words, did I accomplish what I set out to do and how competent was I in completing the task. For HPEMS, it means doing the jobs in the most timely and safest way possible.

HPEMS Production Problems and Their Impact

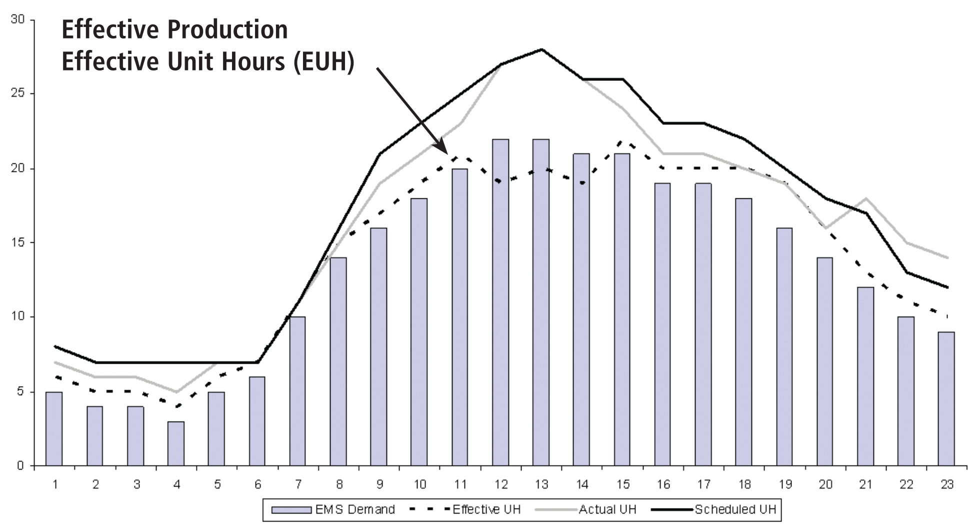
Various issues can come into play to cause problems in the production system of EMS. Errors in **Scheduled Unit Hours** can be a result of the schedule not matching demand, the schedule changed to meet employee needs or just plain inaccuracies in the schedule.

Actual Unit Hours can vary significantly for many reasons. Some of which are:

- Shift trades or shift variations causing over- or under-production
- Headcount/staffing problems
- Poor shift bid procedures
- Call outs/sick personnel
- Mismanaged PTO allowances
- Excessive LOA
- Excessive mid-shift changes

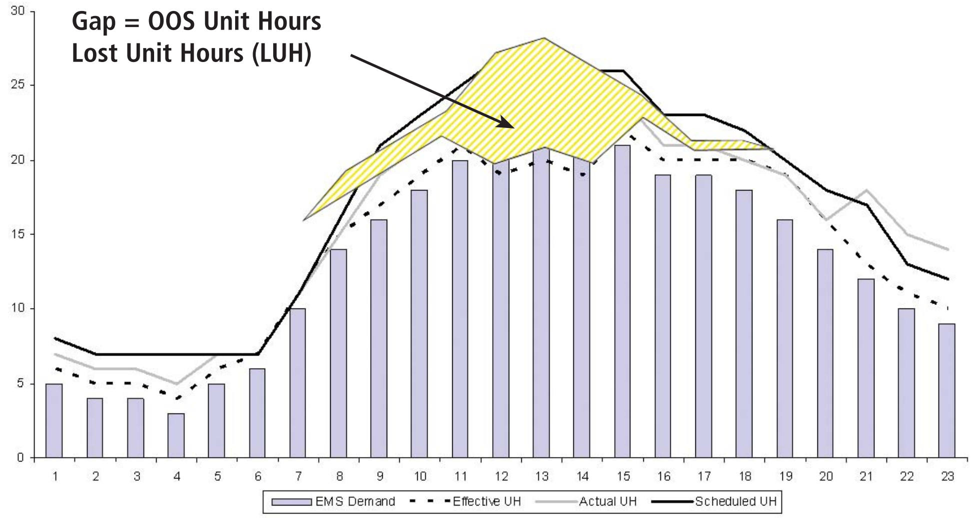
Lost Unit Hours can also be the result of many factors such as labor problems (work slow down), poor logistics such as equipment failures, poor maintenance, or poor mid-shift restock practices; maintenance problems such as fleet failures or a poor PM program; and systems problems such as poor procedures, policies, and practices. Often overlooked or under appreciated is the effect an organization's culture can have on Lost Unit Hours with issues such as employee favoritism, poor work ethic, and morale.

Effective Unit Hours are strongly impacted by LUH. To further discuss the relevance of Effective Unit Hours we will

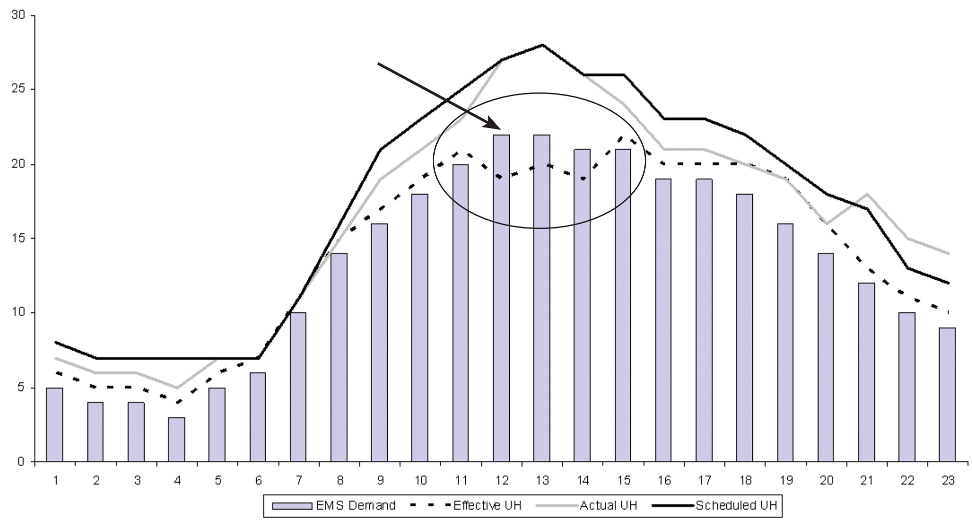


further interpret the graph introduced on the prior page. Shown below is the same graph with the identification of the area of effective production; that is Effective Unit Hours are above Demand for that particular hour of the day.

Here we see the area for Lost Unit Hours or, as was mentioned above, the hours the organization paid for but received no benefit for. In other words, this is an area of inefficiency.



Perhaps the most notable part of the graph is circled below, and one that generally is unacceptable in EMS is an area where Demand exceeds the Effective Unit Hours. The interpretation of this area is that despite an attempt, and plan, to schedule resources of the level of the solid black line, system problems have created a scenario where, due to Lost Unit Hours, the Effective Unit Hours is below the Demand. In this scenario, the system will not have sufficient resources to respond to calls for service.



In summary, most endeavors strive to produce a quality result while minimizing cost. Both of these goals are primarily driven by the issues of efficiency and effectiveness. Within EMS, where an organization is relative to those issues will define the type of delivery system they are operating under. Summarized here is the type of system delivered based upon how the efficiency and effectiveness of the particular organization.

High quality with above-average costs	Effective but inefficient
Low quality with below-average costs	Ineffective but efficient
Low quality with above-average costs	Ineffective and inefficient
High quality with below-average costs	HPEMS systems: effective and efficient

Only by adopting the methodologies of High Performance EMS will an agency achieve the best of both worlds; delivery of high quality medical care and a profitable business model.

The Anatomy of an EMS Call and the Ability to Alter System Effectiveness and Efficiency

Inefficiencies can be caused by a number of factors at the following points in the response sequence:

- Call Received - bad address, failure to confirm patient is with caller, etc.
- Unit Selection -inadequate unit availability, poor placement of units, poor selection, etc.
- Unit Alert - alert initiated too late, communications failure. etc.
- Ongoing/Continued Monitoring - unacknowledged timer prompts, failure to pay attention to the system, etc.
- Unit En Route - slow out of chute, vehicle failure, traffic, MVA, etc
- On Scene - poor/inefficient scene procedures, Inadequate staffing of pick-up facilities, etc
- Destination Selection - hospital diversions, desired facilities more distant
- En Route Destination - lost crew, poor route selection, etc
- Arrive Destination - inadequate staffing of facility, cumbersome info exchange, etc.
- New Post Assignment - wrong post, delayed assignment, encountered call en route, etc

Temporal Demand Analysis and Peak-Load Staffing Models

What is a Temporal Demand Analysis?

A Temporal Demand Analysis (or TDA) is an analysis of arrayed and aggregated historical call volume by week, hour of day and day of week. It is used to help predict and determine the number of Quality Unit Hours needed (demand) for each hour of the day and day of week.

When completed, the analysis will provide staffing needs for a total of 168 hours (total number of hours in a week). From this analysis, a peak load staffing schedule can be built to match the prediction model (matching supply with demand).

Temporal Demand Analysis Fundamental Assumptions

- Assumes each call takes one hour to complete (1:1 S/D Ratio)
- Needs to be adjusted to each system accordingly
- Use Task Time to adjust as needed if average is >< 60 minutes
- Systems with lower task times require less resources
- Systems with higher task times require more resources

Data Set Characteristics

- Bad in/bad out concept
- What to measure and why
  - Requests, responses or transports?
  - Call priorities to include or exclude
  - Standby/special events

- Multi-unit responses
- Other variables (CCT, specialized units, special calls, special circumstances, etc.)

Other Things to Consider

- Desired response time reliability percentage
- Inefficiency (LUH) buffer / cushion
- Call volume seasonality
- Some "Art" (SWAG)
  - Response time requirements
  - Response time zone balancing requirements
  - Effects of city infrastructure (or lack thereof)
  - Effects of traffic patterns
  - Effects of political "Posts"
  - Effects of other unique system anomalies

The temporal demand analysis results in telling you how many quality unit hours need to be produced by hour of day and day of week. Each hour of each day will have its own number for a total of 168 production/demand requirements. You build your "production schedule" to match these numbers. Keep in mind this is the optimal requirement. It is very difficult (if not near impossible) to create a schedule that exactly matches the demand requirements. The **best** schedule-to-demand matching is typically +/- 2% to 3% variation.

Building a Schedule to Meet Demand

Peak Load Staffing - A Balancing Act

If done improperly, scheduling can cost an EMS system tens to hundreds of thousands of dollars. It also has the largest impact on employee well-being of any HPEMS concept/approach/theory, and patient care can be compromised if it's not executed properly. But if scheduling is done properly, it can save a system tens to hundreds of thousands of dollars (or more). It can also provide employees with shifts and options never before available, which improves employee satisfaction. And if done properly, it can significantly improve patient care.

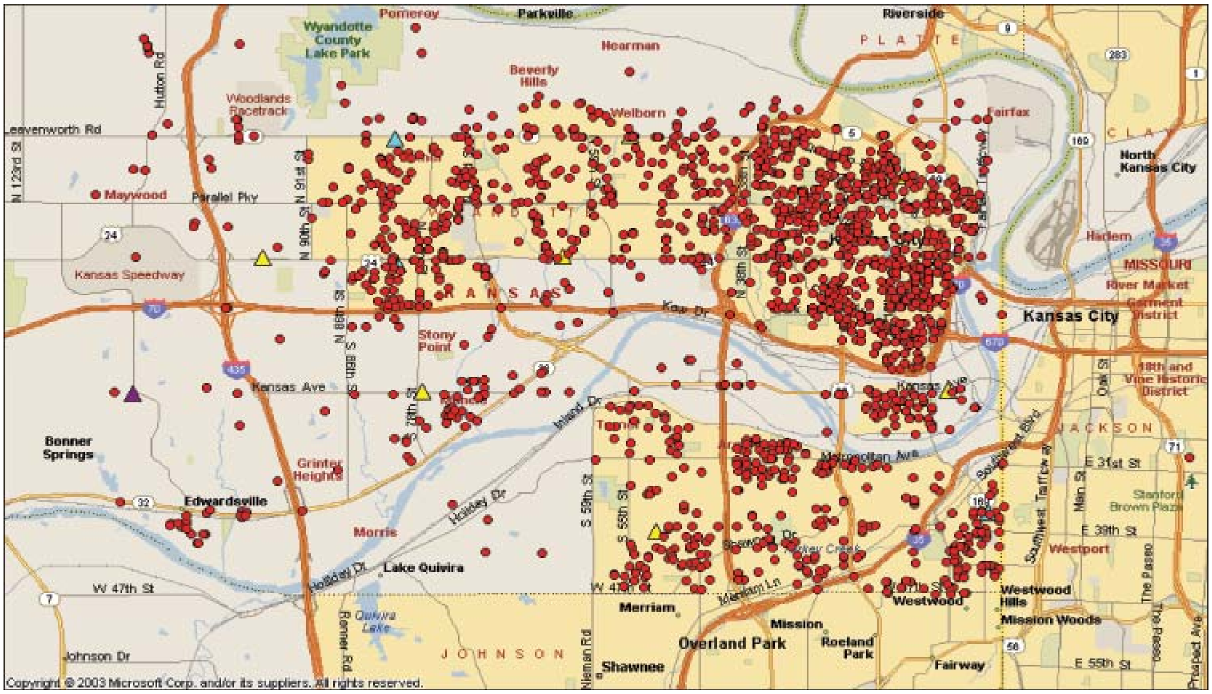
Important things to remember when building a schedule:

- Start of shift and end of shift policies
- Fleet/supply/logistics capacities and reserves
- Simultaneous shift starts and ends
- Headcount/headcount/headcount
- Work rules and policies
- Internal and external politics
- Employee input and participation is NOT optional
- If employees are left out, your HPEMS project is at serious risk

Employee Input and Participation is a MUST

Creating an employee scheduling committee is a good tool to foster participation. Ideally, the committee should be a diverse group reflecting as many special interests as possible (high seniority, low seniority, parents, singles, single parents, etc.) but limited to no more than four to six people. The committee's purpose is to obtain input from all stakeholder groups.

Geographic Demand Analysis and the Posting Plan



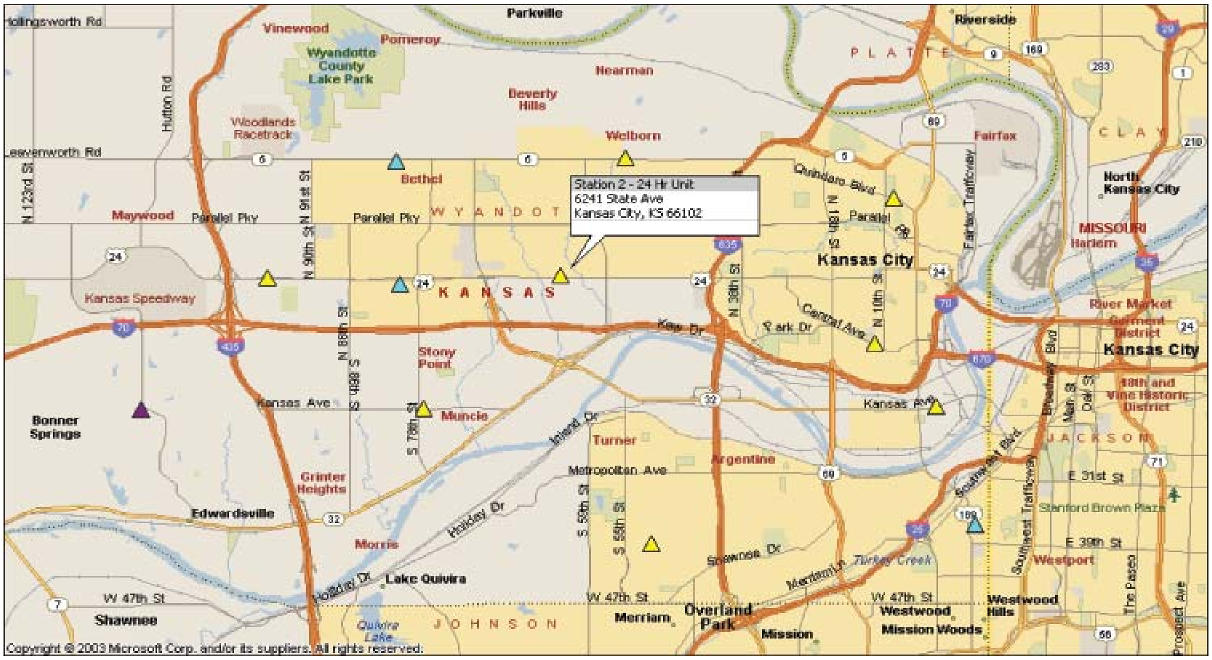
A *Geographic Demand Analysis* (GDA) is used to assess the spatial patterns of call volume by hour of day and day of week. It is a scaled map of calls layered over a map of your service area. This tool is then used to build your vehicle deployment posting plan.

A *Posting Plan* is an algorithm used to determine where ambulances should be placed in the system based on demand, by hour of day and day of week. It uses a combination of available unit levels and post prioritization to deploy resources in the most efficient and effective means possible.

Day: Monday
Time: 06:00 - 07:00
Scheduled Units: 15
NECOL: 7
Call Up Level: 2

LEVEL \ PRIORITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	16														
2	16	17													
3	16	17	61												
4	16	17	61	40											
5	16	17	61	40	55										
6	16	17	61	11	55	3									
7	16	19	61	11	55	3	23								
8	16	19	61	11	55	3	23	41							
9	16	19	61	11	55	4	23	41	15						
10	16	19	61	11	55	4	23	41	15	25					
11	16	19	61	20	55	4	23	41	15	25	40				
12	16	19	61	20	55	4	23	41	15	25	40	52			
13	16	19	61	20	55	4	23	41	15	25	40	52	10		
14	16	19	61	20	55	4	23	41	15	25	40	52	10	43	
15	16	19	61	20	55	4	23	41	15	25	40	52	10	43	18

A **Post** is a geographic location where an ambulance and its crew will sit and wait for the next assignment. Posts can be stations, street corners, gas stations, etc. Careful selection of Post locations to ensure crew comfort (facilities & food) and safety is essential.



Geographic Demand Analysis

A GDA is a map showing call volume spatially or geographically and typically an hour of day/day of week analysis. It may have hours grouped together based on type of system, but most effective is an hour by hour for a total of 168 maps (one for each hour of the day and day of week) e.g. AM rush, midday, PM rush, night by day of week. Maps must be drawn to scale and should include enough detail to recognize major roads and landmarks.

What to Map on a GDA

- Post locations
- Data types to be mapped varies based on response time requirements and system type (emergency, non-emergency, mixed)
- Typically a 20-week analysis of the most recent system call volume
- Typically only map calls that arrive on scene

Building a Posting Plan

This is a manual process where a planning team will sit and look at each GDA map and create a prioritized plan for deployment for each system level, TOD and DOW. The strategy is the 'biggest bang for the buck' concept with minimization of coverage overlap based on patterns of demand versus geographic coverage. Unit coverage is calculated to determine how much of an area a post/unit can cover. Response zones and sub-zone requirements must be taken into account, and any geopolitical considerations that may affect the plan. Contractual obligations may also affect the plan, and be sure to consider time of day and day of week implications such as traffic patterns, special events, and weekday vs. weekend needs. Work to minimize level-based, in-plan post-to-post moves as much as possible. And define and enforce post roaming policies (how far a unit can move from its designated post area).

The process starts by taking the maps and defined post response areas, and then finding the post that covers the most area…this is the Level 1, Priority 1 Post. The process then continues until most demand is covered (while minimizing post coverage overlap). Once demand is covered, we initially use the system level that achieves demand coverage as the NECOL. From this point, work to cover geography, double post areas, etc. until there is a plan level that matches the unit supply level for that hour. This process continues on until all 168 hours of the plan have been completed (or less if using grouped hours approach).

The Evolution of Deployment Planning Technology Solutions

As with other fields of study, the technology of Deployment Planning has evolved. As mentioned above, Deployment planning has historically been done with colored pencils, graphs, lots or erasers and unfortunately, lots of time. With the proliferation of personal computers in the 80's and 90's, the process was made somewhat easier with applications such as Microsoft Excel. But only recently have specific applications been developed for EMS that allow for fast and efficient Resource planning. These latest applications allow for the rapid planning and the easy creation of multiple scenarios and more detailed analysis for determining the number of vehicles for a given time of day, as well as their geographic placement, or post. Development of EMS specific crew scheduling tools have also made the day to day management of operations more efficient.

RescueNet Resource Planner

As outlined in this white paper, optimum schedule achievement requires the execution of industry best practices that includes detailed demand assessment, overlaid with business rules and resource levels. RescueNet Resource Planner is a powerful tool for this demand-based deployment of personnel and resources, balanced with service level agreements and financial goals. EMS organizations use RescueNet Resource Planner to improve their UHU, control shift expenses, improve shift utilization and dramatically decrease the scheduling effort to meet their demand.

With Resource Planner, you can plan the appropriate staffing and resource levels to meet fluctuating demand in a volatile environment. Use a histogram to visualize the distribution of customer demand and synchronize staffing to meet market needs. It also serves as a decision support tool for managers to quickly and effectively develop shift plans to meet a range of business objectives.

You can easily analyze minimum, average and peak demand values with complex built-in statistical calculations. Demand values are used to forecast future call volume, which becomes a basis for shift development. Use the broad range of flexibility to tailor the application by setting organization-specific parameters including service area(s), target staffing levels, shift types and policies, and business priorities. Multiple service areas enable users to balance global limits and goals with zone-based limits and goals to ensure optimized service levels.

RescueNet Resource Planner is a proven solution that is used very successfully in the EMS industry as a first step in efficient deployment planning. And large metropolitan districts such as Los Angeles, San Diego, Seattle, St. Louis, San Francisco, Reno, Nevada, Oklahoma City and others use Resource Planner today.

About ZOLL Data Systems

ZOLL Data Systems of Broomfield, Colorado, develops, markets, and sells the RescueNet suite-computer-aided dispatch, billing, field data collection, and mobile data software for the emergency medical services (EMS) market. RescueNet is the only fully integrated EMS information management system that allows EMS organizations to manage critical information for maximum performance.

For more information, visit www.zolldata.com or call 800.474.4489.