Fundamentals of Deployment

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W’s

• Who:
  – Randy Kearns

• What
  – Fundamentals of Deployment for EMS Systems

• Why
  – Why is this important to me?
  – New sense of urgency to be efficient.

Disclaimer

• UNC
  – Researcher-NC Burn Disaster Program

• NCOEMS

• ASPR

• FEMA (Reservist)
  – Branch Director w/ Specialty: ES Branch
Who cares? Who is our audience?

- Public Safety Model
- Business Model
- Hospital Based Model

What do they want?
and,
What do they need?

Overview

- System status management, dynamic versus static deployment (SSM)
- Call timeline gap analysis, event chain performance improvement, (patient) throughput measurements (ToT)
  - Time on task factors, choke points, etc.
- Unit hour utilization and the relevant variables (UHU)
- Demand analysis versus "waiting-line analysis/measurement" (also referred to in the statistical world as Markov Chain)
- Stand ready costs
- Unit hour costs and how it relates to fees for service/costs for services
- Risk versus Utilization situations and relative costs
- Measuring fixed costs versus variable costs
In a word, deployment is based on... 

RESOURCES

Determining the need for
- Positioning of
- Utilization of
- Cost of

RESOURCES

Definitions

- System Status Management
  - The Strategy of Ambulance Placement
Deployment

- Static
  - Examples
- Dynamic
  - Examples

Static

- What influences selection for a base location?
  - Data
  - Availability of the land?
  - Price of the land?
  - Political influence?
  - Do you redeploy ambulances when there is a call in an adjacent location?

Dynamic

- What data do you use?
- What time blocks do you move?
- How does staffing mirror demand?
- What process do you have in place to redeploy units?
Determining the need for Positioning of Cost of Resources

Utilization of

Time on Task (ToT)
- Pre-call
- Call to 9-1-1 or similar answering point
- PAI and Dispatch (queue)
- Chute Time
- Response Time
- On scene Time
- Transport Time
- Arrival and ready for service

Response Times
- Average
- Fractal
  - (probably best but both are acceptable)
Unit Hours – Unit Hour Utilization (UHU)

- 1 ambulance, 24 hours / day, 365 days / year
  - 1 x 24 x 365 = 8760 unit hours
  - (17,520 worked hours)

- If there is one call per hour then there will be a utilization of 1.0 UHU 24/24 = 1.
  - 2 calls per 24 hr shift = 0.083 UHU (2/24 = 0.083)
  - 8 calls per 24 hr shift = 0.333 UHU (8/24 = 0.333)

UHU Cont.

- 4 calls per 8 hr shift = 0.500 UHU (4/8 = 0.500)
- 6 calls per 8 hr shift = 0.750 UHU (6/8 = 0.750)
- 8 calls per 8 hr shift = 1.000 UHU (8/8 = 1.000)
- 4 calls per 12 hr shift = 0.333 UHU (4/12 = 0.333)
- 6 calls per 12 hr shift = 0.500 UHU (6/12 = 0.500)
- 8 calls per 12 hr shift = 0.667 UHU (8/12 = 0.667)
**UHU Cont.**

- Time on Task issues
- Choke Points

**Determining the need for Positioning of Utilization of Resources Cost of**

**Unit Hour Costs (Direct Costs)**

- 1 ambulance, 24 hours / day, 365 days/ year
  - 1 x 24 x 365 = 8760 unit hours
  - (17,520 worked hours)
- If the average hourly rate is $15.00 per hour, then the salary for the unit is $15.00 x 17,520 = $262,800.
- If the benefits represent 25%, then the benefit value is $65,700
- If the supplies represent 30% of the value of the employee costs then; $140,786
- If the mileage (vehicle component is 30% of the total) then the vehicle component is: $234,643
- $703,929 / 8760 = $80.36 (significantly short of total costs per unit hour)
Medicare Source – Calculating Costs

- Components
  - National Uniform Base Rate – NUBR
  - Relative Value Unit – RVU
  - Geographic Adjustment Factor (GAF [GPCI])
  - Loaded Mileage – LM
  - Mileage Rate – MR
  - Point of Pick up modification – POP
  - Additional Payments for certain specified periods

- \[(\text{NUBR} \times \text{RVU} \times 0.7 \times \text{GAF}) + (\text{NUBR} \times \text{RVU} \times 0.3) = X_b\]

- \[(\text{LM} \times \text{MR} \times \text{POP}) = X_m\]

Understanding Costs

- Direct
- Indirect 20%
  - (Public Safety Argument versus Business Model)
    - Public Safety Includes Stand Ready Costs
    - Business Model based solely on ability to generate revenue
  - Public Safety Approach, add to costs, but also add to value. Such as specialty teams, QRV, etc.

Stand ready costs

- Typically measured poorly
  - (piece of mind)
Risk and Service Availability

- How do you place resources when the services are seldom utilized?
Determining the need for Utilization of Positioning of Cost of RESOURCES

Statistics
- Mean – mathematical average
  - (problem is outliers will skew the results)
- Median – middle value of a set of values
- Range – high and low
Prediction Models

- Demand analysis versus "waiting-line analysis/measurement" (one approach is referred to in the statistical world as Markov Chain Monte Carlo Methods)
- Demand analysis
- Common approach
- Easier to Understand
- Less precise

- Waiting-line analysis
- Common business model
  - (such as fast food)
- More difficult, generally need statistical expertise
- More precise

Demand Analysis

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
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</table>
Demand Analysis for May 06, Staffing vs. Mean and Median Data

Predicting Demand

- Demand analysis versus "waiting-line analysis/measurement" (also referred to in the statistical world as Markov Chains)

Typical View

- Resources = Supply
  - (From the Economics Model; Supply vs. Demand)
  - (Influencing factors; Price, Marketing, Quantity)
Waiting Line Analysis

• Queue
  – A single waiting line
  • (order in which customers are served)
• Waiting line system consists of:
  – Arrivals
  – Servers
  – Waiting line structures

Waiting Line Analysis components:

• Calling Population
• Arrival rate
  – (must be less than service rate or system never clears out)
• Service time
Waiting Line Analysis components:

- Source of Customers
- Waiting line (or queue)
- Served Customers

EMS components
- 9-1-1 decisions, response times, on scene times

Waiting Line Basic Structures:

- Channels (parallel servers)
  - For us, it is the various ambulances/locations
- Phases (sequential servers customers must go through)
  - For us, it includes 9-1-1 call center, response time, on scene time, transport time

http://www.usfca.edu/~villegas/classes/984-307/307ch16/sld001.htm

Multiple-Server Example

Customer service area
- \( \lambda = 10 \) customers/area
- \( \mu = 1 \) customer/ambulance per service rep

\[ P_0 = \frac{1}{\left( \frac{\lambda}{\mu} \right) + 1} \left( \frac{\lambda}{\mu} \right)^{\frac{1}{\lambda}} \left( \frac{\lambda}{\mu} \right)^{\frac{1}{\mu}} \left( \frac{\lambda}{\mu} \right)^{\frac{1}{\lambda - \lambda}} \]

\[ P_0 = \left( \frac{10}{1} \right)^{\frac{1}{10}} \left( \frac{1}{2} \right)^{\frac{1}{10}} \left( \frac{1}{2} \right)^{\frac{1}{10}} \left( \frac{1}{2} \right)^{\frac{1}{10}} \left( \frac{1}{2} \right)^{\frac{1}{10}} = 0.645 \]
## Input Data for Short-Term Events

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>Markov Chain Dis.</th>
<th>Threshold Value</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Starting age of population, in years</td>
<td>64</td>
<td>40</td>
<td>80</td>
<td>Triangular</td>
<td>NA</td>
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<td>Time to CPR, minutes</td>
<td>2.0</td>
<td>1.6</td>
<td>3.4</td>
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<td>NA</td>
<td>9</td>
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<tr>
<td>Time to defibrillation by EMS, minutes</td>
<td>10.8</td>
<td>10.2</td>
<td>11.5</td>
<td>Normal</td>
<td>7.5</td>
<td>9</td>
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<tr>
<td>Time to defibrillation by nontraditional targeted responder, minutes</td>
<td>4.4</td>
<td>4.1</td>
<td>4.7</td>
<td>Normal</td>
<td>6.3</td>
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<tr>
<td>Probability of neurologic impairment (CPC&gt;1)</td>
<td>0.36</td>
<td>0.26</td>
<td>0.8</td>
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<td>NA</td>
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<tr>
<td>Utility of neurologically intact (CPC=1)</td>
<td>0.40</td>
<td>0.36</td>
<td>0.44</td>
<td>Normal</td>
<td>NA</td>
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<td>Utility of neurologically intact (CPC&gt;1)</td>
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<td>0.52</td>
<td>0.64</td>
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<tr>
<td>Cost of automated external defibrillator</td>
<td>$2500</td>
<td>$1000</td>
<td>$4000</td>
<td>Triangular</td>
<td>Industry survey</td>
<td>5/2002</td>
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<tr>
<td>Cost of training responders, per AED</td>
<td>$1047</td>
<td>$524</td>
<td>$1571</td>
<td>Triangular</td>
<td>T. Valenzuela, 3/2002</td>
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<td>Cost of retraining responders, per AED</td>
<td>$226</td>
<td>$113</td>
<td>$240</td>
<td>Triangular</td>
<td>T. Valenzuela, 3/2002</td>
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<td>Cost of EMS run</td>
<td>$489</td>
<td>$245</td>
<td>$734</td>
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<td>PhysioControl Inc, 5/2002</td>
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<td>Cost of hospitalization for nonsurvivor</td>
<td>$3278</td>
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<td>$4917</td>
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<td>Cost of hospitalization for survivor</td>
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<td>$30,200</td>
<td>$104,007</td>
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<td>NA</td>
<td>31</td>
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NA indicates not applicable.

http://circ.ahajournals.org/cgi/content/full/108/6/697
http://demonstrations.wolfram.com/FiniteStateDiscreteTimeMarkovChains/

## Markov Chain Monte Carlo MCMC

- In the statistical world, considered one of the top ten most important algorithms

\[ q(x), w(x) \text{ corrects } f(x) \text{ sampled at that point} \]

\[ f(x) = \sum_{i=1}^{N} w(x_i) f(x_i) \]

Recalibrating the weighted values

http://www.bioss.ac.uk/students/alex/m/MCMCintroPresentation.pdf

## Deployment Conclusions

- Measure what you do.
- Response times: fractal versus average
- Staffing: Demand Analysis versus Waiting Line
- Benchmark – compare what you do to either what you did or others with similar demographics
- Outcomes (QLY or QALY)
Deployment Conclusions – cont.

• Have a plan, follow the plan.
• Process to hold calls or surge capacity to meet demand?

• How do we see ourselves?
• How do others see us?
Questions?

- 101-87
- UNC over Duke
Penguins are black and white.
Some old TV shows are black and white.
Therefore, some penguins are old TV shows.

Logic: another thing that penguins aren't very good at.