Practical Analytic Techniques for Local Government

Techniques for Planning, Monitoring, and Evaluating Programs and Activities

Dale J. Roenigk

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Objectives of this Seminar

…mastery of a few analytic techniques and general familiarity with a wide range of easy-to-learn analytic techniques that can be applied to local government problems.

2

What's the average?

- City Council is considering adding police officers to the town's staff. Council member asks what's the average salary for police personnel.
- Is average shorthand for "typical"?

3

Measures of "central tendency" and "dispersion"…frequently needed in local government analysis

central tendency

- mean
- median
- mode
- also consider "moving averages"

dispersion...how tightly are the data points clustered around the measure of central tendency?

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Which measure of central tendency?

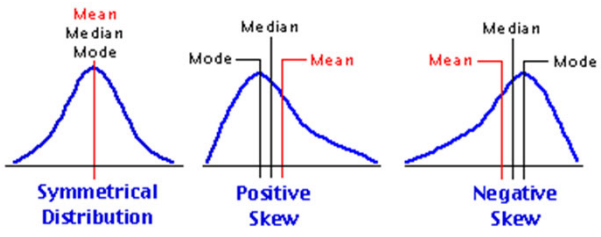
Mean (arithmetic mean)	Sum of all values divided by number of all values
Median	half the numbers above and half are below
Mode	most common value

consider sharing all three

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Mean or Median or Mode



http://analystnotes.com

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Typical police salaries

Category	Staff	Salary	Total
Patrol	40	$ 35,000	$ 1,400,000
Lieut	5	$ 45,000	$ 225,000
Investigator	3	$ 50,000	$ 150,000
Capt	2	$ 65,000	$ 130,000
Chief	1	$ 100,000	$ 100,000
Total	51		$ 2,005,000

Salary	
Average	$ 39,313.73
Median	$ 35,000
Mode	$ 35,000

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"Moving Average" or "Floating Average"

$$\text{Floating average} = \frac{x_1 + x_2 + x_3}{n}$$

where
x = the total for a single period
n = the number of periods included in the floating average

See Ammons, *Tools for Decision Making*, p. 25.

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Fire Losses in the City of Zornig, by Fiscal Year

	Fiscal Year 2009-2010	Fiscal Year 2010-2011	Fiscal Year 2011-2012	Fiscal Year 2012-2013	Fiscal Year 2013-2014
Fire Loss	$210,500	$262,300	$212,387	$338,258	$1,088,600
Fire loss as % of value of properties experi-encing fire	5%	7%	5%	2%	30%

See Ammons, *Tools for Decision Making*, p. 22.

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Depicting Zornig's Fire Loss Stats

SINGLE -PERIOD FORMAT

	FY 11 -12	FY 12 -13	FY 13 -14
Fire loss	$212,387	$338,258	$1,088,600
Fire loss as a percentage of value of properties involved	5%	2%	30%

THREE -YEAR FLOATING ANNUAL AVERAGES

	FY 2010 - FY 2012	FY 2011 - FY 2013	FY 2012 - FY2014
Fire loss, 3 -year annual average	$228,396	$270,982	$546,415
Fire loss as a percentage of value of properties involved, 3-year annual average (unweighted)	5.7%	4.7%	12.3%

See Ammons, *Tools for Decision Making*, p. 25.

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Be careful of the "Flaw of Averages"

- Situations where use of averages may distort the communication, mislead the audience, or even not lead to average results.
- This problem is most pronounced where data has a skewed distribution or where risk is at play.

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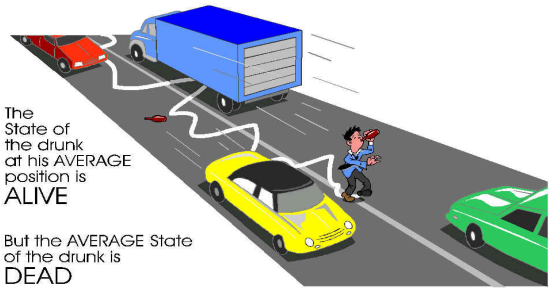
Skewed distributions

- Imagine a department with ten employees.
- Eight employees work 40 hours a week
- Two employees work 20 hours a week.
- The average weekly hours is 36 but that describes no one.

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Averages may be wrong for situations where risk is at play.



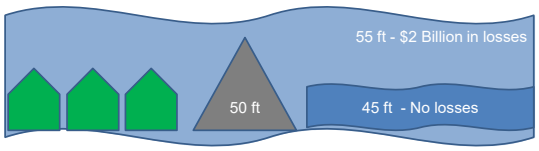
http://web.stanford.edu/~savage/flaw/

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Do we have average losses with average flooding?

Average height is 50ft
But average loss is $1B



Example adapted from Flaw of Averages by Sam Savage.

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How can I measure dispersion or variation?

For the statisticians
- variance
- standard deviation

For most local government audiences
- range
- interquartile range
- percentage within specified range
- fractiles

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Interquartile Range

100th percentile (top of the range)

top quartile

75th percentile

3rd quartile

50th percentile (median)

2nd quartile

25th percentile

bottom quartile

(bottom of range)

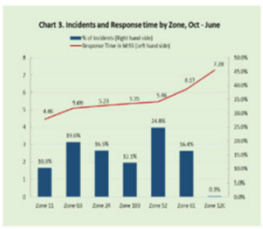
Interquartile Range (the "middle half")

See Ammons, *Tools for Decision Making*, p. 18.

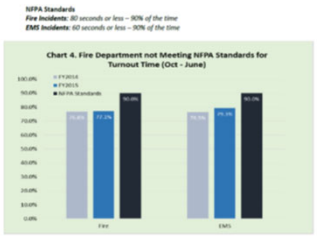
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Response times in Pompano Beach Fire and Rescue

Average Response Time



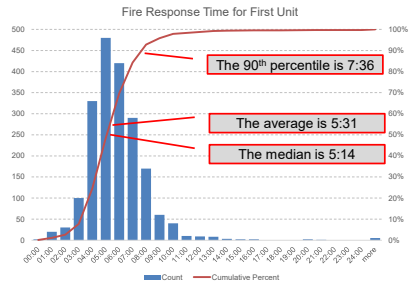
Fractile (Turnout) Time



http://pompanobeachfl.gov/assets/docs/pages/fire/Q3_2015.pdf

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A histogram is a nice way to show the distribution of data to provide a picture of the variation.



- You need to group your data into categories if your variable is continuous.
- By adding a cumulative percent line you can find percentiles or fractiles.

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Our numbers are always changing from one period to another. What should we make of the variation?

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Monthly Meeting of the Blue Heaven Police Stat Group Key Report

May **District Crime Report**

	Crimes	Percent Change from Last Month	Percent Change from Same Month Last Year	Performance Score
District 1	928	3.8%	-16.3%	0
District 2	775	-7.7%	43.3%	0
District 3	443	-6.1%	-1.1%	2
District 4	1048	12.2%	36.8%	-2

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June **District Crime Report**

	Crimes	Percent Change from Last Month	Percent Change from Same Month Last Year	Performance Score
District 1	869	-6.4%	-30.1%	2
District 2	728	-6.1%	21.3%	0
District 3	435	-1.8%	2.1%	0
District 4	1038	-1.0%	5.7%	0

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July **District Crime Report**

	Crimes	Percent Change from Last Month	Percent Change from Same Month Last Year	Performance Score
District 1	715	-17.7%	-36.1%	2
District 2	796	9.3%	37.5%	-2
District 3	484	11.3%	23.8%	-2
District 4	956	-7.9%	-3.7%	2

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Are we confused yet?

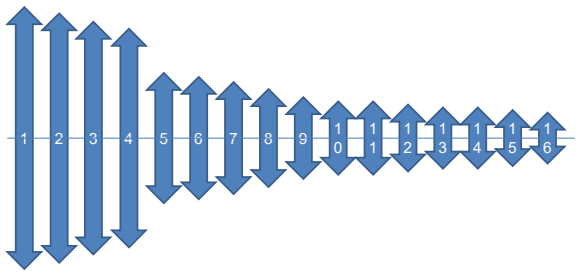
- Who is doing a good job?
- Who's performance is down?

- Everyone had at least one green mark and everyone had at least one red mark.

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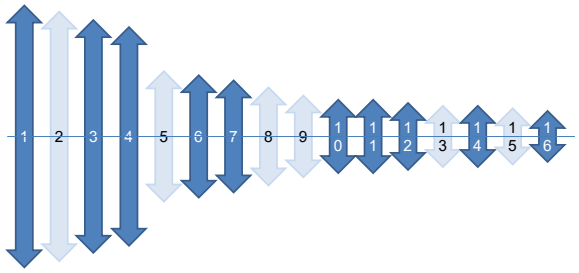
Any process or system has many causes that may be pushing performance up or down.



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But we may not even be identifying all the actual factors driving variation.



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Assessing how we do in traditional tabular reports may lead to misunderstanding and wasted time talking about why the numbers are up or down when common variation is present.

This is likely to be true whether using percentage changes, comparisons to averages, or comparisons to goals or standards.

Fails to show variation in context.

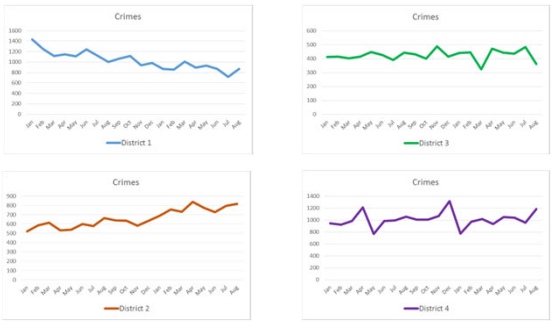
May District Crime Report

	Crimes	Percent Change from Last Month	Percent Change from Same Month Last Year	Performance Score
District 1	928	3.8%	-16.3%	0
District 2	775	-7.7%	43.3%	0
District 3	443	-6.1%	-1.1%	2
District 4	1048	12.2%	36.8%	-2

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Is the picture any clearer with simple line graphs?



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- Plotting the dots is the first step to
  - better understanding,
  - better analysis,
  - better discussions about performance, and
  - better decisions about where action is needed and where it may not be.

May District Crime Report

	Crimes	Percent Change from Last Month	Percent Change from Same Month Last Year	Performance Score
District 1	928	3.8%	-16.3%	0
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District 3	443	-6.1%	-1.1%	2
District 4	1048	12.2%	36.8%	-2



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But we can go further than line charts and try to incorporate limits on what is common variation rather than special causes.

District 4's trend appears flat. But there are spikes of variation. Should be we concerned?

How do we understand the variation in evidence?



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Control Charts as a means to better understand and act on variation.

- Developed by Walter Shewhart in the 1920s at Western Electric later Bell labs.
- Shewhart argued for two types of variation: common cause and special cause.
- Needed a framework to distinguish between normal variation in processes and exceptional causes.

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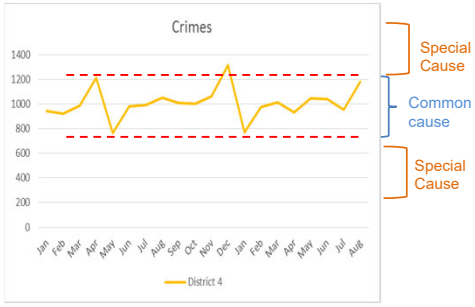
Understanding the difference between the types of variation helps us understand how to interpret the data and how to make improvements.

Type of Variation	Other names	Character	Cause and Effect	Improvement
Common	Predictable, Routine	Always present, can be used to predict the future	No single assignable cause, can't separate out effects.	Comes from changing the process
Special	Unpredictable, Exceptional	Not always present, can change over time, can't be used to predict	Assignable cause dominates.	Finding and removing assignable causes of the variation

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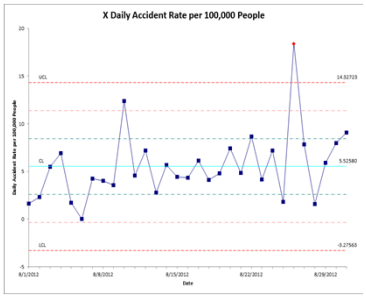
Common is random or routine variation that is part of the process, special cause is exceptional variation that is likely some signal of change.



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The control charts is a trend chart with additional lines added.

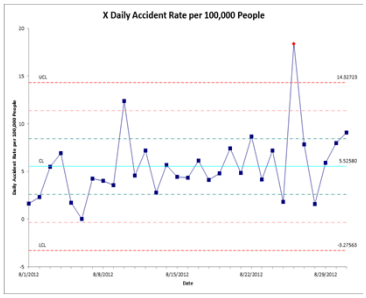


- Centerline (usually an average or median.)
- Other horizontal lines are set out at 1, 2, and 3 sigmas around centerline.
- The outer most lines are called the upper and lower control limits.

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The control chart tells us a story about our process.

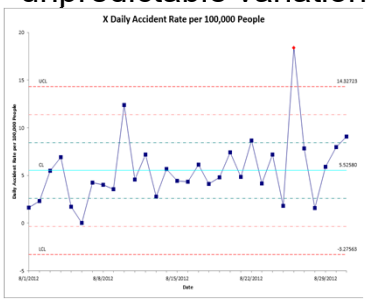


- The centerline gives us our best estimate assuming the process is stable.
- The upper and lower control limits tell us how high/low our data might reasonably be expected to get by chance assuming the process is stable.

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The control chart can also tell us if our process has special or unpredictable variation.

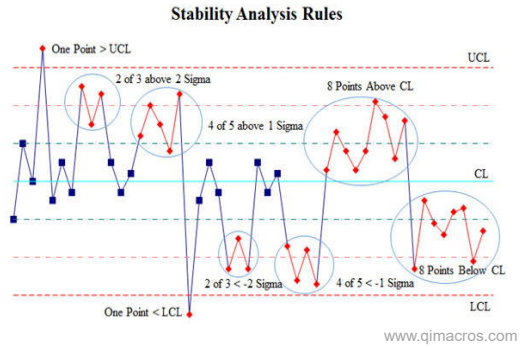


- Certain rules exist to highlight data that does not show predictable variation.
- For example, the highlighted point in red is a data point which is outside the 3 sigma limit meaning there is less than a one percent chance it is random.

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The four most common rules.



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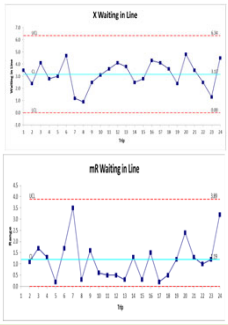
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How to calculate

- We will use a particular kind of control well suited for service and administrative measures call the I-MR or X-MR chart.
- Actually two charts together, one for the range which tells us wide to set the control limits and one for the actual data.

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Imagine tracking how long we wait in line for service.

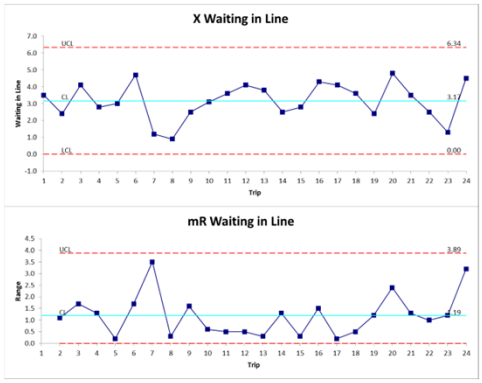


Trip	Waiting in Line	Range
1	3.5	
2	2.4	1.1
3	4.1	1.7
4	2.8	1.3
5	3	0.2
6	4.7	1.7
7	1.2	3.5
8	0.9	0.3
9	2.5	1.6
10	3.1	0.6
11	3.6	0.5
12	4.1	0.5
13	3.8	0.3
14	2.5	1.3
15	2.8	0.3
16	4.3	1.5
17	4.1	0.2
18	3.6	0.5
19	2.4	1.2
20	4.8	2.4
21	3.5	1.3
22	2.5	1
23	1.3	1.2
24	4.5	3.2
Average	3.17	1.19

1. Calculate the range which is the absolute value of the difference between the current point and the previous point.
2. Find the average of the ranges.
3. Create an upper limit for the ranges by multiplying the average by 3.268 and add to the average.
4. Plot the range chart.
5. Find the average for the actual data.
6. Plot upper and lower control limits for the actual data with the formula Average±2.66*Average Range
7. Plot the data chart.

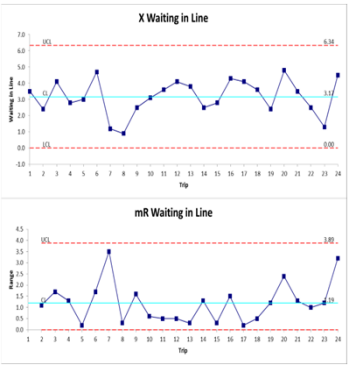
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The end result.



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How to interpret the range chart.

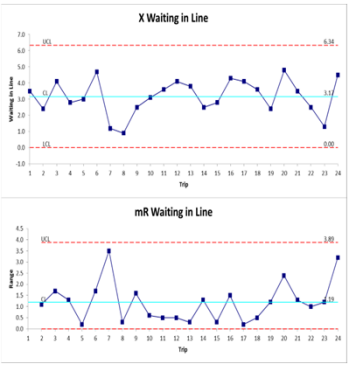


1. The range chart tells us the average movement from period to period is 1.19 minutes and the maximum change in waiting time we should see assuming a predictable process is 3.89 minutes.
2. No points on the range chart are past the 3.89 control limit so there are no points of concern on that chart.

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How to interpret the data chart.

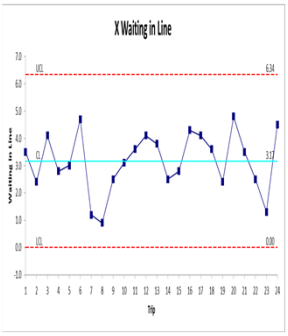


3. On the waiting time data chart, we see that the times while varying all lie within the control limits. We would conclude this is a stable and predictable process.
4. The average waiting time is 3.17 minutes and the maximum that would be expected is 6.34 minutes and we might see instances of zero waiting time.
5. Unless changes take place, we can use this for making predictions going forward and checking when we have problems.

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A few things to note about the chart.

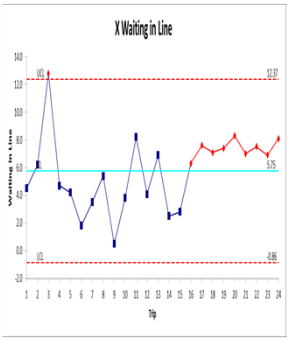


1. The numbers in the graph represent what actually happening called the "Voice of the Process".
2. We may want something better (lower average times or a lower maximum time) but that is a separate question ("Voice of the Customer"). Don't confuse the two.
3. If we want to make changes we do it by focusing on the process overall and not on fixing specific points. Don't confuse common variation with special variation.

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Imagine instead our wait times had looked as follows.

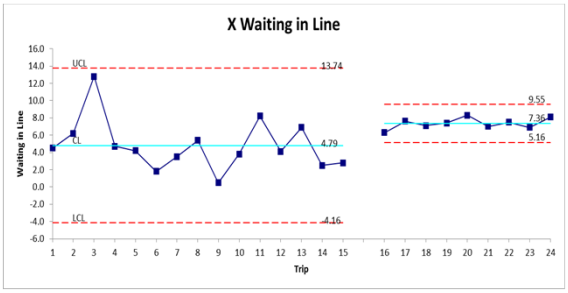


1. We have two places with special variation highlighted.
2. At time 3, we had a wait time of 12.8 minutes, beyond expectations. We should check out what happened at that time and see if an improvement could address it.
3. Starting at time 16, we had a run of nine consecutive measures all above the average which shouldn't happen by chance. Something unfavorable changed in our process and we should determine what it was.

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A revised chart would show that our process has moved to longer times, but a smaller range.



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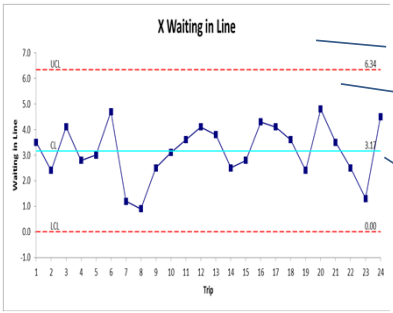
Process behavior or control charts can be used in several ways.

- What is average and what is the predictable range for variation.
- Provide guidance about when to react to variation and when to not react.
- Better discussions about the varying numbers are telling us.
- Test new experiments or asses whether process changes have made a difference.

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Assess and understand the variation in place and know how to react.



Points outside the range are likely signals. Investigate and act on if appropriate.

Don't try to fix individual points in the predictable range. Change the whole process.

The average and limits provide you with a predictable set of numbers to use until the process changes.

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What might explain variation?

- Speculating why numbers vary is usually not hard.
- Finding evidence to test what drives variation can be done with simple scatterplots, correlation, and regression in Excel.

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Fire rates in the cities in the NC Benchmarking project vary significantly. What might explain that difference?

City	Fires per 1,000 Population in FY 2005
Asheville	6.91
Carrboro	3.32
Cary	2.37
Charlotte	3.99
Concord	4.75
Durham	4.72
Gastonia	6.47
Greensboro	4.84
Hickory	4.50
High Point	5.79
Matthews	4.94
Raleigh	3.84
Salisbury	6.02
Wilmington	6.47
Wilson	5.78
Winston-Salem	4.93
Average	4.98

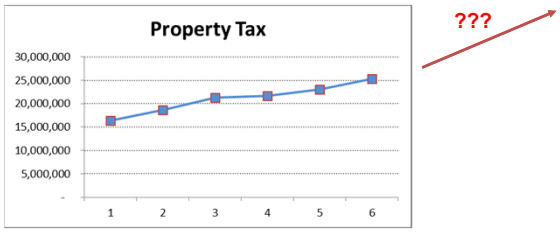
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What might the future hold?

- When dealing with uncertainty, we can use simple regression in Excel graphs to project forward to forecast trends.
- The strong caution is that simple regression works very well when forecasting relatively consistent trends but fails at turning points or with trends that are erratic.

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The property tax in the Town of Blue Sky has been rising steadily. But will the tax base look like next year or over the next five years?



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The councilman said he was reporting random feedback. Was it truly random?

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"Random" does not mean haphazard.

In random sampling, every member of the population has an equal chance of being selected.

- If we interview every 10th shopper outside the Wal-Mart from 4-7 p.m., who has a low probability of being selected?
- Questionnaire in the newspaper?
- Online survey?

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To generate random numbers on the Web or using Excel…

- Research Randomizer at www.randomizer.org
- Random.org at www.random.org/integers/
- Microsoft Excel (for instructions, see Tools for Decision Making: A Practical Guide for Local Government, p. 28)

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Do we have the right amount of resources in place?

- Staffing analysis standards
- Staffing factor calculation
- UHU
- Demand Analysis
- Optimization

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Staffing Analysis

- Are we understaffed or overstaffed?
- Are there any standards that might be helpful in answering the question?

Standards for Mechanics

"Flat Rate Manuals"

Ford F-Series Pickup

Basic Inspection and Road Test
Ford Ranger Pickup, 2003-2006.....0.9 hour
Basic inspection includes checking the horn, ignition switch, lights, starter operation, transmission engagement and operation, speedometer, and gauges for temperature, fuel pressure, oil, etc. Inspector will also examine pedal pads, door catches and cushions, glass, mirrors, wipers, and tire condition.

Engine Compartment Inspection and Adjustment
Ford Ranger Pickup, 2003-2006.....1.4 hours
Scope engine and make any adjustments needed. Record compression for all cylinders. Clean and gap spark plugs. Adjust or replace points. Inspect distributor cap for cracks and carbon runs. Inspect ignition primary and secondary wiring. Check operation of the throttle and choke controls (with linkage). Set engine idling; check and set engine timing. Test battery and clean terminals. Inspect cooling system and service, as necessary.

Chassis and Brake Inspection
Ford Ranger Pickup, 2003-2006.....1.7 hours
Check king pins and bushings, drag link and toe in. Inspect master cylinder. Check power take-off shaft and bearings, hydraulic pump, etc. for wear and leaks. Inspect exhaust system. Check springs and shocks. Inspect drive line and U joints, operation of clutch and pedal clearance. Check brake operations. Remove wheels and drums. Repack bearings, replace seals, and inspect brake linings.

See *Tools for Decision Making*, p. 101.

Checking the Efficiency of Mechanics

Excerpt from Performance Report

Efficiency Ratings, by Mechanic

Mechanic	Date	Work Order	Repair Description	Standard Hours	Actual Hours	Efficiency Rating
Bosquet, Buster	91101	34002	Exhaust	.8	1.1	72.7%
	Total			29.4	30.2	97.4%
Eberhart, Babe	90501	33807	Tune Up	3.1	2.5	124.0%
		33812	Brakes	2.2	2.3	95.7%
		33814	Emissions	.7	.7	100.0%
		33816	Manifold	.9	.9	100.0%
	90601	33820	Alternator	.9	.6	150.0%
		33822	Emissions	.7	.7	100.0%
		32116	Wheel Align	2.4	3.2	75.0%
		33827	Rear Brakes	1.6	1.4	114.3%
	90701	33830	Carburetor	1.6	1.8	88.9%
		33832	Tune Up	3.1	3.1	100.0%
		33833	Oil Change	.5	.5	100.0%
		33835	Radiator/Thermostat	1.4	1.2	116.7%
	90801	33840	Emissions	.7	.7	100.0%
		33842	Universal Joint	1.2	1.0	120.0%
		33845	Struts	1.3	1.3	100.0%
		33849	Ignition	.9	.8	112.5%
		33853	Brakes	1.8	2.0	90.0%
	90901	33856	Shocks	.4	.3	133.3%
		33857	Hydraulics	2.2	2.8	78.6%
	Total			27.6	27.8	99.3%

See *Tools for Decision Making*, p. 103.

The Chief of Police says his department is understaffed. He claims that national standards for "police officers per 1,000 population" show he needs another 30 officers. What is your response? What are your analytic options?

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What are your analytic options?

- Is there a better option than basing the analysis on population? Or population alone?
  - service population rather than resident population?
  - a more direct measure of demand (e.g., "officers per 1,000 calls for service")?
- Identification of the result attributed to "having too few officers" and analysis of other possible causes
- Patrol Availability Factor
  - Percentage of time available for undirected patrol
- Blackout Analysis (Kansas City example)

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A good example of useful analysis in local government…

- **"Blackout Analysis" in Kansas City**

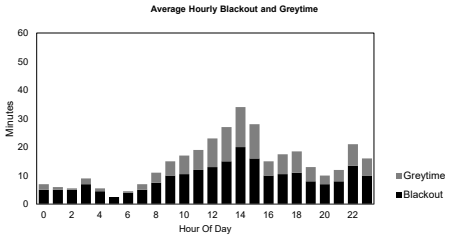
  Police Department said, "We have a staff shortage." Analysts said, "Let's examine staffing and deployment."

  Blackout occurs when all available officers are busy. During the study year, analysts found 156 instances of citywide blackout, nearly all lasting less than 3 minutes.

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Analyzing the Adequacy of Police Staffing and Deployment in Kansas City's Metro Patrol Division



NOTE: Blackout occurs whenever all on-duty officers are engaged on calls for service. Greytime exists when all officers except one are engaged on calls.

Source: City of Kansas City, *Kansas City, Missouri, Police Department Patrol Deployment: Blackout Analysis*. (Kansas City, MO: City Auditor's Office, January 1998), p. 25.

66

Blackout analysis continued…

- "Although day-of-week variations in staffing and calls for service were relatively small, there were some imbalances between the two, suggesting that scheduling changes, such as changes in deployment of rapid response teams, could reduce blackout."
- The Blackout Analysis report can be found by Googling "Kansas City Blackout Analysis"

67

Councilman Jones says, "I think we ought to put another police officer on the street . . ."

…and you say, "Do you mean around the clock? Like 24/7?"

68

How many additional police officers must you hire in order to add one officer around the clock, seven days a week?

69

Staffing Factor Calculation

For Positions that Require Constant Staffing

$$\text{Staffing Factor} = \frac{\text{Hours per year of operation}}{E}$$

where $E = P - A$

E = the number of effective hours per employee per year or hours actually worked by the average employee

P = the number of paid hours per employee per year

A = the average number of hours of paid absences per employee per year (e.g., vacation, holidays, sick leave, etc.)

See Ammons, *Tools for Decision Making*, pp. 229-233.

70

How many additional police officers must you hire in order to add one officer around the clock, seven days a week?

Let's assume the typical officer works 40 hours per week, takes 2 weeks of vacation, has 10 holidays, and uses 8 days of sick leave and other forms of paid absence per year.

$E = P - A = 2{,}080 - 224 = 1{,}856$ hours

$$\text{Staffing factor} = \frac{\text{hrs of op}}{E} = \frac{24 \times 365}{1{,}856} = \frac{8{,}760}{1{,}856} = 4.72$$

71

The EMS Director submits a budget request that increases the number of EMS units from 10 to 13. She defends the request by saying, “In the 8 years since we last added a unit, our population has increased by 27% and our calls for service have increased by 32%. Increasing our capacity by 30% is crucial.” Your response?

72

Your response?

You ask for response time statistics, save rates, and UHUs for each unit.

…What the heck is a UHU?

- Utilization ratio for EMS units

Actually, the 32% increase in calls got your attention. That’s pretty good justification, but it is based on the appropriateness of prior staffing. How confident are we that we had the right staffing 8 years ago?

73

What stats do we need? Response time and UHU…

We asked for these by unit, but for our “dashboard gauge” we need a summative measure or two for response time and UHU. What do you suggest?

What about “average response time” and “average UHU”? These are reasonable choices. Are they the best choices? What are the pros and cons?

74

Demand Analysis

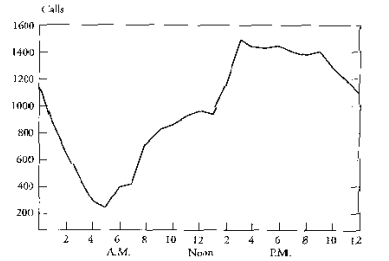
75

What are the objectives of "demand analysis"?

- to identify patterns of demand for services (by time of day, by day of the week, by month, geographically, etc.).
- to examine the extent to which resources (dollars and/or available personnel) match demand.

76

Average Number of Calls for Police Service, by Hour of the Day

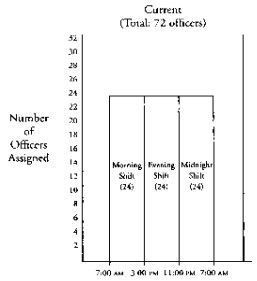


Source: John S. Thomas, "Operations/Management: Planning, Scheduling, and Control," in *Productivity Improvement Handbook for State and Local Government*, ed. George J. Washnis (New York: John Wiley & Sons, 1980), 176. Copyright © 1980 by the National Academy of Public Administration. Reprinted by permission of John Wiley & Sons, Inc.
Note: Based on statistics from the police department of Kettering, Ohio.

See *Tools for Decision Making*, p. 51.

77

Deployment of Newbern's Patrol Officers

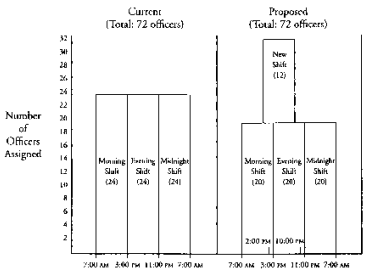


Note: This figure depicts the number of officers assigned to each shift, not the number on duty at a given time. Because of the need to provide two days off per week, plus vacation time, holidays, and occasional absences for illness and other reasons, the number of on-duty officers at any given time will be less.

See *Tools for Decision Making*, p. 52.

78

Plan for Revised Deployment of Newbern's Patrol Officers

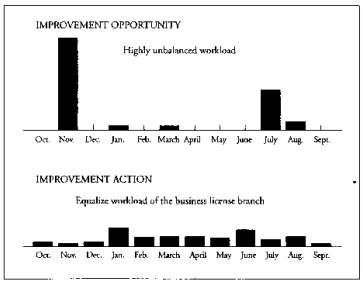


Note: This figure depicts the number of officers assigned to each shift, not the number on duty at a given time. Because of the need to provide two days off per week, plus vacation time, holidays, and occasional absences for illness and other reasons, the number of on-duty officers at any given time will be less.

See *Tools for Decision Making*, p. 52.

79

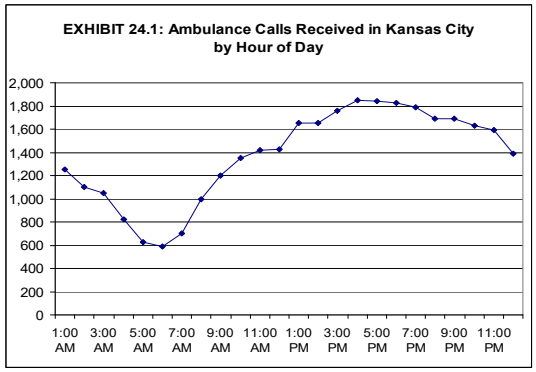
Demand Profile for Business Licenses and Permits



Source: John S. Thomas, "Operations Management: Planning, Scheduling, and Control," in *Productivity Improvement Handbook for State and Local Government*, ed. George J. Washnis (New York: John Wiley & Sons, 1980), 176. Copyright © 1980 by the National Academy of Public Administration. Reprinted by permission of John Wiley & Sons, Inc.
Note: Based on information for business licenses and permits in the District of Columbia.

See *Tools for Decision Making*, p. 55.

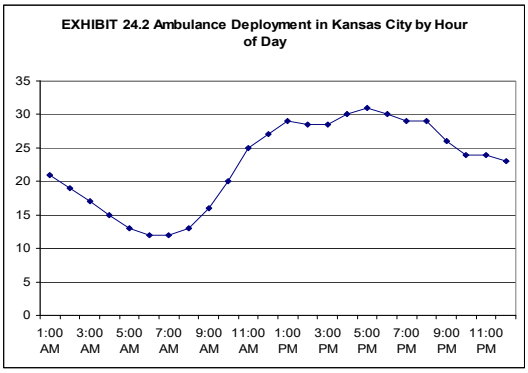
80



See *Tools for Decision Making*, p. 243.

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See *Tools for Decision Making*, p. 243.

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82

What is the best allocation?

- Optimization is a method to find the best combinations to optimize (maximize or minimize) an objective while staying within specified constraints.
- Useful when we have decisions when some of the variables or choices may have dozens or hundreds of possibilities but we want to find the best one.

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Example Optimization Problem

- Town of Blue Heaven is trying to make a capital budget plan. There are twenty projects to consider costing $44 million but council has decided to limit the spending this time to only $10 million.
- Council also wants to make sure there are at least two projects selected covering each of the four major goal areas of public safety, environment, infrastructure, and recreation.

Question: Which projects should be selected to maximize the community value but live within the constraints set by council?

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Blue Heaven Capital Budgeting

Which projects should be selected?

Capital Projects		Category: Public Safety	Environmental	Infrastructure	Recreation	Community Rating	Build	Cost in Millions
Police Substations	Project 1	1				24	0	$1.1
New Fire Station	Project 2	1				70	0	$3.8
New Ladder Truck	Project 3	1				21	0	$1.2
Upgrade 911 Communications	Project 4	1				32	0	$1.5
New Police Cars	Project 5	1				17	0	$0.8
Build Stormwater Detention	Project 6		1	1		85	0	$4.1
Energy Efficiency Building Retrofit	Project 7		1	1		61	0	$1.8
Low Energy Streetlights	Project 8		1	1		39	0	$1.3
Stream Improvement and Trail	Project 9		1		1	79	0	$2.6
New Automated Trash Trucks	Project 10			1		76	0	$3.6
New Public Works Garage	Project 11			1		31	0	$1.5
Water Treatment Upgrade	Project 12			1		93	0	$4.8
New Farmers Market	Project 13			1		29	0	$0.8
Street Resurfacing	Project 14			1		78	0	$2.7
New Sidewalks	Project 15			1		51	0	$1.4
Sidewalk Repair	Project 16			1		42	0	$0.8
New Recreation Center	Project 17				1	81	0	$3.1
New Pool	Project 18				1	88	0	$5.1
Park Upgrades	Project 19				1	18	0	$0.5
New Park	Project 20				1	26	0	$1.5
Projects Selected		0	0	0	0		0	$0.0 Total Cost
		>=	>=	>=	>=			<=
Projects Needed		2	2	2	2			$10.0 Budget Cap

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Some of the ways optimization is used in local government

- Scheduling
- Capital allocation
- Facility location
- Route assignment (school busses and trash trucks)
- School assignment

We'll do some exercises in Excel

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What does it cost?

- Inflation
- Cost of capital
- Full costs
- Go away costs
- Cost of risk
- Life cycle costs

89

Adjusting for Inflation

90

The mayor gave a speech to the Friends of the Library in which he proudly declared that city resources committed to the library had increased 8% during his administration from $1 million 4 years ago to $1.08 million this year.

But what if we examined that record in terms of constant dollars?

91

Inflation Adjustment

Formula for converting "current dollars" to "constant dollars" for a selected base year:

$$\text{current dollar revenue or expenditure} \times \frac{\text{base year CPI}}{\text{current CPI}} = \text{current revenues or expenditures in base year dollars}$$

See Ammons, *Tools for Decision Making*, p. 112.

92

Inflation Adjustment Using the Consumer Price Index

Consumer Price Index (CPI-U)(1982=100.0)

Year	Consumer Price Index (CPI-U)	Change from Previous Year
2014	236.736	1.62%
2013	232.957	1.46%
2012	229.594	2.07%
2011	224.939	3.16%
2010	218.056	1.64%

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.
See http://www.bls.gov/cpi/. Also http://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/

93

What about those funds for the library?

Current dollar Expenditure x $\frac{\text{base year CPI}}{\text{current CPI}}$ = current expenditures in base year dollars

$1,080,000 (in 2014) x $\frac{218.056}{236.736}$ = $994,781 in 2010 constant dollars

Or slightly less "buying power" than $1 million in 2010

94

Inflation Adjustments: Consider IPD as an alternative to the CPI

State & Local Implicit Price Deflator (2009=100.0)

State & Local Govt Consumption Expenditure and Gross Investment

Year	State & Local Govt Implicit Price Deflator (IPD)	Change from Previous Year
2014	112.287	1.95%
2013	110.143	2.00%
2012	107.985	1.95%
2011	105.923	3.12%
2010	102.714	2.71%

SOURCE: Federal Reserve Bank of St. Louis, Economic Research, at https://research.stlouisfed.org/fred2/series/A829RD3A086NBEA, Also see U.S. Department of Commerce, Bureau of Economic Analysis, Table 1.1.9, "Implicit Price Deflators," at www.bea.gov

95

What about those funds for the library?

Current dollar Expenditure x $\frac{\text{base year IPD}}{\text{current IPD}}$ = current expenditures in base year dollars

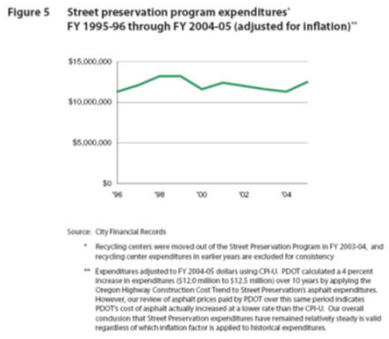
$1,080,000 (in 2014) x $\frac{102.714}{112.287}$ = $987,925 in 2010 constant dollars

Or only 99% of the "buying power" of $1 million in 2010

96

Portland's Street Preservation Program Expenditures

--Adjusted for Inflation--



97

Annualizing Capital Costs

Let's say that you want to know what your annual costs are for a given program. If your capital costs are included in their entirety in the year of purchase and excluded altogether in all other years, your annual costs will be distorted.

98

Annualizing the Cost of Capital Items

Two choices

- usage rate allocation of cost
- straight-line depreciation

See *Tools for Decision Making*, pp. 102-103.

99

Annualizing the Cost of Capital Items: Usage Rate Allocation of Cost

$$a_i = \frac{u_i}{U}(C-S)$$

where

a_i = capital expense allocation for period i
u_i = usage units consumed during period i
U = total estimated usage units in the life of the asset
C = cost of the asset
S = salvage value after U usage units

See *Tools for Decision Making*, p. 138.

100

Annualizing the Cost of Capital Items: Straight-Line Depreciation

$$a_i = \frac{C - S}{N}$$

where

- a_i = *capital expense allocation to each time period*
- *C = cost of the asset*
- *N = total number of time periods in the item's expected life*
- *S = salvage value after N periods*

See *Tools for Decision Making*, p. 139.

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101

Annualizing the Town of Horace's Animal Control Capital Equipment via Straight-Line Depreciation

$$a_i = \frac{C - S}{N}$$

Pickup Trucks

$\frac{\$20{,}415 - 900}{3}$ = $6,505 per year per truck

x 2 trucks

$13,010 per year

Other Equipment

$\frac{\$21{,}380 - 400}{10}$ = $2,098 per year

See *Tools for Decision Making*, p. 140.

Total
$13,010
+ 2,098
$15,108

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Full cost accounting for grants, pricing services, comparing against contractors and benchmarking against others.

- Counting all direct costs (personnel and operations) is usually obvious.
- Don't forget
  - Indirects
  - Overhead
  - Capital (annualized)

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Full cost accounting used in the NC Benchmarking Project.

A. PERSONAL SERVICES
1. Salaries-Permanent
2. Salaries-Temporary
3. OT/Holiday Pay
4. Longevity
5. Sep. Allow.-Law. Enforce.
6. Sep. Allow.-Other
7. Supp. Retirement-Law Enforce.
8. Supp. Retirement-Others
9. FICA
10. Retirement Contribution
11. Hosp/Medical Insurance
12. Disability Insurance
13. Unemployment Comp. Contrib
14. Workers Comp. Contribution
15. Def. Comp./401K Contribution
16. Other Benefits

B. OPERATING EXPENSES
17. Supplies
18. Purchases for Resale
19. Training/Travel
20. Maint/Repair-Equipment
21. Fees/Licenses
22. Advertising
23. Uniform Purchase/Rental
24. Dues/Mems./Subscriptions
25. Telephone
26. Utilities
27. MIS/DP/GIS, etc.
28. Prof/Contract Services
29. Contract Administration
30. Prop/Facility Maintenance
31. Fleet Maintenance
31a. Fuel Costs
32. Misc./Other
33. Spec. Programs Expenses
34. Sublet Work for Fleet Maint.

C. INDIRECT/CENTRAL COSTS
1. City Managers Office
2. City Council
3. City Clerk
4. City Attorney/Legal
5. Personnel/HR
6. Budget & Evaluation
7. Finance
8. Revenue Billing & Collection
9. Purchasing
10. Finance-Professional Fees
11. Risk Mgmt. Administration
12. Liability Insurance
13. Property Insurance
14. Insur. on Equip & Vehicles
15. Support Services
16. Traffic Engineering
17. Other Engineering
18. Transportation Planning
19. Real Estate Management
20. Economic Development
21. City Communications Serv.
22. City Planning
23. Dept. Overhead-Pers. Serv.
24. Dept. Overhead-Operating
*24 a) Organizational Overhead
25. Telephone
26. Utilities
27. MIS/DP/GIS, etc.
28. Prop/Facility Maintenance
29. Fleet Maintenance

D. EQUIPMENT COSTS
1. Equipment Use Allowance
a) Furniture/Office Equipment
b) Maint/Const. Equipment
c) Autos/Light Vehicles
d) Med/Heavy Motor Equipment
e) Data Processing Equipment
f) Light/Misc. Equipment
g) Other equipment
2. Equip/Vehicle Rental/Other

E. FACILITIES COSTS
1. Building Use Allowance
2. Building Rental Charges
3. Water System Infrastructure

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When considering the possibility of outsourcing a function, calculate “go away costs.”

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105

The city’s Purchasing Agent announced that the low bid for custodial services came in $8,042 below the city’s full costs, even when contract administration costs are taken into account.

You were hoping for bigger savings, but you are inclined to take what you can, given the city’s tight budget. But you recall that such decisions should be made on the basis of “go-away” costs rather than full costs.

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Full Cost of In-House Operation Compared to Low Bids

	In-House Full Costs	Contract Costs	Difference
Custodial Services			
Salaries/wages	$72,340		
Fringe benefits	16,638		
Other operating costs	18,500		
Overhead	18,364		
Low bid	-	$113,800	
Contract administration	-	4,000	
Total	$125,842	$117,800	$8,042

See *Tools for Decision Making*, p. 161.

107

"Go Away Costs" Compared to Contract Costs

	In-House Full Costs	In-House Go Away Costs	Contract Costs	Savings Via Contracting[a]
Custodial Services				
Salaries/wages	$72,340	$72,340		
Fringe benefits	16,638	16,638		
Other op. costs	18,500	18,300		
Overhead	18,364	0		
Low bid	--	-	$113,800	
Contract adm.	--	-	4,000[b]	
Total	$125,842	$107,278	$117,800	-$10,522

See *Tools for Decision Making*, p. 162.

108

The Risk Management Officer keeps coming up with a more and more elaborate and costly risk management program. He wants all the latest "bells and whistles." Is there a practical way to analyze his program and its value?

109

Consider "The Cost of Risk"

The "cost of risk" is the combined cost of insurance premiums, deductibles, retentions, uninsured losses, risk management administration, etc.

What would an increase or reduction in one do to the others?

110

The Cost of Risk

Insurance premiums
+ deductibles
+ retentions
+ uninsured losses
+ risk management administration
+ other program costs

The Cost of Risk

111

Supplementing Purchase Price with Lifetime Energy Costs

Life-Cycle Cost	Motor from Ace Electronics	Motor from Burlington Motors
Horsepower	15	15
RPM	3,450	1,160
Bid cost	$1,956	$2,935
Duty cycle	2,600 hrs./yr.	2,600 hrs./yr.
Life	15 years	15 years
Efficiency rating	78.2%	86%
Energy consumption (kilowatts/hr)	14.40	12.58
Energy costs (kwh consumption rate x $.11/kwh x 39,000 hours)	$61,776	$53,968
Life-cycle cost (bid + energy cost)	$63,732	$56,903
Life-cycle cost difference **($63,732 - $56,903 = $6,829)**		

See *Tools for Decision Making*, p. 165.

113

Formula for Life-Cycle Costing

The basic life-cycle cost formula is

life-cycle costs = acquisition cost + lifetime maintenance costs + lifetime energy costs – salvage value

where

acquisition costs	= purchase price + transportation cost + installation cost – trade-ins and discounts,
lifetime maintenance costs	= anticipated costs of keeping the item in operable condition,
lifetime energy costs	= energy consumption rate x cost of energy x duty cycle x life of the item, and
salvage value	= anticipated worth at the end of the item's projected life.

The components of the lifetime energy costs are

energy consumption rate	= the rate at which energy is consumed (kilowatts/hour),
cost of energy	= dollars per energy unit (cents per kwh),
duty cycle	= annual number of hours item is used (number of hours in use per day x number of days in use), and
life	= length of time until item is replaced (number of years in use based on the duty cycle).

Source: Adapted from League of California Cities, *A Guide to Life Cycle Costing: A Purchasing Technique That Saves Money* (Sacramento: League of California Cities, December 1983), 3-4.

See *Tools for Decision Making*, p. 166.

114

Sensitivity and What-if Analysis

115

What if the assumptions change?

- Nearly all analysis requires us to make assumptions about certain choices or uncertain events.
- One of the powerful insights an analyst can provide is to check these assumptions, alternative scenarios, or different choices to estimate the different results.
- A useful approach is to look for the switch point where a decision would change and then focus on that point as a means to make the decision.

116

Looking for a decision point

- Seaside town is looking to purchase or lease two trucks. But critical to the decision is an expectation on how long the trucks may last.
- Lease cost is $14,000 per year.
- The purchase cost of the vehicles is $50,000 with some salvage value expected.
- The fleet director says past trucks in this category have generally lasted 3 years, but the analyst's research suggest this may be too conservative.

117

At what value should you switch between the lease and the purchase?

Lease Costs $14,000 per year

Cost	$50,000	$50,000	$50,000
Years of Life	3	4	5
Salvage	$2,000	$1,200	$600
Straight Line Depreciation Annual Costs	$16,000	$12,200	$9,880

By doing some simple **sensitivity analysis** and comparing multiple assumptions, we can see that the critical **switch point** is between 3 and 4 years. At 3 years of life we should lease, 4 years or more we should purchase.

118

Sensitivity Analysis with Excel

- Excel has a set of three tools to help with sensitivity analysis.
  - Goal Seek
  - Data Tables
  - Scenario Manager
- Use of these tools can be much more effective and accurate than creating multiple copies of spreadsheets.

119

Discipline Yourself to Think Analytically

121

Is analysis calculation or communication?

Instrumental Rationality	Communicative Rationality
Aimed at working towards goals	Seeks to minimize distortions in understanding.
Suggests the analysts role as a calculator	Suggests the analysts role as a communicator





122

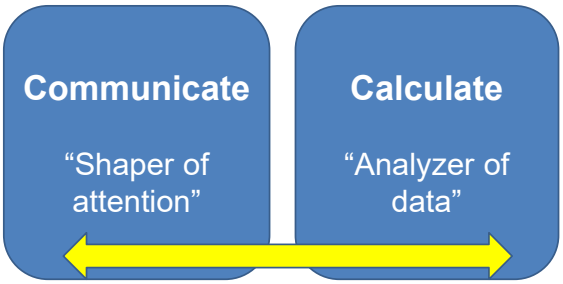
Communicative Rationality

Type of distortion	How we experience it	How we correct the distortion
Comprehensibility	Ambiguity, confusion "What does that mean?"	Reveal meaning "All this really means"
Sincerity	Deceit, insincerity "Can I trust him?"	Check intentions, expose interests "What they mean is"
Legitimacy	Meaning taken out of context "Is this right?"	Determining roles "We don't have to accept that"
Truth	Misrepresentation "Is this true"	Check evidence "I'll check to see if that is true"

The data analyst can play an important role on comprehensibility and truth. The analyst can be a "Shaper of Attention".

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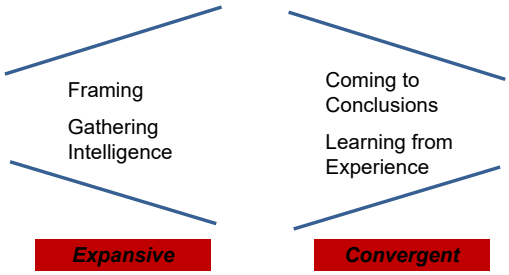
Imagine a more expansive role



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Different Stages, Different Approaches



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Framing Decisions
Defining Decisions

We cannot help but see the world through frames, but we don't have to do so blindly

The key practice is asking questions

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What's your decision space?

- What triggered the problem or decision?
- Why is this a problem that must be dealt with now?
- What are your options?
- What are your constraints?
- **What are your objectives?**

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What's your perspective?

- What are your comparisons?
- What are your yardsticks?
- What are your assumptions?
- What are you boundaries?

What's the perspective of others?

- What do others think?
- What do other stakeholders think?
- Who does this the best in your "business" (decision area), what do they think and what do they do?

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The challenge of framing

- Recognize that framing requires you to be challenging the "decision maker"
- If that is you, you need to be honest with yourself
- If the decision maker is someone else understand that taking a challenging stance may not always be acceptable or easy. Face the task not as an adversary but together. Educate others over time about the value.

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Case Study
"The Police Are Accused of Having Ticket Quotas"

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Analysis is not an end unto itself

- The goal is to support decision making and operations.
- The question to ask is will this help support others in making better choices or is just interesting?
- What's your analytical purpose?

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Some additional resources

- Tools for Decision Making by David Ammons, Sage Press
- Understanding Variation by Donald Wheeler
  - Making Sense of Data by Donald Wheeler
  - Building Continual Improvement by Donald Wheeler
- Excel 2019 Data Analysis and Business Modeling by Wayne Winston
- www.qimacros.com for Excel control chart add-in and training materials on Lean Six Sigma
- http://www.spcpress.com/djw_articles.php for articles by Donald Wheeler on the use of control charts.

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- If you need to contact me with help on any of the techniques today or other analytical questions.
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  - 919-843-8927

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