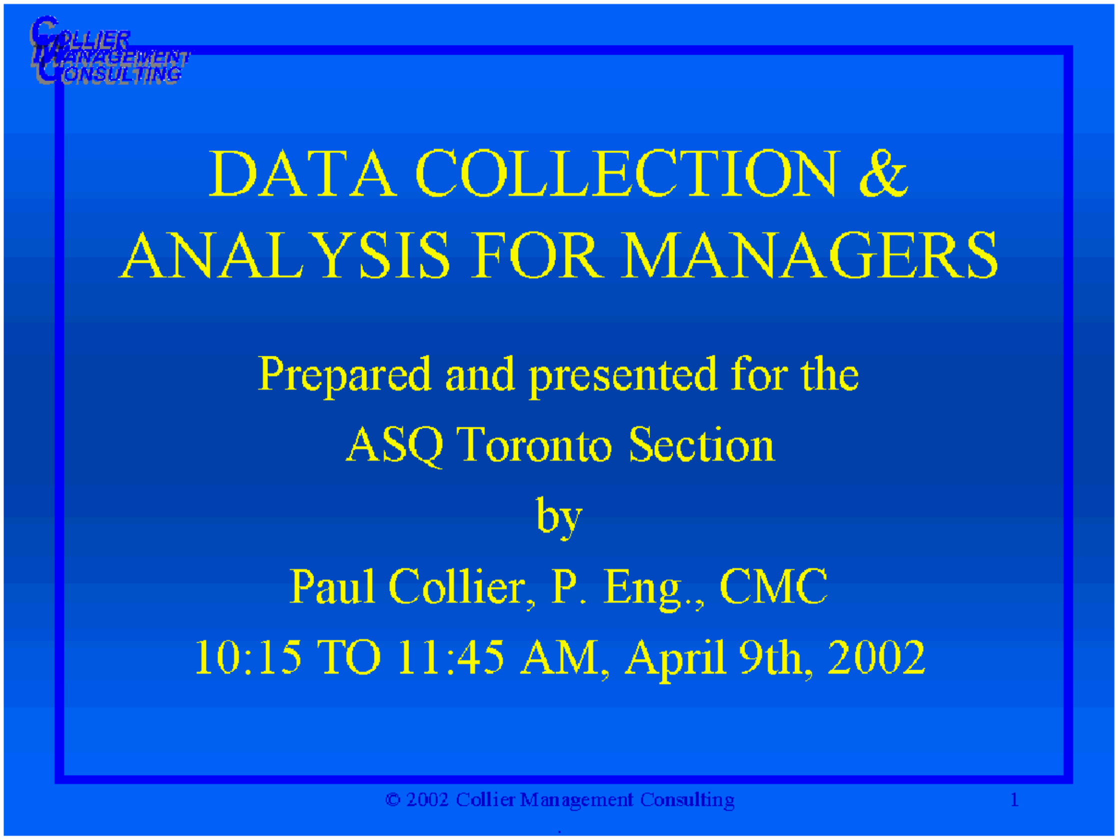
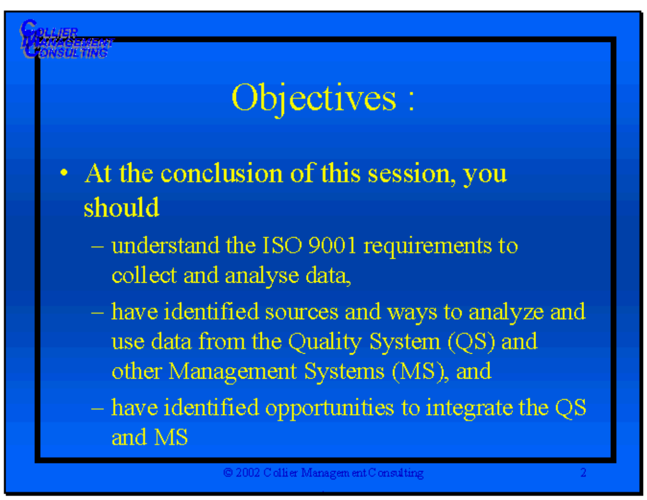
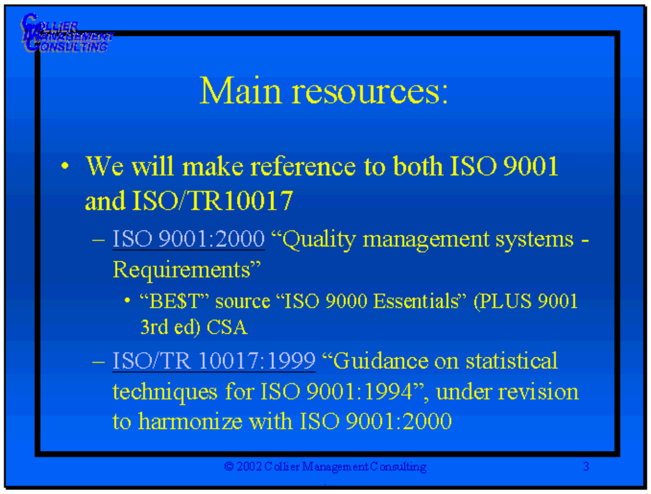




Reason:

Whether motivated by the requirements of a standard or by the needs of business, effective management is based primarily on facts; notwithstanding recent enthusiasm for "right brain" management.

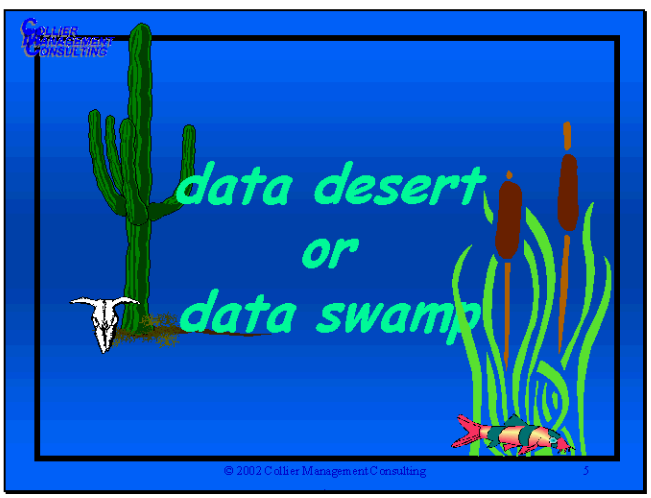
(And the class lawsuits after corporate failures also tend to be fact-based.)



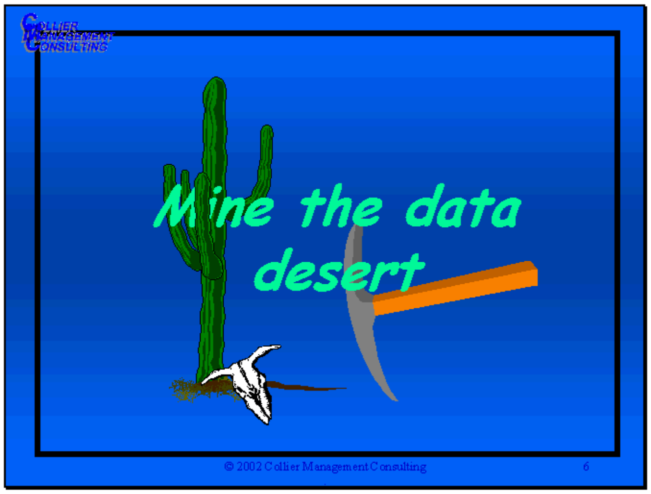
Note that these standards are ©ISO. Please support the international standardization movement by buying your copies. Sources are CSA (http://www.csa.ca/), SCC (http://www.scc.ca/), and ISO (http://www.iso.ch/).

ISO 9001:2000 obligates you to examine the performance of your own quality system by collecting and analysing observations and acting on them to eliminate and prevent problems. A bit like the cod liver oil of your grandparents day, these unpleasant chores yield great benefits to those who don't choke on them.

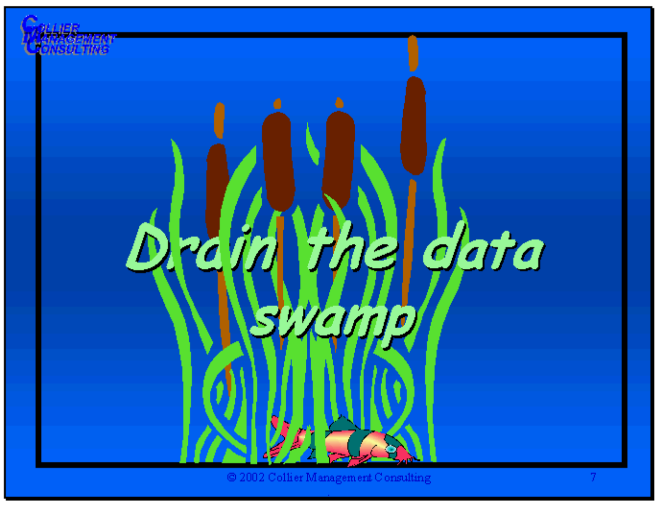
Curiously, most organizations take a different attitude to financial performance. They monitor, analyse and act on every twitch in earnings, stock value or sales volume.



Question: Do you have too much or too little information in your organization?

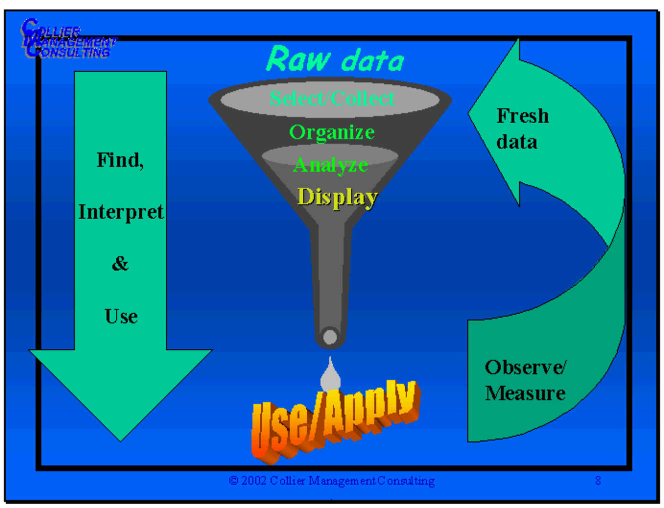


If you don't have info (or don't know that you have it) then you need to go prospecting. It is available, and you ignore it at your peril.



More commonly, management is awash in information. The in-basket deluge is the biggest time management challenge facing most mangers and supervisors. Many handle it by deferring everything they can't quickly comprehend and dealing only the things they think they understand.

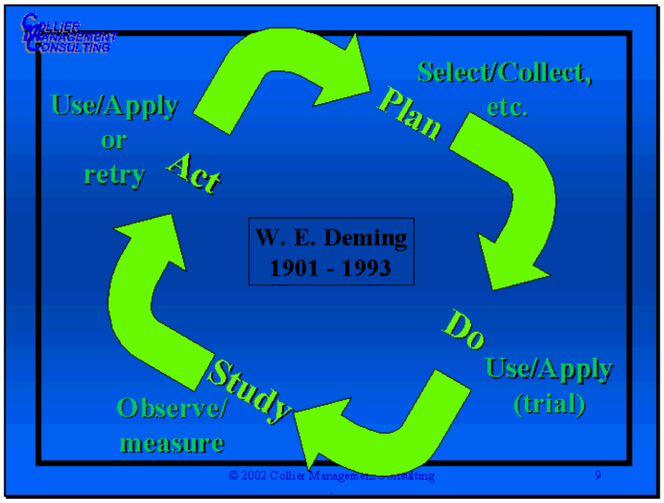
Does this explain the lack of progress and change in many companies?



Data collection and analysis is a closed loop process. It starts with discovery and collection of an incomprehensible and often disorganized mass of facts. It proceeds through filtering, organization and analysis until we create a picture that is intelligible both to ourselves and to others who need to know.

This becomes the basis for creative thinking: speculated causes, possible improvements and outright innovations.

By trying out new ideas and measuring the results we create fresh data and repeat the process.



While not exactly parallel, the process described is related to W. Edwards Deming's famous PDSA cycle for systematic improvement.

Deming actually called this the Shewhart Cycle, crediting the concept to Walter A. Shewhart in his 1931 book, "Economic Control of Quality of Manufactured Product". (Yes, the world has been glacially slow to catch on!)

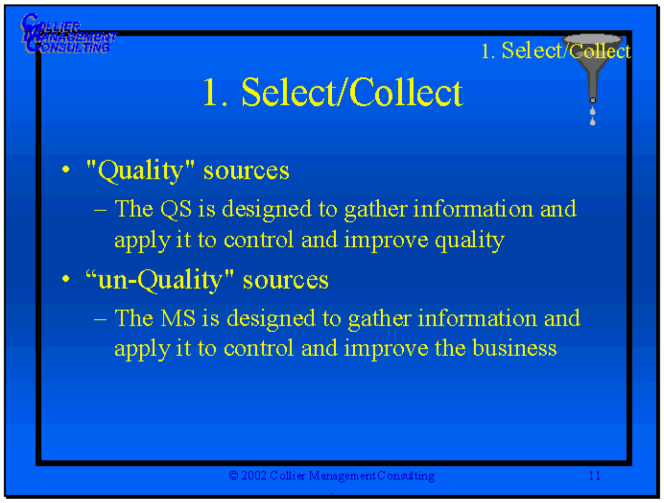
The message Deming intended to convey with this mnemonic was to continually explore the prospects for change and improvement:

- Plan a change or a test aimed at improvement. Design an experiment or pilot run.
- Do the experiment. Carry out the change, preferably on a pilot scale or limited time.
- Study the results of the experiment and draw conclusions as the worth of the change.
- Act by a) adopting the change or b) abandoning it or c) running another experiment to search for a better way.

Introducing a programmed approach to MBD.

These five steps are like the instructions or requirements for a computer programmer. They are not explicit enough to be executed as written, but they tell you (the organizational programmer) to create processes and systems, suited to your own needs, that will:

- identify and collect the data you need to understand and improve operations,
- organize it so that is manageable and intelligible,
- analyze it to reveal patterns and relationships and to draw conclusions,
- display the patterns and relationships so that others can understand the conclusions, and
- apply the conclusions by making improvements to your processes.

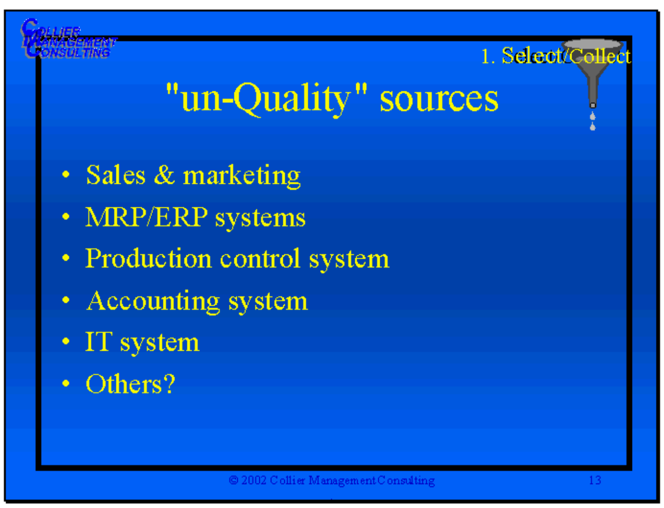


Management systems ("quality" or other) exist to control the behaviour of the organization.

Control by definition requires knowledge of the intended goal, measurement of the actual output, comparison of the two and correction or redirection to reduce the difference.

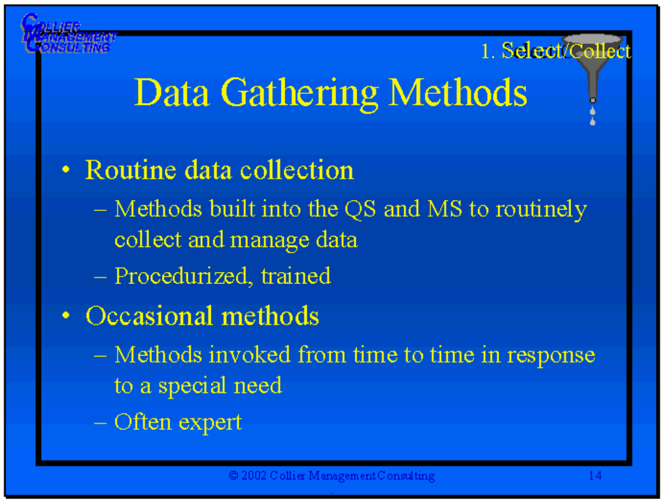
The first step is to select the desired information and to collect it without distortion or bias.

This list is a precis of what data and information you would be required retain under ISO 9001:2000. You are invited to add to it and make it more explicit to your organization.



"Un-Quality" does not mean low quality. Chances are, your organization already has impressive data acquisition systems, many of them automated to the point that they are nearly invisible.

Therein lies the commonest failing of companies preparing a formal quality management system. Unaware of what they already have, they regress several decades and create dozens or hundreds of forms to be completed, entered, filed and (often) forgotten.

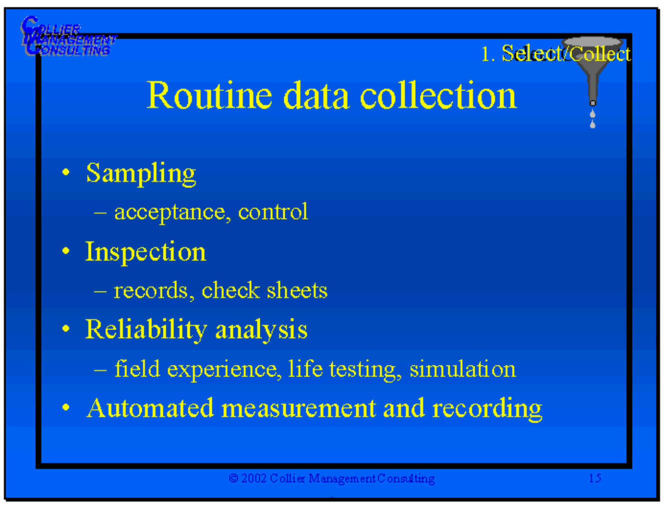


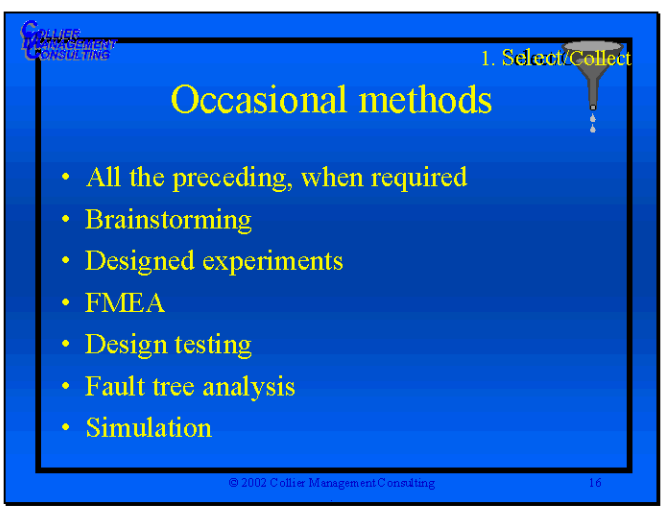
Some data are needed regularly (hourly, daily, weekly, ...) so there is justification to design and implement a regular collection and entry system. Paper forms and computer screens should be self explanatory and easy to use. Automation is inviting: electronic gauges interface directly with a PC; bar code readers count, catalogue and route; process control sensors can send data to a PLC and a record file.

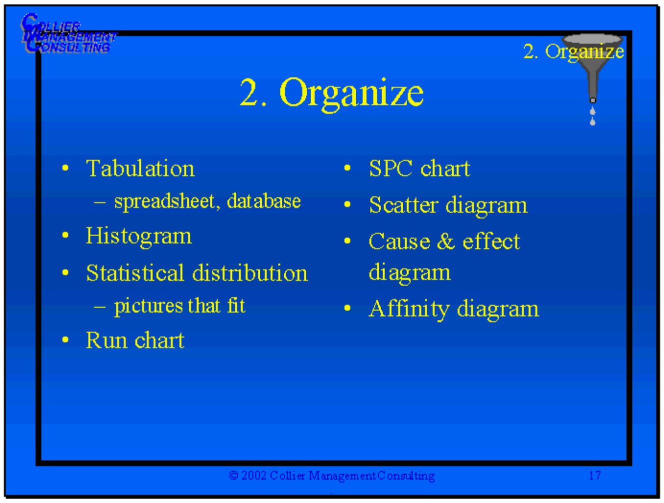
Data needed only for a particular occasion may require the invention of a collection system for the purpose.

Problems:

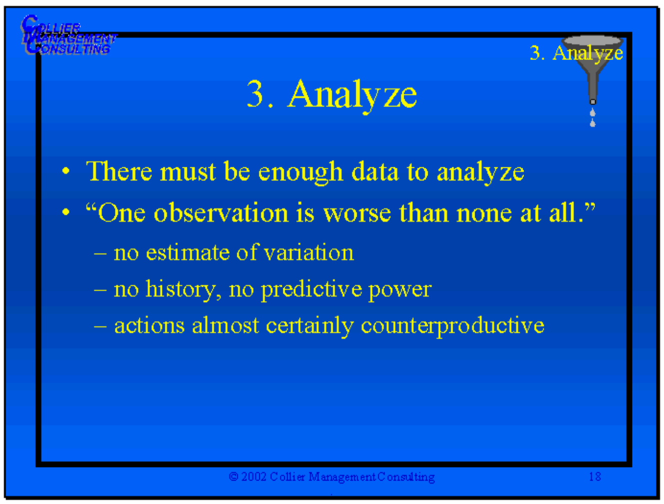
- Routine - People forget why
- Occasional - People forget how







The most valuable single thing you can do with data is to draw a picture.

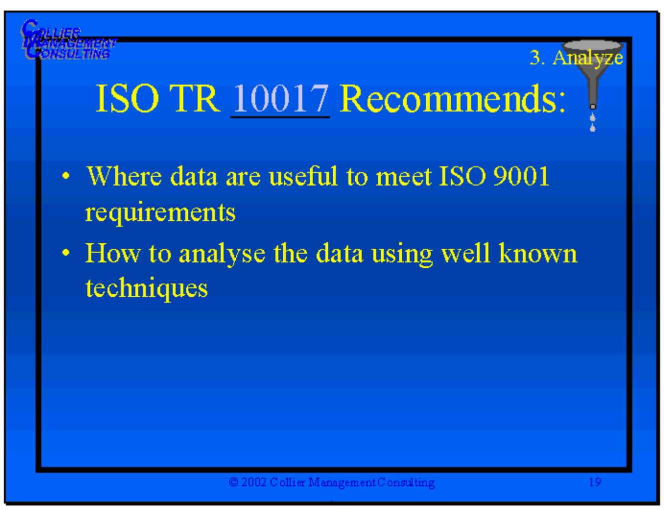


Your newly designed single cavity mould has just produced its first trial part.

Spec = 3.50 ± 0.05

Measurement = 3.52

Action = ?



Will return to this standard later.

Here's a partial index:

1 Scope

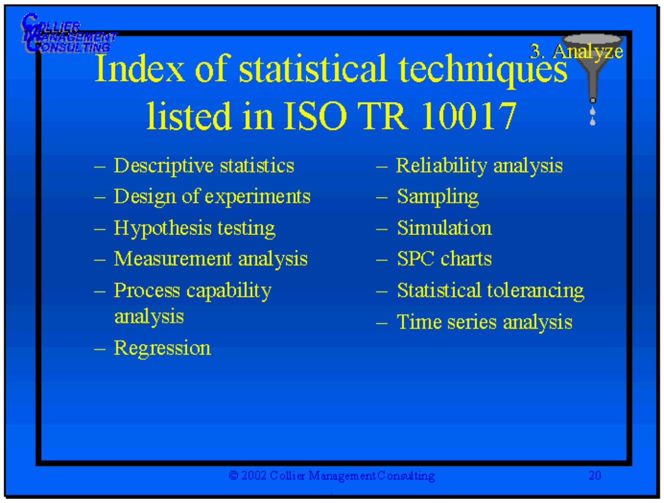
2 Terms and definitions

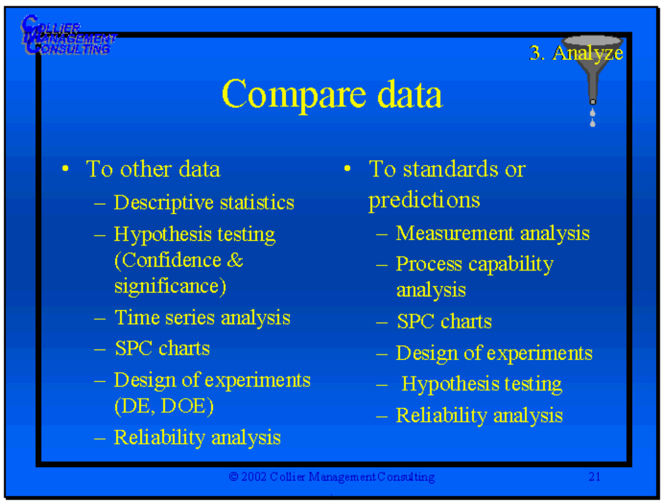
3 Identification of potential needs for statistical techniques

4 Descriptions of statistical techniques identified

(12 useful techniques briefly described.)

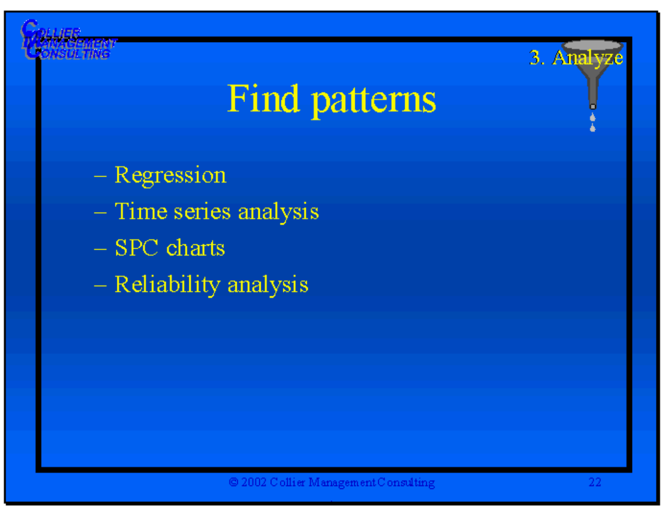
and some handy tables in the Appendix.



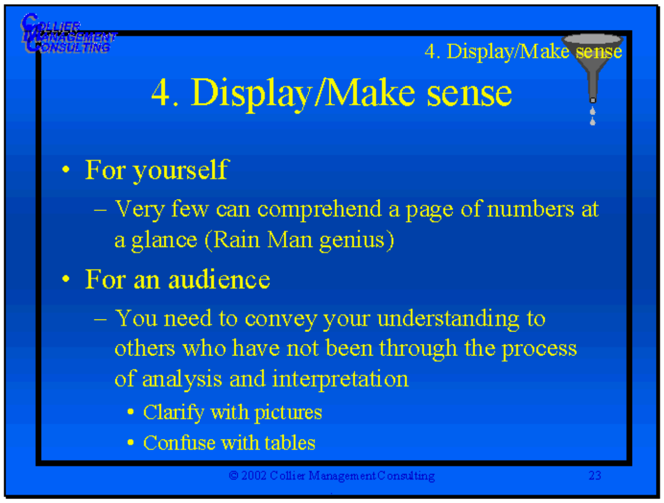


Compare current data to historical data to learn whether things have improved or worsened. Compare to standards to learn whether you meet a requirement.

Compare to predictions to test your understanding of the process.



Patterns in data, especially over time, provide warnings, predictions and insight into causes.

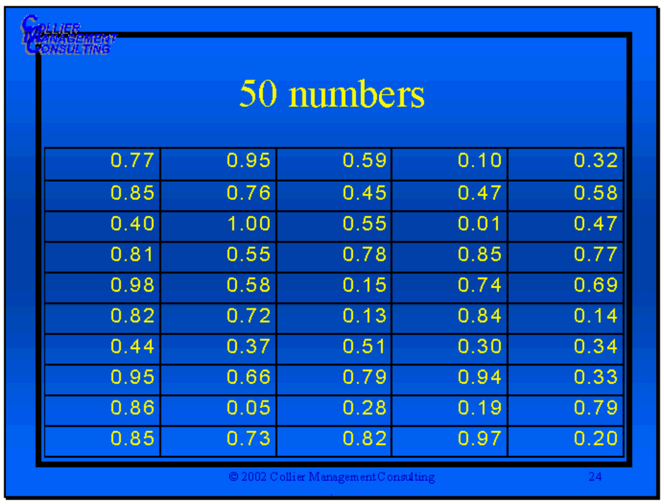


Examine any list or table of 50 or more numbers. (Accountants and inspectors are good sources).

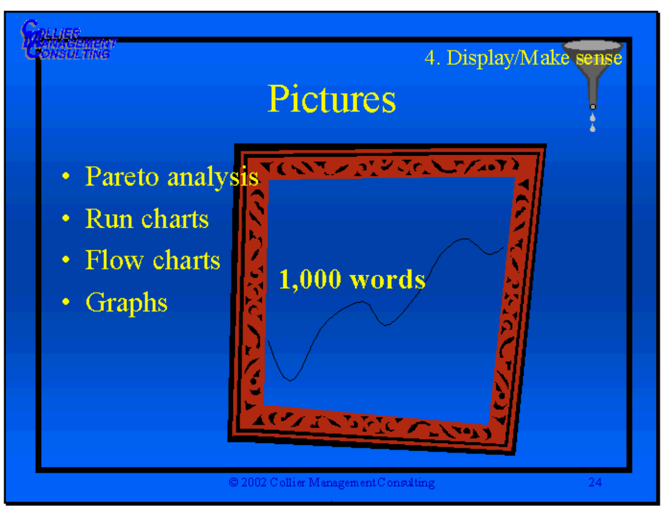
Did you search for the highest and lowest? The one in the middle?

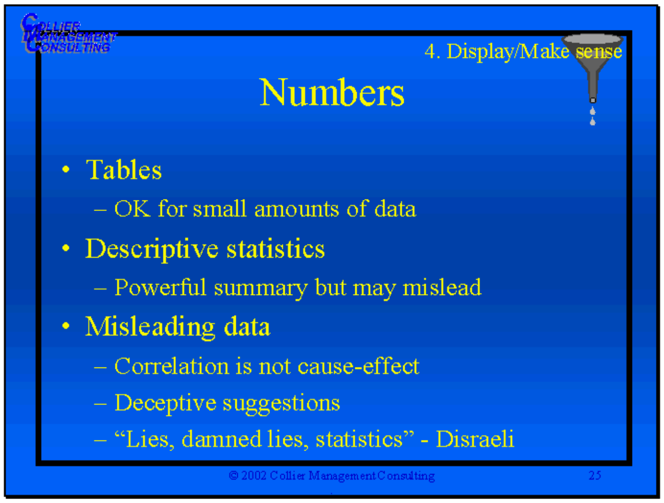
Did you look to see whether the last was greater than the first? Whether they generally increased or decreased?

If you immediately know the largest, smallest, average, etc. you may identify with the Dustin Hoffman in Rainman. (Search “Savant Syndrome” on the web.)



0.77	0.95	0.59	0.10	0.32
0.85	0.76	0.45	0.47	0.58
0.40	1.00	0.55	0.01	0.47
0.81	0.55	0.78	0.85	0.77
0.98	0.58	0.15	0.74	0.69
0.82	0.72	0.13	0.84	0.14
0.44	0.37	0.51	0.30	0.34
0.95	0.66	0.79	0.94	0.33
0.86	0.05	0.28	0.19	0.79
0.85	0.73	0.82	0.97	0.20

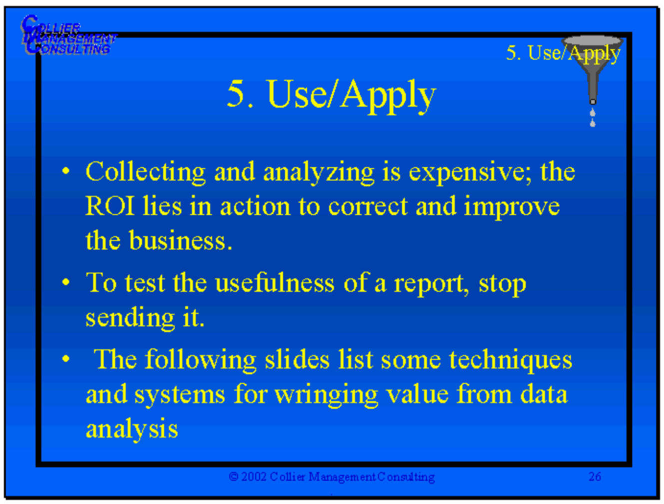




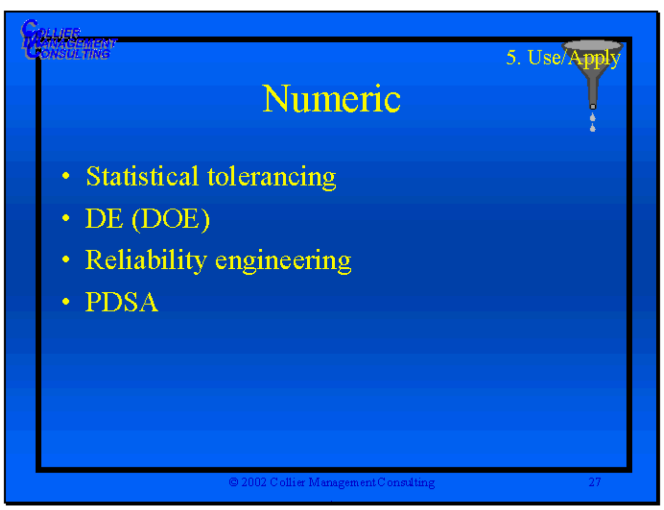
Some numbers you can calculate instantly (e.g. using the Formulas and Data Analysis menus in Excel)

> average (mean), median, mode, maximum, minimum, range, standard deviation, variance, correlation coefficient, ...

Note that some graphical methods taught until quite recently were used mainly because computation was so difficult but they still provide useful pictures to summarize results.



Unused data is a sad waste. If you don't learn from experience, you are destined to have many painful experiences.

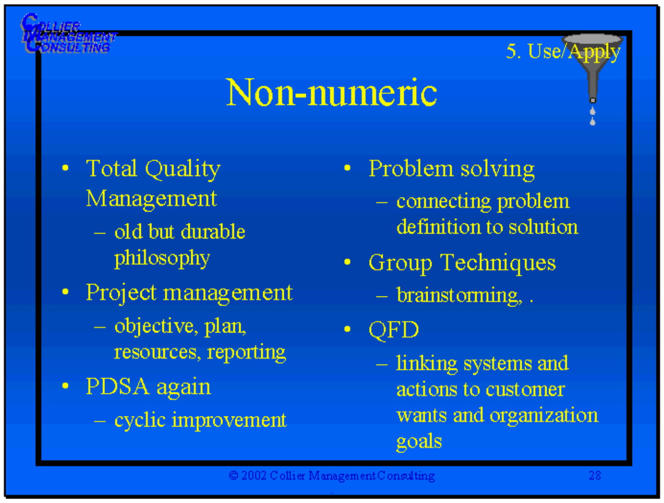


Statistical tolerancing drives you towards a rational combination of requirements and methods; requirements set high enough for the customer, methods that are sufficient and economical .

DE gathers most information with greatest economy and certainty.

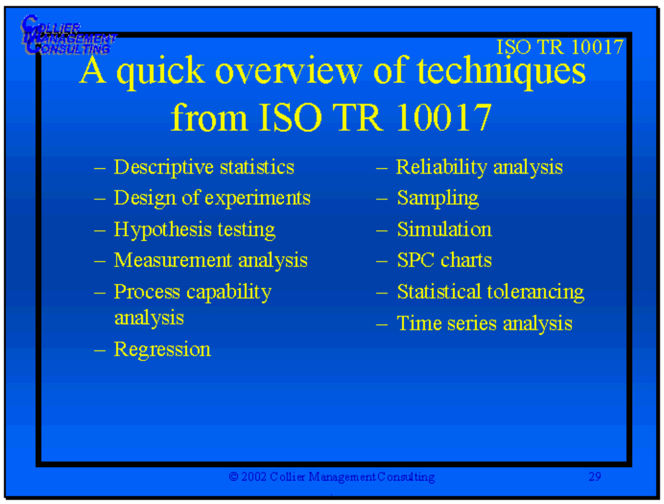
Reliability deals with performance over time.

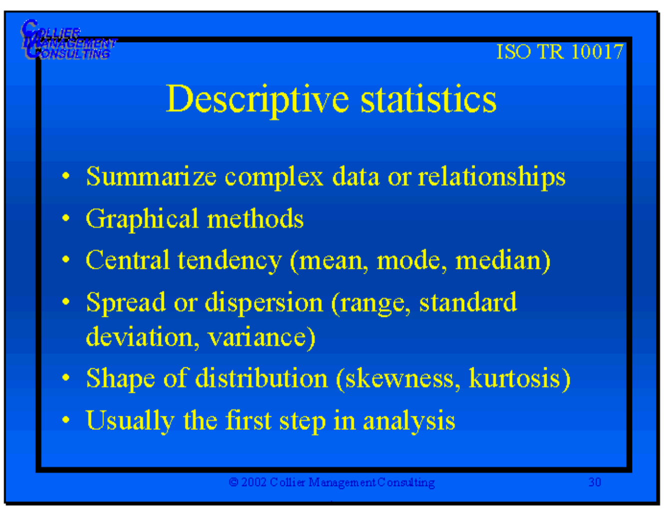
PDSA is a discipline for managing many numerical methods for improvement.



These are beyond the scope of this lecture.

References abound in the literature.





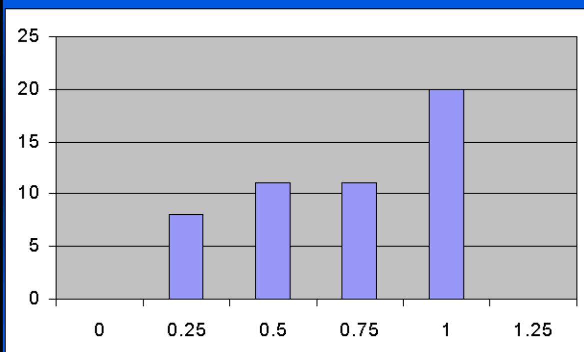
"Descriptive statistics" includes single numbers or pictures that summarize and characterize some aspect of a set of data; e.g., mean, median, mode = location; range, variance, standard deviation = spread.

They may also approximate the "parameters" of an underlying distribution that describes the process that generated the data. The Normal distribution or "bell curve" is the most familiar, but not the only one.

50 numbers

0.77	0.95	0.59	0.10	0.32
0.85	0.76	0.45	0.47	0.58
0.40	1.00	0.55	0.01	0.47
0.81	0.55	0.78	0.85	0.77
0.98	0.58	0.15	0.74	0.69
0.82	0.72	0.13	0.84	0.14
0.44	0.37	0.51	0.30	0.34
0.95	0.66	0.79	0.94	0.33
0.86	0.05	0.28	0.19	0.79
0.85	0.73	0.82	0.97	0.20

Histogram of 50 numbers



Descriptive statistics for 50 numbers

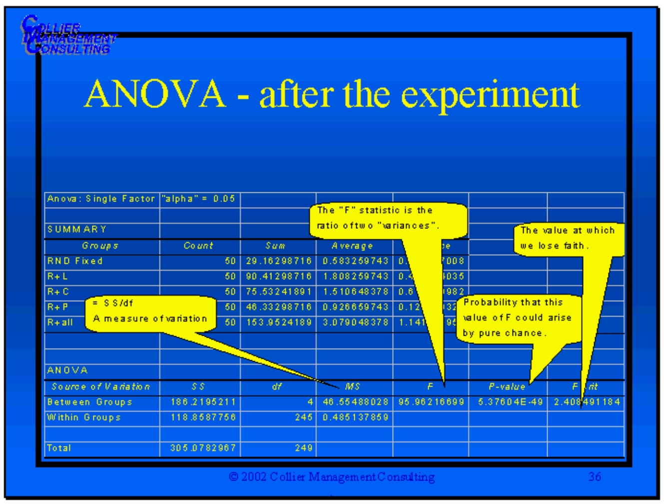
Mean	0.583259743
Standard Error	0.040188806
Median	0.623871339
Mode	#N/A
Standard Deviation	0.284177775
Sample Variance	0.080757008
Kurtosis	-1.023171367
Skewness	-0.408229218
Range	0.989175759
Minimum	0.007396724
Maximum	0.996572482
Sum	29.16298716
Count	50
Largest(5)	0.945692266
Smallest(5)	0.136251805

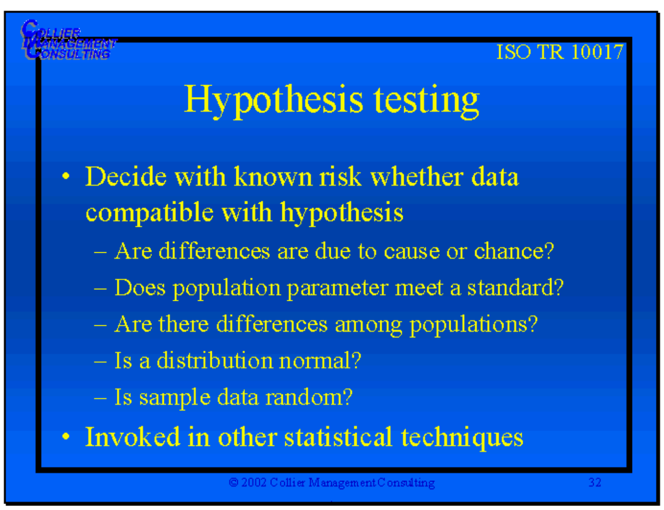
DOE or DE consists of imposing planned changes on a system under investigation and statistically assessing the effects to draw conclusions with a known level of confidence.

The “design” is the plan under which the experiments are performed. It is determined by the objectives of the study and the conditions under which the experiments are done.

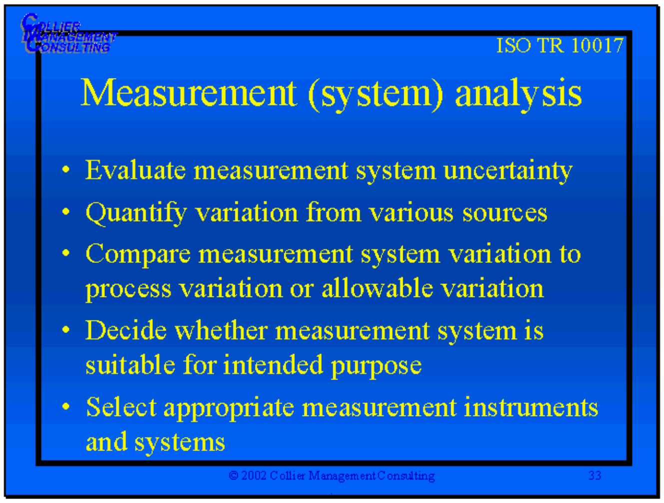
DOE may invoke several of the techniques for data analysis.

In industry, the greatest benefit often lies in minimizing the number of experiments, and therefore the cost and nuisance of disruption to the system.



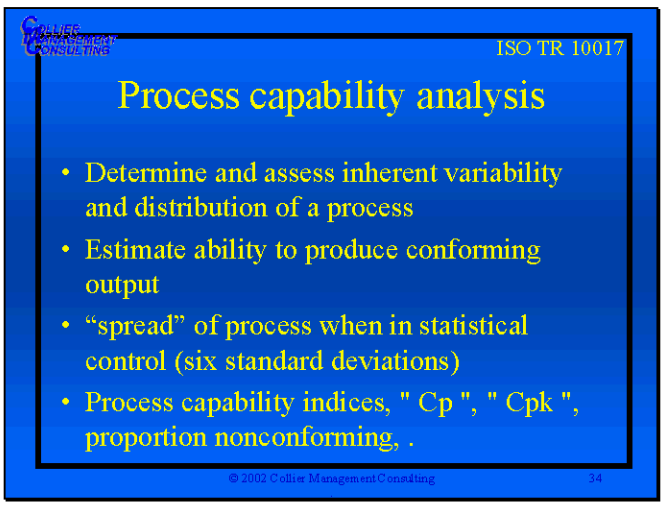


Statistics cannot “prove” anything about a system, but it can establish the level of skepticism to bring to a theory or recommendation. Hypothesis testing helps answer such questions as, “If I repeat the experiment or test some more product, how likely is it that the result will be significantly different?”, or “Should I trust this number to be accurate within ±0.01 units? ±0.005 units?”



To measure something the measurer needs an instrument, a method and a requirement. The commonest requirements are the ability to distinguish between acceptable and unacceptable products with known error and the ability to distinguish process variation from the inherent variation of the measurement system. The measurer may be human, machine or even animal. The instrument may be a physical device, a psychological test or a complex system in its own right.

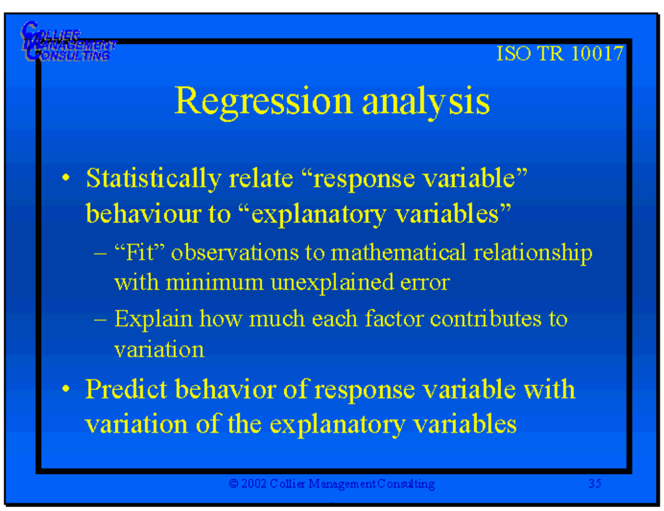
Measurement system analysis helps decide whether a proposed system consisting of measurer/instrument/method is able to meet the requirement.



To make something, or to deliver a service, the producer needs equipment and materials, a process and a requirement. (Remember measurement systems?)

The process needs to produce outputs (products, services) that consistently meet the requirements; best done by knowing and controlling the variability of the process.

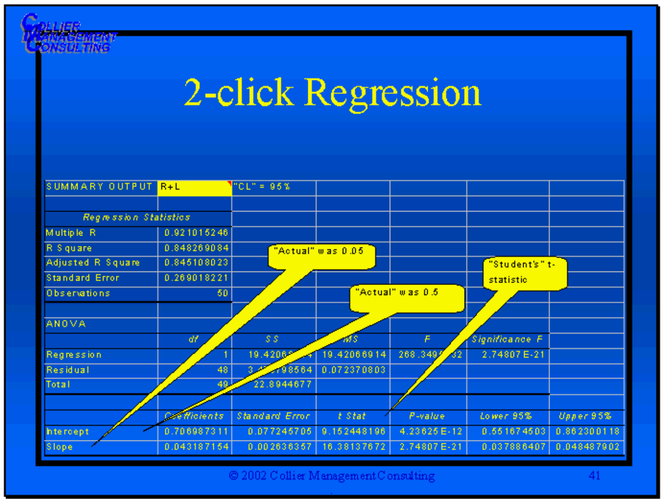
Process capability analysis helps decide whether a proposed system consisting of producer/equipment/materials/process is able to meet the requirement.

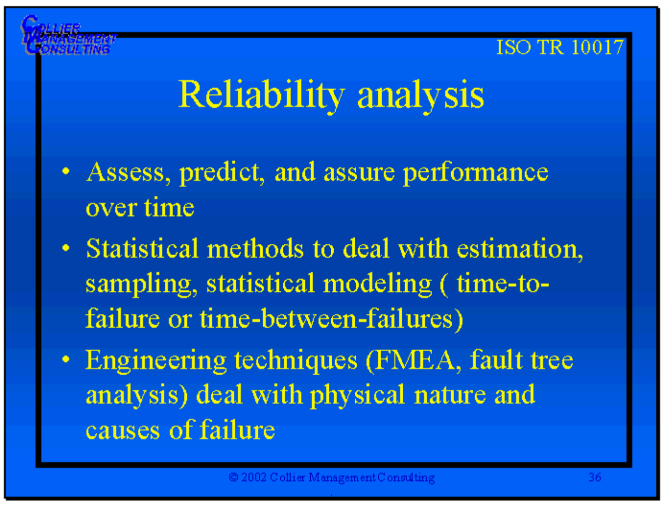


Caution: You can "fit" any curve to any data (provided you don't insist on a very good fit). And you can find a curve that will provide as good a fit as you wish to any data set.

Regression analysis is most meaningful if the explanatory variables really do have a logical/physical connection to the effect you are studying.

(Note: Regression has nothing to do with finding your inner child.)

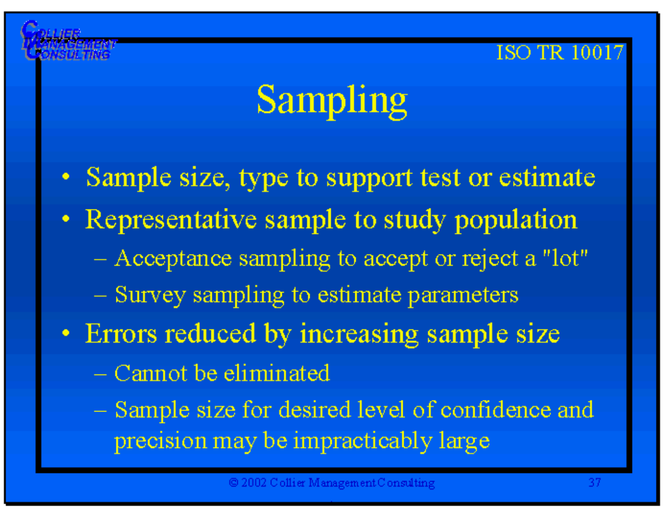




The “bathtub” curve shows the common life cycle failure pattern of many systems, including animals from which we derive some of the common language of reliability: infant mortality, the tendency for the weak or defective items in a new batch to fail early; wearout, the same tendency at end of (useful) life for things to fail.

Reliability analysis invokes other techniques, such as failure mode and effect analysis and fault tree analysis, which focus on the nature and causes of failure and methods for reducing or preventing failures.

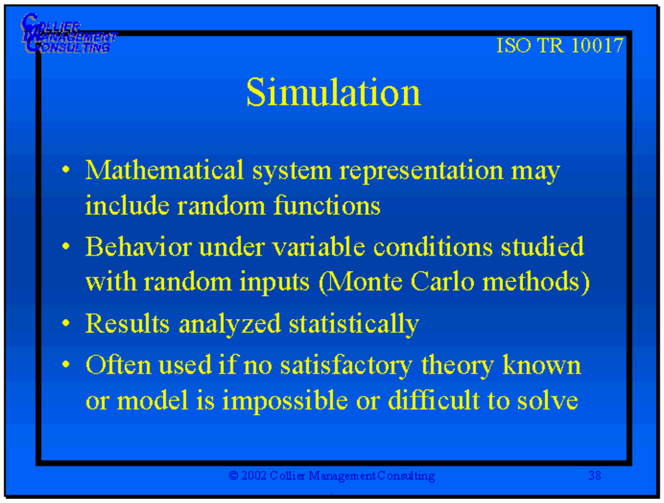
Reliability engineers should have a voice in setting warranty terms and reserves. The economics may be surprising.



First question: How many items do you need to examine to feel confident about the rest?

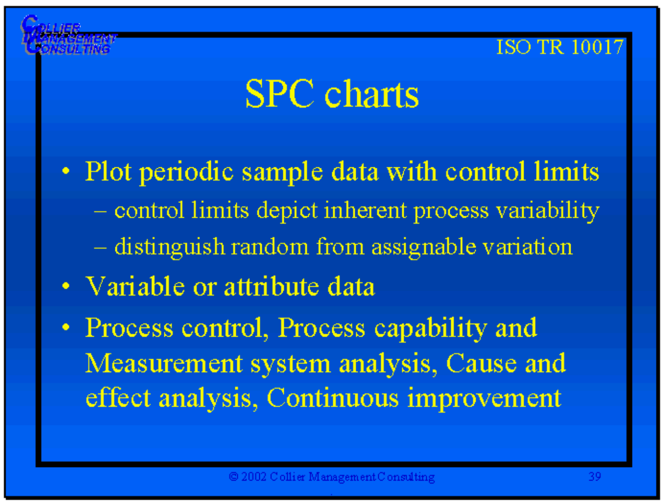
The most sobering conclusion is that any company that relies on acceptance sampling with “modest” or “affordable” sample sizes, is probably running the risk of a massive recall, unless the expectation in their market is so low that no one cares.

Second question: If you were a diabetic, how many contaminated syringes would you accept in a lot?



Simulation of complex systems is often the only economical way to proceed, especially when failure is not an option.

Examples: Traffic management system for urban rail control, all space projects, airport baggage management, ... ; you probably remember cases where the system failed anyway.



Truly ancient history: 1931, Walter A. Shewhart and still misapplied and misunderstood.

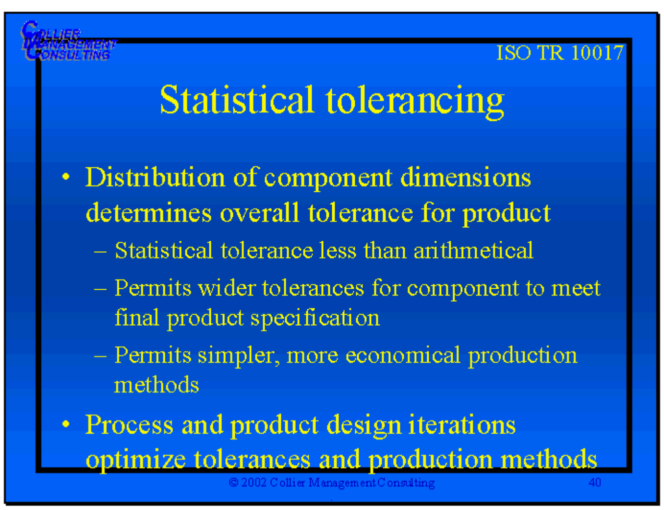
1. A process in statistical control has a stable, predictable average and variation.

2. A capable process is one that is in control and producing consistently within the allowable specifications.

3. Repetitive, small samples can be used to monitor the behaviour of the average and variation.

4. When the average or variation does not behave as predicted, the process is probably no longer in statistical control.

5. When the process is not in control it cannot be capable.



A wall is to be 3000 mm ± 6 mm high.

Bricks are specified to be 100 ± 6 mm thick (4 ± .25”).

If all the bricks in a shipment were 106 mm the wall would be 3180 mm.

If the brick spec were tightened to ±0.2 mm, the wall would be in spec using arithmetic tolerancing.

If bricks are produced with a controlled process, Cp = 2, the wall would be in spec most of the time. (simulate or calculate)

Simulation and Tolerancing

Brick wall simulation and Statistical Tolerancing										
100 mm (4") brick with 6mm (1/4") tolerance					30 bricks	Wall	995.3998	mm		
3 metre wall with 6mm tolerance						Off spec	-2004.6	mm		
Arithmetic tolerance on 30 bricks			0.2	mm						
	brick mm	height mm	bricks #	actual m		Process capability - 50 bricks				
Nominal	100	3000	30			Total	250.9037	250.9037	995.40	mm
LSL	94		30	2820		AVG	5.018073	5.018073	99.54	mm
USL	106		30	3180		SD	0.868601	0.868601	0.82	mm
						6 sig	5.211604	5.211604	4.91	mm
						Cp	2.302554	2.302554	2.45	mm
					99.11	99.75	98.94	100.55	100.25	
					101.09	100.71	99.43	100.39	100.12	
					98.96	101.65	98.85	100.10	98.57	
					99.60	99.53	100.44	100.89	99.59	
					100.17	98.59	100.24	101.01	99.96	
					97.95	100.11	100.70	99.35	100.46	
					99.64	101.44	98.19	99.31	100.59	
					99.90	101.18	99.46	101.68	100.52	
					99.55	99.51	100.10	99.64	101.22	
					99.43	100.37	100.46	100.68	101.00	

© 2002 Collier Management Consulting 47

ISO TR 10017

Time series (trend) analysis

- Graphical & analytical study of behaviour of sequential data
- Trends, “lag” patterns (correlation with preceding observations), cyclical, seasonal, “outliers”
- Predicting future behaviour
  - Detecting turning points in a trend
  - Projecting future values

© 2002 Collier Management Consulting 41

Time series analysis can vary from looking at graphs to Fourier analysis that breaks out all the cyclic components is a varying time line.

In many practical situations, simplicity and common sense work very well - look for coincidences with shifts, seasons, weekends, daylight saving time, maintenance cycles, tool wear, accounting cycles, inventory changes, ...

See also regression analysis.