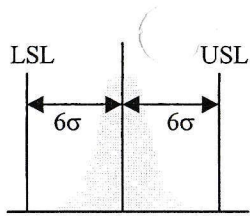


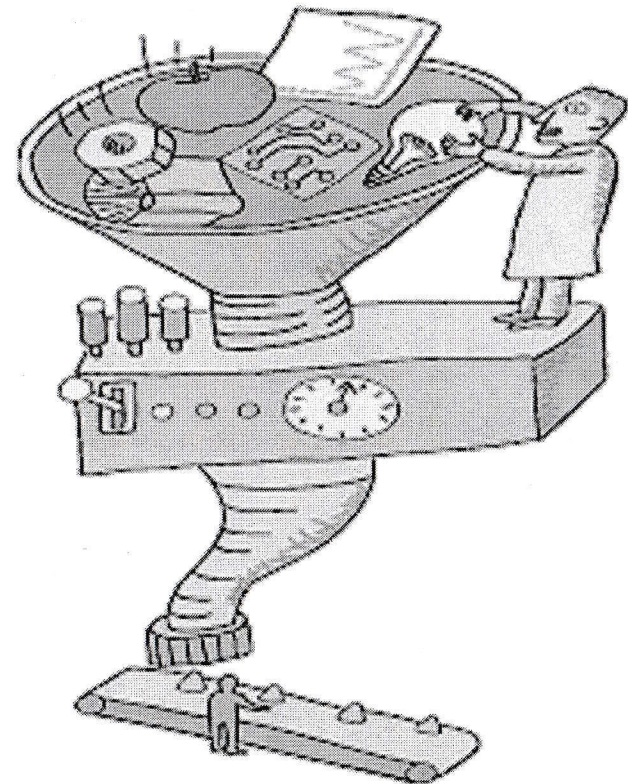
Philosophy of Designed Experiments

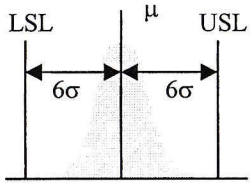
Lean Sigma Black Belt Training



Types of Experiments

- ♦ **Trial & Error**
- ♦ **One Factor at a Time**
- ♦ **Factorial Experiments**
 - ♦ **Full Factorial**
 - ♦ **Fractional Factorial**
- ♦ **Others**



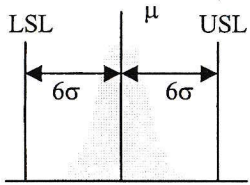


Trial & Error

The most well known problem solving methodology

- The objective is generally to provide a quick fix to a specific problem.
- Fix occurs by randomly and non-randomly making changes to process parameters, often changing 2 or more parameters at the same time.
- Often a “Band-Aid” fix to the problem as the symptoms are removed but the cause of the problem goes undetected.
- In Trial & Error experimentation, knowledge is not expanded but hindered.





One Factor At A Time (OFAT)

Based on the theory:

“Only change one thing at a time and hold everything else constant.”

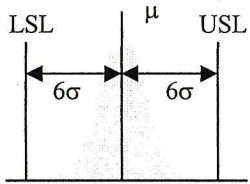
With this method, one can be sure that the any changes in the response is due to the manipulated factor.

- But are they?

Is it reasonable to assume one can hold all factors constant while manipulating one.

- Experience says this is virtually impossible

- What if there are a large number of factors affecting the response variable.
- How long would it take OFAT to identify critical factors and the setting for the best response.
- Is the knowledge gained through OFAT suspect ???

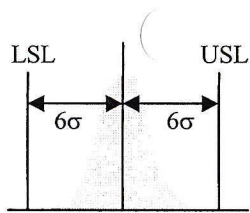


OFAT

Although OFAT simplifies the analysis, a significant amount of experiment efficiency is given up.

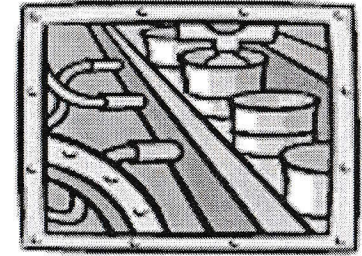
- Do not know the effect of changing one factor because others factors are changing.
- Will run unnecessary experiments
- Time to find casual factors is significant.



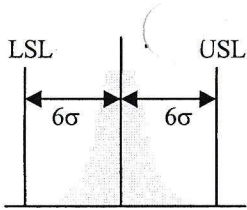


Full Factorials

The Tech Group



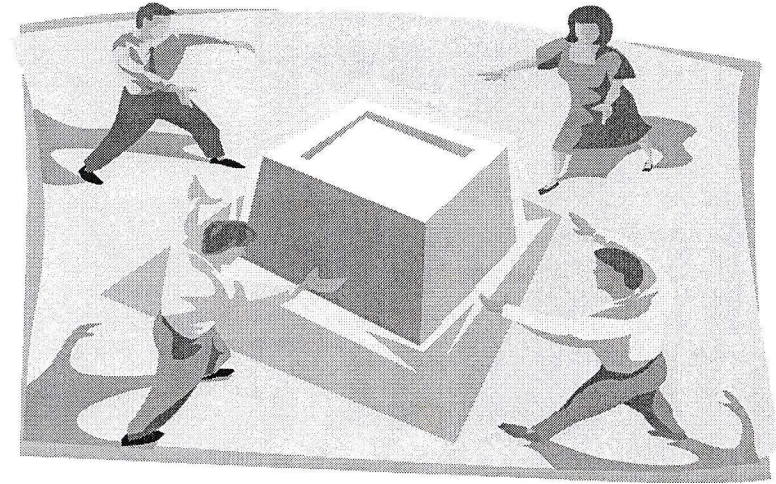
- Full Factorial Designs (Factorial)
- Test every possible combination of factors.
- These experiments are of interest because they *provide a great deal of information*.
- Not very efficient during the early stages of experimentation. The amount of resources needed to run Full Factorial experiments can be exorbitant.
- Full factorial designs can be very effective when used at the proper time in the overall process improvement strategy.



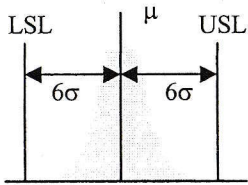
Problem Identification

Before starting a Designed Experiment it is important to develop a clear problem statement and objectives for the experiment. Sources of data which may help in problem identification include:

- *Previous Six Sigma tool application*
- *Customer feedback*
- *Scrap and rework reports*
- *Downtime reports*
- *Pareto reports*
- *End of line testing/inspection*
- *Cost analysis (actual vs. forecasted expenses)*
- *Cycle time fluctuations*
- *Missed deliveries*
- *Unscheduled maintenance calls*
- *Line worker overtime reports*
- *Engineering change orders*



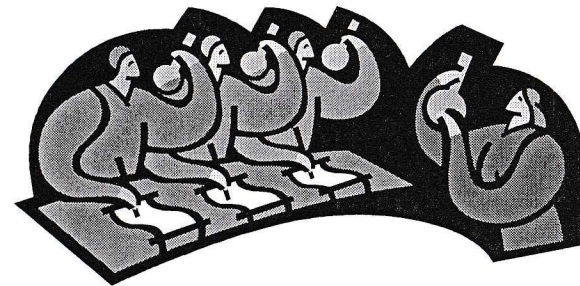
Generally speaking, most companies *can* effectively recognize the existence of a problem. Although, most companies have difficulty quantifying the problems.



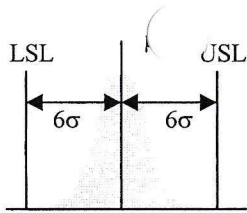
Experiment Objectives

Setting the experiment objectives is in essence determining what question or questions need to be answered. Formulating the appropriate question is very important. Consider these questions: Does the product or process work.....

- When other people use it?
- When it has been installed?
- If the environmental conditions change?
- If raw materials vary?
- If components vary during uses?
- All the time?
- With less expensive components?
- With wider tolerances?
- If the design is simplified?
- If someone spilled a beverage on it?



Through the use of designed experiments, these questions can be answered efficiently. It is important to remember experimental design is a tool to help people do their job more effectively. It is not a substitute, but a catalyst that gets the best out of all disciplines.



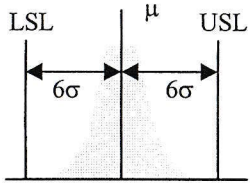
Experimentation Guidelines



- ◎ Clearly define the objective of the experiment and ensure that the team understands and agrees with it.
- ◎ Be aware of the experiment's inference space.
- ◎ Use two-level designs early stages.
- ◎ Utilize bold level settings initially.
- ◎ Subsequent experiments will describe complex relationships.
- ◎ Spend less than 25% of budget on first experiment.

"The purpose of analysis is insight. The best analysis is the simplest analysis which provides and communicates the insight which can be obtained from the data. Complexity, for sake of sophistication, is obfuscation. Unfortunately, there are people who are afraid of clarity because they fear that it may not seem profound."

D.J.Wheeler



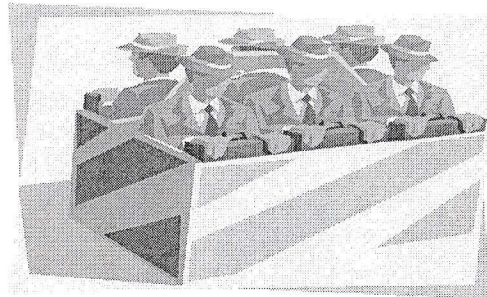
Inference Space

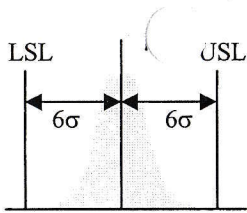
Inference Space- The area within which you draw conclusions based on the results of your experiment.

- Inference space is critical in determining how to run the experiment, how much data is needed, when the should be collected, and in what order the data should be collected.
- There are two typical classifications of inference space: broad and narrow.

Broad- In general, the broader the inference space, more data must be taken over time.

Narrow- Is used to draw conclusions about a small portion of the entire population





Response Variable(s) Questions

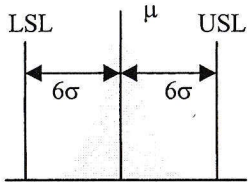
What is the goal of the experiment (optimization, screening, regression, prediction)?

- ☐ Is the response qualitative or quantitative?
- ☐ Is the response variable nominal is best, larger is better, smaller is better or dynamic in nature?
- ☐ Is the concern for process centering, process variation or both?
- ☐ What is the process baseline (i.e., average and sigma) for the response variable (s)?
- ☐ Is the response variable currently in statistical control?
- ☐ Is the response variable affected by time?
- ☐ How much of a change in response variable do wish to detect?
- ☐ Do you know the expected distribution of the response variable?
- ☐ Is the measurement system adequate?
- ☐ Are there multiple responses you are concern with? What are the priorities for optimization?



**You'll need to ask at least 50 questions to get started.
 Focus on the details.**





Summary

- This module sets the foundation for all other DoE modules.
- There are two necessary elements to the learning process; a significant event and a perceptive observer.
- The learning process can be greatly accelerated by creating significant events and observing them. This is most effectively done through designed experiments.
- It is important to realize that learning is a iterative process and information from designed experiments may be combined to get results quickly.
- The use of factorial designs is very helpful in this process as they are the most efficient tests.