

## **6? and its application to software development**

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## ***Objectives and Rationale:***

- **To briefly describe the 6 $\sigma$  statistical term, and its SPC context**
- **To outline the 6 $\sigma$  business tool that has evolved from the statistical tool**
- **To discuss the applicability of 6 $\sigma$  to software development**

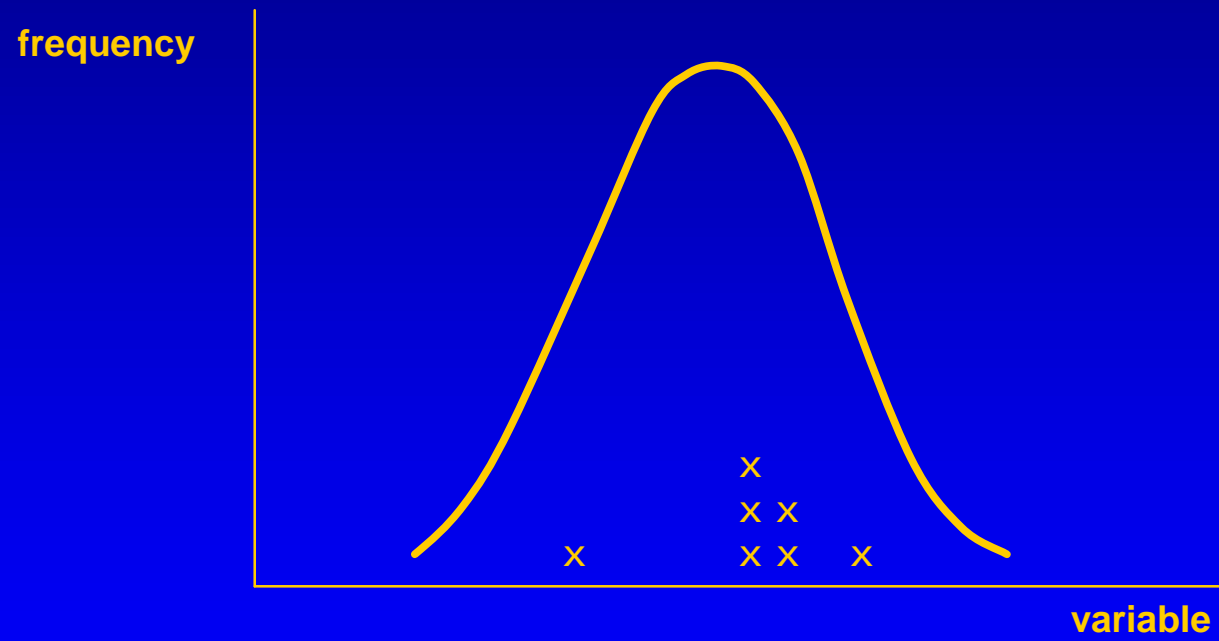
**because**

- ***both* SPC and the new 6 $\sigma$  methodology may be useful as tools for improving software products and processes**

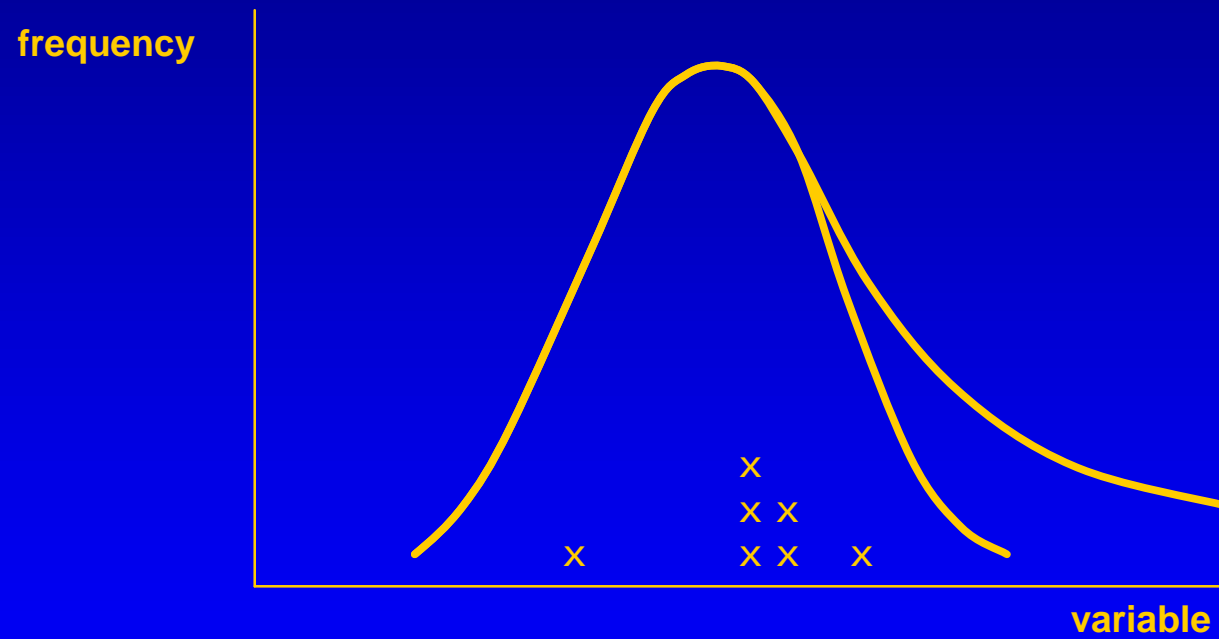
**6? :**

- **originally a term derived from Statistical Process Control**
  - SPC is a production engineering discipline for the control of manufacture of products - i.e. control of *replication* processes.
  - 6? is a term used in SPC methods used to characterize continuous variables, approximately normally distributed...

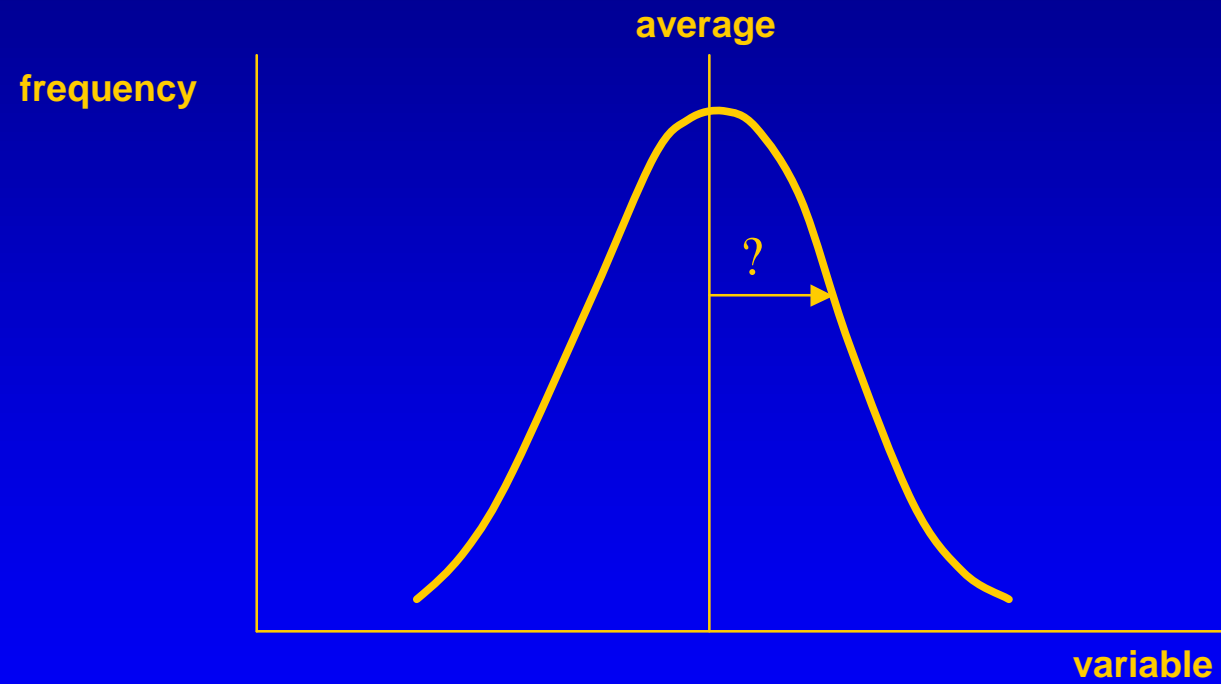
## Measuring variation:



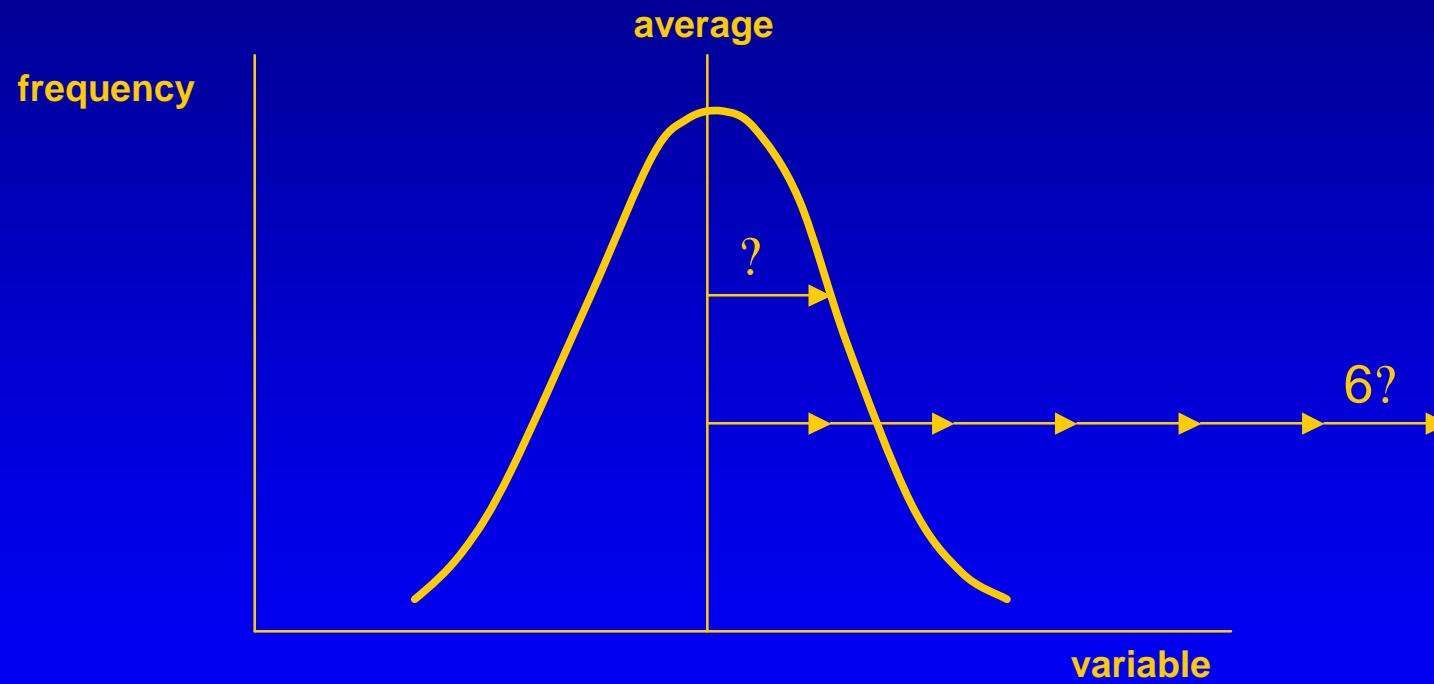
## Measuring variation:



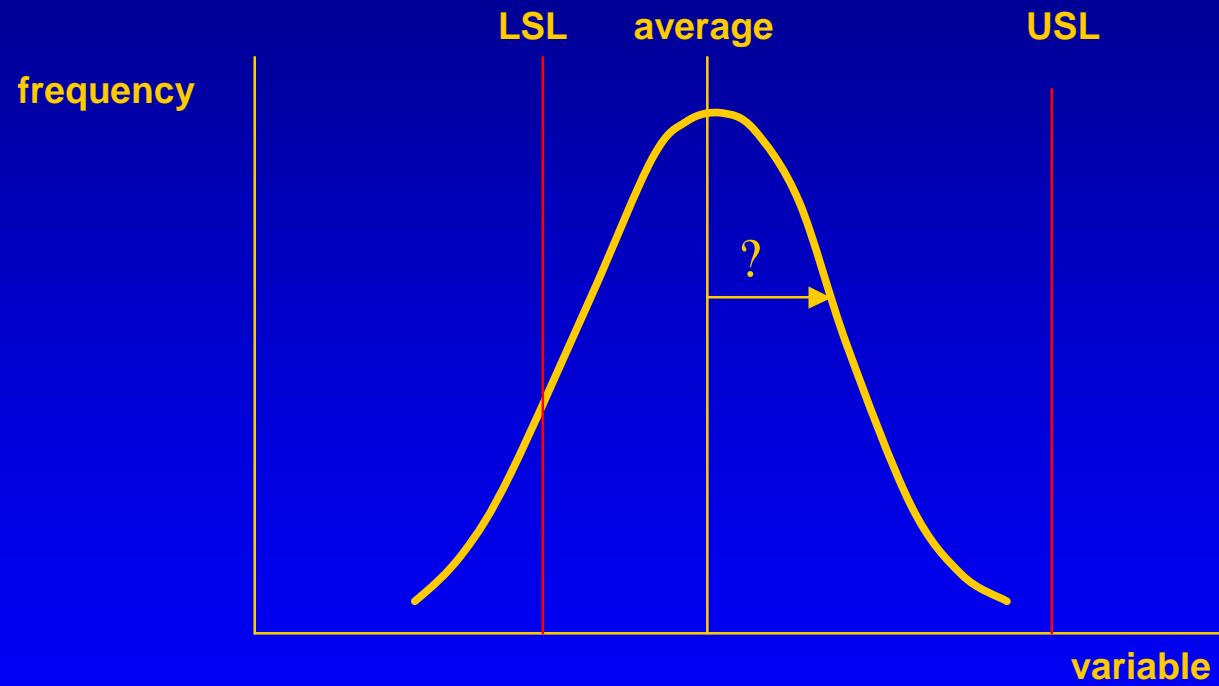
## *Measuring variation:*



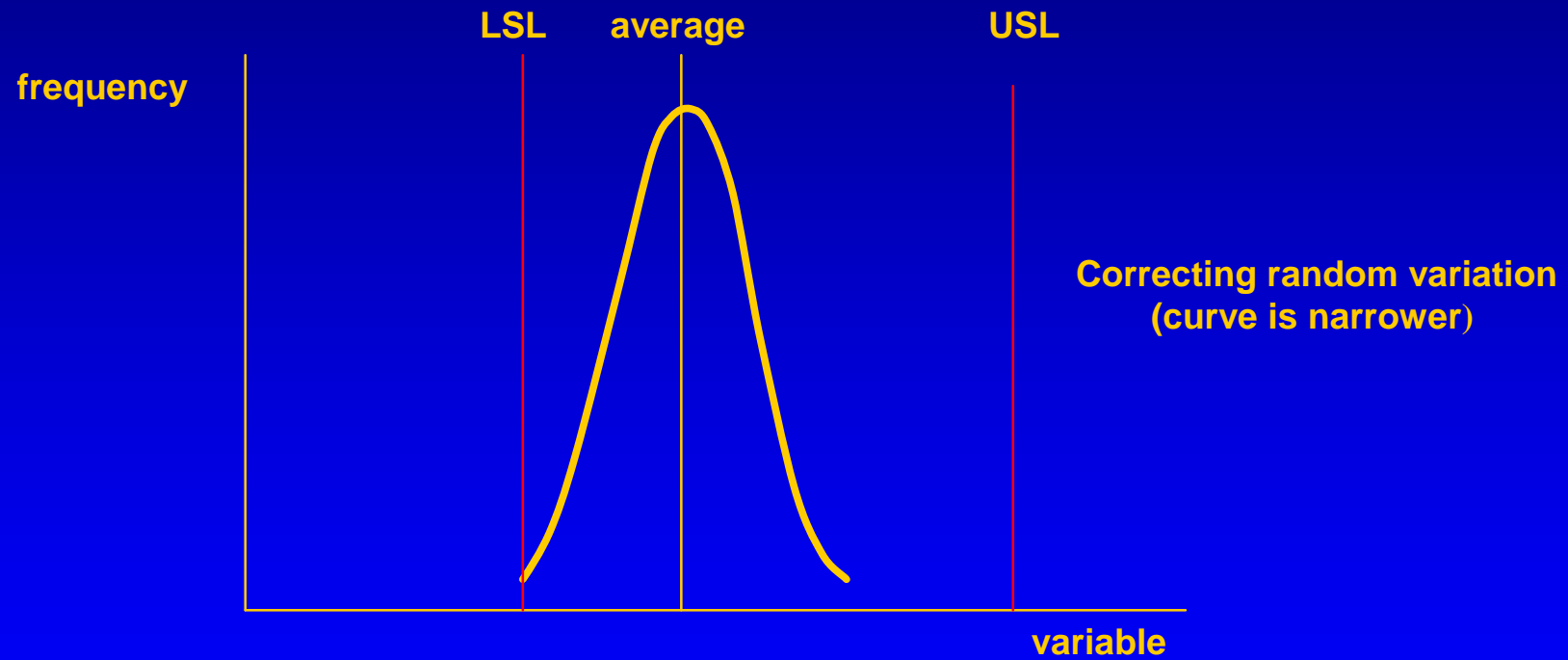
## Measuring variation:



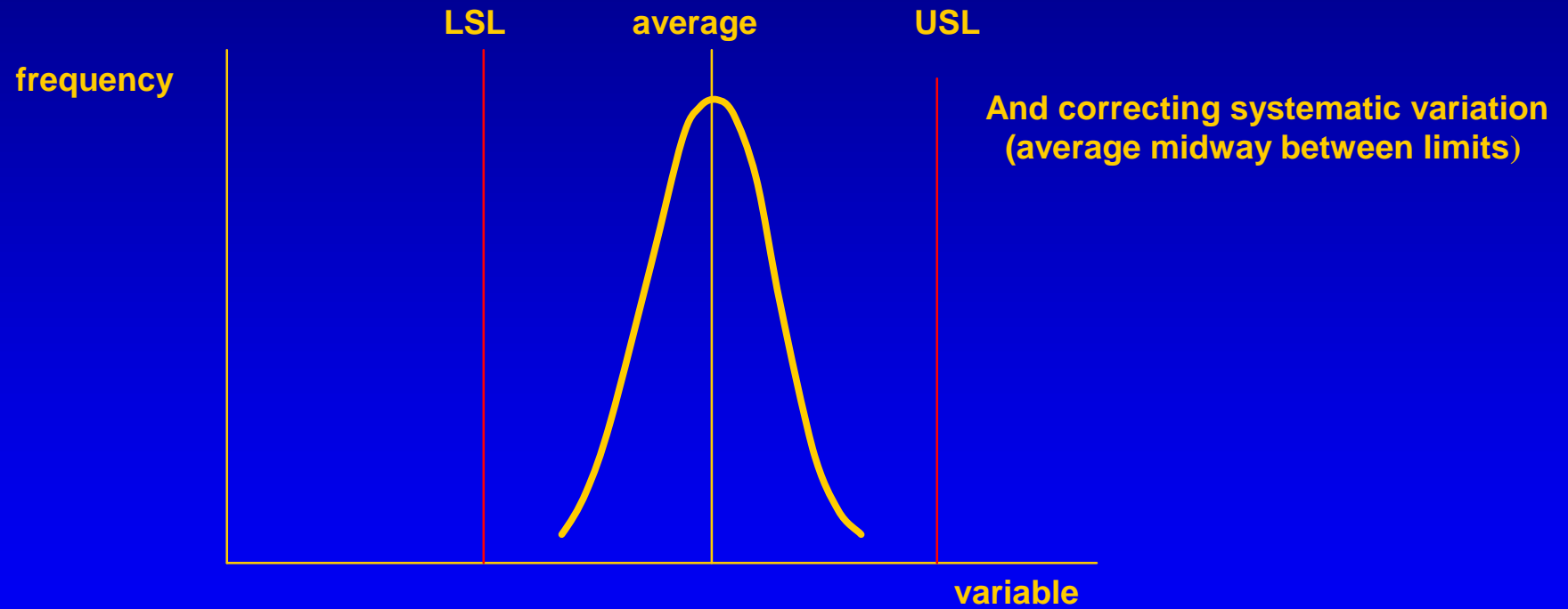
## Measuring variation:



## Measuring variation:



***Measuring variation:***



## ***Measuring variation:***

- **68.3% in between +/- 1?**
- **95.4% in between +/- 2?**
- **99.7% in between +/- 3?**
- **> 99.999999% in between +/- 6? (2ppb) \***

**6? has become synonymous with (almost) zero defects**

**\*translates to 99.9997% or 3.4ppm with a process drift of +/- 1.5 ?**

## ***Process Capability:***

### **Indices for measuring process goodness**

- **$C_p = USL - LSL / 6?$  or  $2T / 6?$** 
  - **$C_p < 1$  process is incapable**
  - **$C_p > 1$  process is capable (6? processes have  $C_p$  of 2)**
  - **does not account for process drift so...**
  
- **$C_{pk} =$  the lesser of  $(USL - \bar{X}) / 3?$  or  $(\bar{X} - LSL) / 3?$**

## ***Caveats and constraints:***

- applicable to a replication process
  - (is software development a replication process?)
- variables data are of at least interval scale type
- data distribution is continuous
- data distribution is, approximately, normal
- (implicit mapping of design parameters to performance characteristics)

'as is' - has limited applicability to s/w processes

however...

## ***Opportunities - control of attributes :***

- There is another branch of SPC...
  - control of attributes (cf variables)
    - discrete distributions
    - integer values
      - *(NB counting - not measuring)*
    - allows qualitative assessment and evaluation

## ***Opportunities - control of attributes :***

- ...There is another branch of SPC
  - control of attributes (cf variables)

**“... An associated problem relates to those articles which, although not completely defective in themselves, may have a number of defects which mar the finished product... ... In such cases the structure, which may be complex, can often tolerate a number of defects before becoming defective itself; the only practical objective, therefore, is to ensure that defects do not increase above a specified level.”**

*Huitson & Keen, Essentials of QC, 1965*

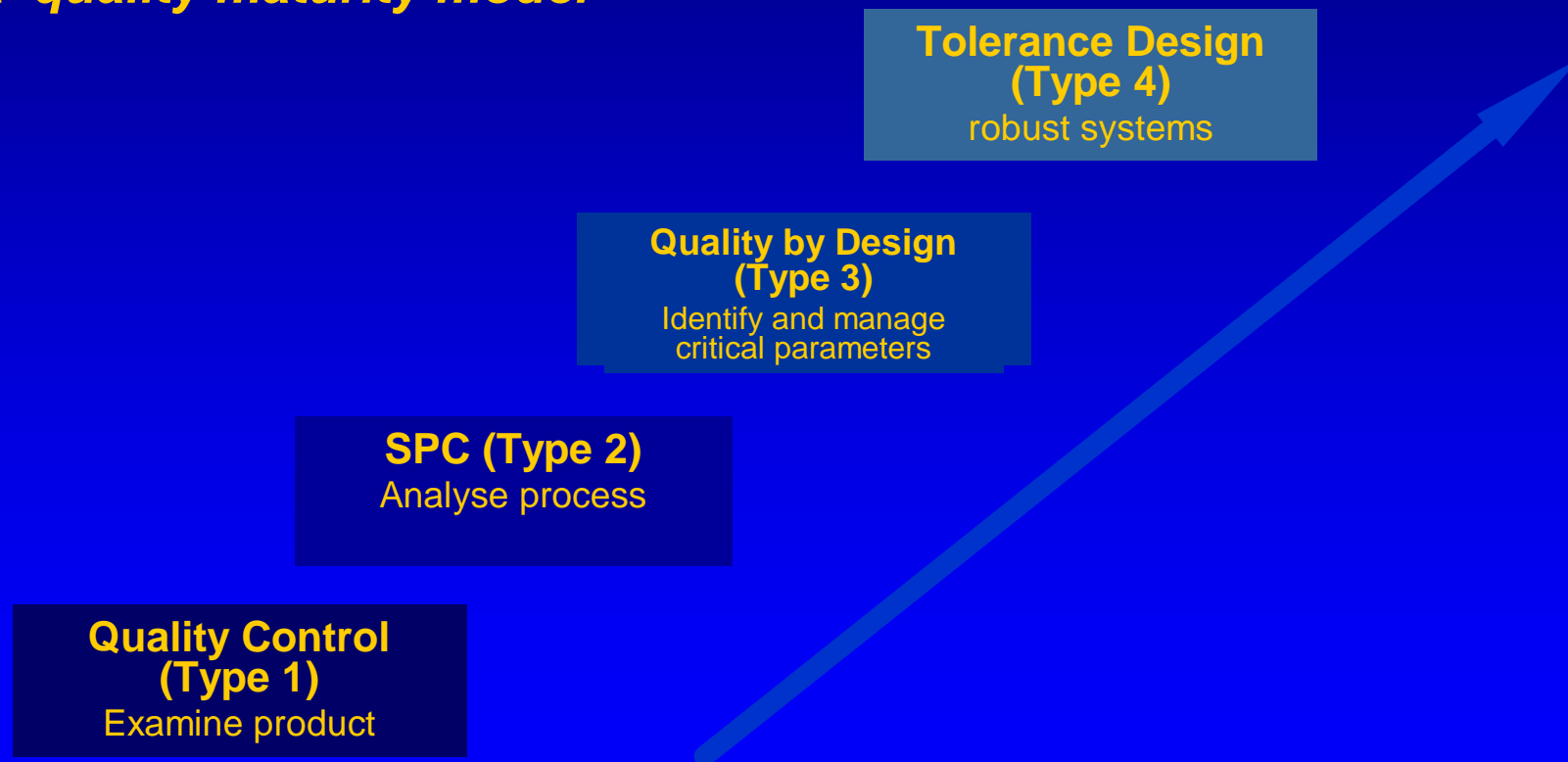
## ***Opportunities - control of attributes :***

- Control of attributes
  - qualitative
    - good/bad, conforming/non-conforming
    - non conformities - counts of defects
    - a *defective* is an item that contains an unacceptable level of *defects*
    - uses sampling
    - defects probability distribution is *binomial*
    - primary tool is np-chart tracking defectives in a sample
    - less sensitive than control of variables
    - cumulative charts aid identification of trends

## *Opportunities - improving design quality:*

- Production Engineers have developed more sophisticated tools to manage the quality of design.
  - DoE/QFD, Parameter Design
  - Tolerance Design (Taguchi)

*A 'quality maturity model'*



## ***A 'quality maturity model':***

- **Type 1**
  - **QC** - examine product, identify defects, either fix defects or scrap product
- **Type 2**
  - **SPC** - examine process (by sampling) and control systematic and then random variations in the process; defect data no longer associated with the product
- **Type 3**
  - **Parameter Design** - identification of critical parameters / QFD / DoE (Taguchi)
- **Type 4**
  - **Tolerance Design** - robust systems

## ***The new 6? :***

- **Origins**
  - developed and extended in Motorola...
  - ...to become a *methodology*
  - adopted and promoted by Jack Welch - CEO of GE

## ***The new 6? :***

- **Characteristics**
  - a *generic* tool to manage business
  - depend on the use of facts and data
  - targets:
    - customer satisfaction
    - reduced cycle time
    - reduced defects
  
  - ‘new’ characteristics
    - monitoring by *middle* management
    - accountability for results
    - requires controls to ensure persistence
    - includes financial accountability (CBA)

## ***The new 6? :***

- **6?**
  - **calculated with +/- 1.5 ? process drift applied**
  - **statistics may be simplified to calculate defects per 'defect opportunity'**
  - **defects are failures to meet parameters 'critical to quality' (CTQ) - the equivalent of LSL and USL**

## ***The new 6? :***

- **Themes:**
  - **Customer focus**
  - **Data driven (management by facts)**
  - **Process orientation**
  - **Proactive management**
  - **Boundaryless collaboration**
  - **Seek perfection, tolerate failure**
  
- **Supports a gradual, evolutionary process of near perfect products, first class service\* and excellent customer satisfaction**

\* software is valued as a service, not a product!

## ***The new 6? :***

- **Context:**
  - **Starting Points:**
    - **Business Transformation**
    - **Strategic Improvement**
    - **Problem Solving**
  - **Roles and Responsibilities**
    - **Champion/sponsor**
    - **'Belts': Green, Black, Master Black**
  - **Training**
    - **'executive' and integrated into projects**
  - **Projects**
    - **duration 4-6 months...**

## ***The new 6? :***

- **Managed as projects:**
  - **Phase 1: Identifying projects (M&M)**
  - **Phase 2: Set up the team**
  - **Phase 3: Chartering**
  - **Phase 4: Training**
  - **Phase 5: DMAIC**
  - **Phase 6: Hand Off**
  
- **4 to 6 months, (perhaps up to nine months)**

## ***The new 6? :***

- **DMAIC- A Model for Problem Solving:**
  - **Measuring the problem**
  - **Focussing on the customer**
  - **Verifying root causes**
  - **Breaking old habits**
  - **Managing risks**
  - **Measuring results**
  - **Sustaining change**

## ***The new 6? :***

- **DMAIC- A Model for Problem Solving:**

- **Define**

- define the problem - who is the customer, what are the benefits...  
...develop the charter.

- **Measure**

- gather data to quantify problem/opportunity and begin analysis to identify causes, define 'sigmas' (input, process, output and outcome)

- **Analyse**

- consider causes, explore 5Ms &1P

- **Implement**

- improve (and implement)

- **Control**

- develop monitoring process, prepare a response plan, provide key management metrics - *including financial*
- Sell solution, hand off, ensure management support

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## ***The new 6? :***

- **Tools:**

- **Ideas and Organization**

- brainstorming, affinity diagramming, multi-voting, structure tree, SIPOC, flowcharting, Ishikawa diagramming

- **Data Gathering**

- sampling, operational definitions, VOC, check-sheets and spreadsheets, MSA

- **Process and Data Analysis**

- process flow analysis, value analysis, graphics (Pareto, histogram, time series (trend), scatter plot (correlation))

- **Statistical Analyses**

- significance (chi square, t-tests, ANOVA), correlation and regression, DoE

- **Implementation and Process Management**

- PM methods, FMEA, Proc Documentation...

## ***The new 6? :***

- **Design for Six Sigma - DFSS:**
  - **6? projects focussed on the design process to improve the quality of design**
  - **Project requires**
    - **detailed VOC specifications**
    - **business rationale (including financial)**
  - **Uses appropriated statistical and analytical tools**
    - **Identification of Critical Design Parameters (CDP) using DoE**
    - **Include skills for design for manufacture , Tolerance Design (Taguchi)**

## ***The new 6? :***

- **Design for Six Sigma - DFSS:**
  - **Motorola approach:**
    1. **Identify customer requirements**
    2. **Define process for doing task**
    3. **Identify process requirements**
    4. **Improve processes to 6? using DoE**
    5. **'Mistake proof' the processes**
    6. **Implement controls**

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## *Applicability to Software Development:*

- **SPC**
  - 6? - no
  - control of attributes - yes
  - PE applied to s/w design - yes
  
- **New 6?**
  - Targets and Themes - yes
  - DMAIC - yes
  - DFSS - yes

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