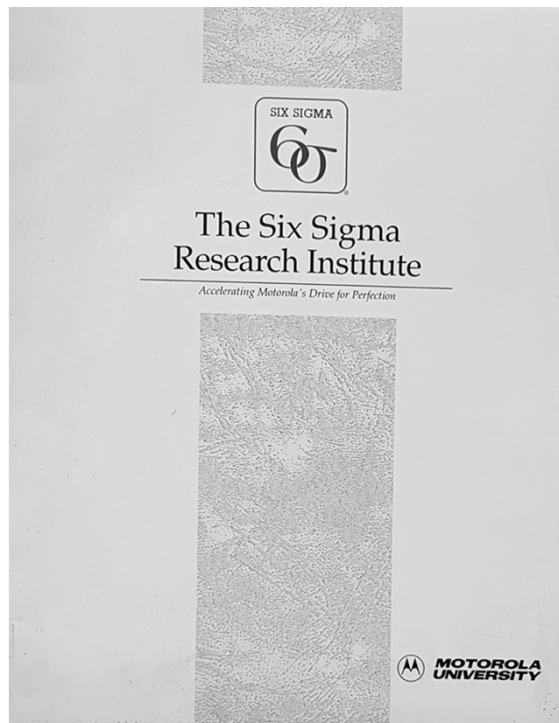
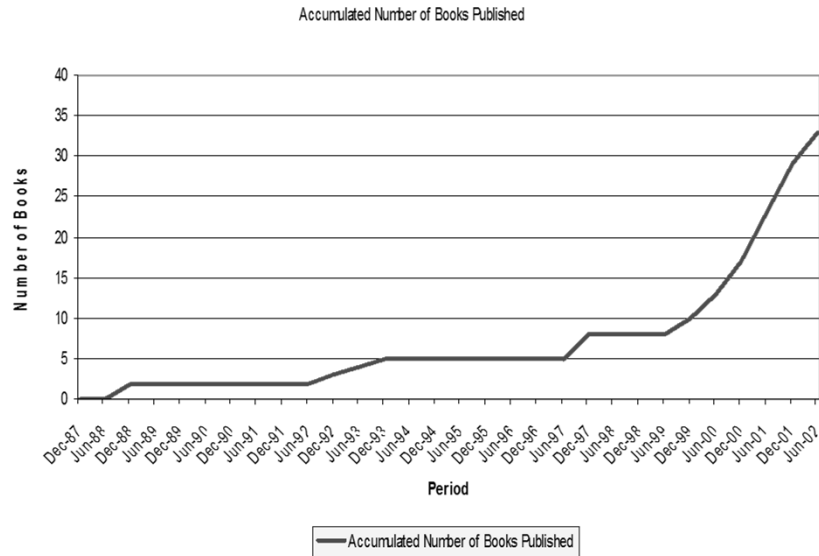


# Six Sigma

MAE  
2019



## Books (in English) related to Six Sigma: The first fifteen years...



## Something About Six Sigma

- Sigma ( $\sigma$ ) represents “Standard Deviation”, which is a measure of variation?
- The less variation, the more predictable is the performance of a product or service
- Why then is a “6 Sigma” process better than, say, “3 Sigma” or “2 Sigma”?
- If “6 Sigma” is associated with a benchmark performance of “3.4 *dpmo*” – less than 4 defects per million opportunities, how does one demonstrate “6 Sigma” when one can only have, say, 1,000 opportunities?

## Something About Six Sigma

- What's so good about using "Sigma Level" as a measure of performance?
- If the more sigma the better, why do we stop at "6 sigma" – why not "7 sigma or "8 Sigma"?
- What's so good about implementing Six Sigma /Design for Six Sigma/Lean methodologies?
- What's so bad about not knowing or not using "Six Sigma"?
- Is "Six Sigma" *necessary* and *sufficient* for excellence in organizational or personal efforts?

## What is Six Sigma?

- Customer satisfaction?
- Quality and reliability of products?
- Excellence in services?
- Continuous improvement?
- Application of statistical methods?
- Company-wide involvement?
- Improving financial bottom line?
- ... *and so on?*

“What is it like”?

Story of six blind men describing  
an elephant...

“All correct and all wrong!”

There can be a short answer and  
there can be a long answer

## Simple Concept

What are the three most common obstacles  
to excellence in products and processes?

**VARIATION**

**VARIATION?**

**VARIATION!**

## How to Calibrate Quality?

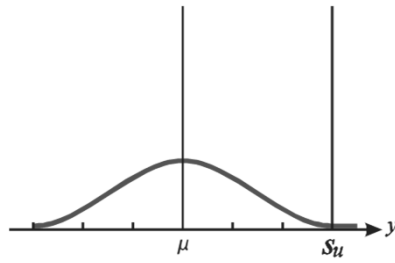
- Quality as a concept applies to both manufacturing and service systems
- Idea of “defects per million parts” for physical products has a corresponding “defects per million opportunities” in transactions
- Hence *dpmo* as a performance index

## Meaning of “Sigma Level” in Six Sigma

- Define a measure that will reflect, *from the customer’s point of view*, what is Critical to Quality - **CTQ**
- Define the range of acceptable values of CTQ
- Understand target CTQ value and specification limit(s) for actual CTQ values

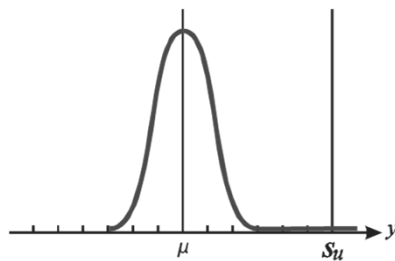
## 3 Sigma Process

1,350 ppm



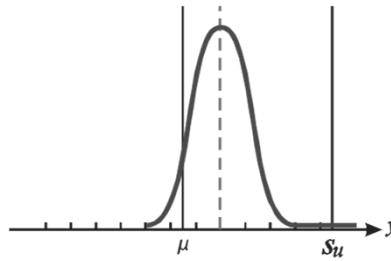
## 6 Sigma Process

0.002 ppm



# 6 Sigma Process

After 1.5 Sigma Shift: 3.4 ppm



## Calibrating Quality with Sigma Levels

(Distribution Shifted  $\pm 1.5$  sigma )

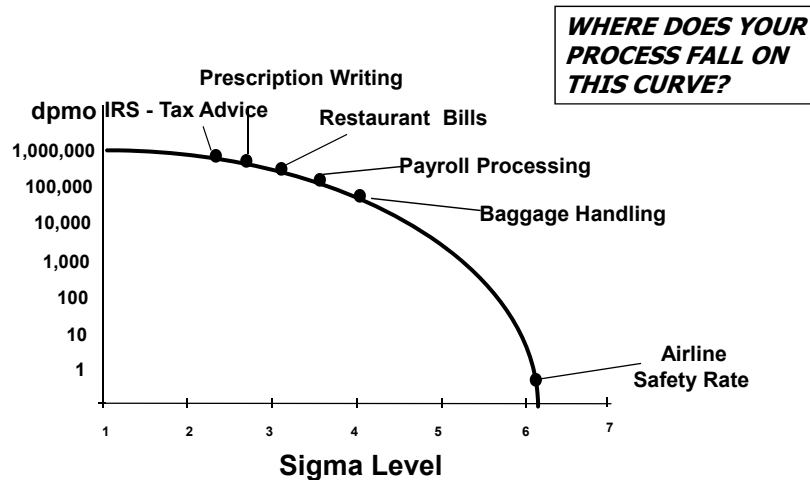
*Sigma  
level*

Directly related to

*dpmo*

$\sigma$	ppm
2	308,537
3	66,807
4	6,210
5	233
6	3.4
<b>Sigma Level</b>	<b>Defects per Million Opportunities</b>

## “Sigma level” as a performance calibrator



## Judging Performance by the “sigma” and “dpmo” Metric

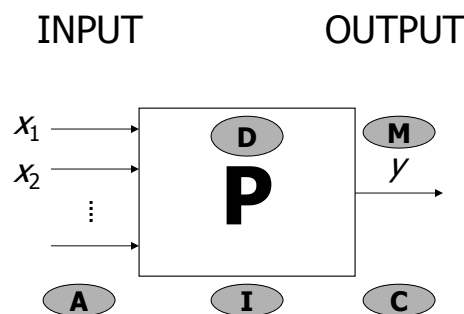
- Six Sigma advocates defect elimination and error prevention
- Advantage: Common, comparable and exchangeable measures of performance across different systems



## Quality tools organized into a Six Sigma framework:

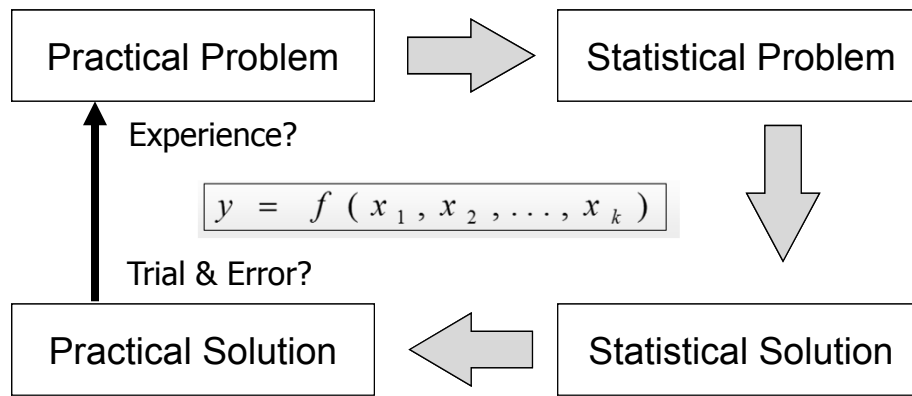
- **Define**
- **Measure**
- **Analyze**
- **Improve**
- **Control**

### Six Sigma Problem-Solving Framework



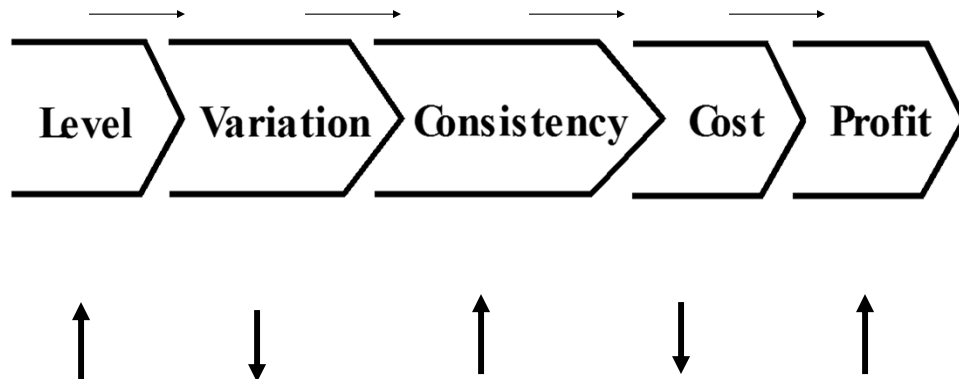
- $y$  represents a measure of CTQ ("Critical to Quality")
- A Six Sigma project improves the sigma level of  $y$

## The Six Sigma Framework



Statistical tools lead to data-based solutions *i.e.* backed by factual information or "voice of the process", with a view to satisfying the "voice of the customer"

## Direction of progress



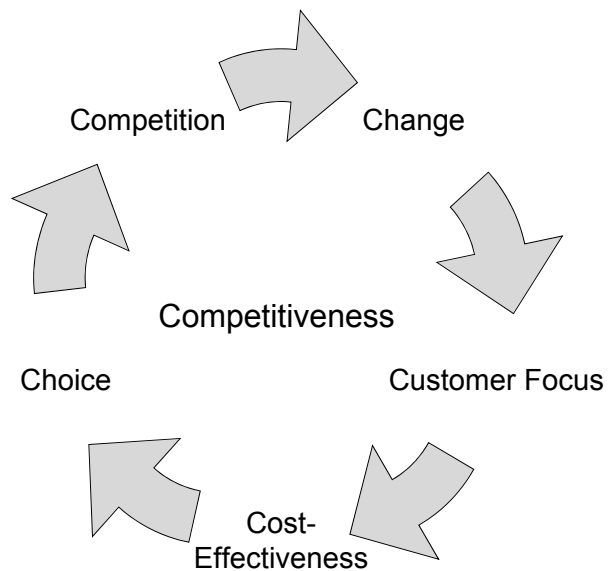
## Six Sigma

- *Aimed at reducing defect rates in **existing** products, services, and processes*

## Design for SS

- *Aimed to design **new** products, services, and processes that are Six Sigma capable*

### 5 C's in Quality by Design - DFSS



## The World is Getting More Complex

- Technological advances
- Instant information and communication
- Internet and e commerce
- Global competition
- Workforce changes
- Market fragmentation and customization
- Varying lifestyles and expectations
- Changing social and political climates

How important is information?

- How you gather, manage, and use information will determine whether *you win or lose.*

Bill Gates, *Business @ The Speed of Thought*,  
1999, p.3



## What is Six Sigma?

*“ Six Sigma... a disciplined method of using **extremely rigorous data gathering and statistical analysis** to pinpoint errors and ways of eliminating them”*

– Mikel Harry

## What is Six Sigma?

*“ Six Sigma is an **information-driven methodology** for reducing waste, **increasing customer satisfaction** and improving processes with a focus on **financially measurable results**”*

– MINITAB

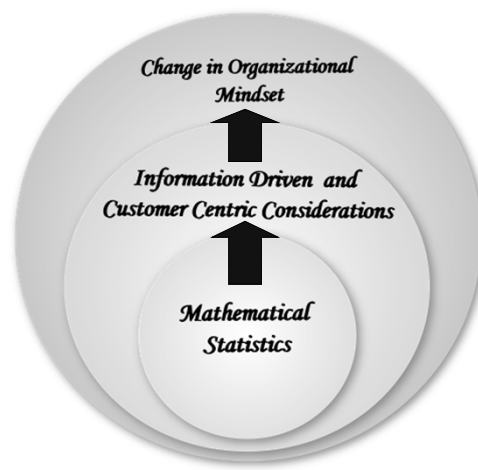
# What is Six Sigma?

*“ ... Six Sigma has **changed the DNA of GE** – it is now the way we work – in everything we do and in every product we design.”*

- Jack Welch, GE

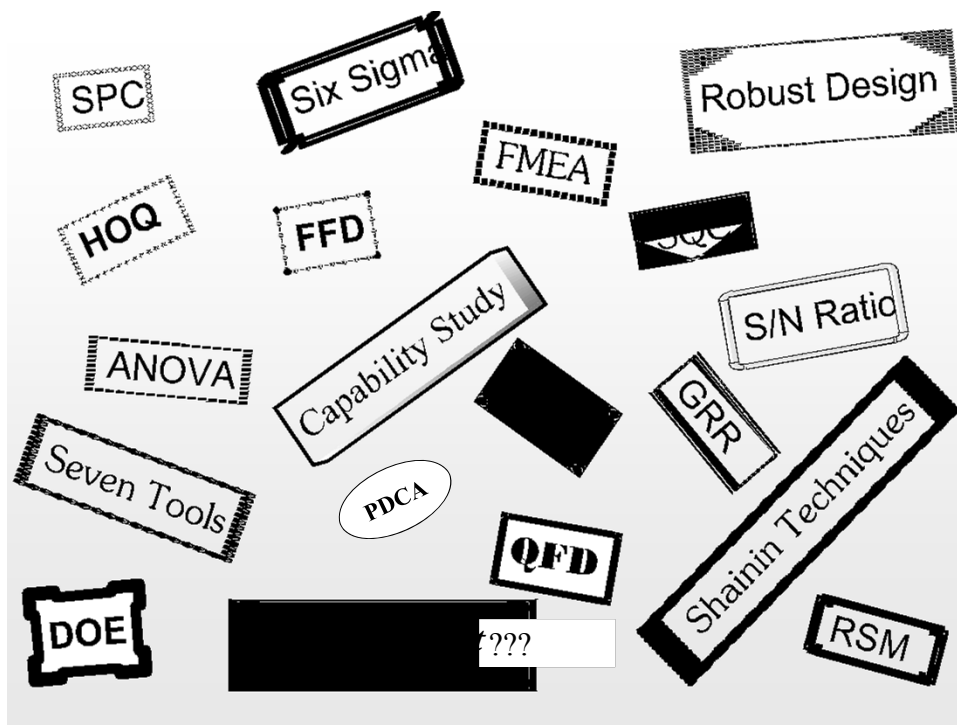
# What is Six Sigma?

- Paradigm Shifts



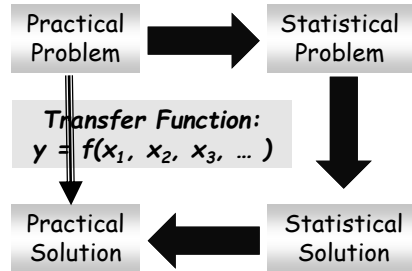
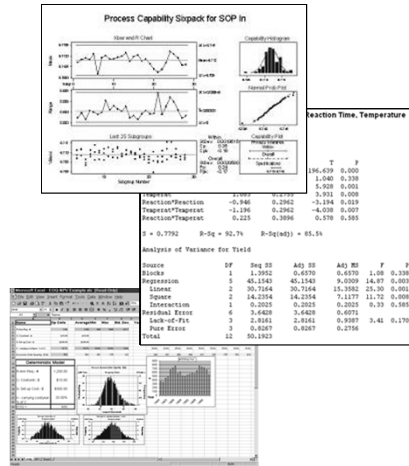
# Six Sigma Success Factors

- Data driven methodology with established statistical tools
- Logical implementation steps
- Systematic personnel development
- Well-focused project management practice
- Applications cover manufacturing and service
- Customer-centric quality initiatives



# Critical Success Factors

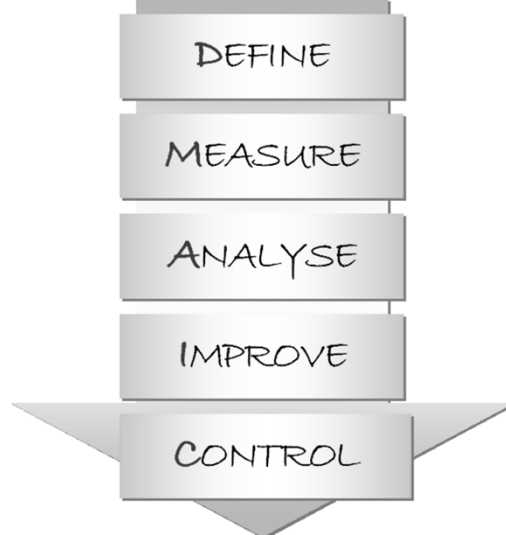
## Data driven methodology with established statistical tools



Knowledge? Judgment?  
Experience? Preference?

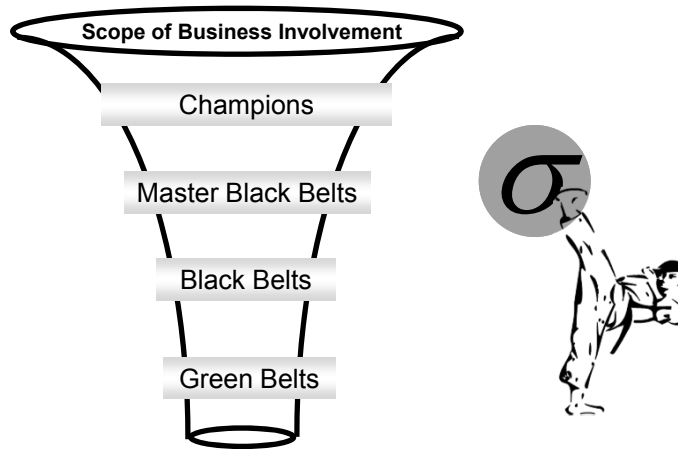
# Critical Success Factors

## Logical implementation process





## Systematic personnel development and management framework



Critical Success Factors

### Well-focused project management practice - for manufacturing & service

- Project-by-project improvements
  - Project selection
  - Project reviews
  - Project tracking
- Clear definition of resources, teams, dates and targets

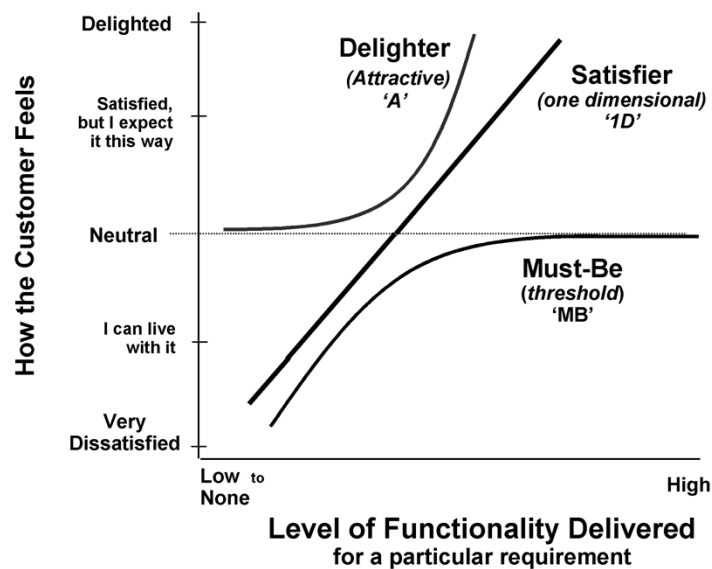
Critical Success Factors

## Customer centric quality initiatives

- Success of project only judged by:
  - Meeting customers' expectations
  - Financial savings



### THE KANO MODEL OF "SATISFACTION"



## **Some features of Service Quality studies**

1. The process can be, and often is, more relevant or felt more important than the product
2. What constitutes a defect or defective could be very subjective
3. A defect or defective is often more noticed than a “good” outcome
4. Level of quality tends to be measured and compared on a negative scale (e.g. *dpmo* instead of yield; complaints about service received seem more attention-catching than compliments)
5. An instance of service tends to have to be highly customized (vs. standardization or mass production in manufacturing)
6. Specification limits or tolerances not only tend to be subjective or impossible, it could also be location-dependent and time-varying
7. Standardization, calibration and benchmarking could be inadequate, difficult, or impossible
8. Delays are common in the recognition of defects or defectives

## **Some features of Service Quality studies**

9. Service quality relates much more with information flow and utilization than what many traditional quality practitioners are used to
10. Recorded information tends to be qualitative (i.e. discrete or attribute data) rather than quantitative (i.e. continuous or measured data)
11. Service systems do not lend themselves readily to data-intensive methodologies such as Six Sigma
12. System boundary could be difficult to draw in a study; noise is usually large and, by definition, not controllable
13. The role of raw material is usually low
14. Inventorization, i.e. accumulation of services, is normally not possible
15. Customers themselves could be voluntarily or involuntarily involved in the way service is generated
16. Cultural factors, values and ethics could be involved in judgments



Any “Customer Focus”?



How many *dpmo* in this performance?



How many  $\sigma$  do you see here?



Sigma?...  $E = mc^2$



*The human  
dimension...*





## *Seeking the competitive edge*

Imagination  
Vision  
Passion  
Insight  
Creativity  
Curiosity  
Judgment  
Perseverance  
Synergy  
Breakthrough  
Innovation  
Entrepreneurship

Also: there is  
more beyond  
the standard  
techniques...

*Thank You!*

