Journal of Positive School Psychology http://journalppw.com
2023, Vol. 7, No. 6, 877-888

Six Plus Sigma Quality Excellence Holistic Focused Model Based On Absolute Zero Defect

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ABSTRACT:

Background: The conventional acceptable low-quality level of ± 3σ (metric) threshold containing 99.73 % pass population has been maintained by the industrialized countries in the past and now it is being maintained by the underdeveloped and developing countries for a long time.
Purpose / Need for Research: This research focuses to develop a futuristic solution for the Integrated / holistic scenario than the isolated/solo solution.
Research Methodology: This research study focused first on the '**Evolution Processes'** and then on the **'Paradigm Shifts Series** Approaches. When one approach reaches its optimum, the next approach may be adopted. The series went from **'Product Focused'** to **'Process Focused'** to **System-Focused** to **Enterprise-Focused** to **'Society Focused'** The bigger chain to get the synergetic quality effects has been resolved through a **Holistic Focused Model (HM).**
Findings: This **HM** model is based on the reduction of functional variances from the past quality Threshold of ±3σ (on a 100 Scale) to the current quality threshold of ±6σ (on a Million Scale). The futuristic quality threshold can be as high as ±10σ plus scale (on billion, trillion scale).
Conclusion: HM integrate several progressive quality improvement paradigm shift series which culminate on six plus '6P sigma'.

Keywords: TQM Philosophy, 6P-Sigma, Paradigm Shifts – Product - Process - System - Business – Society – Holistic Focused Model (HM).

1. INTRODUCTION AND BACKGROUND -THE QUEST FOR QUALITY EXCELLENCE

In past, the conventionally acceptable quality threshold of 99.73% was a benchmark in industrialized countries. However, with the passage of time and development, the demand for high quality was voiced. But the customers in non-industrialized and semi-industrialized societies are still based on higher values of deviation/variance/dispersion of ±3σ (a total of six sigma metric on Normal / Uniform Distribution Curve - NDC / UDC). The main reasons for this low-quality acceptability by customers were due to low economies, moderate accuracy and precision requirements. Hence, low productivity, limited availability of innovative technologies, equipment, instrument, gauges, and low-skilled HR sufficed in these low economies.

On the other hand, customers in industrialized countries set a higher standard of accuracy and precision. This forces the producers and market on the quality improvement road to finally target absolute zero variance (σ = 0) (Besterfield et al., 2011, Nawar, 2008, Zairi, 2020, Juran & Godfrey, 2016, Doney, 2019).

This research study focuses on the design and development of a new and innovative concept of a holistic/integrated approach quality excellence model dovetailing the existing quality concepts, philosophies, tools and

techniques to achieve this futuristic absolute zero variants (σ = 0) in production/manufacturing to satisfy society's needs of quality excellence in all fields.

2. THE PURPOSE / NEED FOR RESEARCH

One aspect of this demand is to acquire and use innovative technology (like deposition and additive technologies and digital manufacturing etc) leading to the highest production rate with more precision of 1 micron to support the new challenging requirements of customers for AZD.

This point must be recognized that the product variations go into a process variation (design specifications) and process variations (input–transformation–outcomes) go into the system functions (HR, technology and protocols) and the system variations go into business functions variations (HR, Finance, marketing, production, sale and purchase etc). Hence, the cumulative variances in product/service quality are finally delivered to the customers in the marketplace of society. Thus, the cumulative variations (σ) effects in quality are delivered from various industries (primary, secondary, and tertiary) to the customers in the marketplace of a society. Hence, society is the ultimate sufferer. This scenario generates the urgent need for a futuristic ultimate and viable solution.

3. LITERATURE REVIEW - THE EVOLUTION AND PARADIGM SHIFTS OF QUALITY IMPROVEMENTS:

In the field of quality, there are two parties in competition; the customers and the producers. Quality has placed a fiercer challenge through customer demands on the producer's capability for a long time now. Customers put the challenges to the producers from lower to zero tolerance of variance in quality acceptability. Resultantly, the producers are forced to either meet the challenges to reduce variance (σ) of Minimal defect in decimal points becomes a highly visible phenomenon in mass / huge production. The low-quality acceptability level indicates a research gap to find a benchmark quality threshold of ± 10 plus sigmas (a total of 20 sigmas plus value) with absolute zero variance (σ = 0) to fulfil customer needs of the future (Nawar and Mushtaq, 2017).

inputs, processes, and output to zero into their production or accept defeat by quitting the business competition. Those producers who accept the challenge have to produce 100% identical/similar products to the customers in the marketplace of society (Juran & Godfrey, 2016, Doney, 2019, ASQ, 2020).

The aim of this most challenging and innovative research study is to introduce the futuristic concept of 'Six Plus Sigma Quality Excellence' based on the Holistic / Integrated Focused Model (HM) of the Absolute Zero Defect (AZD) Concept (Nawar & Mushtaq, 2017). The AZD concept applies to all three types of industries of primary (natural Industries), secondary (manufacturing Industries), and tertiary (services) nature. This AZD reduction can be done through the 6T sigma technique (R-DMAIC-SI) (Nawar, 2005 and 2008, ASQ, 2020, Fernando & Otávio 2019, Ping-Lung and Ching-Chin Chen, 2019, Mihir and Darshak 2021). Thus, assuring acceptable quality level products to the customers. 6M sigma and 6T sigma have already been researched by Nawar (2008). The **evolution phases** are summarised as follows.

- First Phase: 6M sigma, (metric sigma with ±3 value on NDC / UDC)
- Second Phase: 6T sigma Technique (R-DMAIC-SI)
- Third Phase: ZD Concept (the Crosby Concept)
- Fourth Phase: AZD Concept - the author published the concept
- Fifth Stage: 6 Plus Sigma (6P sigma) – New author concept

The current challenge of ±6 σ (a total of 12 sigma metric) is to bring the process variability into the customers' lower tolerance limits. This

represents an excellent quality achievement (99.9999998% acceptable quality level on a million scale) by the industrialized countries. Thus, 3 to 4 PPM (defective parts per million) is becoming a norm (a new threshold). But still, this progress fails to meet the fiercest challenge of **absolute 100 % quality excellence** which means to meet the futuristic threshold of ±10σ plus (a total of 20 metric sigma plus on any scale of measure). This quality challenge is visualized, discussed and developed in the new '6P Sigma Quality Excellence concept. The 6P sigma solution is based on the **Holistic / Integrated Focused Model (HM)** of the AZD concept on all scales of measures. The AZD approach is focusing on absolutely zero defects products both inside and outside the factory and in society (Nawar & Mushtaq, 2011 and 2017).

a. **Applying Design Limits (customer requirements/society demands) on Production / Manufacturing Products**:

The quality design specification is composed of Limits, Tolerance, Accuracy, and Precision (Nawar, 2008; Groover, 2004 Evans & Lindsay, 2005). All these quality measures are related to the core issue of variability (σ) in inputs, products, processes, systems, and business. The acceptable quality level desired by the customers is affected by these measures (Besterfield et al., 2011, Nawar, 2008, Zairi, 2020, Juran & Godfrey, 2016).

b. **Reduction of Product, Process, System, and Business Variations:**

Society (customers) fix the acceptable quality limits on a normal process natural variability (σ) of NDC / UDC due to usage. Hence, all multiples of sigma metric value are required to be brought within this desired limits of the customer to get 100% acceptable quality as shown in Figure 1a – c.

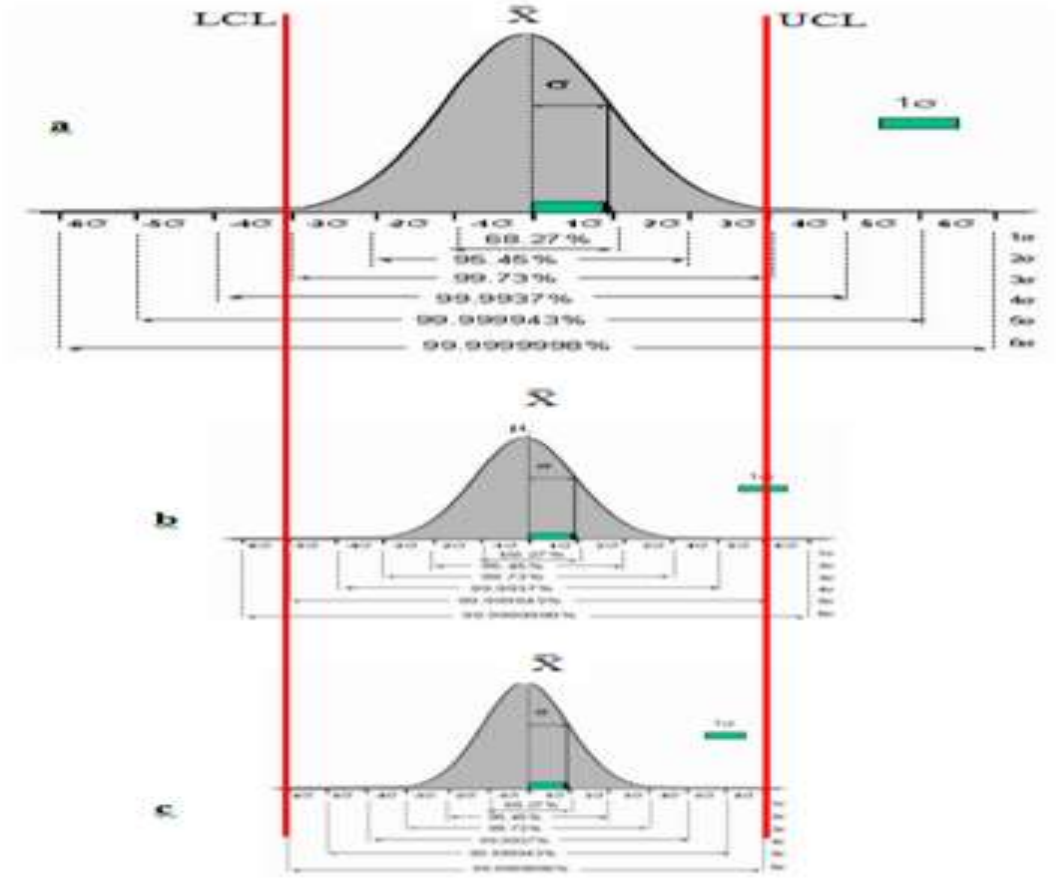

Figure 1a– c: Shows reduction in production variance (σ), thus accommodating ±3σ, ±4σ and ±6 σ within the Acceptable Quality Limits set by the customers / Society

If such a scenario of variance (σ) reduction in quality continues, any new challenge such as ±10σ can be brought with fixed acceptable limits set by the customers. Thus, all stakeholders achieve the absolute 100% correct products on all scales of measures. For this purpose, a large number of tools and techniques of TQM philosophy under 6 T sigma are in use for variance reduction as listed in Table 1 (Crosby, 2005 and Nawar, 2008, Nawar and Mushtaq, 2011 and 2017, Besterfield et al., 2011, Zairi, 2020, Doney, 2019, ASQ, 2020, Juran & Godfrey, 2016, Fernando & Otávio 09 Oct 2017).

Table 1: A Few Major Variations (σ) Reduction Tools and Techniques of TQM Philosophy

1. Work Study (method study and time measurement) 2. Kanban 3. kaizen 4. Automation 5. Zero Defects 6. Failure Mode and Effect Analysis 7. Just-In-time (JIT) 8. Suggestion system/ideas generation 9. Re-engineering, 10. Value analysis 11. Cost-benefit analysis 12. Pareto analysis 13. Cause–effect analysis 14. Human Resource Development (HRD) 15. Infrastructure development 16. Layout 17. Work simplification (process flow chart) 18. Benchmarking 19. Lean production	20. Total Productive Maintenance (TPM) 21. Process Mapping, 22. 5 - S system 23. ANOVA 24. Productivity Improvement Circle (PIC) 25. Linear Regression 26. Teamwork 27. Work Improvement Team (WIT) 28. Cellular Manufacturing CM) 29. Poka-Yoke 30. Brainstorming 31. Force field analysis 32. Nominal group technique 33. Zero-based budgeting 34. Design of experiment 35. Organization structure 36. Quality Control Charts 37. Pareto analysis 38. Six sigma (R-DMAIC- SI)

4. RESEARCH DESIGN AND METHODOLGY

The most significance and innovative 6P sigma quality excellence **research design** is based on a Holistic /integrated Focused Model (HM) of AZD Concept. This HM model has cascaded / integrated structure which have been progressively linked to show a holistic picture. This research design shall meet the mega innovative and futuristic challenge in the following steps.

- Step 1: Absolute 100% Variations Reduction – AZD solution
- Step 2: The use of Innovative Technology solution
- Step 3: The Progressive / cascaded Paradigm Shift Models Approach to reach HM

Step 1: 100% Variation Reduction Aspect of the research design

At present, the 6T sigma technique gives only 99.9999998% acceptable quality level on a

million scale in industrialized countries of the world. However, quality improvement is required to get absolute 100 % quality excellence because of the innovative and highest rate of manufacturing / production / services quantity eg; medicine capsules manufactured per unit time on modern automated machines, the number of flights on the world's busiest airports like; the USA and UK, etc. Thus, the total quantity of prodction / services population through a process is to be brought within acceptable quality design limits (tolerance = 0, variance (σ) = 0). This means zero rejection rate both at input - process and output and outsides the enterprise.

Practical aspect of the research design = Let us find out how many multiples of a metric sigma (σ) (variance) are required to get 100 % production / populaton data within acceptable quality limits. Using the basic formula for the standard normal distribution curve (NDC) of $f(\sigma) = \frac{100}{\sqrt{2\pi}} \int_{-\sigma}^{\sigma} e^{\frac{-t^2}{2}} dt$ (when off-center μ = 0), different multiples of variance sigma (σ) and the included pass percentage of data population is shown in Table 2. It may be noted that precision limit is kept up to the 20th decimal point (extreme precision but still it does not reach absolute 100% quality - AZD) by using 'scientific workplace software version 5.5.

Table 2: Multiple Values of Process Variance (σ) and its included Data Population on NDC

S. No	**Multiple Values of a Sigma (σ) and Data Population it Represent**
1.	f(±1 σ) = 68.268949213708589717
2.	f(±2 σ) = 95.44997361036415856
3.	f(±3 σ) = 99.730020393673981095
4.	f(±4 σ) = 99.993665751633376016
5.	f(±5 σ) = 99.999942669685624161
6.	f(±6 σ) = 99.999999802682470992
7.	f(±7 σ) = 99.99999999974403749
8.	f(±8 σ) = 99.99999999999987558
9.	f(±9 σ) = 99.99999999999999998
10.	f(±10 σ) is taken as 100 but could not be processed further due to software limitations

The major findings/results till this point are summarised as follows;

a. Further reduction in variation is required to accommodate more than 6M sigma (as shown in Table 2) due to the highest productivity – mean production/services per unit time.
b. Further reduction in variation shall continue till the quality acceptable level reaches absolute 100 %. So 6P sigma representing ±10σ plus is the futuristic challenging quality threshold of the 21st century for the acceptable quality level.
c. New scale development would be required to measure the quality improvement as it becomes impossible for the existing scale of 100 per cent to measure it.
d. The past threshold of the acceptable quality level of ±3 sigma (99.73%) was done on a scale of 100 per cent. The present threshold ±6 sigma (99.9999998%) requires a scale of millions in industrialized countries. Then what should be the futuristic scale for a challenging threshold of ±10 sigma? This depends on the user requirements, the level of quality competition, and the availability of excellent resources (highly educated

and skilled HR and Innovative Technology).

Hence, '6P Sigma Quality Excellence' presents a challenging futuristic quality threshold (±10 sigma plus) for all stakeholders (researchers, academicians, suppliers, producers, distributors and end users in society) to meet and then share the benefits gained in the form of absolute zero rework, waste, and rejection, etc. The economics of the project cost (investment) on research, technology replacement, skill enhancement etc must be kept in mind as a project before embarking on the journey of 6P Sigma plus quality excellence (Crosby, 2005 and Nawar, 2008, Nawar and Mushtaq, 2011 and 2017, Besterfield et al., 2011, Zairi, 2020, ASQ, 2020, Fernando & Otávio 09 Oct 2017, Juran & Godfrey, 2016, Mihir and Darshak 2021). However, after the break-even point, every project goes into the profit zone for its lifetime, thus not only recovering all the expenses but giving benefits to all stakeholders.

Step 2: The Technology aspect of the Research Design

a. Process Capability Index

The process capability index (Cpk) is defined as the ratio of the design specifications (limits and tolerance) against the process natural variability (σ) (±3σ, a total of 6σ in the present scenario) for a single parameter production/population data. A capable process should have a Cpk value greater than 1.

Cpk = Design Specification = Design Limits = UCL – LCL

and

*Process Natural Variation *6σ

*6σ

* Process variation from a large sample of production/population for ±3σ values has been used in past as a quality acceptability threshold. The futuristic value of quality acceptability threshold must be taken as ±10σ plus for 21st-century stakeholders to get absolute 100% quality excellence. The process capability index is to be re-calculated when the new level of quality excellence of 6P Sigma of ±10 σ plus is reached. (ASQ, 2020, Zairi, 2020, Besterfield, 2011, Fernando & Otávio 09 Oct 2017, Nawar & Mushtaq, 2008 and 2017, Ping-Lung and Ching-Chin Chen, 2019).

Discussions on the available options of technology aspect: To get ±10σ plus for the 21st century can be summarized as follows to develop a strategy (Evans &Landsay, 2005).

Option # 1: To loosen the design specification (by increasing tolerance limits). This option is almost not available due to the increasing demand of customers for zero variance (highest precision).

Option # 2: Adjustment, calibration and replacement of machinery, equipment, instruments, and gauges can be done. Technology modification and upgradation for improvement of process capability can give a partial solution. This option may be valid for million-scale producers only.

Option # 3: Complete technology replacement with innovative technology is the last option to resolve the issue of absolute quality excellence of 6P Sigma. It is mainly related to technology replacement where process natural variation reduction is the main focus. This option is only possible with more precise and accurate technology. A paradigm shift in technology is required from the 'Product Production Concept' to the 'Product Development Concept' through 'Deposition and Additive Technologies' is the only option for achieving '6P Sigma quality excellence' based on the AZD concept of absolute 100% defect-free production (Tarek, 2000; Nawar, et al.; 2007, Nawar and Mushtaq, 2011 and 2017, Alan et al., 2007, Groover, 2004).

Step 3: The Progressive / Cascaded Paradigm Shifts to attain HM

The nature of quality improvement is not only incremental, vibrant, and dynamic (phased out) but also quantum (paradigm shift models). Great paradigm shifts were observed when one approach was practised and get matured, then it become stagnant at optimal quality value. Then further improvement becomes impossible. Hence, a new paradigm shift (quantum jump) or

new frame of reference is searched which opens a new avenue/arena for quality improvement. Following is a narration of the progressive quality improvement paradigm shifts/quantum jumps (Crosby, 2005 and Nawar, 2008, Nawar and Mushtaq, 2017, Besterfield et al., 2011, Zairi, 2020, ASQ, 2020, Juran & Godfrey, 2016, Ping-Lung and Ching-Chin Chen, 2019).

a. **Paradigm Shift # 1 – The Product-Focused Model (PM):** History shows evidence that initially, the **Product** was the focus for quality control and assurance (product standards/specifications). Here, quality improvement was focused on corrections, reworks, and redoing.
b. **Paradigm Shift # 2 – Process-Focused Model (PRM)**: Later, the focus shift from product to the **Process focus** which converts/transforms the INPUT into OUTCOMES under controlled conditions (process specification/standards). Hence, reduce Process Natural Variability (σ) as shown in Figure 2. Here, the focus is on the prevention of defective product production than corrections.

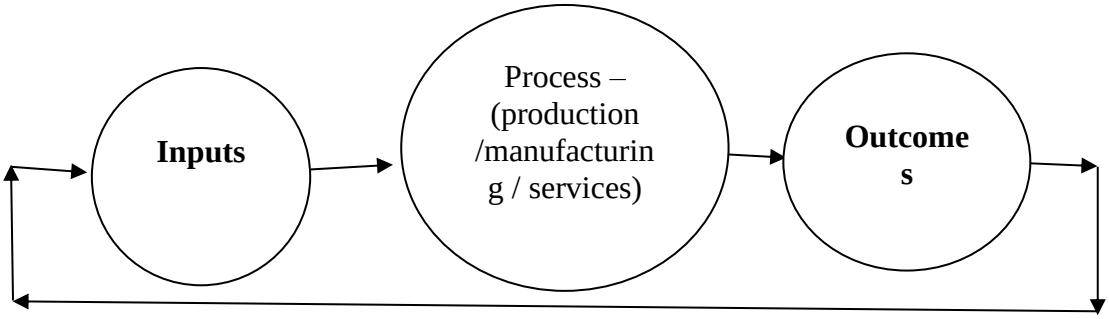

Figure 2: A Generic Process Focused Model (PRM)

Production processes face variations in all characteristics of inputs, transformation, and outcomes like; the type of materials, the strength of the material, moisture content of materials, the composition of cutting tools, measurement gauges used, quality and human inspection capabilities, etc as shown in Figure 3. The reduction in all these variations is the aim of this stage.

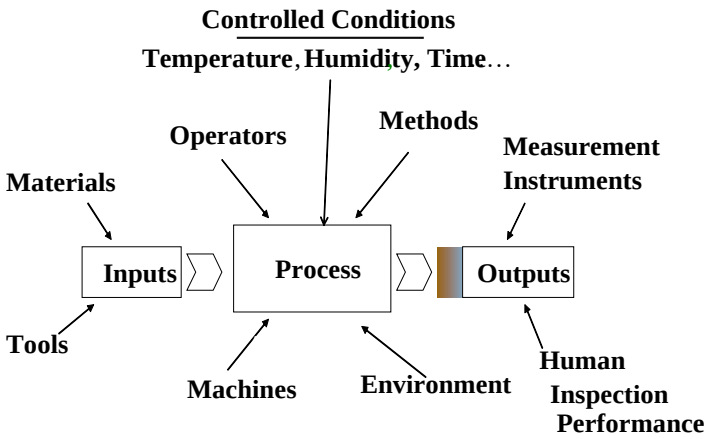

Figure 3: A Process Focused Model (PRM) with Major Sources of Variability

c. **Paradigm Shift # 3 – A System-Focused Model (SM)**: Quality products are produced through a network of multiple components (HR, Technology and Protocols) in a production system as shown in Figure 4.

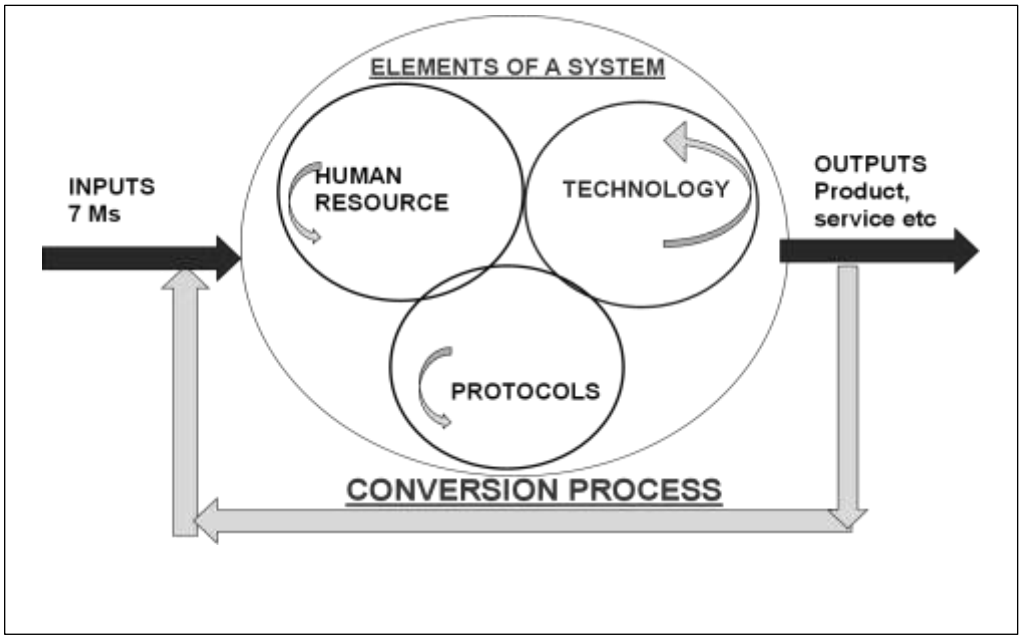

Figure 4: A System Focused Model

Each components of System Model (HR, Technology, and Protocols) are having multiples processes as shown in Figure 5. Here again, the major challenges are the existence of variations in every process of all components of a System-Focused Model (SM). A system may be of any function of an enterprise like HR, Technology, and Protocols etc.

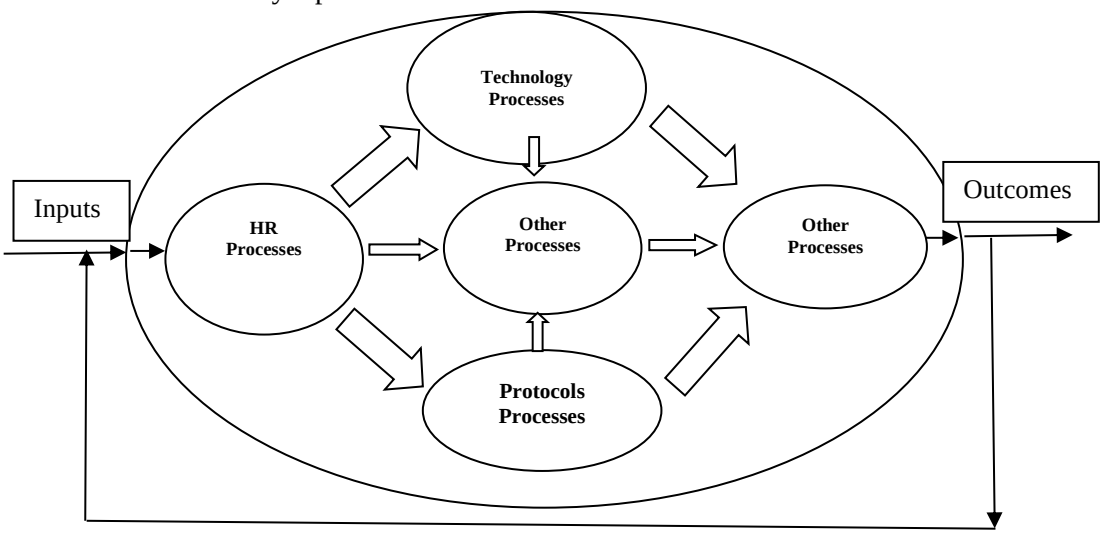

Figure 5: Multiple Processes in Each Component of a System-Focused Model (SM)

d. **Paradigm Shift # 4 – Business-Focused Model (BM):** The paradigm shift continues from a single system (HR, Technology, Procotolos) to

multiple systems (called business functions, like Marketing, Finance, HR, Production, Sale/Purchase, Healthcare, legal, etc). Each of these functions are having the basic system components of HR, technology and Protocols. In fact, a business (marketing R & D) identify and forecast the customers' **Needs** which are required to be **Satisfied**. Thus a **Business-Focused Model (BM) or Enterprise-Focused Model (EM)** is shown in Figure 6. BM is developed for every business of primary nature (agriculture, mining, fishing etc), secondary nature (manufacturing of textiles, cars, medicines etc), and tertiary nature (services like health, education, transport etc) industries to fulfil the society's needs (groover, 2004).

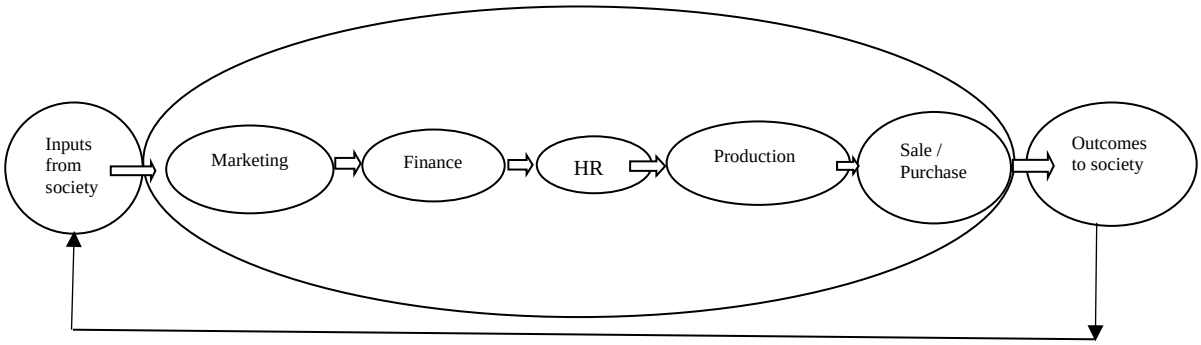

Figure 6: A Business-Focused Model (BM)

e. **Paradigm Shift # 5 – The Holistic / Integrated / Cascaded Model (HM):** This is the ultimate innovative and comprehensive solution design. Six Plus Sigma (6P sigma) Quality improvement is based on this **HM.** HM integrates/dovetails the Product, Process, System, and Business focused models into a Society Need - Satisfaction model. HM model is the ultimate, comprehensive, and most innovative design solution developed in this research study. 6 Plus Sigma Quality improvement based on the HM of AZD concept has opened a new avenue/arena for researchers, managers, and practitioners of industrialized countries to focus on how to get absolute 100% excellent quality products at the societal level (Nawar & Mushtaq, 2017). The underdeveloped and developing countries should first strive to get out of the past low-quality satisfaction vicious trap of ±3σ quality to reach the present ±6 sigma quality standard (99.9999998% acceptable quality) set by the developed countries. Then focus on the ±10σ quality excellence concept as a futuristic target for absolute 100% excellent quality on all scales of measures.

HM Model is the ultimate innovative concept where the society's need (customers' need for zero tolerance, zero variation $\sigma = 0$) is to be satisfied by the producers knowing the **progressive paradigm shifts from PM to PRM, to SM, to BM to get HM based on AZD** on all transitions as shown in Figure 7.

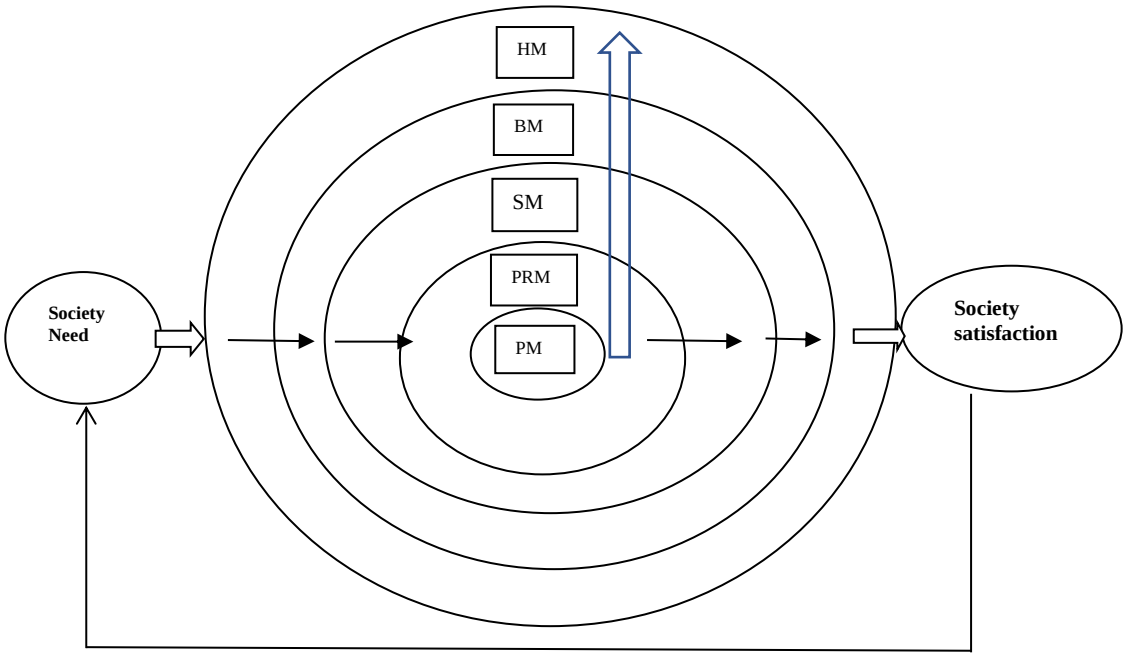

Figure 7: An HM based on Integrated Approach to Satisfy Society's Needs

5. **RESEARCH OUTCOMES** – The most innovative outcome of this research study is the development of a feasible HM. The 6P Sigma quality excellence is based on this Holistic / Integrated / Cascaded focused HM model based on AZD. This HM includes a paradigm shift from isolated PM to PRM to SM to BM to HM. This innovative concept is much bigger and broader than isolated product, process, system, and business model approaches. The holistic / integrated focused model finally interacts with society in the marketplace to satisfy the customers' needs.
6. **DISCUSSIONS:** This research study has developed and presented an advanced version of the 6 Sigma techniques. It crosses the threshold of the latest million scales into a new arena of billion and trillion scales of measuring variances, errors and defects beyond the measure of the AZD concept. This innovative concept is a paradigm shift to meet 21st-century quality excellence challenging requirements.
7. **ORIGINALITY:** In this research study, a new and most innovative model has been conceptulized, designed and developed, called a **Holistic Focused Model (HM)** based on the **'Integrated Paradigm shift concept'** (linking the product - process – system – enterprise and society in one chain).
8. **CONCLUSION:** The quest for quality excellence moves from ±3σ to ±6σ and shall cross the conceptual barrier further to reach the hallmark of quality excellence of ±10σ sigma plus logically and progressively under the innovative concept of 6P sigma plus. Quality improvement is required in the design specifications of products, products materials, processes, elements of systems, and business functions. This improvement wave is to be followed by another improvement layer in the development of expert skills, methods, tools, and techniques of TQM, HR, and innovation in production/manufacturing technologies and their metrology. Last but not least is the Quality improvement in measurement scale of billion and trillion

scales instead of per cent and million scales. Hence, there is a need to understand and implement a Holistic / Integrated approach to the quality evolution quantum model than the stand-alone/isolated entity models.

9. **IMPLICATIONS:** The HM based on AZD quality presents challenges to every stakeholder in a living society of industrialized, semi-industrialized and non-industrialized countries of the world to meet its requirement in all its conceptual and contextual aspects.

RECOMMENDATIONS: Academicians, quality managers, consultants, and users must equip themselves for the incoming challenges of 6P Sigma, and AZD concepts through education, and training. National Quality Foundations can be established to cope with the incoming challenges of AZD as an integrated network of activities. Technology managers of both Public and private sectors in production/manufacturing/services organizations should carry out their 'technology audit' to check the suitability of existing technology with present-day and futuristic highly precise quality requirements of HM based on the AZD concept.

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