QUALITY FUNDAMENTALS IN SUPPORT OF AIR POWER

P.V. ATHAWALE

Most executives are of the opinion that the term **'quality'** has relevance only for design, development, production, repairs and logistics support activities. Nothing can be farther from reality than such a misconception about the limited applicability of 'quality'. Can't we say that quality (flight safety) matters far more directly in flying operations than all the work on the ground? It certainly does, with any activity related to men or machines that go up in the air as compared to all other ground systems. Quality does matter to administration, finance, resource planning and human resource development and training in equal and significant measure. The concepts have, however, evolved around manufacturing or technical processes. Therefore, **the one key element** in discussions on maintenance paradigms has to be **'quality'**.

Inspection in the military has been such a preoccupation that all other means and methods seem to converge onto this last act to get the desired quality output **for fear of inspection**. Confining ourselves to maintenance, let us remind ourselves that quality cannot be enhanced by predominantly increasing inspection. Quality is holistic, it cannot be achieved in patches; quality is *not an add-on* that can be injected into an aircraft at the *tyre-check point*. It is also not quite something which can be meticulously adhered to inside a cockpit or a lab while being lackadaisical in all other disciplines. **Quality relates to 'character'**—*it's a way of life!*

Air Marshal **P.V. Athawale** PVSM, AVSM, VSM (Retd), former AOC-i-C Maintenance Command is a Distinguished Fellow at the Centre for Air Power Studies, New Delhi.

Let us remind ourselves that quality cannot be enhanced by predominantly increasing inspection.

Sow a thought and you reap an action
Sow an act and you reap a habit
Sow a habit and you reap a character
Sow a character and you reap a destiny
— Ralph Waldo Emerson

In the 1990s, Base Repair Depots (BRDs) had started certification to the ISO 9000 Quality Management System (QMS) standard. The leadership had considered it necessary to establish processes conforming to the international standard and especially to certify through external audit because BRDs carried out factory-like technical activities of repairs/overhaul and indigenised manufacture for substitution of parts. It could be argued that the factory-like working by BRDs in no way qualified only BRDs, leaving out all other maintenance activity in the Air Force. But, BRDs were the right place to begin. By 2005 or so, most large BRDs were ISO certified, which was a distinct *mark of pride* for the top management. However, a few years later, a review indicated that a well meaning initiative had drifted away from its objective. The QMS had remained far from being integrated in the depots' vital activities like production, indigenisation and supply chain management. Except for the *'ISO 9000 Certified'* statement of pride, the QMS served little purpose or value addition to the main tasked functions of a depot. By now Air HQ and HQ Maintenance Command (MC) together envisioned a lean engineering project at 11 BRD to realise the passionate goal of production process optimisation. The BRD/MC team, working with the consultants from the Indian Institute of Technology (IIT), Kharagpur, soon realised that it was not a one-time effort and that 'lean engineering' could also fall into the large pile of overheads to perform without a value addition to the fundamental production process. All this was not because either the *QMS* or *lean* was not worthy, but due to the fact that we had an exceptional ability to *adopt new methods without changing*; the new schemes soon transformed into *'data fields'* for inclusion in impressive quality performance reports. Instead of keeping quality and lean efforts isolated from the main process as overheads, or, on the other extreme dumping these

worthy measures, we considered it appropriate to *revitalise quality management to realign with the main functions of each BRD.*

We are indeed obliged to Col B.J. Singh for the revival of quality culture in BRDs and its spread across the Equipment Depots (EDs), which were till then considered separable from quality.

The thrust to redefine QMS found unprecedented support from the large working level staff, thanks to our consultant. Long ago, I had an opportunity to take *quality lessons* from **Col B.J. Singh**, a retired Corps of Electronics and Mechanical Engineering (EME) officer, who very kindly consented to be with us to infuse *'quality passion'* among our men and women, which he so aptly called *'junoon'*. We are indeed obliged to him for the revival of quality culture in BRDs and its spread across the Equipment Depots (EDs), which were till then considered separable from quality. Personnel from all branches and trades got into the act of identifying and redefining processes within their own areas. As we identified and zoomed into individual process flow charts, we found it amazingly simple to visualise potential areas for optimisation, even without the aid of any technique. The *'quality charged'* lot could then move on to the extension of 'lean' implementation from 11 BRD to all the other depots.

EVOLUTION OF QUALITY AND THE MILITARY

Craftsmen in 13th century Europe had unions called guilds. These made rules for product and service quality, on the basis of which the inspection outcome was used as a benchmark. This product inspection approach continued through the industrial revolution; the process getting included only by the beginning of the 20th century. The military began dominating the quality domain by the end of World War II. However, product inspection of virtually every piece in due course gave way to inspection of smaller quantities using sampling techniques. Later, prompted by the Japanese movement, *'Total Quality Management (TQM)'* began in the USA. TQM stressed on organisational process improvement through people rather than inspection. Thus, the product oriented and inspection dominant reactive approach made way for proactive process orientation. The theme behind the shift was that if processes were well

defined and controlled, the product quality could be reasonably assured. The ISO 9000 series of process oriented standards were first issued in 1987.

With this shift to process orientation around the world, various inspection agencies shifted their focus from inspection to Quality Assurance (QA). In India, however, the defence establishments changed mainly in semantics as the names of Inspectorates were changed to Controllerates of Quality Assurance. With inherent inertia, we continued our **emphasis on inspection**. It would not be out of place to pause and ponder upon the reasons why Inspector General (IG) changed to Director General (Inspection and Safety) [DG (I&S)], but did not transform into a Quality Assurance and Safety Agency.

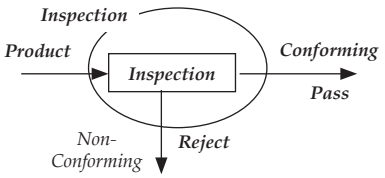
It is important to understand that quality assurance is inclusive of inspection. While **mere inspection is wasteful,** QA assures that the processes and their interfaces are well tuned within a defined **Quality Management System** to assure quality. Adequate inspections are carried out at relevant points, reducing waste (rejections) as well as the overall quantum of inspection. Unfortunately, immersed in complicated definitions, one doesn't quite comprehend what QA is. As a result, in our domains, QA and inspection are commonly misused as synonyms as we hope to solve every problem with enhanced inspection. I have yet to come across as simple an illustration as made by Col B.J. Singh to explain the terms **Inspection**, **Quality Control** and **Quality Assurance—**such that one never forgot the importance of QMS. Thanks to him, I explain below.

GAPS AND SHORTFALLS IN OUR SYSTEM

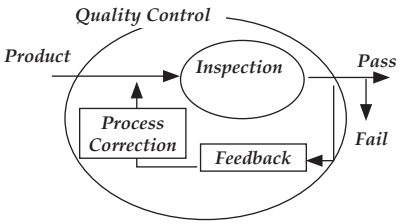
Since ancient times, military requirements have led technological developments, resulting in the strong fixation of the military with product specifications. The onset of the Information Age reversed this trend. Only as an exception, a few critical technologies' development is now initiated for military use. Otherwise, most technological developments in the commercial domains and especially those related to information technology have distinctly gone ahead of military requirements. And yet, while writing the Services Quality Requirements (SQRs), we surprisingly get tempted to define specifications unique to our requirements rather than picking them up Commercially-Off-The-Shelf (COTS) wherever

possible. Despite this product fixation, however, we have been inherently process oriented. During ISO certification of most depots, the external auditors often said that our processes and procedures were already so well defined that these needed to be only well documented and compiled together with the necessary records for certification. In comparison, before getting introduced to the process approach, the civil industry hasn't been backed by a set of procedures like the armed forces. Our Standard Operating Procedures (SOPs), Station Standing Orders, Air Headquarters (HQ)/ Command HQ/ Station/ Squadron and Flight Orders, Technical Orders, Administration Instructions, etc. have been exceptionally well conceived. Despite such strength of well defined SOPs, *orders and instructions*, it is surprising that **a strong inspection fix keeps us away from process visualisation**.

Fig.1



Inspection checks for conformity to specifications – passes the conforming product and rejects the non- conforming one.



We begin to control quality when the outcome of inspection is used to provide a feedback to enable correction to processes in line before inspection

We assure quality when we envelop the Quality Control within a well defined Quality Management System. The QMS defines processes and the stated norms according to which the quality would be assured. Beginning with quality policy, quality manual, identification and definition of processes, control of documents and records, customer related processes and feedback, demonstration of continual improvement and audit are important parts of the QMS.

Do we then have gaps in our otherwise self-perceived process approach to doing quality work? Let us look at a few real examples to appreciate the need for a review:

- The Air Officer Commanding-in-Chief (AOC-in-C) wishes to issue a directive. The staff puts up a draft with the last line stating **"This supercedes all previous instructions on the subject"**. On a query, the staff cannot put up any such instructions for reference. The issuing authority itself does not know how many instructions exist on the subject. But, *it is considered safe to put up that last line, just in case. . .*
- As a follow-up of an accident, the Service Maintenance Staff Officer (SMSO) of an Operational Command sends a directive to the Chief Executive Officers (CEOs) of concerned bases to *issue technical orders* to direct technicians to **carry out an existing order more meticulously**.
- There are severe technical problems with older types of MiG-21 aircraft. One major cause of engine problems is believed to be the lack of 'fuel discipline'. **More severe inspection** is suggested to the top management as the remedy for fuel problems.
- An Op Command's Maintenance Instructions are issued under the authority and signature of the AOC-in-C. The next month, a few corrections are issued under the signatures of the SMSO. A few minor corrections are further issued under the signatures of the Chief Engineering Officer (C Eng O) of the Command. The corrections do not even indicate approval of the AOC-in-C.
- During inspection visits, Commanders are shown the duties and responsibilities of the workers down to the level of Corporals. The workman's appropriate fit in the functional process and interface with the other processes are seldom verified.
- The AOC-in-C's aircraft lands at Kanpur. After the AOC-in-C departs, the aircraft is towed to Hindustan Aeronautics Limited (Transport Aircraft Division) [HAL (TAD)] for repairs. On the way, the wing tip bumps into a wall and gets damaged.
    - After the aircrew leaves the aircraft, the ground crew asks the station duty crew to tow the aircraft to HAL (TAD) for repairs that were

pre-planned but the duty crew was not informed.

- Duty crew personnel later said that they had no experience in towing aircraft as visiting AN-32s were looked after by 1 BRD and the other aircraft, including AVROs, were never required to be towed. In such unforeseen circumstances, usually the captain, along with his air and ground crew, should have taken control, with further assistance from the station duty crew.
- This was the AOC-in-C's aircraft, so no questions were asked. The in charge (I/C) Duty Crew went along with the ground crew to get the aircraft towed by the on duty Civilian Motor Transport Driver (Civ MTD), who incidentally was not certified to tow aircraft. *Everyone went along without anyone taking charge*!
- *There was no incharge*; the duty crew was helping the command freight ground crew, who were, in turn, helping the duty crew, and the Civ. MTD was helping the general cause without being trained and experienced.
- *The Court of Inquiry (C of I) found no one to blame*, till reassembled by the orders of HQ MC.

- A Head Up Display (HUD) is despatched from an ED to a Wing. The HUD gets damaged in transit, with a knob visibly broken on the front panel. A Discrepancy Report (DR) is raised by the Wing. *After five years of processing, the case is referred to the AOC-in-C for the first time, seeking recommendations for write-off action* of tens of lakhs of rupees for repairs. He is advised of the following facts.
  - The equipment was packed (not known whether correctly or not) in the original packing case.
  - There was no evidence, but the consignment might have been trans-shipped on the way without care, although the transporter was contractually bound for it.
  - Although the receiving station had raised a DR, one couldn't be sure that the damage did not occur on receipt there.
  - There was no other trace back. It was suggested that after five years, even if the AOC-in-C so desired, a trace back effort would be futile.

- Therefore, it was recommended that *no one was to blame*, and the only corrective action visualised was to get better packing cases designed by HAL.

- Locally made (crimped using original Russian connectors) hydraulic hoses by a BRD for MI-8 helicopters prematurely leak in the field. The BRD confirms faulty fabrication:
  - On posting out of previous workmen, the procedure for fabrication was not well understood by the changed set of workers.
  - The process sheet was found to be not foolproof, for unambiguous understanding.
  - The BRD identifies the faulty batches delivered and informs all users.
  - The top management raises the question, "**Who inspected the hoses***?"*
  - Despite several reminders from the BRD and HQ MC, the Op Commands could not get their stations to confirm accounting and return of unused hoses from the faulty batch.
  - Without a positive check of all faulty hoses recovered, one was never sure that someday a hose from the old stock would not be used.
- An arrester barrier net is flown out of the ED to a Wing for immediate replacement after the existing barrier net is damaged due to engagement. When the wooden drum is opened, rats jump out of the drum. Parts of the net are also visibly termite eaten. Another piece is picked up from a station, which had received the same recently from the ED. The condition of this net is as bad as the earlier one.
  - The stores I/C had written a letter some time ago to the Quality Assurance Service (QAS) for inspection of packing cases.
  - *The C of I finds fault with the Aerial Delivery Research and Development Establishment (ADRDE)* concerning the design and material used for packing. They also find *lacunae in contracting by Air HQ*, but find *no one to blame* within.
  - When a reconvened inquiry finds the stores I/C to blame, the senior staff at the Command opines that the working level staff was being singled out for blame.

- A new check is introduced for R-29 engines at 200 hrs, to be carried out at a BRD. The availability of packing cases is inadequate for transporting the required engines from the operating Wings to the BRD. Various actions of placement of orders for new cases are reported. But, the Command staff is unable to make an assessment of the optimum number of packing cases that should have existed in the system. Such an assessment for any fleet seems too mathematical for the staff that comprises erstwhile instructors at the College of Defence Management (CDM). With a small unforeseen variable thrown in, the *situation could be repeated with any fleet any time*!

All the above examples appear to be simple and stupid, with straightforward answers. But, these incidents would be repeated if we don't look at process corrections.

- While working towards improving productivity (serviceability) and quality during the 'Year of Maintenance', the senior staff gives an impression that people are working hard in *an ongoing process*. The problems are elsewhere! Everyone in different formations is dissatisfied with someone else who is not chipping in with the effort. *The problem is always elsewhere – the man in front is never to blame*!

The only real mistake is the one from which we learn nothing

— John Powell

All the above examples appear to be simple and stupid, with straightforward answers. But these incidents would be repeated if we don't look at process corrections. Is there really a plethora of instructions and workers not sure about how many are applicable? Further, are all instructions doable? Is every process well defined, especially at interfaces with external elements? And, finally, *do we have relevant records to provide convenient trace back at all times without having to assemble Cs of I to take statements on oath?* Yes, we do have large gaps, but these are quite manageable because we have great people within a disciplined environment. A sincere review of not only the BRDs

and EDs, but also the field maintenance and logistics functioning would be necessary. Just that fundamental effort in realignment will transform us into an organisation with an excellent quality management approach.

OPTIMISATION PHILOSOPHIES

During the quality initiatives, the biggest challenge was to tackle with the participants' loss of focus on the programme due to misinformation or lack of knowledge about various optimisation methods. Misconceptions like "*We can't leave it to the depots to decide what to do and how far to go, they need to be given a GOAL*", "*ISO 9000 is not good enough, we need TQM*", "*Accuracies like in the 6-Sigma approach are essential*", and "*Everyone is going in for 'LEAN' and we are stuck with ISO*", etc. were commonly going around. Half knowledge is more dangerous than nothing at all and one is bound to come across various views without great commitment on the part of those making the comments. My professor at IIT, Kharagpur, maintained that to be a great programmer, one needed to understand the nuances of at least six programming languages before starting work in any one of these. Similarly, I think that a maintenance man develops best background knowledge through awareness of different quality approaches before following one chosen path or a combination of these.

A QMS comprises the *organisational structure*, *processes* and *resources.* All QMS models have advocated transparency and sustainability to provide enhanced quality and customer satisfaction. A few other popular philosophies are essentially optimisation methods for production or business processes. One or more of these approaches used to complement each other rather than one having to replace the other can bring great results. Therefore, I wish to briefly introduce many approaches together before concluding with recommendations for our actions.

TOTAL QUALITY MANAGEMENT

Total Quality Management (TQM) is an organisation-wide effort to improve quality. It is an approach where all members of an organisation participate in improving processes, products, services and the organisational culture.

TQM has been influenced by many great leaders while its core has the **Deming System of Profound Knowledge**, which stated the following four requirements for managers:

- **Appreciation of a System:** Connecting customers, suppliers and producers.
- **Knowledge of Variation:** Statistical sampling.
- **Theory of Knowledge.**
- **Knowledge of Psychology:** The human nature.

  Deming presented fourteen key principles, for quality transformation.
- Create **constancy of purpose** aimed at product and services improvement.
- Adopt the **new philosophy**. Leadership for change.
- **Cease dependence on inspection** to achieve quality.
- **End** the practice of business on the **basis of a price tag**. A single supplier with a long-term relationship of **loyalty and trust** to minimise cost may be the answer.
- **Improve constantly** and forever.
- **Training on the job**.
- Institute **leadership** and **supervision to help people** and infrastructure.
- **Drive out fear**.
- **Break down barriers between departments**.
- **Eliminate slogans**, exhortations, tall order for zero defects.
- **Eliminate work standards** and numerical goals. **Substitute with leadership**.
- Change **sheer numbers to quality**. Institute pride of workmanship.
- Institute a vigorous programme of **education and self-improvement**.
- **The transformation is everybody's job**.

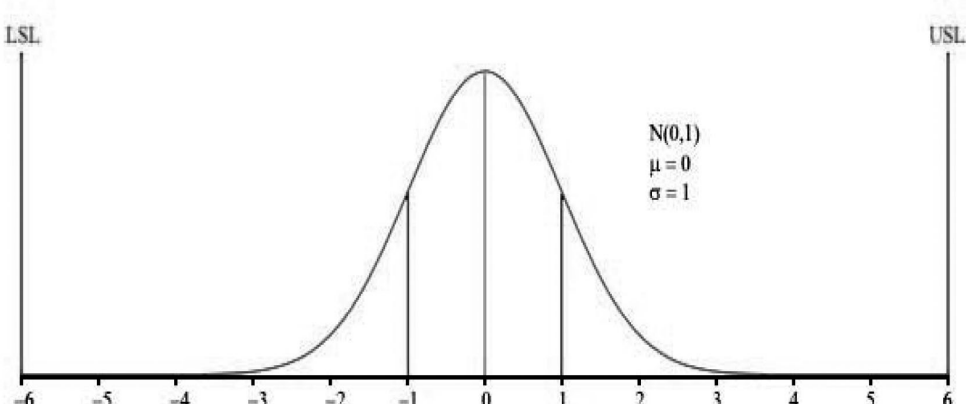
Deming believed that a transformed individual will set an example, be a good listener, teach others and move ahead without the burden of the past.

SIX SIGMA

Originally developed in 1986, Six Sigma has been a registered trademark of Motorola Inc. Motorola set a goal of "six sigma" for all its manufacturing operations. Minimising variability and defects in manufacturing and business through *identification and removal of the causes* is the aim. People within the organisation, empowered through management and statistical training as "Black Belts", "Green Belts", etc. catalyse the execution.

A defined sequence of steps is followed with quantified financial targets. Statistical modelling is the basis of the six sigma process approach in which 99.99966 percent of the products manufactured are statistically expected to be free of defects (3.4 defects per million).

Fig 2



The fundamental theme is that if one has six standard deviations between the process mean and the nearest specification limit, as shown above, *practically no items will fail to meet specifications*.

The process measure is the number of standard deviations between the mean and the nearest specification limit. As the standard deviation increases, or the process mean shifts away from the centre of the tolerance, fewer standard deviations will fit between the mean and the nearest specification limit. The result would be increasing the likelihood of items outside the specification, evaluated as a lower sigma process.

The processes usually do not sustain the measure in the long term. As a result, the number of sigmas that will fit between the process mean and the nearest specification limit may reduce with time. To account for this drop, an empirical 1.5 sigma shift is introduced to indicate that a 6 sigma process would be only 4.5 sigma in the long term. Accordingly, a popular definition of a six sigma process is one that produces 3.4 defective parts per million opportunities.

Inspired by Deming's Plan-Do-Check-Act cycle, six sigma projects follow methodologies known by the acronyms DMAIC and DMADV.

- DMAIC (Define, Measure, Analyse, Improve, and Control) is used for projects aimed at improving an existing business process.
- DMADV (Define, Measure, Analyse, Design, and Verify) is aimed at creating new product or process designs. The DMADV project methodology is also known as DFSS ("Design for Six Sigma").

LEAN ENGINEERING

Not everything that can be counted counts, and not
Everything that counts can be counted

— Albert Einstein

The term '*LEAN*' was coined in the late 1980s by Jim Womack's team at MIT to describe *Toyota's business*. The theme has been of maximising *customer value* while minimising waste. In other words, this would mean *creating more value for customers* with *fewer resources.* A popular misconception, like in all other quality concepts, exists with lean, that it is suited only for manufacturing. Lean is not a cost reduction programme. Lean applies in every business and process and resides in the heart of an organisation. The word transformation or lean transformation is often used to characterise a company moving from an old way of thinking to lean thinking. A long-term perspective and perseverance are required for a complete transformation on how a company conducts business.

People, technology and systems are the three entities worked upon in the lean approach. People are educated, involved and motivated through

'total employee involvement', 'control through visibility', 'housekeeping' and 'total quality focus'. 'Small lot production', 'set-up reduction', and 'fitness for use' are focussed upon while maintaining structured flow. 'Preventive maintenance', 'supplier partnership', and 'pull systems to seek material only when needed to produce' ensure a balanced flow.

Lean is primarily identification and removal of waste—so that everyone becomes more productive, efficient, result oriented and customer focussed. This is carried out by the following steps:

- 5 S for housekeeping: Sort, Set, Shine, Standardise, and Self-discipline.
- Flow Kanban: Produce only what is needed by the next person in the chain or customer.
- Visual controls e.g. a chart showing current status vs. scheduled.
- Job standardisation with defined procedures and standards to ensure repeatability.
- Attempt 'set up' reduction after a job, before starting the new job.
- Continual improvements through reiteration of the above steps.

The seven wastes identified for reduction are:

- Motion
- Transportation.
- Waiting time.
- Overproduction, in excess of customer requirements.
- Processing time.
- Defects, scrap and rework.
- Inventory.

An honest review of the current situation is made before adjustments to address inefficiencies one by one. Changes are made only after verification of every incremental step. Lean engineering and lean manufacturing are not exactly the same, even though both share concepts and aim at improving efficiency. Lean manufacturing is a proven process used to increase the production efficiency of a manufacturing shop through inventory control and production process improvements. On the other hand, engineering doesn't have an inventory, but has a number of customers ranging from the shop floor to purchasing to the end customer.

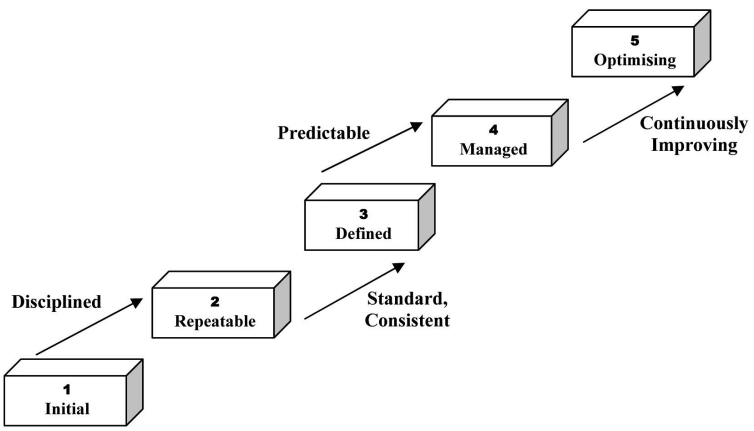
CAPABILITY MATURITY MODEL (CMM)

Watts Humphrey developed the **Capability Maturity Model (CMM)** on the surmise that organisations mature their processes as they solve problems in stages. CMM is an evolutionary process model for software development designed by Carnegie Mellon University originally for assessing the ability of government contractors' *processes* involved in a software project. *Although specific to the software engineering field,* CMM is used in many other areas like system engineering, system acquisition, project management, risk management, human resource management, etc. CMM is built around five basic characteristics viz. *maturity levels, key process areas, goals, common features and goals.*

Maturity levels indicate predictability, effectiveness, and control of an organisation's software processes, maturity level 5 being the best.

- **Level 1.** The *initial* starting point. It may be chaotic, ad hoc and marked by individual heroics.
- **Level 2.** The process is adequately documented to promise *repeatability*.
- **Level 3.** The process is *defined* and broken down to the level of work instructions.
- **Level 4.** The process is quantitatively managed.
- **Level 5.** *Defect prevention,* conscious process optimisation/improvement and change management are ensured.

Fig 3: Processes at Different CMM Levels



Key Process Areas (KPAs) identify a group of activities to be performed for achievement of goals. KPAs are further characterised by goals, commitment, ability, measurement and verification.

Goals of a key process area denoting intent and scope provide for a measure of achievement. Goals accomplishment is an indicator of the capability the organisation has established at that maturity level.

Common Features like commitment to perform, ability to perform, activities performed, measurement and analysis, and verifying are used for implementation.

Key Practices are methods which contribute most effectively to the implementation of the KPAs

THEORY OF CONSTRAINTS

The **Theory of Constraints (TOC)** was professed by Eliyahu M. Goldratt as an overall management philosophy. First in 1984, with a book titled *The Goal,* he illustrated how an organisation makes efforts, and progresses in achievement of its goals. Then, in 1997, through his book *Critical Chain,* he professed the theory before publishing an extension to the concept in 1999.

Goldratt maintained that *the goal* of a business company *itself is to make money*. All other objectives are derived, directly or indirectly. Variations in measures of **throughput**, **operational expense** and **inventory** are used by the Theory of Constraints to evaluate and control organisations. In the military domain, identification of *war preparedness as the goal seems simple*. But, its *measure of accomplishment is extremely complex*. Therefore, war preparedness has to be further sub-divided into visible and measurable objectives.

As per TOC, "*any manageable system is limited in achieving more of its goals by a very small number of constraints*", and that "*there is always at least one constraint*". *A chain is no stronger than its weakest link.* Constraints could depend upon equipment, people or policies and could be internal, e.g. lack of production due to inadequately trained manpower, or external, e.g. lack of the Original Equipment Manufacturer's (OEM's) support. The TOC recommends identification of the constraint and organising support of other elements around it through the following actions:

- Identification of the constraint, *resource or policy.*
- Decision on exploitation of the constraint to *get the most capacity out.*
- Subordination of all other processes to *align the whole system or organisation to support the decision made above*.
- Elevation of the constraint through *other major changes required to break the constraint*.
- To reiterate the above steps, if the constraint has moved. And to avoid inertia becoming a constraint.

In the military domain, identification of *war preparedness as the goal seems simple.* But, its *measure of accomplishment is extremely complex.* Therefore, war preparedness has to be further sub-divided into visible and measurable objectives.

TOC follows the assumption that *with one constraint in the system, all other parts of the system must have sufficient capacity to maintain pace* with the work at the constraint and to catch up with delays, if necessary. Buffers are used in the process to protect the constraint from variations in the rest of the system. Buffers before the constraint safeguard the constraint from starving while those placed downstream prevent blockage of the constraint's output.

The following types of plants are classified:

- **I-plant:** This has a straight sequence of events (one-to-one). Every entity has one input and one output. The slowest operation is the constraint.
- **A-plant:** The general flow is many-to-one, like the final assembly. The main problem is in synchronising.
- **V-plant:** The general flow is one-to-many, the example being one raw material or a sub-component going into many product lines. "Robbing" is the main problem, where one process comfortable with the supply has material but the one starving does not. Sometimes, post preprocessing even rerouting without significant rework may not be possible.
- **T-plant:** Many-to-many relationship. The sequential flow like an I-plant later splits into many assemblies. Most manufactured parts are used in multiple assemblies and nearly all assemblies use multiple parts.

Accordingly, T-plants suffer from both synchronisation as well as robbing problems.

The *recommended supply chain logistics is like our FSS and ARS*. Inventory is held at an aggregation point near the source. Initial buffers are established, and replenishments are made only when the inbound quantity plus the quantity on hand is less than the buffer size.

Finally, the theory of constraints does *not look at only the engineering* processes. All business processes, including *marketing, sales, design and development, acquisition, internal/external supply chains, budget and finance* assume significance for meeting the **overall goal**.

A SYSTEMS VIEW: THE FIFTH DISCIPLINE

Peter M. Senge has introduced "The Art and Practice of the Learning Organisation" in his book *The Fifth Discipline.* He calls an entity "A Learning Organisation" where people continually endeavour to learn together to accomplish results and create a new reality; an organisation where collective aspirations and desires are nurtured. In a sense, we could possibly relate it to a self-evolving organisation.

The book deals with the subject through tools and prototypes that help in identification of problem areas which he calls "learning disabilities". The simplicity of the solutions' approach then presented through handling of the underlying structures is such that the reader ends up saying *"I knew it!"* The five disciplines of "the learning organisation" explained are:

- **"Systems Thinking":** We may call it the BIG picture; systems thinking is at the core of this philosophy. The need for a systems view, an integrated approach and the distortions created by a disconnected 'my view alone' have been emphasised and reiterated.
- **"Personal Mastery:** What we simply call professional ability has been explained with subtle difference as individual ability and hunger for continually enhancing one's own knowledge and acumen, and especially the preparedness to learn under any situation.
- **"Mental Models":** Deeply embedded images of experiences have an impact on our thinking and assumptions. These mental fixes are

required to be discovered to free our minds from them to enable rational thinking. The author has called it "turning the mirror inward".

- **"Building Shared Vision":** Shared vision has been explained as something beyond a "Mission Statement" made by the top management. We may use the analogy with the Commander's intent. Building a shared vision enables the organisation's people to identify and pursue it as their own rather than one being directed by the leader.
- "**Team Learning":** Genuine analysis and examination by the team together; this way, synergising the team's intelligence and output well beyond the individual sum.

All the above mentioned routinely appear in many a leadership book and paper. But, a vital point of difference here is the emphasis on the *systems thinking as the dominant discipline*, around which all the five disciplines are put together. Systems has to integrate all the other disciplines. And, therefore, this has been called **"The Fifth Discipline"**.

Some of the hurdles in progress, called "*learning disabilities*" are exceptionally well explained by Peter Senge.

- **"I Am My Position":** People tend to see their responsibilities restricted to their domains. They do not identify themselves as a part of the bigger organisation, considering areas outside their own as beyond their sphere of control, well detached from them.
- **"The Enemy Out There":** There is always something or someone else to blame.
- **"The Illusion of Taking Charge":** Being aggressive in actions does not mean being proactive.
- **"The Fixation of Events":** Adverse effects happen rarely as a result of sudden events. These are usually a result of gradual changes in processes or environment.
- The parable of the "**Boiling Frog"** is that we get used to gradual degradation.
- The **"Delusion of Learning from Experience":** We rarely experience the consequences of our own actions in time.
- The "**Myth of the Management Team"** is that a management team or a

Solutions often shift problems from one area to another within the system. A different set of people inherit new problems, making it difficult to detect or trace back to the original problem.

task force representing an organisation's different functional areas would study and resolve cross-functional problems. We never admit that we don't know the answer.

The 11 Laws of the Fifth Discipline appear to be self-explanatory and simple common sense.

- **"Today's Problems Come from Yesterday's Solutions:"** Someone other than the one who solved an earlier problem, inherits the problem, resulting in this new problem. Solutions often shift problems from one area to another within the system. A different set of people inherit new problems, making it difficult to detect or trace back to the original problem.
- **The Harder you Push, the Harder the System Pushes Back:** The compensating feedback comes into effect, not permitting the desired benefits. An example could be a contract with the OEM for the overhaul of a significant number of engines overhaul because of lack of spares with the BRD. An undesired and unexpected outcome is that the OEM gets tempted to throttle future spares supply, hoping to get further overhaul contracts.
- **Behaviour Grows Better Before it Grows Worse:** The solution often looks for immediate results to please the boss rather than comprehensive merits. When the problem returns after a few years, the original problem solver as well as the then boss, both would have moved away.
- **The Easy Way Out Usually Leads Back in:** Familiar solutions generally lie in the comfort zone of acceptance by everyone. Even worse is the case that we tend to push harder on the same path when problems persist.
- **The Cure can be Worse than the Disease:** Casually arrived at non-systemic solutions are ineffective, also making local people incapable of solving their own problems.
- **Faster is Slower:** An attempt to go faster than optimal usually gets roadblocks, as is often experienced while short circuiting procedures in procurement. Procedural lacunae later result in inappropriate vendor

proposals and retendering. Similarly, shortening some maintenance tasks has usually been seen to result in rework.

- **Cause and Effect are not Closely Related in Time and Space:** Taking the other way for granted, most of us begin looking for the cause within the same time and space zone; or we look for results of reforms in the current zone. Impatience makes solutions which don't show a direct relationship unacceptable. An example would be tightening the noose around the technician's neck for reuse of seals (correctly assessed by him as worthy of reuse) instead of solutions for improving the Automatic Replenishment Supply (ARS) system.
- **Small Changes Can Produce Big Results:** The "Trim Tab" is the best example. However, the fact is that the *points with high leverage are usually not quite obvious*. There can't be a simple rule to teach, but a look into fundamental structures rather than events is necessary.
- **You can Have Your Cake and Eat it Too—but Not all at Once:** The systems view may bring a new realisation. *Higher quality does not have to necessarily cost more.* Well structured maintenance and training activity on *'Maintenance Days'* does not result in lost time, but, on the other hand, increases quality and productivity.
- **Dividing an Elephant in Half Does not Produce Two Small Elephants:** Issues at hand related to the organisation as a whole are to be seen regardless of the boundaries. The three branches, Operations, Maintenance and Administration, cannot be seen as three isolated organisations for optimisation.
- **There is no Blame:** There is no "you" and "me". You and I are part of a one system. *The solution always starts with me* and lies in understanding and complementing the strengths and weaknesses of each other.

ISO 9001

The ISO 9000 series is one of the most widely implemented of all QMS regimes. The family of standards has been developed to **apply to all types of organisations** regardless of function, size, and whether it is in the private, or public sector. ISO 9001:2008 is the standard against which organisations

can be certified—although **certification is not a compulsory requirement of the standard.** As per the **standard, the organisation itself may audit, invite its client to audit** or engage an **independent quality system certification body** to certify conformity to ISO 9001:2008.

ISO 9000:2005 describes the fundamentals and vocabulary of QMS and the terminology and the ISO 9004:2009 standard **explains how organisations can use a quality management approach to achieve** sustained success. And, ISO 9001:2008 specifies requirements of a QMS, which an organisation needs to demonstrate. **The gist of requirements of the standard in plain language can be expressed as follows:**

- The quality policy is a statement by the management about the business aims linking its plans with the customer. The quality policy is communicated throughout the organisation and understood by one and all.
- The organisation identifies and documents business processes, drawing up the interfaces clearly.
- *Procedures and work instructions* for different levels of work within the main process and sub-processes are defined and documented.
- Procedures for *control of documents and records are defined.*
- The organisation defines methods of identifying customer requirements, and further communicating with the customer about the product quality feedback, complaints, contracts, etc.
- *Plans* are charted for the development of a new product, its test requirements at each stage.
- The organisation defines procedures to deal with non-conformance, whether due to internal or external elements.
- The QMS is *periodically audited* for effectiveness by an external auditor. The QMS effectiveness is also regularly evaluated through *internal audits*. Consequent *corrective actions* are undertaken and recorded along with the results of such actions.
- The organisation makes a demonstrated effort in making continual improvement in its performance. The actions and results are recorded.

The essentials of ISO 9001:2008, as per various clauses of the standard, again in plain language, are described below:

- To develop the QMS, i.e. establish, document, implement, maintain and improve the organisation's process-based QMS.
- To document the QMS, i.e. develop documents and ensure that these reflect and respect the organisation's function and how it is performed, prepare QMS manual, control QMS documents, and establish QMS records.
- To show commitment to quality through support to development, implementation and continual improvement of the QMS.
- To focus on customers and enhance customer satisfaction by ensuring that customer requirements are identified and met.
- To support quality policy by ensuring that the policy serves its overall purpose, is clear about requirements to be met, has a commitment to continually improve, supports quality objectives, is communicated down the line, and is reviewed periodically.
- To support and establish quality objectives, and make sure that these are affective.
- To plan establishment, documentation, implementation, maintenance, and continual improvement of the QMS.
- To allocate QMS responsibilities and authorities.
- To provide required QMS resources.
- To provide necessary infrastructure.
- To ensure product realisation requirements by controlling customer related processes, identification of unique product requirements, communication with customers, product design and development, purchasing and purchased product, production and service provision, monitoring and measuring equipment.
- To establish monitoring and measurement processes.

A typical soldier would doubt the applicability of QMS, which refers to customer, cost and profit, as we are not a business organisation. The point is that we have a customer unlike any civil agency – it is that man or woman who picks up an aircraft to fly a mission on complete trust. A customer is also the operations planner whose plans depend on an expected material resource. The cost benefit would be obvious as the operational

availability of systems increases with reduced waste of effort as well as resources. *The most important aspect usually missed out by critics is that ISO 9001 does not restrict us from using different methods as well as looking at all areas of functioning including operations and administration with a process approach.* Many organisations would like to think of themselves as unique. A small "Mr. and Mrs." enterprise, a multinational manufacturing company with service components, a public utility, or a government administration, all so different from each other can establish their QMS as per ISO 9001:2008 requirements. The standard only lays down the requirements, and leaves open the flexibility and scope of implementation. The flexibility provided by ISO 9001 transforms it into very simple implementation with a provision for continuous improvement. The whole theme can be understood in just a few lines:

Say what you do, Do what you say
Record what you do
Check for results, Act on difference
Do better today than you did yesterday

THE COMMON PRECEPT

A few quality management models, a couple of production or business overall optimisation theories and the ISO 9001 standards have been briefly described in the preceding text so as to create a mental picture with different views. A common precept in all these that may be noticed by the reader is that *every method highlights the process approach* either directly or in a subtle way, dealing with processes without using that term. Once the processes are identified and well defined (also interactions among them), visualisation of inadequacies, cause and effect becomes simple. The *combination of all the processes is, in fact, the system*, and therefore, the systems view is all important in any treatment of contributing elements. We may understand and appreciate the virtues of different optimisation philosophies, but we need a QMS to link all the methods used within a framework where conformance requirements are understood and complied with at working levels.

There is never one perfect solution approach to a problem. Therefore, a wider view enables us not to force one method on a problem at hand. While we are free to choose the most suitable method, we need to be careful not to wander around without focus. The ISO 9000 series of standards have been so well drafted as to not bind the implementing organisation with any specific philosophy or method. A small organisation may choose to rely on pure common sense in optimising processes identified under the QMS established in conformance of ISO 9001. In comparison, a complex organisation may work around one or more of the concepts like lean or TOC for optimisation of different processes. Different methods can be wonderfully accommodated within the framework of conformance to ISO 9001. It is for this reason that I consider ISO 9001 to be the **'outer cover'** of the whole quality effort, which has a well laid out standard for definition and conformance to *policy, objectives, procedures, work instructions, work records, management reviews, statistical evaluation and continual improvements,* etc. At the core of different processes, a specific methodology can be implemented in great detail.

I do believe that the ISO certification by an external agency would *not be necessary* **for Indian Air Force (IAF) units, field stations or BRDs alike. It would be far more effective if the DG (I&S) issues his own standard through** *adaptation of ISO 9001* **to our specific needs.**

In fact, I do believe that the ISO certification by an external agency would *not be necessary* for Indian Air Force (IAF) units, field stations or BRDs alike. It would be far more effective if the DG (I&S) issues his own standard through *adaptation of ISO 9001* to our specific needs. I wish to call it the **Air Force Standard (AFSTAN)**. Inspections by the Directorate of Air Staff Inspection/Directorate of Maintenance Inspection/Command Air Staff Inspection/Command Staff Inspection (DASI/DMI/CASI/CSI) should be carried out to verify conformance to AFSTAN, the QMS, which would automatically ascertain optimisation of all material and human resources towards fulfilment of operational objectives.

To conclude, the following action points would be in order:

- Create an outer cover of a standard for the QMS, be it ISO 9001 or our own DG (I&S) approved AFSTAN.
- Identify all processes within the main process (i.e. a department's main function). *Define* these processes with *as much clarity and simplicity* as possible.
- Pay special attention to identification and definition of *interfaces* among processes.
- Optimise processes using suitable methods.
- For every process, create a *convenient display system*, which would indicate status and current bottlenecks. Appropriate design will ensure transparency for management to intervene without waiting for reports and review.
- Create records (formats) at appropriate places or events; especially at hand-shake points between two sets of workers, two processes or two departments. These records should be meaningful, easy to inspect and readily available for trace back without conducting Cs of I.
- Be conscious of the need to **reduce inspection while enhancing the quality**—meaningful record-keeping and inspection in stages will reduce net inspection requirement.
- **Involve workmen** in the above steps through to the writing of procedures, work instructions and work records—only workmen are capable of doing it.
- Create constant awareness about quality by regular talks/ discussions. **Create a 'junoon' yourself**, beginning with you.
- Hire a consultant if necessary.
- **Define orders** with great care so as **to not create a plethora, which nobody can remember**.
- **Remove fear** from the minds that someday an unknown existing instruction would be pulled out to show non-conformance. Provide for an authenticated easy reference list of all applicable orders. An example is the 1st Command Maintenance Instruction for every year to list out all applicable instructions on date.
- Exercise caution about **detached solutions** bringing short-term gains

but **enhancing problems elsewhere** in the system.

- Use simple mathematics where possible for analysis and estimation. The results are easy to understand and the effect of minor changes in variables convenient to visualise.
- *Promote systems' thinking*. Identify yourself and your function with the BIG picture. Align functioning with the purpose of your Air Force, Command, Station, Squadron, Flight, Section and your team.
- The problem may be elsewhere, but *'what have I done to solve it?'* needs introspection first. Suggest before asking for comments.
- Identify the *internal customer* and work towards his satisfaction without regard to branch, trade, rank and appointment.

My message is:

Quality consciousness has to reside within the core of our being
And not put on as an overall before beginning work
Display that character and core with pride
And instill and appreciate the same in fellow workmen

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6. "ISO 9000:2005" issued by the International Organisation for Standardisation.
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INSPIRATION

1. *Col B.J. Singh* (Retd) for the *'junoon'*.
2. *Fellow engineers, technicians* and *logisticians,* especially at Maintenance Command and its depots.