TPM and TPM^3 – Australasian Lean

Supporting the journey to Business Excellence

History of TPM

Total Productive Maintenance or TPM had its genesis in the Japanese car industry in the 1970s. It evolved at Nippondenso, a major supplier of the Toyota Car Company, as a necessary element of the newly developed Toyota Production System. It was not until 1989, with the publication in English of the first of two authoritative texts on the subject by Seiichi Nakajima, that the western world recognised and started to understand the importance of TPM as a critical element of the Toyota Production System. It soon became obvious that TPM was a critical missing link in successfully achieving not only world class equipment performance to support Lean Production but was a powerful new means to improving overall company performance.

In Japan there has been many great TPM success stories involving significant improvements in safety & environment, capacity (OEE = A x R x Q), quality to customer, delivery, productivity, cost and morale all leading to significant sustained improvements to Return on Investment at the sites.

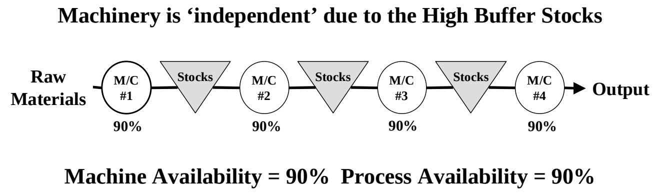
Since the early 90s, TPM has been tried by many Non-Japanese manufacturing, mining, processing, utilities and service companies however due to poor understanding of the important subtitles and some gross misinterpretations, only a small number of non Japanese companies have achieved sustained success. As such a lot of effort has gone into developing non-Japanese approaches to applying the principles and practices of TPM with varying degrees of success. In 1998 an Australasia version of 3rd Generation TPM was developed called TPM^3 which through further ongoing development has produced significant sustainable results for manufacturing, mining, processing, utilities and service companies and is currently being taken to countries such as Thailand and Indonesia again with excellent results.

The Evolution of TPM and the Toyota Production System

Prior to our understanding of the Toyota Production System, many companies allowed high buffer stocks to develop between major pieces of machinery or equipment within their plants to ensure that if there were a problem with one piece of machinery or equipment then it would not affect production in the rest of the plant. Hence the role of maintenance was to cost effectively ensure major pieces of machinery & equipment were available for an agreed period of scheduled time.

Because of the practice of retaining high buffer stocks, most machines or equipment could be considered independent. If the machinery in a process was maintained such that it achieved 90% availability, the availability of the process was 90% (see Figure 1). If the machinery started to cause quality problems, these would probably be noticed in final quality inspection and the cause traced back to the offending piece of machinery or equipment and corrected by maintenance.

Fig 1.

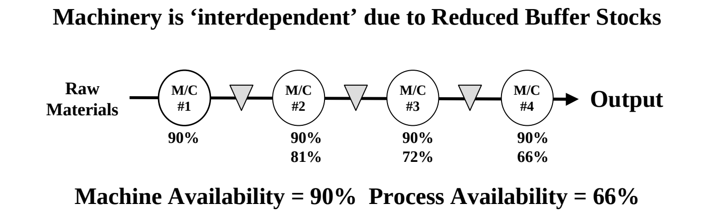


At Nippondenso in 1970 with the introduction of the Toyota Production System, the buffer stocks were substantially reduced in their quest for one-piece flow to allow Deming's[1] quality concept of 'Prevention at Source' to be applied so as to be able to pick up problems at the earliest possible time. This resulted in shorter Lead Times, lower costs and improved quality. Statistical Process Control (SPC) was also introduced to supported "Prevention at Source" and assist in identifying quality problems at the earliest possible time. This approach was also driven by the need to create a flexible workplace that could respond to customer's changing needs and maximise customer value by providing the highest quality at the lowest cost supported by quick responsiveness and superior customer service. Hence Lead Times were reduced to minimise buffer stocks and force the identification of any 'cost consuming' problems. Unfortunately, this also resulted in any individual machinery or equipment availability problems affecting the availability of the whole process.

The Impact of the Toyota Production System on Process Availability

If one machine stopped then shortly afterwards the whole process stopped. Without the excess buffer stocks, the machinery and equipment became interdependent. Hence, the availability of the process became the product of the individual availabilities of each machine or piece of equipment. For example, a process involving four machines maintained at 90% no longer had an overall process availability of 90%, but an overall process availability of 90% x 90% x 90% x 90%, or 66% (see Figure 2).

Fig 2.



Furthermore, as the quality approach changed to "Prevention at Source" by controlling process variables, machinery and equipment performance problems were identified much earlier resulting in conformance and reliability becoming much more important.

As buffer stocks reduced, process availability reduced resulting in substantial pressure being placed on the maintenance department to improve process availability. From a maintenance perspective, the maintenance department's performance had not deteriorated, yet demand for the substantial improvement in machinery and equipment availability was overwhelming. This caused friction between the production and maintenance departments. Production departments demanded former levels of process availability and quicker response times from

[1] Dr Edwards Deming from the USA, developed the concepts of Prevention of Source and taught it to the Japanese after WWII

maintenance however they were often unable to comply due to traditional organisation structures which keep maintenance as a separate function. After much conflict between maintenance and production, engineering were called in to find a solution. They soon realised that mathematically for the four machines to achieve their original process availability goal of 90%, the machine's individual availability needed to increase from 90% to 97.5%.

The solution to maintenance was quite obvious. If they had more money to purchase spare parts and extra resources, and more time to access the machinery and equipment they felt they could increase the availability of each machine to the required 97.5%. Unfortunately management who were driven by the desire to maximise customer value which included lower costs and reduced Lead Times, could not agree to maintenance's request. In fact they demanded that maintenance reduce their costs by some 50% and only have the machines down for the absolute minimum amount of time. This seemed a daunting task until it was suggested that maintenance should talk to their production colleagues about their new Quality approach of 'Prevention at Source" to product quality improvement to see if this approach could be applied by maintenance to achieve management's goals.

The Maintenance Challenge

The traditional view by maintenance was to balance maintenance cost with an acceptable level of availability and reliability often influenced by the level of buffer stocks, which hid the immediate impact of equipment problems. In traditional companies, maintenance is seen as an expense that can easily be reduced in relation to the overall business, particularly in the short term. Conversely, maintenance managers have always argued that to increase the level of availability and reliability of the equipment, more expenditure needs to be committed to the maintenance budget. With the on set of substantial availability problems caused by the new way of running the plant (see Figure 2), management soon realised that just giving more resources to the maintenance department was not going to produce a cost effective solution.

This conflict between maintenance cost and availability is similar to the old quality mind-set before the advent of Deming's Quality approach: that higher quality required more resources, and hence cost, for final inspection and rework. Deming emphasised "prevention at source" of the problem rather than by inspection at the end of the process. Instead of enlarging the inspection department, all employees were trained and motivated to be responsible for identifying problems at the earliest possible point in the process so as to minimise rectification costs. This did not mean disbanding the quality control department but having it now concentrate on more specialist quality activities such as variation reduction through process improvement. This new approach to quality demonstrated that getting quality right first time does not cost money but actually reduces the total cost of operating the business.

The Birth of Total Productive Maintenance (TPM)

This new Quality approach of "prevention at source" was translated to the maintenance environment through the concept of Total Productive Maintenance (TPM) resulting in not only superior availability, reliability and maintainability of equipment but also significant improvements in capacity with a substantial reduction in both maintenance costs and total operational costs. TPM is based on "prevention at source". It is focused on identifying and eliminating the source of equipment deterioration rather than the more traditional approach of either letting equipment fail before repairing it, or applying preventive / predictive strategies to identify and repair equipment after the deterioration has taken hold and caused the need for expensive repairs.

An important outcome of this new approach to maintenance has been that senior management have realised that TPM is a critical element of the Toyota Production System and as such is strategically important for a world competitive operation. TPM involves having the operators identifying equipment problems at the source and communicating this in a timely manner to maintenance can respond in a timely manner. In developing their TPM methodology Toyota found they were faced with 3 key challenges:

- How to train the operators to know what to look for;
- How to change the equipment so it easy for operators to find the problems; and
- How to create a maintenance support capability that can respond to small problems and issues identified by the operators.

Hence they realised that TPM cannot be implemented by the maintenance department alone. It needs to be a company wide improvement initiative integrated into the Lean Production journey involving all employees.

The Development of TPM and TPM^3 – Australasian Lean

Originally known as Total Productive Maintenance, the words correctly interpreted mean all employees (Total) creating greater return on investment (Productive) by caring for the plant & equipment (Maintenance) so as to maximise performance and output. To better reflect this correct interpretation the letters TPM now stand for a variety of words such as: Total Productive Manufacturing; Total Process Management; Total Productive Mining.

TPM has expanded significantly over the years since 1970. Originally the Toyota Production System model involved 5 Pillars or Activities of TPM that are now referred to as ***first*** generation TPM (Total Productive Maintenance). It focused on improving equipment performance or effectiveness from an equipment focus perspective. Late in the 80's as more companies in Japan started to adopt TPM it was realised that even if the shopfloor were committed fully to TPM and the elimination or minimisation of the "six big losses"[2], there were still opportunities being lost because of poor production scheduling practices resulting in line imbalances or schedule interruptions (Stable and Standardised Processes is a key foundation of the Toyota Production System). Hence the development of ***second*** generation TPM which focused on the whole production process and incorporated an extra Pillar of TPM activity called Support Department Improvement – Production Planning.

Since the 90's we have seen an increase in capital investment in most companies to reduce labour costs and increase productivity. This has bought about the greater realisation that the whole company can benefit from the people, equipment and processes working perfectly and in harmony so as to maximise output, quality and safety. Hence the development of ***third*** generation TPM which involved the expansion of the Support Department Pillar to include all support areas and value streams along with the addition of two further Pillars focusing on

[2] 'Six Big Losses' refer to Breakdowns, Set-ups, Speed, Minor Unrecorded Stoppages, Scrap & Rework, Start-up & Yield

quality and safety to create ***third*** generation TPM, which encompasses 8 Pillars of TPM Activity as shown in Figure 3.

Further developments in TPM have also included the creation of ***fourth*** generation TPM which involves expanding the improvement activities to include Suppliers and ***fifth*** generation TPM which includes involving Customers along with incorporating all the principles and practices of the Toyota Production System.

Fig 3. **Development of the TPM Pillars**

1st Generation TPM (Equipment Focus)	2nd Generation TPM (Production Process Focus)	3rd Generation TPM (Company Focus)
1. Improving Equipment Effectiveness (Six Big Losses)	1. Improving Equipment Effectiveness (Six Big Losses)	1. Focused Improvement (16 Major Losses)
2. Autonomous Maintenance by Operators	2. Autonomous Maintenance by Operators	2. Autonomous Maintenance
3. Planned Maintenance	3. Planned Maintenance	3. Planned Maintenance
4. Training to improve Operating and Maintenance skills	4. Training to improve Operation and Maintenance Skills	4. Education and Training
5. Early Equipment Management	5. Early Equipment Management	5. Early Management
	6. **Support Department Improvement - Prod Planning**	6. **TPM in Administration & Support Departments**
		7. **Quality Maintenance**
		8. **Safety & Environmental Management**
Source: **TPM Development Program** **S Nakajima 1982/1989**	**Source:** **New Directions in TPM** **T Suzuki 1989/1992**	**Source:** **TPM In Process Industries** **T Suzuki 1992/1994**

In Australasia, where our workplace culture is quite different from the Japanese, we have developed TPM³ (an enhanced and expanded Australasian version of 3rd, 4th and 5th Generation TPM thus focusing on the entire Supply Chain and incorporating the principles and practices of the Toyota Production System). This involved:

- expanding the Focused Equipment Improvement Pillar into covering both Equipment and the Processes associated with such, along with taking both a Macro (big picture perspective to understand all losses in Defined Production Areas and pick some early wins to create time for further improvement) and Micro, Special Micro and Mini Micro (specific area or specific loss perspective to focus resources) view to improvement;

- the addition of two extra Pillars – Work Area Management and People Support Systems to address the need for the transition to an inductive approach to improvement (pull culture change), which is fundamental for the success of TPM in an Australasian workplace culture; and

- the renaming and expansion of the Administration & Support Department Pillar to Logistics (Value Streams) & Support Improvement so as to cover the entire Supply Chain using Lead Time Reduction supported by Value Stream Mapping as the driver for improvement.

Fig 4.	Development of the TPM^3 Pillars
3rd Generation TPM (8 Pillars - Company Focus)	**TPM^3 – Australasian Lean (10 Pillars - Supply Chain Focus)**
8. Safety & Environmental Management	1. Safety & Environmental / Risk Management
1. Focused Improvement (16 Major Losses)	2. Focused Equipment & Process Improvement
	3. Work Area Management
2. Autonomous Maintenance	4. Operator Equipment Management
3. Planned Maintenance	5. Maintenance Excellence Management
7. TPM in Administration & Support Departments	6. Logistics (Value Streams) & Support Improvement
5. Early Management	7. New Equipment / Product Management
4. Education and Training	8. Education & Training
	9. People Support Systems
6. Quality Maintenance	10. Process Quality & Innovation Management

We also found it appropriate to:

- change the names of some of the Pillars to words with more relevance to our work environment;
- change the order of some of the Pillars eg Safety Pillar to number 1 rather than number 8; and
- expand the name to TPM^3 – Australasian Lean to better reflect the methodology is in fact an Australasian approach to Lean that initially focuses on equipment performance as a drive to engage employees.

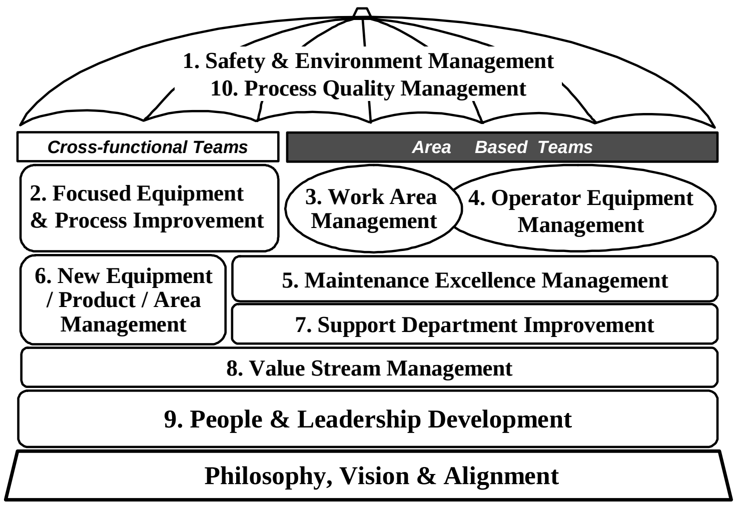
A conceptual model outlining how these 10 Pillars of TPM^3 – Australasian Lean integrate is shown in Figure 5.

Fig 5.

A Conceptual Model of the

TPM^3 - Australasian Lean Methodology

incorporating the 10 Pillars



C = Core Pillars S = Support Pillars F = Flow Pillar D = Development Pillar

A key strength of the methodology is the synergistic integration of all the TPM^3 Pillars. This is why if you haphazardly cherry-pick the 'Pillars of TPM^3' the result can be vastly different from a proper integrated approach.

We have also learnt that TPM^3 – Australasian Lean needs to be viewed as a journey to Lean Production and hence implemented accordingly so that it will have the maximum positive impact on the overall performance of the company.

The Rules underpinning the Toyota Production System

In an article in the Harvard Business Review in 1999, several authors reported on an extensive study into what really makes the Toyota Production System work. The results can be summarised into 4 key previously unwritten rules. These rules guide the design, operation, and improvement of every activity, connection and pathway for every product and service.

The rules are as follows:

Rule 1: All work shall be highly specified as to content, sequence, timing, and outcome

Rule 2: Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses

Rule 3: The pathway for every product and service must be simple and direct

Rule 4: Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organisation

All the rules require that activities, connections, and flow paths have built-in checks, to signal problems automatically. It is the continual response to problems that makes this seemingly rigid system so flexible and adaptable to changing circumstances.

Source: Decoding the DNA of the Toyota Production System, HARVARD BUSINESS REVIEW Sep-Oct 99

Rule 4 is the key to sustainable improvement. Any improvement methodology needs to recognise the importance of Rule 4 and provide Team Member Manuals for both Cross-functional improvement teams and Area Based improvement teams to ensure a structured, step-by-step (scientific) method is followed that is flexible enough to suit all sites' unique characteristics.

The 14 Management Principles, which underpin the 'Toyota Way':

Long Term Philosophy

1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals

The Right Process will Produce the Right Results

2. Create continuous process flow to bring problems to the surface
3. Use 'pull' systems to avoid over production
4. Level out the workload (***Heijunka***)
5. Build a culture of stopping to fix the problems, to get quality right the first time

6. Standardised tasks are the foundation for continuous improvement and employee empowerment
7. Use visual controls so no problems are hidden
8. Use only reliable, thoroughly tested technology that serves your people and processes

Add Value to the Organisation by Developing your People and Partners

9. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others
10. Develop exceptional people and teams who follow your company's philosophy
11. Respect your extended network of partners and suppliers by challenging them and helping them improve

Continuously Solving Root Problems Drives Organisational Learning

12. Go and see for yourself to thoroughly understand the situation (***Genchi Genbutsu***)
13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly (***Nemawashi***)
14. Become a learning organisation through relentless reflection (***Hansei***) and continuous improvement (***Kaizen***)

The 3 Key Principles further underpinning TPM^3 – Australasian Lean

For improvement to be sustaining, especially in an Australasian workplace environment, we have found that management must understand and apply to their every day decision making the 4 Rules and 14 Principles that underpin the Toyota Production system and The Toyota Way along with the 3 key principles that further underpin TPM^3 – Australasian Lean.

The 3 key principles that further underpin TPM^3 – Australasian Lean are based on:

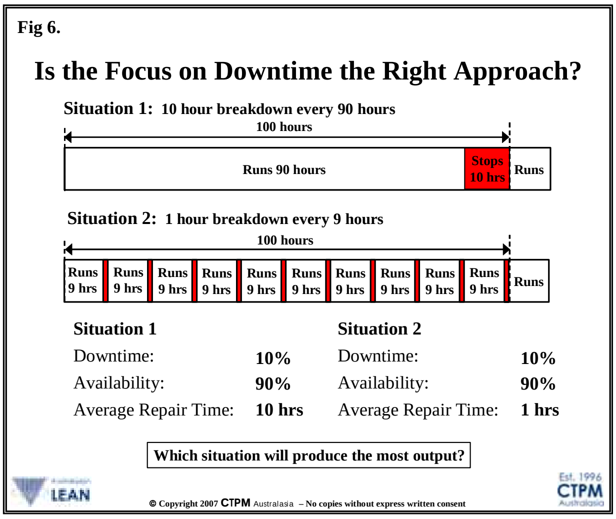
- Holistic Measurement of both equipment and the workplace
- Workplace Ownership of both the work area & equipment and decisions
- Formal Continuous Improvement involving both Cross-functional and Area Based Teams

Holistic Measurement

Often when we commence working with a client to assist them to commence the TPM^3 journey, we take the opportunity to visit both the maintenance department and the production department to assess their current approach to equipment management. During several visits of late, a familiar scenario appears to be present in many companies.

We will visit the maintenance department and ask the obvious questions about how things are going and hear a reply like "fine, availability is on budget and we are now responding much quicker to production's urgent requests resulting in the plant getting back on line a lot faster". We will then go next door to the production department (rarely do we find them together) to ask similar questions only to get a totally different response like "~!$#@%^&.. maintenance, the plant is always breaking down, and our output is down some 20% on budget". So we go back to maintenance and start again. How are things going and again the reply is the same: "fine, availability is on budget and we are responding much quicker now to production's urgent requests and getting the plant back on line a lot faster". So where's the problem?

To understand what is happening, let us look at the two case study situations shown in Figure 6 for the same plant operating at two different timeframes.



In Situation 1, we have the plant running for 90 hours and it suffers a breakdown that takes 10 hours to repair. The Availability of the plant is 90% and the Average Repair Time (Maintainability) is 10 hours. Some twelve months later in Situation 2, the same plant has a different scenario. The Availability is still at 90% meanwhile the Average Repair Time has significantly improved to 1 hour.

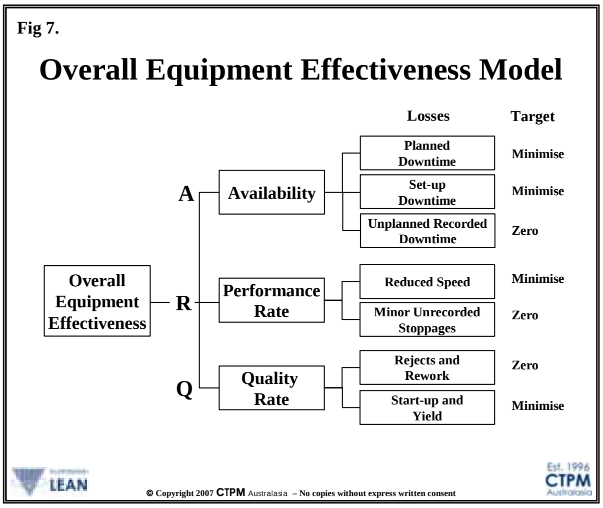
Obviously the maintenance group has been responding "much quicker" but has this really helped?

In both situations the Availability has remained constant at 90%, however what impact do these two situations have on the production department's issue of output?

Which plant situation do you believe would produce the most output?

In analysing the plant output it soon becomes clear that the Situation 1 scenario has the potential to produce more output than Situation 2 due to the disruption caused by the many short delays in Situation 2. Every time the plant stops unexpectedly or breaks down there is the opportunity for output to be lost (scrap) or damaged (rework). Also we have the added reduction in output due to the time required to bring the equipment or process back to normal running speed. Most equipment / processes do not start up instantaneously at their full or optimum running speed but rather ramp up over a period of time.

This case study leads to the question "Is Availability or Downtime by itself a relevant measure for equipment performance?" The answer is obviously no. That is why many companies who recognise the important role equipment and process performance have on bottom-line results are turning to the measure, which drives TPM^3 called Overall Equipment Effectiveness (OEE). OEE incorporates not only Availability but also Performance Rate and Quality Rate. In other words, OEE takes an **holistic** view of all losses that impact on equipment performance: not being available when needed; not running at the ideal rate and not producing first pass A1 quality output. A key objective of TPM^3 is to cost effectively maximise Overall Equipment Effectiveness through the elimination or minimisation of all losses. A simple model outlining these losses is shown in Figure 7.



Various equations exist to help us measure OEE (see Figure 8) which is based on Availability x Performance Rate x Quality Rate, however many companies are finding the simple high level measurement of OEE created by reducing the equations in Figure 8 where:

$$\textbf{OEE} = \frac{\text{Good Output Produced}}{\text{Required Production Time x Ideal Speed}}$$

as a good starting point to identify whether opportunities for improvement exist. Obviously this simple measure does not identify where the losses are coming from but it does give you an accurate indication of the effectiveness or lack of effectiveness of your equipment.

When many organisations first measure Overall Equipment Effectiveness it is not uncommon to find they are only achieving around 40% - 60% (batch or discrete manufacturing) or 50% - 70% (continuous processing plants) whereas the international best practice figure is recognised to be >85% (batch or discrete manufacturing) and >95% (continuous processing plants) for Overall Equipment Effectiveness.

In effect, this means there exists in most companies the opportunity to increase capacity and productivity by ***25% - 100%.***

Fig 8.

Calculating Overall Equipment Effectiveness Using Equations

OEE = % Availability x % Rate x % Quality

$$\textbf{Availability} = \frac{\text{Required Production Time – All Recorded Downtime}}{\text{Required Production Time}}$$

where All Recorded Downtime = Planned Downtime + Set-up Downtime + Unplanned Recorded Downtime

$$\textbf{Rate} = \underset{\text{(Reduced Speed)}}{\frac{\text{Actual Speed}}{\text{Ideal Speed}}} \text{ X } \underset{\text{(Minor Unrecorded Stoppages Loss)}}{\frac{\text{Processed Amount}}{\text{Reported Production Time x Actual Speed}}}$$

where Reported Production Time = Required Production Time – All Recorded Downtime

$$\textbf{Quality} = \frac{\text{Good Output Produced}}{\text{Processed Amount}} \quad \text{(Mass Balance approach)}$$

Note: Ideal Speed is measured in Output / Time

The other part of holistic measurement is how we measure the performance of the entire workplace where the equipment is located. Experience has demonstrated that focusing on just one measure; take OEE for example, no matter how good the measure is it does not give a holistic view of the workplace performance. As such we have developed a balanced scorecard type approach, which looks at a range of measures that also act as a counter-balance to OEE to ensure a balanced behaviour pattern is established in the workplace. These complimentary measures are:

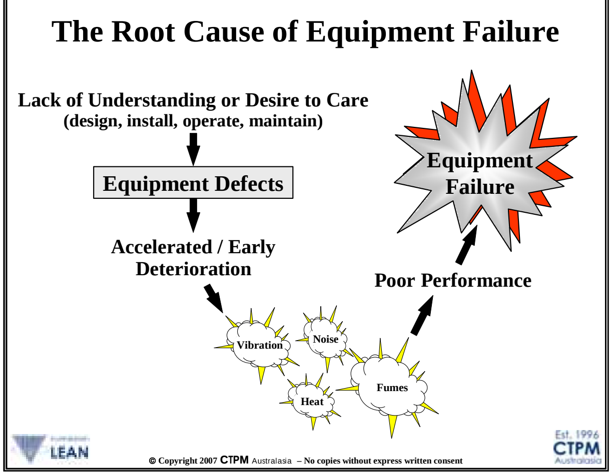
- **Safety & Environment**: to ensure employees aren't doing unsafe tasks to keep OEE high
- **Asset Performance**: to ensure excess inventories are not built up by deferring product changeovers to keep OEE high
- **Quality Performance:** to ensure we do not lose sight that Quality is the most expense of all the losses associated with OEE
- **Customer Satisfaction Performance:** to ensure there are no downstream customer complaints which would result from a strong focus of getting product out to achieve a good OEE result
- **Supplier Performance:** to ensure losses are not being incurred due to supplier delivery or quality issues
- **Human Resource Performance:** to ensure more people aren't allocated to the area to compensate for problems affecting OEE performance or employees aren't pressured into working harder to keep OEE high then have excessive time off
- **Financial Performance:** to ensure costs are not haphazardly generated in order to keep OEE high

Workplace Ownership

Since the mid to late 80s, in order to address the constraints of demarcation between different groups within the workplace, we have seen the introduction of multi-skilling.

Although multi-skilling has often been successful in creating a more skilled and flexible workforce, experience now highlights that while employees move from area to area, to develop their broad skills and often increased their remuneration, they lack the training or lose the motivation to seek out basic equipment problems or defects which if left unchecked, will cause accelerated or early deterioration and equipment failure (see Figure 9). The operators often demonstrate a **lack of understanding or desire to care** for the equipment or take training seriously, because they know they will soon be moved to another area or piece of equipment.

Fig 9.



However as more and more companies go through this experience, the importance of the issue of ownership becomes apparent. Through bitter experience many companies have now come to realise that without a sense of **ownership** employees tend not to develop and understanding or desire to care for equipment or take training seriously. Take the simple example of the company Ute or pickup truck versus the manager's car. Both vehicles are the property of the company, yet the manager's vehicle, because of the perceived 'ownership' of it by the manager is often more reliable, performs better and has lower operating / servicing costs than the company Ute or pickup truck which is driven by everyone and owned by no-one.

In a traditional multi-skilling environment our plant & equipment becomes like the company Ute or pickup truck - performs poorly and has high operating / servicing costs.

Without the framework of effective Area Based Teams of some 4 to 8 employees including a working Team Leader where team members can develop both multi-skilled base skills to ensure team flexibility (eg able to operate all work stations within their team's area of responsibility) as well as diagnostic mastery skills to ensure expertise at identifying the root cause of safety, quality and equipment problems at the earliest possible time (eg able to understanding the functioning of specific equipment within their team's area of responsibility) along with the maturity to be involved in many of the decisions required in their area of responsibility, the journey to operations excellence is bound to falter.

Formal Continuous Improvement

The third principle is Formal Continuous Improvement. However, before we address Formal Continuous Improvement, let us discuss who gets to see and fix the problems at your site.

From our experience it is often the workers who come across the majority of problems including the many small frequent problems and frustrations that can add up to a lot of waste.

On the other hand, management, supervision and support staff, often only get to see or hear about the larger problems occurring in the workplace.

When it comes to who is going to fix the problems, it is often the role of management, supervision and support staff to fix the problems with the workers only involved in a few as they are to busy getting product out the door.

To sustain fixes to problems we now recognise the importance of having the people who see and experience the problems involved in their solution as they often understand the background to problems the best, and know more about the implications of any solutions.

However, often the workers alone do not have the skill or resources to solve the problems. Hence we see the role of Cross-functional Teams and Area Based Teams as the most effective medium to address problems in the workplace where:

- Cross-functional Teams consist of up to 8 employees with representation from different departments to ensure the technical expertise is present to address the specific problem. They normally focus on all the value-add improvements (changes to the integrity of the product because the correct technical expertise will be present) along with all the technical (as opposed to people) non value-add issues that involve support groups from outside the Area Based Team's responsibility.
- Area Based Teams consisting of 4-8 employees on the same shift with a defined area of responsibility supported by clear boundaries. They normally focus on non value-add losses and waste: areas of improvement that often impact on people issues but do not affect the technical integrity of the product.

The impact of engaging all your employees will positively change the culture at the site however the critical issue is to find the time for your employees especially operators, to get involved in formal continuous improvement team activities. This leads to the fundamental question:

What do we employ our operators to do for our company? What is their role?

We describe the primary role of operators as: To achieve the Production Plan (make the product that is required to be made to satisfy the customer requirements) in a **safe** way, in a **quality** way, **cost** effectively and without affecting the **environment**.

However we also see operators having a critical secondary role: To formally improve the way they achieve the Production Plan through Formal Continuous Improvement activities.

We have all heard about Continuous Improvement, and most companies certainly promote Continuous Improvement. The problem we see is that in many cases, Continuous Improvement is done in a haphazard way. Often, many employees are trying to find a better or easier way to achieve their tasks, yet in some situations you have different shifts doing things slightly differently because they believe it is the better way.

Who has this situation in their workplace – where different shifts do things slightly differently?

This can lead to what Deming refers to as 'variation in the process'. When we do have a problem we are often confronted with this 'variation in the process', which creates many headaches in trying to identify the true reason or root cause of the problem.

For this reason, we refer to Formal Continuous Improvement. This is where the problem is clearly identified and measured, the root cause is identified, a solution is tested, the results are measured to verify it is an improvement, and documentation that all will follow, is created to lock in the improvement.

Recognising this definition for Formal Continuous Improvement, what percentage of their time do you see your operators – not your support staff or supervisors, involved in Formal Continuous Improvement activities.

We regularly conduct workshops throughout Australasia, and the most common answer we get to this question is 99% of the time focused on achieving the production plan and only about 1% of the time involved in any Formal Continuous Improvement activities.

We do however have some people who speak up and disagree with the majority. At one public workshop we were conducting in Melbourne several years ago, we had a couple of gentlemen speak up and say 'at our plant we run a ratio of 85% to 15%' (they were assembly managers from Toyota's Altona Plant).

At another workshop in Melbourne, we had a gentleman from Kodak who also stated that they were working at a ratio of 85% to 15% for their workforce in one of their production areas.

At Proctor & Gamble when we visited their site back in 1996, the team on the shampoo bottling line was working at a ratio of 75% to 25%. Admittedly a lot of their Formal Continuous Improvement TPM Activities were being done while the line was operating because they had solved most of the problems with the line and they could have meetings etc in the area while the line was operating.

What do you believe your ratio is at your site? We find most people tend to agree to the ratio of around the 99% to 1% mark or even lower sometimes.

The interesting thing we have found as we discuss this with many, many companies is that there is a correlation between this ratio and the OEEs at the site.

We find that the companies that are running at a ratio of around 99% to 1% normally have OEEs of around 40% - 60% and the companies that talk about ratios of 85% to 15% have OEEs of around 80% - 85%.

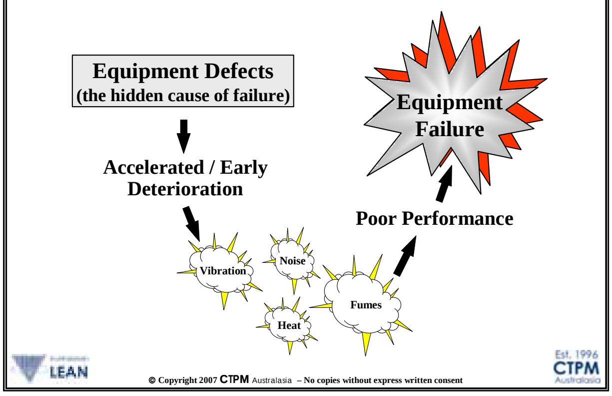
Often we see situations in some companies where they have special project teams go into areas and implement solutions, which have an immediate impact on the OEE performance. However, in a lot of situations, after about 6 months after the special project team has moved onto another area, the improvement tends to drop back to the original performance.

Who has ever seen this occur at their site? Why do the improvements not sustain?

We believe it has a lot to do with the second principle – Ownership. What we find is because the people in the area have little or no ownership of the solution, they don't care about the solution and soon the performance reverts back to what it was before the special improvement team came into the area.

We also know if we want the people who see and experience the problems to fix the problems (the workers) we need to increase the ratio. However if you instantly increase the ratio without doing any improvement first there is a very good chance you would not be able to achieve your production plan, which wouldn't do your customers any good and consequently wouldn't do your company any good.

Fig 10.
The Importance of Recognising and Eliminating Defects & Defect Generators



The key to address this problem is to first-up use a Cross-functional improvement team with only a few operators involved so you do not impact on the ability to achieve the production plan. As you improve the OEE you can introduce all the operators in the area to Formal Continuous Improvement through Area Based Team activities to ensure ownership and sustainability of the solutions.

The key to this process is to monitor the OEE and as the percentage increases, gradually increase the percentage of Formal Continuous Improvement time. For example if your OEE was at say 50% and you increase it to say 60% (still short of the best practice figure of >85%) could you afford to increase the formal continuous improvement time of your operators from say 1% to 5%. This 20% increase in capacity for an increase to 5% of operator time on Formal Continuous Improvement is obviously a good investment, however sadly, many companies miss this important issue of improvement sustainability and reduce the level of operators for a short term cost gain then wonder why performance drops over time, rather than increase the ratio of Formal Continuous Improvement time to ensure the improvement in OEE continues to the best practice levels of >85%.

Challenging our Mind-sets through TPM^3 – Australasian Lean

Although TPM^3 is not rocket science, and is based on common sense, it does challenge some of our traditional mind-sets we have developed over the years. Having management understand and taking on board these challenges is fundamental for the success of TPM^3 – Australasian Lean.

Two key challenges are:

- Recognising and Eliminating Defects & Defect Generators
- Reducing the Hidden Cost of Poor Equipment Effectiveness

The Importance of Recognising and Eliminating Defects & Defect Generators

A key objective of TPM^3 is to eliminate or minimise, not just reduce the equipment and process losses. To achieve this, TPM^3 is an ongoing journey to excellence that challenges our mind-sets. One such important challenge is the traditional mind-set that focuses on either actual or potential failures or breakdown and largely ignores equipment defects that can be the hidden cause of failure (see Figure 10).

Equipment defects or imperfections with our equipment are subtle and not always obvious. They "flow" into our plant & equipment due to various reasons: poor initial design or changes to the initial design requirements of our plant & equipment due to output requirement changes; the way we operate our plant & equipment and the environment we operate our plant & equipment in; imperfections in the maintenance materials we use and the way we carry out our maintenance activities; and last but not least, as a consequence of any failures which occur to our plant & equipment. They are often difficult to identify and correct because they are traditionally accepted as the norm. Equipment defects play a major part in causing "losses" in equipment performance.

Even though it is well known that defect removal is the most cost effective means to stop early deterioration of equipment and hence expensive failures, many companies ignore the importance of defect identification and rectification.

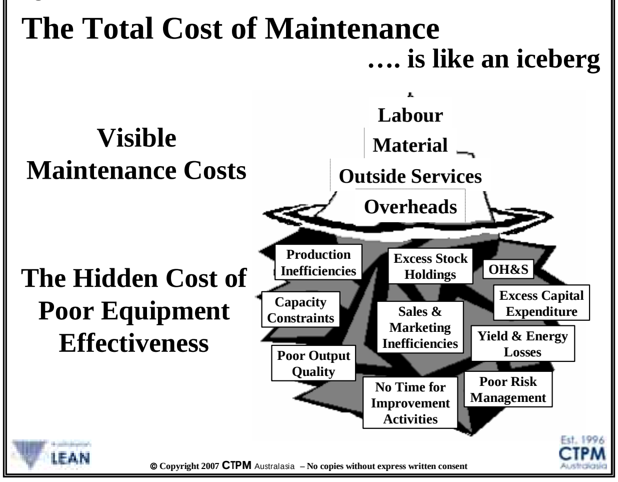
TPM^3 implementation experience has shown that there is a definite relationship between failures and equipment defects in that most failures can be traced back to equipment defects (see Figure 9). In a TPM^3 environment, the aim is to focus on equipment defects through the Operator Equipment Management Pillar so as to eliminate the occurrence of failures and early deterioration. This focus on equipment defects has a large bearing on the way everyone in the company needs to become involved with TPM^3.

All managers and supervisors need to ask the question "am I encouraging our employees to identify and arrange rectification of equipment defects". Ultimately all employees need to ask the question: "are my actions focused on avoiding equipment defects or merely addressing the issues associated with equipment defect removal". Being able to identify and correct equipment defects and then find their source so they can be avoided in the future is a major ingredient in the process of implementing TPM^3.

Understanding and Reducing the Hidden Cost of Poor Equipment Effectiveness

When talking about maintenance costs, most companies immediately relate to their maintenance budget costs, however camouflaged within the accounts of every company are costs associated with equipment not running effectively. Figure 11 provides a good analogy of what we find in most companies. The maintenance costs of labour, materials, outside services and overheads make up the top of the iceberg, which is quite visible, while underneath this are the costs associated with poor equipment effectiveness. In fact, what we have found is the lower your Overall Equipment Effectiveness the larger the bottom of the iceberg.

Fig 11.



In some large capital-intensive companies we have seen ratio's of 1:10 where "for every $1 spent on maintenance $10 can be identified as the cost incurred by the company due to the poor overall equipment effectiveness of the plant". In many average Australasian sites where OEE is around 40% - 60% we have found the hidden cost of poor equipment effectiveness to be in the order of 4 to 6 times the maintenance budget costs.

By focusing on improving the Overall Equipment Effectiveness of your plant through TPM^3 you are actually attacking the bottom of the iceberg costs. This can give quite a significant positive impact to your bottom-line results even though initially there may be a slight increase in your maintenance budget as you address the equipment defects in your plant.

Making TPM^3 – Australasian Lean Happen

Discussed ahead are the 3 Core Pillars and 1 of the Support Pillars, which are applied during the initial stages of a typical TPM^3 Introduction Plan (refer Figure 5 on page 5 for the conception model of all the 10 Pillars of TPM^3 – Australasian Lean).

Focused Equipment & Process Improvement (Macro & Micro) - Core Pillar

Macro Focused Equipment & Process Improvement in 20% of the site's Defined Production Areas that are causing the most grief is normally the starting point for the introduction of TPM^3 to a site. Its aim is to identify all the losses and address agreed losses so as to free up time for Area Based Team TPM^3 activity by increasing Overall Equipment Effectiveness (OEE) by some 10% - 25% as well as breaking down possible barriers between production and maintenance, and shopfloor and management while building relationships between these groups. It involves the formation of a Cross-functional Team for each selected Defined Production Area (typically the bottleneck areas of the plant). By systematically analysing equipment & process losses using a 9-step approach, various opportunities will be identified which will result in both a significant improvement in the OEE and a significant reduction in sources of frustration for the operators. Each Macro Focused Equipment & Process Improvement team should aim to complete their mandate of improvement within 12 weeks following a half-day kick-off workshop.

Micro, Special Micro and Mini Micro Focused Equipment & Process Improvement Teams follows on from the Macro Focused Equipment & Process Improvement (Macro FE&PI) as a means to address the specific losses identified by the Macro FE&PI Team but not addressed within the 12 weeks. A similar 9-step approach is used with the focus being on the technical losses, with the people related losses being addressed by Area Based Teams applying the Work Area Management and Operator Equipment Management Pillars.

Work Area Management - Core Pillar

Work Area Management is about forming Area Based Teams and allocating each team or shift-team a defined area of their workplace so that they can commence formal improvement activities that will assist everyone by establishing a 'place for everything and everything in its place'. This process not only makes the workplace more productive, safer and less frustrating for everyone - employees will no longer waste time trying to find tools, information, materials etc, but it also promotes communication between shifts. Once a workplace has reached an acceptable level of tidiness and orderliness, as verified by a formal audit process, the teams are ready and prepared to move forward with Operator Equipment Management activities.

Operator Equipment Management - Core Pillar

Operator Equipment Management is about training operators to 'care for equipment at the source' so as to ensure that 'basic equipment conditions' (no looseness, no contamination, perfect lubrication) are established and maintained. This then allows the successful implementation of planned preventive and predictive maintenance to be successfully administered by the maintenance department.

In his book, TPM in Process Industries, Suzuki raises this important issue when he states:

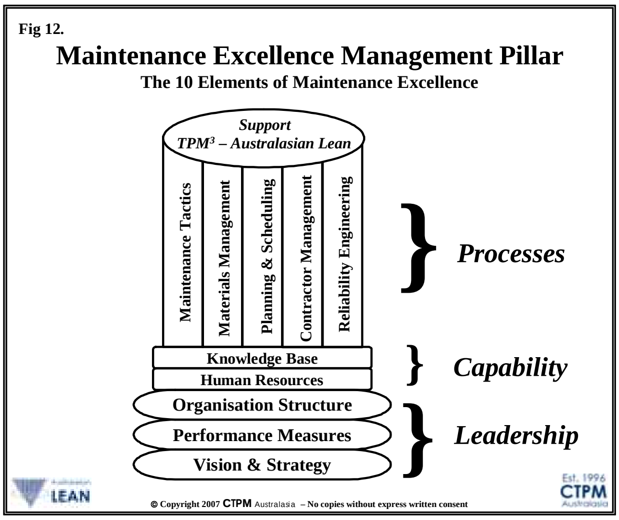
> *"Implementing a periodic / preventive maintenance system before establishing basic conditions - when equipment is still dirty, nuts and bolts are loose or missing, and lubrication devices are not working properly - frequently leads to failures before the next major service is due.*
>
> ***To prevent these would require making the service interval unreasonably short, and the whole point of the preventive maintenance program would be lost.***
>
> ***Rushing into predictive maintenance is equally risky. Many companies purchase diagnostic equipment and software that monitors conditions, while neglecting basic maintenance activities.***
>
> ***It is impossible, however, to predict optimal service intervals in an environment where accelerated deterioration and operating errors are unchecked."***

Introduction and implementation of Operator Equipment Management needs to be specific to the situation and plant environment, with the final goal being to achieve equipment-competent operators in synergistic Area Based Teams, responsible for the Overall Equipment Effectiveness (OEE = A x R x Q) of their plant & equipment along with the Safety, Quality to Customer, Delivery, Productivity, Cost and Morale in their designated workplace. Operator Equipment Management does not mean operators carry out all maintenance activities, but that they are responsible for knowing when they need to carry out the simple defect avoidance and minor service work themselves and when they should call in maintenance experts to repair problems, which they have clearly identified.

Maintenance Excellence Management - Support Pillar

The Maintenance Excellence Management Pillar is about freeing up the time of maintenance employees and reducing their frustrations by addressing the 'Time Lost' factor and thus improving the level of maintenance support to promote and enhance TPM³ so as to significantly reduce maintenance costs while improving the capacity of your plant & equipment and the safety and morale of your employees.

Fig 12.



To achieve maintenance excellence, which is essential to sustain TPM³ in the long term, the framework of Leadership, Capability and Maintenance process elements are essential. The Maintenance Excellence Management Pillar shown in Figure 12 is a conceptual model based on the 10 Elements of Maintenance Excellence Management. By completing a Time Lost survey of all maintenance employees, the issues identified can be used to prioritise the order in which to address the elements that need improving, however, without the foundation of a clear and well-communicated strategic direction and purpose for maintenance supported by the right performance measures and an appropriate organisation structure that promotes ownership, the site-wide implementation of TPM^3 almost always fails. For this reason, it is advisable to establish a Maintenance Excellence Leadership Team to complete a maintenance analysis before developing a site-wide TPM^3 implementation plan to determine to what extent, if any, the maintenance elements need to be strengthened.

TPM^3 Introduction and Implementation: A Four Phase Approach

Just as TPM^3 will have unique requirements for each application, so too will the TPM^3 methodology need to be specific to the situation and plant environment.

CTPM has developed a flexible methodology, involving four key phases, based on practical research and experience with a variety of Australasian companies. It is proving to be a very successful guide in many diverse applications in both achieving and sustaining the desired results.

Our experience over the years has allowed us to evolve a structured, yet flexible, step-by-step robust process for the successfully introduction of TPM^3 such that it will be sustaining and achieve the desired results. The process involves four key phases as shown below.

Key Phases of TPM^3
Awareness & Preparation Phase *initial education and the development of a TPM^3 Introduction Strategy supported by a site briefing*
Demonstration & Learning Phase *introduction of the core pillars to several (typically 4) pilot areas to gain a greater understanding of the issues and have a positive impact on the site's performance*
Assessment & Planning Phase *development of a site-wide implementation plan based on the learnings to date*
Site-Wide Implementation Phase *cascading of TPM^3 throughout the site*

However, we have also learnt that the methodology used must be flexible enough to ensure the following key issues of:

- How do we get Senior Management to actually understand the TPM^3 journey to operations excellence rather than think they understand it;
- How do we get all employees to contribute and participate in the TPM^3 journey;
- How do we ensure TPM^3 is integrated into existing improvement initiatives or existing improvement initiatives are integrated into the TPM^3 journey; and
- How do we ensure that we develop the in-house capability to progress and sustain the TPM^3 journey to operations excellence

are adequately addressed.

Our Approach

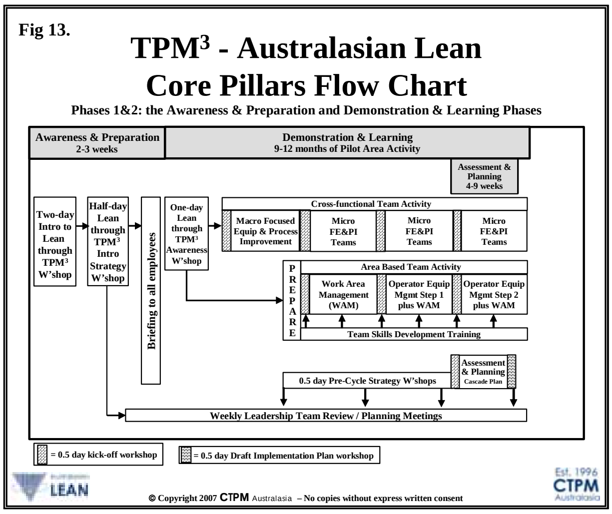


Fig 13.

To allow management to understand TPM^3 before cascading across the whole site we have divided our four-phase approach into two parts.

Part 1 involves the introduction of TPM^3 to several (typically 4) pilot areas and covers the Awareness & Preparation and the Demonstration & Learning Phases.

Part 2 involves the cascading of TPM^3 across the whole site and covers the Assessment & Planning and Site-Wide Implementation Phases.

This approach is supported by quarterly Pre-cycle Strategy planning workshops to allow realistic goals and checkpoints to be established along the TPM^3 journey to ensure measurable results are regularly monitored.

TPM^3 Introduction

Awareness & Preparation Phase

This phase consists first of a two-day Introduction to Lean through TPM^3 workshop for decision-makers and key employees (note: this workshop could be conducted over two non-adjoining days or over 4 half-days however the logistics of this would need to be understood and considered).

Although TPM^3 may seem a very bottom-up approach to improvement, for it to sustain it must be led by management. For this reason one of the initial key success factors for TPM^3 is the establishment of a TPM^3 Site Leadership Team that includes at least the Plant or Site Manager (leader / sponsor) Operations / Production Manager, Maintenance / Engineering Manager, Human Resources / Training Manager and Accountant / Financial Controller along with a designated TPM^3 Co-ordinator.

It is essential that the Site Leadership Team have a reasonable level of TPM^3 education before developing their TPM^3 Introduction Strategy or commencing any pilot area activity. We therefore strongly recommend that all Leadership Team members attend a two-day **Introduction to Lean through TPM^3** workshop.

The second component is the **TPM^3 Introduction Strategy** half-day planning workshop and is extremely important in order to finalise the objectives and ground rules for the Demonstration & Learning Phase. A key part of this workshop is to reach consensus on the selection of the pilot Defined Production Areas such that sufficient areas are chosen to ensure an impact on the business. To assist this process a high level flow chart of the production processes including all key equipment is created outlining where OEE can be measured and where there are at least 4 permanent employees per shift (Defined Production Areas). By identifying which Defined Production Areas are causing the most pain (bottleneck, low OEE, high safety problems, high cost etc), pilot areas can be chosen that will have a significant impact on business performance (basically it is using the 80:20 rule where 20% of the Defined Production Areas are probably causing 80% of the pain). The next most neglected area that causes the most problems is not having some clear guidelines or policies established and not being able to communicate clearly to everyone why TPM^3 is being introduced and why the pilot areas have been selected over other areas. The Site Leadership Team and the TPM^3 Co-ordinator need to attend and participate in the TPM^3 Introduction Strategy planning workshop.

The workshop will finalise the following key issues (some of these would already have been discussed during the 2-day Introduction to Lean through TPM^3 workshop):

- Selection of the initial Defined Production Areas (pilot areas)
- TPM^3 structure & roles
- TPM^3 guidelines or policies
- Scheduling of TPM^3 activities
- Monitoring TPM^3 progress
- Definitions to support OEE and the site's Goal Aligned Performance Measures (holistic workplace measures)
- TPM^3 communication strategy

The final component is briefing sessions for all employees to address the following questions:

- What is TPM^3 and why are we introducing TPM^3?
- What will it mean for employees? (or addressing the "what's in it for me")
- How is TPM^3 going to be introduced?
- Who is responsible for the introduction of TPM^3?
- When will employees get involved?
- When can employees expect to see the impact of TPM^3?
- What are the initial key milestones for something to happen?

Demonstration & Learning Phase

The first component is the one-day **TPM^3 Awareness** workshop for all employees who did not attend the two-day Introduction to Lean through TPM^3 workshop and are involved in pilot areas. Our experience is that employees who do not receive the TPM^3 Awareness training tend not to fully understand what is involved in progressing the TPM^3 journey and what the benefits for them personally will be, and hence may not fully support TPM^3. This will be reflected in either their attendance (or lack of) at meetings or their ability to complete their allocated tasks. The TPM^3 Awareness training can be provided over 1 full day or 2 half-days however the logistics implications may need to be considered in deciding the best option.

The next component is kicking off your pilot area teams. It is normally recommended that a company start with a Cross-functional Macro Focused Equipment & Process Improvement (Macro FE&PI) team in several Defined Production Areas (pilot areas) in order to have an impact on the business and address a number of critical issues:

- To establish a Baseline or "stake-in-the-ground" for the pilot area by documenting current and past performance and establishing an ongoing measurement system
- To understand in detail the extent and reasons for all the equipment & process losses occurring in the pilot area
- To educate both senior management and shopfloor employees in the usefulness of the measure of Overall Equipment Effectiveness (OEE) as the "driver" for focusing improvement activities
- To identify possible cost-effective solutions and implement approved solutions so as to significantly improve the Overall Equipment Effectiveness of each pilot area (typically target at least 10% to 25% improvement)
- To create a positive environment to allow maintenance and production to gain a greater understanding of each others situation and build relationships
- To create a positive environment to allow senior management and shopfloor employees to gain a greater understanding of each others situation and build relationships
- To reduce the frustrations and free up time of all employees in each pilot area so there will be a desire (pull) to establish Area Based Teams and introduce formal continuous improvement activities involving all employees on all shifts through Work Area Management and Operator Equipment Management
- To provide a foundation of loss analysis to allow the Leadership Team the opportunity to create further cross-functional Micro, Special Micro or Mini Micro FE&PI teams to address outstanding technical related losses
- To promote learning within the workplace and to allow employees to experience the success and value of being a cross-functional team member and develop their team working and problem solving skills.

Our experience has been that to achieve the above objectives and minimise the impact on production, the preferred make-up of a Macro FE&PI team would be:

Area Supervisor;
1-2 Operators (same shift);
1-2 Maintainers;
1-2 Tech Support (horsepower for data analysis);
1 Manager (Leadership Team member); and
TPM^3 Co-ordinator.

The pilot area Macro FE&PI teams would meet for a maximum of 1.5 hrs per week preferably on the same day at the same time each week such that all team members can attend during their normal working time.

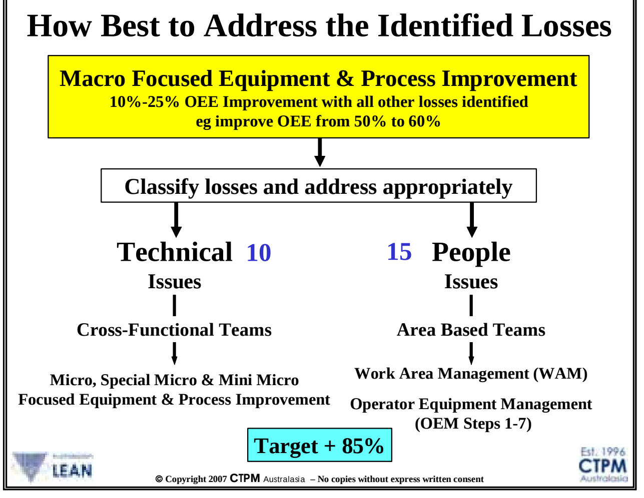
We also recommend a TPM[3] Navigator provides facilitation / training / navigation support to the team. This ensures the team is given expert (been there and done it before) guidance and training to achieve their mandate (maximum return for the company) and most importantly in some cases to ensure the manager on the team is properly facilitated to ensure he/she does not dominate any meeting.

The training includes a half-day kick-off workshop to help the teams understand the Macro FE&PI process, how they are to work together as a team, and an overview of the Team Member Manual which provides a detailed step-by-step process to follow along with copies of forms to provide a structured approach to their meetings and activities.

We would expect each team would complete their 12 week cycle with a final presentation that would not only highlight their achievements and lessons learnt but more importantly an outline of how all the remaining losses should be addressed. A summary of a typical outcome is shown in Figure 14.

Once the Macro Focused Equipment & Process Improvement (Macro FE&PI) Teams have completed the 12 meeting cycle (typically 3 months) and presented to the Leadership Team, the next cycle involves 2 streams of activity as shown in Figure 13. To address technical loss issues we recommend the use of Micro, Special Micro or Mini Micro Focused Equipment & Process Improvement Cross-functional teams. To address the people loss issues we recommend engaging all employees on all shifts within each pilot area through Work Area Management (WAM) by creating Area Based Teams of some 4-8 employees.

Fig 14.



A key outcome from Work Area Management (WAM) apart from creating a workplace that has 'a place for everything and everything in its place' is to significantly improve communications between shifts.

Once initial losses have been addressed and relationships have been built between the different groups (ie production and maintenance) through the Macro FE&PI cycle, and Area Based Teams have been established with basic formal improvement disciplines and all shifts have developed effective means to communicate with each other through the WAM cycle, we recommend the commencement of Operator Equipment Management (OEM).

The 4 Stages and 7 Steps of Operator Equipment Management

Stage 1: **Recognise and Rectify Equipment Defects so as to achieve Basic Equipment Conditions and thus reduce variation in Equipment Component Life and Improve Safety and Quality**

1. Cleaning for Inspection
2. Countermeasures to Sources of Contamination and Difficult to Clean Areas
3. Standards for Cleaning and Lubrication

Stage 2: **Understand how Equipment Functions so as to diagnose problems at the earliest possible time, identify and improve Design Weaknesses and achieve Zero Breakdowns and Improve Safety and Quality**

4. Training for Inspection
5. Standards for Equipment Care

Stage 3: **Understand the Relationship between Quality and Equipment Conditions so as to achieve Zero Quality Problems and Improve Safety**

6. Process Quality Assurance

Stage 4: **Manage the Workplace so as to always achieve the Production Plan (in a Safe, Quality, Cost Effective, and Environmentally sound way) and achieve Zero Accidents**

7. Workplace Management

The aim of the Work Area Management and Operator Equipment Management activities is to have a positive impact on the business and address a number of critical issues:

- To establish Area Based Teams with clear responsibilities and boundaries for agreed Improvement Areas for each shift
- To establish a communications Noticeboard to support sharing of information between shifts to gain agreement and buy-in on improvements
- To establish a Scoreboard for each Area Based Team to provide feedback to the team and everyone else at site on the progress of their improvement activities
- To create a positive environment to allow maintenance and production to gain a greater understanding of each others situation and build relationships
- To create a positive environment to allow management and workers to gain a greater understanding of each others situation and build relationships
- To create time and reduce the frustrations of all Area Based Team members so that there will be a desire (pull) to support the ongoing Operator Equipment Management steps
- Create a learning environment within the workplace to allow employees to experience the success and value of being Area Based Team members and develop their team working and problem solving skills.
- Standardise practices for Work Area Management across all shifts / areas
- Introduce the practice of Area Based Team self-assessments
- Improve safety, productivity and morale by establishing “a place for everything and everything in it’s place” through Work Area Management activities
- Engage both the team members and the teams in working together to improve their work area and equipment so as to reduce their frustrations
- Develop self-managed equipment-competent operators who can:

    - Recognise equipment defects or problems at the earliest possible time
    - Initiate and ensure rectifications are promptly carried out
    - Understand equipment functions and mechanisms
    - Detect causes of defects or abnormalities
    - Carry out minor servicing of their equipment where appropriate
    - Understand the relationship between equipment and quality (yield loss)
    - Predict problems in quality (yield loss) and detect their causes
    - Manage own workplace
- Develop synergistic mature Area Based Teams recognising the 4 stages of team development
- Provide everyone with the training, systems and opportunities to care for their own equipment & workplace
- Ensure Production and Maintenance work in harmony
- Make use of equipment as a means of teaching employees new ways of thinking and working
- Create a failure-free, trouble-free, safe workplace

Alternate Approaches

Our experience has been to strongly recommend that Macro Focused Equipment & Process Improvement (Macro FE&PI) be considered first followed by Work Area Management (WAM) supported by Micro FE&PI activities before commencing Operator Equipment Management (OEM) however it is not mandatory, as some companies believe they have already achieved some of the Macro FE&PI objectives for example, through their existing quality programs. Hence if a site has achieved:

- A good understanding and measurement of OEE (A x R x Q) and the counter-balance / holistic workplace measures of Safety & Environment, Asset Performance; Quality Performance; Customer Satisfaction, Supplier Performance, Human Resource Performance (Productivity, Morale), and Financial Performance (Costs) for their Defined Production Areas
- Sufficient spare capacity to allow all employees in the Defined Production Area across all shifts to stop the line / equipment in normal time for say 2.5% - 5% of their time (1 to 2 hours per week) for Area Based Team formal improvement activities (Work Area Management and Operator Equipment Management)
- Excellent relationships between production and maintenance employees so the Area Based Teams will receive excellent support for their improvement requirements

Then the logical starting point would be engaging all employees on all shifts within the pilot Defined TPM^3 Areas through Work Area Management.

Many companies discuss the possibility of starting with Work Area Management, however after giving it some thought, they generally conclude it makes more sense to start with Macro FE&PI, in order to ensure that the measures are in place, the team understands all the issues impacting the OEE (A x R x Q), and sufficient gain in OEE has been achieved to allow the introduction of Area Based Team TPM^3 activities without impacting on the ability to achieve the production plan.

We have also found that with some companies there is a strong desire to go straight into Operator Equipment Management, especially where industrial housekeeping initiatives (eg 5S) have been introduced. Our concern has always been that if the work area is not sorted out first supported by demonstrated disciple across all shifts in maintaining agreed standards, and good communications and relationships have not been established between the shifts, there may be a lack of discipline within the workplace to sustain Operator Equipment Management activities apart from a flashy "initial clean for inspection".

Assessment & Planning Phase

After the pilot Defined TPM^3 Areas have completed their first cycle of Operator Equipment Management (Step 1) which is normally about 9 months into your TPM^3 journey, we suggest that the TPM^3 Co-ordinator supported by the TPM^3 Champions (Production Managers) and Co-Champion (Maintenance Manager) conduct a review of the learnings to date, and assess the potential benefits for the site based on the results in the pilot areas. This would also entail identifying all the possible Defined TPM^3 Areas at the site, and mapping out a realistic roll-out-plan based on the bottleneck constraints, and the availability of facilitation and maintenance support resources.

Site-Wide Implementation Phase

Approximately 12 months after commencing TPM^3 introduction the company will be able to use the experience gained in the Demonstration & Learning phase and the outcomes from the Assessment & Planning Phase to fully roll out $TPM^{\mathbf{3}}$ to all remaining areas / equipment / employees including all logistics and support staff.

Typical Benefits from Our Approach

Our experience highlights that the initial introduction of TPM^3 can, within the successful completion of your first cycle of Macro FE&PI pilot area teams (3 months), have a significant bottom-line impact in the pilot Defined TPM^3 Areas, and if 20% of the most 'painful' possible Defined TPM^3 Areas have been chosen then significant positive impact on site performance.

This occurs when the increased output from a typical 10% - 25% OEE improvement, results in increased revenues from the increased output along with a decrease in costs due to a reduction in waste and other production-related losses.

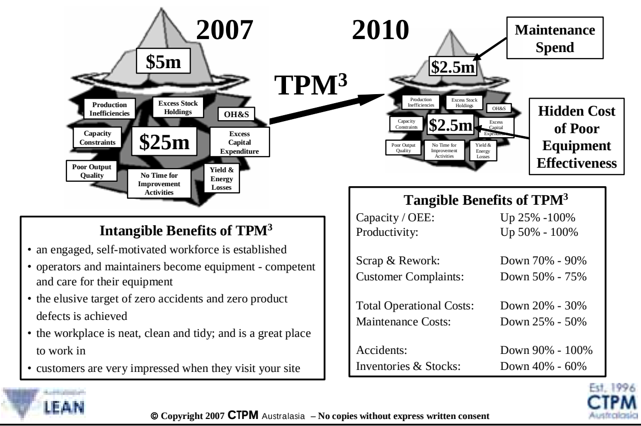
Overall this can also lead to a significant unit cost reduction especially if the increased output can be sold.

Other benefits achieved in the pilot areas during the full Demonstration and Learning phase which covers not only the Macro FE&PI cycle but also several Micro FE&PI cycles and the introduction of Work Area Management and the initial steps of Operator Equipment Management, include further significant enhancements to OEE, shorter and more reliable production lead times; increased customer satisfaction, improved levels of skills, safety and morale for employees.

Summary of Benefits

Based on a typical average OEE of say 50% - 60%, we estimate the benefits to a site from the first 12 months (3 cycles) of the Demonstration & Learning Phase of your TPM³ journey for your pilot areas (20% of your Defined Production Areas that are causing the most grief) to be 25% - 50% increase in OEE (A x R x Q) resulting in increased revenues and reduced unit costs along with a significant impact on Safety, Quality to the Customer (internal and external), Delivery, Productivity and Morale translating to a 10% - 20% decrease in the Hidden Cost of Poor Equipment Effectiveness (Bottom of the site's Iceberg).

Fig 15.
Expected Benefits from a Successful TPM³ – Australasian Lean Journey at a Site



After some 3 years these improvements could cover the entire site and be significantly greater as highlighted in Figure 15, with positive impacts being experience by your customers, employees, and shareholders.

Sample of Companies engaged on their TPM³ - Australasian Lean Journey

Automotive	Holden Engine Operations (VIC), Cooper Standard Automotive (SA)
Building Industry	Hynds Pipe Systems (NZ)
Food	Coopers Brewery (SA); Fonterra Australia (VIC, TAS); Sanitarium (NSW); Simplot Australia (NSW, VIC, TAS): Sugar Australia (VIC, NSW, QLD)
Metal Processing	Wundowie Foundry (WA)
Mining	Banpu Lampang Coal Mine (Thailand); Banpu Tandung Mayang Coal Mine (Indonesia); Banpu Indominco Coal Operation (Indonesia); Zinifex Rosebery Mine (TAS)
Packaging	Cryovac Sealed Air (NZ)
Paper	APRIL Pulp & Paper (Indonesia); Carter Holt Harvey Tissues (NZ)
Pharmaceuticals	Alphapharm (QLD); CSL Bioplasma (VIC)
Personal Hygiene	SCA Hygiene Australasia (NZ, VIC)
Pet Food	Masterfoods Petcare (NZ)
Printing	Pacmetal Services (NSW); Oberthur Gaming Technologies (NSW)
Refinery / Smelter	Zinifex Port Pirie Smelter (SA)
Service	Simplot Agricultural Services (TAS)
Timber	Juken New Zealand (NZ)

Reported Long-term Achievements from TPM^3 - Australasian Lean
(Source: TPM^3 Forums in Aust & NZ)

Simplot Australia

Commenced their TPM^3 journey in September 2003 at 3 of their sites (Kelso NSW, Echuca VIC and Ulverstone TAS). In November 2004 they expanded their TPM^3 journey to their remaining sites (Bathurst NSW, Devonport TAS and Agricultural Services TAS). To date 3 sites have been awarded Level 1 of the 5 Level Milestone TPM^3 Excellence Award (Kelso Sept 05, Devonport Aug 06, Echuca Feb 07) with the other sites aiming to achieve similar by early 2007. Some of their publicly reported achievements include:

2005 Simplot Australia – Kelso (NSW): Reduced product spillage by 87% and increase OEE by 4.5% equating to an annual saving of $182,000 on one product line. Total Plant OEE has improved from 64% to 83% in 12 months (Sep 04 to Aug 05)

2006 Simplot Australia – Bathurst (NSW): A New Equipment Management Team for Capsicum Processing reported a $19,165 savings due to early commissioning of the new line and an annualised saving of $156,578 due to increased throughput and recovery along with two new commercial opportunities due to improved quality results. They also reported improved safety, communication and morale along with better understanding of quality requirements by the process workers.

Sugar Australia – Glebe Island

Sugar Australia – Glebe Island site is one of Sugar Australia's 4 bulk supply depots with packaging plants. The depot has 28,000 tonnes of white refined sugar storage capacity, which is supplied via a special purpose 19,000 tonne capacity ship from the Mackay Sugar Refinery in Queensland. Both dry and liquid sugar is supplied to Food & Beverage Manufacturers, Food Service Industry and Retail Markets.

The Glebe site commenced their TPM^3 journey in October 2005, and to date have completed 3 cycles of formal improvement activity with all employees engaged resulting in:

- 96% increase in the Retail Line OEE
- 180% increase in the Industrial Line OEE
- 25% reduction in Labour Costs

Hynds Pipe Systems – East Tamaki Site in New Zealand

Commenced their TPM^3 Journey in September 2001. On March 2006, the East Tamaki site was the first New Zealand site awarded Level 1 of the 5 Level Milestone TPM^3 Excellence Award. They are currently progressing Cycle 13 with some 80% of their employees involved in TPM^3 improvement teams.

They have achieved a 90% increase in output from the plant since commencing their TPM^3 Journey

Other publicly reported achievements at the site include:

2003: Reported that one section of the plant had been able to increase capacity 62% allowing the introduction of ongoing Area Based Team improvement, which has more than sustained the gains.

2004: Operations Manager reported their TPM^3 activities had resulted in a 12% reduction in operating costs and a 20% increase in output from the site compared to last year, with little to no capital expenditure.

2006: A team focusing on improving the yard layout, storage and traffic flows at their site produced impressive results including a 30% increase in storage space, a reduction in loading time, a 23% increase in productivity and an increase of 4% in truck fill.

Juken New Zealand Limited – Northland Mill at Kaiatia

Commenced their TPM^3 Journey in January 2005 and over the first 12 months completed 3 cycles of TPM^3 team activity engaging 28% of their workforce in their Sawmill and Veneer Plant. On 30 November 2006, while progressing Cycle 6, the site was awarded Level 1 of the 5 Level Milestone TPM^3 Excellence Award. In their press release to announce the award they stated they now have **93%** of ***their workforce involved in improvement activity every week***. Achievements to date include:

- *88% reduction in Lost Time Injury Frequency*
- *34% increase in Sawmill Capacity (OEE)*
- *16% increase in Veneer Plant Capacity (OEE)*
- *93% increase in Sawmill Yield*
- *67% reduction in Sawmill Maintenance Costs*
- *29% reduction in Sawmill Electricity Costs*

all contributing to a ***50% reduction in Total Manufacturing Costs***.

SCA Hygiene Australasia – Te Rapa (NZ)

At the 2004 TPM^3 Forum in Rotorua NZ, the Production Manager reported that over the past 2 years the site has achieved over 600,000 hrs LTI free along with many other gains including one Area Based Team through their Operator Equipment Management activities achieving an annual savings of $511,000.

At the 2006 TPM^3 Forum in Rotorua NZ, it was reported how an Area Based Team came up with an improvement to a Log Saw that cost only $32 in materials and achieved a $635,000 annual saving.

Further Reported Gains from TPM^3 - Australasian Lean

At the 2005 TPM^3 Forum in Melbourne **ai Automotive – Adelaide (SA)** reported how their first cycle of TPM^3 involved 4 Macro Focused Equipment & Process Improvement teams, which delivered annualised savings of over $400,000. One of the teams in an assembly cell improved OEE from 47% to 63% (34%) and improved first pass Quality from 93% to 99%.

At the 2003 TPM^3 Forum in Sydney, an **ACI Plastics Packaging – Kirrawee (NSW)** team reported how during their 12 week cycle, they reduced material losses resulting in an annualised savings of $178,788.

Also at the 2003 TPM^3 Forum in Sydney**, Zinifex (formally Pasminco) Rosebery Mine – Rosebery (TAS)** reported how over their first 12 months they reduced Crusher Roll change-outs saving $160,000 per annum; improved capability in mine development from 100 to 125 metres / week; and improved metal recovery in their conversion plant by 3% giving a revenue increase of $1.6m per annum**.**

At the 2004 TPM^3 Forum in Rotorua NZ a **Fonterra - Edgecumbe (NZ)** team reported how they applied set up reduction to their CIP process, and shaved 1 hr 9 min off the turn-around time achieving a $1.5m increase in revenue per year.

At the 2004 TPM^3 Forum in Rotorua NZ the **Fletcher Challenge Forests – Rainbow Mt (NZ)** Site Manager reported how a Logistics & Support Improvement team within 12 weeks reduced on site transport costs by 12% savings $100,000 per year along with reducing by 2 the number of forklifts required on site. There has also been a 15% reduction in Work In Progress Inventory and a 27% reduction in the average manufacturing lead-time.

Conclusion

As the need to create a workplace that can quickly take on the new innovative requirements of a highly competitive market place expecting the lowest cost, best quality and quickest response time from its suppliers, becomes a greater imperative, equipment performance and people performance is becoming a more critical and strategic issue for companies throughout Australasia.

TPM^3 has been developed to assist companies with this challenge. It is a proven company wide improvement strategy that initially focuses on equipment management with the flexibility and capability to allow management to expand the methodology throughout the supply chain, ultimately involving all employees.

TPM^3 is a structured, yet flexible and practical, phased journey to World Class Performance, consisting of 10 integrated Pillars, each with defined steps that reduces frustrations in the workplace and hence achieves good buy-in from all employees generating a significant positive impact on capacity (OEE = A x R x Q), safety, quality to customer, delivery, productivity, cost, and most importantly morale.

However, it should be acknowledged that TPM^3 is not a 'silver bullet' or a 'short-term fix' but a clearly defined flexible journey to World Class Performance. Significant improvements will be evident in the initial pilot areas within the first cycle (3 months), however full implementation and full benefits can take several years depending on the rate of cascading decided by your site management team.

Summary

We recommend sites consider commencing their TPM^3 – Australasian Lean journey by completing the TPM^3 Awareness & Preparation Phase.

This entails conducting an in-house two-day Introduction to Lean through TPM^3 workshop for the site's decision-makers and key employees (normally about 20 employees).

This should be followed about a week later by an in-house half-day TPM^3 Introduction Strategy planning workshop for the TPM^3 Leadership Team to determine the Defined Production Areas that are suitable for the pilot teams, to agree on the number of pilot teams required to have a significant impact on the site's performance, and to set boundaries and policies to support the TPM^3 journey.

After the half-day TPM^3 Introduction Strategy planning workshop the site should have a critical mass of decision-makers and key employees with a sound understanding of:

- what TPM^3 is all about;
- what makes TPM^3 happen;
- what is required to make TPM^3 happen; and
- have a realistic introduction plan to kick-off TPM^3 in sufficient pilot areas to have a significant impact on the site's performance.

Once the TPM^3 Introduction Strategy is in place the site would be in a position to commence the Demonstration & Learning phase of their TPM^3 journey in their selected pilot Defined Production Areas knowing the Leadership Team will be in a position to regularly monitor progress and ensure adequate resources have been provided to ensure success for all involved.

About **CTPM** Australasia

Originally know as The Centre for TPM (Australasia), CTPM was established as an outcome of the first conference dedicated to TPM in Australasia held in Sydney in 1995. During the conference, which was chaired by Ross Kennedy, there was a call from the delegates to establish a much-needed Institute for TPM to support industry, academia and government similar to those already present in Japan, USA and Europe. Responding to this call, Ross with several colleagues launched The Centre in January 1996 with its head office located in Wollongong (a major city some 80 kilometres south of Sydney on the NSW South Coast).

TPM was developed in 1970 as an integral part of the Toyota Production System. Originally known as Total Productive Maintenance, the words correctly interpreted mean all employees (Total) creating greater return on investment (Productive) by caring for the plant & equipment (Maintenance) so as to maximise its performance and output.

In order to better suit our Australasian workplace culture, TPM^3 was developed in 1998 as an enhanced and expanded Australasian version of the Japan Institute of Plant Maintenance (JIPM) third generation TPM model. In 2006, we further expanded and enhanced our methodology and renamed it TPM^3 – Australasian Lean to better reflect our Australasian approach to applying the principles and practices of the internationally recognised Toyota Production System and began formally trading as **CTPM** Australasia.

CTPM is a membership-based organisation with the charter to develop, promote and advance the knowledge and practice of TPM and more recently TPM^3 - Australasian Lean.

The TPM^3 – Australasian Lean methodology synergistically integrates 10 Pillars of improvement activity, so as to allow companies to unleash the full potential of their People, Equipment and Processes as they strive to achieve World Class Performance.

CTPM and its membership continue to grow. There are now more than 20,000 company employees covered by CTPM membership and over 30 sites covering 14 Industry Groups from Manufacturing, Mining, Processing, Utilities and Service companies currently progressing their TPM^3 – Australasian Lean journey to World Class Performance.

CTPM is very mindful of the need for companies to establish their own in-house capabilities to lead, manage and facilitate their TPM^3 – Australasian Lean journey in order to achieve sustained success. However we also acknowledge that TPM^3 – Australasian Lean has been developed based on more than 30 years of practical experience and research, and as such, establishing or developing internal capabilities is not achieved just by attending one or two training courses. Proper training from a recognised authority is critical (such as the TPM^3 Leadership / Instructor's Program which was developed in November 1997 and to date, some 20 courses later, has over 250 graduates from some 30 companies), however most of the learning comes from doing. There are very few short cuts to experience. For this reason, CTPM has developed a proven flexible methodology covering a range of educational training courses, introduction and pre-cycle planning workshops, team kick-off workshops supported by comprehensive step-by-step Team Member Manuals, a site wide assessment & planning process, the 5 Level Milestone TPM^3 Excellence Award supported by our Milestone Assessment Process, and most importantly, a full-time team of experienced TPM^3 Navigators to provide facilitation and training support who are located in Sydney, Wollongong, Melbourne, Launceston and Adelaide in Australia, Tauranga in New Zealand and Jakarta in Indonesia.

About the Author

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A fitter and turner by trade, Ross has a Mechanical Engineering degree from the University of New South Wales and a Management degree from the University of Wollongong.

He has more than 20 years of hands-on manufacturing and operational experience covering maintenance, production, operations and executive roles. In 1985 Ross developed his passion for Lean Production following his involvement in the Value Added Management (JIT) initiative by the NSW Government. Ross quickly and effectively applied the new Lean principles and practices firstly at the CMA Foam Group Lullaby Bedding Factory while Factory Manager, then CMA's Cable Accessories Factory as Site Manager before moving to David Brown Gear Industries as Manufacturing Manger to establish and oversee the relocation of the company from Sydney to Wollongong to a new facility set up on Lean principles and practices. In 1989 after the new facility was well established and recognised for its leading edge improvements based on Lean, Ross was invited to join the new JIT / Lean practice being established by the Manufacturing and Operations Group of Coopers & Lybrand's International Management Consulting Practice.

Over the next 5 years Ross had the opportunity to work on major assignments with some of the firm's leading Lean practitioners from USA, Canada and the UK. It was also during this time that he first came across TPM (a critical missing link in the Lean tool kit) in 1990 when he led one of the first implementations of TPM in Australasia under the guidance of John Campbell who was Partner-in-Charge of Coopers & Lybrand's Global Centre for Maintenance Excellence based in Canada and author of the internationally recognised maintenance book – Uptime.

In August 1994 Ross established his own consulting practice specialising in TPM. He organised and chaired Australasia's first TPM conference in 1995 and, as at the request of the delegates at the conference, Ross with several colleagues founded The Centre for TPM (Australasia) or CTPM in January 1996 to provide a membership-based organisation to support Australasian industry and academia.

After extensive research including a trip to Paris in 1997 to attend Europe's first World-Class Manufacturing & JIPM-TPM Conference and associated workshops with leading TPM practitioners from throughout the world, the CTPM launched its TPM^3 methodology in January 1998, which is an enhanced and expanded Australasian version of 3^{rd} Generation TPM embracing the Toyota Production System and spanning the entire Supply Chain.

Since then CTPM has been involved with a wide range of leading manufacturing, mining, processing, utilities and service companies. For example from Sept 1998 to June 2003 CTPM assisted Telstra roll-out their TPM initiative to over 200 teams servicing their Customer Access Network in 16 Regions throughout Australia resulting in over $110m in savings.

Ross has been actively involved with Lean since 1985, TPM since 1990 and TPM^3 since 1998 and has delivered publicly over 200 workshops and papers on the subjects both within Australia and overseas.

CTPM, under the direction of Ross with his team of experienced full-time TPM^3 Navigators, is presently assisting over 30 sites spanning some 14 different industry groups located in Australia, New Zealand, Thailand and Indonesia on their TPM^3 – Australasian Lean journeys to World Class Performance.