Introduction to TPM and TPM^3

(TPM^3: an enhanced and expanded Australasian version of 3rd Generation TPM focusing on the entire Supply Chain)

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History of TPM

Like the Quality movement, 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, which was originally thought to only incorporate Total Quality Control (TQC), Just in Time (JIT), Industrial Housekeeping (5S) and Total Employee Involvement (TEI). It was not until 1988, 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. It soon became obvious that TPM was a critical missing link in successfully achieving not only world class equipment performance to support TQC (Variation Reduction) and JIT (Lead Time Reduction), but was a powerful new means to improving overall company performance.

Since the early 90s, TPM has rapidly spread throughout the western world, significantly improving the capacity, productivity, quality, delivery, safety, morale and bottom line results of manufacturing, processing, utilities, and mining companies. TPM is also having a major impact on revitalising and enhancing previous quality management or continuous improvement initiatives.

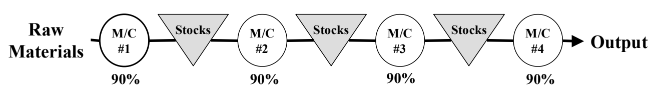
Background to the Evolution of TPM

Traditionally in many manufacturing companies, high buffer stocks were allowed to develop between major pieces of machinery or equipment within our 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, for example 90%.

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.

Machinery is 'independent' due to the High Buffer Stocks



Machine Availability = 90% Process Availability = 90%

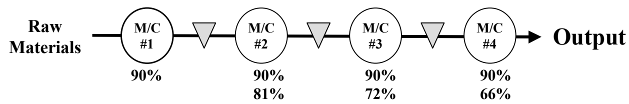
At Nippondenso in 1970 with the introduction of the Toyota Production System, the buffer stocks were substantially reduced in their quest for shorter Lead Times, lower costs and improved quality. Statistical Process Control (SPC) supported by "Prevention at Source" was introduced to ensure quality right first time. This approach ensures maximum customer value by providing the highest quality at the lowest cost supported by quick responsiveness and superior customer service. Hence buffer stocks were reduced to both reduce Lead Times and force the identification of any ‘cost consuming’ problems. Unfortunately, this also resulted in any individual machinery or equipment problems affecting the whole process.

The Impact of the Toyota Production System

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. Thus, 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.

Machinery is ‘interdependent’ due to Reduced Buffer Stocks



Machine Availability = 90% Process Availability = 66%

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 performance. 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 maintenance, whom 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 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 less than 2% of the time. This seemed a daunting task until it was suggested that maintenance should talk to their production colleagues about their new Total Quality Control 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 Total Quality Control (TQC): that higher quality required more resources, and hence cost, for final inspection and rework. TQC 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 TPM

This new Quality approach of "prevention at source" was translated to the maintenance environment through the concept of 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 equipment management, which is now supported by many success stories throughout the world in a variety of operational industries, has been that senior management have realised that TPM is both strategically important for a world competitive business and that TPM cannot be implemented by the maintenance department alone. TPM is a company wide improvement initiative involving all employees.

The Development of TPM and TPM^3

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

TPM has developed significantly over the years since 1970. Originally there were 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 it was realised that even if the shopfloor were committed fully to TPM

and the elimination or minimisation of the "six big losses", there were still opportunities being lost because of poor production scheduling practices resulting in line imbalances or schedule interruptions. 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.

In more recent times it has been recognised that the whole company can benefit from your equipment operating perfectly resulting in significant improvements in output, quality and safety hence the expansion of the Support Department pillar to include all support areas along with the addition of two further pillars focusing on quality and safety to create ***third*** generation TPM, which encompasses 8 Pillars of TPM Activity as shown in Figure 3.

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

1st Generation TPM (Equipment Focus)	2nd Generation TPM (Manufacturing 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. **Quality Maintenance**
		7. **TPM in Administration & Support Departments**
		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**

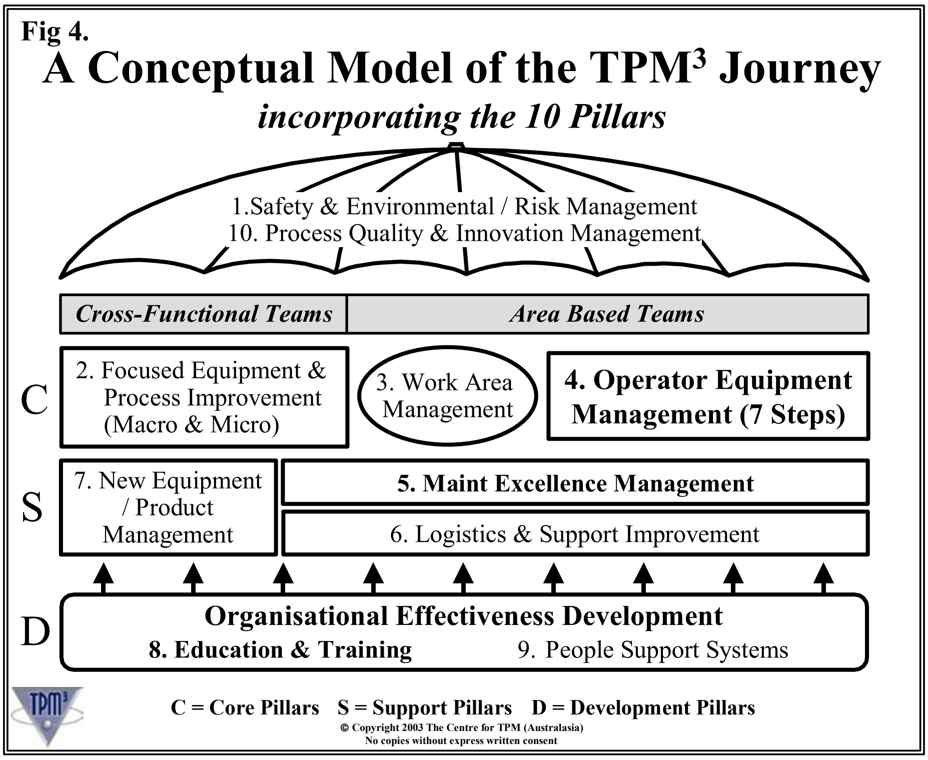
In Australasia, where our culture is quite different from the Japanese, we have developed TPM^3 (an enhanced and expanded Australasian version of 3rd Generation TPM focusing on the entire Supply Chain). This involved:

- 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 and pick some early wins to create time for further improvement) and Micro (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 and TPM^3; and

- the renaming and expansion of the Administration & Support Department Pillar to Logistics & Support Improvement so as to cover the entire Supply Chain using Lead Time Reduction as the driver for improvement.

We also found it appropriate to change the names of some of the Pillars to words with more relevance to our work environment and to change the order of some of the Pillars eg Safety Pillar to number 1 rather than number 8. A conceptual model outlining how these 10 Pillars of TPM^3 integrate is shown in Figure 4.



The Key Principles underpinning TPM^3

For improvement to be sustaining, especially in an Australasian environment, we have found that management must understand and apply to their every day decision making the 3 key principles that underpin TPM^3.

The 3 key principles 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

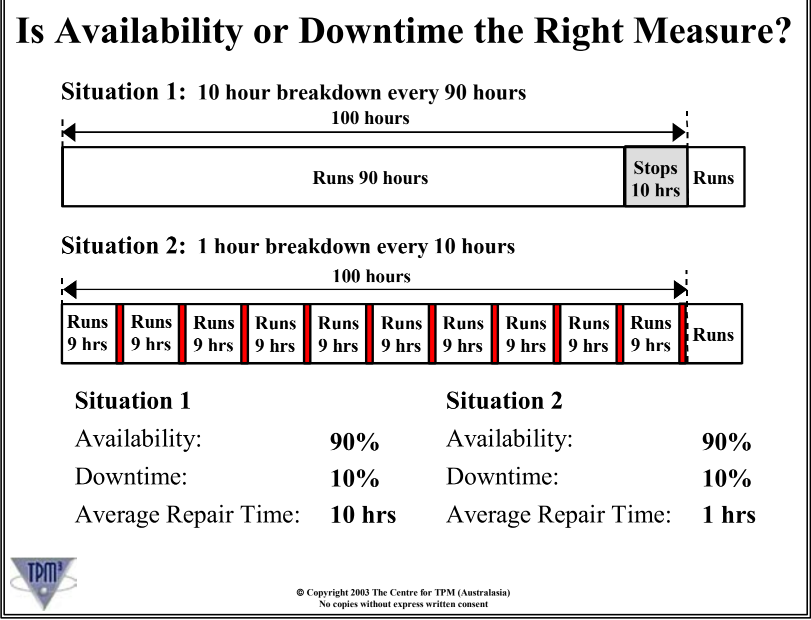
Often when we commence working with a client to assist them to commence the TPM^3 journey, we take the opportunity to visit both the maintenance department and the production department to assess their current approach to equipment management. During several visits of late, a familiar scenario appears 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 5 for the same plant operating at two different timeframes.

Fig 5.



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?

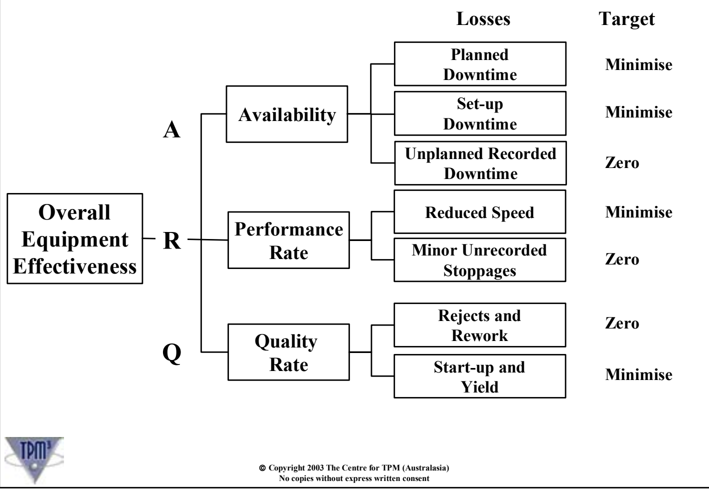
Which plant situation do you believe would produce the most output?

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 6.

Fig 6.

Overall Equipment Effectiveness Model



Various equations exist to help us measure OEE (see Figure 7) 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 7 where:

Fig 7.

Calculating Overall Equipment Effectiveness Using Equations

OEE = Availability x Rate x Quality

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

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

(Speed Loss) (Minor Unrecorded Stoppages Loss)

$$\text{Rate} = \frac{\text{Actual Rate}}{\text{Ideal Rate}} \times \frac{\text{Processed Amount}}{\text{Reported Operating Time x Actual Rate}}$$

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

$$\text{Quality} = \frac{\text{Good Output Produced}}{\text{Processed Amount}}$$

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

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% - 75% (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%.***

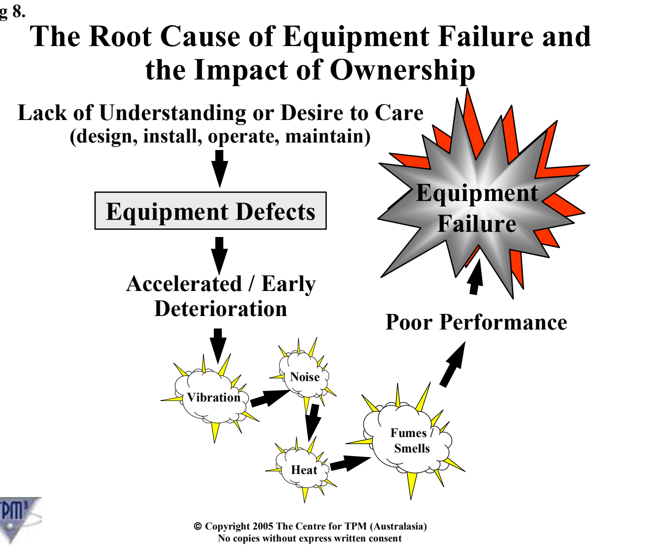
The other part of holistic measurement is how do we measure the performance of the entire workplace where the equipment is located. Experience has demonstrated that focusing on just one measure; take OEE for example, no matter how good the measure is it does not give a holistic view of the workplace 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 (to ensure employees aren't doing unsafe tasks to keep OEE high)
- Quality to Customer (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)
- Delivery Performance (to ensure product changes are not deferred to maximise Set-up Downtime losses in the OEE measure)
- Productivity (to ensure more people aren't allocated to the area to compensate for problems affecting OEE performance)
- Cost (to ensure resources aren't haphazardly allocated to the area to keep OEE high)
- Morale (to ensure employees aren't pressured into working harder 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.

Fig 8.



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 8). 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.

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 supported by a working team leader where team members can develop both multi-skilled base skills to ensure team flexibility as well as diagnostic mastery skills to ensure expertise at achieving the production plan, frontline safety, frontline quality, frontline care and frontline formal continuous improvement, along with the maturity to be involved in many of the decisions required in their area of responsibility, the TPM^3 journey to World Class Performance 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 75% - 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 now 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.

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 TPM^3 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 70% (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 10%. This 40% increase in capacity for an increase to 10% 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

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.

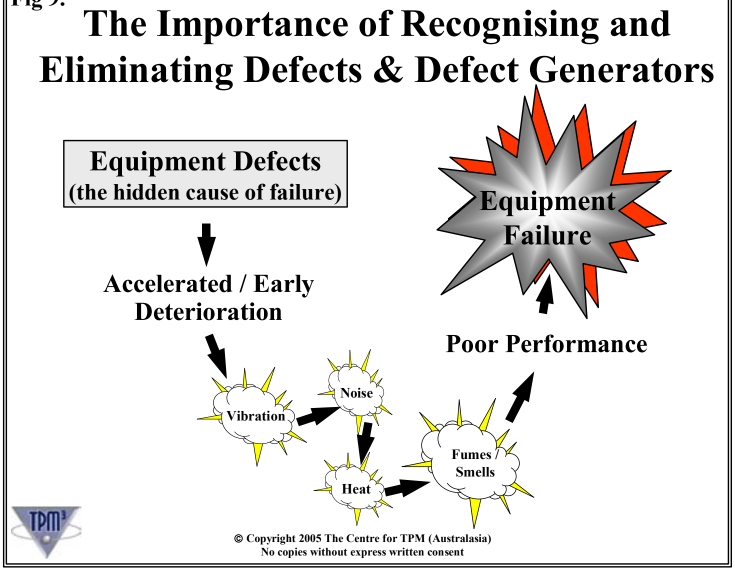
Two key challenges are:

- 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 9).

Fig 9.



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.

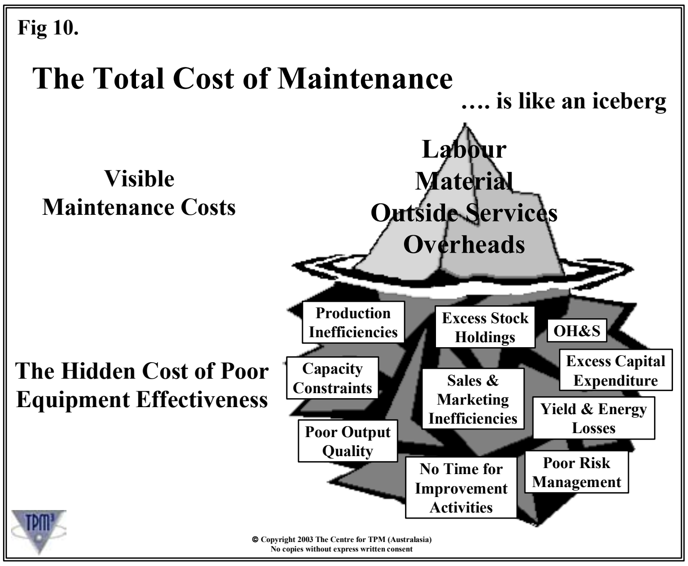
Even though it is well known that defect removal is the most cost effective means to stop early deterioration of equipment and hence expensive failures, many companies ignore the importance of defect identification and rectification.

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 10 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.



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 Happen

Discussed ahead are the 3 Core Pillars, 1 of the Support Pillars and 1 of the Development Pillars, which are applied during the initial stages of a typical TPM^3 Introduction Plan (refer Figure 4 on page 5 for the conception model of all the 10 Pillars of TPM^3).

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

Macro Focused Equipment & Process Improvement in two or more defined bottleneck areas 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 defined bottleneck area. 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.

Micro Focused Equipment & Process Improvement follows on from 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.

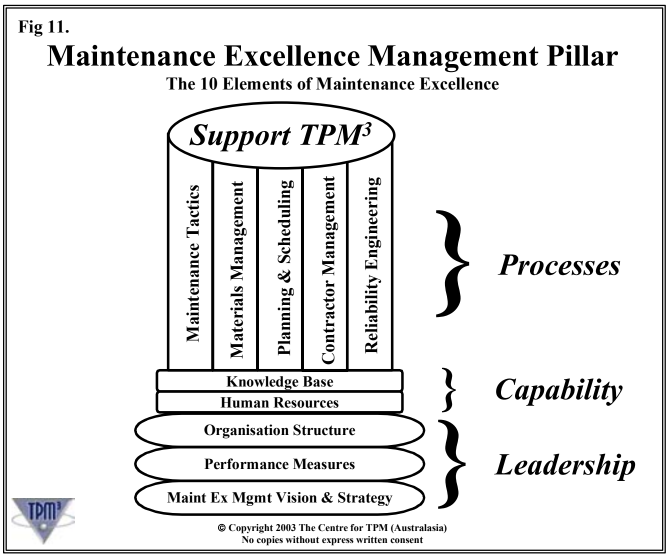
In his book, TPM in Process Industries, Suzuki raises this important issue when he states:

> *“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 improve the level of maintenance support to promote and enhance TPM^3 so as to significantly reduce maintenance costs while improving the capacity of your plant & equipment and the safety and morale of your employees.



To achieve maintenance excellence, which is essential to sustain TPM^3 in the long term, the framework of leadership, capability and maintenance process elements are essential. The Maintenance Excellence Management Pillar shown in Figure 11 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.

The Centre for TPM (Australasia) 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.

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, any methodology used must be flexible enough to ensure that the following key issues are adequately addressed:

- how do we get Senior Management to actually understand TPM^3 rather than think they understand TPM^3;
- how do we get all employees to contribute and participate in TPM^3;
- how do we ensure TPM^3 is integrated into existing improvement initiatives; and
- how do we ensure your company develops the in-house capability to sustain TPM^3

The Demonstration & Learning phase is the most critical as it provides practical learning experiences for both shopfloor and senior management by demonstrating the viability of TPM^3 in several important pilot areas.

The Assessment & Planning phase builds on this experience to help justify the expected improvements / payback from implementing TPM^3 site-wide to ensure management gives the implementation, which can take some two to four years, the correct priority and support.

The Site-Wide Implementation phase normally commences about 12 months after commencing TPM^3. 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^3 to all remaining areas / equipment / employees including all logistics and support staff.

Summary of the Benefits from TPM^3

Based on a typical Australasian average OEE of say 50%, we estimate the benefits to a site from the first 12 months (3-4 cycles) of the ***Demonstration & Learning Phase*** of your TPM^3 journey **for your pilot areas** to be:

40% - 60% **Increase in OEE (A x R x Q) resulting in increased revenues and reduced unit costs**

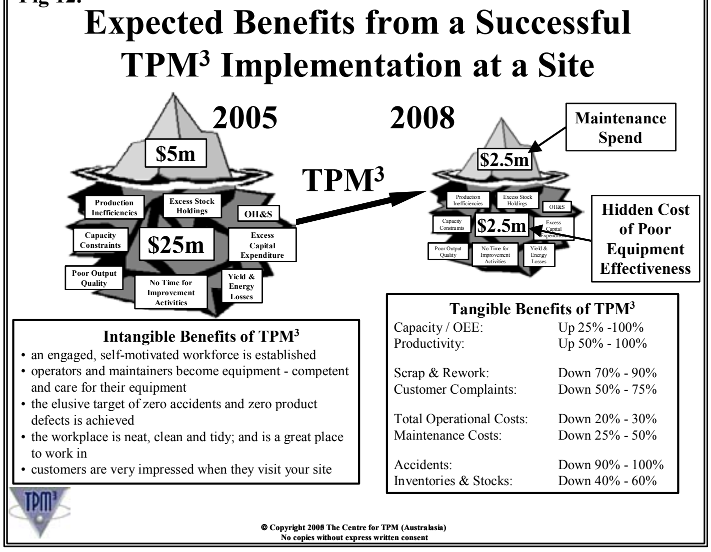
25% - 50% **Decrease in the Hidden Cost of Poor Equipment Effectiveness (Bottom of the Iceberg)**

25% - 50% **Safety Improvement**

plus **Significant Improvements in Quality to Customer, Delivery and Morale**

After some 3 years these improvements would cover the entire site and be significantly greater as highlighted in Figure 12, with positive impacts being experience by your customers, employees, and shareholders.

Fig 12.



Examples of Companies progressing their TPM^3 Journey

Automotive	ai Automotive (SA), Holden Engine Operations (VIC), ION Automotive (NSW)
Building Industry	Hynds Pipe Systems (NZ)
Food	Coopers Brewery (SA), Fonterra - Edgecumbe (NZ), Sanitarium (NSW), Simplot Australia (NSW, VIC, TAS)
Metal Processing	Pacmetal (NSW), Wundowie Foundry (WA)
Mining	Banpu Lampang Mine (Thailand), Zinifex Rosebery Mine (TAS)
Packaging	Cryovac Sealed Air (NZ)
Paper	SCA Hygiene - Australasia (NZ)
Pharmaceuticals	Alphapharm (QLD), CSL-Bioplasma (VIC)
Personal Hygiene	SCA Hygiene - Australasia (VIC, NZ)
Refinery / Smelter	Zinifex Port Pirie Smelter (SA)
Service	Simplot Australia Agricultural Services (TAS)
Timber	Blue Mountain Lumber (NZ), CHH Woodproducts (NZ), Juken New Zealand (NZ), Tenon (NZ)

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, productivity, quality, cost, and most importantly safety and 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, and regularly reviewed, by your site management team.

About The Centre for TPM (Australasia)

The Centre for TPM (Australasia) was created 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, established The Centre for TPM (Australasia) in January 1996 with its head office located in Wollongong (a major city some 80 kilometres south of Sydney on the NSW South Coast).

The Centre is a membership-based organisation established to develop, promote and advance the knowledge and practice of TPM^3 (an enhanced and expanded Australasian version of 3rd Generation TPM) throughout Australasia.

Our Quest is to support Australasian industry to achieve World Class Performance by providing the best value and most innovative training, navigation, research and networking in TPM^3

The Centre and its membership have grown rapidly. There are now over 35 sites covering some 12 industry groups from Manufacturing, Mining, Utilities and Service companies that are currently progressing their TPM^3 journey to World Class Performance. Over 10,000 employees are covered by CTPM membership and our research group has links with the University of Wollongong and the Australian National University.

The Centre is very mindful of the need for companies to establish their own in-house capabilities to lead, manage and facilitate their TPM^3 journey in order to achieved sustained success. However we also acknowledge that TPM^3 has been developed based on over 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 CTPM TPM^3 Instructor's / Leadership Program which was developed in Nov 97 and to date, some 17 courses later, has over 200 graduates from some 30 companies), however most of the learning comes from doing. There are very few short cuts to experience.

For this reason, The Centre for TPM (Australasia) has developed a proven flexible methodology for Australian and New Zealand companies 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 TPM^3 Excellence Awards, 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 throughout Australasia in Wollongong / Sydney, Adelaide, Melbourne, Launceston, and the Gold Coast in Australia, and Tauranga in New Zealand.

About the author: Ross Kennedy - President, The Centre for TPM (Australasia)

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 manufacturing and operational experience covering maintenance, production, operations and executive roles followed by 5 years of international consulting experience with the Manufacturing and Operations Group of Coopers & Lybrand's International Management Consulting Practice, where he first came across TPM in 1990 when he lead one of the first implementations of TPM in Australasia.

In August 1994 Ross established his own practice specialising in TPM. He organised and chaired Australasia's first TPM conference in 1995 and, as an outcome of that conference; Ross founded The Centre for TPM (Australasia) with several colleagues in January 1996.

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 Centre for TPM (Australasia) launched its TPM^3 methodology in January 1998, which is an enhanced and expanded Australasian version of 3rd Generation TPM focusing on the entire supply chain.

Ross has been actively involved with TPM and TPM^3 since 1990 and has delivered publicly over 200 papers and workshops on the subject both within Australia and overseas. The Centre for TPM (Australasia), under the direction of Ross and his team of experienced TPM^3 Navigators is presently assisting over 35 sites covering some 12 different industry types located both in Australia and New Zealand, on their TPM^3 journeys to World Class Performance.