

**Elevating Maintenance and Reliability Practices**  
**The Financial Business Case**  
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**Abstract**

In order to elevate maintenance and reliability practices, there not only needs to be a change in the approach to maintenance but there needs to be a some translation and language, strategy, and tactical adjustments, to communicate the tremendous business value associated with elevating maintenance and reliability practices to top executives in the company.

A big part of the reliability picture can be summed up with the phrase “More Predictive and Less Preventive”. Predictive Maintenance is driving a large percentage of work on a daily basis at the top performing plants and these plants have attacked the opportunity holistically – weaving all of the aspects of a top-level practice carefully together to unlock the hidden benefits.

Direct benefits from this approach will come from maintenance spend reduction, spare parts inventory reduction, reduced energy consumption, improved quality, reduced scrap and increased throughput/asset utilization. There is a correlation between success of any corporate improvement initiative and improved reliability practices. The indirect benefits come from unlocking hidden benefits in other parts of the business previously thought to be unrelated to reliability, and they can be substantial.

The financial business case for reliability is here, and the awareness in the executive suite is emerging.

**Introduction:**

This paper will attempt to put the technical and engineering aspects of maintenance and reliability into business terms – essentially into the context of a financial business case that is hopefully interesting and natural for the readers and for the most senior-level executives in industrial corporations world-wide. Hopefully, this paper will help you to make the translation and adjust your language, strategy and tactics to communicate to top executives and people not directly involved in maintenance, the tremendous business value associated with elevating maintenance and reliability practices in your company. In this paper, I will discuss:

- The current state of maintenance and reliability, the level of awareness among business executives of financial business performance that can be achieved with top level reliability practices, and “what good looks like” in the few successful companies which have reached top quartile performance and enjoyed significant benefits
- Performance yet to achieve - even by the top performers
- Statistics showing the potential benefits in United States industrial companies and how that might extrapolate out to companies world-wide

- What the business case might be at your corporation

### **Current State, Awareness & What Good Looks Like:**

As recently as five years ago, I think it is fair to say, there was very little awareness at the corporate executive suite level of the contribution to financial and business performance improvements that can come from improved levels of physical asset reliability. In addition, I think it is fair to say, five years ago we did not enjoy an accepted consensus among industry experts about what good maintenance and reliability practices look like. If we asked what are the characteristics exhibited by top performers who have increased operational performance of their physical assets - while reducing the overall cost of production (including reducing the cost of maintenance), we were likely to get varying answers depending on who was asked. In fact, as recently as five years ago, there were no true success stories in this arena. There were some spotty, incremental achievements, but no enterprise-wide success stories.

Today, although there are only a handful of companies that have, in fact, seriously elevated their maintenance and reliability practices, and improved business performance as a result, those few companies provide ample data that paints a very consistent picture of what good looks like and what results can be expected. Companies like Rohm and Haas, Allied Signal/Honeywell, Dofasco Steel, and, more recently, Cargill Corporation, among a few others, have made dramatic shifts in their physical asset management strategies that have driven significant financial results in many parts of their businesses. Several lessons should be taken from these success stories.

First, the characteristics exhibited by these “Early Adopters” are remarkably consistent regardless of the industry in which they operate. These characteristics generally but clearly show:

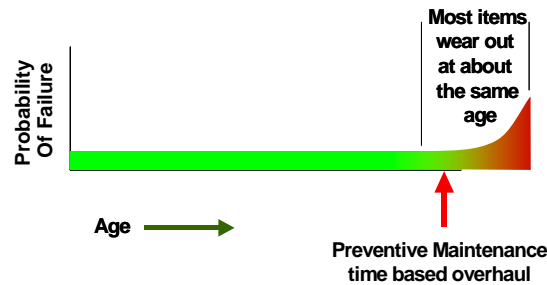
- Annual maintenance spend below 2-3% of Replacement Asset Value (RAV)
- Significant use of a variety of Predictive Maintenance (PdM) and condition monitoring technologies on the majority of the candidate equipment population
- LESS time-based, invasive preventive maintenance (PM) – less than 25% of the equipment population in a top performer is covered by time-based invasive PM

Of note in the top performers is the depth into the asset population to which these multiple PdM technologies are applied. For example,

- From 63% to 95% of rotating machines (depending on the industry) are included in a robust vibration analysis program – not just the critical equipment!
- 91% to 100% of electrical equipment is included in a robust thermography program (incidentally, 58% to 79% of mechanical equipment is also included in the thermography program at top performers, particularly smaller motors and gearboxes in packaging and similar operations)
- Lubrication analysis and contamination control practices are extensive and comprehensive

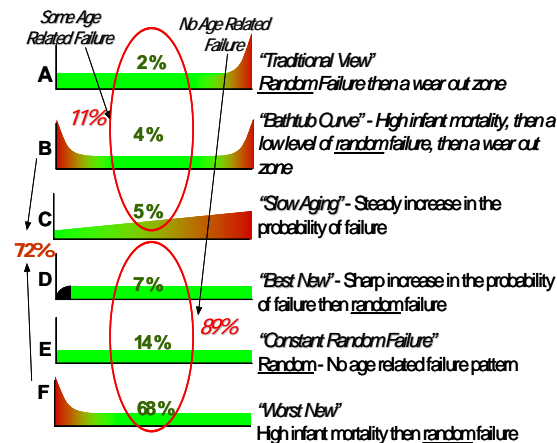
- Use of Motor Circuit/Current Evaluation (MCE) technology for drivers is extensive
- Extensive use of ultrasonics (airborne and contact) and various non-destructive testing (NDT) technologies for piping and pressurized assets is also present at top performers
- And again, only 20% to 25% of the equipment population in a top performing plant is covered by traditional, time-based, invasive PM

This last bullet is worth emphasizing a bit. After World War II, it was believed in general industry (despite knowledge to the contrary in the aerospace and airline industries and some branches of the United States military) that most equipment behaved in a time-based predictable pattern – that-is, that the probability of failure was relatively low and constant until a so-called “wear-out” zone was reached, at which time rapid and exponential increase in failure probability occurred. Traditional time-based Preventive Maintenance was designed to intervene into the equipment right before the wear-out zone was reached. See the diagram below taken from RCMII by



John Mobray:

In reality, a precious small percentage of equipment actually behaves in this fashion. In fact, as the following diagram below (again taken from RCMII by John Mobray) shows, there are many failure patterns of machinery behavior, and only about 11% of the equipment in a typical industrial plant has a time-based predictable “wear-out” zone:



Note the phenomenon of infant mortality, depicted above by the initial high probability of failure upon commissioning an asset into service. About 72% of equipment in a typical industrial plant (this of course varies by industry) experiences infant mortality, while, again, only about 11% has a time-based predictable wear-out pattern. By relying predominantly on PM as a maintenance strategy for most of our assets, we are potentially adding value on a small percentage of equipment, and potentially introducing infant mortality on a high percentage of our assets – unnecessarily – doing more harm than good. I remember coming out of engineering school in the mid-1970's and arriving at a nuclear power plant full of vigor with great ideas, and being confronted by a school of thought that held "if it ain't broke, don't fix it". At the time, I thought these folks were unaware of the science of machinery behavior. It turns out that I was the one that was uninformed. They knew intuitively and based on their experience that machine failure was very likely shortly after doing work on that machine. They may not have known the engineering behind the experience, but they were right.

We are not saying that we shouldn't do anything to our machines until they fail. We are saying that while most of our machines do not have the time-based predictable wear-out pattern, failure is predictable on a large percentage of our equipment using predictive maintenance and condition monitoring. Eliminating the unnecessary PMs and introducing PdM enhances our ability to proactively manage our assets to be more reliable, and reduces the cost of maintenance at the same time!

At the top performers, these PdM technologies are the primary work identification system. These PdM technologies are actually driving about 80% of the daily work. Again, the performance characteristics at top performers are remarkably similar regardless of industry. Here are some highlights of top-quartile work-flow:

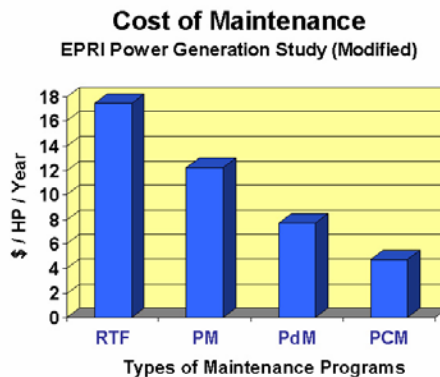
- Over 50% of the daily work order hours are related to the PdM program
  - 15% Collecting and Analyzing Condition Information
  - 35% Performing PdM "Results" Corrective Work (PdMr)
- About 30% of the daily work order hours are related to the PM program
  - 15% Collecting and Analyzing Condition/Operating Parameters
  - 15% Performing PM "Results" Corrective Work (PMr)
- Less than 20% of the daily work orders were initiated via a traditional work request from equipment operators

Keep in mind that the use of the PdM technologies objectively identifies corrective work based on real science and real data, and the early and objective identification of machine faults, if acted upon properly, should avoid catastrophic failure and collateral damage, meaning that the repairs that are made are typically less extensive, using less labor and less parts. This all drives costs down.

Traditional work identification based largely on the "five-senses" of the equipment operators provides inadequate time to effectively plan corrective work, which handicaps schedule compliance, which undermines the credibility of and trust in maintenance on the

part of the operators, and so on. The domino effect is clearly present here if the root cause of the problem – work identification - is not addressed. A top-quartile objective work identification system, based on comprehensive PdM, allows the Planners to plan the “PMr” and “PdMr” Corrective work orders. By virtue of early and objective machine fault identification, these work orders can be effectively planned because we have ample time. Once planned these work orders can be advanced to a ready-to-schedule status – feeding a more effective scheduling process. This in turn allows wrench-time of the maintenance workers to approach (and in some cases exceed) 50% (note that the average wrench-time in the United States industrial plant is about 28%). This also eventually will allow the equipment operators to trust the schedule and actually prepare the work-site and the equipment for the scheduled repair.

Of course there are many studies that prove planned work is significantly less expensive than unplanned work. In addition, a work mix more heavily weighted toward PdM will drive costs down, as the following chart summarizing one study shows:



In addition, a well-planned work order provides ample time for an experienced and skilled craftsperson to perform a precision repair that should result in more reliable operation once the machine is restored to service.

A second lesson learned from the top performers is that a holistic approach to changing practices, recognizing that the benefits cannot be unlocked by attacking individual components of the entire strategy, must be employed. If only the Maintenance people are involved in the process, it won't drive results. The entire organization must be involved to unlock the benefits. And, all aspects of the strategy must be addressed simultaneously. You cannot piecemeal your way to prosperity. For example, planning and scheduling cannot improve if we don't fix the work identification system. We can't identify work objectively and early (before collateral and catastrophic damage occurs) without extensive use of PdM and condition monitoring. “Results” work orders will never be slotted into the schedule unless the operators understand and trust the technology. This is just a small example of how every aspect of the strategy acts as a link in the chain. If any link is missing, or broken, the entire strength of the chain is compromised.

A third, and perhaps critical lesson we take from the success stories, is that the culture change required to accomplish success is recognized early as a significant impediment to success, and the top performers incorporated all kinds of tools and methods to address culture change, including awareness training, consistent measurement systems, alignment of performance to rewards, etc. In fact, the top performers believe that the most challenging part of their journey was the “softer side” of the problem. If we think in terms of people, process and technology (which many companies do today), not surprisingly it is the people aspect that is the most challenging. Despite our intuition that this is true, most companies fail to dedicate the proper amount of attention and resources to this aspect. Many companies complain that their CMMS system has not delivered the promised results, but the CMMS alone cannot deliver reliability. Concentrating primarily on the process and technology does not result in sustainable higher performance.

So the key catch phrases for top performers include:

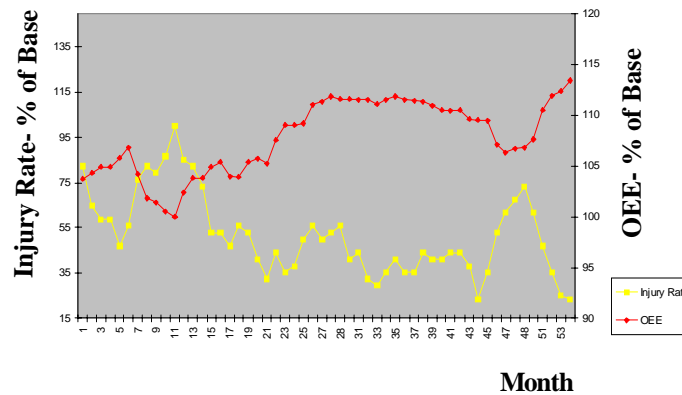
- More predictive and less preventive
- PdM used broadly and applied deeply into the asset base
- Objective and early work identification
- Planning & Scheduling the PM/PdM Results
- Integrated, holistic approach – you can’t piecemeal your way to prosperity
- Culture change is more than half the battle

### **Performance Yet to Achieve:**

Despite the success stories that should guide us with their consistent practices, even the successful companies that have achieved great results have done so in individual plants or business units. None of the case studies for success have demonstrated uniform elevation of these practices enterprise-wide, at every single plant. In addition, the success that is evident is still somewhat (if not highly) dependent on influential leaders without whom the performance is not sustainable. In other words, in some of these companies, the changes have yet to be institutionalized for sustainable performance and continuous improvement. This of course takes time, resources and perseverance, and it should be pointed out that some of the companies recognize this and are actively addressing it.

If we are looking for a parallel to guide us in institutionalized and sustainable change across the entire enterprise, we need look no further than the area of safety. Those of us who are old enough can remember a day when safety was a responsibility of a limited number of people in a department. Today, safety is knitted into the fabric of every industrial company, and it is everyone’s responsibility. It is part of the way we do business. Safe working practices are enabling other business performance improvements that would not be possible otherwise. It is worth referring here to the chart below showing the remarkably direct correlation that has been established between Injury Rate and Overall Equipment Effectiveness (OEE), presented some time ago by Ron Moore of The RM Group, Inc.

Figure 1A: Injury Rate v. OEE  
over Time - Company A



I have been preaching for quite a few years that reliability needs to become knitted into the fabric of our companies much like safety has. Why do I believe this? Every corporate improvement initiative, whether it is related to Lean Manufacturing, TPM, Six Sigma, Quality Circles, Supply Chain Optimization, Market Share Increase, Cost-of-Goods Reduction, Value-added Services, Increase in Sales, Asset Utilization Leverage – no matter what it is - it is my belief that success in these initiatives is either directly or indirectly enabled and enhanced by the reliability, stability and dependability of our physical assets. My contention is that there are incremental benefits related to all of these programs that are “locked” without addressing a fundamental foundational aspect of our business – namely rendering our physical assets reliable – and doing so efficiently. Could the injury rates at the companies that show direct correlation have gone down to those levels without reliable assets? I say no. With particular regard to Lean, we have seen or heard of cases where significant lean principals were applied in manufacturing plants only to uncover previously hidden reliability issues. With all of the flexibility and wasted movements removed from the plant, unreliable or unstable assets result in larger production penalties because there is no flexibility to adjust and react. So I argue that business performance can actually degrade if Lean is implemented in the absence of establishing a reliable and stable asset base. In any event, if this foundation is in place, I believe that incremental benefits for the corporation can be un-locked, and the performance of the company, in whatever part of the business the “C” suite is focused on, will improve.

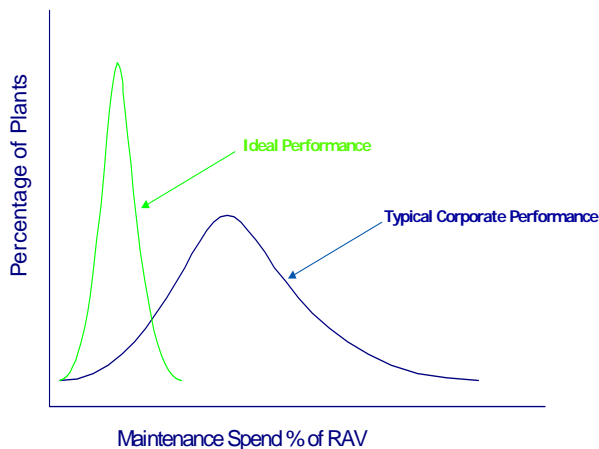
Gladly, the people in the executive suites of our industrial companies are beginning to understand this – partly because they have witnessed dramatic business performance improvements in the early adopter companies. The CEO of Chevron Corporation, Mr. Dave O’Reilly, said in a recent letter to employees “Reliability, like safety, is a critical element of operational excellence and requires our constant attention.” The Vice President of Operations at Anheuser Busch, Michael Harding, said in a recent public speech to the Society of Maintenance and Reliability Professionals, that “As goes Maintenance, so goes the business”. There are more examples of executives focusing on maintenance and reliability. If you want to develop a financial business case in your company, find out what initiative the CEO is concerned with, and I guarantee you that

reliable assets will materially contribute to the results of that initiative – either directly or indirectly. This environment of increased awareness and understanding bodes well for a significant elevation of maintenance and reliability business practices.

Nonetheless, some obvious impediments stand in the way of uniform, enterprise-wide performance, including:

- Lack of Executive Initiating Sponsorship
- Lack of Executive Sustaining Sponsorship
- Lack of Defined Standards
- Lack of Consistent Basis for Measurement
- No Ties Between Performance and Compensation
- Lack of Systems to Efficiently Leverage Work Done at One Plant to Other Plants

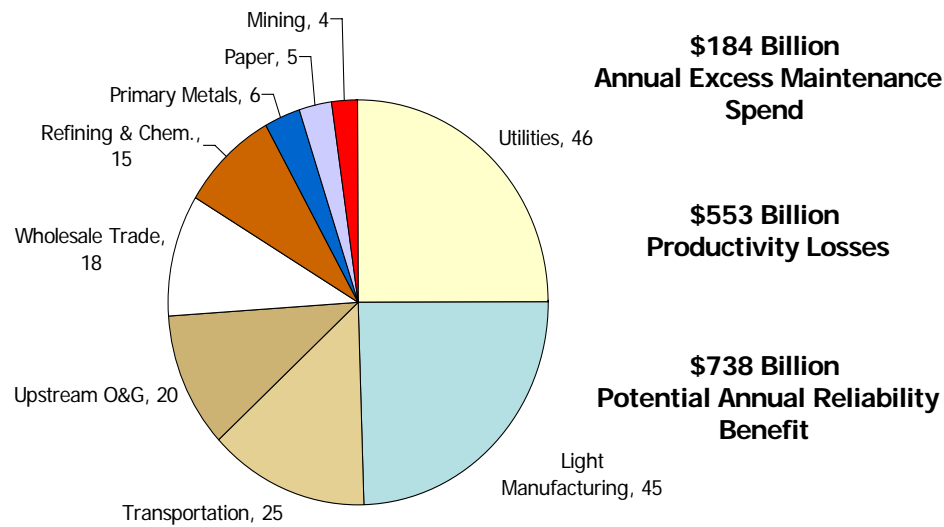
There are others as well but these are major ones. Perhaps a good way to express what we believe is necessary within a large corporation to elevate practices uniformly across the entire enterprise, is to use the chart below. This chart shows a wide variation of maintenance spend across a fleet of plants in a typical corporation (shown by the blue curve). The goal in our view is to reduce the variation in your corporation (shown by the green curve). This would mean that there is less variation in performance from plant to plant, and, presumably, the level of performance is elevated beyond what it could be by simply attacking the opportunity plant-by-plant.



It should be noted that we know of no company in existence today that has achieved uniform elevated levels of reliability performance across the entire enterprise – fleet-wide. Several companies are vying for the notoriety, but more importantly, the business performance that will come if this is achieved.

### **How Big Are The Benefits?**

Recently, we studied statistics from the United States Department of Commerce, including their measurement of what they call “Net Stock of Private Fixed Assets” in various industries. This measurement is a close proxy of Replacement Asset Value (RAV). In 2003 (the latest statistics available from the USDOC), there were \$4.9 Trillion



of physical assets on the ground in United States industry. We applied our Four Quartile Benchmark Statistics of Maintenance Spend as a percentage of RAV, and we dollarized the value of elevating Fourth Quartile plants to the First Quartile in maintenance spend, moving the Third Quartile plants to the First Quartile, and moving the Second Quartile plants to the First Quartile. As you can see from the following chart, industry wastes approximately \$183 Billion in excess maintenance spend annually in the United States alone!

**Calculated from Department of Commerce Current-Cost Net Stock of Private Fixed Assets in 2003 (Total \$4.9 Trillion)**

Further, we can assume from numerous published case studies that three to seven times the maintenance spend reduction benefit is accomplished in operational benefits (including increased uptime, improved quality, more efficient production scheduling, reduced waste, reduced energy consumption, reduced inventories, etc.). Taking the conservative end of that statistic (three times maintenance spend reductions), you can see from the chart that another \$553 Billion in “Productivity Losses” can be re-claimed through the maintenance and reliability improvements, making the financial business case in the United States alone \$738 Billion in annual, recurring benefits.

What is this number world-wide? Good question. We are currently trying to quantify that with good data, however our intuition is that, if the U.S. opportunity is conservatively estimated at  $\frac{3}{4}$  of a Trillion dollars, the world-wide annual benefits could be \$2 Trillion or more!

The following chart depicts the Reliability Adoption Life Cycle.

Assuming that 25% of plants have figured this all out (top quartile), the market is at the Early Adopter/Early Majority stage. 75% of plants have improvements to make and work to do. If we look for an example of a company that has uniformly elevated their practices fleet-wide, there are no examples, so we are still looking for the innovators. It should be pointed out though, that attacking the opportunity fleet-wide will ease the journey by reducing the level of effort necessary to implement the practices and make the

changes. Attacking this fleet-wide should leverage work done once for reuse avoiding the re-inventing of reliability over and over again. The resultant lower investment should make it easier to justify the expenditures for foundational and culture change work, enhance the Return on Investment and speed the Rate of Return.

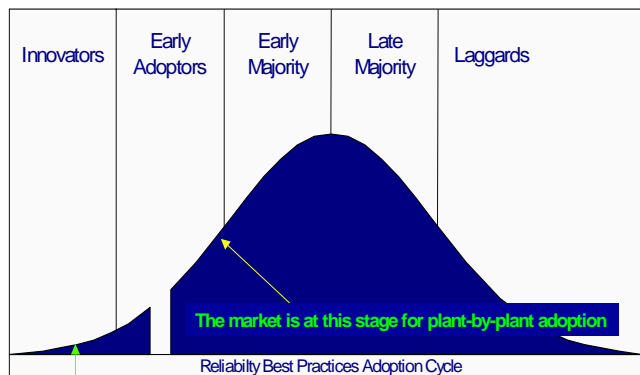
### What are the Benefits in Your Company?

Quantifying the potential benefits, as well as the likely costs to improve performance, in your corporation, is necessary. Here is some guidance.

**Benefits** - Here are some of the major benefit categories with some guidance on how to calculate the potential:

- Maintenance Spend Reduction:** Calculate your maintenance spend as a percentage of Replacement Asset Value (RAV), and dollarize the improvement to top quartile performance (approximately 2 – 4% of RAV or better). If you are currently spending 5 – 6% or more, this benefit could be significant. The benefit comes from eliminating unnecessary work, working more efficiently, reducing the need for abundant stocked spares, eliminating collateral damage thereby reducing use of spare parts, reducing use of contractors, reducing overtime.
- Inventory Reductions:** Calculate your stocked inventory value (include satellite spares, etc.) as a percent of RAV, and dollarize the improvement to top quartile performance (approximately 0.5% - 1.5% of RAV). The actual reduction will

Reliability represents a substantial ROI opportunity for 75% of plants in equipment intensive industries. Greatest ROI will come from a corporate wide approach.



yield on average \$0.20 cents on the dollar of reduction (some inventory will have to be scrapped). This is a one time benefit. In addition, the recurring annual avoided carrying costs will be on average 25% of the full inventory reduction value – annually.

- Energy Consumption Reduction:** Published guidelines show us that smoother running rotating equipment and leak-free operation of water, steam and

compressed gas handling equipment will consume from 3% to 14% less energy (electricity, fuel).

- **Increased Uptime:** Increased Asset Utilization can have a variety of substantial financial benefits to a company, including selling more product on the existing capital assets (assuming the demand for the additional product is present), or reducing the cost of goods made on the capital assets through more stable operations (even if the demand for additional product is not present). Two downtime areas should be targeted: Unscheduled Maintenance-related Downtime, and Scheduled Maintenance Downtime. Unscheduled Maintenance-related Downtime can eventually be almost eliminated. Scheduled Maintenance Downtime in a plant heavily dependent on time-based Preventive Maintenance strategies can be reduced by from 30% to as much as 60% (depending on the starting point). Dollarizing the value of this varies from business to business, however remember that these benefits can be as much as 3 to 7 times larger than the maintenance spend reduction!
- **Improved Quality:** Typically, scrap material and rejected/returned off-spec product is measured accurately in most corporations. Calculate the value of the scrap material and assume that between 5% and 16% of that value can be eliminated through sound reliability practices. In addition, calculate the value of the rejected/returned product and assume that between 1% and 5% of that value can be eliminated through sound reliability practices. These statistics will vary business to business.

**Costs** – Top performers begin with some form of gap analysis to understand the current state of relevant practices and to measure gaps that exist between current state and top performance. From that point, calculating costs to close gaps is objective and fairly accurate. Major investment categories typically include:

- Development of Corporate Standards for work management, materials management, configuration change management and reliability excellence
- Development of a Roll-out and Implementation Strategy taking advantage of work done at one plant as appropriate for other plants
- Creation or Improvement of Foundational Information (Functional Location Hierarchy, Master Equipment List, Spares Materials Catalog, Bills of Material/Parts Lists)
- Objective Criticality Ranking of Equipment
- Methodical Analysis of Failure Modes, using combination of Reliability Centered Maintenance Analysis (RCM), Failure Modes and Effects Analysis (FMEA), and templating where appropriate, to determine the optimum PM and PdM activities that need to be deployed for your population of equipment
- Based on methodical analysis, perform PM Optimization, eliminating unnecessary PMs, deploying recommended PdM, and creating the PM/PdM work orders in the CMMS system to automatically schedule these activities
- Creation of Balanced Metrics Measurement system

- Training and Awareness
- Culture Change and Rewards System Alignment
- Compliance Monitoring and Continuous Improvement

There is a lot of guidance that can be used to estimate the costs of closing gaps, but for purposes of this article, suffice to say that while these costs are not insignificant, in the context of the benefits and the financial business case, they are almost always easily justifiable, with typical Returns on Investment (ROI) from 8:1 to 16:1 and higher, and with Internal Rates of Return (IRR) from 50% to 250% or higher.

### **Summary:**

Well, in summary, what do we know and what do we believe?

We know what good looks like, and a big part of that picture can be summed up with the phrase “More Predictive and Less Preventive”. We know that Predictive Maintenance is driving a large percentage of work on a daily basis at the top performing plants, and this, of course, is good news. Our time has come!

We know that the top performers achieved their success using remarkably similar practices – regardless of their industry, so we shouldn’t spend a lot of time debating what good looks like.

We know that you can’t piecemeal your way to prosperity - the top performers attacked the opportunity holistically – weaving all of the aspects of a top-level practice carefully together to unlock the hidden benefits.

We know that even the top performers have been unable to uniformly elevate their maintenance and reliability practices across the entire enterprise, and we believe there are good business reasons for trying to do so, including reduced cost of implementation company-wide (vs. taking a plant-by-plant approach) and increased ROI.

We believe the size of the opportunity is \$¾ Trillion annually in the U.S. alone, and could exceed \$2 Trillion world-wide!

We know the direct benefits will come from maintenance spend reduction, spare parts inventory reduction, reduced energy consumption, improved quality, reduced scrap and increased throughput/asset utilization.

We believe there is a correlation between success of any corporate improvement initiative – whatever it is - and improved reliability practices. The indirect benefits come from unlocking hidden benefits in other parts of the business previously thought to be unrelated to reliability, and they can be substantial.

Finally, we know that the financial business case for reliability – including predictive maintenance - is here, and the awareness in your executive suite is emerging. If you are

involved in predictive maintenance, I urge you to be confident in what you are doing because the role you are playing is essential for your corporation to achieve success – and the executives in your company are figuring that out!

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#### Biography

In 1987, Mr. DiStefano co-founded Management Resources Group, Inc. As MRG's chairman he leads the company in formulating its strategic mission, strategic services delivery framework, and market dominance in translating maintenance and reliability engineering tactics into tangible and compelling strategic financial benefits. He has degrees in Engineering Technologies, Mechanical Engineering and Engineering Management.