Reliability Center, Inc.
www.Reliability.com
804-458-0645
info@reliability.com

Enhance the Ability to Perform Root Cause Analysis With Reliability Physics

Mark A. Latino, President, RCI

Over the years Root Cause Analysis (RCA) has become a word that is now associated with many types of problems. At one time the National Transportation & Safety Board (NTSB) was unique in its use referencing the conclusion of an airline crash investigation as the root cause analysis of the mishap. Today the word Root Cause is heard on the news more often and associated with all kinds of events. Events can range from the Root Cause of 9/11 to the Root Cause of a factory explosion.

The words Root Cause mean many things to many people. It is so diverse people use it without fully understanding its meaning. Because of this, the word Root Cause is thrown out at times when people are looking for answers. Most people don't understand what it takes to get those answers. This article will help give a deeper understanding of what Root Cause Analysis is and what it takes to get to the root causes of an event.

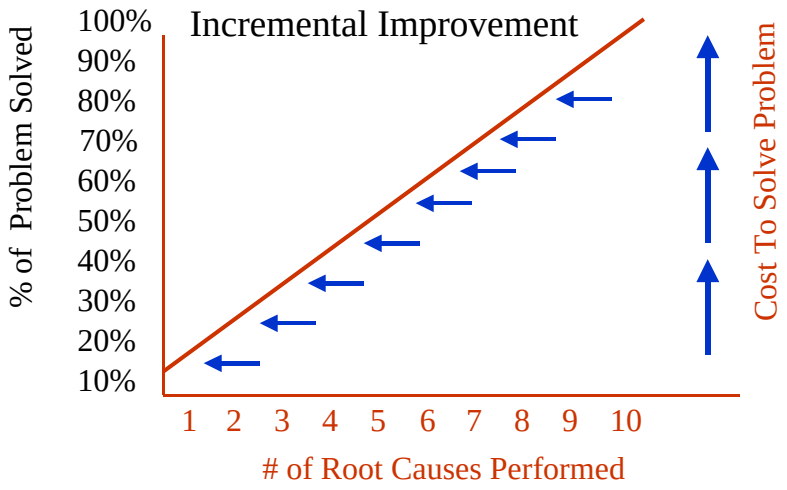
Root Cause Analysis is analyzing undesirable events down to their Latent Root Causes, which are the deficiencies in management systems and restraining cultural norms that allowed the failure to occur.

Seldom is the time or effort taken to drive an RCA past the physical condition of the event into the human intervention (decision making process) and the system/systems that are supposed to drive the human behavior to correct actions. There is a quantum difference in the returns to a company when the extra effort to understand the total failure mechanism is taken.

The power of RCA is in its leverage. To eliminate a failure that is currently under investigation in a "one at a time" fashion should be a secondary objective of RCA. When RCA investigations drive down into the Latent System Roots of an event or problem, companies will discover the Latent System Roots are common to failures both past and future. These are in equipment and systems that are entirely different or even in another facility. They may share nothing in common with the current failure being analyzed except the Latent System Roots.
When latent Root causes are discovered, their correction justified and their elimination finalized, the facilities will have been raised to an unprecedented high reliability. This quantum level of reliability could never be reached by only the secondary objective of solving one failure at a time.

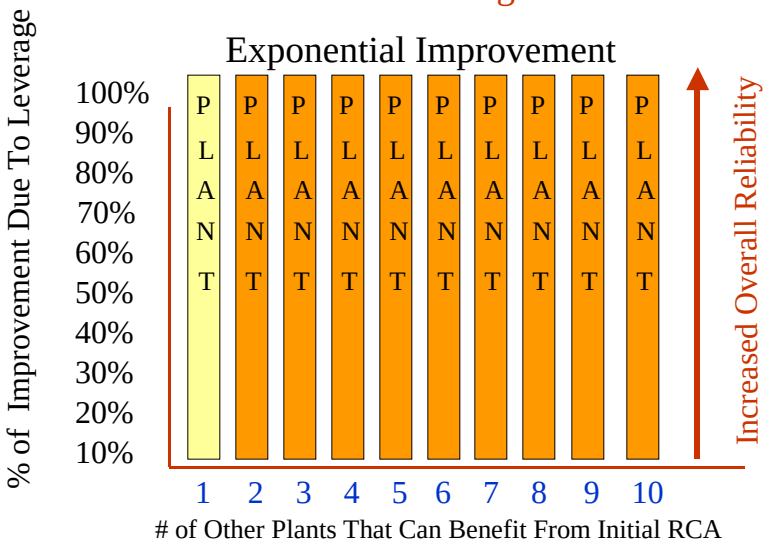
Leveraged Root Cause Analysis

Strait Line RCA - Not Leveraged



Leveraged Root Cause Analysis

Out Of The Box RCA - Leveraged



Using the definition above in a perfect world would reward the RCA investigator as being some kind of problem solving genius. The reality is this is very difficult to do because there are so many agendas in play at the same time. The RCA investigator must be equipped with all the tools necessary to solve problems nearly single handedly. This goes against what most root cause methodologies teach. However, if the event is not a significant loss and in the eye of the stakeholders, the problem becomes a low priority and the resources to solve the problem are not made readily available for some investigators.

The RCA investigator must have a solid understanding of how systems work to understand how systems fail. Having a basic understanding of the reliability physics of mechanical, electrical, and human failure can equip the investigator with enough knowledge to solve eighty percent of the events they investigate.

Mechanical failure surfaces can tell the investigator particular information about what was physically happening to the component at the time of the failure. This is valuable information for the investigator. It is important to get to the physical cause of a failure as fast as possible. This is usually not difficult because the reliability physics of material is strait forward in the majority of investigations. An example of this would be a shaft that failed in torsion overload such as the one shown in *figure 1*.

The forty five degree angle of the break indicates the shaft was in torsion at the time of failure, the surface corrosion indicates the shaft's material fatigue strength was weakened, and the chevron marks or river marks on the fractured surface indicate the material was overloaded. This information allows the investigator to rule out fatigue and erosion and focus the failure scenarios that would explain how the shaft came to be corroded and shaft material strength overloaded.

Figure 1

The RCA investigator can also benefit from a solid understanding of electrical failure modes in such equipment as breakers, relays, batteries, transformers, etc. If a relay fails and there is a signal loss that could have been due to high resistance the investigator would look for things that would cause high resistance such as a connection failure, sulfur or chloride contamination, insulation breakdown, thermal cycle fatigue and or mechanical fatigue failure of connections. Understanding the clues gives the investigator a great step forward in solving the problem.

I have spoken of the physical failure, which is the first and easiest understanding of any failure. Materials, in most cases fail in a familiar manner that can be explained using the properties of

materials, service environment, and the conditions such as motion and flow that the material was performing. This is needed, but it is the lesser concern because it has already happened and the components will be replaced and the equipment will quickly be restored to service. What should be the concern at this point is how the material or components came to be in the failed condition. This is more difficult to uncover because the human is now introduced into the failure mechanism. The human element has remained a constant over time. The human when asked to expose what they may have done wrong to contribute to a failure situation will almost always skirt around the true chain of events to make it unclear as to their contribution if any. I have often found the concern of being implicated is high enough that people will not give up information just in case it might look like they have had involvement in the event.

It is extremely important for the root cause investigator to understand human error and how it manifests itself in the work environment. I am going to talk about this to some extent because it is the corridor to the true root causes of events.

The place to start when dealing with human error is with the supervision of the work force. Good supervision makes all the difference in reducing the human error rate. A good supervisor motivates the employees through leadership. This means the supervisor has informed the employees of the expectations and has taken an active role in enforcing those expectations though a means that gets the point across in a non-threatening manner. This is accomplished through a consistent style of addressing expectation problems immediately and not waiting until it has become a bad habit (habits are hard to change). The other part of this is to constantly reinforce the expectations until those expectations are a part of the work culture. Good supervision is the number one approach for reducing human error. There are nine other skills a supervisor should strive to master.

1. Accountability
2. Field Surveillance
3. Review & Verification
4. Pre-job Briefing
5. Complacency Mitigation
6. Problem Solving
7. Command & Control
8. Communication & Coordination
9. Crew Turnover

This is the framework that begins the process of reducing human error.

Other things that affect the human error rate are considered to be human error traps such as time pressure to perform work. This is the top reason that human error occurs. Employees generally want to do a good job and deliver for their supervision. Often in our work culture there are perceptions that are reinforced by actions that production is paramount over all other management concerns. This manifests itself through the supervisor asking are we ready to start

up? Or how much longer will it take? This type of pressure real or perceived causes employees to cut corners or to miss steps in a sequence that cause secondary events to occur such as injury, delayed start –ups, and maintenance mishaps.

Now let's combine a distractive environment with the pressure to get done on time or to start up on time. A distractive environment is defined as some type of interruption every 5 to 15 minutes. This would include the management asking is it ready yet to field personnel, asking questions about job sequences or job routines. This manifests itself in cultures where the employees are micromanaged or when practice and rehearsal job training are not routine. This culture is one where there is poor supervision and the workforces are not confident enough to make decisions on their own. There are of course other things that may come into play as contributors but if you encounter this type of manifestation you can count on the higher rate of human errors. The added distraction with pressure can increase the possibility of human error to as high as a 31% chance.

Other things that contribute are:

1. High Workload
2. First Time Evolution
3. First Working Day After Days Off
4. One-Half Hour After Wake-Up or Meal
5. Vague or Incorrect Guidance
6. Over-Confidence
7. Imprecise Communication
8. Work Stress

If the root cause investigator understands human error and how it affects the work, they can make recommendations that will minimize the human error rate. This is usually learned during a root cause investigation but it can become a proactive tool in reducing the need for performing root cause in the future.

Common latent root causes that are discovered are procedural problems, training issues, culture issues, design issues, supervision issues, accountability issues, proper tool issues etc. When the root cause investigator drives into the latent roots of a problem, quantum benefits can be gained by the company as I expressed at the beginning of this article. Leveraging what is learned from the investigation back into the company is the most important part of the root cause investigator's job.

At this point cost becomes a large factor as to how much the management is willing to invest toward the correction of the root causes identified. As an example let's say an identified root cause is a procedure that is inadequate for the job. There were steps missing and if the steps were added and followed the event would have been avoided. The management will now have to make some decisions, add the missing steps, revamp the entire procedure, train the personnel

involved on how to properly perform the particular job task, discipline the individual or some combination of these items. PITFALL.

From a cost standpoint it is cheaper to add a few steps and take discipline against the individual. This covers the management as far as compliance goes but it does not solve the problem. Adding procedure steps doesn't guarantee compliance and discipline for honest mistakes doesn't work for attaining long term compliance. It may have been the procedure wasn't just missing steps, it was also too difficult to follow and now as a quick fix we add more steps to make it more complicated. If this is the case, the root cause investigation has not uncovered all the root causes and management's decision to only add steps has allowed the failure mechanism to stay in place. Usually there would be a procedure review to look for human error traps and rewrite the procedure without the traps. Then do some training on the proper execution of the procedure. Taking the cheap way out removes the ability for leveraged quantum benefits and leaves you with incremental improvement at best.

To conclude, you as root cause investigators have a responsibility to get to the true root causes and to have the training and tools to allow you to accomplish this task. The management has the responsibility to review the root causes, implement recommendations that will remove the failure mechanism and leverage the learned knowledge back into the organization.

Mark Latino is President of Reliability Center, Inc. (RCI). Mr. Latino came to RCI after 19 years in corporate America. During those years a wealth of reliability, maintenance, and manufacturing experience was acquired. He worked for Weyerhaeuser Corporation in a production role during the early stages of his career. He was an active part of Allied Chemical Corporations (now Honeywell) Reliability Strive for Excellence initiative that was started in the 70s to define, understand, document, and live the reliability culture until he left in 1986. Mr. Latino spent 10 years with Philip Morris primarily in a production capacity that later ended in a reliability engineering role. He is a graduate of Old Dominion University and holds a BS Degree in Business Management that focused on Production & Operations Management. Contact information: 804-458-0645, mlatino@reliability.com.