Root Cause Analysis - Learning from Past Failures

“Those who cannot remember the past are doomed to repeat it” – George Santayana (1863)

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Abstract
“Learning” can be defined as the acquisition of knowledge or skill through experience, study or by being taught. This blog series addresses a decades old debate regarding the value of leveraging pre-existing hypothetical failure causes in Root Cause Analysis. In essence “learning” from previous failures. Does the re-use of such pre-existing information and knowledge help or hinder the analytical process? Could this information expand the critical thinking of the team/analyst or would it lead the team/analyst away from other conclusions that are outside the base of pre-existing knowledge?

Introduction
“I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if were a nail.” – Abraham Maslow (The Psychology of Science)
Anecdotally Maslow was trying to convey that solutions to problems will often resemble previous solutions to previous or similar problems because of an innate over-reliance on the familiar. In many cases “critical thinking” or “thinking outside the box” only occurs after all of the familiar solutions have either been disproven or just don’t fit.

Background
Root Cause Analysis as a tool or methodology really gained widespread use in the 1960’s - 1980’s. The methodology of diagrammatically linking hypothetical causes to actual failures was first popularized in Japan by people such as Kaoru Ishikawa, who pioneered the use of Fishbone or Herringbone diagrams such as the one shown below as a problem solving tool or method.

This problem solving method was later enhanced with the Kaizen concept “change for the better” and “continuous improvement”, which eventually led to what is known today as TPM (total productive maintenance). One of the main objectives of TPM is to increase the productivity of a production facility with a modest investment in maintenance. As such RCA (root cause analysis) is seen as a fundamental element of any Asset Performance Management program or initiative.

It should be understood that undesirable outcomes are the result of multiple cause and effect relationships that line up over time. Irrespective of the RCA tool that is used to represent these
relationships (e.g. logic tree, fault tree, causal factors tree, fishbone, etc...) we can nonetheless agree that these relationships must exist for the undesirable outcome to materialize.

Expanding upon the cause and effect relationships let us begin with the concept that “flawed systems” oftentimes adversely impact human decision making. These systems are the information systems that we use to help us make better decisions. Such systems include but are not limited to our training systems, purchasing practices, procedures, policies etc...In the following example the operator in a particular area may have decided to use too much lubricant which resulted in a premature bearing failure on a pump. The basis of the decision to over-lubricate is that the operator who was tasked with pump lubrication was insufficiently trained in proper lubrication practices. The over-lubrication decision was further impacted by recent maintenance reductions that shifted lubrication responsibility from the maintenance department to the operations department. Diagrammatically examining this failure clearly shows the cause and effect relationships and how they are impacted by the “systems” that feed our decision making process.

It does not matter how the RCA approach used labels causes (e.g. approximate causes, near root causes, contributing causes etc...) as long as they represent the cause-and-effect relationships in manner similar to what is represented above.

Learning in the context of RCA
So what is the role of pre-existing failure cause information in RCA and how can we “learn” from it? The greatest learning that will come from any successful RCA effort will be the learning that takes place during team meetings. By continually asking “how” something could have happened we must explore in our own minds how it could have occurred from a cause and effect standpoint. From the bearing failure example above your responses to “how” the bearing could have failed would likely include;

1. Misalignment
2. Improper installation
3. Wrong bearing
4. Defective bearing
5. Over lubricated
6. Under lubricated
7. Wrong lubricant

When dealing with RCA people are taught to view the vertical cause and effect tree as a timeline. If we know that the bearing failed we can mentally visualize the cause and effect by moving backward and forward along the timeline to hypothesize as to what could have happened that would cause the bearing to fail. Hypothesizing in this manner we can see that there are really only four (4) plausible ways in which the bearing could have failed.

Any of the other possibilities listed above would eventually cause one or more of the failure modes shown in the diagram above. If it was proven that “fatigue” was the failure mode in this case and there was no evidence of additional failure modes, we would mark those failure modes as “not true” and continue following the fatigue path down the tree. The next natural question would then be “How could the bearing fatigue have occurred?” And the questioning goes on the same.

As this knowledge is being extracted from the team members, we are actually constructing a knowledge or experience tree. This is often referred to as “corporate memory”. The team members are learning because their minds are being exercised as to which hypothesis is the cause and which is the effect. It is not always as simple as we would like it to be but having to think through it is definitely the greatest learning opportunity. In the end, when the analysis is complete and recommendations have been implemented, we should be able to measure the effectiveness of an analysis by its impact on the bottom-line.

**Corporate Memory**

Many of you will remember the “re-engineering” era of the late 80’s and early 90’s was popularized by the book series “Re-engineering the Corporation” by Mike Hammer. Unfortunately re-engineering became associated with census reduction and efficiency measures. This certainly was the era of the golden handshake where people were incentivized to accept early retirement packages so that the census could be reduced. This seems logical in concept but was very poorly applied in application. Corporations started to indiscriminately offer these retirement packages hoping that a certain number of people would take them. One Fortune 100 company estimated that 6,000 people would take the
package and 12,000 actually did! This created a “cottages industry” of consultants that were really retirees which came back to their former employers as contractors. Oftentimes those the new retirees were hired back at greater rates.

Who tended to take these early retirement packages? Those that knew they could get a healthy severance and another job quickly……in other words those with the most experience! When you have a mass exodus of talent in a corporation what danger does that pose? The danger posed is the loss of “corporate memory”. The knowledge and experience of the best problem solvers just left the corporation and took their internal laptops (their brains) with them. Therefore all of those people that knew how to solve the specific problems of their workplace are gone and the problems are now the responsibility of those left behind. This scenario was and is real today and represents a significant safety risk to the corporation and also millions of dollars in potential production losses and unnecessary costs.

How can we combat against this real world scenario? We can do so by capturing the successful logic of expert problem solvers using the RCA methodologies and tools described earlier. This is rarely done and when it is attempted, the manner in which the logic is collected is inconsistent with the methodology and tools being applied.

Reliability Center, Inc. (RCI) has been developing such logic over the years. The end result is a series of successful logic trees which we will now call PROACT® Logic Tree Knowledge Management Templates. These hundreds of templates have been developed using the logic of expert analysis in the field. They represent the actual logic used to solve equipment, process and human related failures over the past few decades.

Imagine being in an RCA team meeting and getting stuck on a hypothesis where you have exhausted the team’s experience and seek to see what others might have suggested when they faced the exact situation in a prior analysis. Imagine doing this real-time and using key words to call upon the logic used by others at that point in the logic tree. Think of the efficiencies that this brings to the table to expedite the analysis while actually making it more comprehensive and accurate.

Potential Pitfalls
As stated earlier, the greatest learning that can occur from RCA is from the questioning process that goes on during a team meeting. The constant striving or effort to understand the order in which factors occur, cause-and-effect, is the critical learning point in the analysis. Templates, when not properly used, can reduce the effectiveness of this learning opportunity.

The key to optimizing the value of the templates is to use them as supplemental knowledge to that of the team members. If the templates are used as the primary knowledge to the analysis, then there is a potential for the learning process to be expensed. This is akin to “performing RCA like paint-by-the-numbers”. This is when the templates are used as a pick list of options and the intent is to finish “a” logic tree quickly that on the surface will impress the people it is presented to. It does not mean it is right, it just looks good.

It is human nature to seek shortcuts or time savings when performing a task. This is especially true when we are under pressure or time constraints. In RCA, those shortcuts come in the form of qualification, verification and validation of our hypotheses. If our goal is to complete an analysis quickly, we will rush to construct a logic tree and chances are, not properly prove that our hypotheses are correct using satisfactory verification methods. When faced with either having a metallurgist look at a failed part or taking the opinion of a mechanic who has not been trained in metallurgy, when under
stress we may opt to go with the path of least resistance and take hearsay over science. In the end, the responsibility of doing what is right falls on the lead analysts and their teams.

Templates are no panacea, they should be treated as supplemental knowledge. When using templates we should be cognizant that the template content cannot include all possible hypotheses for a particular failure mode, instead they are a collection of knowledge that can be used to enhance the corporate knowledge and experience base.  

We should continue to press the boundaries of our corporate knowledge and experience by looking at unique possibilities that could have occurred, learning from those experiences and enhancing the template content that is available.

Applying this type of rationale in an “enterprise” application where multiple business units exist beneath a single corporate entity will drive sharing and consistency, by “pooling” the corporate knowledge and expertise of the analysts at various sites and business units within the organization.

Template Types
Templates typically take on one of two forms. They are either “Explanatory” based on actual events (case studies) and seek to explain what happened in a given failure. Or they are “Exploratory” in nature and focus not only on what happened, but also on all of the hypotheses that were explored and were ultimately proven or disproven. This is essentially the difference in answering the question “Why?” vs “How Could?” When asking “How Could?” something have occurred, this forces the RCA team to consider all of the possibilities instead of only the obvious. The advantage is that something that was found “not true” on a previous analysis may prove to “be true” in the current analysis. Therefore we are exploring all possibilities instead of viewing only limited ones.

There is a key hand-off in an RCA where we move from the physical world to human aspects of the failure. These are the decision points that were made that led up to the physical failure. Understanding and addressing the reasons behind a physical failure does not address the “flawed systems” that provided the information that was used to make the decisions that led to the failure. These are known as “Human Causes”. Underlying the human causes are the “Latent Causes” which are the reasoning for the decisions. Thus any corrective action that seeks to prevent repeat type of physical failures will also seek to remedy or address the underlying “human” and “latent” causes as well.

This is the area where some RCA methodologies fall short because they fail to consider the human and latent causes that led up the failure. If we consider that at its roots every asset problem is in essence a “people problem” we can see that ignoring or skipping over the human and latent causes of the failure will only remedy the symptoms but will do nothing for the real causes. Assets can fail for a variety of reasons but these often fall into familiar “human” causes categories, such as;

- Improper Operation
- Improper Maintenance
- Incorrect Application

Thus if we have encountered a failure which is symptomatic of “infant mortality” it would be helpful to learn about other failures where “incorrect application” was noted as the one of the hypothetical causes to see not only how those causes were either proven or disproven but also additional causes associated with those incorrect application failures.

Template use can be regarded or visualized as “puzzle pieces” floating in space where the analyst is able to find similar causes through key word searches that will yield responses in the form of complete
cause/event “logic strings”. From the template example below we can determine possible and also plausible causes for failure of an AC Motor. In order to effectively utilize the template content the user can search by Category, Name, Topic, and Details or any combination thereof. Once the logic string has been selected the hypothetical causes of the failure will be added to the logic tree that is currently being built and analyzed thus enriching the degree of rigor being applied to the problem that is being analyzed.

**Conclusion**

The PROACT® Logic Tree Knowledge Management Templates can help you optimize RCA investigations by providing expert knowledge and experience that allows you to maximize the efficiency of your RCA process. The Templates represent a powerful tool in your RCA arsenal. When used properly they will take your RCA efforts to the next level!