Root Cause Analysis as a Problem Solving Tool for Leaders and Managers: Application to Environmental Measurement Systems

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Summary

Root cause analysis is a key tool for use in resolving concerns with measurement systems and may or may not be applied correctly in response to audit findings. One methodology, "cause-and-effect diagrams," may also be applied by leaders and managers as a basic problem solving tool. This technical paper lays the basis for cause-and-effect root cause analysis and demonstrates how it may be used to solve problems at various steps in the lifecycle for the development of environmental measurements. The environmental measurement lifecycle include both field and laboratory activities such as: planning, sample collection, sample handling, laboratory operations, and post-laboratory information and data handling. A novel example of the Titanic Sinking is followed by a practical approach for measurements.

Keywords

Root cause, corrective action, preventative action, cause and effect, continuous improvement, validation

Introduction

In response to internal and external audits and assessments, there is often a rush to identify the cause and begin rapid implementation of corrective actions. When used in this manner, a true root cause analysis is not frequently conducted. The reviewer simply claims that the identified cause is the root cause without exploring the underlying actions that causes the nonconformance. Taking the time to understand the cause-and-effect relationship is an important skill for quality managers. Managers also should consider the use of cause-and-effect diagram to diagnose and correct any problem in an organization. Root cause analysis is not just for the technical operations; it should be clearly identified as a problem solving tool across the entire organization.

This technical paper presents the basics of the cause-and-effect analysis as a tool for root cause analysis. There are other useful approaches that can be explored by quality managers and general managers. In particular, the "Fishbone Diagram" approach may be useful for environmental system managers. Another approach is known as the "5 Whys" approach and this should also be considered to get a handle on a root cause, although this method tends to be more subjective.

The following provides an overview of cause-and-effect. Also examined is the basic life cycle for environmental management systems and the basics of environmental measurement. A classic model of the sinking of the Titanic was selected to illustrate the use of cause-and-effect to conduct root cause analysis. A great deal of analysis has been conducted of this event. That is followed by an example in an environmental management system framework.

Overview of Cause-and-Effect

The cause-and-effect process is documented as a tool for analysis in the form of a "cause-and-effect" diagram. The cause is placed in a box on the right side of the diagram and the effect is placed in a box on the left side of the diagram. Therefore, time always moves from right to left. Determining which specific causes and effects to place in the diagram is dependent upon the questions that are asked. Typically the questions are based on some observed deficiency. For example if tire went flat on your car, then the question might be, "Why did the tire go flat?" The flat tire is the effect and you must identify a cause. Maybe the tire ran over a nail.

Continuing on, the effect, flat tire, becomes the cause for some other effect. That is also determined by asking a question. What is the impact of the flat tire? You were late for a meeting. That then becomes the effect. After spending some time with these examples, managers may want to consider applying this technique to some basic challenges in many different areas, essentially anywhere there is a problem. Some examples follow:

- Why doesn’t the team work well together?

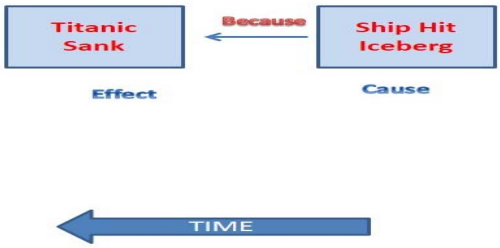
- Why don't we have better work relationships with our clients?
- Why aren't all our business processes documented?

It can be quite surprising to discover how useful it is to take a little extra time to use a formal problem-solving approach.

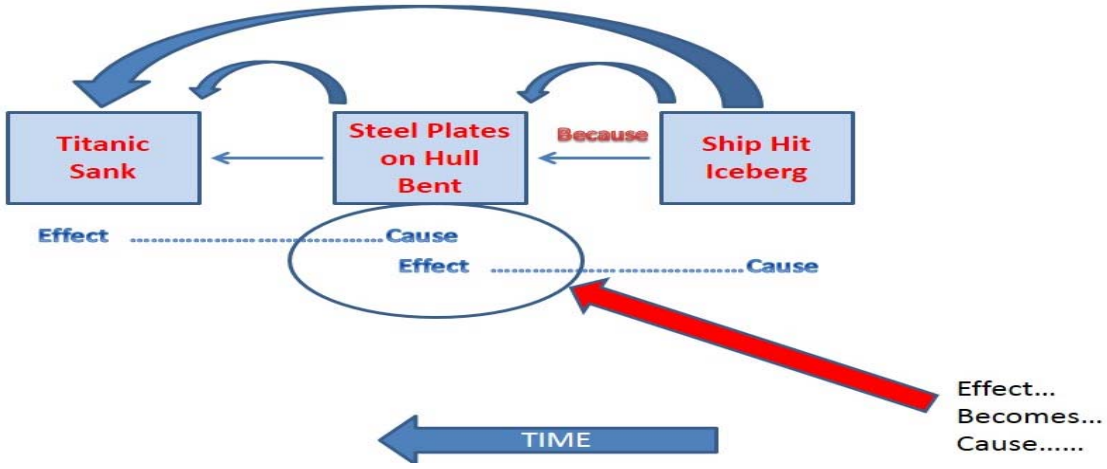
Cause-and-Effect for the Titanic

The sinking of the Titanic is a commonly used model to demonstrate root cause analysis using cause and effect diagrams. The cause is typically on the right side and the effect on the left; this approach also means that times move from right to left.

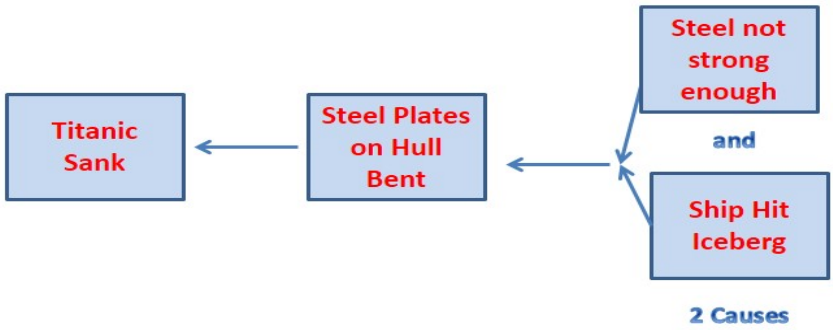
The analysis starts with a simple question: **WHY DID THE TITANIC SINK?**



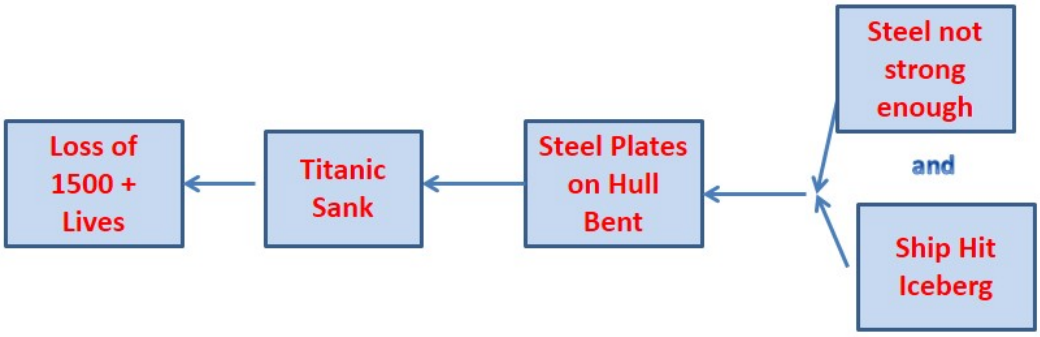
The most obvious answer, of course is that the ship hit an iceberg. The analysis continues. Yes, it hit the iceberg, but then why did it sink? One reason is that the steel plates in the hull bent or collapsed allowing water to enter the hull. The cause leads to the effect, and then that effect becomes the cause for the next effect.



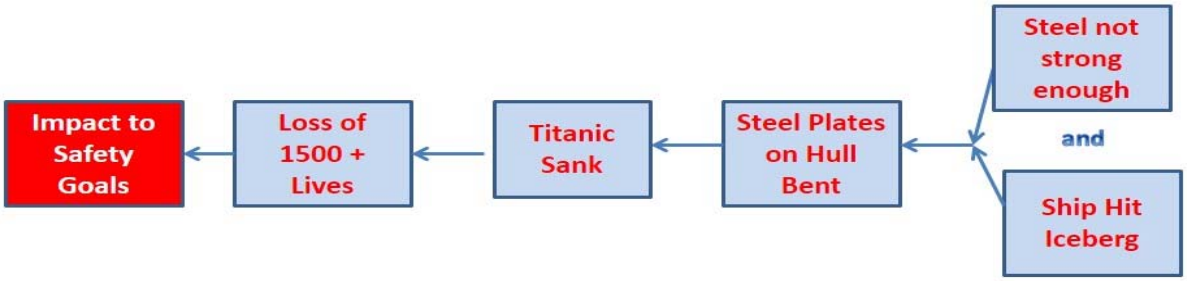
Another question comes to mind, "Why did the steel bend or fracture?" One answer it that it was not strong enough. Now we have expanded into two cause for a single effect, the bending of the steel.



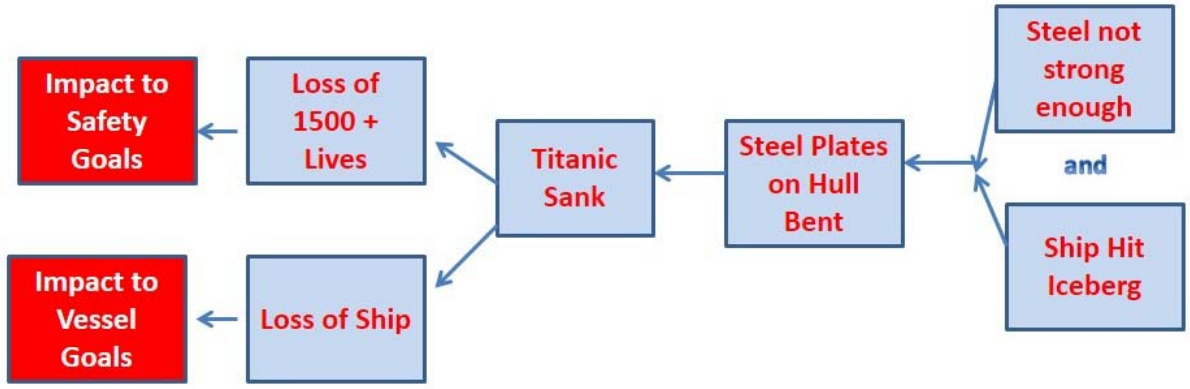
Focusing on the other end of our cause and effect diagram, is the real concern here about the sinking, or is it more important to look at the outcome which was the loss of life. This is then added as an effect.



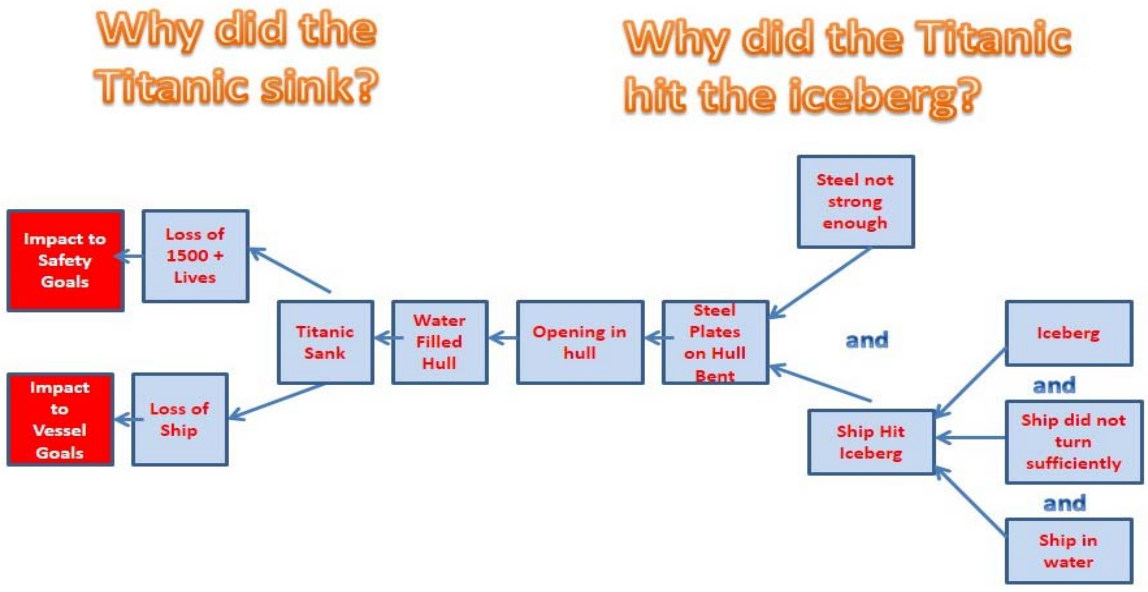
Adding another perspective which takes into account the overall planning aspects of the company, it becomes obvious their safety goals were not met.



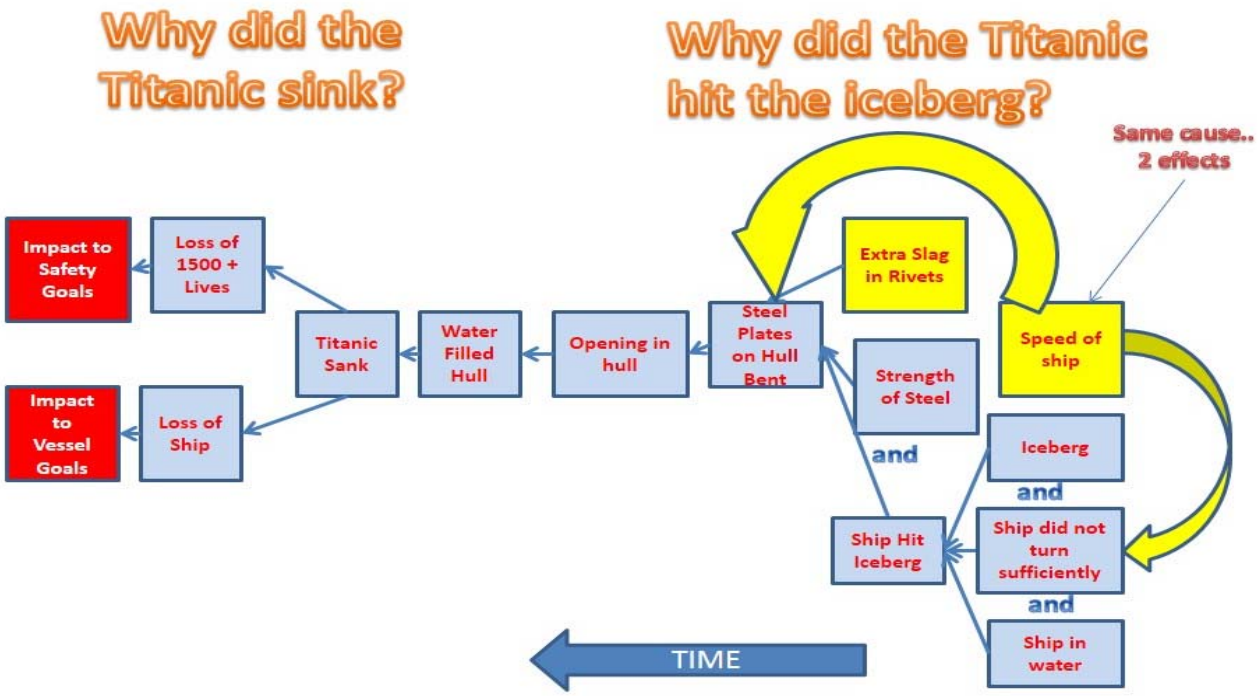
Further examination of the goals reveals the loss of the ship and impact to the vessel goals as well.



Another key question to ask is "Why did the Titanic hit the iceberg?"



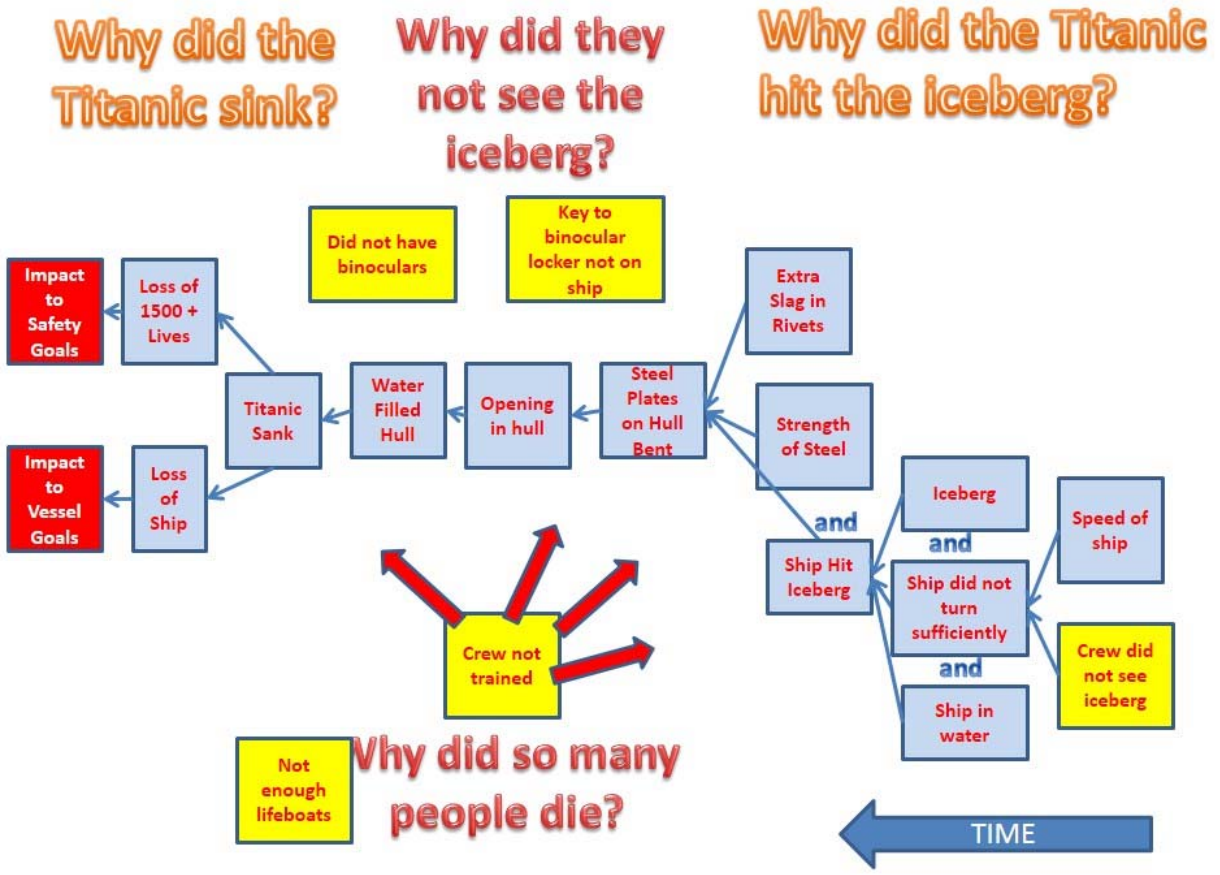
Namely, why did the ship not turn? Maybe it was the speed of the ship. Maybe the ship was going too fast. What is interesting about this proposed cause is that the speed can affect not only turning ability, but also how much the steel might bend. Also, a key area that some quality experts have focused on is that there may have been inferior rivets or inferior steel. Even today, this is a key focus area in construction where there are concerns about "counterfeit parts."



A final analysis step for the scope of this technical paper is shown in the next diagram. Why didn't they see the iceberg? Why did so many people die?

There has been lots of discussion about these topics in the literature. Maybe the speed of the vessel has a third effect, not sufficient time to provide warning of an iceberg. Maybe they did not have the binoculars and other equipment needed to spot the iceberg. Why did the crew not completely fill the lifeboats? Why were there so many problems loading the lifeboats? Did the staff have adequate training?

And maybe a last point, why was the ship going so fast? Was the Titanic trying to beat the record? Was it going too fast for the conditions? The analysis can continue.



It is interesting to note that training can crop up as a cause at many levels. The crew may not have been sufficiently trained to: react in a real disaster, fill life boats, observe icebergs, etc.

Corrective actions

The ultimate purpose of the exercise is to ensure that the identified causes do not occur again. That process is termed "corrective action." That might get a little complicated. It is very important to note that there is often NO SINGLE ROOT CAUSE. Looking for a single root cause can be counter-productive to the correction process. Understanding which causes to focus on is very important. Once they are identified, there is not always a single corrective action to be taken in response to a finding.

After identifying all the causes and needed corrective actions, they should be documented as an overall Corrective Action Plan (CAP). That CAP usually takes the form of a table and links the causes to the corrections and provides estimated milestones for each correction. Monitoring the implementation of the corrective actions is an important quality control function.

Ensuring an "effective solution" to the problem is very important. An effective solution is one that prevents the problem for recurring.

Validation of the corrective action is an advised additional step. Validation confirms both that the corrective action was performed AND that the action did actually correct the cause. If the validation fails, then a new corrective action may need to be developed.

Preventative actions

The cause-and-effect analysis may be performed for a variety of reasons. Often it is done in response to a serious problem, as in the case with the Titanic sinking. Other times it is performed in response to a finding of non-conformance or deficiency observed during an audit or assessment.

Sometime during an assessment or even during the cause-and-effect analysis, a reviewer observes a "potential problem." This is a situation where a nonconformance has not actually occurred but there is the potential for the non-conformance to take place. In these situations, the organization may choose to pro-actively implement preventative actions to strengthen operations and reduce risk. The same rule applies here. There may need to be more than one preventative action to address a single problem area. Validation processes are also advisable with a preventative action.

Considerations for an Environmental Measurement System

What exactly is an environmental measurement system? For those who are not familiar, measures of the environment are unique in that the environment is not repetitive. The measurement can only occur once in that particular place and time and under those particular conditions. The measure can be made "in situ" in the form of simple observations or using field measurement equipment if available. In many cases, the environment must be "sampled" and placed in some type of container. The processes used in all these activities become an environmental management system when they are subject to management or internal "controls" which can include any and all of the following: documentation, standard operating procedures, document controls, plans, quality management plans, etc.

In general, management planning and quality planning can be viewed as one in the same for these types of systems. Quality controls are the chief controls in place; however, it is not as simple as field sampling, lab analysis, and report and conclusions. The following considers all aspects of the process for consideration in a cause-and-effect analysis.

Possible Points of Failure for Environmental Measurement Systems

Thinking about an environmental management systems in terms of a product development cycle is a useful means to match quality failure to various components.

Product development step	Nature of the quality concern
Customer requirements determination	Failure to completely capture or completely understand the customer requirements.
Product design phase	Failure or inability to capture customer requirements in the design of the product including in the design of the sampling or analysis plan or the improper statement of study goals.
Procedures phase	Failure to develop procedures and processes that can be fully understood and can be implemented in the manner intended. The result may be shortcuts or modification during later implementation because the procedures are not adequate.
Implementation phase	Failure to follow the procedures and processes in performing required activities regardless of how well they are written. This
Test and inspection phase	Failure to develop adequate testing approach or failure to fully test and inspect resulting product to verify conformance to customer requirements and design specifications.
Servicing phase	Failure to adequately service product or output in response to customer concerns or ongoing service needs.
Product improvement phase	This phase is only applicable for repeating environmental measurement processes where there is an opportunity to identify and implement measures to strengthen activities. Failure to implement process to capture improvement opportunities.

In order to use cause-and-effect for root cause analysis in environmental management systems, it is important to have a general understanding of where the potential sources of error may be in the overall environmental management system. The following model is offered as a tool to support that analysis.

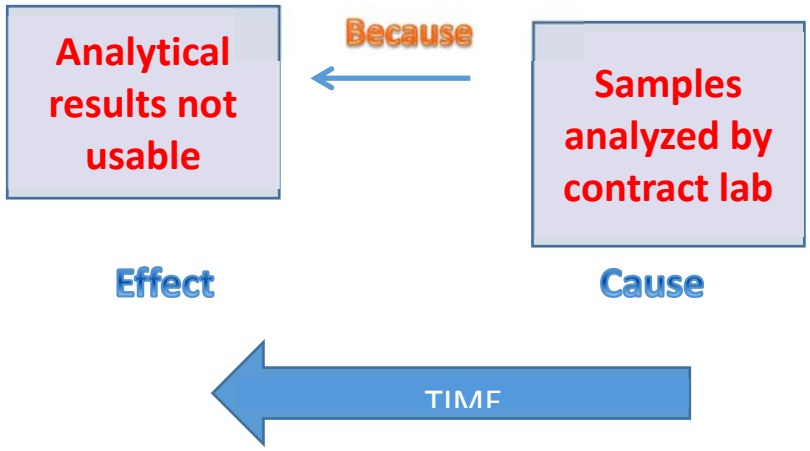
CATEGORY	SUB-CATEGORY
CUSTOMER REQUIREMENTS	
	Environmental measurement system purpose
	Sampling needs
	Analytical needs
	Identify challenge
DESIGN	
	Project management plan
	Sampling plan
	Analytical plan
	Training plan
	Validation process
FIELD	
	Sampling procedures
	Sample bottle preparation procedures
	Sample tracking, labeling, and accountability procedures
	Sample sub-sampling and splitting
	Field QC, bottle, method blanks, etc.
	Sampler competency
	Sampling implementation
	Field sample storage and preservation
	Custody procedures
	Field records
LABORATORY	
	Laboratory quality program
	Receiving procedures
	Sample tracking, labelling, and accountability procedures
	Laboratory information management system (LIMS) procedures
	Storage and preservation procedures
	Analytical method procedures
	Standards preparation
	Instrument calibration
	Instrument maintenance
	Equipment cleaning
	Balance maintenance
	Data verification and validation
REPORT PREPARATION	
	Data acceptability determination
	Technical analysis and determination if technical goals are met
	Written report
	Quality review
	Peer review

Example environmental measurement problem

The following example scenario is a typical problem encountered in an environmental management system.

> PROBLEM STATEMENT - The laboratory contracted for the environmental measurement system provided results that did not meet validation criteria.

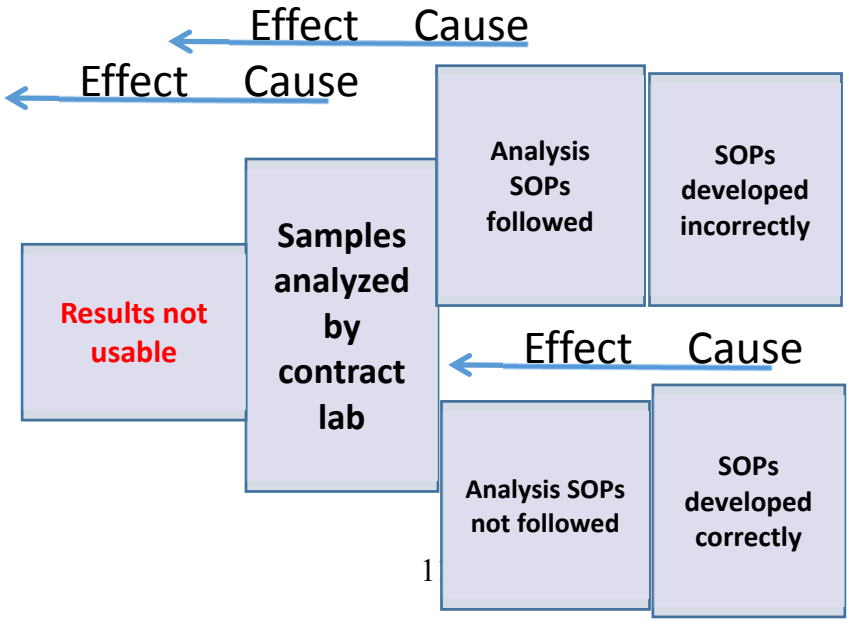
Cause and effect for this is written as:



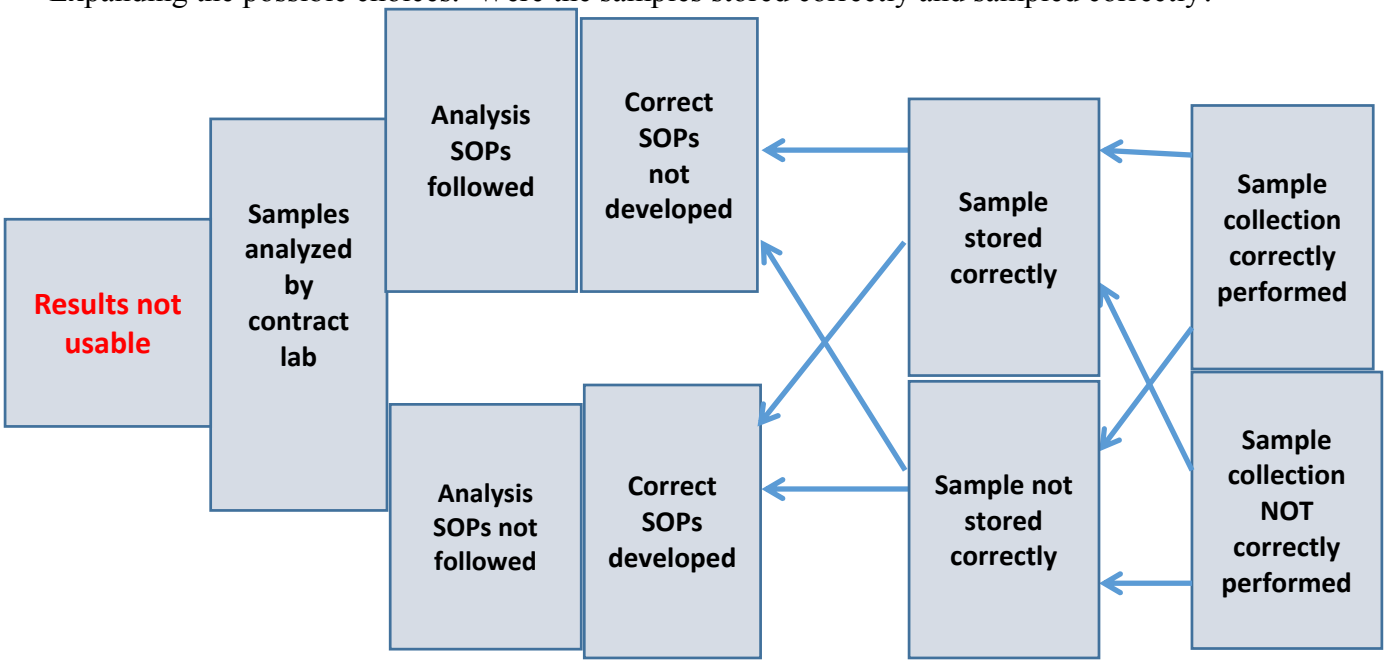
Some follow-up questions may include:

- What if the analytical protocols were followed and the result were still not usable OR they were not followed, that is two options.
- Also, were the samples collected correctly?

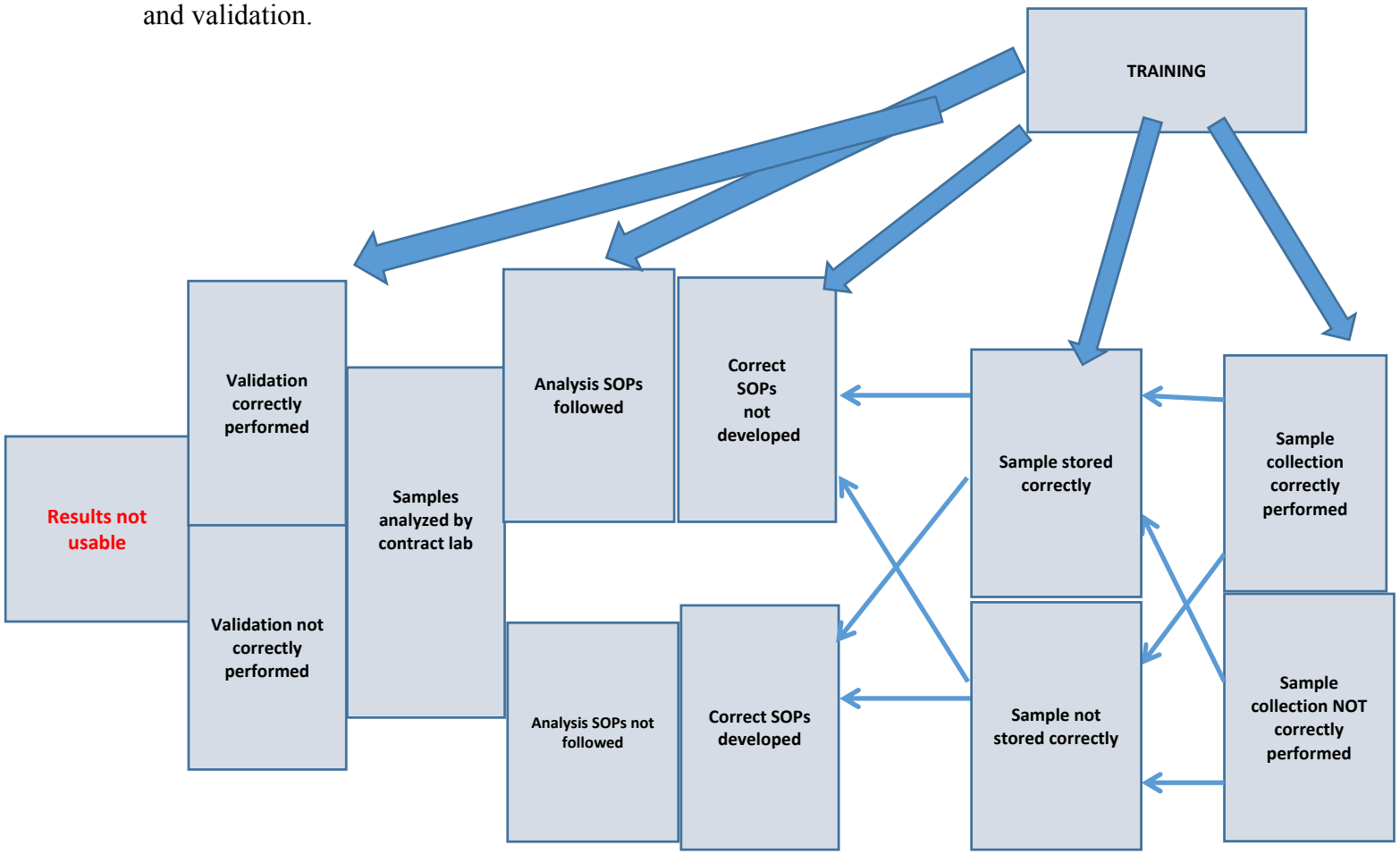
REMEMBER - the effect becomes the cause for the next item to the left!



Expanding the possible choices. Were the samples stored correctly and sampled correctly?



With this approach, there are several possible paths through the cause-and-effect diagram. It is important to note, that just because one step may not have been appropriately performed, that does not mean that is the only step. There may be multiple errors made prior to validation of the results. If that is the case, determining the multiple errors may be difficult. Let's add training and validation.



The root cause analysis with this approach can continue until all questions are asked. Following determinations of where errors were made, the chart can be simplified to include only those options that are determined to be true.

Only one root cause?

Great care must be taken to not assume that a single root cause is identified out of convenience. There can be a lot of pressure to identify a single root cause and not identify other root causes or contributing causes. In fact, having a single root cause alone is really quite rare.

For example, if someone did not develop the correct SOPs, developing new SOPs is clearly necessary. Also, the reviewer must determine if the reason is lack of training or some other reason. Particularly with lack of training, one may have to ask if this may have impacted other operations and determine if other corrective or preventative actions are necessary.

Conclusion

Cause-and-effect diagrams are much more than a concept taught in quality and management seminars. They are valuable problem-solving tools and should be actively employed by both administrative managers and technical managers in conducting root cause analysis to identify all possible causes for an organization's problems. Identifying a root cause through a casual analysis is not root cause analysis, that is quick problem fixing. Understanding that there may be multiple root causes and contributing causes is important to ensuring that the corrective actions are effective.

Up-front understanding of the basic components of the environmental management system will form a good basis for any subsequent analyses.

Last note

Sometimes during the course of reviews by external bodies (i.e., third parties), the reviewers identify causes and suggest possible corrective actions or preventative actions. This may be useful independent information; however, it is the responsibility of the organization, not the reviewer, to conduct the root cause analysis. While it may be tempting to accept this free analysis and to "please" the assessors; the organization must still perform their own root cause analysis because only the organization has a true picture of its internal operations.