CASE STUDY

ADVANCED PROBLEM SOLVING

A Systematic Approach to Root Cause Analysis

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Quality Support Group

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Executive Summary

Attached are excerpts from the workbook for Jim Leonard's two-day Advanced Problem Solving/Systematic Root Cause Analysis workshop. The course teaches a structured approach to problem analysis that is both systematic and facts- and data-driven. Briefly summarized on Attachment A is the six-step, systematic procedure that is presented in the seminar, based on the Kepner-Tregoe problem-solving technique.

After the critical first step of Naming the Problem, step two of the procedure seeks to clearly define the problem; if you will, to construct the problem specification. The problem solver uses a series of controlled questions (summarized on Attachment B) to describe the problem within the dimensions of WHAT, WHERE, WHEN, and SIZE. The controlled questions help to describe the problem not only in terms of what the situation is, as observed, but also in terms of what the situation could be but is not.

Carl Jung, the late Swiss psychologist, once said that it would be an expansion of knowledge to know what isn’t affected. “This leads to another set of facts that is useful, but often ignored, in describing a problem – namely, the contrasting data.” Once the problem is clearly defined, theories of possible causes of the problem are generated via brainstorming at step three of the six-step procedure. At step four, the theories are tested against the facts noted in the problem specification. (i.e., “Does this theory explain the facts noted in the problem specification?”) All theories brainstormed at step three of the procedure are possible causes. What the problem solver is trying to determine at step four is the answer to the question, “Is it a likely cause” (given the facts at our disposal)?

Testing theories of causes at step four leads to step five: Identifying the most likely cause (or causes; more than one may survive the test). Finally, at step six of the systematic procedure, the problem solver seeks to verify the true cause in the cheapest, quickest, easiest manner possible. In other words, before proceeding to corrective action, one seeks to verify (or refute) that the most likely cause is indeed the true cause. Once the true cause if verified, we can move on to effective and lasting corrective action.

THEORY OF VARIATION

After describing, applying, and summarizing the systematic approach to root cause analysis, a "word of caution" is provided to the problem solver. An excerpt from Dr. W. Edwards Deming's book, Out of the Crisis, describes a situation in which a Vice President of Operations required his engineers to identify and address the cause of every defect found in final inspection. The VP wondered why the level of defective tubes in his plants continued at 4-1/2 to 5-1/2 percent for two years – the same period that his engineers never stopped until they'd identified and addressed the cause of every defect reported. Deming's answer: "The engineers were confusing common causes with special causes. Every fault to them was a special cause, to track down, discover, and eliminate. They were trying to find the causes of ups and downs in a stable system, making things worse, defeating their own purpose."

What sets this seminar's problem-solving approach apart from others is our insistence that it's not enough to be skilled in Kepner-Tregoe, 8D, 5 Why and other techniques for root cause analysis. We must connect our skill with knowledge – knowledge of the theory of variation. In the face of one type of variation, the systematic approach to root cause analysis works like a hot knife through butter. In the face of a different type of variation, apply root cause analysis at your peril! We hope you have a lot of time and resources to waste; we hope you're willing to join the engineers Deming wrote about – defeating your own purpose, making things worse.

Thus, the seminar proceeds to review the analytic theory of variation. This enables the problem solver to differentiate between common causes of random variation (that come from within the process or system) and special causes of non-random variation (from outside the process or system). Common cause variation is the result of multiple causes of variation. So, in the face of common cause, systemic variation, the appropriate strategy is not to try to apply root cause analysis. There will be no single, smoking gun, root cause of the problem to be found. Rather, in the face of common cause, systemic variation, the appropriate strategy is to take on a balanced, holistic, multi-variate approach – such as design of experiments (DOE) or Process Failure Mode & Effects Analysis (PFMEA). On the other hand, in the face of non-random, special cause variation, root cause analysis is the appropriate strategy for the problem solver. If there is one, smoking gun, special, root cause (singular) of variation to be found, systematic root cause analysis will surface it.

ADVANCED PROBLEM-SOLVING PROCESS

On Attachment C, a process map is provided that summarizes the connection between systematic root cause analysis and applied knowledge of the theory of variation. If enough data are available, a statistical process control chart can be constructed. The control chart will indicate whether the evaluative data fall into a random pattern or a non- random pattern. A non-random pattern indicates the presence of special cause variation; and the systematic approach to root cause analysis, driven all the way to the verification of true cause, will be used to identify the special cause.

If the data plot in a random pattern on the control chart, this indicates that the source of the variation (or problem) is common causes of variation. One will not be able to identify one, smoking gun, root cause of the problem. Instead, one must work on the process to identify and address multiple (common) causes of the variation.

In R&D or new product development applications, however, one seldom has enough data to construct a valid control chart or to perform a valid stability study. In the absence of enough data, one can just pay attention to the words used to describe patterns or trends in response to some of the controlled questions in the WHEN and SIZE dimension. If one uses words like sporadic, intermittent, increasing, decreasing, non-random, one time only or never seen before to describe a trend, that is a pretty strong indicator that one is dealing with special cause variation. In such a case, root cause analysis is the appropriate strategy for corrective action.

On the other hand, if one uses words like consistent, repeated, continuous, or steady to describe a trend, that is a pretty strong indicator that one is dealing with random, systemic, common cause variation. In such a case, root cause analysis would not be the appropriate corrective strategy.

This is not to say, however, that this systematic approach to root cause analysis cannot be used in the face of random, common cause variation. It must just be applied with great caution, guided by knowledge of theory. Even in the face of random, common cause variation, one can still apply root cause analysis – but only up to the point of testing and reducing the list of possible causes. We can't drive the analysis to one, smoking gun, root cause of the problem – because there's never just one cause of systemic issues or problems! Guided by knowledge, however, one can still generate an unprecedented level of detail, definition, and understanding of the problem at hand, then test and reduce the list of possible causes in a very efficient manner.

Some engineers use the procedure to select factors for their designed experiments. They don't want to waste experimental time and resources on factors that don't "meet the spec," and systematic root cause analysis (just taken up to step 4 to test and reduce the list of possible causes) can add efficiency and speed to future experiments. A team at an automotive components manufacturer, for example, was facing a problem related to transfer and scale-up of a new design. They used this technique to reduce their list of variables to test from 32 to just seven. The other 25 "suspects" failed to explain some of the facts in their problem description, so they eliminated them from future tests and diagnoses. The systematic root cause analysis procedure was applied – guided by knowledge of variation – to result in an extremely efficient 8-run screening experiment to examine the surviving seven factors.

Case Studies

Before leaving the seminar, participants apply the procedure a real work problem, the seminar includes several case studies. Attachment D provides the completed Root Cause Analysis worksheet for one of the case studies included and discussed in the workshop. Another of the applications is a classic case study from Harvard Business Review. The shortest case study in the seminar often turns out to be the hardest for trainees to solve, because it deals with a people problem. These applications help trainees to get more comfortable with the technique before applying it to real work issues. Applications to on-job problems are interspersed throughout the seminar, and in the "final exam" participants apply the entire procedure to one of their actual, on-job problems.

SUGGESTIONS FOR MANAGERS

To reinforce the training, the following suggestions are offered for managers of people who attend the Advanced Problem Solving/Root Cause Analysis seminar:

1. Review the attached materials to familiarize yourself with the technique and terms.
2. On occasion, use some of the controlled questions (see Attachment B) when discussing on-job problems with staff members.
3. Most importantly, managers should encourage (if not insist upon) the application of the technique by their employees. The employee may be directed to perform a root cause analysis on a problem, then document their analysis on one of the worksheets provided in their seminar materials. Managers should review and discuss that document with the employee. One or two rounds of such an application will not only encourage the use of the technique, but also lead to a greater level of comfort and effectiveness in applying the technique on the part of the employee.
4. Finally, managers interested in more information about the systematic approach to root cause analysis are encouraged to meet with their employees to discuss the technique and what they learned in the seminar. It may also be a good idea to borrow and browse the employee's seminar workbook for additional information.

ATTACHMENT A

THE SYSTEMATIC APPROACH TO ROOT CAUSE ANALYSIS

1. **Name the Problem *(Problem Statement)***
   Include both and object and an action.
   Be specific, and deal with only one problem.
   Make sure it names a problem for which the cause is unknown.

2. **Describe the Problem *(Problem Specification)***

Dimensions	IS	IS NOT	Distinctions	Changes
WHAT				
WHERE				
WHEN				
SIZE				

3. **List possible causes**

4. **Test possible causes**
   Against the facts noted in the Problem Specification

5. **Identify the "most likely" cause**

6. **Verify the true cause**
   Pose and seek answers to good open questions.

ATTACHMENT B

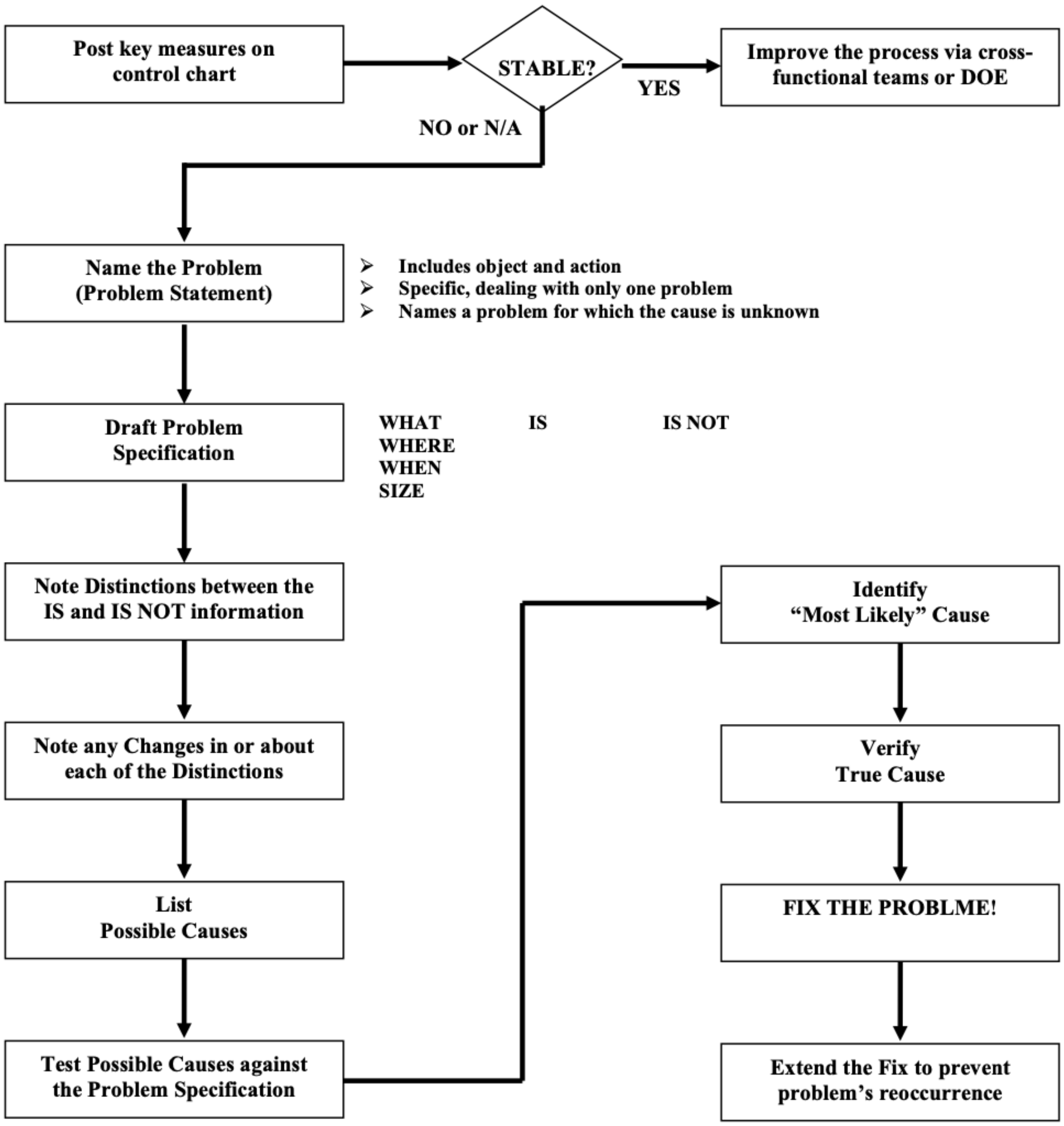
CONTROLLED QUESTIONS

For Constructing a Complete Problem Description/Specification

Dimension	IS	IS NOT
WHAT	What specific item/object/unit(s) has the defect?	What similar item could logically have the defect, but does not?
	What specifically is the defect?	What other defects could logically exist, but do not?
WHERE	Where is the defective item/object/ unit(s) observed (geographically)?	Where else could it be observed, but is not?
	Where is the defect on the item?	Where else could the defect be on the item, but is not?
WHEN	When was the defective item/object/ unit(s) first observed?	When else could it have been first observed, but was not?
	When has it been observed since (pattern or trend in terms of *frequency of observation*)?	When else, or at what other times, could the defective item have been observed, but was not?
	When in the item's normal cycle of operation or history was/is the defect observed?	When else in the normal cycle of operation could the defect be observed, but is/was not?
SIZE	How many items/objects/units have the defect?	How many similar items could have the defect, but do not?
	What is the size and impact of a single defect?	What other size could the defect be, but is not?
	How many defects are on each item?	How many defects could there be, but are not?
	What has been the trend?	What other trends could occur, but were/are not seen?

ATTACHMENT C

ADVANCED PROBLEM-SOLVING PROCESS FLOW



Common cause variation?

If yes, *stop here!*

ATTACHMENT D: SAMPLE SYSTEMATIC ROOT CAUSE ANALYSIS WORKSHEET

BLISTERS RCA WORKSHEET.

PROBLEM STATEMENT:	Blisters and bumps on pins

DIMENSIONS	IS	IS NOT QUESTIONS	IS NOT	DISTINCTIONS	CHANGES
WHAT					
What specific item/object/unit(s) has the defect?	Connector pin for Customer A's cable adapter	What similar item could logically have the defect, BUT DOES NOT?	All other nickel-gold plating parts	This adapter is used by Customer A only.	Learned about Customer A wash-bake cycle in Feb 2016.
What specifically is the defect?	Blisters and bumps	What other defect(s) could logically exist, BUT DO NOT?	Corrosion, chipping, delamination, plating adhesion failures		
WHERE	WHERE	WHERE	WHERE	WHERE	WHERE
Where is the defective item/object/unit(s) observed geographically?	Plating vendor's plant and our assembly plant	Where else could it be observed, BUT IS NOT?	Customer A's plant	Defects sorted out before reaching customer. Our plant finds 2-4x more defects than plating plant.	No changes - Our plant performs 100% inspection; plating plant samples only.
Where is the defect on the item?	All over the pin	Where else could the defect be on the unit,	Specific zone or area of pin		
WHEN					
When was the defective item/object/unit(s) first observed?	Reported by customer as "spots" in Feb 2016. Our assembly plant confirmed existence of blisters in early Apr 2016.	When else could it have been first observed, BUT WAS NOT?	Before or after	Time	(1) Introduced wash-bake to mimic customer in Feb. (2) Separated plated and unplated part numbers in Mar. (3) Changed plating vendors in Mar. (4) Went from 50/50 to 70/60 thickness spec in Mar. (5) Doubled original thickness spec two weeks later.
When has it been observed since (pattern or trend in terms of *frequency of observation*)?	Continuous	When else or at what other times, could the defective item have been observed, BUT IS/WAS NOT?	Sporadic, intermittent, isolated event	Continuous pattern despite numerous changes between Mar 2016 and present.	Six different process plans introduced between Mar and Aug: testing methods; wash test; handling methods; spec changes; plating methods; cleaning methods.
When in the item's normal cycle of operation or history was/is the defect observed?	(1) Post-plating, before bake. (2) Post-plating, after bake. (3) Incoming inspection at our assembly plant. (4) Post-assembly inspection in our plant.	When else in the normal cycle of operation could the defect be observed, BUT IS/WAS NOT?	SEM inspection of parts received from machining supplier at plating plant.	Operations	(1) Wash-bake introduced in our plant's receiving and final inspection in Feb. (2) Wash-bake introduced at plating vendor's plant after plating in May. (3) Expanded to bake-wash-bake in vendor's plant in Jul
SIZE					
How many items/objects/units have the defect?	2-5 %	How many similar items could have the defect, BUT DO NOT?	More or less		
What is the size and impact of a single defect?	10 um; Customer very dissatisfied	What other size could the defect be, BUT IS NOT?	More or less than 10 um Affecting schedule, production, deliveries		
How many defects are on each item?	From 1-5 up to 25. 90% are blisters.	How many defects could there be, BUT ARE NOT?	More or less		
What has been the trend?	Steady at 2-5 % levels	What other trends could occur, BUT WERE/ARE	Increasing or decreasing		

Possible Causes	Does not explain . . .	Explains (only if ...)	Further Questions
Bake-wash-bake introducing the defects	Defects observed post-plating both before and after bake-wash-bake.		
Contamination	No plating adhesion failures.	Individual contaminants too small to affect	
Plating deposits	Blisters not found on any other parts.		
Current disruption	Only 2-5% of pins have blisters/bumps	Much higher percentage of pins have the defects.	
Operator error	Only 2-5% defects; blisters not found on other parts processed by same operators.		Do our operators get stupid only when plating Customer A parts?
Porosity	SEM receiving inspection of raw parts from machining supplier shows very little porosity.	Bright dip fails to reduce porosity	
Left in bright dip too long	Only 2-5% of pins have blisters/bumps	Much higher percentage of pins have the defects.	

List and Test Most Likely Causes

Rank Order	Identify and List "Most Likely" Cause	How to verify/address likely cause	Verification Results
1	Contamination	(1) Institute better incoming inspection for contamination/cleanliness of parts; (2) Assure that machining supplier performs proper first cleaning - vibratory finishing - final cleaning protocol; (3) Adopt vapor degreasing of parts prior to plating.	Nov 2016: Plated one lot of parts after vapor degreasing. Zero blister defects found via 100% inspection both before and after bake-wash-bake.
2			
3			