The Latent Causes of Industrial Failure ....How to Identify Them, and What to Do About Them

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Abstract: Hidden but powerful forces within our organizations are causing people to make serious mistakes. Until someone deals with these forces, they will continuously but unpredictably snare people into doing things they should not do. These forces are like a "trap," waiting to catch the next person. The most proactive of all industrial action might be to identify and remove these latent traps. But all our attempts to identify and remove these latent causes of failure start at the human. Humans do things "inappropriately," for "latent" reasons. In order to understand these reasons, we must first understand what "errors" are being made. This puts people at risk – especially the "culprits." Once exposed. They are in danger of being inappropriately disciplined. This paper attempts to clarify the subject of latency. It addresses the root causes of all failure – the human. More importantly, it suggests what to do about the causes once they are identified.

Keywords: Root Cause, Latent Cause, Incident Investigation, Failure Analysis, Human Error, Human Factors

I. INTRODUCTION

As organizations see the value in addressing latent issues and begin attempting to remove the traps, many problems begin to emerge: What, exactly, are we after? Is there a specific method that helps identify latent causes? What are we supposed to do when we identify the latent issues – they are HUGE issues!

To make matters worse, each inquisitor seems to pursue the latent causes of a failure to different depths. Each seems to have his own style of approaching "latency" – his own idea of where the investigation should end. Because of the frustration this produces, more than one organization has decided to avoid looking into the latent causes of a failure altogether: *Why get into something that no-one seems to understand?*

Clearly, the subject of latency is in need of clarification. However, too much clarification (too much structure) will not only destroy the discovery process that is necessary for true learning – it could hide what is really down there at the root levels. We must keep our methods of pursuit free enough that the truth can be discovered, whatever it might be. I offer the following as "food for thought" -- an attempt to provide a middle ground between "confusion" and "conclusion."

II. IT IS ESSENTIAL TO KNOW WHAT PEOPLE DID *INAPPROPRIATELY* IN ORDER TO IDENTIFY THE LATENT CAUSES, EVEN THOUGH NO-ONE WANTS TO DIVULGE THIS TYPE OF INFORMATION.

All physical failures are triggered by humans. But humans are negatively influenced by latent forces. The goal is to identify and remove these latent forces.

The quest cannot begin in earnest until someone (or some group of people) is "charged with" methodically and consistently defining the human causes of failure – in a very particular, delicate manner.

The following bullets briefly summarize the process of defining physical and human causes in preparation for the probe into the latent causes of a particular failure:

- Determine the **physical causes** of the physical failure using a **WHY Tree**, following the **physical evidence**.

The **WHY Tree** should be the **standard** for all formal investigative efforts. Although other tools can be used in the background if necessary, the WHY Tree should be the vehicle used to graphically represent investigative learning's. It is the

only known device capable of showing both the logic AND sequence of an unfolding failure. It is important to standardize on this investigative tool, then expect it to be meticulously used. As deficiencies are found in the tool, they can be eliminated for the benefit of everyone. (Please recognize that much instruction and comment are available pertaining to the WHY Tree. However, more detail is beyond the scope of this paper)

It is important to focus initially on the physical causes of a physical failure. The physical causes cannot be conclusively defined without physical evidence. Therefore, the WHY Tree (and other supportive tools) should ALWAYS be **fueled by evidence** (physical failures always produce physical evidence). A WHY Tree generated without physical evidence should be taken with "a grain of salt." It is not possible to know the physical causes without physical evidence.

✘ Determine the first "parallel" points of **inappropriate human intervention (IHI)**.

Physical failures are triggered by people – usually several people. We trigger failure by our actions – parallel and series actions. It is the parallel actions that are of initial interest. They are the starting points for a structured "latency probe."

For example, a fire occurred because a bearing overheated. The overheated bearing is the physical cause. But the bearing overheated because: the wrong bearing was installed AND the bearing was not lubricated AND the overheated bearing was not detected. Each of these underlined items are the **first parallel points of inappropriate human intervention (IHI's)**. Each of them led directly to the physical cause (the overheated bearing). These IHI's are the starting points for an evaluation of latent causes.

✘ After someone defines the first parallel points of IHI's, **the probe into the latent causes can begin** in earnest.

It is always essential to remember that a difference exists between WHAT people do, and WHY they do it. When people do inappropriate things, we call their actions inappropriate (IHI's). When we attempt to understand WHY they did the inappropriate thing, we are engaged in a latency probe.

III. A SIGNIFICANT DIFFERENCE EXISTS BETWEEN THE LATENT CAUSES AND ROOT CAUSE OF A FAILURE.

It is essential to note that the causes of each of the parallel IHI's can be driven to varying depths -- the inquisitor can "stop" whenever he desires. In other words, one cannot correctly say: Aha – I have found ***the*** latent cause of this IHI – I have driven as deep as possible! It would be more correct to say: Aha -- I have uncovered one of the many layers of latent causes for this IHI – I know that more layers exist.

Latent causes reveal themselves in layers. One after the other, the layers can be peeled back, similar to peeling the layers off an onion. It often seems as if there is no end. The inquisitor is often left with a feeling of frustration: *Am I there yet? When do I stop the probe?* It is this uncertainty that causes people to think: *why get into something no-one seems to understand?*

To help clarify this confusion I find it useful to jump ahead – to the end of the pursuit. It is useful to consider the meaning of the word "root," as opposed to "latent" cause. In

contrast to the elusive nature of "latent causes," **the "root cause" of a failure is the end of the pursuit**. There are no more answers – there is no-where else to go. When one reaches the "root cause" of a failure, one *can* correctly say: Aha -- I have found ***the*** root cause -- I have driven as deep as possible!

Where is this point? How does the investigator know he has arrived? What does this "root cause" level look like? A level (point) must be defined at which all inquiry will stop – so that the words "root cause" mean the same things to the same people. Fortunately, this level exists naturally – it does not have to be fabricated. It would be easier (and not as controversial) not to enter into this discussion, but then the issue would remain muddied.

The intent of the next few paragraphs is to define the end-point of inquiry. It is important to know what is there. But once we find out, we will come back to the IHI's and to begin the journey to the end-point. **The journey contains the latent causes of the failure**. Please remember this as you read the next few paragraphs.

IV. THERE'S NOTHING WE CAN DO ABOUT THE ROOT CAUSE OF A FAILURE

It has been stated in a number of different ways by many different peoples and cultures throughout the ages:

The root cause of all true failure is *"the human condition."*

We all have a built-in ability to decipher between right and wrong. The ability seems either strengthened or weakened, depending on how often it is exercised. At the root of all true failure is the **choice** that must be made when the two options (right versus wrong) present themselves.

Although we all are able to distinguish between *what we ought to do (right)* versus *what we would rather do even though we should not (wrong)*, we often make the **wrong choice**. Even when we are aware that we are making the wrong choice, we often seem to think: ***we can get away with it this time***, or, ***it will not hurt anyone***, or, ***no-one will notice***.

It is important to note that it is not just any choice which is at the root level of failure. It is only when we are presented a moral choice between two options – where one is perceived as "right" and the other "wrong," that we addressing a root-level cause. This is an important distinction, because life presents us with many choices that are not matters of the conscience. And although these choices could lead to problems also, they are not at the root-cause-level of failure. It is only the conscious decision to do something we know is "wrong" that is worthy of the term "root cause."

However, two major dilemmas emerge when the causes of a failure are chased to this point. Firstly, when "the culprit" who chose to ignore his conscience is found, the tendency is to discipline him. After all, he did something even though he was fully aware that it "was not right!" If there is ever a time when discipline is appropriate, it seems to be here.

But if discipline is applied to this person, should it not also be applied to everyone who chooses to ignore his conscience? And if we discipline everyone who is guilty of ignoring their conscience, who would be able to plead innocence? A conflict emerges because the reasoning behind the discipline becomes circular:

We are all born into the human condition.

The human condition causes all failure.

A failure has occurred -- let's find out what caused it!

We found someone guilty of "the human condition."

We must discipline the guilty party!

Wait a minute – we are all guilty!

We are all born into the human condition.

To discipline someone for ignoring their conscience is to discipline someone for being human. Certainly, we all ought to try our best to listen, then abide by the voice of the conscience. But just as certainly, we choose not to listen – all of us – many times per day. Do you see the dilemma?

In response to this line of reasoning, one person actually said: "***Then what's the point of digging down to this level -- what you're saying is that 'original sin' is the root cause of everything that goes wrong! That's a cop-out – there's nothing we can do about that!***" To this I must say three things. First, it is not *I* who said that original sin is the root cause of everything that goes wrong. Secondly, for those who do not believe that we were all born with a flaw that seems impossible to overcome, all one must do is look closely within themselves: in spite of knowing better, we all choose to ignore our consciences! The fact that each of us does this is undeniable, ***if*** we take the time to look. Finally, how can anyone say: *what is the point of digging down to this level?* Here we are at the root levels of things that go wrong, and we say: *what is the point?*

In the preceding page, I suggested that there were two major concerns that emerge when we start looking for the "tug-of-war." The first concern was that we do not know what to do, even when we find the "root cause." The second concern is even more mind-boggling. Consider the following real example.

The shaft on a boiler feed-water pump broke. A fatigue fracture occurred. The shaft material was improperly specified when pump was designed. The engineer did not take the time to understand the application. He knew he should have taken more time, but was under pressure to move onto other assignments. Why was he under pressure?

Everyone in the facility was "under pressure to move on to other assignments" (other faulty decisions were being made for the same reasons). A new plant manager had recently arrived, and was determined to turn the plant around. Part of his strategy was to bid on all sorts of new work in hopes of increasing orders. The strategy paid off, but the factory was not staffed to handle the new workload. The plant manager knew better, but decided keep staffing at minimal levels. Why did he decide to keep staffing at minimum levels?

The plant manager was under pressure. He knew he had a year to turn the plant around, or someone else would take his place. Although his factory was making a 19% return on investment, the plant manager's CEO was not satisfied. His corporation had been giving its stockholders a 30% ROI. This plant was one of the primary causes of the lower than usual return – the 19% was not high enough. Although the CEO understood the potential negative consequences that occur from pressuring the plant manager (as well as the workforce), he only gave him 1 year to increase performance. Why did the executive decide to take the risk?

The motivations of the stock market had to be considered, as did the free-market economy in general. Even deeper, the way the world trades amongst itself became a consideration, as did world politics. Eventually, almost everyone was included in the scenario – not only people living in the present, but even those in past generations. **In the limit, humanity itself was found "guilty" of the boiler feed-water pump failure.** And the same can be found for all failure! In other words, if we chase it far enough we find that the true causes of things that go wrong can be traced to many people, most of them having lived long ago. Mind-bogging!

Now back to the dilemma! What in the world can we do about this? What can be done about the human condition in the

business world? If all our probes end at: *From "day 1," humanity has not been doing the right things, even though they knew better,* what are we supposed to do about it? Are our businesses either interested in, or capable of addressing this issue? *Some say: This is not a business issue!* But if the root causes of injuries and fatalities, high maintenance costs, and poor product quality can be traced to this "human condition," how can it NOT be a business issue?

There is another half of the tug-of-war which has not been discussed yet – the reasons WHY we decide to do "the wrong thing." There are always COMPELLING REASONS to OVERRIDE what we know we ought to do. In other words, **there are always REASONS for making the wrong choice -- LATENT reasons!**

Therefore, although it is our first duty as "root cause investigators" to remind people that the human condition is what causes failure (this is the truth, and people ought to know it), our second duty appears a bit more practical. **We must understand WHY people did not do what they ought to have done!** In a sense, your job is NOT to find the root cause -- we already know what that is. Instead, your job is to identify the "booby-trap(s)" that activated the root cause (by enticing someone into making the wrong decision).

V. BUT THERE IS MUCH WE CAN DO ABOUT THE LATENT CAUSES OF A FAILURE, WHEN WE MAKE THEM VISIBLE

This is where things get interesting. This is also where most investigative efforts stop. Most investigators are either engineers, or at least have some sort of technical background. As such, they can be excellent at determining physical cause – and are capable of driving toward that end with vigor. But when these same investigators discover the IHI's that precipitated the physical causes, most of them shy away from digging any deeper. It's as if there is an unwritten rule that an investigation will NOT probe into the motivations of the "culprit." "After all, engineers are not psychiatrists." Furthermore, most people think that it does not matter WHY people do "wrong" things. "Isn't it enough to find out WHO did the wrong thing, then punish them?"

Investigators must always remember their "role in life," i.e., they exist to understand WHY. They must be driven by the question WHY. Their passion must ALWAYS be motivated by open-ended curiosity, rather than closure. They should be highly resistant to thinking about "solving," or imposing discipline, or anything apart from their primary mission – to help everyone SEE the CAUSES of the incident. Although punishment might be appropriate in some cases, you will never know if it is or not until you understand WHY a person did what he did.

One of the best ways of understanding latency is to consider the Leaning Tower of Pisa. Imagine being born within the confines of the tower, living all your life on the tower, not ever having left the tower for any reason. Obviously, you would have to walk cockeyed, prop up your dinner table so that the soup would not slide off, and expend more energy to walk in one direction versus the other. You would not even think twice about these things, had you spent your entire existence in the tower. Yet the latent forces induced by the slant of the tower would affect all your actions. Not until you step off the tower and look at it from another perspective would you realize you were subjected to those forces. But when the tilted tower becomes visible to you, it becomes a permanent part of your understanding – a new understanding that alters you forever.

In order to act on latent causes, they must be made visible -- VERY visible. When they are made visible, they are no longer latent!

VI. THE BEST WAY TO SEE LATENT CAUSES IS "IN RETROSPECT."

Fortunately (for the investigator), failure helps make things visible. It provides the occasion for the necessary probing. In retrospect, what was uncertain and considered "risky" before the failure occurred becomes certain and undeniably flawed after the incident. Latent causes can be clarified using this 20/20 hindsight.

The following model has been discussed, applied, modified, and finally embraced as a key aide to understanding the latent causes of an incident. It helps look at human behavior in retrospect. Prerequisite to the use of the model is a specific delineation if each inappropriate human intervention (IHI).

The Situation/Filter/Outcome Model

As situations are presented to us, we filter them, which results in a specific behavioral outcome. In fact, life can be viewed as a series of human responses to the situations we encounter. Each situation is filtered, as if the situation was a beam of light traveling through a lens. The outcome of the filtering process depends on the condition (makeup) of the filter. Each of the three facets of the model is briefly described below.

Outcome (the starting point of the latency probe):

When something goes wrong, the OUTCOME of the filtering process is the first piece of the puzzle discovered by the investigator. **The OUTCOME is the IHI – inappropriate human intervention,** the transition between the physical and latent causes of failure. The OUTCOME of the filtering process is NOT the root cause, nor the latent cause of the failure – it is merely the STARTING POINT of a true latency probe.

Situation (the trigger):

In order to understand WHY a person did (or did not do) something, it is imperative to understand the situation he was responding to. Most, if not all of our human actions are a reaction to a situation. Either *someone*, *something*, some *condition*, or some *time* makes itself known to us – either gradually, or suddenly. Situations seem to present themselves to us for our consideration, as if they were requesting our attention. In response to their appearance, we react (or choose not to react). It's hard to think of a human action that is not triggered by some type of situation. Even boredom is a conditional situation that we first become aware of, then decide to act upon (or accept).

For example, I was sitting in my office working on a project for a client. The telephone rang. It was a person from the IEEE inviting me to write and present a paper at their 1997 conference. This is a perfect example of a situation presenting itself for consideration (obviously, I chose to accept the invitation).

Filter (residence of latent and root causes):

As humans, we each "see" our existence through the lens of a filters. Although each of our filters are similar in many ways, each is also unique. Because of the distinctive differences in each of our life experiences, we all see any given situation from a unique perspective – not totally unique, but different enough to cause varying responses and opinions. We all marvel at the variety of opinion brought forth by the situations and conditions of life.

To a large extent, we do not choose to see differently – we just do! Therefore, to criticize people for what they "see" through their filters is ridiculous. It's like criticizing someone for seeing the color green. Admittedly, we all have the ability to regulate what goes into our filters to some degree. But none of us is able to control it totally.

When something goes wrong, its causes can always be traced to deficiencies within our filters – always. In fact, this should be one of the investigator's criteria for having completed the inquiry; am I addressing someone's filtering process? All true failure is caused by flawed filters. The intent is to make the flaw VISIBLE. Once visible, it often "evaporates" on its own.

Adding Contrast to the Situation/Filter/Outcome Model

Investigative inquiry is a study in contrasts. Although it often happens subconsciously, investigators are constantly comparing ACTUAL versus DESIRED observations as they progress into the causes of a failure. For example, if a broken pipe is being viewed the investigator automatically knows it should not be broken because he has made a quick contrast in his mind between ACTUAL (unbroken) and DESIRED (broken). However, all observations are not as obvious -- valve positions, for example. If a value is found open, the investigator must know that it should have been closed (or whatever) before his observation has meaning – once again he must contrast ACTUAL versus DESIRED.

There seems to be very little, if anything, that humanity knows without contrasting it to something else. (What would "up" mean unless "down" existed, man without woman, old without new, etc.) The same seems true with human behavior.

The Situation / Filter / Outcome model that was introduced in the preceding paragraphs yields little useful information until the investigator begins to CONTRAST actual versus desired behavior. Whereas desired behavior is not always known ahead of time (before the failure), it becomes much clearer IN RETROSPECT.

VII. THE ONLY WAY TO ASSURE CHANGE IS TO EXPERIENCE PAIN

The following is the desired and typical response to a serious incident or failure: A team of high-powered people has been formed. The metallurgists, mechanical engineers, and process experts form one third of the team. The field personnel who helped gather the physical evidence are the second third. The eyewitnesses are the last third of the team. A principal investigator has been chosen to lead the inquiry. Finally, the "customer" is in attendance (whoever asked you to do the investigation, or whoever has authority to act on your findings). This team, typically numbering 10 - 15 people, has met three times. They are confident of their physical cause findings. They have identified six IHI's. They are ready to drive into the latent causes.

Before their next meeting, the principal investigator should approach the supervisors of each of the "culprits," asking for their involvement in one or two more meetings. After obtaining permission, the should be invited to attend the next meeting (along with their union representatives, where appropriate). The principal investigator should do everything in his power to set the proper stage for this meeting, especially with the culprits (and their union representatives). This is NOT to be a "kangaroo court," or a "lynch mob," or anything of the sort. Remember, the sole purpose of a latency study is to understand WHY people did what they did. If anything, discipline will be diminished as a result of the study, never augmented.

Nevertheless, the culprits will be afraid. The union representatives will be fully armed. The remainder of the team will be very apprehensive. But then, just as he has done throughout the investigation, the principal investigator must stick relentlessly to his objective and rely on known procedure by using the accompanying chart. If the chart is used as intended, the **conversations** will be constructive.

So here we are at the end of the paper, and the subject is "conversations." The subject

could have been "agreed-upon actions," or "decision-making forums," or "recommendation tracking systems." I could have discussed some fancy techniques to draw a crowd towards a "solution" to the problem. But such is NOT the end objective of a true "root cause investigation."

The end objective is to help people see differently, i.e., to change the makeup of their filters. Quoting a recent client after having sat through a root cause investigation:

I don't think it is possible for a WHY Tree, or any other device to CHANGE PEOPLE to the same degree as DIRECT INVOLVEMENT in ROOT CAUSE TEAM SESSIONS

Paraphrasing John S. Carroll (MIT Sloan School of Management):

The incident review process should have learning rather than fixing as its goal. Incidents should not be approached with the expectation of finding the single "root" of the problem, nor is there a "solution" to the problem. Instead, the incident should become **an occasion to identify and discuss issues**, to encourage new insights, and to explore possibilities for change and their consequences.

A very large natural gas compressor failed four times in three months. The plant where this compressor was operating had undergone extensive cutbacks in personnel. The remaining workforce was overworked, but highly competent. The maintenance supervisor, in reaction to the first compressor failure (the triggering situation), decided to repair the compressor by installing non-OEM (original equipment manufacturer) parts. He would have installed OEM parts if they had been readily available, but they were not. To avoid extensive downtime at a time when customer demand was at a peak, he decided to have the part made at a local shop. After all, it was "only" a bushing (sleeve bearing).

After installing the bushing, the compressor was restarted. It ran for a few weeks then failed again. The response of the maintenance supervisor was the same – he thought the bushing failure was secondary to another primary failure. He had another bushing made, and restarted the compressor. It failed again. The story repeated itself one more time, until corporate resources were called in. The maintenance supervisor was fully expecting to be blamed for the series of failures (this is the same incident referred to in the initial paragraphs). Instead, the team identified the following latent causes:

- We are supposed to do the best we can do, without calling for outside help. Outside help cost money at a time we are trying to save money.
- Production is of paramount importance during certain times of the year – much more important than "using OEM parts."
- We are not sure when to do a root cause investigation. All we know is that they take a lot of time, and we just do not have the time.
- We rely heavily on the on-site OEM representatives for guidance. Since we were not advised against making our own parts, we do.

A full investigation revealed that the home-made bushings were, in fact, the cause of the second, third, and fourth failures (the first failure was caused by something else). Now, in retrospect, this maintenance foreman knows how critical that particular bushing is, and will never try to make his own again. However, if the plant wants to avoid similar incidents in the future, each of the above "flaws" within the his filtering process must be explored more fully – **each is crying for attention**. Even more, each of the above flaws is bound to exist in many other filters

throughout the plant. Undoubtedly, these same flaws are causing other failures "as we speak."

I am personally convinced that the latent causes of things that go wrong in industry can only be "solved" by involving many, many people in the dialogue. Each failure, as stated above, is an opportunity to expose additional people to the root cause mentality, and to sensitize them to those latent forces that are causing things to go wrong.

REFERENCES

[1] C. Nelms, *What You Can Learn from Things that Go Wrong*, First Edition. Failsafe Network, Richmond Virginia 1994

[2] C. Nelms, *The GoBook (Summaries, Procedures, Checklists, and Forms in support of Operation Failsafe)*, Third Edition, Failsafe Network, Richmond, Virginia 1994

[3] John S. Carroll, "Incident Reviews in High-Hazard Industries: Sensemaking and Learning Under Ambiguity and Accountability," *Industrial and Environmental Crisis Quarterly*, in press

[4] Charles Perrow, *Normal Accidents*, Basic Books, 1984

[5] Trevor Kletz, *Learning from Accidents in Industry*, Butterworths,1988

[6] Diane Vaughan, *The Challenger Launch Decision*, Chicago, 1996

BIOGRAPHY

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