

Is There a Direct Correlation Between Reliability and Safety?

By Robert J. Latino, CEO, Reliability Center, Inc.

Why Explore this Potential Correlation?

I recently presented at a conference called the Human Performance, Root Cause & Trending (HPRCT) conference. I listened with great interest to a presentation on Human Performance Improvement (HPI) by Dr. Todd Conklin and Dr. Sidney Dekker, advocating a 'Learning Team' approach. I had come to the conclusion at this conference that these *new* learning teams were being viewed as the basis for Human Performance Investigations¹. These learning teams were certainly being positioned by the speakers as a replacement for traditional RCA as known in the Maintenance and Reliability fields. So I wanted to know more, what is HPI?

Human Performance Investigation: HPI strives to understand and explain what happened without judgment, in order to understand the story and to provide a just and honest conclusion in each case. This gives the organization information that is incredibly comprehensive, makes it easier to identify what to correct than with 'old school' methods (Conklin, 2014, p. 45). HPI constructs the event context, and looks not at the individual pieces but at the relationships between those pieces (Conklin, 2014, p. 68).

So essentially to me, this was contrasting the basis between a Safety investigation and what we would call in Reliability as a 'Root Cause Analysis' or RCA. Being in the RCA business, this naturally piqued my curiosity.

I was not very familiar with this HPRCT conference but I quickly learned that it was predominately attended by progressive Safety professionals in high hazard industries (especially power generation/nuclear).

This was the first time I had heard Root Cause Analysis (RCA) referred to as 'old school' and 'obsolete', not to mention this was expressed by leading researchers and academics. This got me to thinking, given I have been in the RCA business for decades, is what I do for a living...obsolete?

To be honest, up until this point I had always *assumed* there was a direct correlation between Safety and Reliability, but I now realized that not everyone outside of the Reliability field, feels the same. So I sought out to understand why the differences in perspective exist; and is there a valid correlation between them?

¹ Conklin, Todd. 2012. *Pre-Accident Investigations*. Burlington. Ashgate Publishing Company.

An Ironic LinkedIn (LI) Post Caught My Attention

Shortly after this conference, I came across this graphic (See Figure #1) used in a LinkedIn post². It was quite a hot topic based on the responses it received.

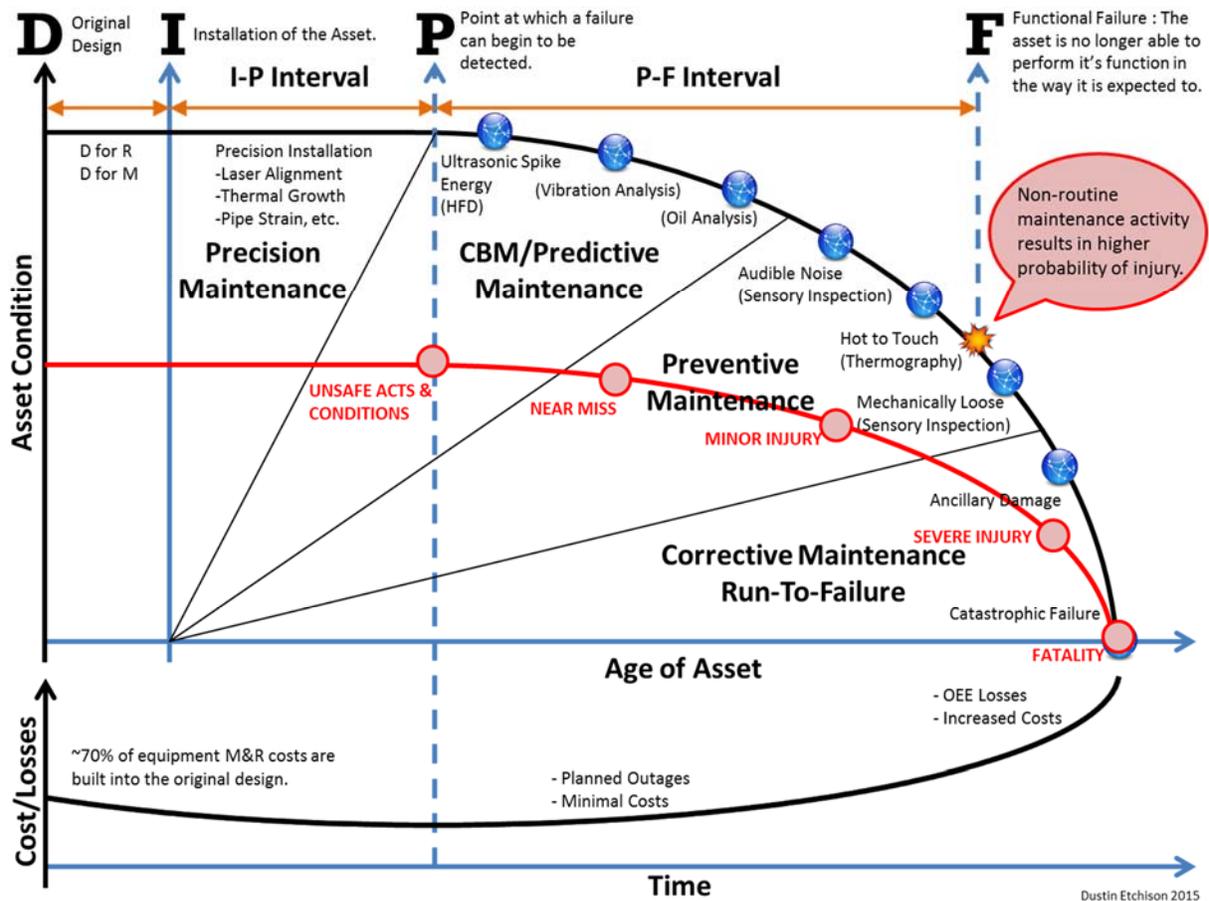


Figure #1. The Application of the Heinrich Pyramid to the DIPF Curve

Now this graphic drew the following conclusions in the cited posted paper:

- The probability of an injury is significantly increased with non-routine maintenance activity resulting from equipment failures.
- Connecting the importance of human safety to the importance of equipment reliability is critical in driving an injury-free culture.

² Etchison, Dustin. The Impact of Equipment Reliability on Human Safety. Accessed on 1.17.18 at <https://www.linkedin.com/pulse/impact-equipment-reliability-human-safety-dustin-m-etchison-cmrp/>

While this appears to make logical sense on the surface, is it true? Does a direct correlation exist between Reliability and Safety as these conclusions suggest? I wanted to understand the reasoning as to why experts in the Safety world would not agree with this expression of such a correlation.

It is a very prevalent position in Safety that the Heinrich Pyramid has been debunked for decades, so that is one reason they would likely not totally agree with the overlay of this Safety curve.

In an article entitled, 'Examining the Foundation: Were Heinrich's Theories Valid and Do They Still Matter?'³, James Howe (Safety Solutions in Medford, OR) is quoted as stating the following:

"The pyramid theory has really done a disservice to the safety profession because it has misled people running safety programs into thinking that if they work on minor incidents, major incidents will go away. And many, many companies are aware that that is not the case. In fact certain companies with award-winning low injury rates have suffered some of the worst catastrophic incidents during the past 10 years."

So as you can tell, there is no love lost for Heinrich's research to many in the Safety community. However, I am looking in generalities to see if there is a valid correlation between injury rates and organizational Reliability, and not seeking a debate on the validity of Heinrich's pyramid.

Keep in mind as you read this paper that comparisons are being made between the perspectives of Safety researchers/academics and that of career Reliability practitioners in the field. I think those dynamics play a role in the world view of both perspectives.

The Safety Research Perspective

As part of my exploration, I read Dr. Nancy Leveson's 'Engineering for a Safer World: Systems Thinking Applied to Safety'⁴. Dr. Leveson is a highly respected researcher and her text is a very well-respected one that is considered the 'Safety Bible' by many. I will add that I thoroughly enjoyed the read and learned a great deal. I pulled the following relevant excerpts from this text:

"Assumption 1: Safety is increased by increasing system or component reliability. If components or systems do not fail, then accidents will not occur.

This assumption is one of the most pervasive in engineering and other fields. The problem is that it is not true. Safety is a system property, not a component property, and must be controlled at the system level, not the component level. (Leveson, 2011, p. 7)

³ Johnson, Ashley (October 1, 2011). "Examining the foundation". Safety+Health Magazine

⁴ Leveson, N.G. 2011. Engineering a Safer World: Systems Thinking Applied to Safety. Cambridge: MIT Press

Her proposed 'New Assumption' was stated as:

New Assumption 1: High reliability is neither necessary nor sufficient for safety. (Leveson, 2011, p.13)"

This contradicts the common belief that there is a direct correlation between Safety and Reliability. I personally, being in the Reliability field for 30+ years, have always believed there is a correlation between Reliability and Safety, but I would assert it is not a direct correlation. This is because we can have a reliable operation and it still be unsafe, and we can also have a safe operation that is unreliable. As a word of caution, please note that a correlation is not necessarily causation.

But I firmly believe (and have experienced) that a reliable operation is inherently a safer operation, as opposed to an unreliable one. In a reliable operation, there are fewer stops and starts and unexpected situations that deviate from control systems in place (requiring a reactive response). It stands to reason then, under reliable conditions, there are fewer needs to quickly correct a deviation from a standard or norm.

However, Reliability is viewed by many in Safety as strictly a *component* property and as not having system properties (as Safety does). Many in Reliability would take issue with that assumption. But we have to concede that while we experience safety incidents due to poor Reliability, we also experience Safety incidents that have nothing to do with operational (component) Reliability. Injuries occur all the time in areas unrelated to the operation of an industrial facility.

As the DIPF curve clearly expresses (Figure #1), there are many facets to an effective Reliability process. For the purposes of trying to draw this correlation, I wanted to focus on understanding what detracts from optimal Reliability? If we better understand the systemic reasons why we have unexpected outcomes, would closing that gap make our workplace safer?

I have come to learn that based on the perspectives and definitions regarding Root Cause Analysis (RCA) in Safety, their approach and goals are different than those in Reliability. This is important because in the Reliability field, effective RCA is critical to optimizing Reliability. We have to 'control the fix' and not let the 'fix control the operation'.

Based on definitions and descriptions I have read and heard at these Safety conferences, many seem to equate all RCA as being equivalent to the comprehensiveness of the traditional 5-Whys approach. They view 'RCA' as always following a linear path. Unfortunately that is not how failure occurs in the real world. The only RCA approach I know that is strictly linear, is the traditional application of the 5-Whys. Any investigator worth their salt knows that most failure paths occur simultaneously and converge at some point to cause a bad outcome.

Safety also views 'RCA' as a tool where the deliverable is a single 'root cause', and that identified root cause is usually mechanical in nature (at the component level). Again, that perception of 'RCA' is simply inaccurate when compared to the realities of the proper field applications of RCA by seasoned investigators.

As Reliability is mischaracterized by Safety as not having holistic properties (viewing an organization as a system, not merely a series of mechanical components), it appears the same type of mischaracterization is taking place with their grossly limited view of 'RCA'.

The traditional 5-Why's approach (See Figure #2) simply lacks the depth and comprehensiveness to effectively analyze the more serious and complex incidents. While the 5-Why's has its positive attributes when applied under appropriate conditions, its expression of linearity and a singular cause limits its capabilities when investigating complex incidents with simultaneous paths to failure and complex interdependencies.



Figure #2. *The Traditional 5-Whys Approach*

Safety also appears to have a different approach and purpose to conducting an RCA. This perspective is based on personal observations; when there is a reportable injury and/or fatality, typically the wheels quickly go in motion to first ensure that all appropriate policies and procedures are in place to meet regulatory requirements. The first priority is often to ensure the proper safety controls and infrastructure were in place and therefore the corporation is less likely to be liable for any present and future claims. Once that base is covered (knowing all the paperwork and 'rules' were in place at the time of the incident), the search moves towards 'who' violated the rules/controls. This is typically followed by blame and discipline. Again, I speak

in generalities, because there are much more progressive organizations who do not ascribe to this particular approach to a Safety investigation. Certainly advocates of Human Performance Improvement and Just Culture do not support this blame mentality, but seek a system's understanding as well.

This bottom-up approach to understanding bad outcomes is the opposite of what I am used to in the Reliability world. As evidenced by the excerpt mentioned earlier from Dr. Leveson, many in Safety do not seem to believe that human performance and system's thinking are a critical part of an effective Reliability strategy, when in fact Reliability is not strictly component based, but systems-based.

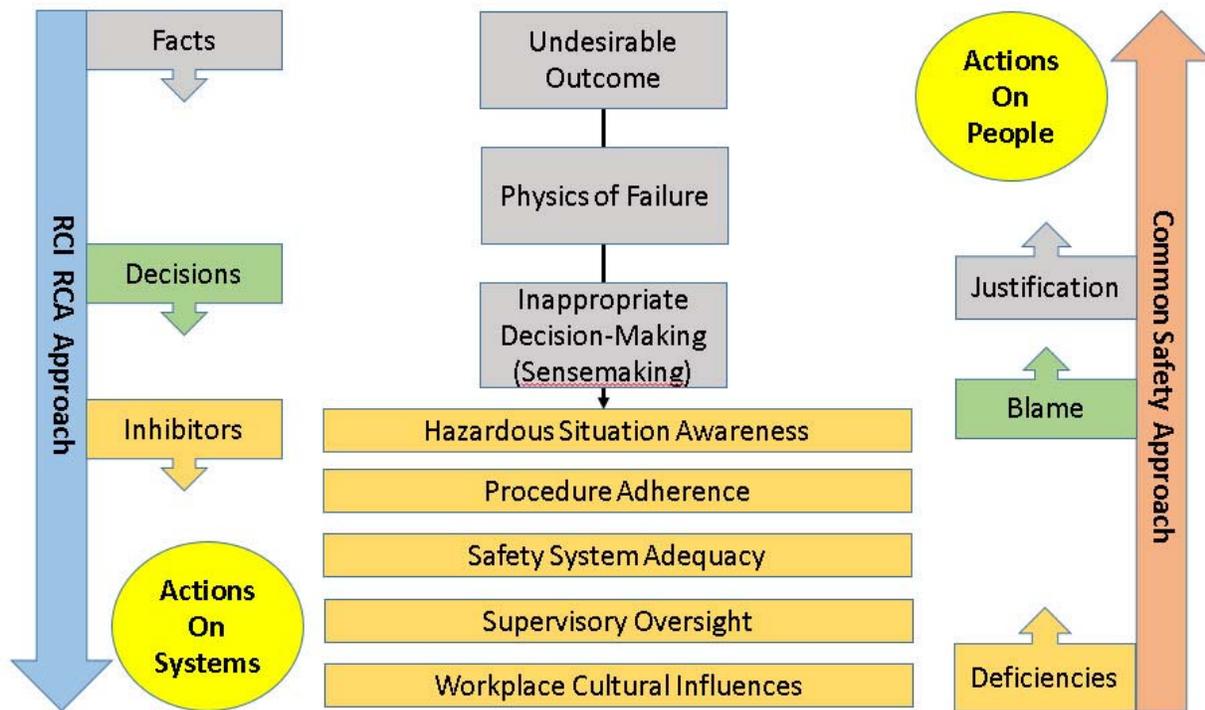


Figure #3. Differing RCA Approaches between Reliability & Safety

Let's now explore the Reliability practitioner's perspective.

The Reliability Practitioner's Perspective

Since optimizing Reliability has a great deal to do with thoroughly understanding gaps (expected and unexpected) in performance, RCA plays a big role in this understanding. If 'shallow cause analysis' is practiced, as opposed to 'root cause analysis', then such gaps in performance may continue to persist as failures will tend to repeat. So how we analyze deviations from an operational potential, is critically important.

There is an emerging group of Safety professionals that are advocates of Dr. Dekker's 'Safety Differently: Human Factors for a Different Era'⁵ approach. This group views all 'RCA' through a very narrow lens and therefore believes it is of limited value.

I believe their view and definition of RCA is not accurate at all, and does not represent the reality in the field of those who practice effective RCA approaches on a daily basis. Sure there is an abundance of 'shallow cause analysis' approaches that mask themselves as RCA, but that happens in every field (i.e. – RCM). We don't discount the value of the entire discipline because of the actions of a few bad actors within it. We move on and let our bottom-line results do the talking for us.

This is an example of this narrow view of RCA, from the Safety field. This is Dr. Conklin's published definition of RCA:

Root Cause Analysis: RCA is widely viewed as a reactive tool that requires a high severity trigger in order to be applied. The trigger could be excessive costs/downtime, regulatory violation, injury and/or death. RCA is often associated with being a tool applied effectively, only on mechanical (physical) failures. In a classic RCA, it deconstructs the event down to its minutest part, analyzes those parts and fixes whatever is broken (Conklin, 2014, p. 68)

In my white paper, 'Do Learning Teams Make RCA Obsolete?'⁶, I go into great depth to describe the elements of an effective, holistic RCA approach. In just breaking down this definition of RCA, Dr. Conklin is concluding that:

- RCA is strictly a reactive tool triggered only by severe incidents, and
- RCA is primarily only applicable to mechanical failures, and
- RCA stops at a component-level and identifies only a single, physical root cause

As a career Reliability practitioner with a specialty in RCA, the above conclusions are not an accurate representation of the practical application in the field.

As shown in Figure #3, in the Reliability world, the investigation starts with the available evidence (facts) and then strives to re-construct the failure. As the re-construction drills backwards in time we will normally come across causes attributable to the physical nature of the failure (i.e. – erosion, corrosion, fatigue and overload). However, a true RCA will continue to drill down and understand how those physical conditions came to be.

⁵ Dekker, Sidney. 2014. Safety Differently: Human Factors for a Different Era. CRC Press. Boca Raton.

⁶ Latino, Robert. Do Learning Teams Make RCA Obsolete? Accessed on 1.17.18 at <https://reliability.com/pdf/rca-vs-hpi-2017-rci.pdf>.

Inevitably we will come across a human element where there was a decision error. These are usually errors of omission (we didn't do something we should have) or errors of commission (we did something we shouldn't have). It is here, where it would be easy to blame the decision-maker. However, the more sophisticated operations and investigators realize that it is at this point, the investigation is really just beginning.

This is because the goal of a true RCA is to understand the reasoning behind the decision errors (the 'whys' or 'sensemaking'), and not necessarily who made the bad decision.

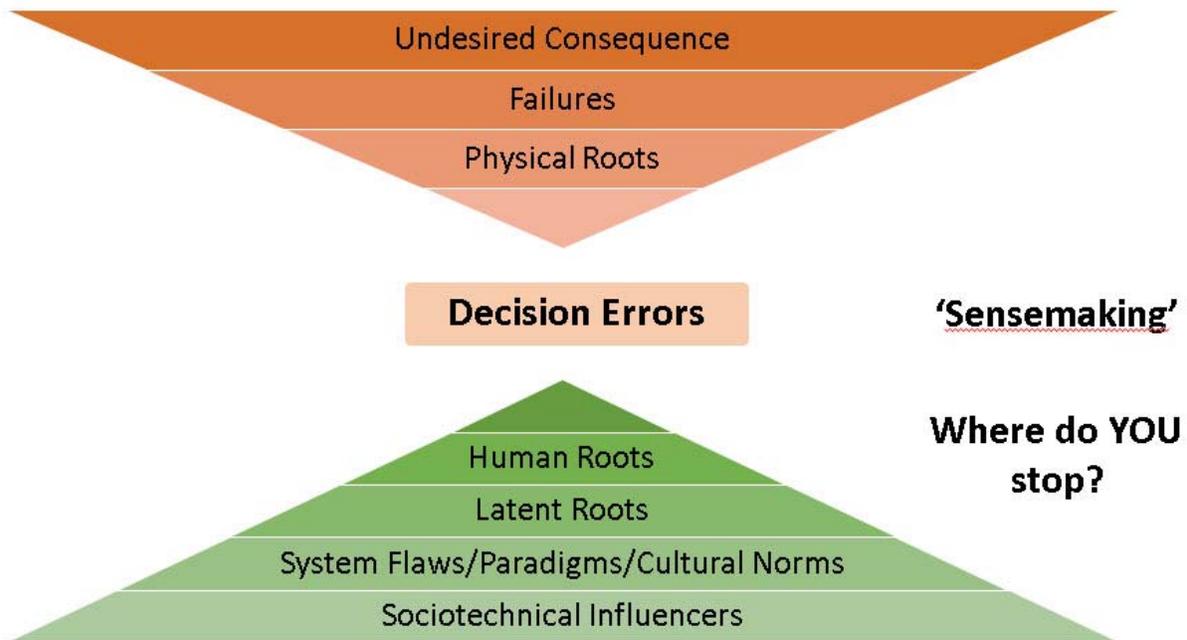


Figure #4. *Reconstruction of an Event When Applying Effective RCA Approach*

The reality from an RCA practitioner's perspective is:

- RCA can be applied proactively to analyze why unacceptable risks exist (as defined by risk assessment tools like FMEA), as well as near-misses (and even high frequency, low cost chronic failures)
- RCA can be applied to any gap in performance of any kind. Simple examples could be where financial expectations were not met, customer complaints, late deliveries, and lacking sales performance
- An effective RCA does not stop at the component level. It explores why good people made bad decisions at the time, and does not seek to blame someone. It goes on to ask 'why did the decision-maker think it was the right decision at the time?' The answers to these questions will uncover organizational system flaws, restraining paradigms, cultural norms and sociotechnical factors that

influences those decisions. This level of depth is where the gold is...but only if we choose to explore that level of depth!

Depending on where the investigator stops their reconstruction effort, will determine how effective the RCA will be. If we stop at the physics of the failure (i.e. - replacing broken parts), or worse yet at blaming someone, then we will likely see a recurrence of the event. If we stop short of understanding human reasoning, or system deficiencies, then I consider this a 'shallow cause analysis' approach. We may be compliant by regulatory standards, but that does not mean we are safer.

Uncovering system deficiencies will affect much more than the event we are investigating. This is because systems are created for populations of people and not just a single person. So when there is a system flaw (i.e. – an obsolete procedure that remains in place), the potential for an undesirable outcome is higher because other people using that system may make similar erroneous decisions.

Each of the intervals cited on the DIPF curve in Figure #1, could contribute to an overall lapse in Reliability if they are not functioning as intended. This simply means that an effective RCA could capture that deficiency and drill down to its systemic roots.

We can see, if one holds such a narrow view of RCA, it would certainly contribute to poor Reliability performance. If RCA's don't delve into understanding human performance and human factors, then the risk of recurrence is greater...hence is the risk of harm to employees is greater.

This is an excerpt from the BP U.S. Refinery Independent Safety Review Panel that is relevant at this point, "Preventing process accidents requires vigilance. The passing of time without a process accident is not necessarily an indication that all is well and may contribute to a dangerous and growing sense of complacency. When people lose an appreciation of how their safety systems were intended to work, safety systems and controls can deteriorate, lessons can be forgotten, and hazards and deviations from safe operating procedures can be accepted. Workers and supervisors can increasingly rely on how things were done before, rather than rely on sound engineering principles and other controls. People can forget to be afraid.⁷"

So, Does a Correlation Exist?

So far we have discussed the differing views of Safety and Reliability, and how they can result in differing conclusions. I often wonder if Safety were to define Reliability in the holistic manner that seasoned Reliability professionals do, would their perspectives be different?

⁷ 2007. BP U.S. Refinery Independent Safety Review Panel. Page i.

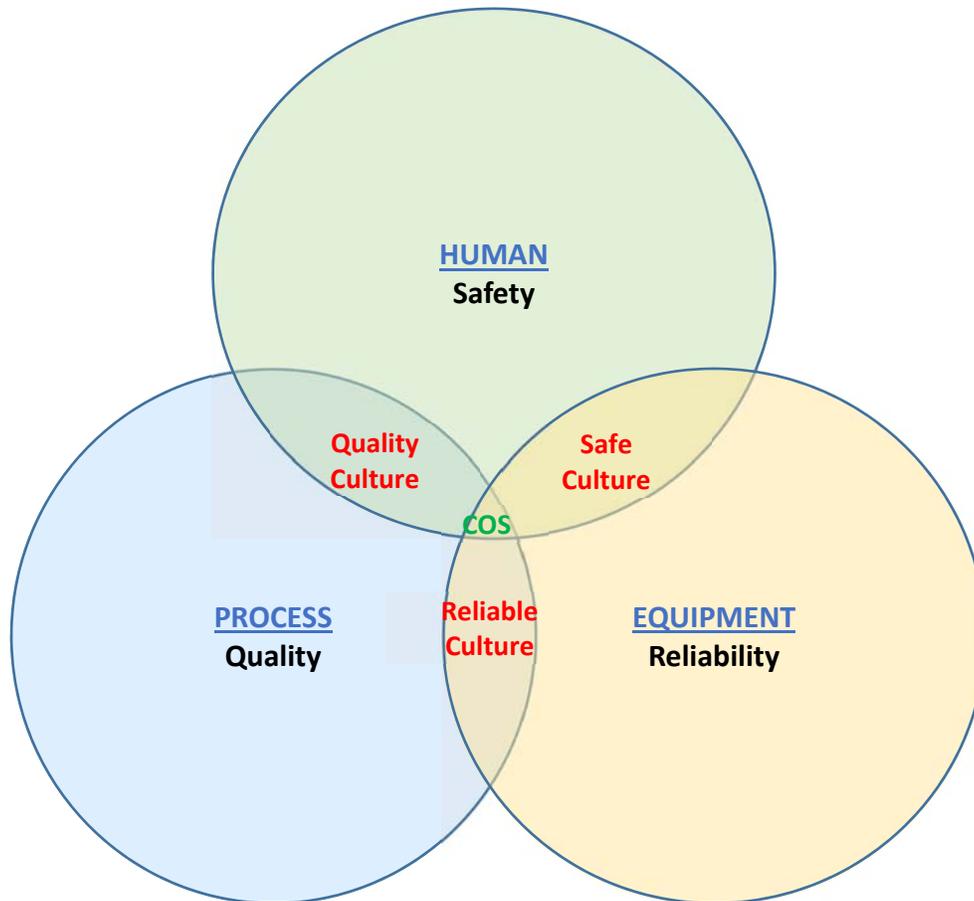


Figure #5: *Holistic Reliability: Equipment, Process and Human Reliability*

A holistic Reliability approach will include equipment, process and human Reliability. As Figure #5 shows, these critical elements of Reliability are inter-dependent. As stated earlier, many view Reliability only as dealing with equipment and its components. However, process Reliability is also a necessity for uniform operations. Product Quality, in part, relies on a reliable process. Lastly we have the human element which is integral to both equipment and process Reliability. Human Performance obviously is the foundation of Safety. So an effective Reliability approach will include Quality and Safety approaches in order to be successful. Unfortunately these fields are often treated as their own silos and operate independent of each other.

My initial intent was not only to discuss the potential correlation, but to seek out field data that would support or refute it. On my original LI post on this topic⁸, I asked for such data from those in the Reliability and Safety communities. With over 27k views of that post and over 100 comments, only one source of such hard data was offered to support such a correlation, although not a direct correlation (as I suspected). I will note that many who did respond were vehement that such a correlation existed in their experience, but their 'evidence' was more along the lines of 'gut feel' as opposed to having hard numbers to back it up. I too was in that 'gut feel' camp.

An article was brought to my attention, 'A Reliable Plant is a Safe Plant is a Cost-Effective Plant'⁹ by Ron Moore. I have known Ron from many years ago and reached out to him for his perspective on this important issue. In my opinion, Ron is undoubtedly one of the most respected Reliability pioneers of this era.

Ron stated that "This (Dr. Leveson's data) appears to be an incorrect interpretation or characterization of the data. My data says that safety is improved by improving system Reliability (and by inference component reliability). If you reduce the failures, both component and system level, you reduce the exposure to the risk of injury and therefore the probability of injury. However, I agree that it does not mean that accidents will not occur, since accidents are caused by any number of variables, some of which are not controlled by Reliability excellence. I also agree that Safety is a system property, not a component property, and must be controlled at the system level. In my view, one of the best, if not the best, measure for Reliability is OEE/AU, a system level measure. Reliability isn't just about maintenance, but her (Dr. Leveson) statements/assumptions seem to imply that it is. Indeed, my data says that maintenance typically only controls some 10% of the loss of production capacity captured in the OEE measure. Moreover, Reliability is driven by our practices in design, procurement, stores, installation, startup, operation and maintenance, all of which contribute positively or negatively to system level Reliability (not just equipment or components). Reducing the number of defects in these practices, both within each function and cooperatively as a team, will improve Reliability and reduce the risk of injury, while reducing costs and environmental incidents."

To ensure we are all on the same page, Ron's definition of OEE/AU used is as follows:

Overall Equipment Effectiveness (OEE) and Asset Utilization (AU) - both of which measure the percent of ideal at which a plant is operating – the higher the OEE or AU, the more reliable the plant. AU is OEE + No-Demand Losses; so if you're sold out, they're equal.

⁸ Latino, Robert. Is There a Direct Correlation Between Reliability and Safety?. Accessed on 1.17.18 at <https://www.linkedin.com/pulse/direct-correlation-between-reliability-safety-bob-latino/>

⁹ Moore, Ron. A Reliable Plant is a Safe Plant is a Cost-Effective Plant. Accessed on 1.17.18 at https://www.ice.com/A-Reliable-Plant-is-a-Safe-Plant-is-a-CostEffective-Plant-1266.html?lipi=urn%3Aii%3Apage%3Ad_flagship3_detail_base%3B1H3nPy1KS%2Fadof86TbHgEA%3D%3D.

In the article it shows a graph (See Figure #6) that demonstrates the correlation between Reliability (Production Capability) and Safety (Injury Rate). This graph is from a large U.S. manufacturing company (\$7B+ in annual revenues) over a five year period, representing 10+ plants around the world.

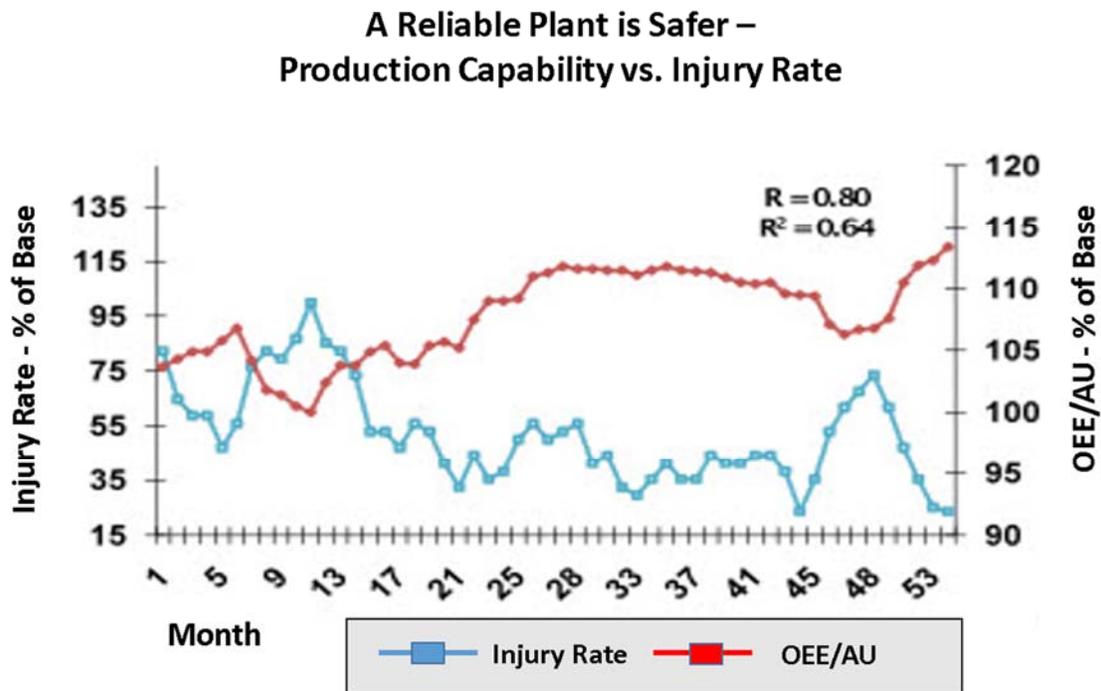


Figure #6. Production Capability vs. Injury Rate*

* The data have been normalized, that is, a base number was selected and all the other numbers divided by the base number. The correlation coefficient, or R, is 80% for this data, a remarkable correlation for industrial data. This data makes the argument that when the plants are running well (high Asset Utilization), then injuries are less likely. You're not reacting to the most recent failure and risking injury, as well as higher costs and poorer overall performance.

While I am citing only one case study of Ron's, he indicated he has several (6 that include paper mills, pulp plants, steel mills, food plants and chemical plants) but the results are all very consistent with each other. Based on this hard data, a strong case can be made that a reliable plant is a safe plant (as well as a cost effective plant and environmentally-sound plant).

Conclusion

We started this paper by exploring how Safety views Reliability, as expressed in Dr. Leveson's and Dr. Conklin's cited books. Their view of Reliability is very narrow from that of the seasoned practitioner's

perspective. If this research/academic view represented reality, the conclusions drawn in the text would almost certainly be valid.

However, when Reliability professionals talk about Reliability, they are applying system's thinking and looking at the whole business enterprise (i.e. – OEE and AU) - the refinery, paper mill, steel mill, chemical plant to be able to deliver its product in a timely, cost effective, and safe manner.

When Reliability is viewed as a holistic system and not simply component-driven, the field data presented, shows when the OEE improves, safety improves. Also, we have only been able to show data from a single organization, with multiple facilities. Ideally we would like to have like data sets from multiple organizations to increase the sample size. I am not sure if this data exists and I suspect, if collected from the different organizations, what was collected and how it was collected would vary widely.

Another concern that would come to mind would be leadership support at each organization and their respective infrastructures to manage the initiatives. We all know those variables would differ as well, making comparing the two data sets nearly impossible.

Some questions I would have of any data collected, would be:

1. In the case presented, we demonstrate a reliable operation is a safer operation. However, is a safer operation a more reliable operation (likely not as the costs and constraints of an ultra-safe operation would most certainly restrict optimizing Reliability)? These battles are fought daily on the production floors.
2. Does data exist to show the % of time that reported injuries and fatalities occur during uptime or downtime periods? Or, the % of time that injuries and fatalities occur during planned or unplanned downtime?

Relative to question #2 above, I was able to find the following data:

1. DuPont reported¹⁰ that the most likely person to be injured is*:
 - a. a maintenance technician,
 - b. with less than two (2) years' experience,
 - c. doing reactive work
2. Exxon-Mobil reported¹¹ that accidents are five (5) times more likely in maintenance when doing breakdown work than when doing planned and scheduled work.

¹⁰ Andrew Fraser. Reliable Manufacturing, Ltd.

¹¹ Levitt, Joel. Uptime Magazine. Aug/Sept. 2011

3. In ~66% of companies, ~60% of injuries occur while doing reactive maintenance¹².

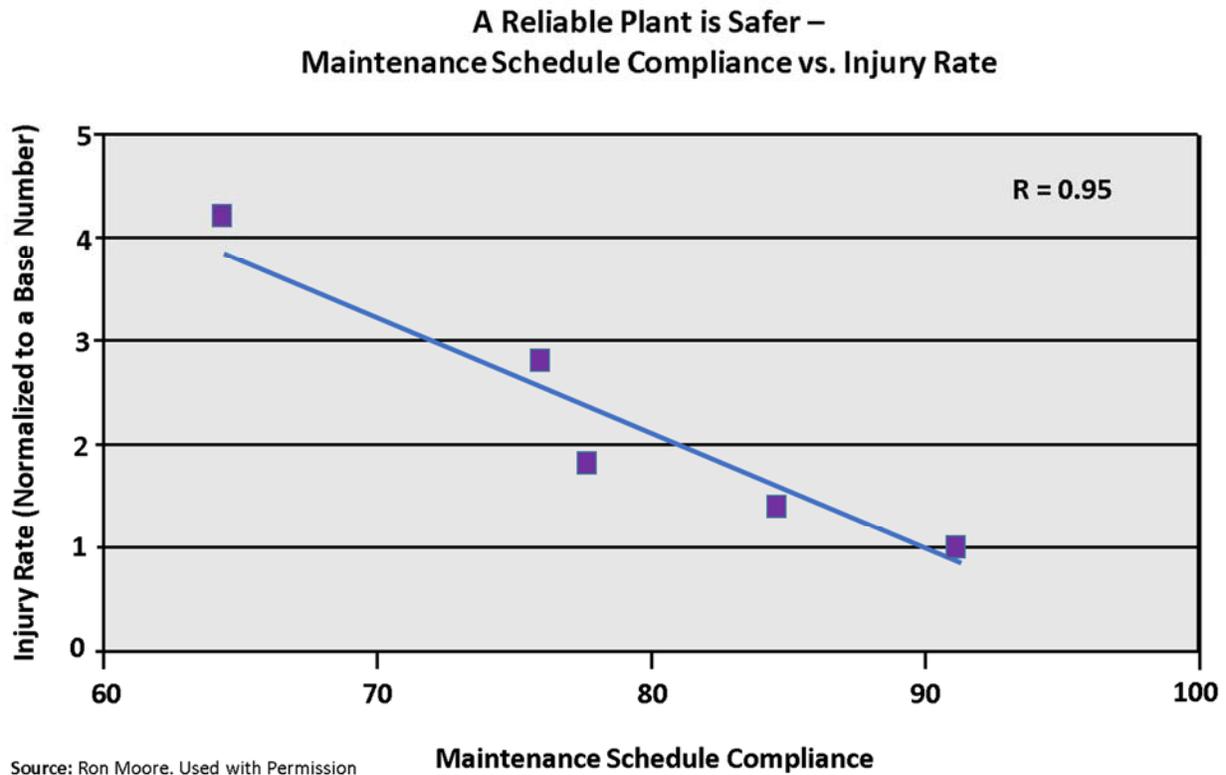


Figure #7. *Injury Rate versus Maintenance Schedule Compliance*

These reports are consistent with Ron Moore’s data, in this case, Figure #7 is demonstrating that injury rates are higher during periods of non-compliance with maintenance schedule (reactive maintenance)¹³.

This preliminary data supports that most injuries do occur during reactive periods (unexpected upsets and reactive maintenance). Given that, we have demonstrated a loose correlation exists, but not a direct correlation. We all know that safety is certainly impacted by the actions of those not directly responsible for optimizing operational Reliability, so injuries and fatalities can occur outside the envelope of Reliability.

If we work in a facility that runs continuously (high reliability operation) we worry less about getting hurt. When we have downtime (especially unplanned downtime), there is a disruption to the norm which introduces uncertainty and a degree of chaos. It is at these times where we do not feel as safe as we would

¹² Christer Idhammer, IDCON, Raleigh, N.C.

¹³ Moore, Ron. A Reliable Plant is a Safe Plant is a Cost-Effective Plant. Accessed on 1.17.18 at

https://www.lce.com/A-Reliable-Plant-is-a-Safe-Plant-is-a-CostEffective-Plant-1266.html?lipi=urn%3Ali%3Apage%3Ad_flagship3_detail_base%3B1H3nPy1KS%2Fadof86TbHgEA%3D%3D

during continuous operations. The individual is thinking more about solving the problem at hand and less about protecting their individual safety.

In the absence of such definitive data, I think this boils down to our own intuitiveness about safety and our own situational awareness.

I always like to end with something for us all to think about. This saying seems appropriate for both the Safety and Reliability topics discussed in this paper:

“We *NEVER* seem to have the time and budget to do things right, but we *ALWAYS* seem to have the time and budget to do them again!”

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