# HUMAN ERROR & ROOT CAUSE ANALYSIS

## A Quick Reference Guide

SOLOGIC®

— An eBook By Sologic

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# Human Error - An Overview

## Forward

As long as there have been humans on the earth, humans have committed errors. Most of the time, these errors do not amount to much. We burn the eggs, forget to move clothes from the washing machine to the dryer, take a wrong turn, or say something embarrassing. But sometimes our errors result in events that have significant negative impacts.

For instance, what happens when a nurse miscalculates the dosage of a medicine by a factor of 10? Or when a pilot chooses the wrong course of action during an in-flight crisis? Or when an unprotected worker in a chemical plant rushes into a confined space to render aid to an unconscious colleague?

These are the kinds of errors we encounter when conducting a root cause analysis. To that end, this eBook is intended to:

- Provide you with a brief and useful overview of human error.
- Root out some common misconceptions about human error.
- Help you manage human error in the context of a root cause analysis.
- Provide guidance for finding the best ways to control errors.

**KEY POINT**

**When the consequences of failure are severe, we need to minimize the risk of errors by identifying and controlling the underlying causes.**

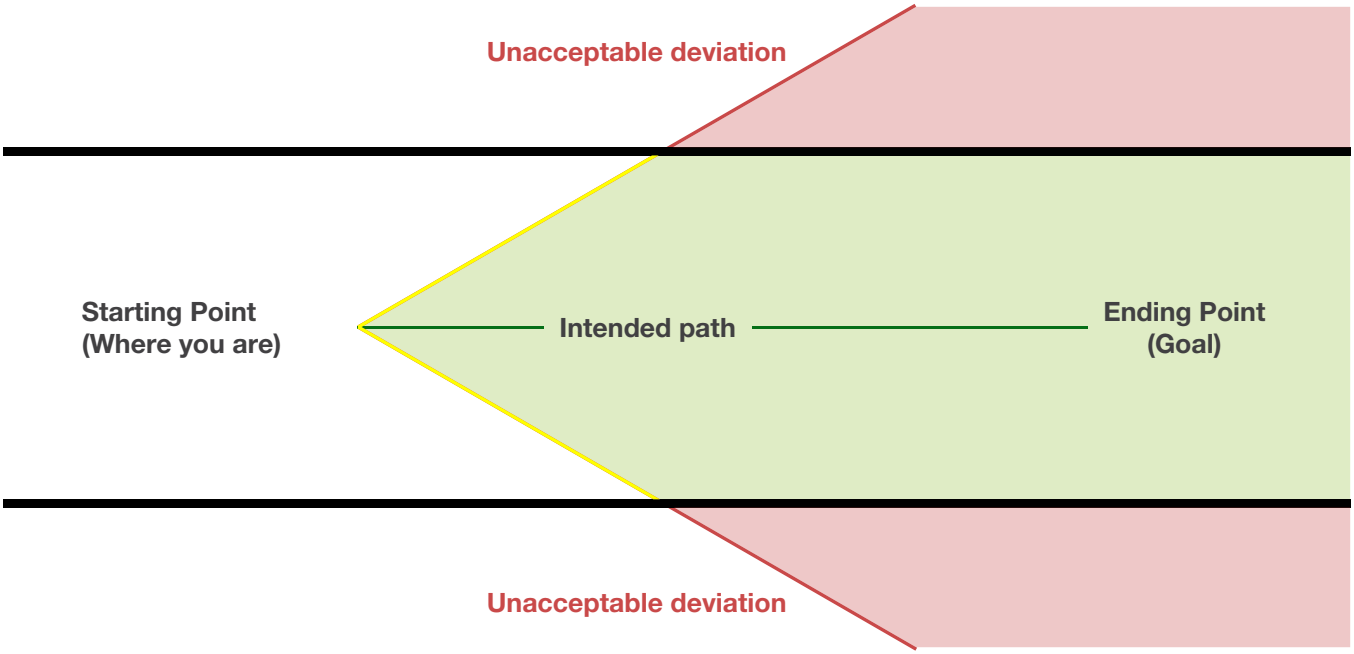
## Definition of human error

An “error” is a deviation from intent.

## Examples of human errors

| Intended Outcome | Actual Outcome |
|---|---|
| Perfectly fried eggs. | Eggs that are burned crispy on the bottom while still raw on the top. |
| A house painted with blue as the main color and white as the trim. | A house painted with white as the main color and blue as the trim. |
| Ordering 500 parts from a supplier. | Ordered 500 cases of parts from the supplier. |
| Open a chemical supply line to conduct maintenance. | Opened the chemical supply line while it was under pressure and containing residual product. |
| Lock-Out, Tag-Out completed and verified. | Tags placed on an energy source, but no lock. |

The list goes on, but you get the idea. The following figure may be helpful to visualize the mechanism of deviation:




This diagram shows the intended path to goal along with deviations.
Once the deviation crosses an upper or lower boundary (read: “Becomes bad enough”) it becomes a problem.

**KEY POINT**

**Any significant deviation from your intended pathway towards your goal represents a “problem.” Many problems have at least one human error component. If we are to achieve our goals, we need to become better at managing errors.**

## Common misconceptions of errors

### Errors are personal shortcomings:

This is absolutely not the case. Everyone commits errors. And no error on its own is sufficient to cause an undesirable outcome – it takes a system of causes (including the error) for that to occur.

### Errors are always bad:

No, not always. Sometimes errors lead to positive, unforeseen outcomes. The best systems protect people from the downside of errors while maximizing opportunities for upside potential.

### Punishment keeps people from making errors:

Hardly ever is this the case, and only under certain circumstances. The vast majority of people intend their actions to result in positive outcomes. Punishing them for committing an error is often not effective because it does nothing to address the underlying causes of the error. Punishment that is perceived as unjust will cause adverse events to go unreported and will cause people to withhold information in order to protect themselves and those they work with. This actually increases risk because issues cannot be effectively addressed when they remain hidden.

**KEY POINT**

**Everyone commits errors given enough time, errors are not always bad, and we cannot punish our way to success. Therefore, we need systems that are inherently less likely to result in errors.**

## Human error and human nature

Humans have an immense capacity to process information. We do this through our five senses. Even though the amount of information we process is enormous, we filter out most of it because if we didn't, it would be overwhelming.

When we draw conclusions based upon incomplete information, there is a chance we could be incorrectly or incompletely interpreting the situation. This sets up the perfect condition(s) for errors.

Everyone is different.  Each of us sees the world in our own way and through our own filters. Therefore, different people will interpret the same situation differently.

But when you think about it, our diversity is also the source of our innovation. Some of the best ideas were the result of failures, such as the "failed" adhesive on Post-It® notes. To err is human, but innovation can also be the result of unexpected or unplanned deviations.

We need systems that hedge against the downside of errors while creating learning opportunities that come along with calculated risk-taking.

**"Success represents the 1% of your work which results from the 99% that is called failure."**
**— Soichiro Honda**

**KEY POINT**

**Innovation is often the result of mistakes. In 1968, Spencer Silver of 3M was trying to develop a super-strong adhesive, but came up short. Then another employee (Art Fry) thought it would work to hold a bookmark in place in his hymn book, and he was right. This led to the innovative and widely lucrative Post-It® note product line!**

## Errors at different organizational levels

We are all prone to errors. But errors at the lower levels of the organization tend to be visible and to have immediate consequences, whereas errors at higher levels take longer to manifest and may not be readily apparent. A hole drilled in the wrong place, an imperfect weld, or an off-spec batch will likely be found right away.

Errors at higher levels may actually do more to put the organization and its people at risk because decisions at this level often have a much greater impact. And these kinds of errors may not become visible for a much longer period of time.

**KEY POINT**

**No matter where errors come from, we need to understand and control the causes of these errors. All of us need to do our part to own up to our errors by recognizing them as opportunities to improve.**

## Errors are born from risk

Have you considered where errors come from?

You might be able to predict what you will eat today, but will you be able to predict what the weather will be six months from now? Not likely. This is due to risk. While we often think about risk as being the potential for something bad to happen, this is only half-right. Risk is the measurement of variation. The greater the variation, the harder it is to predict what will happen, and the greater the risk.

But how does risk/variation lead to errors? When a system contains variables, it's harder to predict what kinds of choices you might be faced with. Decisions in the presence of uncertainty lead to a greater range of outcomes. And some of those outcomes will be undesirable. Systems with higher degrees of variation will always produce a higher number of errors over time.

Consider the following scenarios:

**Driving in a major city during rush hour:**
There are many variables in play during rush hour traffic which makes it difficult to predict. But what makes this scenario potentially dangerous is the fact that the cars are moving at a high velocity, they weigh a lot, and they are generally made up of hard things – whereas we humans occupying them are basically just fancy bags of water that are easy to damage. It's not a great combination.

**Riding a train:**
Riding a train is relatively boring and predictable. The engineer operates the train while the passengers sit and watch the world fly by. However, if something unexpected did occur, the people riding the train or who happened to be close by would be in danger. And trains are subject to others who could interact with the train, such as vehicles at a crossing.

**Flying in an airplane:**
Similar to travel by train, the passengers have no control over how the plane flies. Variations occur (weather, traffic, and mechanical anomalies for example). But over the past several decades, travel by plane has become extremely safe – mostly due to the rigorous problem-solving efforts by operators, manufacturers, and regulators.


**Assessing risk requires that we look for the variable components of an activity. The more variables, the harder the outcome is to predict. An environment with more variables is more likely to produce errors.**

## Errors are learning opportunities

Errors, no matter the outcome, are always learning opportunities. They show us where our systems are vulnerable. And if we do a thorough job uncovering the valuable lessons each error has for us, we can create more resilient systems that are less risky, more predictable, produce fewer errors, and are more likely to help us achieve our desired outcomes.

"Near-miss" (some would say "near-hit") events offer the best learning opportunities. These low-impact, high-potential events could have been a lot worse but for slight differences in the way they unfolded.

For example, a US Air Force flight crew flying a C130 on a night training mission in mountainous terrain nearly flew into the ground after the navigator accidentally mixed up the target drop altitude with the actual elevation above sea level. Had the pilot not recognized the error at the last minute and pulled up, the plane would have flown into the side of the mountain. This is an extreme example of a near-miss that involved an error, and it's also an invaluable learning opportunity.

**TRY IT!**

**Think about some of your most memorable errors. What learning opportunities did they provide for you? Did you actually learn from them? Who else could have just as easily committed those errors? What could be done to ensure that such an error could never be committed again, by you or anyone else?**

## Errors and disciplinary action

Did you ever have a coach who rewarded failure on the field or court with punitive exercise? Or a teacher who shamed a student in front of the class who did poorly on a test? Did you know there was a time when if a soldier assigned to watch duty was caught sleeping, he would be summarily executed?

While fear may govern our actions in the short-term, provide an example to others to "be diligent," and to "not mess up," how often are errors the result of an intent to do harm? While there are appropriate situations for disciplinary action, most of the time it is ineffective compared with alternative courses of action.

Highly punitive cultures cause people to be inherently afraid of failure. This creates a climate where employees avoid making decisions. And why should they? If things go wrong, the penalty for error is more severe than for doing nothing. This added burden of fear actually increases the likelihood they will make mistakes. And when they do, it increases the likelihood that these opportunities will go unreported. Energy is spent covering up errors and protecting our colleagues instead of openly examining them for opportunities for systemic improvement.

Why do you think some people choose to manage human error through punishment? Maybe they came up in such a system and see it as the only way. Perhaps they think that fear is a constant and positive motivator. It's possible they want to demonstrate decisive action in the face of failure. Or maybe they simply know of no other way.


**We can't fix it if we don't know about it, and people will be much less likely to report errors in a culture that punishes them for doing so. Recognizing that errors are the consequence of deeper underlying causes that we can identify and correct offers us the pathway to building more resilient systems.**

# Managing Errors in a Root Cause Analysis

## Error recognition and managing emotions

Finding an error isn't hard. In fact, errors can be discovered in most RCA investigations. And while you may know that an error represents a valuable opportunity, it can be uncomfortable for the person or people involved. Even if you've taken disciplinary action off the table, it can still be very difficult to admit our mistakes.

We've been conditioned since we were young that making mistakes is nothing to be proud of. Exposing mistakes and analyzing them in front of a group of peers may put even the most level-headed person on the defensive.

One way to help mitigate this is to set a positive tone from the very beginning. Explain up front that errors are opportunities, that the team has an obligation to understand the underlying causes of the error and then act to keep the error from happening again.

Watch for signs of discomfort and defensiveness and be prepared to counteract them. You may want to send the group on a break and then discuss it one-on-one with the uncomfortable person/people.

**KEY POINT**

**Imagine you are the person who committed the error. What would the RCA Facilitator need to do in order to make you feel comfortable discussing it in front of your co-workers?**

## Sources of causes and evidence

It is helpful to recognize that causes and evidence come from multiple sources, only one of which has to do with people. Consider the following statement:

**"People interact with hardware/software/systems via procedures, and they do this in some sort of environment."**


This is nearly always true. Yes, people play a role in many different types of events. But they don't exist in a vacuum. We can, and should, find causes from a variety of different sources and then show how they act together to contribute to any given outcome.

For example, I have a friend who came to me and said that his car was "driving funny" ever since he filled up the tires. Apparently it was bouncing around and having a hard time tracking. When I asked how full he filled the tires, he said "all the way."

Now I'm no genius, but I know that tires have a certain optimal pressure level. So this answer puzzled me. "All the way?" I said... what does that even mean?

Of course, I had to see this for myself. When I saw the tires on his car, they were so obviously overinflated they looked more like roller blade wheels than car tires. After checking the pressure with a tire gauge, I found that each tire exceeded the range of the gauge. The gauge goes to 50 lbs per square inch but it instantly jumped to the maximum. After letting out what I considered to be a substantial amount of air, I tested again... and saw the same result. Wow! How did they get so full?

# Managing Errors in a Root Cause Analysis

My friend has very limited experience with cars. He grew up in New York City and rarely ever drove anywhere. When he saw the “low tire pressure” indicator on the dashboard, he knew enough to seek out a tire pump at a gas station. But he mistakenly thought he needed to fill the tires until they would not accept any more air... in other words, “all the way.”

In this scenario, you can see how my friend might be ridiculed for his ignorance of proper tire inflation. But objectively, he was only one factor.

The tires were low in the first place... why were they low?

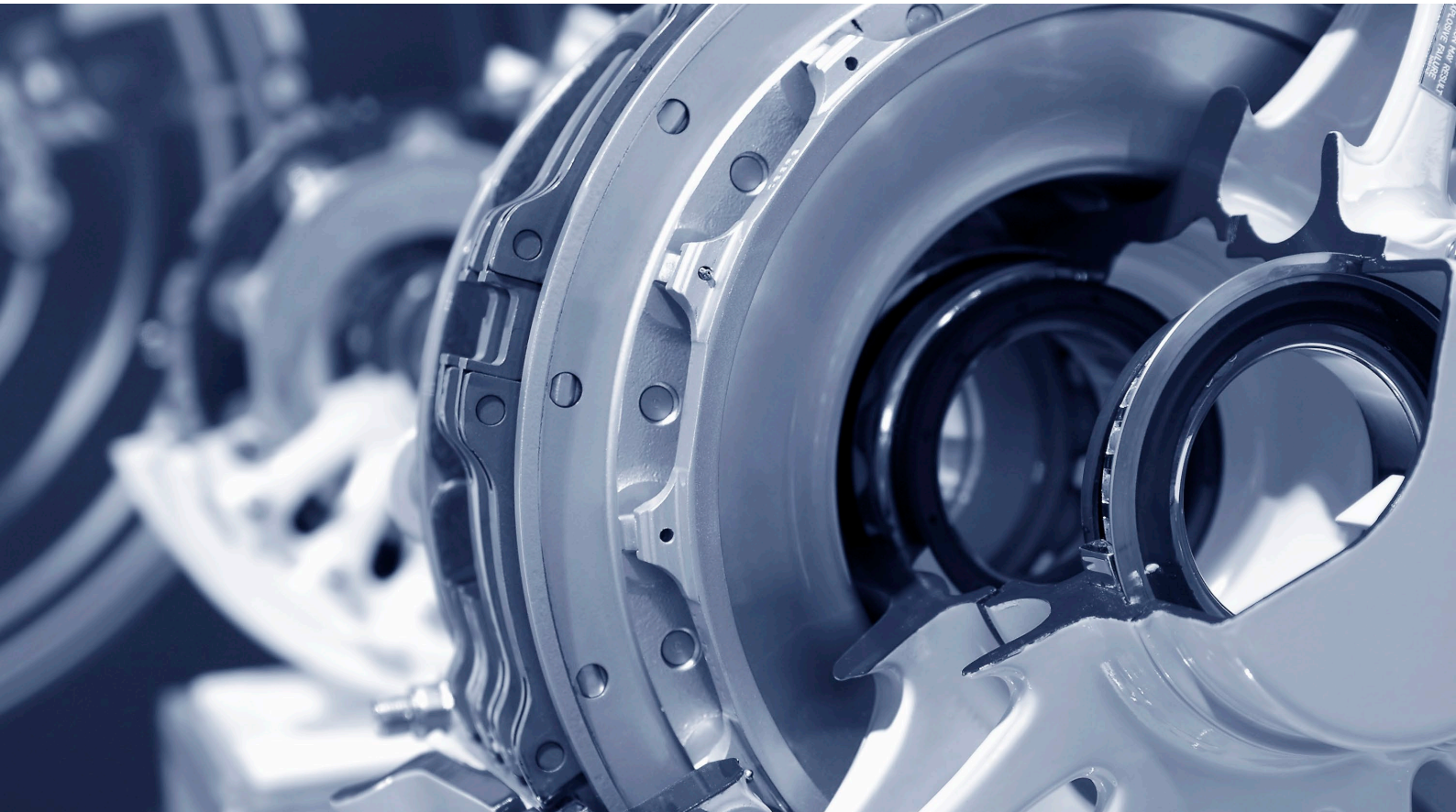
He did not follow a standard step-by-step procedure, choosing instead a more ad-hoc course. Why did he make this choice?

The air compressor was not equipped with any kind of auto-shutoff once it reached a certain pressure. Why not?

So you can see that people, procedures, and hardware all come together to result in the overinflated tire situation – it’s never just one factor. In fact, given all these different factors, this outcome was all but inevitable!

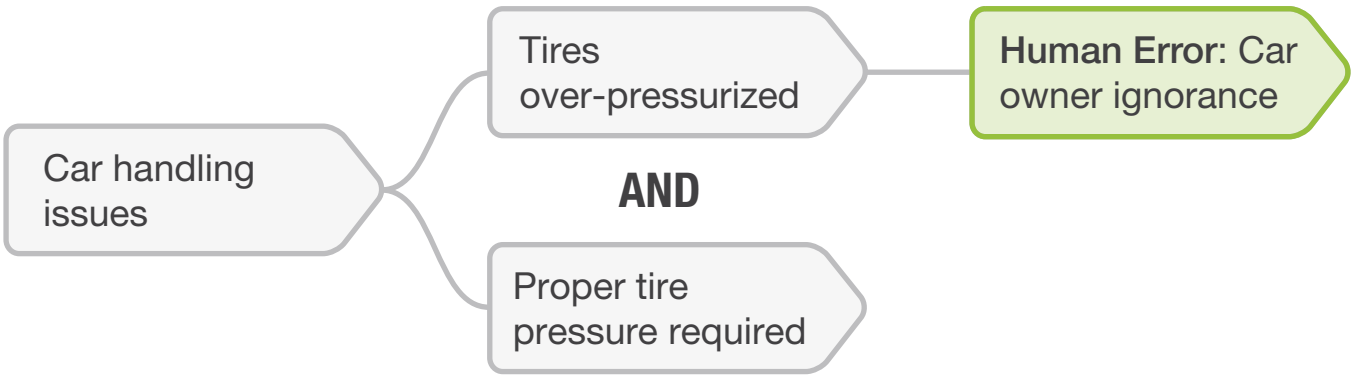
**KEY POINT**

**When people see that they are just one contributor to a problem, and not the sole or most important contributor, they are less likely to feel singled-out and defensive.**



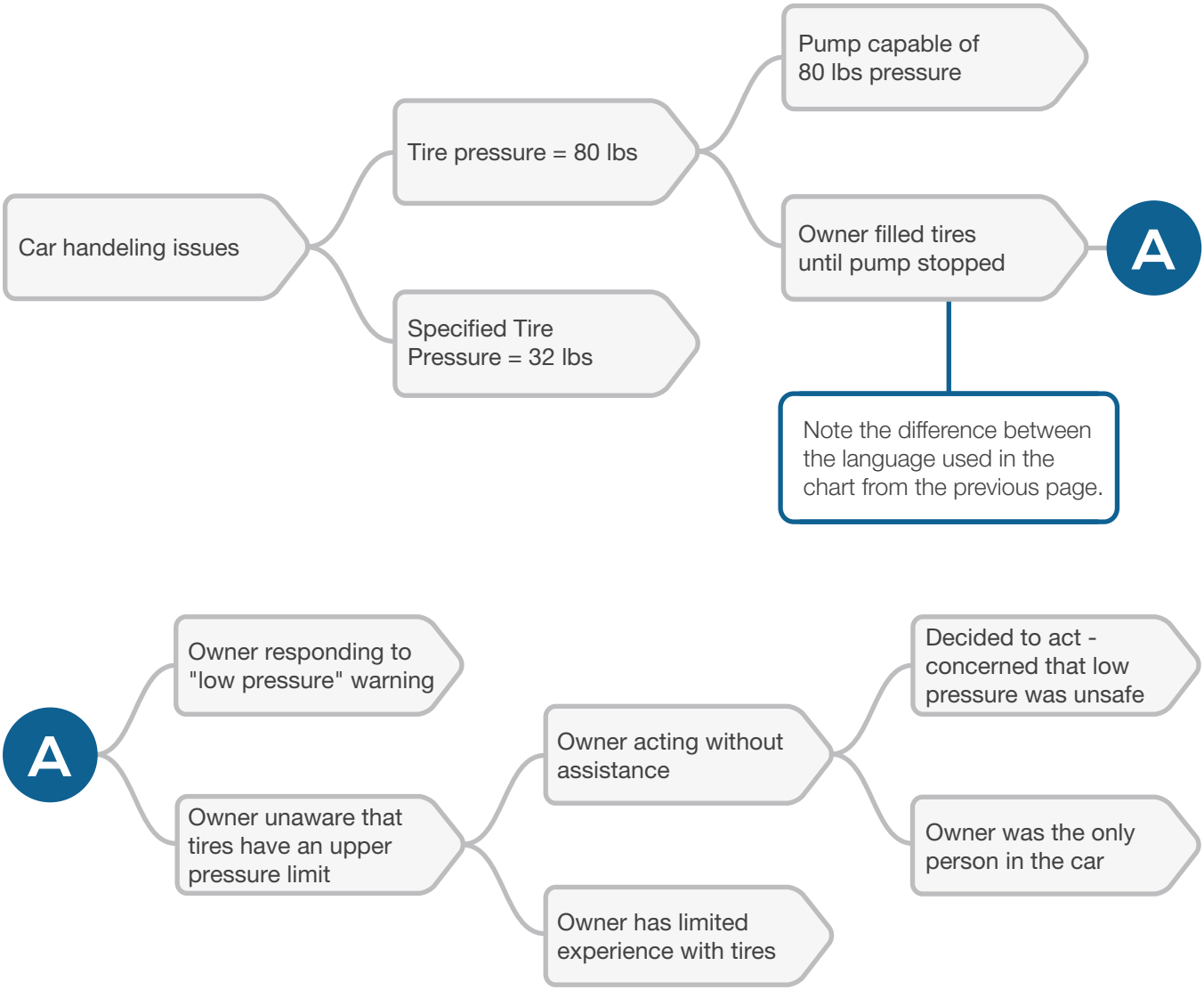
## "Cause + 2" Strategy

Too many people stop investigating once they've found an error. But this always compounds the problem. We need to identify the causes that led up to the error and apply solutions to them. Focusing solely on the error leaves its causes in place, ready to potentially play a role in future errors.




By stopping at the error and using judgmental language such as "wrong," we are left with few good options to understand how the error occurred and, more importantly, how to actually solve the problem. It also sets up a 'blame' environment. We need to go beyond the error to gain a deeper understanding. The "Cause + 2" strategy suggests going ***at least*** two causes beyond the error.

## Let's try again...




We now have a much clearer picture of how the error occurred, and much better options for preventing it from happening again.

**KEY POINT**

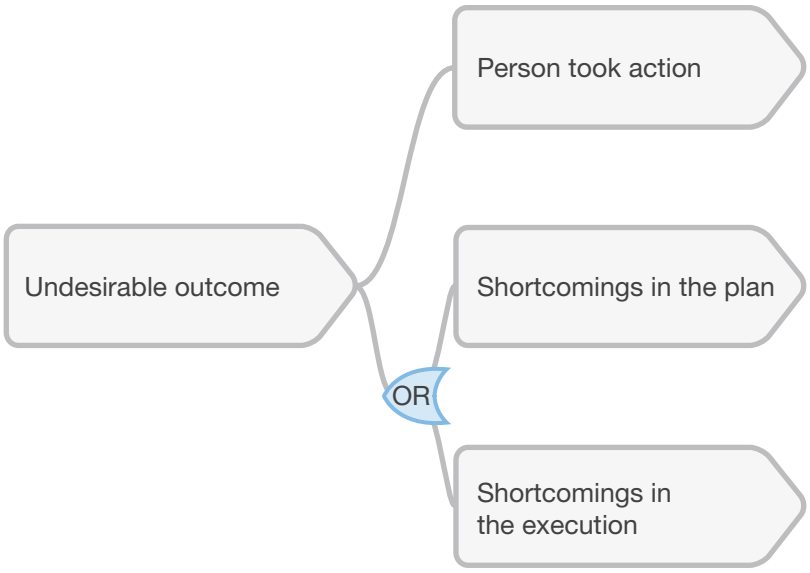
**We need to resist the urge to stop investigating when we find an error. An error isn't the end of an investigation, but the beginning! When we examine at least two levels beyond the error, we discover what led up to it. This sets us up for more effective solutions.**

## Error types

An undesirable outcome can be thought of as the result of either an ineffective plan or ineffective execution of the plan, or sometimes both. In the example above, the car owner planned to add air to the tires, but the plan was ad-hoc and informal. It was missing certain important steps that would have been helpful to a person with limited knowledge and experience. However, the execution was flawless... the owner managed to start the pump and get air into the tires.

Sometimes the opposite is true. A person may have a complete and validated plan, but fail to execute the plan effectively. We see this often in sports when a coach calls in a play, but the players on the field fail to execute the play. If you've ever heard anyone say in frustration "I know what to do, I'm just having a hard time actually doing it!" you'll know that the outcome is the result of execution shortcomings.

Exploring these types of errors can be very helpful in understanding how the error occurred and can provide valuable insights into how to fix it.




**KEY POINT**

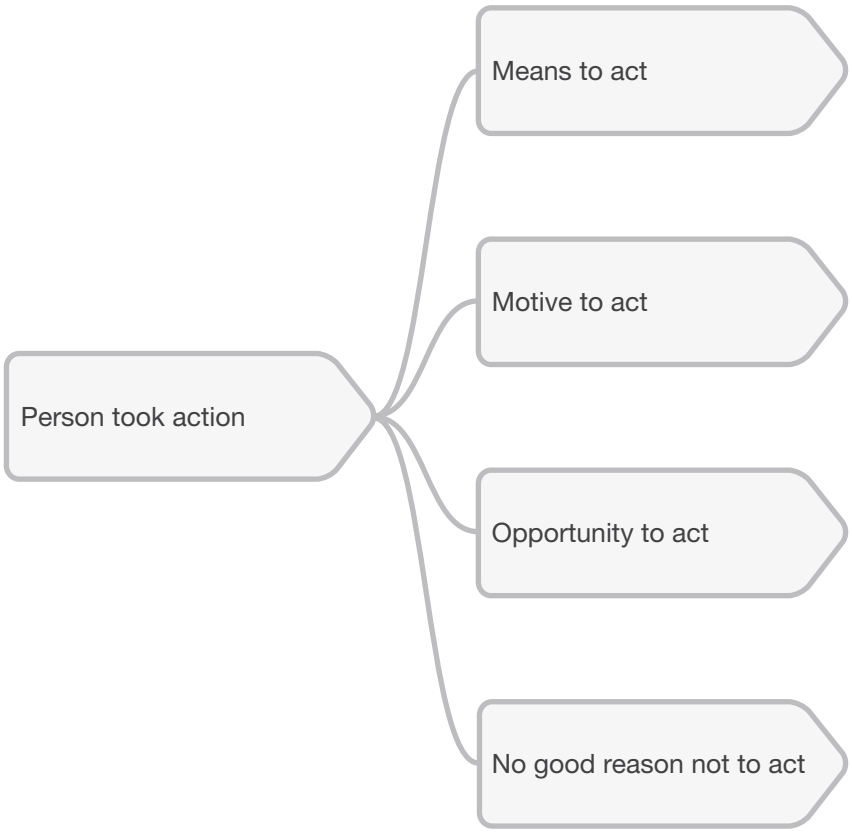
**Think back to a time when you made an error... was it an execution failure or a breakdown in the plan? Or were there elements of both?**

## Why do people act?

In the cause model on the previous page, we see that the "person took action" was a critical part of the error. In fact, it's not possible for a person to commit an error without deciding to act. But what are the underlying components of such a decision?

- Means to act: You cannot take action if you aren't capable of acting.
- Motive to act: You will not act without motivation.
- Opportunity to act: You cannot act if you don't have the opportunity.
- No good reason not to act: If a person has a good enough reason not to act, they won't.

In the tire over-pressurization example, my friend had the **means** to do what needed to be done to get air into the tire. He was also **motivated** to take action – he saw the indicator showing low pressure and wanted to fix it before it became a more serious problem. He also found the **opportunity** to act – he was passing by a service station with air supply equipment. And he saw **no good reason not to proceed** with the operation.




**KEY POINT**

**Understanding the causal basis for action is very helpful in understanding the error and provides a great foundation to identify solutions.**

## Sources of Errors

Okay, so now we know a bit about why people take action. But what would cause an execution or planning failure?

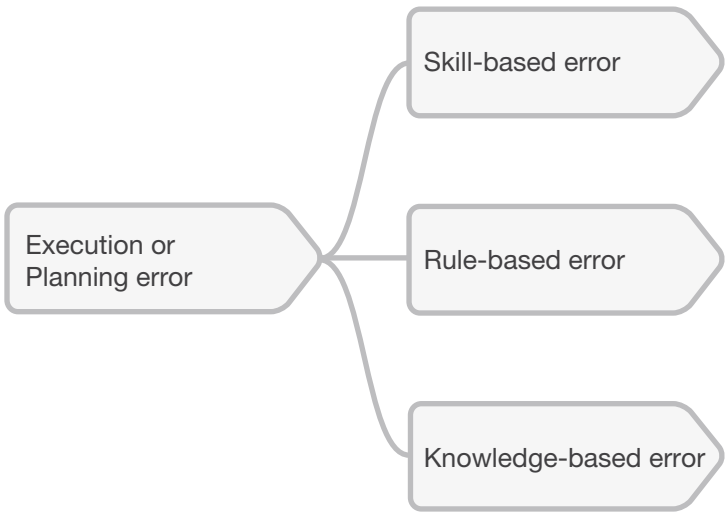
The inimitable James Reason has provided us with a very helpful model for characterizing these sorts of failures and it centers around the experience level of the person or people involved.

**Skill-Based Errors:** Sometimes we just make mistakes while carrying out routine tasks. We know how to do the work, we have done it often, and we still mess it up. An example of this would be putting the milk away, but in the cupboard rather than the refrigerator. Skill-based errors are slips or lapses.

**Rule-Based Errors:** Other times, we are presented with a situation that calls for a bit more thought. In these cases, we often apply a set of "if, then" rules. For instance, if I see a white wire and a black wire attached to a plug, then I know the black wire is "hot" and the white wire is neutral. But if the wires were reversed, my error would be rule-based because I applied a rule (that is usually true), yet did not achieve the desired outcome.

**Knowledge-Based Errors:** Given enough time, life will present us with a unique situation for which we have limited knowledge. In these cases, we will be more likely to commit an error due to the unique nature of the event. Go back to the example of my friend and his over-inflated tires. He had no previous skills, rules, or knowledge regarding the process of filling tires to the proper pressure. Therefore, the outcome was the result of a knowledge-based error.

When investigating errors, consider which of these types it more closely aligns with. This will provide you with a more robust understanding of the error and point you towards solutions to help reduce the risk of recurrence.



# Solving Human Error Problems

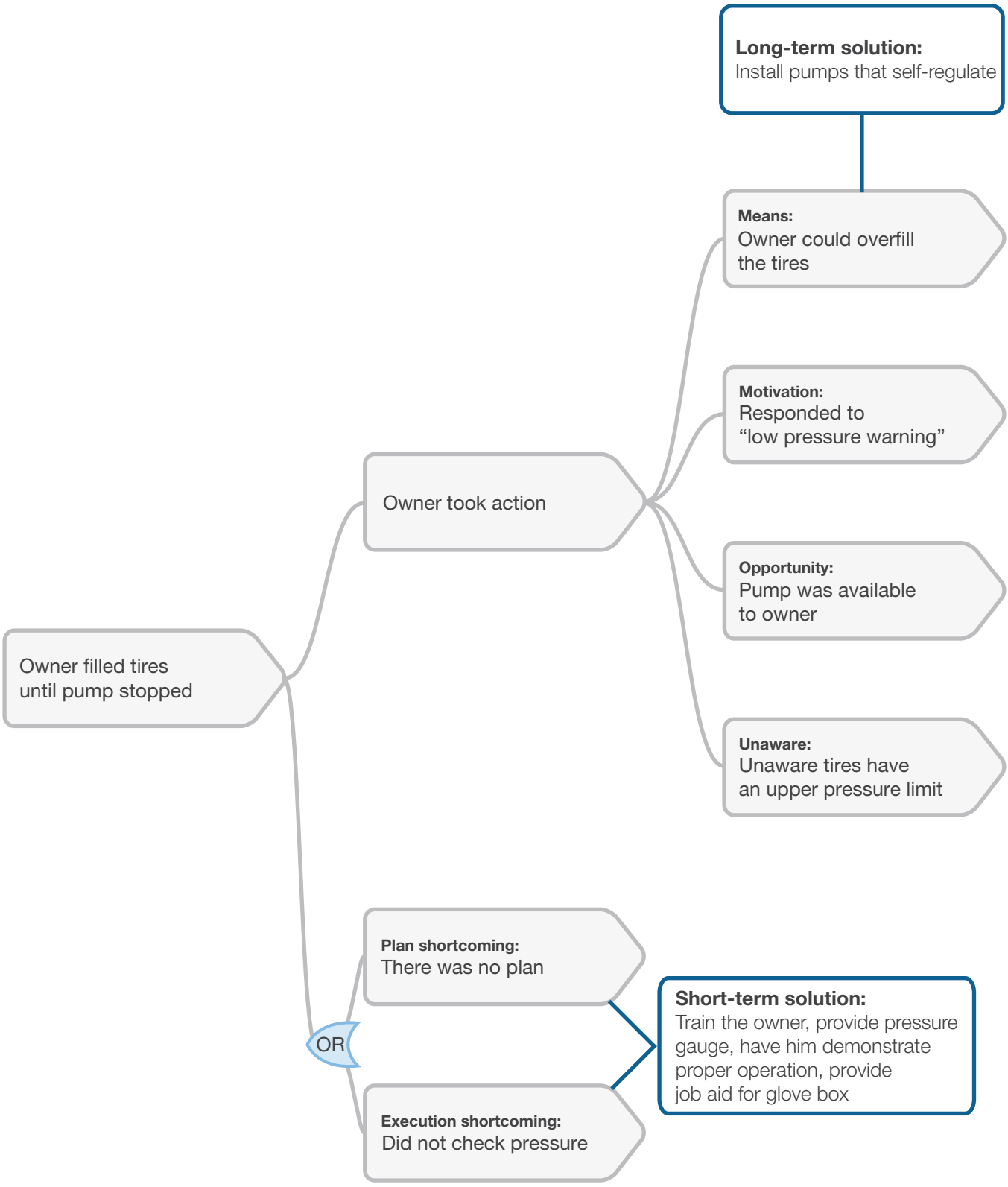
Once you have a thorough understanding of the error, you can proceed to solving it. The only way of preventing a problem from happening again is to control one or more of its causes. If you've done a good job with your causal analysis, you've got a terrific basis to develop a set of solutions. That's right... a set of solutions. Nothing says you have to limit your efforts to a single cause. In fact, the best way to solve a problem is by identifying a list of short-term things that you can accomplish right away along with longer-term solutions that may require a larger investment in time and money. Just be sure you aren't recommending solutions that cost more than the problem itself is worth.

Examples of shorter-term solutions include changes to procedures, training, auditing, and supervision. These solutions often provide an immediate and cost-effective means to reduce the risk of the same error happening again. However, if you want to build resiliency into your systems, you need to find solutions that engineer the risk out of the system for everyone.

For instance, going back to the tire over-pressurization error, we could immediately train my friend how to use a pressure gauge, operate the compressor, and ensure that the tires were inflated properly. We could provide a job-aid that he could put in the glove box. We could even make him demonstrate proficiency. All of these actions will help reduce the risk of this happening again... for him.

But how far will those limited actions go towards eliminating the risk of similar future errors? I had the same issue a few weeks ago... the tire pressure indicator warning appeared on my dashboard and I pulled into the service station. But the air pump was different than I had seen before. This pump asked me to dial in the appropriate pressure. Then all I had to do was fill the tire until it reached the pressure I entered. Had my friend used a machine like this, he never would have had the problem in the first place!

# Putting It All Together



# Going Forward

1. Be sure to understand the common misconceptions about human error.
   a. Everyone commits errors
   b. Not all errors are bad
   c. Punishing people for errors is rarely effective
2. Errors have causes, just like any other event. We control errors best when we control the causes of the error.
3. People may be uncomfortable discussing errors. But this typically goes away when they see how their error was only one of the causes in the system.
4. Be sure to go at least two causes beyond the error in order to identify it's precursors.
5. Look for errors in planning and execution.
6. Look for skill-, rule-, and/or knowledge-based errors.
7. It's best to find multiple solutions for any problem.
8. Solutions that only focus on people will have limited impact.
9. Solutions that engineer out the risk will be much more sustainable and resilient.

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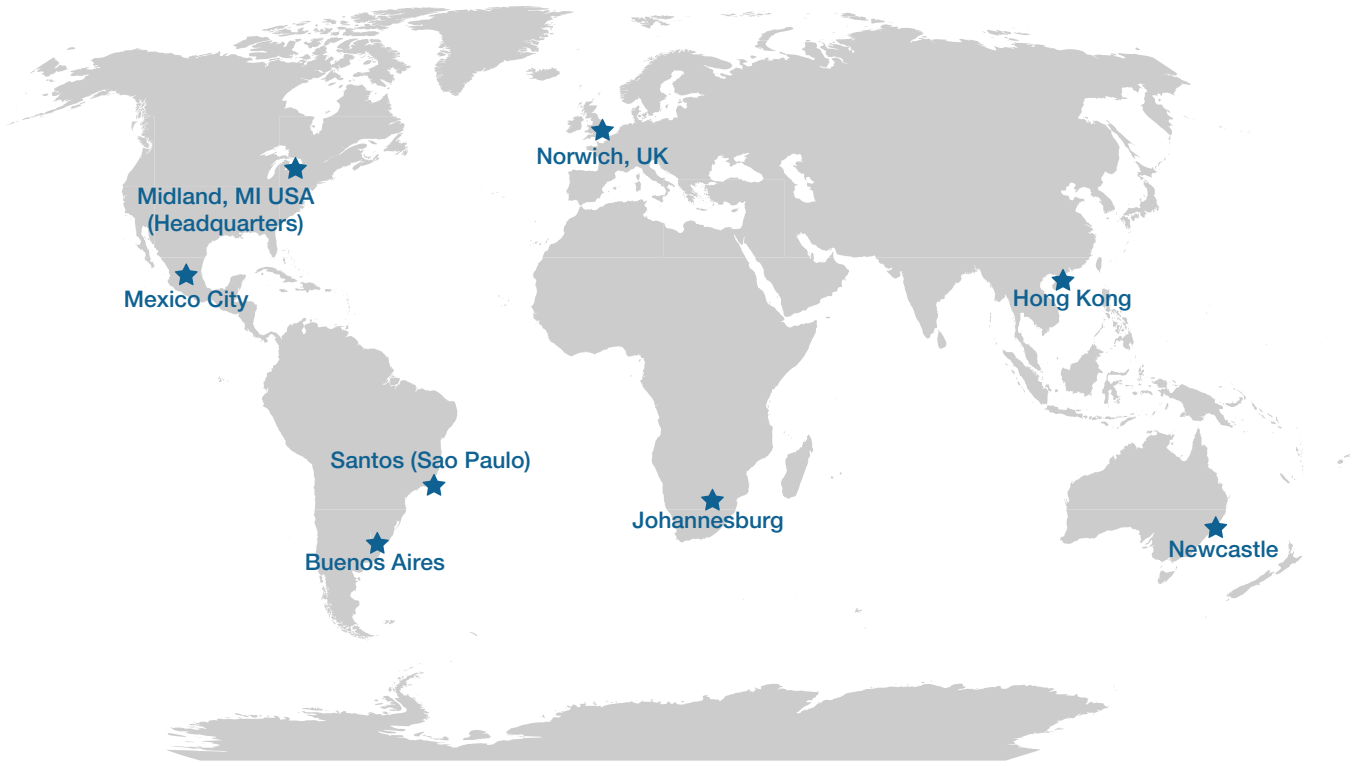


## USA and Canada
info@sologic.com

## Asia & Pacific Rim
asia@sologic.com

## Europe
europe@sologic.com

## Mexico and Central America
mexico@sologic.com

## South America
southam@sologic.com

## Africa
africa@sologic.com

## Australasia
australasia@sologic.com