

The True Meaning of Root Cause and Root Cause Analysis (RCA)

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TE Connectivity
2013 ASQ World Conference
ICQI 22 (with updates)



Why This Topic

- Gary Jing, Flip The Switch - Root Cause Analysis Can Shine The Spotlight On The Origin Of A Problem, *Quality Progress*, Oct. 2008, P50 – 55.
- Gary Jing, Digging For The Root Cause, *Six Sigma Forum Magazine*, May 2008, P19-24.
- Gary Jing, Root Cause Analysis and Troubleshooting Techniques, *Encyclopedia Of Information Systems And Technology*, To be published.
- Gary Jing, PEX Video Interview on RCA, April 2013, <http://www.processexcellencenetwork.com/six-sigma-quality/videos/are-you-troubleshooting-or-getting-to-true-root-c/>



Topics to be Covered

- The true meaning of root cause
- The point of RCA
- The connection between troubleshooting and RCA
- Techniques generic for RCA
- Techniques good for troubleshooting
- Summary

* The workshop is based on the publication series the speaker authored



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Speaker's Connection to This Topic

ASQ Fellow, MBA, PhD in IE, CQM / CQE
Sixsigma DFSS Award. Finalist of IQPC MBB of The Year.
 Editorial Review Board of [Six Sigma Forum Magazine](#)
 Founding MBB @ Seagate TCO
 Sr. Mgr., Global LeanSigma / Founding MBB @ Entegris
 LDFSS Deployment Leader / MBB @ TE Connectivity (ADC)

Two patents in disc drive modeling from his Sigma work
 Series publications on Lean Sigma
 Personally trained dozens of BB's
 Development of ASQ BB Certification Program (participant)
 Delphi panel expert for SME/AME/Shingo Lean Certification Program
 More details on <http://www.linkedin.com/in/ggaryjing>.



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The Definition of “Root Cause”

From Wikipedia:

- A root cause is an **initiating** cause of a **causal chain** which leads to an outcome or effect of interest. Commonly, root cause is used to describe the depth in the causal chain where an **intervention** could reasonably be implemented to change performance and prevent an undesirable outcome.
- The term root cause has been used in professional journals as early as 1905, but the **lack of a widely accepted definition** after all this time indicates that there are significantly different interpretations of exactly what constitutes a root cause.

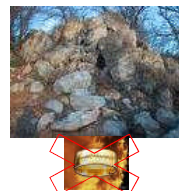


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The True Meaning of “Root Cause”

- A Paradigm Shift

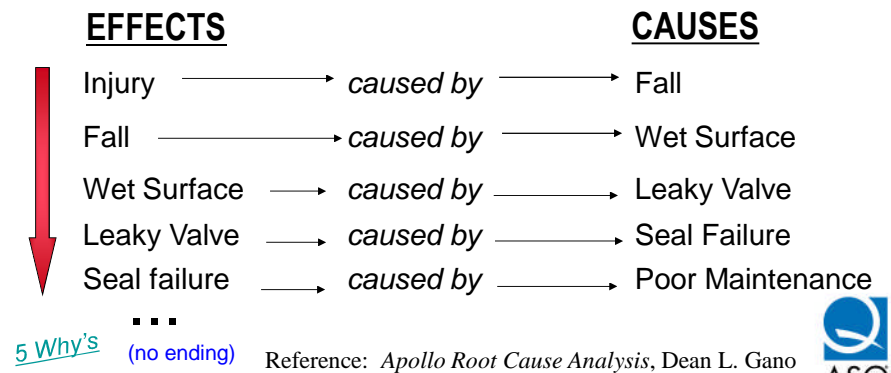
- “Have you found ‘the root cause’ yet?”
 - The term “root cause” is somewhat misleading
 - Tons of publications explaining tools / methods to do RCA
 - Hardly any literature explains or explores the true meaning of root cause (RC)
- What’s in your mind about root cause?
 - Is it like treasure hunting – Gold buried somewhere waiting to be discovered?
- **The truth: There is no “true” absolute RC per se.**
 - A so-called “root cause” is something subjectively chosen to serve that role – a moving target



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The Concept of Infinite Chain of Causation

- Cause-effect relationship relies on the law of nature and physics to establish.
- The same item is both a cause and an effect at the same time.
- Causes and effects form an infinite chain of causation.



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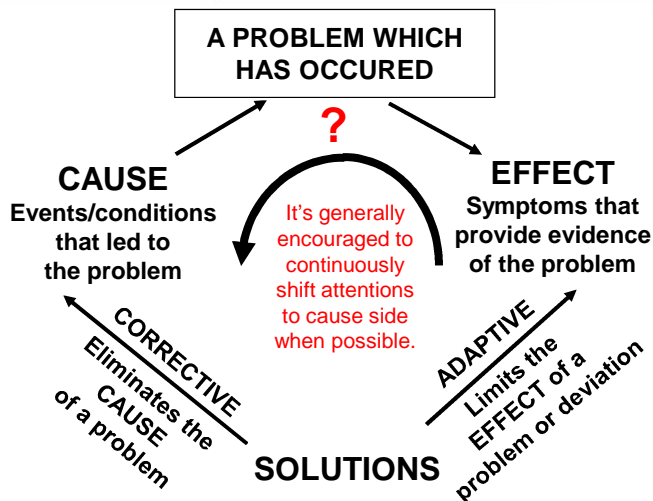
The Concept of Infinite Chain of Causation

- Not widely recognized in the engineering world.
- Widely seen in philosophical level discussion. e.g., [Hegel's philosophy](#).
- "An important feature of causality is the continuity of the cause-effect connection. The chain of causal connections has neither beginning nor end. It is never broken... And no one can say where this chain began or where it ends. It is as infinite as the universe itself. There can be neither any first (that is to say, [causeless](#)) cause nor any final (i.e., [inconsequential](#)) effect. If we were to admit the existence of a first cause we should break the law of the conservation of matter and motion. And any attempt to find an 'absolutely first' or 'absolutely final' cause is a futile occupation, which psychologically assumes a belief in miracles." - [A. Spirkin, Dialectical Materialism](#)
- Applied by [Dean L. Gano](#) in *Apollo Root Cause Analysis - A New Way Of Thinking*, He warned that "because this book challenges conventional wisdom, it may not validate your existing belief system". -



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Root Cause Analysis (RCA)

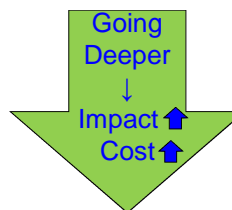


Dave Wessel, "An Ounce of Prevention", *Quality Progress*, Dec, 1998



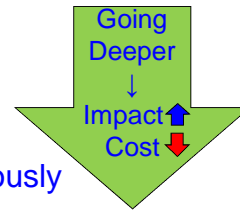
The Point of RCA

- Traditional RCA Theme
 - Continuously migrate the focus to upstream causes
 - Keep asking “why” like a 2-year old
- – Why? Impact ↑
- **Challenge!!!:**
 - The research cost ↑ too.
 - With infinite layers of Cause and Effect, how do we know **where to stop** and claim “Root Cause”?
- Case study 1: [Jefferson Memorial](#)
 (Detailed discussion refers to Jing, [Flip The Switch](#), *Quality Progress*, Oct' 08.)



So, Where to Stop? – The Psychology

- The trick is **not to find the “true” root cause**.
- The trick is to find the **leverage point** that benefits the problem most then treat it as the root cause.
- That wisdom is what differentiates an adult from a 2-year old; an expert from a novice.
- The key is ROI (return on investment).
 - low cost with high return (reward).
- **That's what people are doing subconsciously without realizing it.**
- Staying within the scope of the pursuit helps ROI.



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ROI Leverage Point Thinking

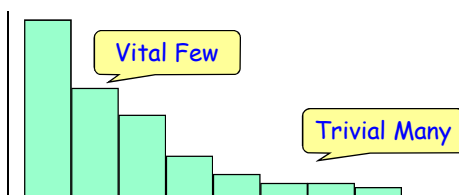
- A lot can be said about ROI assessment. In a way, RCA is about ROI calculation, intentionally or unintentionally.
- Realizing it or not, that's what going through people's mind, maybe subconsciously, when choosing RC.
- The trick: solution cost ↓ = research cost ↑ + implementation cost ↓↓
- ROI assessment could be **short-term or long-term, internal (self), external (customer) oriented**. The results could be very different. – Tends to be overlooked.
- **Short-term fixes** are mostly driven by cost constraint.
- ROI may **change over time**, so does root cause.
- To make the fix long lasting or sustainable, all parties' (stakeholders) interests need to be **balanced**.



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Three Tips to Find the Leverage Point

- Pareto Principle – 80 / 20 rule
- Desirability Matrix for Leverage Point
- Span of Control / Sphere of Influence

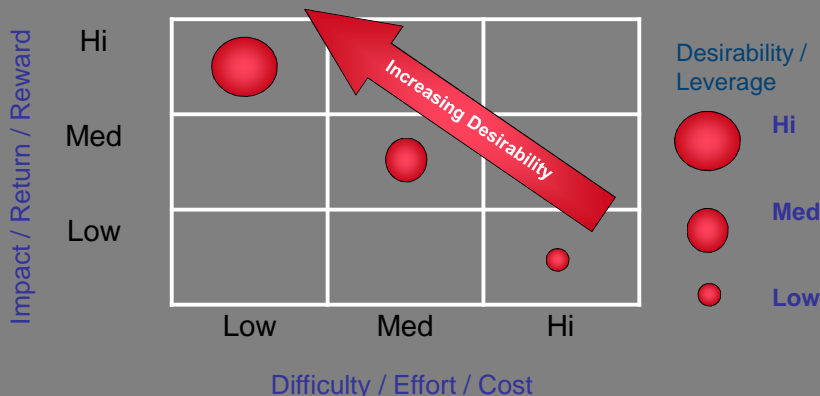


Pareto Principle
 80 / 20 rule: 80% of the problems are caused by only about 20% of the contributing factors.



ROI Matrix for Leverage Point

The desirability of an item increases as you move from the lower right to the upper left, and as the circle gets larger:



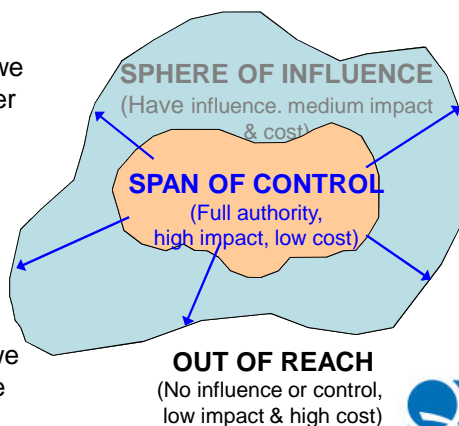
Span of Control / Sphere of Influence

Ideally, the root causes should be situated within the span of control; at worst, they should be within the sphere of influence.

Span of Control - areas where we have a high degree of control over parts or functions, virtually complete authority to change anything

Sphere of Influence - areas where we can influence things to varying degrees but don't have direct control.

Outside Environment - where we have neither control nor influence



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Scope of the Pursuit vs. Self-imposed Constraint

- Staying within the scope of the pursuit improves ROI and leverage.
- Going beyond the intended scope causes distractions, dilutes the effort and diminishes the return.
- BUT be careful, sword has 2 edges.
 - Self-imposed scope also serves as constraint.
 - It may prevent longer-term solutions.



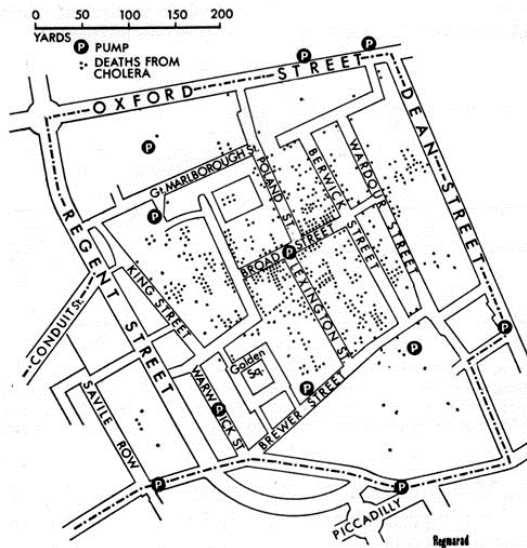
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Case Study 2: 1854 London Cholera Epidemic

The “Snow Map”

The cause of the 127 deaths in 3 days: cholera outbreak.

Detailed discussion refer to Jing, Flip The Switch, Quality Progress, Oct' 08.



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Case Study 2: 1854 London Cholera Epidemic

- Snow knew nothing about cholera.
- A decade later, Italian scientist Filippo Pacini was credited as discovering cholera.
- The poor living conditions of Soho neighborhood was the more fundamental cause of the series breakout.
- Snow wasn't anywhere close to identify the true “root cause”. But he was able to get the “handle” of the problem, literally.
- For More Info:
<http://www.ph.ucla.edu/epi/snow.html>



John Snow Memorial and Pub on the Broadwick Street, London



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RCA Summary

- Potential causes (cause-effect relationships) rely on **the law of nature and physics** to discover.
- Root cause is selected based on **ROI** within the scope of the pursuit.



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Connection B/W Troubleshooting & RCA

- Troubleshooting is the 1st of the 2 stages of RCA.
- **Difference is in scope** of the pursuit.
 - 1st stage focuses on **what happened (where and how)**, **short-term oriented** for quick turnaround.
 - 2nd focuses on **why** happens, **long-term** oriented.
 - No obvious transitions in many cases.
- Consumers usually care about 1st stage / troubleshooting, while providers care about 2nd / RCA.
- Focusing on RCA 2nd stage when the need is troubleshooting may cause distractions, dilutes the effort and diminishes the return.



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Five Popular Generic RCA Techniques

- Simple
- ↓
- Difficult
1. Is/Is Not Comparative Analysis – Zoom in through [segregation](#)
 2. [5 - Whys](#) – [Go deep](#)
 3. Fishbone Diagram (Cause-effect Diagram) - Traditional approach to brainstorming and diagramming Cause-Effect relationships. Good tool when there is [one primary effect](#) being analyzed. [Go broad](#).
 4. Root Cause Tree - A problem analysis diagram that combines Fishbone and 5-why together and allows to study relationships between causes. [Go complex](#).
 5. Cause & Effect (X-Y) Matrix - Used to study the relationship of a group of causes (inputs, X) and a group of effects (outputs, Y) and quantify the relationships / impacts.



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Cause-Effect Analysis

*I keep **six** honest serving men,*

They taught me all I knew,

Their names are

What, Why, How, Where, When and Who

Rudyard Kipling



Is / Is Not Comparative Analysis

- Zoom in through segregation. Divide and conquer

Problem Statement:			
	Is	Is Not	Differences and Changes
What	What is the specific object has the defect? What is the specific defect?	What similar objects could have the defect but do not? What other defects could be observed but are not?	
Where	Geographically? Physically on the part?	Where, when and what size could the defect have been but it was not?	
When	When was the defect first observed? When since then? When in the product life cycle?		
Size	How many objects with the defect? How many defects per object? Size of defect? Trend?		

Fish Bone Diagram

- Focusing on single effect with simple cause-effect relationships
- Search broad but not deep



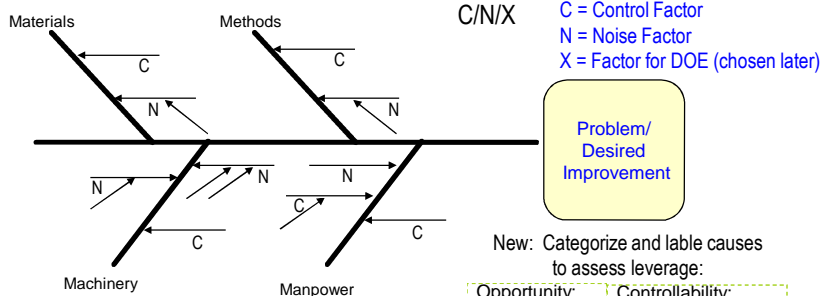
“Fishbone” Cause-Effect Diagram

Advantages

- Helps organize and relate factors
- Provides a structure for brainstorming
- Involves everyone

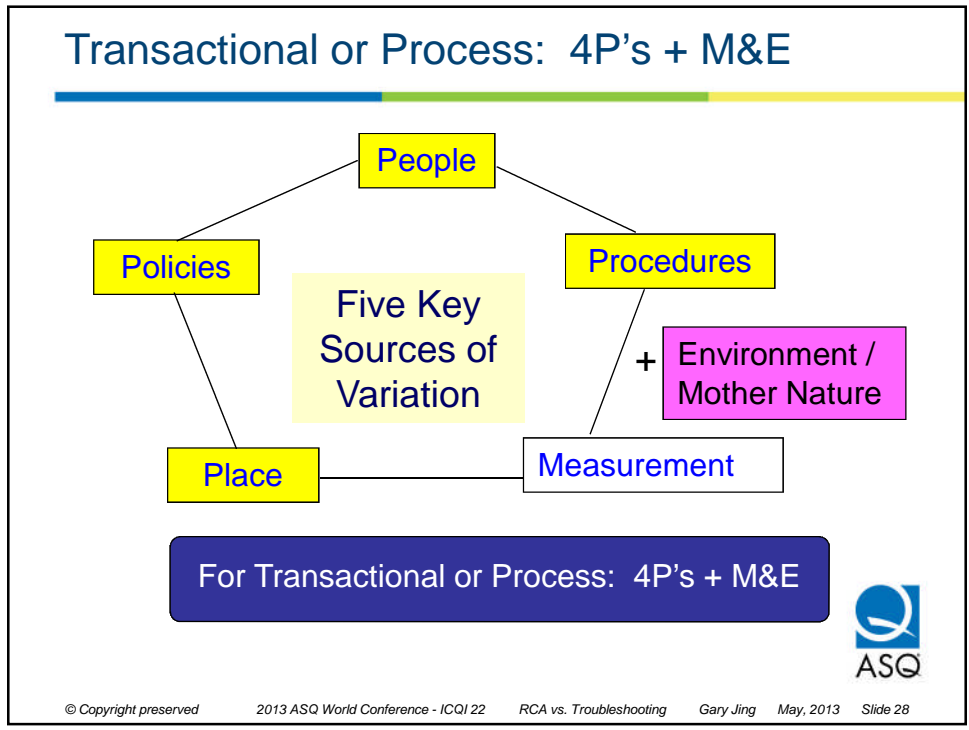
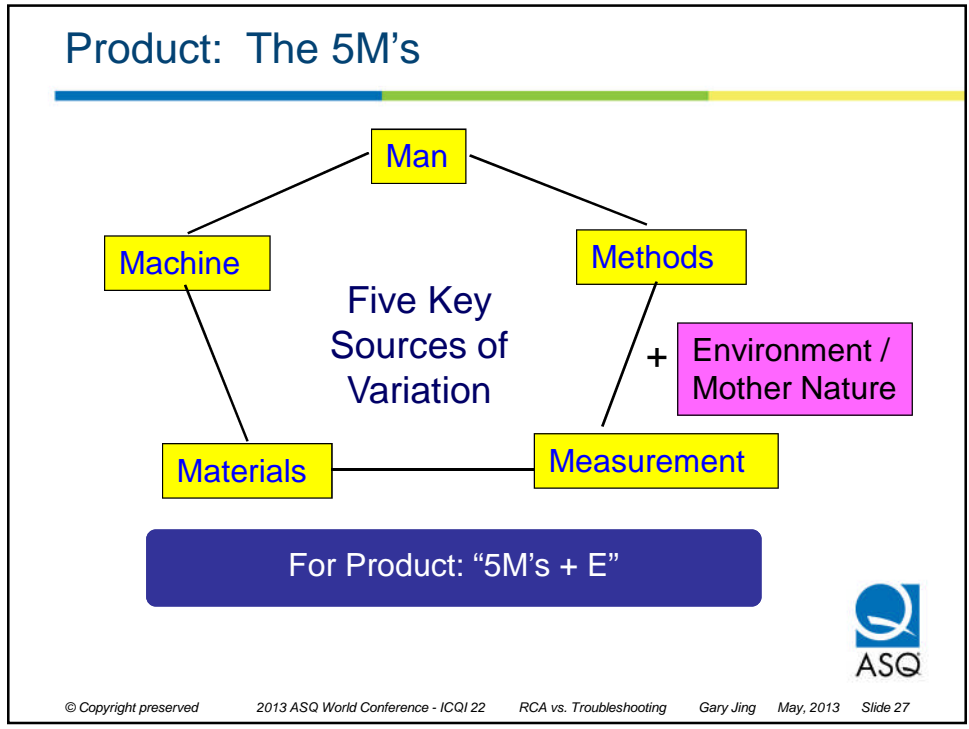
Drawbacks

- Might become very complex
- Requires patience
- Does not rank the causes in an *if-then* manner



Opportunity:	Controllability:
H: High	C: Within control
M: Medium	I: Have influence
L: Low	N: No influence





Root Cause Tree (RCT)

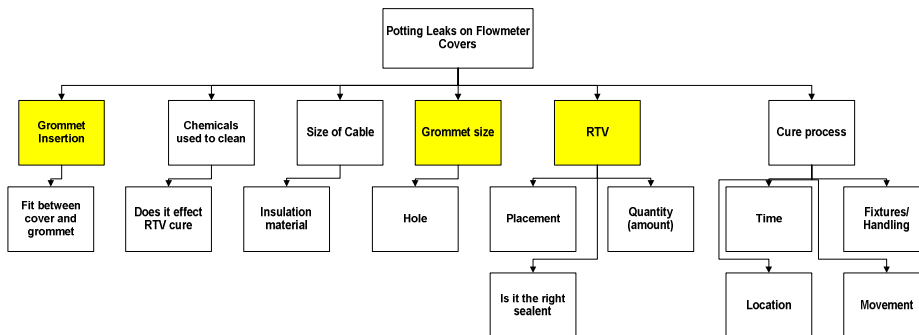
- For more complicated cause - effect relationships (causes may be dependent on each other)
- Combination of Fishbone and 5-Why



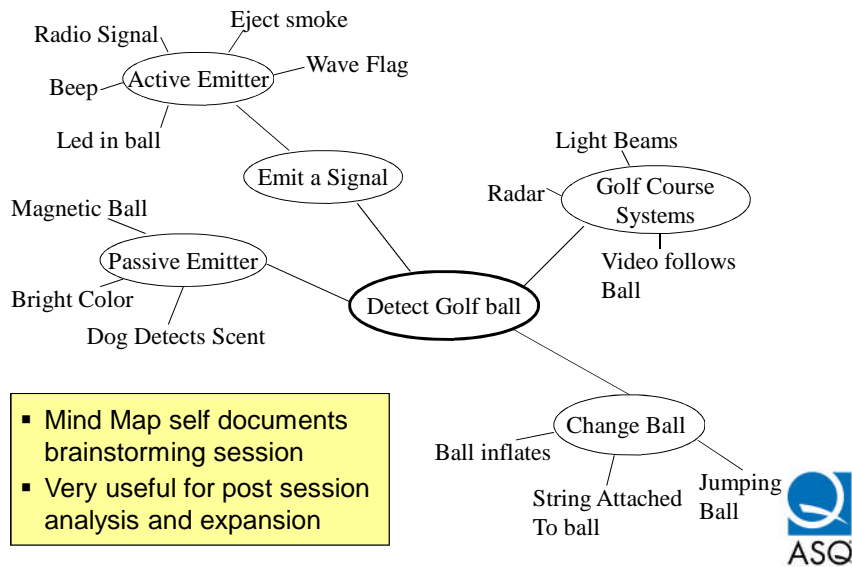
Example of RCT

AGB project: Potting Leaks

Flowmeter Cover Potting Leaks
Cause/Effect

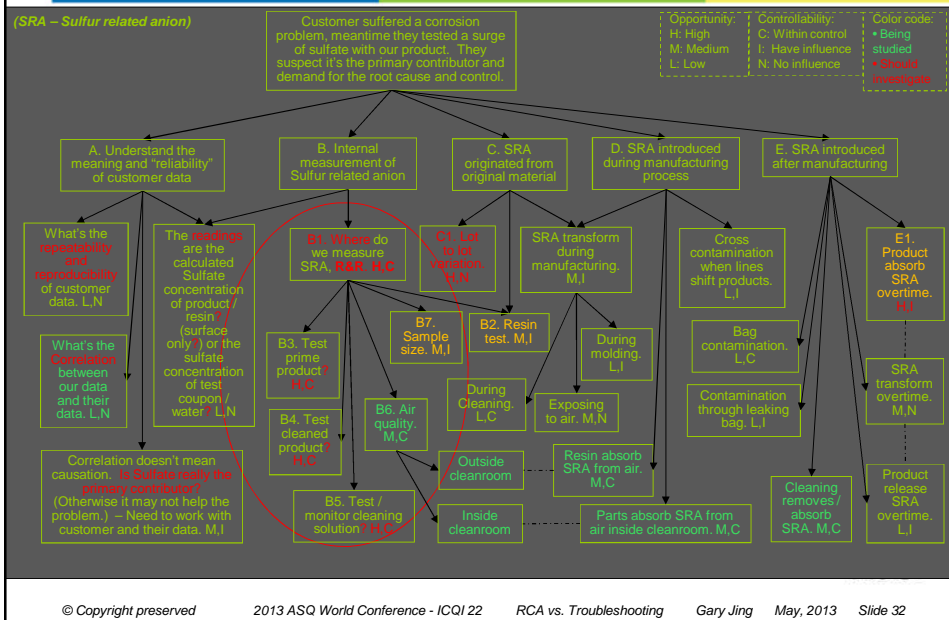


Mind Map Example



- Mind Map self documents brainstorming session
- Very useful for post session analysis and expansion

Example RCT



Focus on Undesirable Effects

Which statements are positive, negative or neutral? *Effects can be*

1. "The window is closed"
2. "The people in the office are sweating from the heat" – Desirable
3. "My in-basket is overflowing with paperwork" – Undesirable
4. "Everyone in the office enjoys going out to lunch" – Neutral

- UDE's are negative on their own merit
- No further explanation why is needed
- Effects are negative at face value

Two "Rules of Thumb"

1. What bearing does the effect have on the system goal?
2. Does the effect pass the "So What" test?



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How to Generate the Tree

Top down approach

1. **Fish Bone 1st**, if not enough, turn the bone structure 90 degree counter clock wise to form the initial tree; study the (and, or) relationship among the existing causes and then expand from there.
2. **5-why "horizontally"** to exhaust all possible 1st layer causes; study the relationship among the 1st layer items; repeat the same process on the previous layer items and keep expanding to next layers.
3. **Mind mapping** to generate ideas; study relationship and consolidate items and rearrange in tree structure.

Bottom up approach

4. **Affinity Diagram** to generate and organize ideas.



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Cause and Effect Matrix

- To evaluate and quantify the impact of a group of causes (inputs, X) on a group of effects (outputs, Y)



C-E Matrix: Example

Rating of Importance to Customer		10	6	9	8			TOTAL	%
		1	2	3	4	5	6		
PROCESS INPUTS		Efficiency	Commonality	Yield (accuracy)	Change Implementation	Sometime it's used to rank Fishbone inputs.			
1	Customer Input	8	6	8	8			252	11.36%
2	Equipment Specs	8	5	10	8			264	11.90%
3	Bill of Materials	7	5	10	5			230	10.37%
4	# of Revisions	8	6	10	8			270	12.17%
5	Documentation Label	8	2	8	9			236	10.64%
6	CC Drawings	5	3	2	2			102	4.60%
7	Pre-CCP Metting	5	5	2	2			114	5.14%
8	Ownership	8	10	8	8			276	12.44%
9	Approval Cycles	8	8	5	8			237	10.69%
10	AMK Delays	8	8	5	8			237	10.69%
								2218	



Cause-Effect Matrix Analysis Example

		Output Variables that Reflect the Impact of Adjustment										AGB project: Inventory Accuracy	
Weight		0.1	0.5	1	3	5		1	-2	1	-2	Rank	
Material	# of adjustment entry / Total	Added quantity / total	Subtracted quantity / total	Added \$ / Total	Subtracted \$ / Total	Overall	Added quantity/consumption	Subtracted quantity/consumption	Added \$/consumption	Subtracted \$/consumption	Rank without Consumption Info	Rank by Subtracted \$	Overall Rank
225	0.001	0.000	0.036	0.000	0.013	0.102	0.028	-2.807	0.028	-2.807	18	17	2
7500-0585-03	0.007	0.020	0.037	0.003	0.004	0.076	0.358	-0.317	0.357	-0.316	28	51	3
01-001638	0.004	0.000	0.003	0.042	0.184	1.050	0.011	-0.036	0.011	-0.036	1	1	4
01-006154	0.005	0.004	0.010	0.008	0.014	0.108	0.183	-0.244	0.157	-0.209	15	15	5
4002-5973-02	0.002	0.002	0.006	0.004	0.012	0.081	0.102	-0.202	0.102	-0.202	24	20	6
01-004488	0.003	0.001	0.005	0.009	0.061	0.337	0.027	-0.134	0.027	-0.134	2	2	7
8100-0100-01	0.012	0.009	0.000	0.067	0.000	0.206	0.564		0.564		7	403	8
200	0.003	0.009	0.034	0.005	0.013	0.117	0.071	-0.135	0.071	-0.135	13	18	9
7500-0585-07	0.003	0.024	0.017	0.008	0.004	0.071	0.258	-0.092	0.258	-0.092	30	52	10
1032-047	0.018	0.052	0.000	0.014	0.000	0.069	0.570		0.569		32	403	11
PKG-782	0.017	0.131	0.000	0.009	0.000	0.096	0.530		0.530		20	403	12
01-009871	0.002	0.002	0.005	0.018	0.030	0.212	0.072	-0.083	0.071	-0.084	6	3	13
01-009644-17C02	0.001	0.000	0.001	0.006	0.017	0.103	0.047	-0.107	0.046	-0.103	17	11	14
9700-7036-01	0.003	0.004	0.002	0.049	0.018	0.241	0.141	-0.037	0.141	-0.037	4	8	15
01-001651	0.003	0.003	0.005	0.015	0.020	0.152	0.073	-0.070	0.073	-0.070	9	7	16
160	0.001	0.000	0.001	0.000	0.016	0.079		-0.095		-0.094	25	13	17
01-018514	0.016	0.034	0.000	0.073	0.000	0.238	0.203		0.203		5	403	18
01-021524	0.001	0.001	0.003	0.008	0.016	0.109	0.062	-0.069	0.047	-0.071	14	12	19
01-009897	0.003	0.002	0.008	0.003	0.011	0.076	0.029	-0.076	0.029	-0.077	27	21	20
01-021554	0.001	0.000	0.002	0.001	0.012	0.069	0.013	-0.073	0.014	-0.087	31	19	21

Sometime the ranking can be objective, data driven.

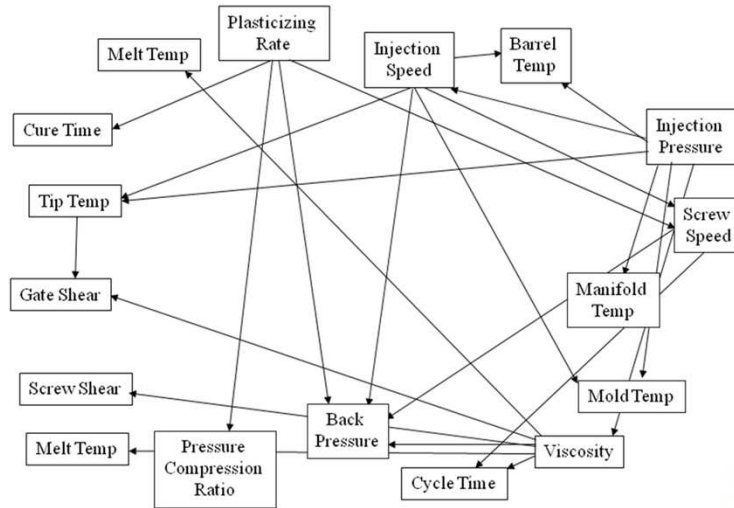


Techniques Good for Troubleshooting

1. Is/Is Not Comparative Analysis
2. Relationship Diagram
3. Fault Tree Analysis (FTA)
4. Event Tree Analysis (ETA)

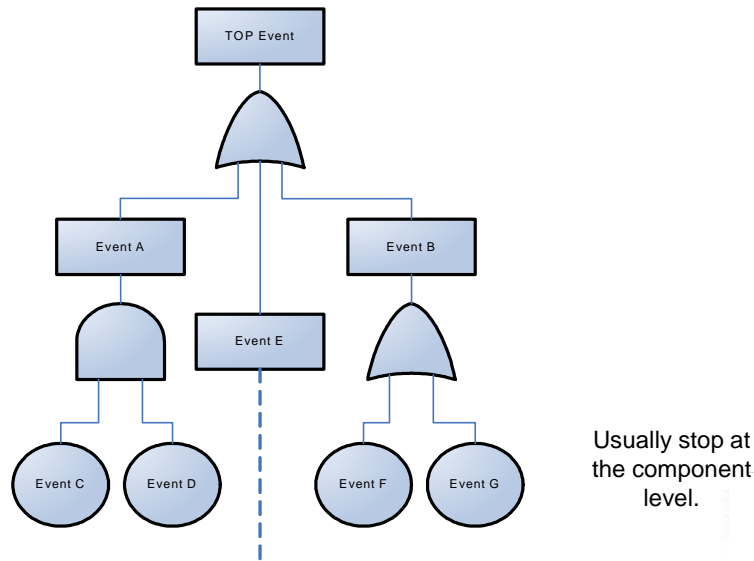


Relationship Diagram



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Fault Tree Analysis



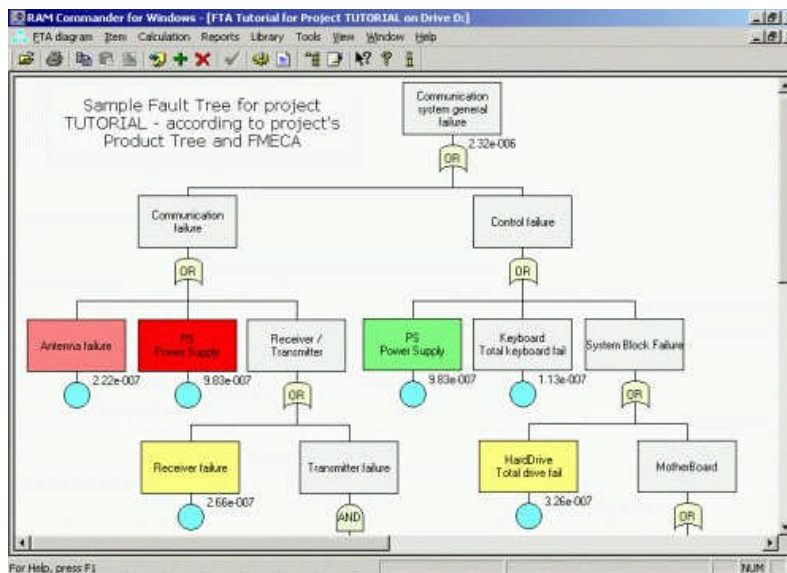
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Common Symbols Used to Create Fault Trees

	AND Gate If all input events occur, the output event will occur		Priority AND Gate Output event occurs if all events occur in the right order from left to right
	OR Gate If any input event occurs, the output event will occur		Exclusive OR Gate Output event occurs if one, but not both of the two input events occurs
	Event Any higher level event that is a result of lower level events		Inhibit Gate Input produces output when conditional event occurs
	Basic Event The lowest level event. The limiting resolution in our analysis.		Conditional Event Used with inhibit gate



Fault Tree Analysis with Probability



Event Tree

- Similar to FTA but different.
- Examine a chronological series of subsequent events or consequences
- Display event sequence in opposite direction to FTA.



Event Tree Examples with Probability

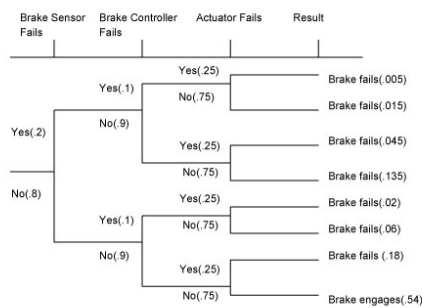
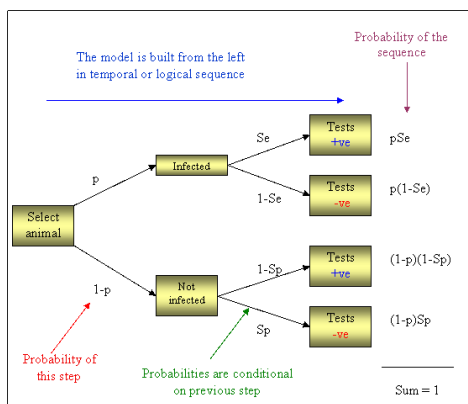


Figure 1: Example of an event tree for a brake system



Summary

- Truth of root cause – **None**, subjectively chosen
- The point of RCA - **ROI**
- Popular RCA Tools, focusing on why.
 - Is / Is not analysis
 - 5 Why's
 - Fishbone Diagrams (Cause-effect Diagram)
 - Root Cause Tree
 - C&E Matrix
- Tools good for Troubleshooting, focusing on what.
 - Is/Is Not Comparative Analysis
 - Relationship Diagram
 - Fault Tree Analysis
 - Event Tree Analysis

