Introduction to Diagnostic Quality Problem Solving

Six Sigma Europe GmbH

Passion for Excellence

Theodor-Heuss-Ring 23

50668 Cologne

Tel. +49.221.77109.560

Fax +49.221.77109.31

Table of Contents

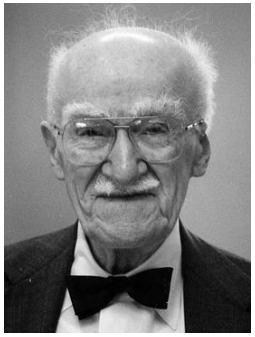
Company Introduction

- Six Sigma Europe, founded in 2007, is committed to the competitiveness, profitability and enterprise value of its client companies. Together with management, we initiate changes in the value creation areas of the company, mobilize the necessary forces and accelerate the implementation process.
- Our clients can count on three outstanding qualities:
  1. Consulting teams with personalities who help to tackle the entrepreneurial challenges of growth, efficiency and turnaround
  2. Function specialists who implement pragmatic solutions with proven know-how in the important operational functions
  3. Data-factual related consulting approaches, so that the result of our consulting services is measurable
- Our team consists exclusively of highly experienced consultants who have worked in international consulting projects for at least 10 years. The project managers we employ also have experience in management positions in industry. By interlinking experienced consultants with technical and integrative skills, we can guarantee an optimal staffing of the project teams for every project requirement.
- References: SIEMENS, DURA, AIRBUS, HUTCHINSON, iglo, Mercedes-Benz, FUJITSU, MITSUBISHI MOTORS, GE, AUTOMOTIVE LIGHTING, BRÜHL, BAYER, Continental

Quality Problem Solving History and Status Quo

Quality Gurus

Juran



- **Joseph M. Juran (1904-2008):**
  - ❖ “Pareto applied to business”**,** “diagnostic journey from symptoms to causes” & “remedial journey from causes to remedy”
- **Dorian Shainin (1914-2000):**
  - ❖ Red X® “branch-and-prune strategy” (somewhat weak foundation in science, treat critical tools as proprietary)
- **Charles Kepner (1922-2016) & Benjamin Tregoe (1927-2005):**
  - ❖ “branch-and-prune strategy” (somewhat weak foundation in science)
- **Bill Smith (1929-1993):**
  - ❖ Six Sigma (Motorola 1987) – DMAIC framework, collection of (brainstorm) tools, frequentist statistics (assume uncertainty due to randomness), only a rudimentary strategic structure

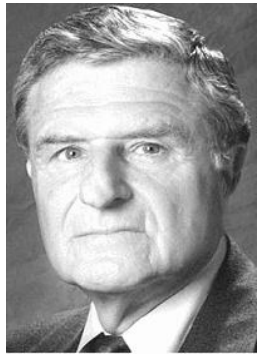
Shainin

Scientific literature:

- Troubleshooting of devices
- Medical diagnosis
- Bayesian statistics (uncertainty due to ignorance)
- Causal Networks
- Artificial Intelligence

Smith

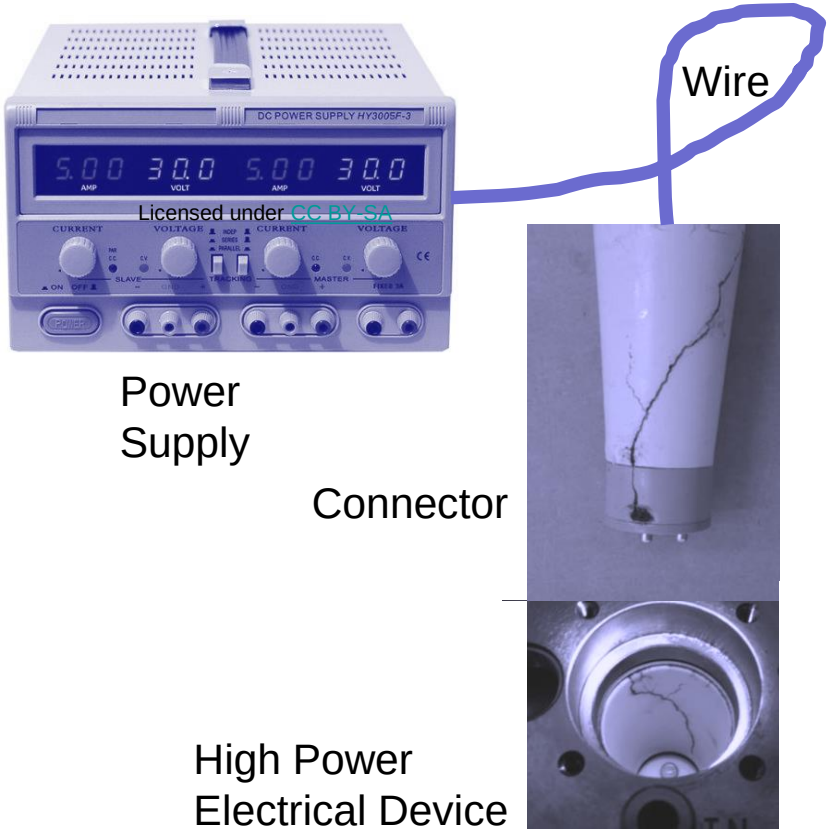
Kepner

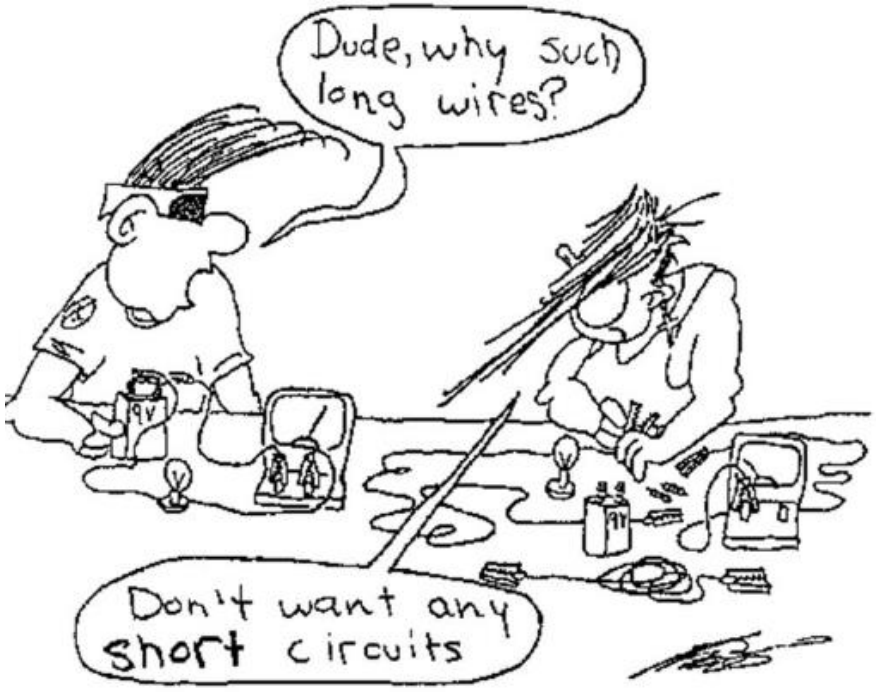


Tregoe

A Typical Industrial Problem Case

Electrical Instabilities





Credit to Ehren Stillman

A Typical Industrial Problem Case

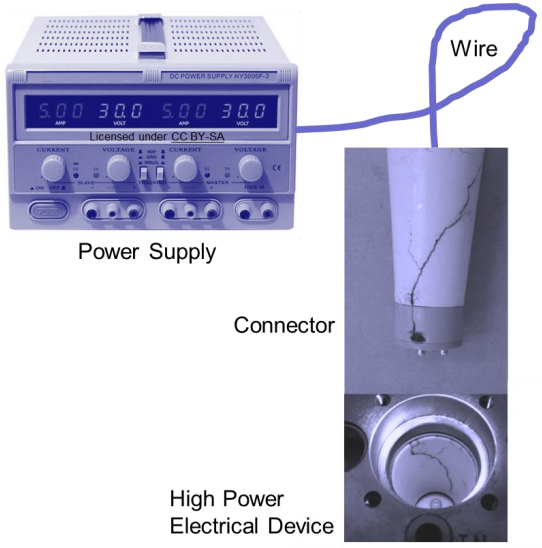
Electrical Instabilities

Problem Definition (symptom)

- Device and Connector damaged when connected to Power Supply.

Focused Problem Definition on System Level (Kepner & Tregoe)

Is	Is Not
Is: Device A	Is Not: Device B
Is: End of Line Check	Is Not: field
Is: from wk. 1, 2019 onwards	Is Not: before wk. 1, 2019
Is: avg. 10% of devices	Is Not: increasing or decreasing failure rate

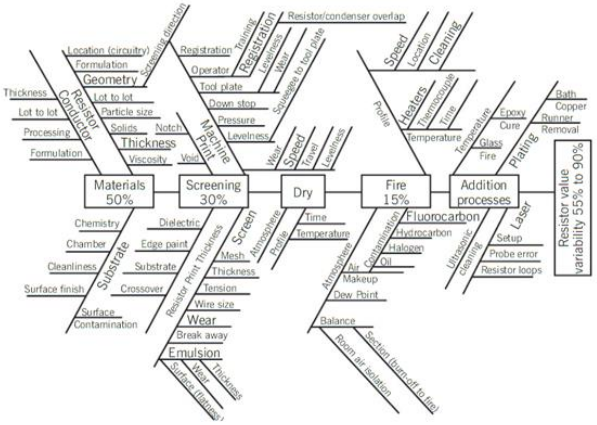


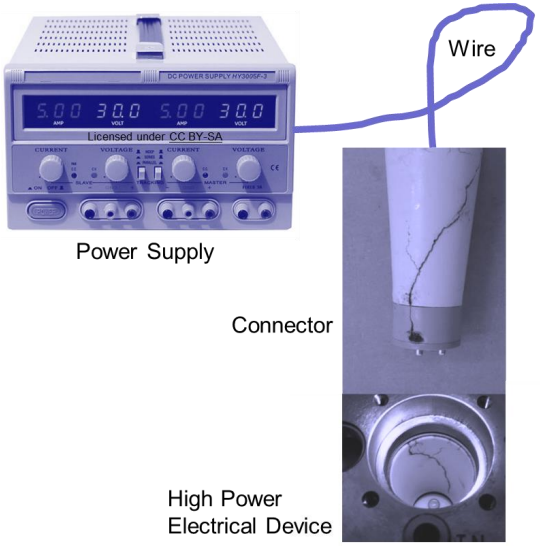
A Typical Industrial Problem Case

Electrical Instabilities

Typical Root Cause Investigations:

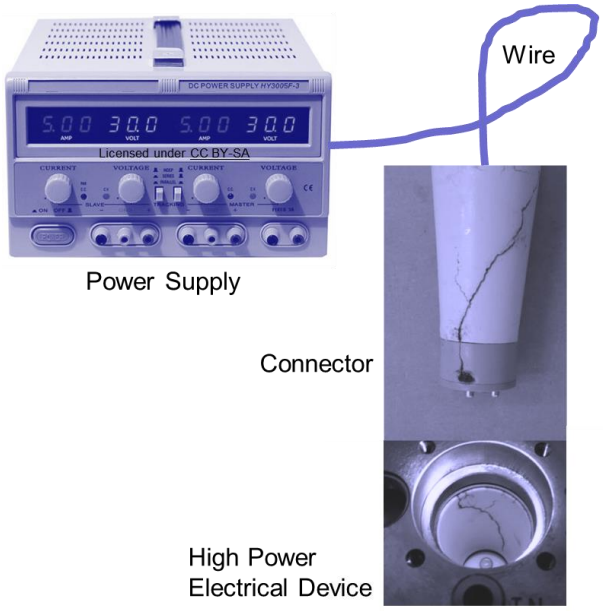
- Check for production process deviations:
  - Connector dimensions, compare with tolerances
  - Color differences
  - Tool contamination
- Brainstorming: > 80 potential causes
  - Main suspect is the connector





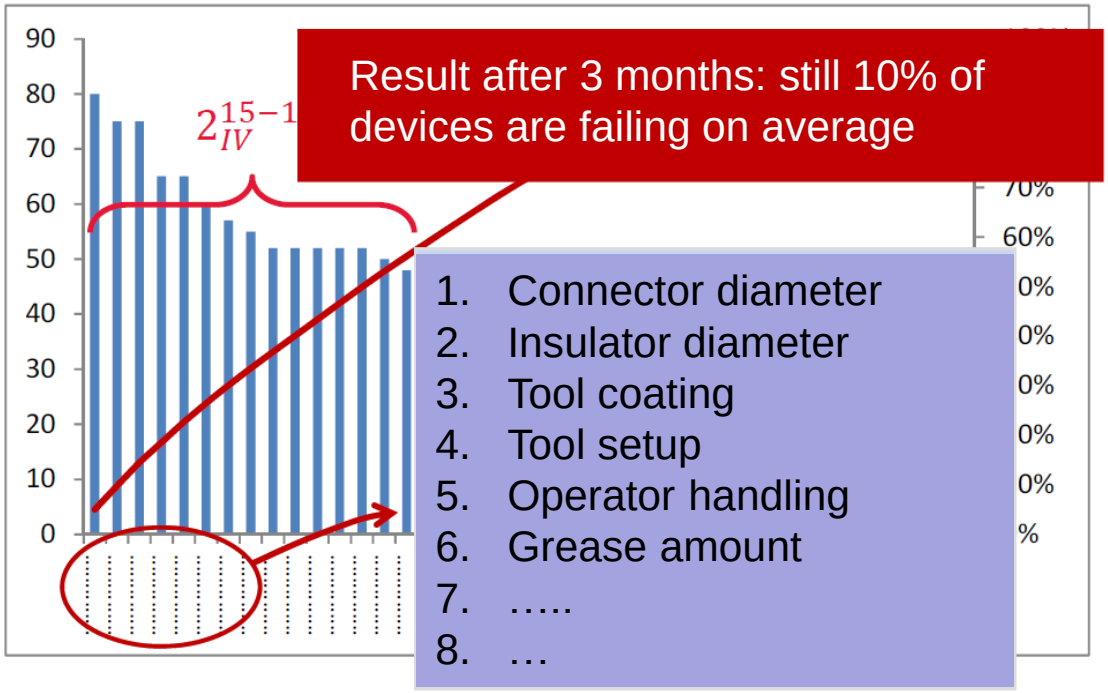
A Typical Industrial Problem Case

Electrical Instabilities



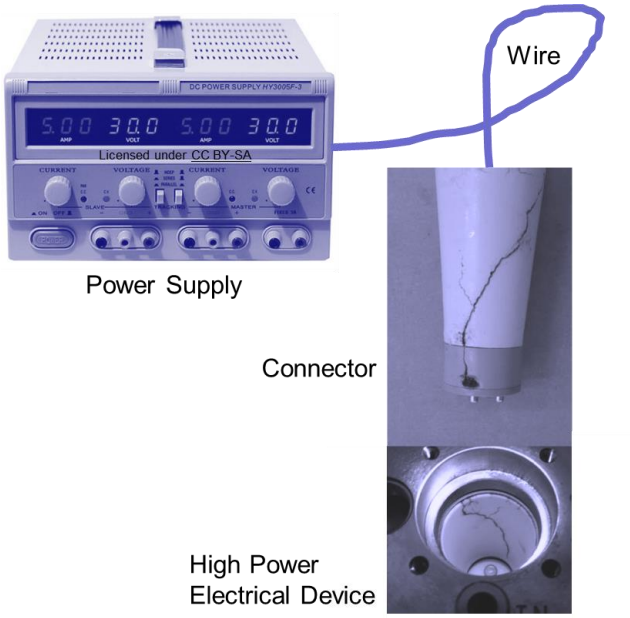
Typical Root Cause Investigations (cont'd):

- Sort 80 potential causes by multi-voting
- Design fractional factorial experiment for top 15



A Typical Industrial Problem Case

Electrical Instabilities



Conclusions for this problem case using Brainstorming & Design of Experiments:

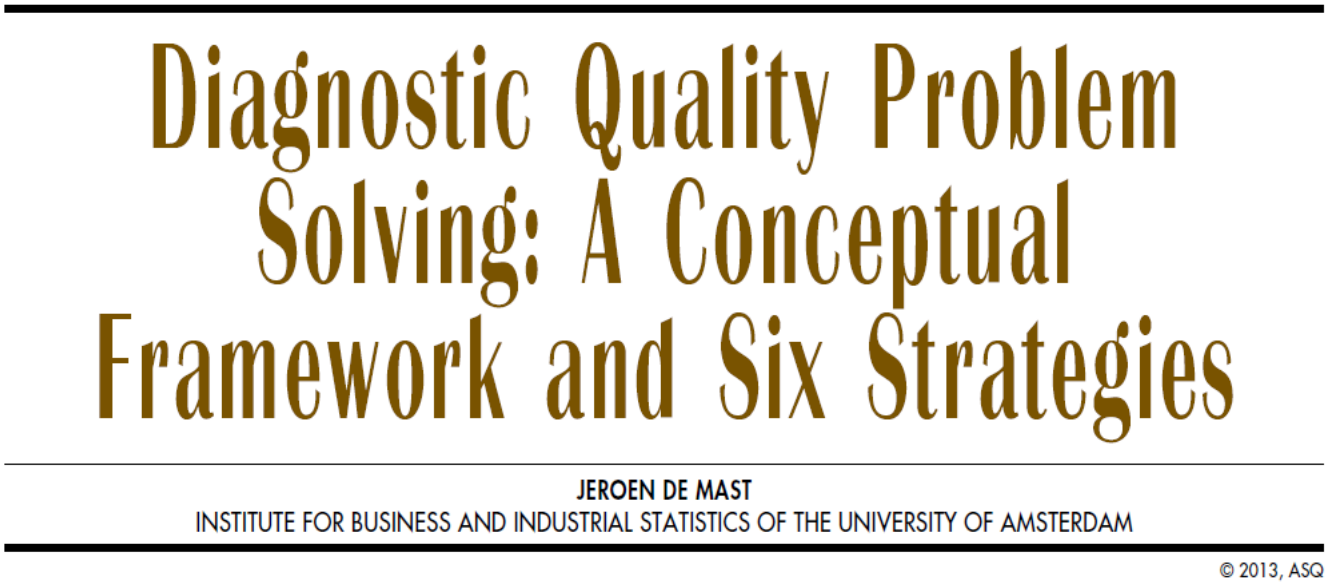
- Difficult and time-consuming due to initial divergent thinking about numerous, non-countable causes. This results in an extensive search space.
- The problem solver can get stuck in the wrong part of the search area, especially if the dominant cause is not in the list.
- The chosen suspects are not specific enough to effectively experiment with them.

What is required to overcome these difficulties?

- ***Diagnostic strategies that enable us to focus*** (= narrow the search area in a fact-based way)

A Conceptual Framework

Prof. Dr. J. De Mast proposed a Conceptual Framework, which resulted from the interaction between academic research and the application to real problems.



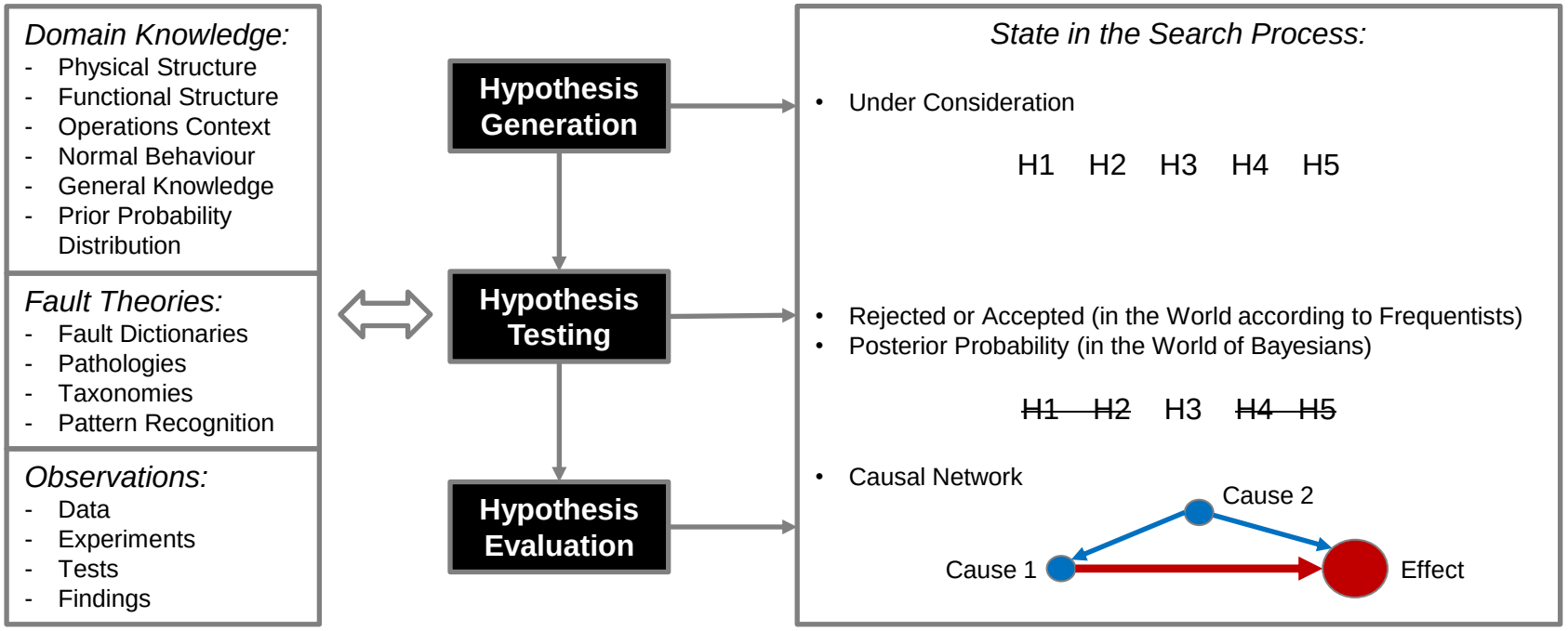
Diagnostic Quality Problem Solving: A Conceptual Framework and Six Strategies

JEROEN DE MAST
INSTITUTE FOR BUSINESS AND INDUSTRIAL STATISTICS OF THE UNIVERSITY OF AMSTERDAM

We build on this framework…

A Conceptual Framework

De Mast: "Diagnosis is a search through a state space of hypotheses until a goal state is reached"



A hypothesis (H_i) is a potential explanation for a quality problem

Common approach:

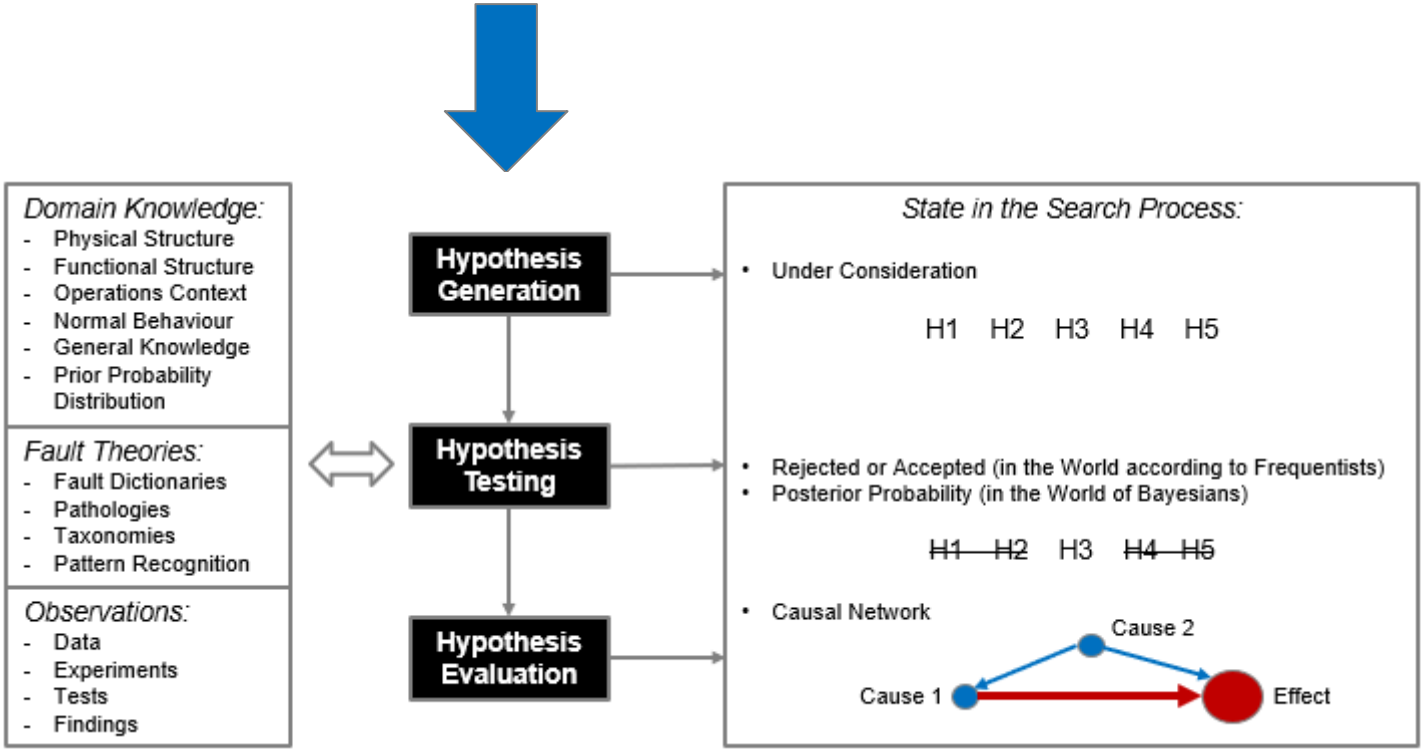
1. *Generation* by Brainstorming
2. *Testing* by Experiments (DoE)
3. *Evaluation* by
   a. Statistical Inference, i.e. the process of inversion required to go from an effect (the data) back to a cause (the process or parameters)
   b. Counterfactual Analysis, resulting in a causal network. This breakthrough method will be introduced in 2019!

A Conceptual Framework

Diagnostic Strategies make the search process more efficient

Diagnostic strategies that enable us to focus:

how, when, in what order?



Diagnostic Strategies

A powerful Six Pack based on human thinking patterns

De Mast's Six Strategies

1. **Blind Trial & Error**
2. **Branch & Prune Tactics**
3. **Known Problem**
4. **Proximate Cause Strategy**
5. **Syndrome-Based Search**
6. **Funneling Strategy**

This sequence of strategies or one single strategy is not followed rigidly. At each stage in the search, the situation and its tactical consequences are reassessed. Think like a detective…

Diagnostic Strategies

Strategy 1: Blind Trial & Error

- Randomly try out candidate causes until the root cause is found
- Finite number of causes = *n* → average number of trials = *(n+1)/2*

- Works for simple problems
- Effectively the least efficient search strategy for complex problems

Credit to Zachary Kanin

Diagnostic Strategies

Strategy 2: Branch and Prune

- Divide the space of all possible causes in high-level sub-classes (“branching”)
- Next, by observation and testing try to rule out whole branches at once (“pruning”)

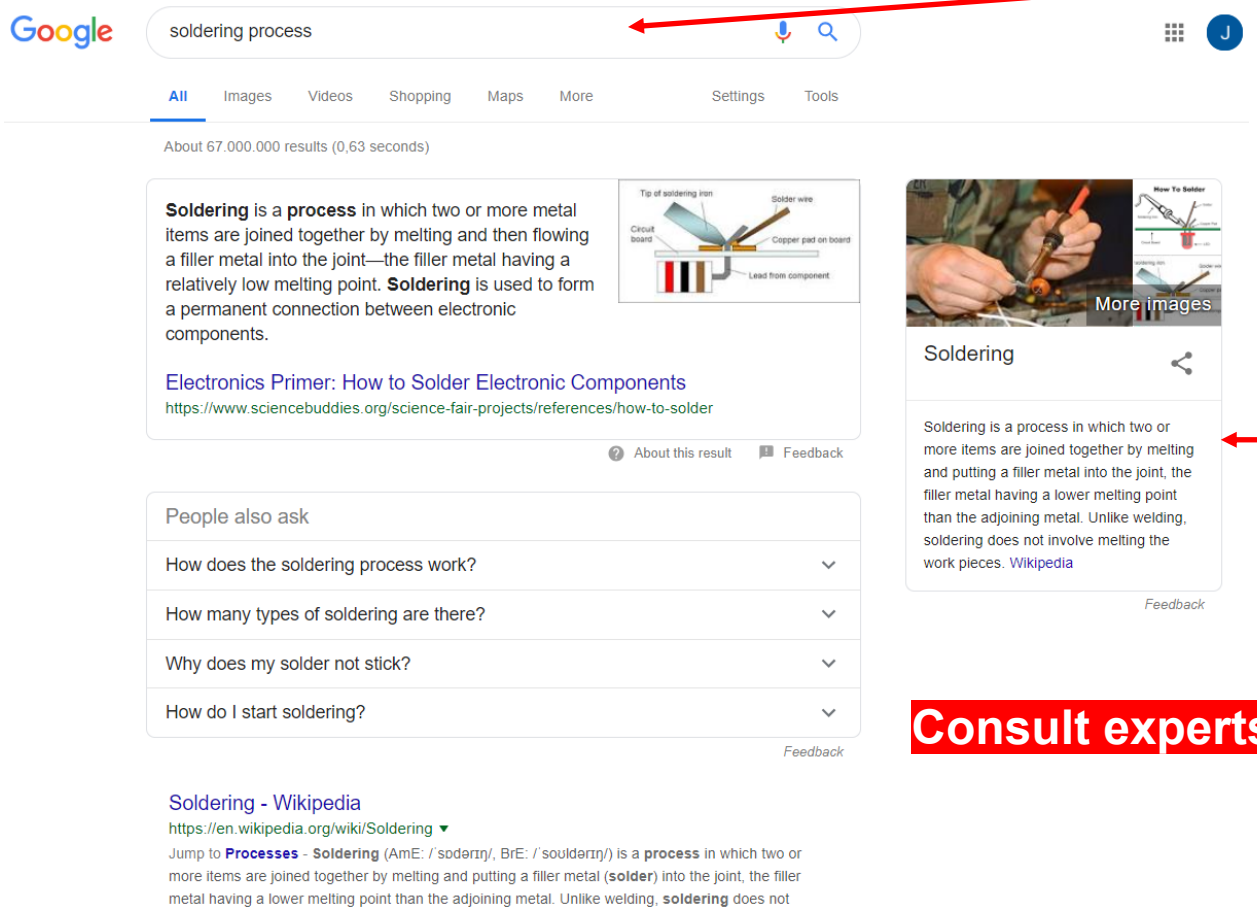
"I don't like the looks of this at all — there's nothing wrong!"

Credit to Chris Wildt

Diagnostic Strategies

Strategy 3: Known Problem

Symptoms
(for Device A the causal chain included the soldering process)



Possible Explanations

Consult experts…

Credit to Chris Wildt

Diagnostic Strategies

Strategy 3: Known Problem (cont'd – electrical instabilities case)

Power Supply

Wire

Connector

High Power Electrical Device

Literature search for known issues with similar electrical devices:

- Enclosures of air bubbles
- Contamination with dust
- Contamination with metal particles
- Contamination with salts

Diagnostic Strategies

Strategy 4: Proximate Cause Strategy

- Reason backwards from the observed symptoms to the immediate (“proximate”) causes. Technique: ask “why?” five times.
- This gives a more focused problem definition.

Electrical instabilities

↓

Short circuit

↓

↓

Redefine the problem: where does the salt deposit come from?

Diagnostic Strategies

Combining Clues

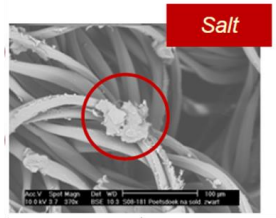
Cause of electrical instabilities

~~Assembly~~ | Device **A**, B | ~~Connector~~ | ~~Wire~~ | ~~Power Supply~~

Soldering Process

Soldering Flux:
- Used for device A, not for B
- Introduced in week 1, 2019
- Contains salt

Electrical instabilities → Short circuit



Redefine the problem: where does the salt deposit come from?

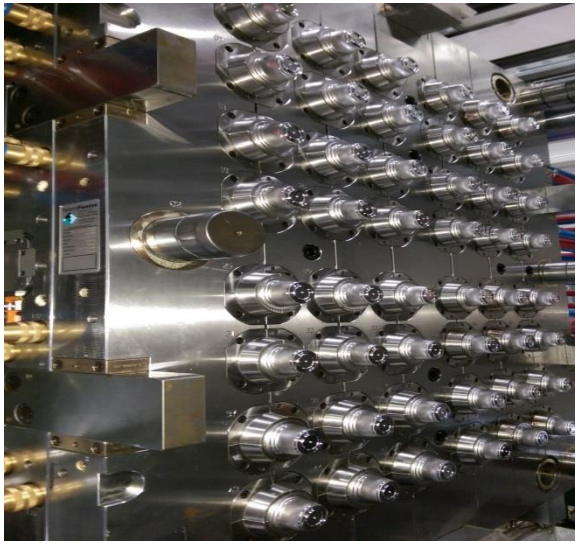
- **Solution**: soldering flux discontinued → 0 electrical instabilities → problem solved!
- **Prevent recurrence** by updating PFMEA, standards and verification tests

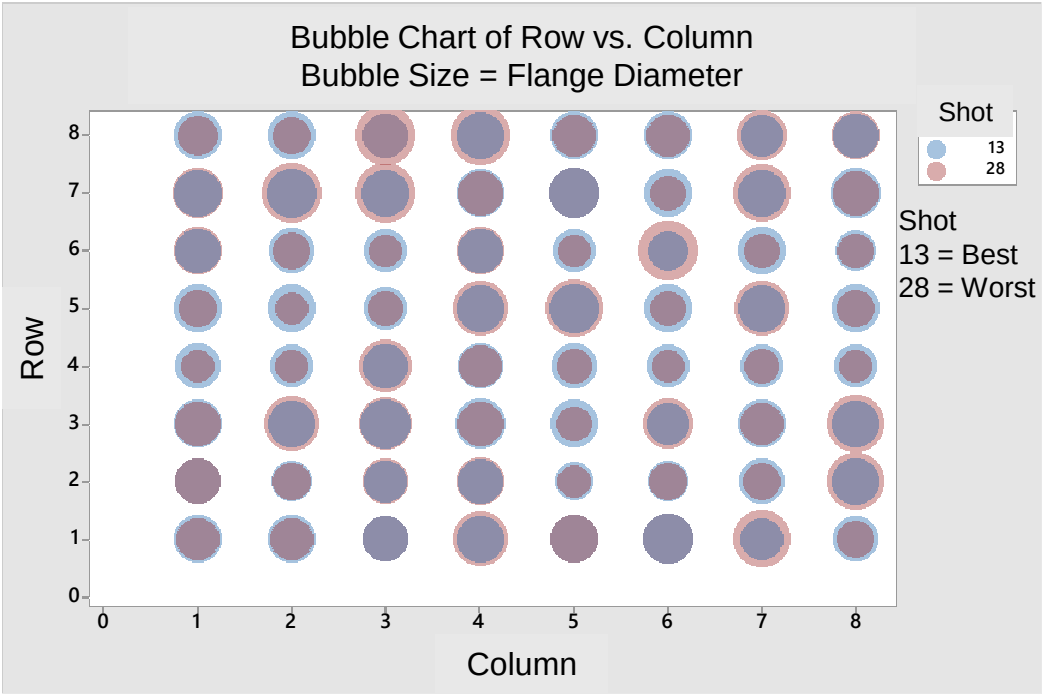
Diagnostic Strategies

Strategy 5: Syndrome-Based Search

- Observe several occurrences of the problem and compare them to normal behavior. Capture the total variation, good vs. bad comparison.
- Try to find a pattern of accompanying symptoms and characteristics that occur along with the problem. This pattern is the syndrome and can reveal characteristics of the causal mechanism and help exclude other options.

- Example: injection molding
  (high cavity-to-cavity variation)



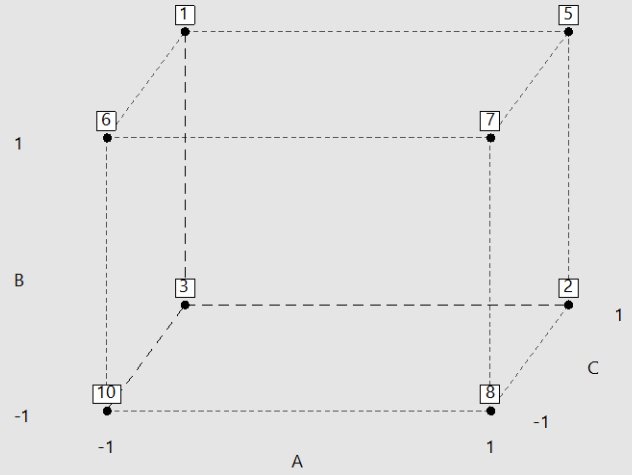


Diagnostic Strategies

Strategy 6: Funneling Strategy

- *After* the search space has been narrowed down (focus):
  - Generate a list of specific and detailed hypotheses (by brainstorming)
  - Design an efficient test strategy (for example: Design of Experiments) and/or use a *hypothesis-free* and *model-free* algorithm (MondoBrain AI) to *extract the drivers and the ranges* that have the strongest impact on a key performance indicator

DoE with 3 factors A, B, C and a Response



DoE = predictive modeling

MondoBrain AI: explore alternatives, move ranges, and iterate until you find the best solution

MondoBrain AI = prescriptive decision making

Diagnostic Strategies

Think strategically like a detective…

- ***Use pruning principles to focus the search***
- ***At each stage in the search, reassess the situation and its tactical consequences***

1. **Known Problem?**
2. **Blind Trial & Error (avoid for complex problems)**
3. **Proximate Cause Strategy (reason backwards)**
4. **Branch & Prune Tactics**
5. **Syndrome-Based Search (contrasting)**
6. **Funneling Strategy**

Achieve and maintain focus on the relevant part of the problem space

Efficient testing of highly detailed hypotheses, perform prescriptive analyses

Take Quality Problem Solving To The Next Level

Discover the new quality of our problem solving approach!

- *Six Sigma Europe GmbH organizes tools in a strategic structure (grounded in science provided by Prof. Dr. J. De Mast) and closes the deficits of the classic Six Sigma DMAIC framework.*
  - ***Download our training program***
    http://six-sigma-europe.com/dqps
- *Six Sigma Europe GmbH cooperates with MondoBrain AI to offer you an unprecedented problem solving power for the most complex tasks.*
- *Stay in touch with us so that you are the first to benefit from a real breakthrough technology: our introduction of Causal Discovery & Analysis in 2019!*

SIXSIGMA Europe | www.six-sigma-europe.com

Diagnostic Quality Problem Solving (DQPS)

Strategien, Suchtaktiken und einfache Tools zur Lösung von technischen Qualitätsproblemen

Ihre Situation

Die Reduzierung der Fehlerkosten, insbesondere in den Bereichen Qualitätskontrolle, Prozessdiagnose und Produktionsüberwachung, zahlt sich direkt und oft erheblich auf den Gewinn aus. Dieses Potenzial wird nur selten genutzt. Dies ist oft auf den Ressourcen- und Zeitaufwand traditioneller, Blindversuch & Irrtum Methoden zurückzuführen. Ist Ihnen diese Problematik schon mal aufgefallen?

Was passiert, wenn Sie diesen Ist-Zustand bei der Qualitätsproblemlösung akzeptieren? Besteht die Gefahr, dass die Profite im Laufe der Zeit weiter sinken? Was würden Sie gewinnen, wenn Sie die Problemlösungszeit um den Faktor vier verkürzen und 90-100% der Ursachen statt der üblichen 20-50% beseitigen könnten?

Dieser Gewinn ist zu erwarten, wenn Sie Diagnosestrategien und Suchtaktiken in Ihr Portfolio von Problemlösungswerkzeuge und -methoden aufnehmen.

Unser Ziel für Sie

Sie sind in der Lage, komplexe Qualitätsprobleme strukturiert anzugehen, so dass Sie alle beobachteten Symptome aus einer Kausaldiagnose mit Hilfe einer effektiven technischen Diagnostik erklären können.

Was Sie aus diesem Seminar mitnehmen

Sie werden lernen, das Symptom zu beobachten, das Problem zu kategorisieren und kristallklar zu definieren, strategisch zu denken, Schnittprinzipien anzuwenden, um die Suche zu fokussieren. In jeder Phase der Suche lernen sie, die Situation und ihre taktischen Konsequenzen neu zu bewerten. Mit Hilfe einfacher, meist grafischer Werkzeuge können Sie die Ursache(n) eines komplexen Qualitätsproblems schnell nachweisen.

Jede Strategie und Methode wird ausführlich beschrieben. Die konkrete Umsetzung wird Ihnen anhand von Praxisbeispielen erläutert. Für jedes Tool werden die Einsatzmöglichkeiten im eigenen Unternehmen diskutiert.

Zielgruppe:

Führungskräfte und Mitarbeiter, die sich mit der Weiterentwicklung und Qualitätsverbesserung der Produkte und Prozesse im Unternehmen beschäftigen.

Inhalt

- *Idee und grundlegender Ansatz der DQPS-Methode*
  - *Sechs Diagnosestrategien*
- *Fokussierte Problemdefinition*
  - *Problemtypen*
  - *Ist / Ist Nicht Beschreibung*
- *Strategisch konvergierende Fragen*
- *DQPS-Roadmap*
- *Prüfung des Messsystems*
  - *Grafische Methode*
- *Multi-Vari-Bild*
  - *Variationsfamilien erkennen durch grafische Analyse*
- *Konzentrationsdiagramm*
  - *Identifizierung von Mustern oder Fehlerhäufungen innerhalb von Einheiten / Teilen*
- *Paarweiser Vergleich*
  - *Identifizierung des maßgeblichen Faktors ohne Demontage der Produkte*
- *Komponententausch*
  - *Identifikation fehlerhafter Komponenten*
- *Prozessparametersuche*
  - *Abtrennung wichtiger von unwichtigen Prozessparametern*
- *Variablentausch*
  - *Effektives Aussortieren einer großen Anzahl von Ursachen*
  - *Quantifizierung von Haupt- und Interaktionseffekten*
- *Voll-faktorieller Versuchsplan*
  - *Optimierung und Toleranzzuweisung*
- *A zu B Analyse*
  - *Bestätigung der optimalen Parametereinstellungen*
- *Anwendung im eigenen Unternehmensumfeld*

Dauer: 2 Tage

Termine: siehe Homepage

Preis: 1.995,00 EUR, inkl. Unterlagen und Verpflegung
Frühbucherrabatt: 10% (bis 8 Wochen vor Beginn)
Anmeldeformular auf Seite 2 oder
Online anmelden unter www.six-sigma-europe.com
Auch als Inhouse-Training möglich.
Preis für Inhouse-Training auf Anfrage.

SIX SIGMA Europe GmbH | Theodor-Heuss-Ring 23 | 50668 Köln | Tel. +49.221.77109.560 | Fax +49.221.77109.31 Seite 1

Take Six Sigma To The Next Level

Enhanced Service

- ***Do you have products that fail at the customer, whether in the field or on a test bench?***
- ***Do you have difficulty explaining what is really happening?***
- ***Do you need a quick response?***

Contact us directly at +49.221.77109.560

- ***We will help you to solve the problem in a targeted manner.***
- ***We only need minimal resources and time.***
- ***We make sure that a sustainable, cost-effective solution is implemented.***

Take Six Sigma To The Next Level

Enhanced Service: *a 3-hour on-site workshop free of charge*

Our ***free offer*** includes a ***3-hour on-site workshop*** in which we help our client to better ***focus on a quality issue*** so that converging strategies and search tactics can be applied in the next step.
Our motto is: "A well formulated problem is half solved".

Content of the workshop:

1. Problem presentation by the task force
2. Identification of the problem type
3. First run of an IS / IS NOT problem description

From this workshop our client receives:

1. A clear problem definition. Answers the questions:
    a. Which strategic category does the problem belong to?
    b. What makes this problem real and current?
    c. Whose problem is it?
    d. What does success look like and when is it achieved?
    e. Where are the limits of the solution space (e.g. resources, time frame and context)?
    f. Who has a say in solving this problem, and what do these people want?
2. First possible elements of the causal chain, which logically result from the IS / IS NOT analysis
3. Action points for further fact-finding
4. A solid basis for subsequent strategies and search tactics