Root Cause Analysis: How can the Data help you ?

HI Reliability Seminar

Coen Smits

14 October 2021

POWERFUL SOLUTIONS

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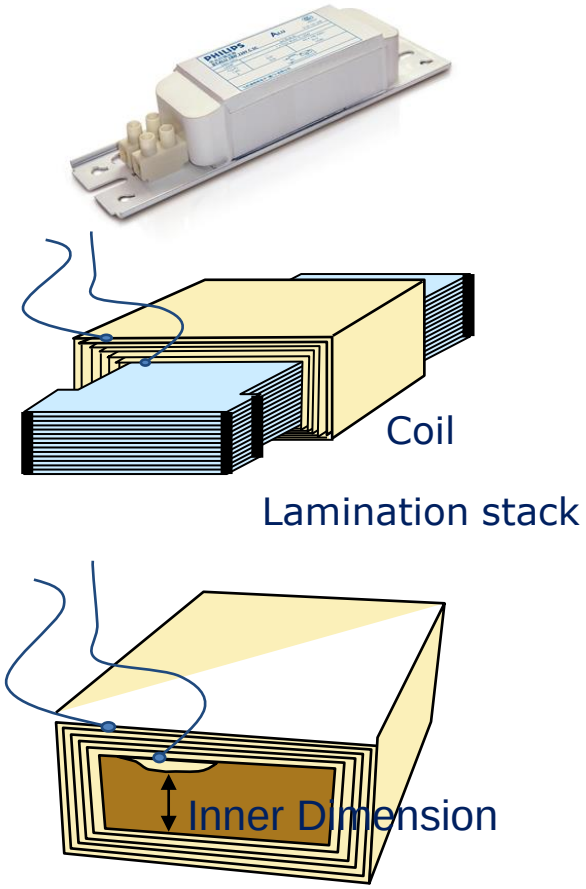
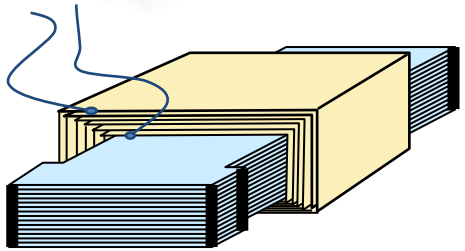
Statistical Engineering: Collapsed Ballast Coils Case

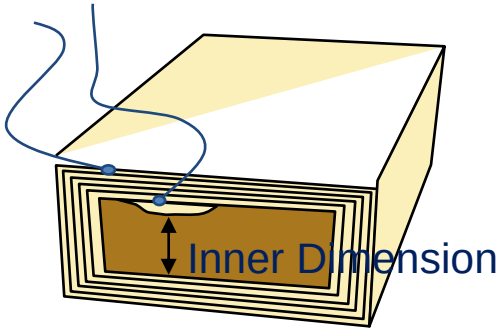


- Problem - Coil inner dimension won't fit over lamination stack if it collapses.
  - Adjust winding machine tension
  - Change material
- DoE approach (e.g. Tension, Material, Winding speed, etc.)
- Result - Production continues scrapping coils

Solution: Collapsed Ballast Coils

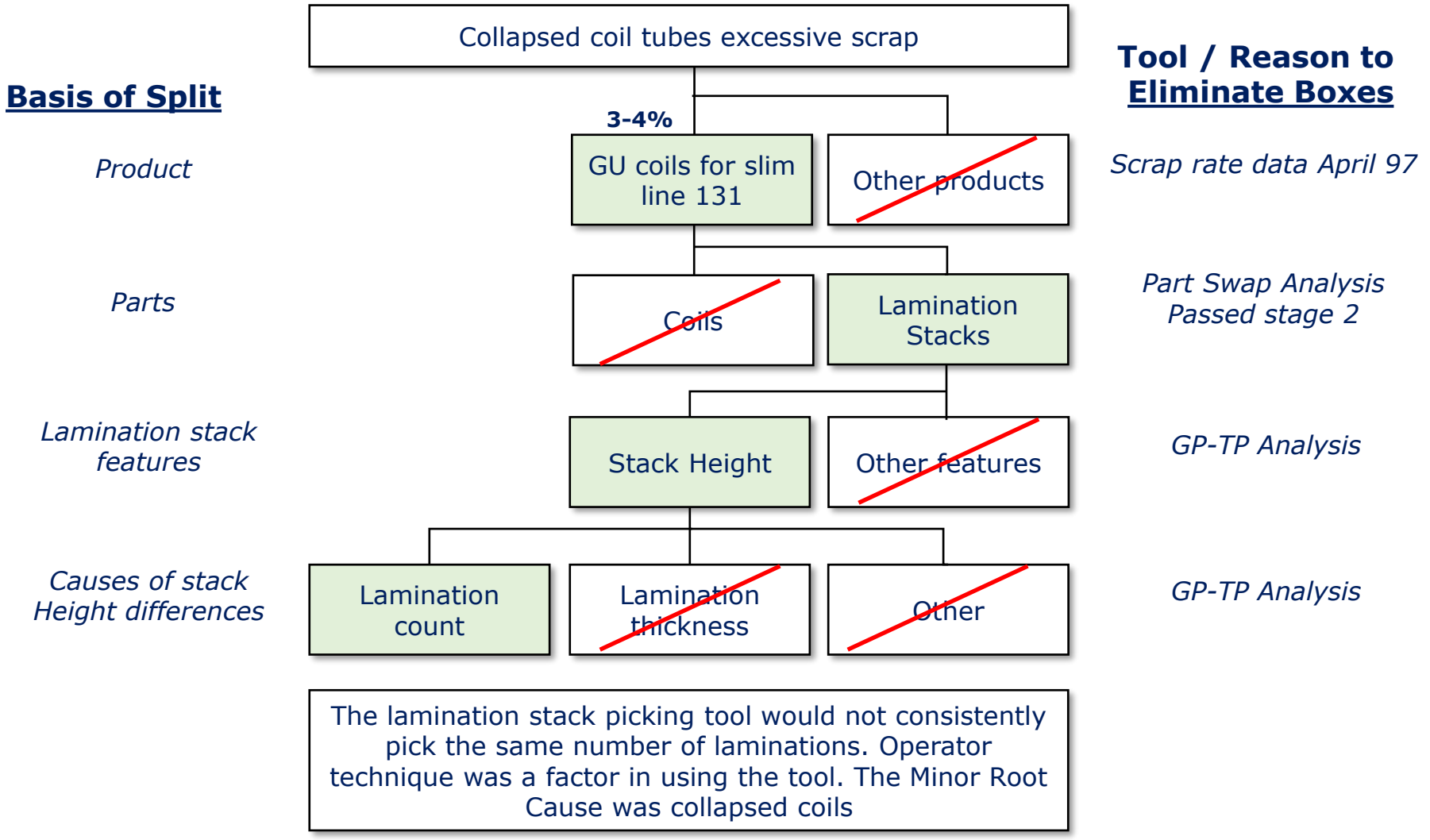


Lamination stack



- Major Root Cause:
  - Interaction of lamination stack height and copper coil ID.
  - Stack height variability not recognized because of prior work.
- Result:
  - Coil scrap reduced from 4% to < 2% ($75K/yr)
  - Solved in 1 Hour
- Lesson Learned:
  - Break through by thinking backwards
  - “Effect-Cause Relationship”

Statistical Engineering: reasoning & documentation



General RCA approaches

Lucky guess

- First shot based on experience
- Not used within SE

- Inefficient for new problems
- May guide in a false direction

Symptom search

- Find symptoms in a library
- E.g. common software issues
- Limited use within SE

- Suitable for known problems
- Requires a well-kept database

Branch & prune

- Split root cause parameter space
- Exclude all options but one
- Can be done on any basis

- Dedicated experiments
- Stepwise problem solving
- Backbone of SE

General RCA approaches

Proximate Causes

- Work from effect to cause in steps by backward reasoning
- Basis for approaches like 5 x Why

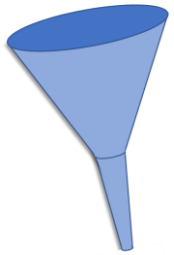
- Basis for “Logic splits” in SE

Syndrome driven

- Find commonalities among instances of the same problem
- Basis for approaches like Kepner-Tregoes Is-Is not

- Limited use within SE near the end of the investigation
- GP-TP Analysis and Group Comparison are based on this

Funneling – Hypothesis testing



- Starts with an enumerable list
- Efficiency-driven experiments
- Often combined with DOE

- Used within SE when the list of remaining potential Root Causes is short

Statistical Engineering vs Data Science

Statistical Engineering seeks focus first; then create dedicated data

“Branch and prune”

vs

Data Science can process large amounts of data to find patterns

“Syndrome-driven”

Mismatch??

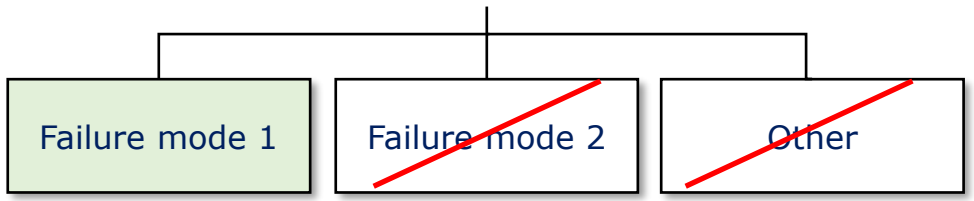
How can we make Data Science and Statistical Engineering work together?

Going together: data science & statistical engineering

- Although at first sight there seems not to be a lot of interaction between statistical engineering and data science, still several possibilites exist
- Some examples amongst others:
  1. Focus on a specific problem / failure mode
  2. Mapping processes
  3. Multi-Vari Charts

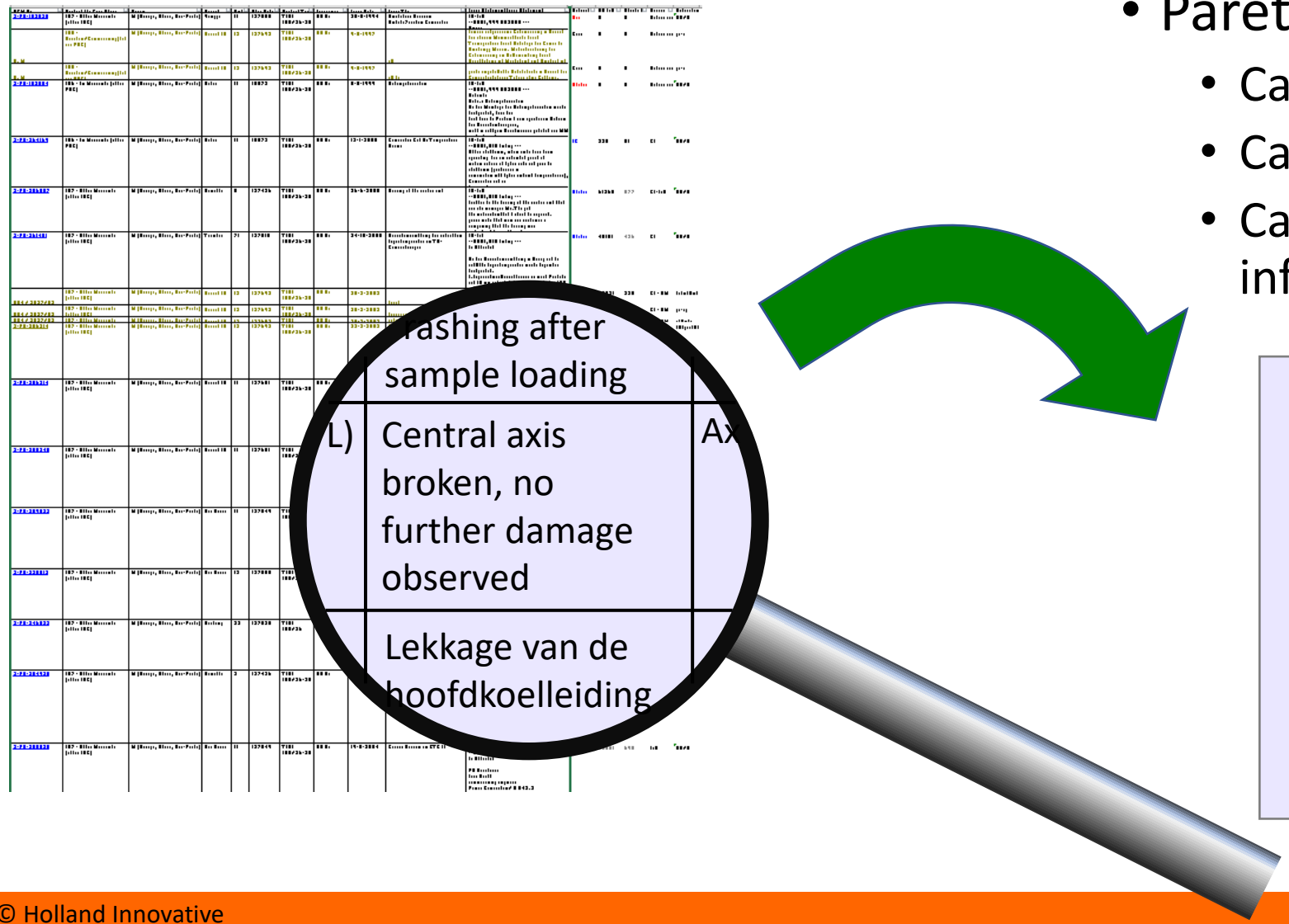
1. Project definition: focussing on a problem

- In any Root Cause it is important to define what problem will be solved exactly
- Often many problems are present
  - E.g. for the performance indicator “availability loss” many different failure modes will contribute
  - Before solving any problem we need knowledge on the relative magnitude of all issues

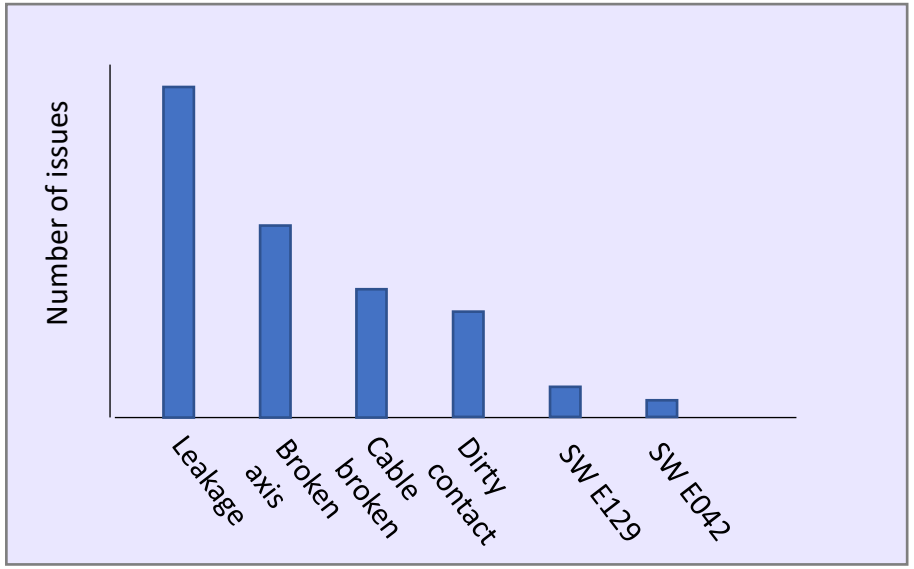


Pareto Analysis

Data science can help to focus

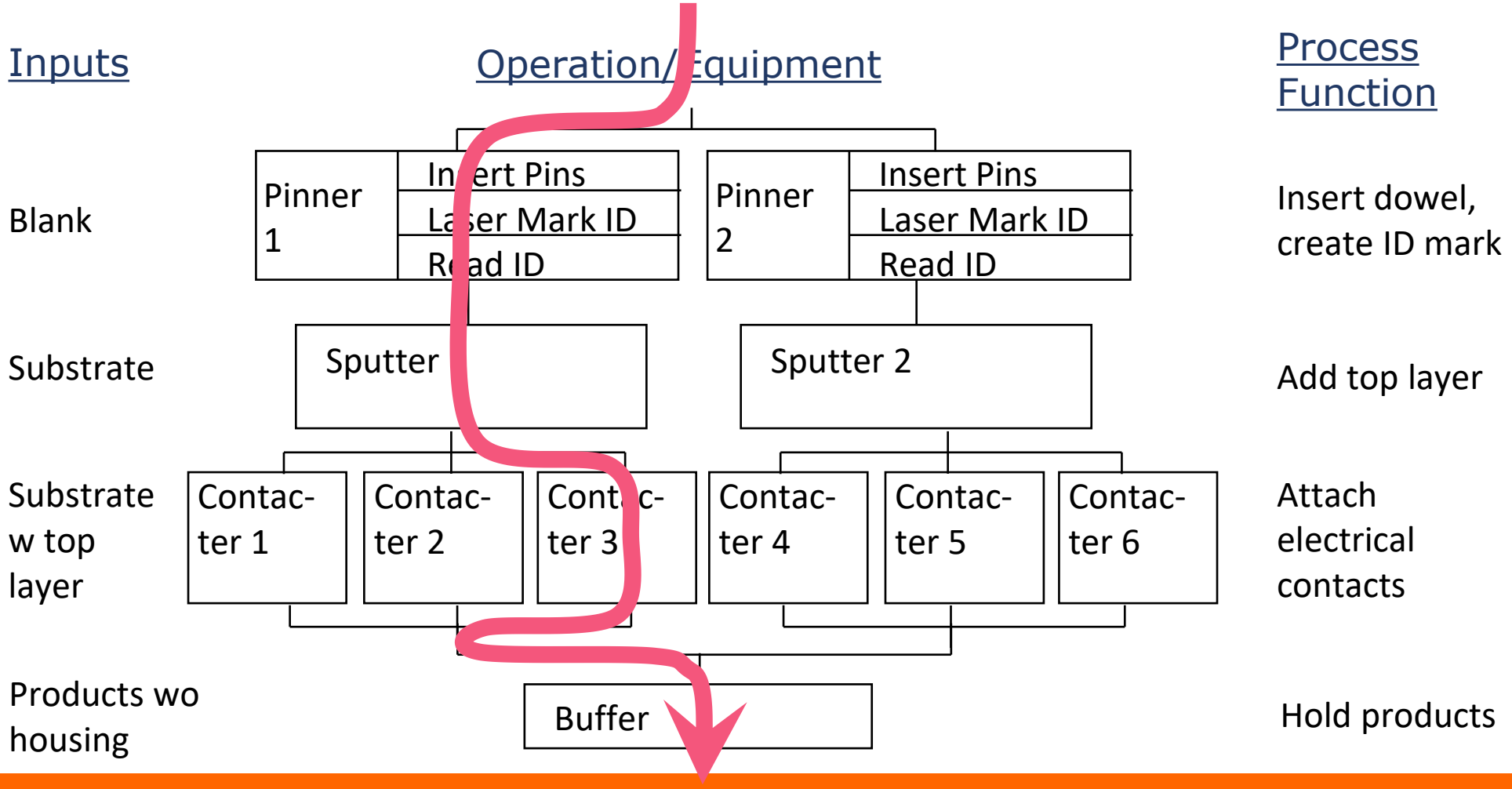


- Pareto based on keyword search
  - Can handle different languages
  - Can filter double entries
  - Can combine different pieces of information for a single record



2. Process breakdown

If the root cause lies within a process, Statistical Engineering aims to split the root cause parameter space into process steps ⟹ make a Process Flow Diagram



Using MES data to trace product flow

Time	RFID	Length	Width	Duration	Temperature	Relative humidity
08:00:01	af-ed-90-3a	79.99	44.98	00:00:05	20.1	39.8
08:00:08	af-ed-90-3b	79.97	44.98	00:00:05	20.1	39.7
08:00:15	af-ed-90-3c	79				39.8
08:00:22	af-ed-90-3d	79				39.7
08:00:29	af-ed-90-3e	80				39.6
08:00:36	af-ed-90-3f	80				39.8
08:00:43	af-ed-90-40	80				
08:00:50	af-ed-90-41	80				
08:00:57	af-ed-90-42	80				
08:01:04	af-ed-90-43	80				
08:01:11	af-ed-90-44	80				
08:01:18	af-ed-90-45	80				
08:01:25	af-ed-90-46	79				
08:01:32	af-ed-90-47	80				
08:01:39	af-ed-90-48	79				
08:01:46	af-ed-90-49	80				
08:01:53	af-ed-90-4a	79				
08:02:00	af-ed-90-4b	80				
08:02:07	af-ed-90-4c	79				
08:02:14	af-ed-90-4d	79				

Time	Pressure	Temperature	Duration
08:00:12	2.5	20.9	00:00:15
08:00:39	2.5	20.9	00:00:16
08:01:09	2.5	21.1	00:00:16
08:01:37			
08:02:06			
08:02:33			
08:03:00			
08:03:30			
08:03:57			
08:04:24			
08:04:53			
08:05:20			
08:05:49			
08:06:17			
08:06:45			
08:07:13			
08:07:41			

Time	RFID	Voltage	Current	Power
08:04:37	af-ed-90-3a	11.99	0.0186	0.222964
08:04:50	af-ed-90-3b	12.00	0.0156	0.186993
08:04:57	af-ed-90-3c	12.00	0.0113	0.135278
08:04:57	af-ed-90-3d	12.00	0.0083	0.099619
08:05:06	af-ed-90-3e	12.00	0.0245	0.29435
08:05:12	af-ed-90-40	12.00	0.0216	0.25865
08:05:18	af-ed-90-3f	11.99	0.0061	0.072991
08:05:27	af-ed-90-41	12.02	0.0196	0.236099
08:05:33	af-ed-90-42	11.99	0.0209	0.250766
08:05:45	af-ed-90-43	12.02	0.0162	0.194201
08:05:47	af-ed-90-45	12.00	0.0091	0.109494
08:05:54	af-ed-90-44	12.00	0.0090	0.107406
08:06:02	af-ed-90-46	12.00	0.0173	0.207483
08:06:06	af-ed-90-47	12.00	0.0113	0.135253

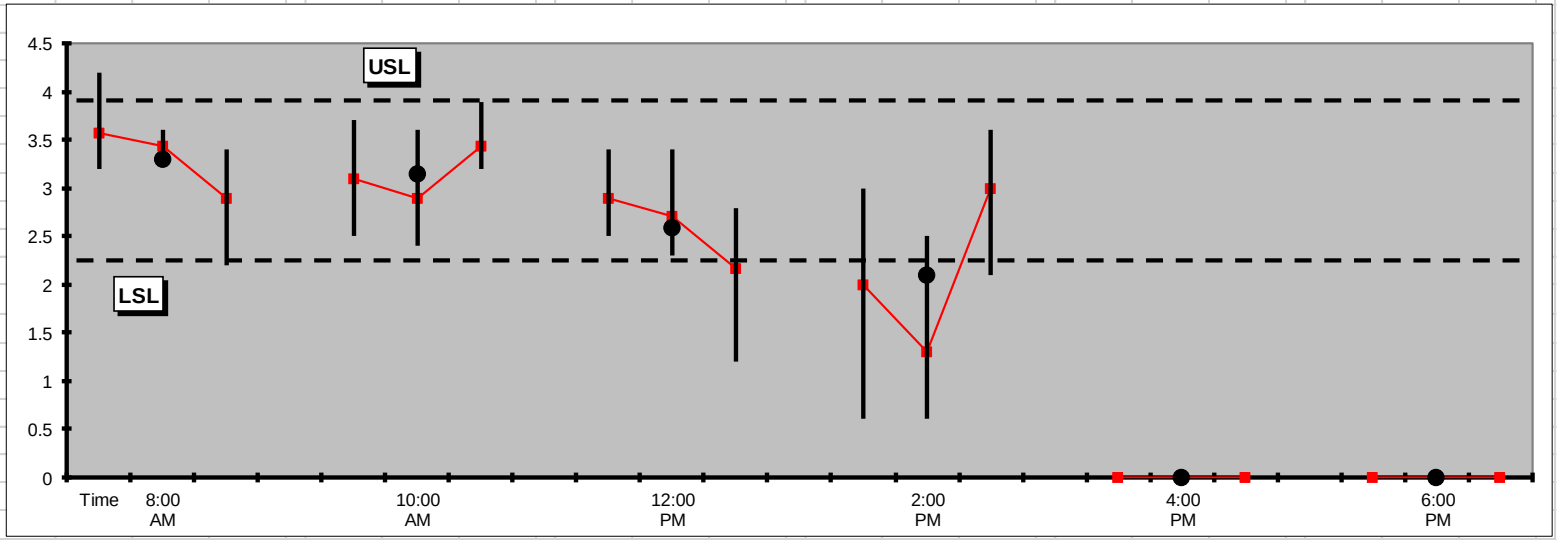
- Data science tchniques can be used to find the routing for each product
- Explicitly: via tracing / RFID
- Implicitly: via repeatedly measured properties, timing, etc.

3. Multi-vari charts

- In SE Multi-Vari the variation is split into “families”
  - Within product
  - Between product
  - Over time
- A family is a partioning of the root cause parameter space
- By determining which family the root cause lives in, one can exclude whole classes of potential root causes

	Time	8:00 AM			10:00 AM			12:00 PM			2:00 PM			4:00 PM			6:00 PM		
Within Unit	Date																		
	Unit ID	11	12	13	167	168	169	314	315	316	453	454	455						
Front		4.2	3.4	3.4	3.7	3.6	3.9	3.4	3.4	2.5	3	2.5	3.3						
Center		3.2	3.3	2.2	3.1	2.4	3.2	2.8	2.4	2.8	0.6	0.8	2.1						
Back		3.3	3.6	3.1	2.5	2.7	3.2	2.5	2.3	1.2	2.4	0.6	3.6						
	Min	*3.2*	*3.3*	*2.2*	*2.5*	*2.4*	*3.2*	*2.5*	*2.3*	*1.2*	*0.6*	*0.6*	*2.1*	*0*	*0*	*0*	*0*	*0*	*0*
	Max	*4.2*	*3.6*	*3.4*	*3.7*	*3.6*	*3.9*	*3.4*	*3.4*	*2.8*	*3*	*2.5*	*3.6*	*0*	*0*	*0*	*0*	*0*	*0*
	Range	*1*	*0.3*	*1.2*	*1.2*	*1.2*	*0.7*	*0.9*	*1.1*	*1.6*	*2.4*	*1.9*	*1.5*	*0*	*0*	*0*	*0*	*0*	*0*
	Unit Average	*3.567*	*3.433*	*2.9*	*3.1*	*2.9*	*3.433*	*2.9*	*2.7*	*2.167*	*2*	*1.3*	*3*						
	Unit-to-Unit Range		*0.667*			*0.533*			*0.733*			*1.7*							
	Time Average		*3.3*			*3.144*			*2.589*			*2.1*							

Multi-Vari Chart
One Measurement Per Part, Multiple Parts "Within" Units



Spec Limits:
USL=
4
LSL =
40

Variation Ranges:
Within Unit
2.4
Unit-to-Unit
1.7
Time-to-Time
1.2

Problem Title :	Layer uniformity
CTQ[Units] :	Thickness (µm)
By :	[redacted]
Date :	

Conclusions & Rationale :

Data science and multivari

- Actually, a multi vari is already Data Science, only with small data sets
- Data science may be used to extract the Multi Vari data from large quality control data sets, turning *“big data”* into *“right data”*

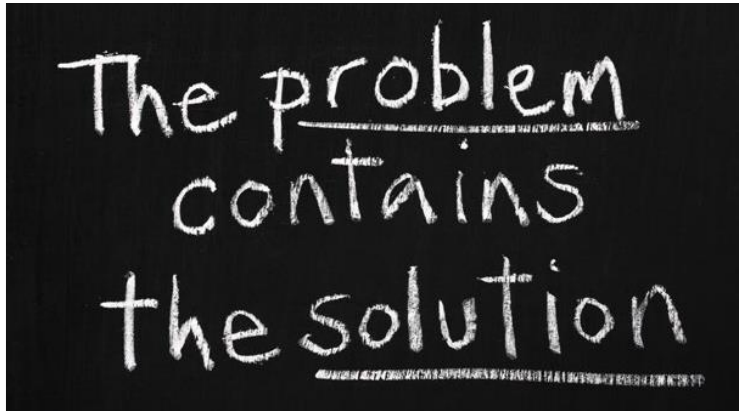
- One step further, Data Science can help finding contrasts over time or process structure, thereby suggesting relevant families of variation
  - This can go as far as predicting their relative magnitude
  - It becomes even more powerful if you combine this with the process flow analysis mentioned before, i.e., a multivari analysis for each process step
  - Caution however, process steps may be confounded if using production data

Conclusion

- Although Data Science and Statistical Engineering seem opposites at first sight, Data Science can strengthen the SE approach
- Data Science can quickly sift through the hay stack
- … while Statistical Engineering ensures you're looking at the right hay stack

ACADEMY

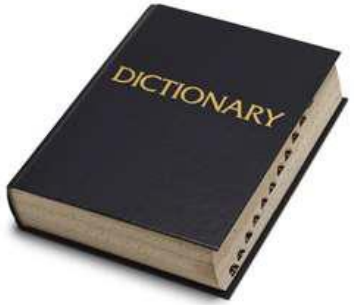
Problem Solving through Root Cause Analysis – Statistical Engineering

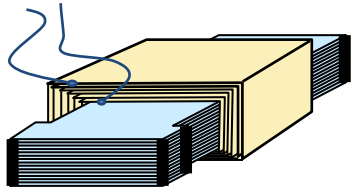


Major Root Cause Paradigm

MjRC

Listening to the parts





POWERFUL SOLUTIONS

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Problem Solving through RCA - StatEng course

With this course (5 modules of 1 day) you'll learn:

- How the Statistical Engineering methodology works
- How to deal with failing products and how to report progress to management
- To become a complete problem solver

The Statistical Engineering (SE) methodology helps to create the starting grid for problem analysis and to understand a measurement system. It provides insight into which products and data to investigate and which statistical tools to use for that.

https://www.holland-innovative.nl/academy/rf10-problem-solving-root-cause-analysis/


Click here for more information

Problem Solving through Root Cause Analysis

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Does one of the following sound familiar? "We are not sure whether we really solved the problem." "The root cause analysis team has been trying many things but nothing seems to work." "We do not have enough resources for root cause analysis." In that case our training Problem Solving by Statistical Engineering will give insight how to get out of the impasse, following state-of-the-art techniques.

Problem Solving by using Statistical Engineering

Register: www.holland-innovative.nl

The aim and result of the training

This training focusses on using a structured and efficient root cause analysis to solve the problems in your product. Processes commonly result in a certain spread on the output - i.e. the function of your products - causing a number of products to not fulfill the requirements and thus have a problem. The participants are trained to be able to perform a root cause analysis for problem solving using the Statistical Engineering (SE) methodology in an independent and professional manner. The SE methodology exploits the fact that one root cause always has the largest contribution to the problem and the goal is to find this Root Cause and to understand it. The subsequent solution then becomes apparent.

A selection of the skills that will be acquired

This training will make clear to you why and how the SE methodology works. This methodology helps to create the starting grid for a problem analysis and to understand a measurement system. Furthermore, it provides insight in which products and data to investigate and which statistical tools to use. The SE methodology includes many special tools that will be taught extensively during this training. Participants will learn how to deal with failing products and how to report progress to management. The training provides a complete program to become a complete problem solver.

Target group

This training aims at all engineers and specialists working in technical areas. The training is specifically meant for those who want to learn the efficient root cause analysis methods and be able to apply them in their own organization.

In-company

Holland Innovative offers this training also as an in-company training, with an option to include on-the-job coaching on ongoing problem solving projects. The training can be tailored to needs when necessary.

Course duration and number of participants 10 Half day sessions spread over 5 or 10 days. Maximum group size: 12 participants.

Instructors Dr. Ko Dousma, Dr. Ir. Coen Smits

Location and investment Holland Innovative, High Tech Campus 29, Eindhoven. The investment is €3.500,- (ex. VAT) per participant. This includes the 5 training days, a syllabus of the training material, templates and tools, lunch and refreshments. The training can also be given in-company. The training can be tailored to the requirements and wishes of the company.

Dates, registration and more info See www.holland-innovative.nl under Academy.

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Focus on complex business processes