# AltaNova Introduction

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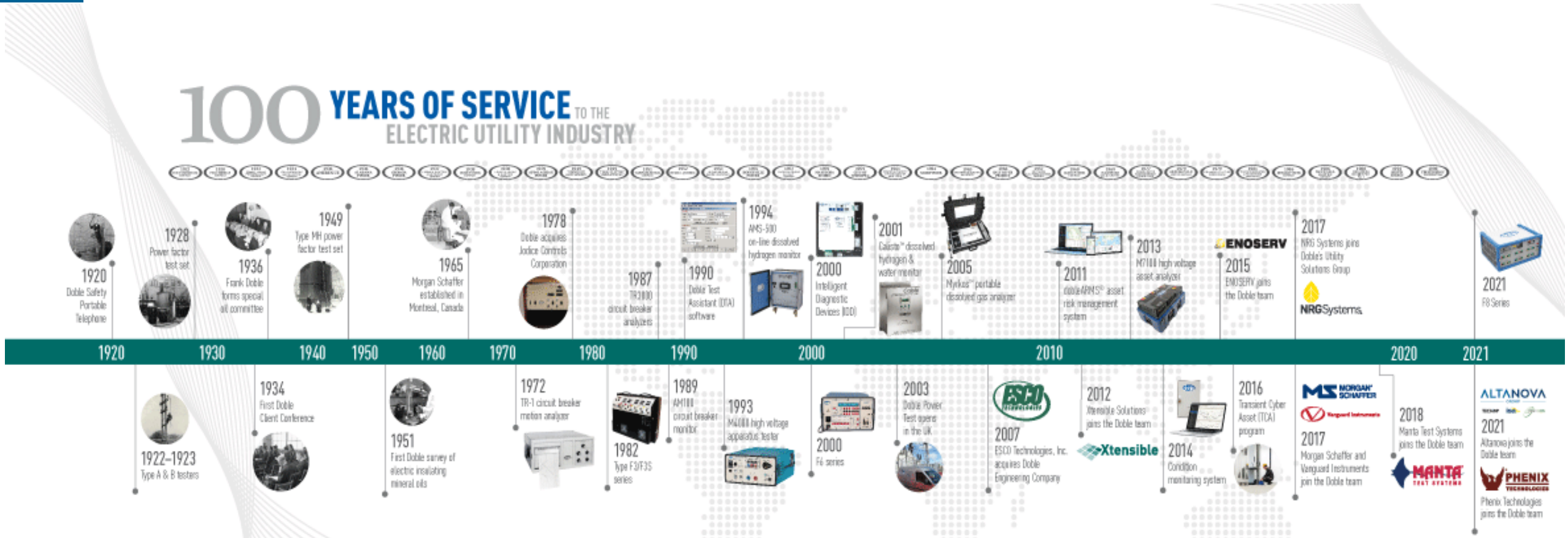
# Doble History



# Altanova History

**1938** I.S.A. Istrumentazioni Sistemi Automatici S.r.l. is established in Taino ITALY

**1999** TECHIMP was born as a spin-off from the University of Bologna ITALY.

**2017** I.S.A. and TECHIMP merge giving birth to the ALTANOVA GROUP

**2019** INTELLISAW joins ALTANOVA GROUP

**2021** ALTANOVA GROUP becomes part of ESCO Technology Group and joins the Doble Engineering Company, as part of the USG division.

# Altanova Today

ALTANOVA
A DOBLE COMPANY

**100**
**COUNTRIES**

**12**
**GLOBAL FACILITY LOCATIONS**

**150+**
**EMPLOYEES**

**150+**
**SALES PARTNERS**

**5550+**
**CUSTOMERS GLOBALLY**

**Part of ESCO Technologies' Utility Solutions Group**

## PRODUCT BRANDS

doble® isa MORGAN® SCHAFFER PHENIX TECHNOLOGIES TECHIMP Vanguard Instruments

# Our Solutions

## Electrical Test Equipment

Essential for day-to-day maintenance tests of electrical assets. Useful in specific phases of the asset lifecycle:

- Procure
- Operate
- Maintain
- Decommission.

## Professional Services

Diversified offer according to the electrical asset lifecycle:

- Installation and commissioning
- Diagnostic test
- Data analysis
- Consultancy
- Training.

## Monitoring Systems

Shift from a time-based maintenance to a condition-based maintenance.

Focus on predictive maintenance and shift in focus from electric asset value cost to network outage costs.

Strong evolution of digitalization trend in the power industry.

# Testing And Monitoring Solutions For:

ALTANOVA
A DOBLE COMPANY
doble isa MS MORGAN SCHAFFER PHENIX TECHNOLOGIES TECHIMP Vanguard Instruments

- Power transformers
- Circuit breakers
- HV gas insulated switchgears
- MV/HV/EHV cables
- MV/LV switchgears
- Batteries
- Current & voltage transformers
- Protective relays
- Meters and transducers
- Rotating machines
- Variable speed drives
- Overhead lines






# Creating and using meaningful Asset Health Indices (AHI)

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# Agenda

Presenter Background

A little on transformers

Some aspects of Asset Health Indices

- Failure modes, expectations and health indexing
- Dunning-Kruger
- Risk of Using Risk Matrices
- Tooth Fairy Science
- Anscombe

Conclusion/Discussion

## Aim:

Provide you with something of interest/value/use in your ‘day job’.

# Presenter background

- National Grid UK: substation tech specialist, transformers
  - Go/NoGo decisions: timescales & actions
- National Grid US: Substation Asset Mgr.
  - >2,000 power transformers, many >80 years old…
- Doble Engineering
  - Asset Management and Monitoring Technology

# Asset Management Context

- ISO 55000: Asset management
- Talk technical to financial people… financial to technical people
  - ‘Translation’ needed – AHIs sometimes used as a substitute
- Risk – Cost – Performance – Sustainability
- Risk is a combination of hazard probability and consequence
- Expectations – actions – feedback
- Plan – do – check – act
- Smart analytics: 95% can be achieved through cleaning up the data and use of standard statistical tools...
- Make data available…


“Plans are of little importance, but planning is essential.”
— **Winston Churchill**

# Transformer Assets:

Big Money, Big Data…

…big responsibilities!

# Failure modes are not always obvious

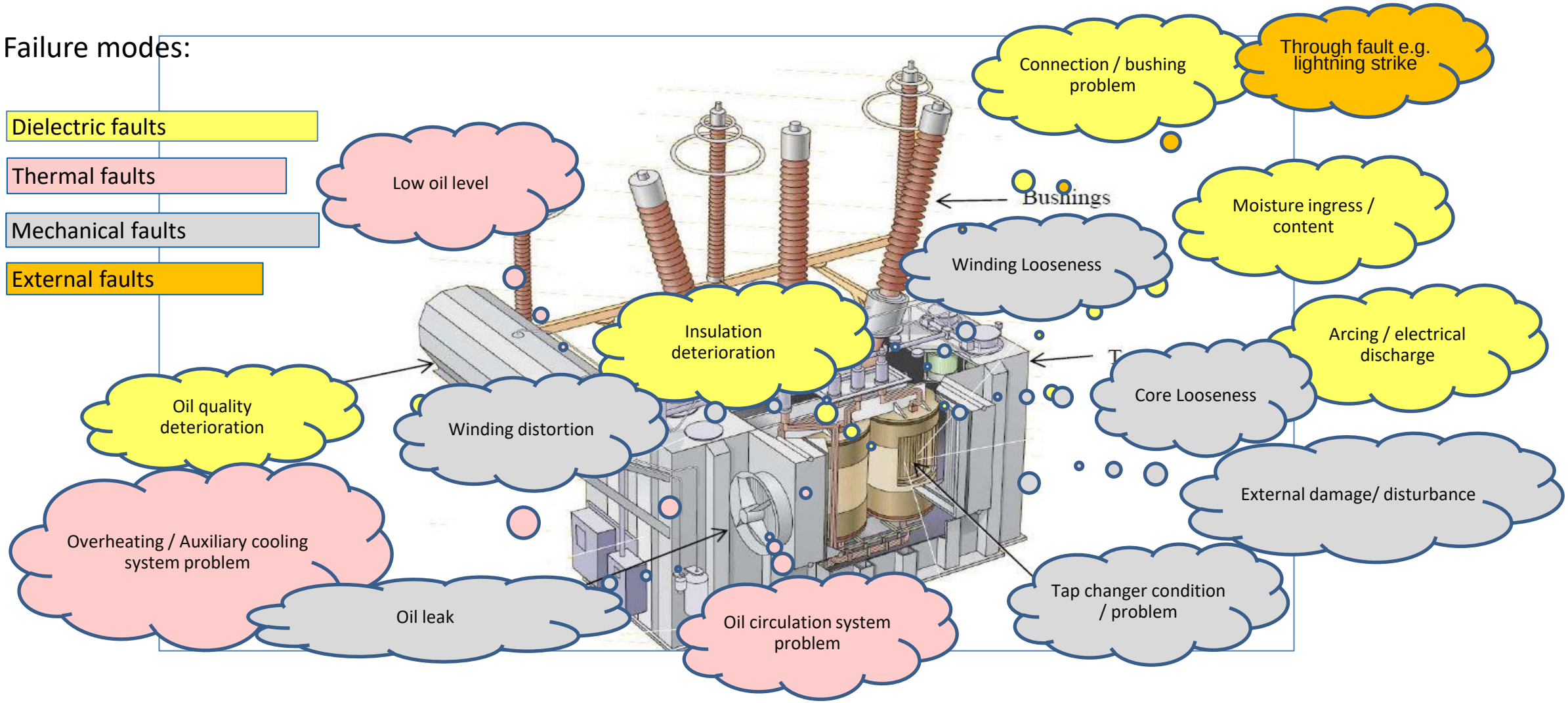

From “Field Experiences with SFRA”
Various, Doble Client Conference, Boston, 2002-2019

# The unexpected…

# Expectations: failure modes[1]

Failure modes:

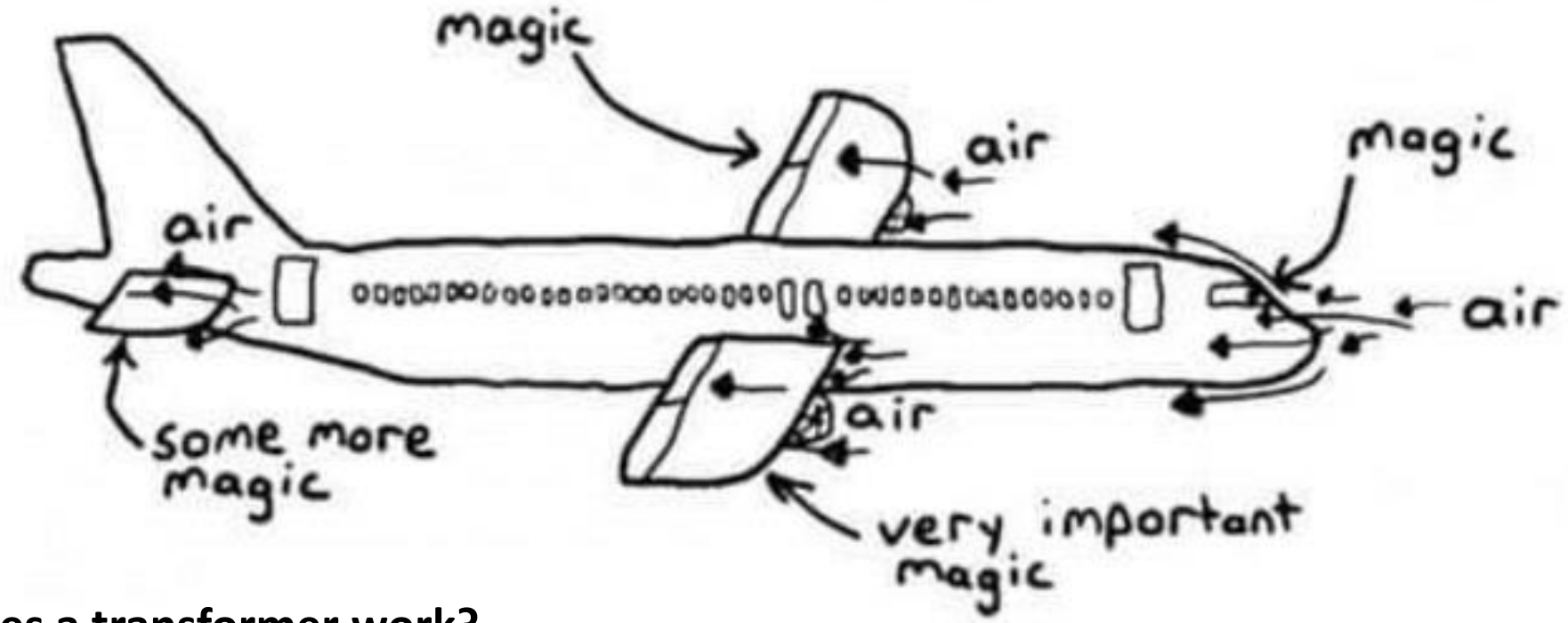
- Dielectric faults
- Thermal faults
- Mechanical faults
- External faults




1: ISO 18095 “Condition Monitoring and Diagnostics of Power Transformers”

# How does the electric supply system work?

Use air transport systems as an analogy: how do planes work?




**How does a transformer work?**

**How much does the decision maker know?**

**Purchasing decisions? Viability? Commodity approach?**

# Expected Life?

What is the **probability of failure** of an asset?

# 100%

Economist: J. M. Keynes:
“ *In the long run* **we are all dead.**”

Singer/Songwriter: Paul Simon
“**Everything put together, sooner or later, falls apart.”**

So… we need to have some interest in time: probability of failure, by when?

# Probability of Failure: when???

Story of the tires… if they fail, you may need a new car…

Pressure is at 15 psi for front left tire: **what's the PoF** of the car?

PoF this week? PoF this month? Today?

More data?

It's Tuesday (+/-15%, you may need to check…)

Ok… you're doing 100 kph (62.5mph)


And the pressure is now 12 psi…

Too late. Result?

Misery…

No tacos…

# Asset Health Index

A number/code/color/term to represent the health of an asset:
it is our ‘best estimate’ of the asset health: it is a ***model***

Whatever index we derive…

… it should not be a **surprise**!

It should ‘document’ what we *think* we know!

It ***may*** be a proxy for ‘Probability of Failure’

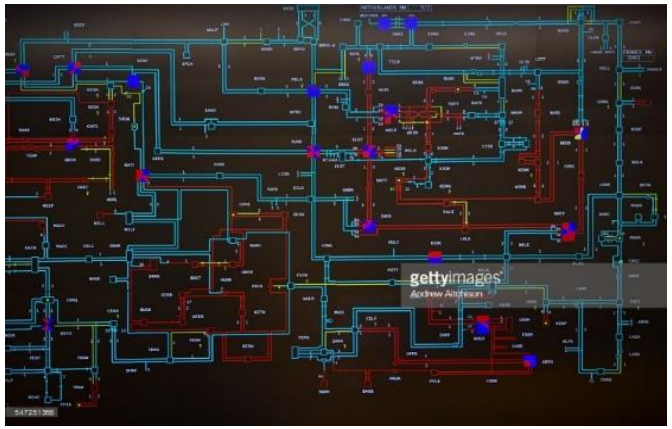

“Turning an Asset Health Index into a Probability of Failure”, CEATI Report 30113 (2018)

# Physicist Richard Feynman

On physics:

*"…you have to have an understanding of the connection of the words with the real world."*

These blocks are not transformers…




These health indices are not transformers…

| | | | | | Overall Condition | | | Core and Windings | | |
|---|---|---|---|---|---|---|---|---|---|---|
| T-N | Ratio | Design | sign | Year | Now | Mitigated | Possible I | Dielectric | Thermal | Mechanic |
| T4315 | 400/132 kV | A04a | 32 | 1965 | 221 | 213 | 8 | 100 | 100 | 1 |
| T3040 | 275/132 kV | E11b | 32 | 1959 | 170 | 103 | 68 | 30 | 60 | 1 |
| T6975 | 400/275 kV | G02b | 104 | 1994 | 170 | 135 | 35 | 30 | 60 | |
| T3039 | 275/132 kV | E11b | 32 | 1959 | 154 | 143 | 11 | 30 | 100 | 1 |
| T4259 | 275/66 kV | D07 | 12 | 1965 | 152 | 126 | 26 | 60 | 60 | 1 |
| T2370 | 275/132 kV | M01 | 5 | 1957 | 151 | 94 | 57 | 30 | 60 | 1 |
| T5961 | 400/275 kV | H02 | 111 | 1971 | 147 | 100 | 47 | 3 | 60 | |
| T6201 | 275/33 kV | P21 | 104 | 1972 | 144 | 139 | 5 | 1 | 3 | 100 |
| T5566 | 400/132 kV | C04 | 32 | 1968 | 138 | 85 | 54 | 10 | 60 | 1 |
| T4409 | 275/132 kV | H07a | 12 | 1964 | 133 | 107 | 26 | 1 | 100 | 1 |
| T5581 | 400/132 kV | A04b | 102 | 1967 | 132 | 106 | 26 | 10 | 60 | 1 |
| T4686 | 400/132 kV | P06a | 131 | 1967 | 131 | 107 | 24 | 1 | 60 | 1 |
| T4406 | 275/132 kV | H07a | 12 | 1964 | 129 | 106 | 23 | 1 | 100 | |
| T2300 | 275/132 kV | E11a | 102 | 1955 | 129 | 105 | 24 | 10 | 60 | 1 |
| T4258 | 275/132 kV | H07a | 12 | 1966 | 129 | 106 | 23 | 1 | 100 | |
| T3041 | 275/132 kV | E11b | 32 | 1959 | 129 | 107 | 22 | 30 | 60 | 3 |
| T2521 | 275/132 kV | F08 | 120 | 1956 | 124 | 105 | 19 | 3 | 60 | 1 |
| T3583 | 275/132 kV | L05 | 111 | 1962 | 122 | 99 | 23 | 1 | 60 | |
| T5434 | 400/132 kV | A04b | 102 | 1967 | 122 | 96 | 26 | 1 | 60 | |
| T3139 | 275/66 kV | A10 | 3 | 1960 | 122 | 106 | 16 | 100 | 3 | 1 |

**They are *representations* of transformers… they are '*models*' … digital twins!**

***"All models are wrong, some models are useful"*** *C.J. Box*

# More thoughts from inside a Box[1]

“Since all models are wrong… you cannot obtain a "correct" one by excessive elaboration.”

“Since all models are wrong… you must be alert to what is *importantly wrong*. It is inappropriate to be concerned about mice when there are tigers abroad.”

“The only question of interest is: ‘**Is the model illuminating and useful?’**”

And from Dr. Cox[2]:

“The idea that complex physical, biological or sociological systems can be exactly described by a few formulae is patently absurd.”

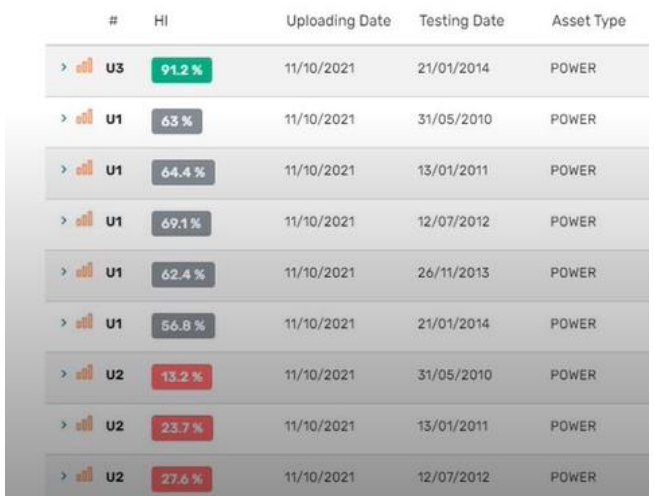
1: Box, G. E. P. (1976), "Science and statistics” *Journal of the American Statistical Association*

*2: Cox, D. R. (1995), "Comment on "Model uncertainty, data mining and statistical inference"", Journal of the Royal Statistical Society, Series A,*

# What does a health index mean

Depending on how you built the ‘health index’, it could:

- Summarize what we already know
- Indicate likely failure modes and timescales for action
- Help rank assets for intervention based on ‘urgency’
- Have poor precision/accuracy
- May not indicate ‘serious issues’ if we do not test for them



| # | HI | Uploading Date | Testing Date | Asset Type |
|---|---|---|---|---|
| U3 | 91.2 % | 11/10/2021 | 21/01/2014 | POWER |
| U1 | 63 % | 11/10/2021 | 31/05/2010 | POWER |
| U1 | 64.4 % | 11/10/2021 | 13/01/2011 | POWER |
| U1 | 69.1 % | 11/10/2021 | 12/07/2012 | POWER |
| U1 | 62.4 % | 11/10/2021 | 26/11/2013 | POWER |
| U1 | 56.8 % | 11/10/2021 | 21/01/2014 | POWER |
| U2 | 13.2 % | 11/10/2021 | 31/05/2010 | POWER |
| U2 | 23.7 % | 11/10/2021 | 13/01/2011 | POWER |
| U2 | 27.6 % | 11/10/2021 | 12/07/2012 | POWER |

A ‘health index’ CAN NOT tell you that the asset will NOT fail in a given time period

Key words: Calibrated, Monotonic
Auditable, Justifiable

**"Life is under no obligation to give us what we expect”**

***Irrfan Khan, Actor***

# Key Words

- **Calibrated**:

  All identical indices have **identical timescales** for action

  *(all '3s' need to be checked in 1 month, say)*

- **Monotonic:**

  A 'worse' index is always associated with a **more urgent** condition

  *(all '3s' are worse than all 2's, say)*

- **Auditable**

  We can track the index back to **data, failure modes** and timescales

  *(we have the evidence and the analysis)*

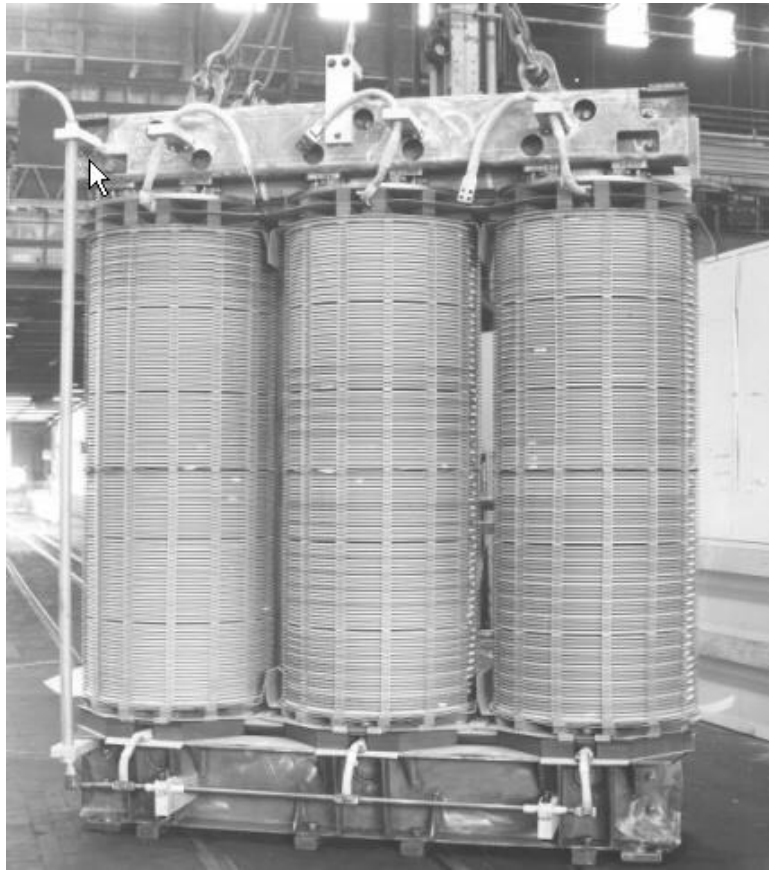
- **Justifiable:**

  The process of generating an index is based on **failure mode analysis/urgency**

  *(the analysis makes sense)*

# What if we just had one or two assets?

- Gather data
- Read the manuals/guides
- Test and assess
- Make a plan to intervene:
  - maintain, replace, refurbish…
- Act on the plan in a timely manner
- Repeat



- Who needs a health index?
- A health index… what would it do for our one or two assets?

# Raw data to an index

Start with something ‘simple’ – tire pressure in psi. If the tire pressure drops too much, the tire may fail, possibly taking the car with it.

The more the pressure drops, the more urgent the situation is!

How much of a drop is too much? Where are you on the failure mode curve?

How do we turn the measured pressure into a health index?


# Creating an Index

What question are you trying to answer?

For just one asset:

- what data do you need, what analysis, what resources?
- **Can you identify failure modes and timescales?**
- What intervention is needed? When?

What do you want the index to ‘look like’: letters, numbers, other?

What categories are acceptable? Useful?

| Code | Code | Code | Timescale For Action |
|---|---|---|---|
| A | 1 | John | ‘Regular’ activity |
| B | 2 | Paul | 5 - 15 years |
| C | 3 | George | 2 - 5 years |
| D | 4 | Ringo | 0.5 - 2 years |
| E | 5 | Bert | <6 months |

# Linear weighted scoring

Evaluate components… choose a scoring system: say **1=good** through **5=bad**

| Factor | Trf 1 | Trf 2 | Trf 3 |
|---|---|---|---|
| DGA Main Tank Score | 2 | 1 | 1 |
| Dielectric Score | 1 | 1 | 1 |
| Thermal Score | 2 | 1 | 1 |
| Mechanical Score | 3 | 4 | 1 |
| Oil Score | 1 | 1 | 1 |
| DGA LTC Tank Score | 3 | 1 | 5 |
| Operational Score | 2 | 3 | 3 |
| Design/manufacturer Score | 1 | 4 | 1 |
| Subject Matter Expert Score | 3 | 1 | 2 |
| Sum | 18 | 17 | 16 |

HOW DID WE GET THESE INDIVIDUAL SCORES???
Note: NO AGE SCORE !!!

If you were given this data today…
…which transformer would you investigate first?
And why?

Trf 3 because this is the most urgent component

**Timescales** need to be **calibrated** so all ‘X’s are the same **timescale:**
For example: If a Thermal ‘5’ means do something in 3 months then a DGA ‘5’ also means do something in 3 months…

# MAX and ENUM

## Calibrated scores: **1=good** through **5=bad**

| Factor | Trf 1 | Trf 2 | Trf 3 |
|---|---|---|---|
| DGA Main Tank Score | 2 | 1 | 1 |
| Dielectric Score | 1 | 1 | 1 |
| Thermal Score | 2 | 1 | 1 |
| Mechanical Score | 3 | 4 | 1 |
| Oil Score | 1 | 1 | 1 |
| DGA LTC Tank Score | 3 | 1 | 5 |
| Operational Score | 2 | 3 | 3 |
| Design/manufacturer Score | 1 | 4 | 1 |
| Subject Matter Expert Score | 3 | 1 | 2 |
| **Sum** | **18** | **17** | **16** |
| Normalized Sum (%) | 40.0 | 37.8 | 35.6 |

Trf 3 has a MAX of 5 and is highest priority – even with lowest overall score.
What if there were two Trfs with a MAX of 5?

Use enumeration to count how many of each score: the ranking is then highest Enum first, lowest last

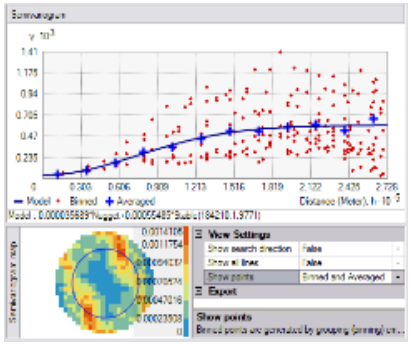
| Trf | 5's | 4's | 3's | 2's | 1's |
|---|---|---|---|---|---|
| Trf 1 | 0 | 0 | 3 | 3 | 3 |
| Trf 2 | 0 | 2 | 1 | 0 | 6 |
| Trf 3 | 1 | 0 | 1 | 1 | 6 |

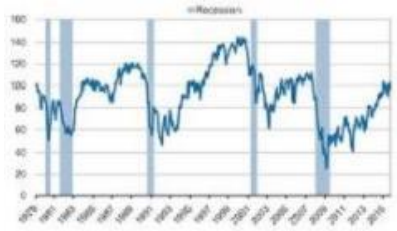
| Enum |
|---|
| 00333 |
| 02106 |
| 10116 |

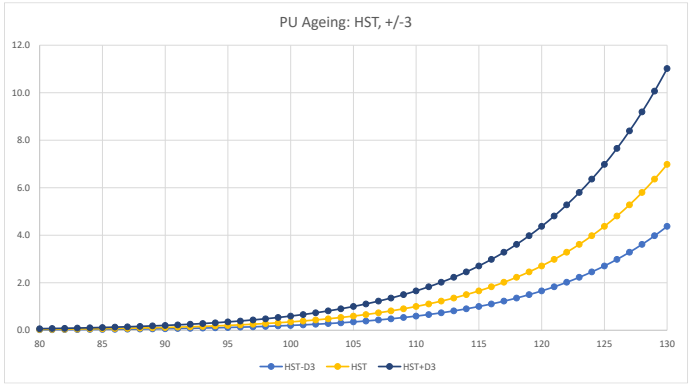
| Rank |
|---|
| 3 |
| 2 |
| 1 |

The ENUM system is easy to start small and grow – and retain urgency

# Key question

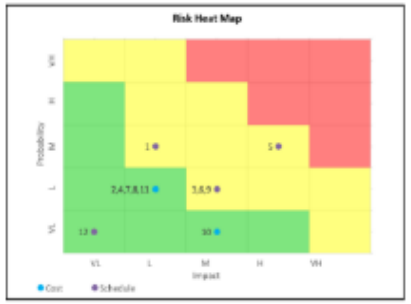


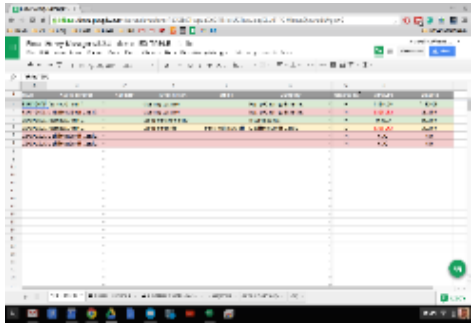




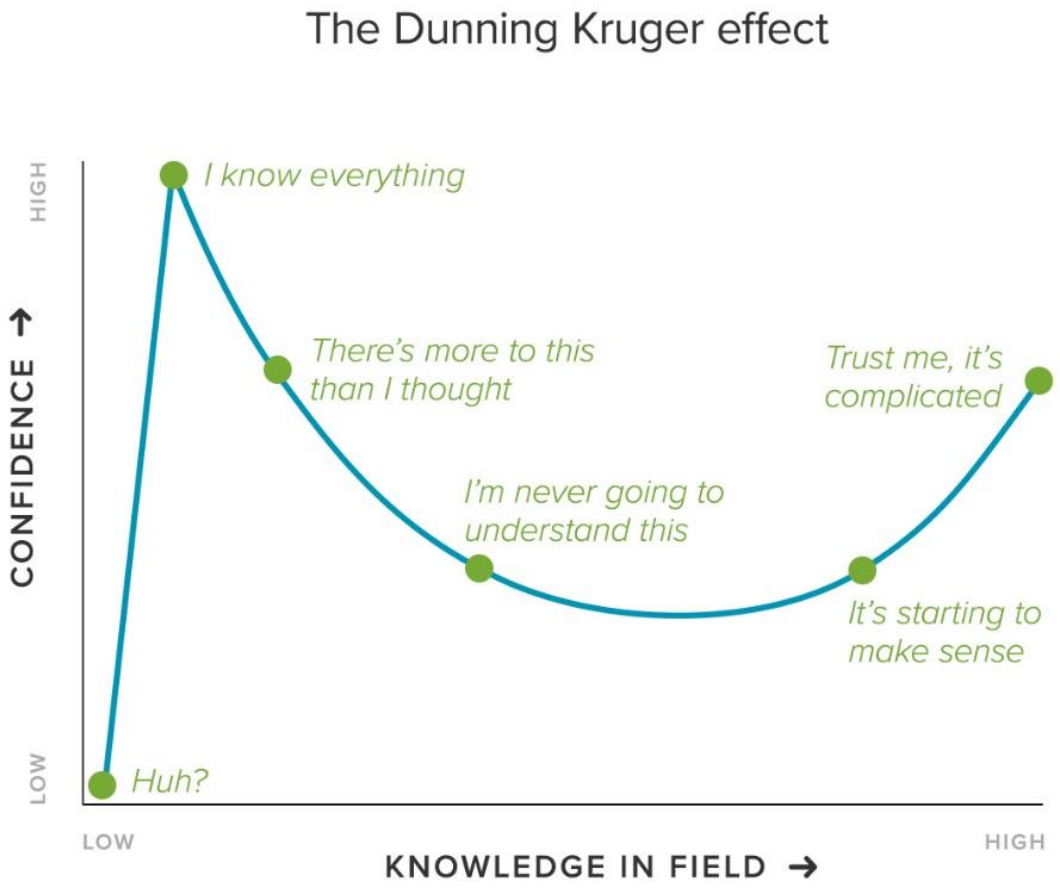

**AHI = 5.7**

**“What does 5.7 mean???”**



# A little learning?




Kruger, Justin; Dunning, David (1999).

"Unskilled and Unaware of It"

Journal of Personality and Social Psychology.
77 (6): 1121–1134

*" People with a little knowledge usually have overconfidence in their ability"*

# Get started and grow

## System Overview: only 4 codes! (Categories)

## Original System 1=bad, 4 = good

| Code | Original System |
|---|---|
| 1 | transformer is on active list for replacement within 2-5 years |
| 2 | transformer is expected to last up to 5 years and may need to be replaced in 5-10 years |
| 3 | Plan to replace ahead of anticipated asset life, design issue identified |
| 4 | transformer is expected to last for the foreseeable future, and at least 15 years. No plan to replace. |

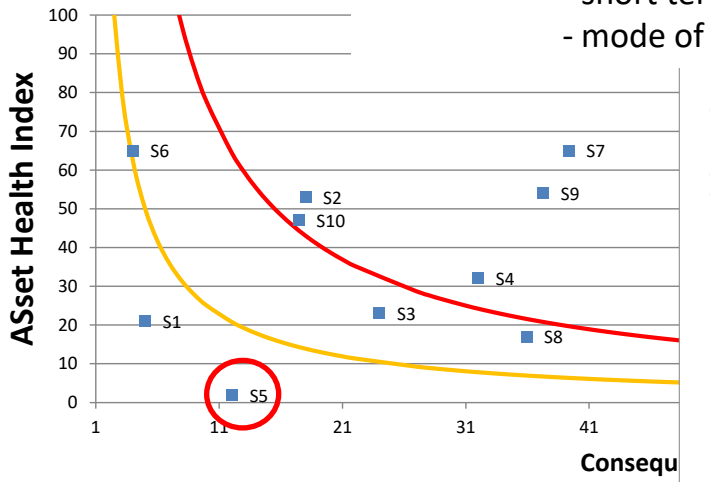
## Revised System – still 1-4, but more detail

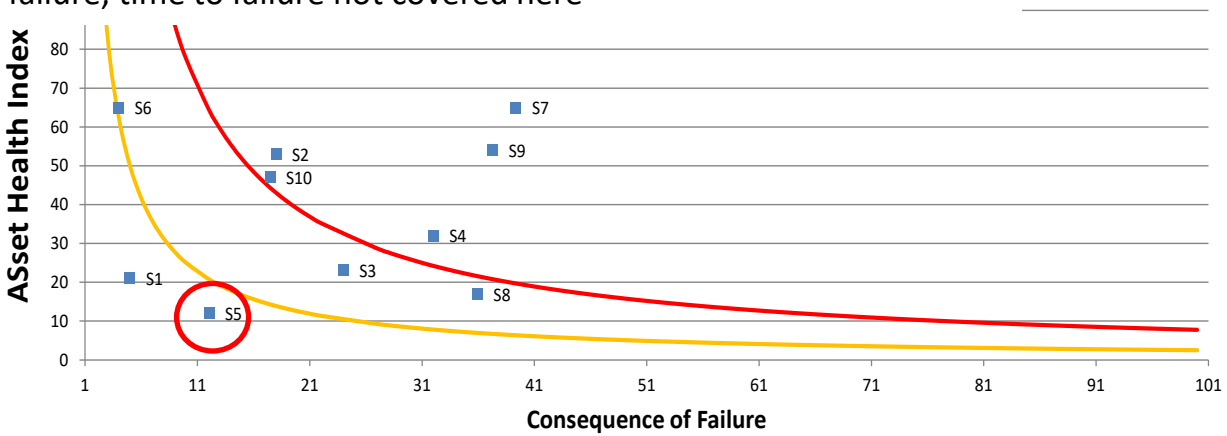
| Code | Original System |
|---|---|
| 1 | transformer is on active list for replacement within 2-5 years |
| 2a | transformer is expected to last up to 5 years and may need to be replaced in 5-10 years, may well develop into a 1 |
| 2b | transformer is expected to last up to 5 years and may need to be replaced in 5-10 years due to insulation ageing. |
| 3a | Plan to replace ahead of anticipated asset life, design issue identified |
| 3b | Plan to replace ahead of anticipated asset life, design issue identified but not serious. |
| 4 | transformer is expected to last for the foreseeable future, and at least 15 years. No plan to replace. |

# System in use in N. America

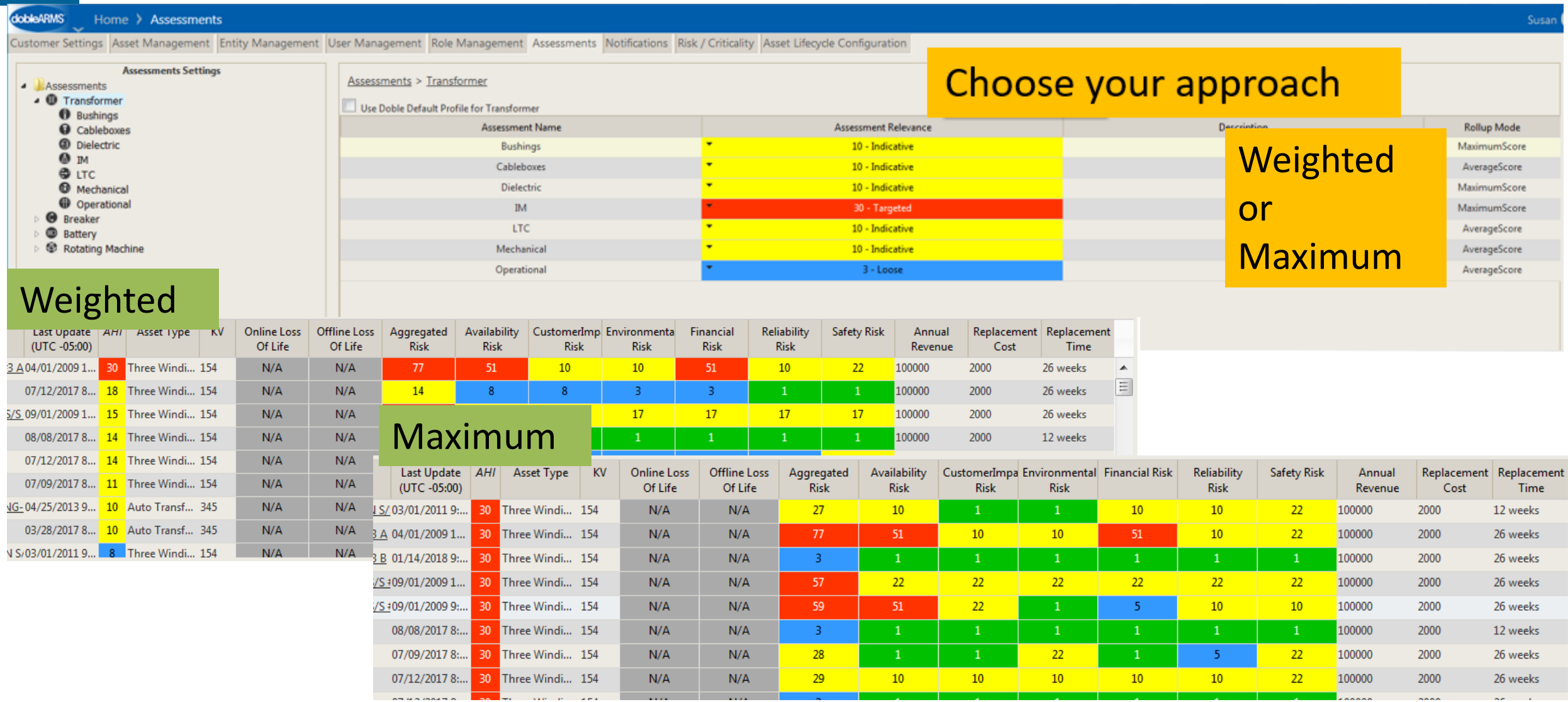
| | % Final Weighting | 25.00 5 | 10.00 2 | 10.00 2 | 10.00 2 | 5.00 1 | 5.00 1 | 5.00 1 | 10.00 2 | 20.00 4 | | Sum | 100.00 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Substation** | | DGA | FQ | Transformer Power Factor | Bushing Power Factor | Age Score | Faults | Load | Failure Rate | TYPE | TYPE LTC | TYPE Bushing | | AHI | Consequence | | RISK |
| S1 | | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 3 | 4 | 0 | | 21 | 5 | | 105 |
| S2 | | 4 | 0 | 0 | 4 | 0 | 0 | 5 | 0 | 0 | 0 | 5 | | 53 | 18 | | 954 |
| S3 | | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 5 | 0 | | 23 | 24 | | 552 |
| S4 | | 1 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 5 | | 32 | 32 | | 1024 |
| S5 | | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 2 | 12 | | 24 |
| S6 | | 5 | 0 | 4 | 5 | 2 | 0 | 0 | 0 | 5 | 5 | 5 | | 65 | 4 | | 260 |
| S7 | | 4 | 1 | 0 | 4 | 0 | 0 | 5 | 5 | 0 | 0 | 5 | | 65 | 39 | | 2558 |
| S8 | | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | | 17 | 36 | | 611 |
| S9 | | 4 | 1 | 0 | 4 | 2 | 0 | 0 | 5 | 3 | 0 | 0 | | 54 | 37 | | 2013 |
| S10 | | 4 | 0 | 0 | 4 | 3 | 0 | 0 | 0 | 3 | 4 | 0 | | 47 | 17 | | 821 |
| Max | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 100 | 100 | | 10000 |

System is supposed to help with longer term investment justifications
- short term operational response covered 'elsewhere'
- mode of failure, time to failure not covered here



# Choose your modeling approach



# How about Log/Exp scales?

## League table for transmission operator:

### sorted by worst overall condition score

Design/Manufacturer

Current and Mitigated Condition

Possible improvement in score

Component score based on sub-components

| | | | | | | | Overall Condition | | | Core and Windings | | | Oil | | OLTC | Exterior |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T-N | Ratio | Rated P | Manufact | Design | sign | Year | Now | Mitigated | Possible I | Dielectri | Thermal | Mechanic | Ageing | Contamina | h | |
| T4315 | 400/132 kV | 240 MVA | AEI Wythen | A04a | 32 | 1965 | 221 | 213 | 8 | 100 | 100 | 1 | 13 | 10 | 3 | 10 |
| T3040 | 275/132 kV | 120 MVA | EEC | E11b | 32 | 1959 | 170 | 103 | 68 | 30 | 60 | 1 | 190 | 10 | 10 | 10 |
| T6975 | 400/275 kV | 1000 MVA | GEC | G02b | 104 | 1994 | 170 | 135 | 35 | 30 | 60 | | 36 | 100 | | 1 |
| T3039 | 275/132 kV | 120 MVA | EEC | E11b | 32 | 1959 | 154 | 143 | 11 | 30 | 100 | 1 | 23 | 10 | 10 | 3 |
| T4259 | 275/66 kV | 180 MVA | CP | D07 | 12 | 1965 | 152 | 126 | 26 | 60 | 60 | 1 | 70 | 10 | 1 | |
| T2370 | 275/132 kV | 120 MVA | MVE | M01 | 5 | 1957 | 151 | 94 | 57 | 30 | 60 | 1 | 160 | 10 | 3 | 10 |
| T5961 | 400/275 kV | 750 MVA | HHE | H02 | 111 | 1971 | 147 | 100 | 47 | 3 | 60 | | 140 | | | 3 |
| T6201 | 275/33 kV | 100 MVA | PPT | P21 | 104 | 1972 | 144 | 139 | 5 | 1 | 3 | 100 | 13 | | 1 | 10 |
| T5566 | 400/132 kV | 240 MVA | CAP | C04 | 32 | 1968 | 138 | 85 | 54 | 10 | 60 | 1 | 140 | 30 | 1 | |
| T4409 | 275/132 kV | 240 MVA | HHE | H07a | 12 | 1964 | 133 | 107 | 26 | 1 | 100 | 1 | 70 | 10 | 3 | |
| T5581 | 400/132 kV | 240 MVA | AEI Wythen | A04b | 102 | 1967 | 132 | 106 | 26 | 10 | 60 | 1 | 70 | 10 | 3 | |
| T4686 | 400/132 kV | 220 MVA | PPT | P06a | 131 | 1967 | 131 | 107 | 24 | 1 | 60 | 1 | 63 | 10 | 1 | 10 |
| T4406 | 275/132 kV | 240 MVA | HHE | H07a | 12 | 1964 | 129 | 106 | 23 | 1 | 100 | | 63 | 10 | 1 | |
| T2300 | 275/132 kV | 120 MVA | EEC | E11a | 102 | 1955 | 129 | 105 | 24 | 10 | 60 | 1 | 70 | | 1 | 10 |
| T4258 | 275/132 kV | 240 MVA | HHE | H07a | 12 | 1966 | 129 | 106 | 23 | 1 | 100 | | 63 | 10 | 1 | |
| T3041 | 275/132 kV | 120 MVA | EEC | E11b | 32 | 1959 | 129 | 107 | 22 | 30 | 60 | 3 | 43 | 30 | 10 | |
| T2521 | 275/132 kV | 120 MVA | FER | F08 | 120 | 1956 | 124 | 105 | 19 | 3 | 60 | 1 | 50 | 10 | 1 | |
| T3583 | 275/132 kV | 180 MVA | FUL | L05 | 111 | 1962 | 122 | 99 | 23 | 1 | 60 | | 63 | 10 | 1 | |
| T5434 | 400/132 kV | 240 MVA | AEI Wythen | A04b | 102 | 1967 | 122 | 96 | 26 | 1 | 60 | | 70 | 10 | 3 | |
| T3139 | 275/66 kV | 120 MVA | AEI Rugby | A10 | 3 | 1960 | 122 | 106 | 16 | 100 | 3 | 1 | 40 | 10 | 1 | |

# Categories Feedback Loop

| Transformer | Asset Health Category | | % Accurate |
|---|---|---|---|
| | Before Scrapping | After Scrapping | |
| 1 | 2a | 1 | 50 |
| 2 | 2a | 2a | 100 |
| 3 | 1 | 2a | 50 |
| 4 | 2b | 2b | 100 |
| 5 | 2a | 2a | 100 |
| 6 | 2b | 2b | 100 |
| 7 | 1 | 1 | 100 |

| Transformer | Asset Health Category | | % Accurate | Reason for Scrapping |
|---|---|---|---|---|
| | Before Scrapping | After Scrapping | | |
| 8 | 1 | 2b | 50 | Overheating fault - thought un-repairable but it was! |
| 9 | 1 | 1 | 100 | Failed Suddenly but RMHZ in place as suspected winding circulation currents, known design issues. Operated to failure. |
| 10 | 2b | 3 | 50 | Suspected overheating issues and not in the windings. Overheating on shield rings (known design issues). But not as aged as predicted. |
| 11 | 2b | 3 | 50 | Suspected very aged insulation, poor design. Not as aged when scrapped. Even with >3ppm 2-FAL. |
| 12 | 2b | 3 | 50 | Suspected very aged insulation, poor design. Not as aged when scrapped. |
| 13 | 4 | 2b | 25 | Failed Suddenly/Insulation Ageing. FFA level had been masked due to oil processing/regeneration |
| 14 | 2a | 2a | 50 | Failed Suddenly/Selector fault. But had suspected core/frame insulation issues which were correct |

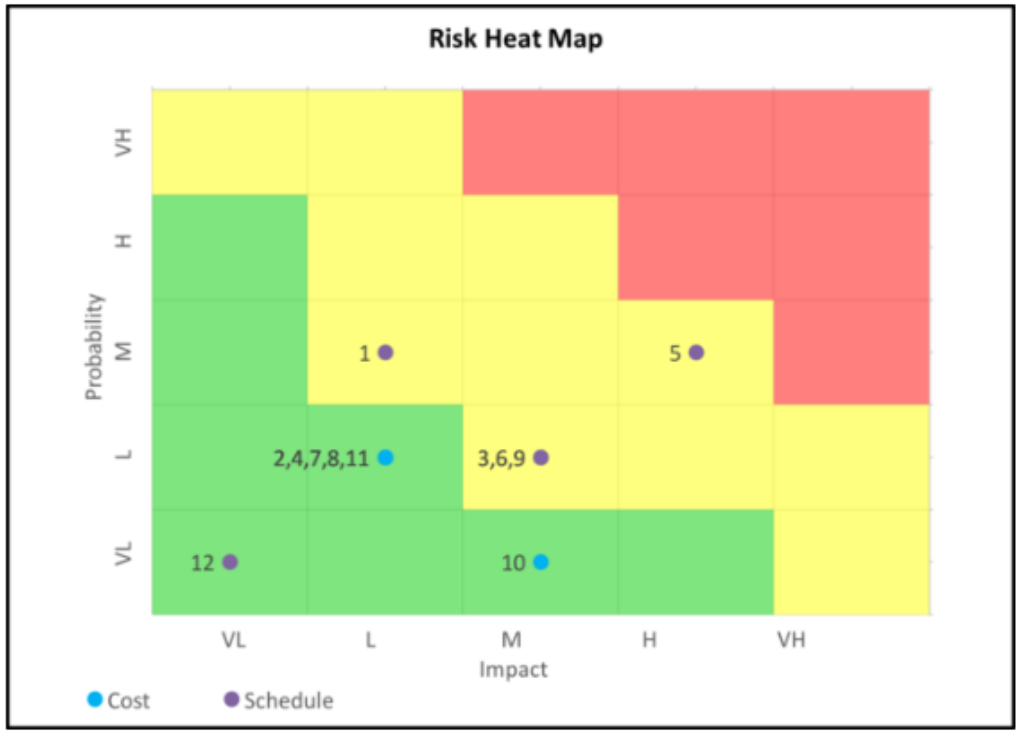
# “The Risk of Using Risk Matrices”

“Furthermore, Risk Matrices (RMs) are recommended in numerous international and national standards such as ISO, API, and NORSOK. The popularity of RMs has been attributed in part to their visual appeal, which is claimed to improve communications.”

“Despite these claimed advantages, **we are not aware of any published scientific studies demonstrating that RMs improve risk-management decisions**. (The use of RMs to analyze and manage risks ***may*** be better than doing nothing.)”

- Range compression: same category for very different risks
- Centering bias: people avoid the extremes
- Category definition bias: people make stuff up
- Ranking reversal issues: changing scales can be bad
- Lie factor: misrepresentation (Stanford)
- “How to measure anything”…

**Sapolski**: *‘We think in **categories**[2]’*




1: “The Risk of Using Risk Matrices”, Thomas, Bratvold & Bickel, Soc. Petroleum Engineers, Annual Tech Conf., New Orleans, USA, 2013

*2: Stanford University, “Introduction to Human Behavioral Biology” https://www.youtube.com/watch?v=NNnIGh9g6fA*

# Using an Index

You've compressed a lot of data, rules, guides and detail into a single value.
You have put groups/codes/categories in place:
DOES IT HELP???

Problem of thinking in categories:

- Things within a category are seen as more similar than those in other categories
- Things in other categories are seen as more different than those in this category
- Why treat the members of a category in the same way

Use a percent score? Percent of what? **What does the number mean?**

Is the index 'useful'??? **Calibrated, Monotonic, Auditable, Justifiable?**

What was the question again?

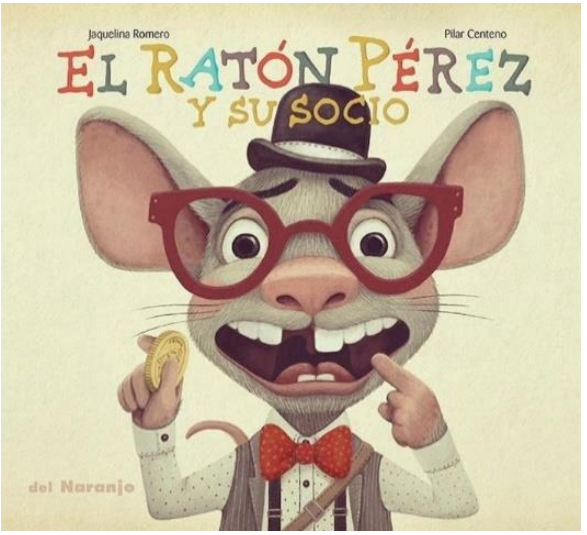
# *Tooth Fairy Science… Raton Perez[1]?*

## Harriet Hall, MD[2]

You could measure how much money the Tooth Fairy leaves under the pillow, whether she leaves more cash for the first or last tooth, whether the payoff is greater if you leave the tooth in a plastic bag versus wrapped in tissue versus ‘free’, multiple teeth, tooth under pillow or by the pillow etc etc…”


“You can get all kinds of good data that is **reproducible** and **statistically significant**.”

“Yes, you have learned something. **But you haven’t learned what you think you’ve learned**, because, sadly, there is no real Tooth Fairy.” *(So far as we know…)*




1: https://skepticalinquirer.org/exclusive/tooth-fairy-science-part-1/ 2: “Memoirs of a Female Flight Surgeon”, H. Hall

# Post hoc, ergo propter hoc: Placebos?

## Present fleet status

| I.D. | YoM | Age | DGA Score | indings Sco | Age Score | Weighted Sum |
|---|---|---|---|---|---|---|
| S1 | 1987 | 29 | 3 | 1 | 2 | 2 |
| S2 | 1952 | 64 | 1 | 1 | 5 | 1.8 |
| S3 | 2001 | 15 | 2 | 1 | 2 | 1.6 |
| S4 | 1971 | 45 | 1 | 1 | 4 | 1.6 |
| S5 | 1976 | 40 | 5 | 1 | 3 | 3 |
| S6 | 1968 | 48 | 4 | 1 | 4 | 2.8 |
| S7 | 1976 | 40 | 1 | 1 | 3 | 1.4 |
| S8 | 1959 | 57 | 1 | 2 | 4 | 2 |
| S9 | 1975 | 41 | 1 | 5 | 3 | 3 |
| S10 | 2015 | 1 | 1 | 1 | 1 | 1 |
| S11 | 1959 | 57 | 1 | 2 | 4 | 2 |
| S12 | 1986 | 61 | 2 | 1 | 5 | 2.2 |
| S13 | 1958 | 58 | 1 | 1 | 4 | 1.6 |
| S14 | 1965 | 65 | 1 | 2 | 5 | 2.2 |
| S15 | 2004 | 12 | 2 | 1 | 1 | 1.4 |
| S16 | 1965 | 51 | 5 | 1 | 4 | 3.2 |
| S17 | 1960 | 56 | 1 | 1 | 4 | 1.6 |
| S18 | 1964 | 52 | 2 | 1 | 4 | 2 |
| S19 | 1996 | 20 | 1 | 1 | 2 | 1.2 |
| S20 | 1983 | 33 | 1 | 2 | 3 | 1.8 |
| Average | Average | 42.25 | 1.85 | 1.4 | 3.35 | 1.97 |

| Weights | | |
|---|---|---|
| | Age | 20 |
| | Windings | 40 |
| | DGA | 40 |

| | |
|---|---|
| Expected life | 60 |
| Replace number ~ | 3 |

## Replace only oldest

| New Age | New Age Score* | New weighted |
|---|---|---|
| 29 | 2 | 2 |
| 1 | 1 | 1 |
| 15 | 2 | 1.6 |
| 45 | 4 | 1.6 |
| 40 | 3 | 3 |
| 48 | 4 | 2.8 |
| 40 | 3 | 1.4 |
| 57 | 4 | 2 |
| 41 | 3 | 3 |
| 1 | 1 | 1 |
| 57 | 4 | 2 |
| 1 | 1 | 1.4 |
| 58 | 4 | 1.6 |
| 1 | 1 | 1.4 |
| 12 | 1 | 1.4 |
| 51 | 4 | 3.2 |
| 56 | 4 | 1.6 |
| 52 | 4 | 2 |
| 20 | 2 | 1.2 |
| 33 | 3 | 1.8 |
| 32.9 | 2.75 | 1.85 |

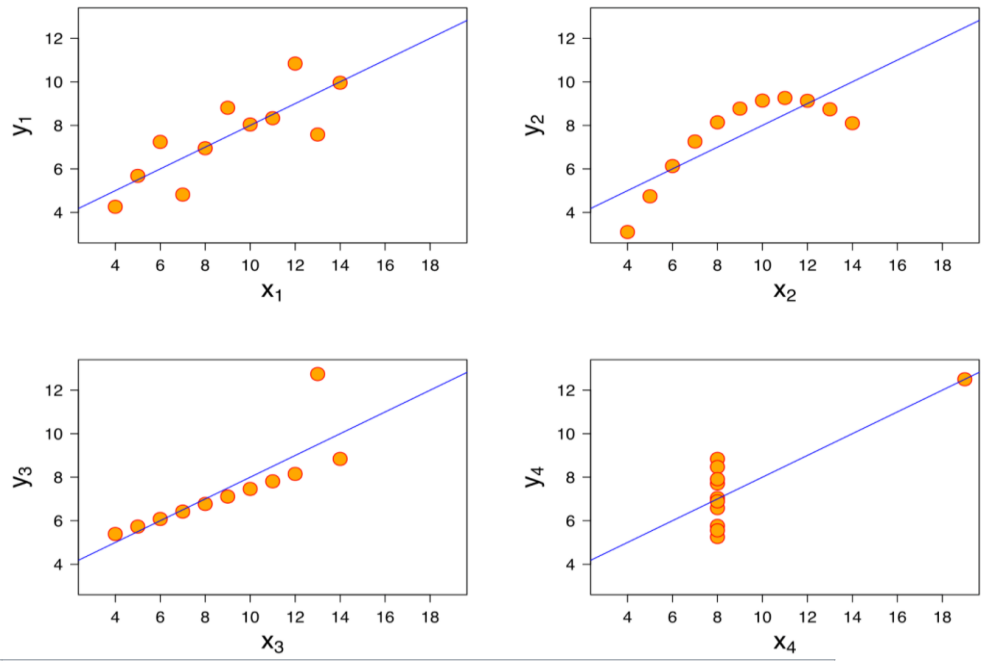
## Replace at random

| Replace? | New Age | New Age Score* | New weighted |
|---|---|---|---|
| | 29 | 2 | 2 |
| | 64 | 5 | 1.8 |
| | 15 | 2 | 1.6 |
| | 45 | 4 | 1.6 |
| | 40 | 3 | 3 |
| * | 1 | 1 | 2.2 |
| | 40 | 3 | 1.4 |
| | 57 | 4 | 2 |
| | 41 | 3 | 3 |
| | 1 | 1 | 1 |
| | 57 | 4 | 2 |
| | 61 | 5 | 2.2 |
| * | 1 | 1 | 1 |
| * | 1 | 1 | 1.4 |
| | 12 | 1 | 1.4 |
| * | 1 | 1 | 2.6 |
| | 56 | 4 | 1.6 |
| | 52 | 4 | 2 |
| | 20 | 2 | 1.2 |
| | 33 | 3 | 1.8 |
| | 31.35 | 2.7 | 1.84 |

# Perils of Summary Statistics

Anscombe Quartet[1]: 4 data sets with similar statistical properties:

| Property | Value |
|---|---|
| Mean of $x$ | 9 |
| Sample variance of $x$ : $s^2_x$ | 11 |
| Mean of $y$ | 7.50 |
| Sample variance of $y$ : $s^2_y$ | 4.125 |
| Correlation between $x$ and $y$ | 0.816 |
| Linear regression line | $y = 3.00 + 0.500x$ |
| Coefficient of determination of linear regression | 0.67 |




Anscombe Quartet: the visual properties, however, are quite different

1: https://en.wikipedia.org/wiki/Anscombe's_quartet
2: http://www.thefunctionalart.com/2016/08/download-datasaurus-never-trust-summary.html
3: https://www.autodesk.com/research/publications/same-stats-different-graphs

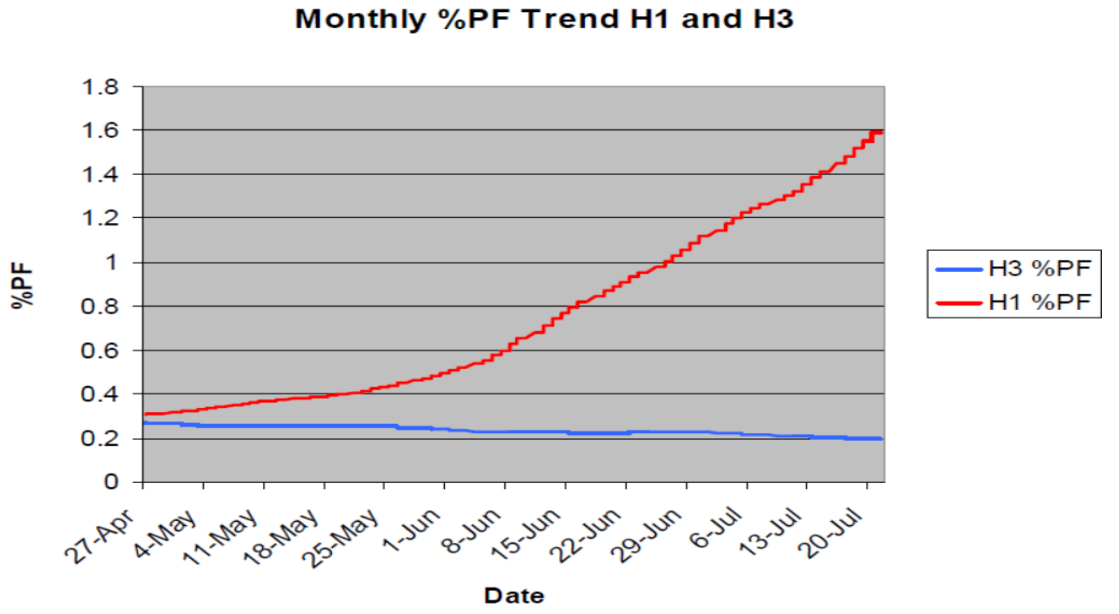
# Condition Monitoring?

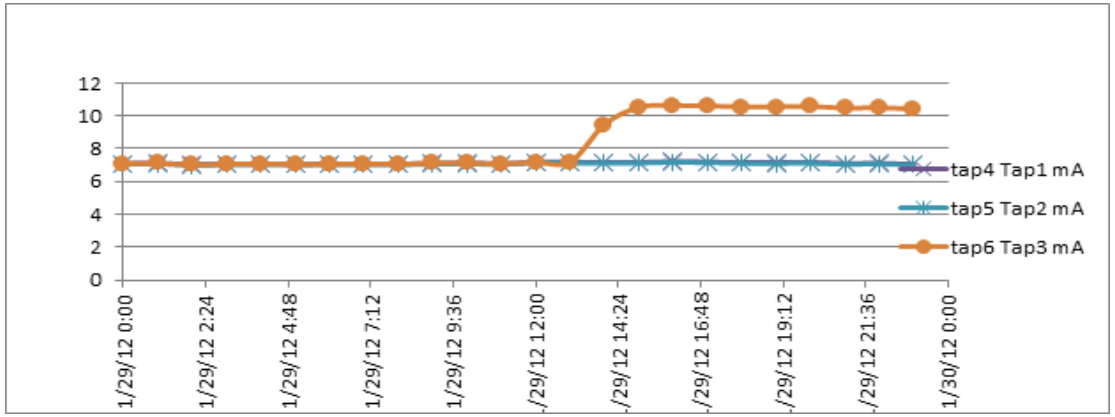
If a monitor gives an alert – use that ‘by itself’ to trigger the action plan you put in place when the monitor was installed.

Tell me you have thought about the alert settings!

Tell me you’ve a plan for every alert on every monitor?

Don’t go from ignorance to negligence… an index won’t save you!



# Conclusions?

**Risk** from a **hazard** = f(Prob,Con)

**Probability** of failure is difficult to **evaluate** (nuanced)

**Consequence** is easier to evaluate (**calibrate**)

**Asset Health Indices may be misleading** (4 adjectives)

**Sapolsky**: We think in **categories** (which is misleading)

**Risk Heat Maps are usually misleading** (many reasons)

**Box**: All models are wrong, some models are **useful**

**Duning-Kruger**: A little learning is a **dangerous** thing

# Discussion

**Questions? Comments? Feedback?**

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# Thank you!

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ALTANOVA
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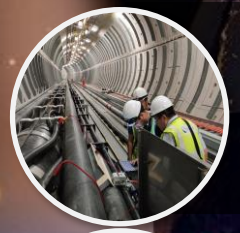
# Next ALTANOVA **WEBINARS**

**09** Feb — Medición y detección de descargas parciales



**10** Feb — Diagnóstico en línea de cables subterráneos

**15** Feb — Creating and using meaningful Asset Health Indices (AHI) - APAC

**16** Feb — Methoden zur Zustandsbewertung von Mittel- und Hochspannungsbetriebsmitteln

**22** Feb — Desarrollo y utilización de Índices de Salud (AHI) más significativos en Activos Eléctricos