



## 27th Technical Convention 2019

The 4th Industrial Revolution (“4IR”) | *Building the Power Utility of the Future, Today*

### **Early Detection of Impending Failure in HV Cable Terminations – An Intelligent Asset Management Necessity**

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# Case Study Substation

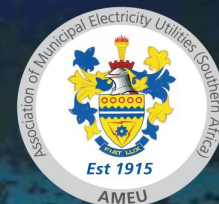
- Failure of Cable terminations
- Electricity supply disruption and high replacement costs
- Root cause analysis of cable termination failure
- Smart maintenance solution



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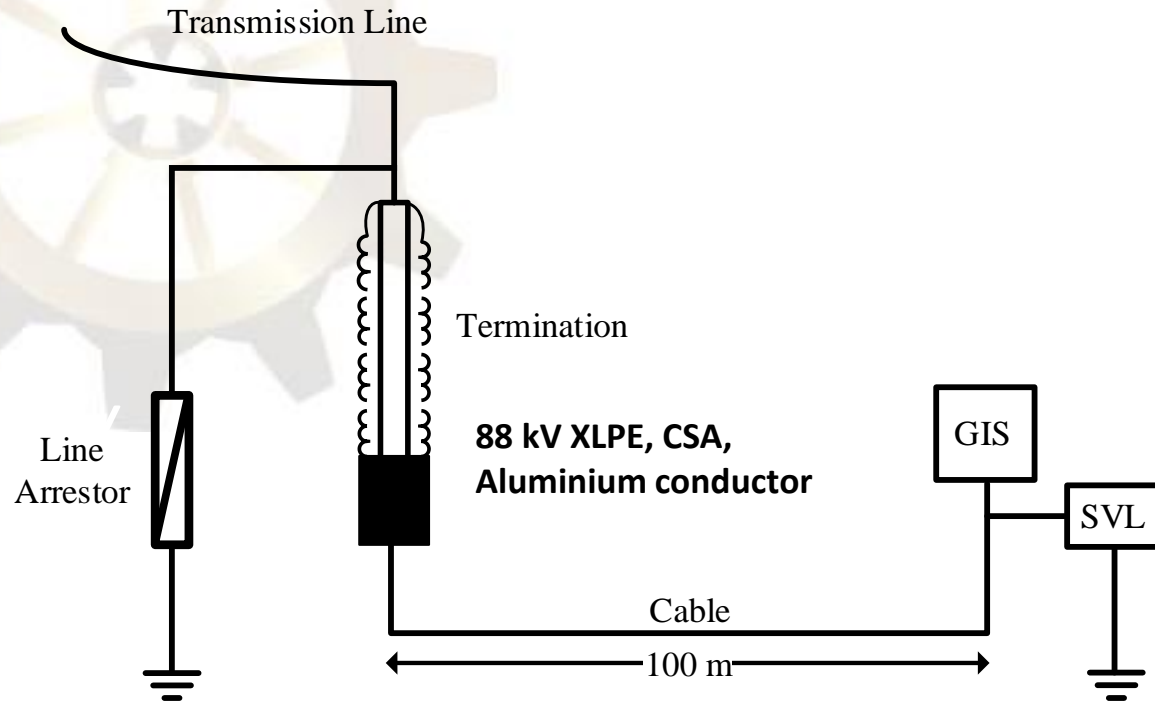
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# Case Study Cable System

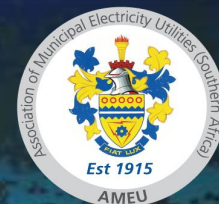


- Site weather conditions and lightning stroke count data
- Black Box system (Real time operating parameters 1.5 milliseconds)
- Statistical time-to failure data

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# Forensically Identified Degradation Mechanisms



- Thermomechanic fatigue
- Corrosion
- Electrothermal

Fatigue fracture



Location of erosion and electro-thermal failure



Galvanic corrosion



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# Forensically Identified Degradation Mechanisms



Erosion &  
Thermal Failure

Creeping  
discharges

Lower surface  
resistance



Aluminium foil sheath  
disintegration

Floating earth

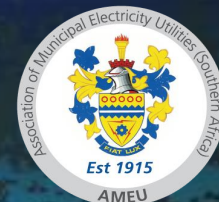
Arcing



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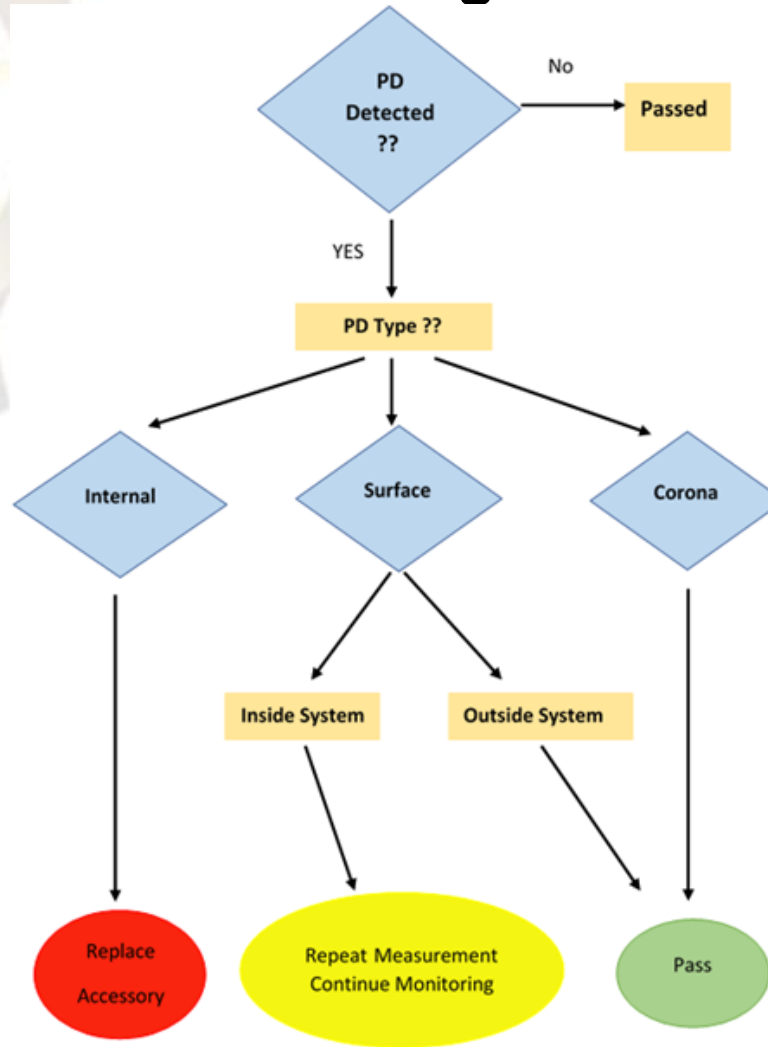
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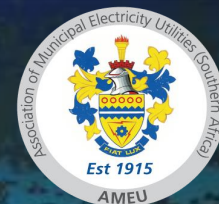


# Partial Discharge Decision

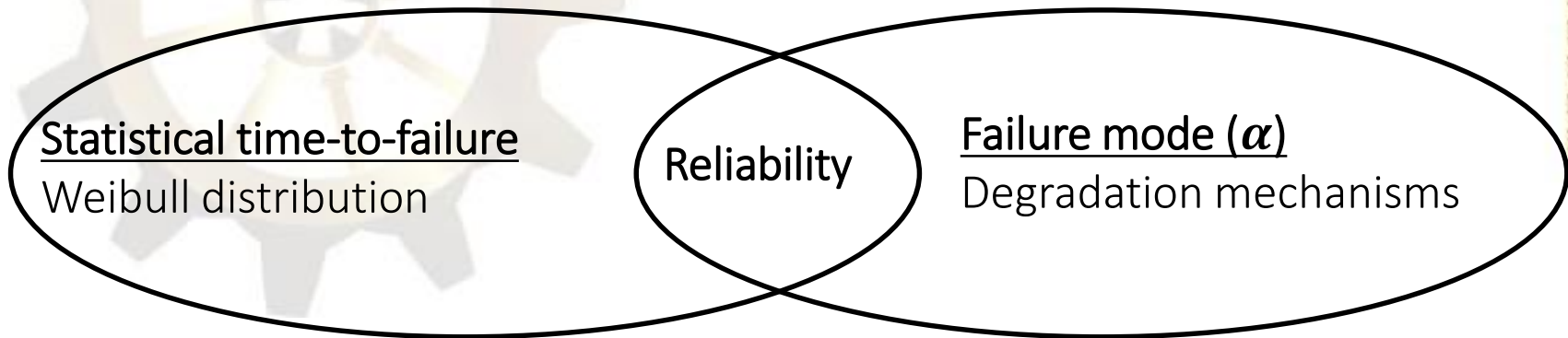


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# Developing The Reliability Model



## Weakest Link Principle

$$R(t) = R_E(t)R_T(t)R_N(t)R_C(t)$$

$$R_{E,T,N,C}(t) = \exp\left[-\left(\frac{t}{\alpha_0 \cdot \alpha_{E,T}}\right)^\beta\right] \cdot \exp\left[-\left(\frac{t}{\alpha_0 \cdot \alpha_N}\right)^\beta\right] \cdot \exp\left[-\left(\frac{t}{\alpha_0 \cdot \alpha_C}\right)^\beta\right]$$

$\beta$  – shape parameter

$\alpha_0$  – scale parameter (63<sup>th</sup> percentile time of failure)



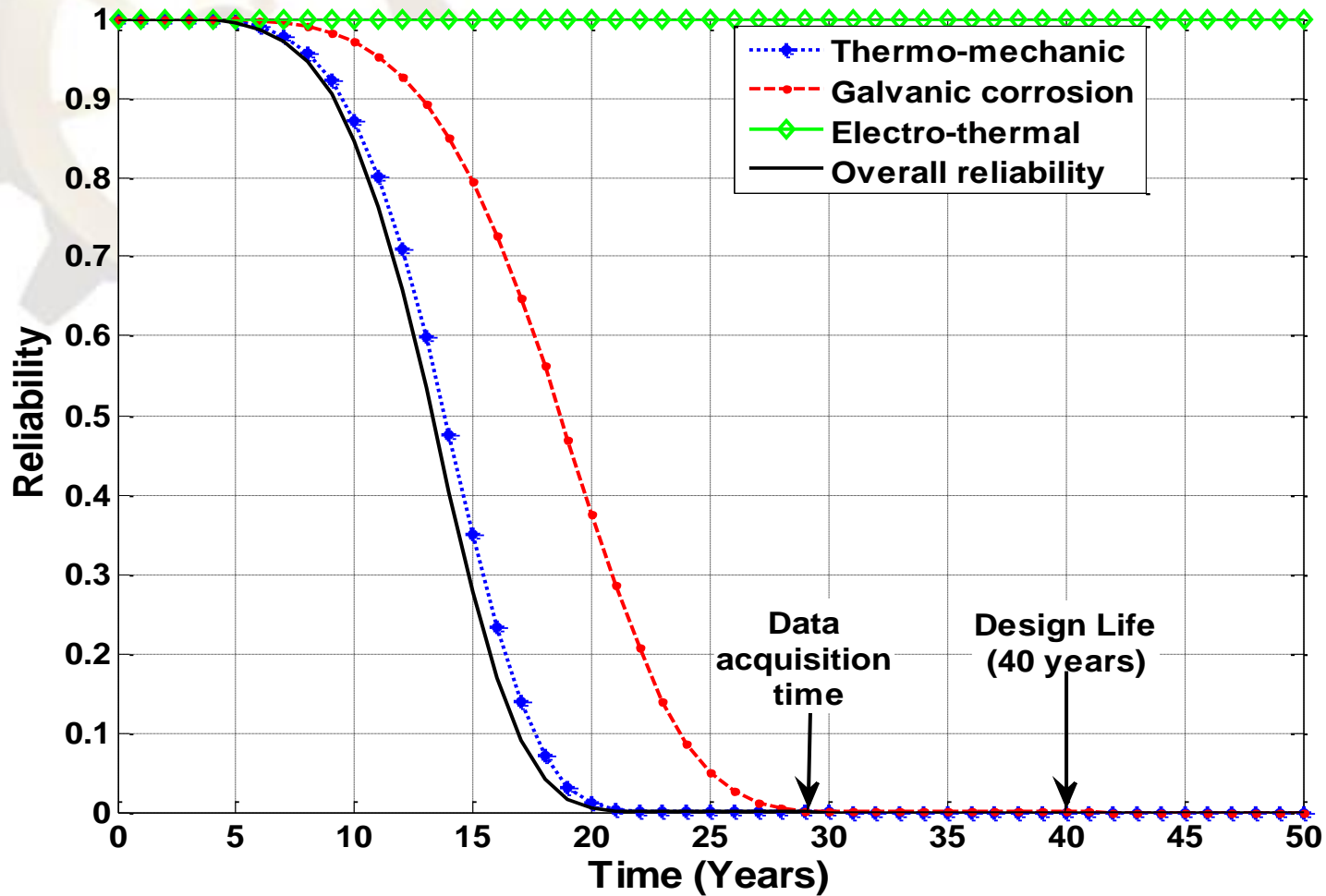
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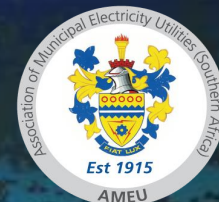


# Model Results



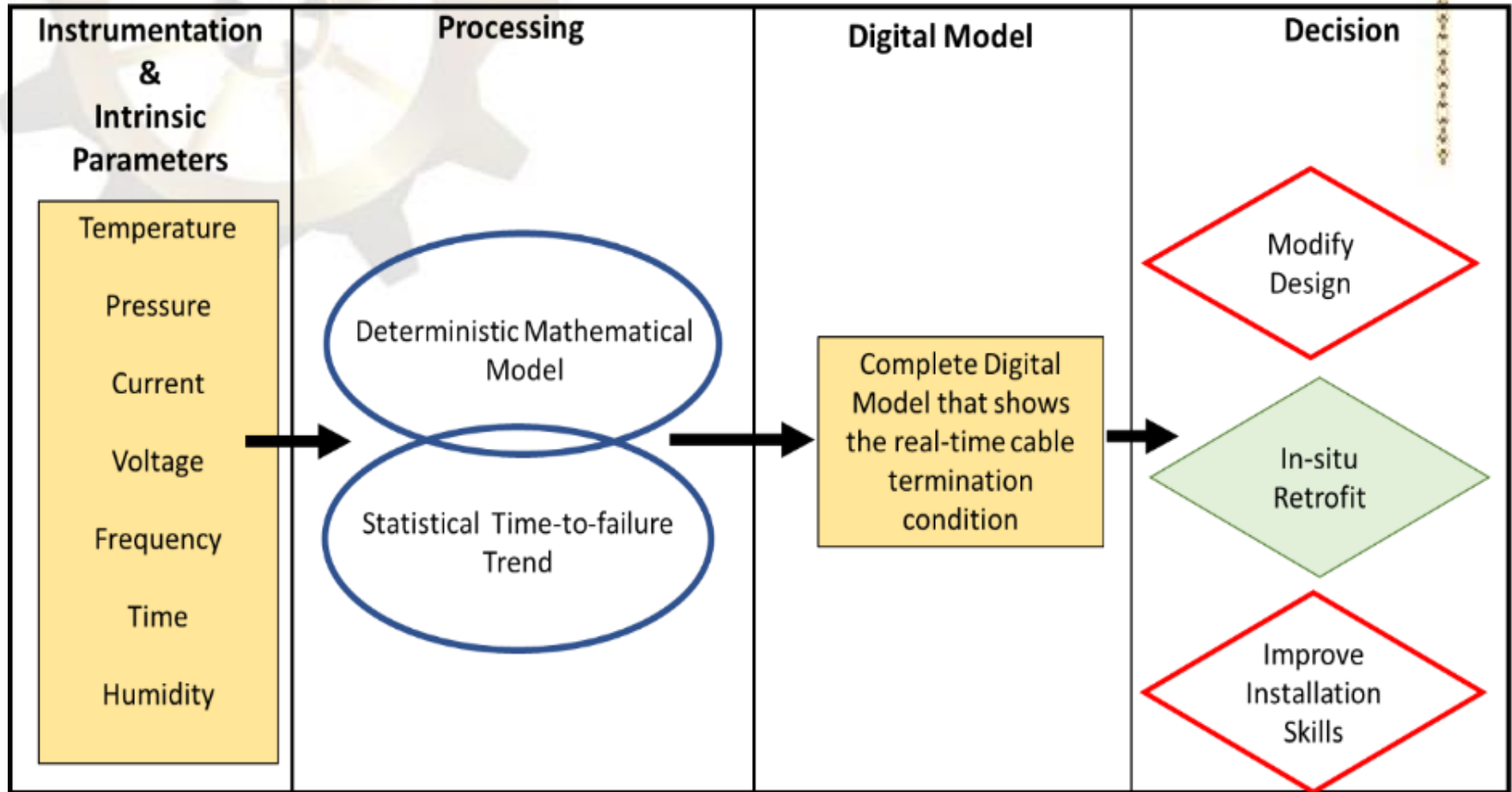
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# Intelligent Asset Management



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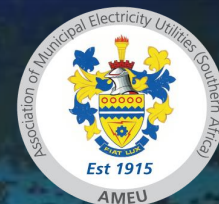
# Digital Twin

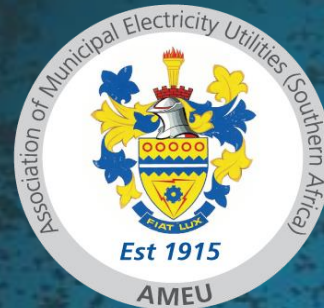
- Real time operating parameters are used in mathematical reliability models to inform the maintenance engineer.
- Dynamic real-time multiphysics modelling (Digital twin)
- Information is dynamic and supplements online condition monitoring
- A more accurate reason of failure can be achieved

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## Thank you

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