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ADVANCED CABLE ANALYTICS

AMLD 2022 – AI & Sustainable Energy

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Why Cable Analytics?

Cable failure is caused by…

- construction works

- cable overloads

- moisture in insulation material

- repair activities of the DSOs themselves

- weather and environmental influences

… leading to power outages causing high costs!

Customer needs

Reduce risk of cable failure
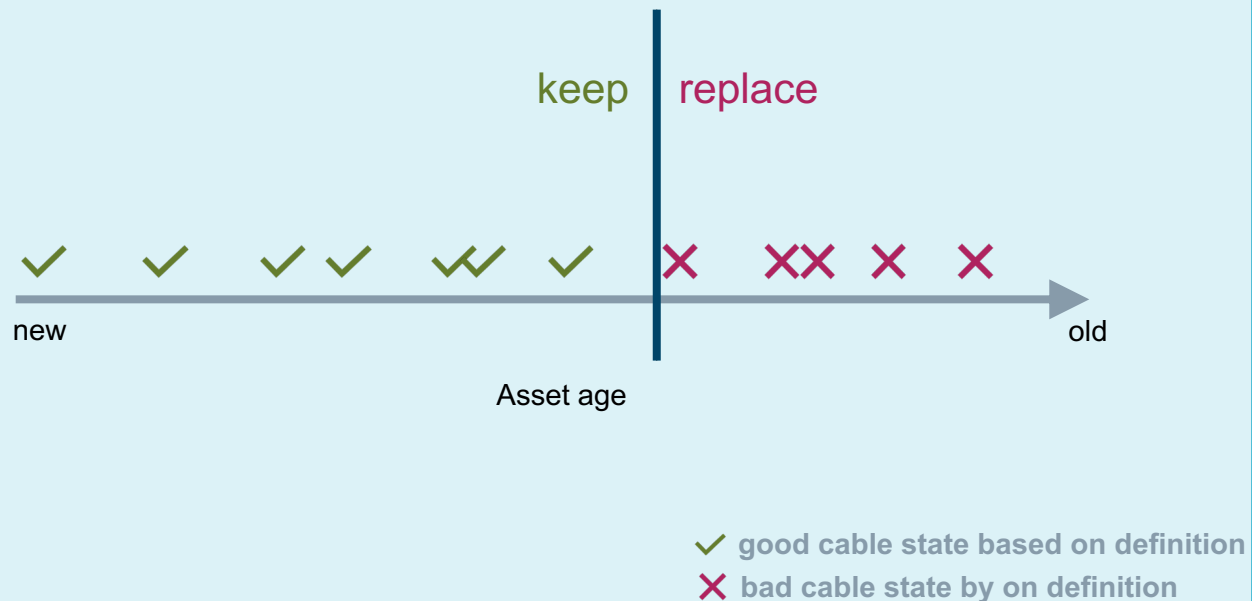
Manage assets more efficiently

Optimize Investments

Improve Safety

Classical Asset Management – Typical approach based on asset age

Overview

One-dimensional classification

keep | replace

new ——————————————→ old

Asset age

✓ good cable state based on definition
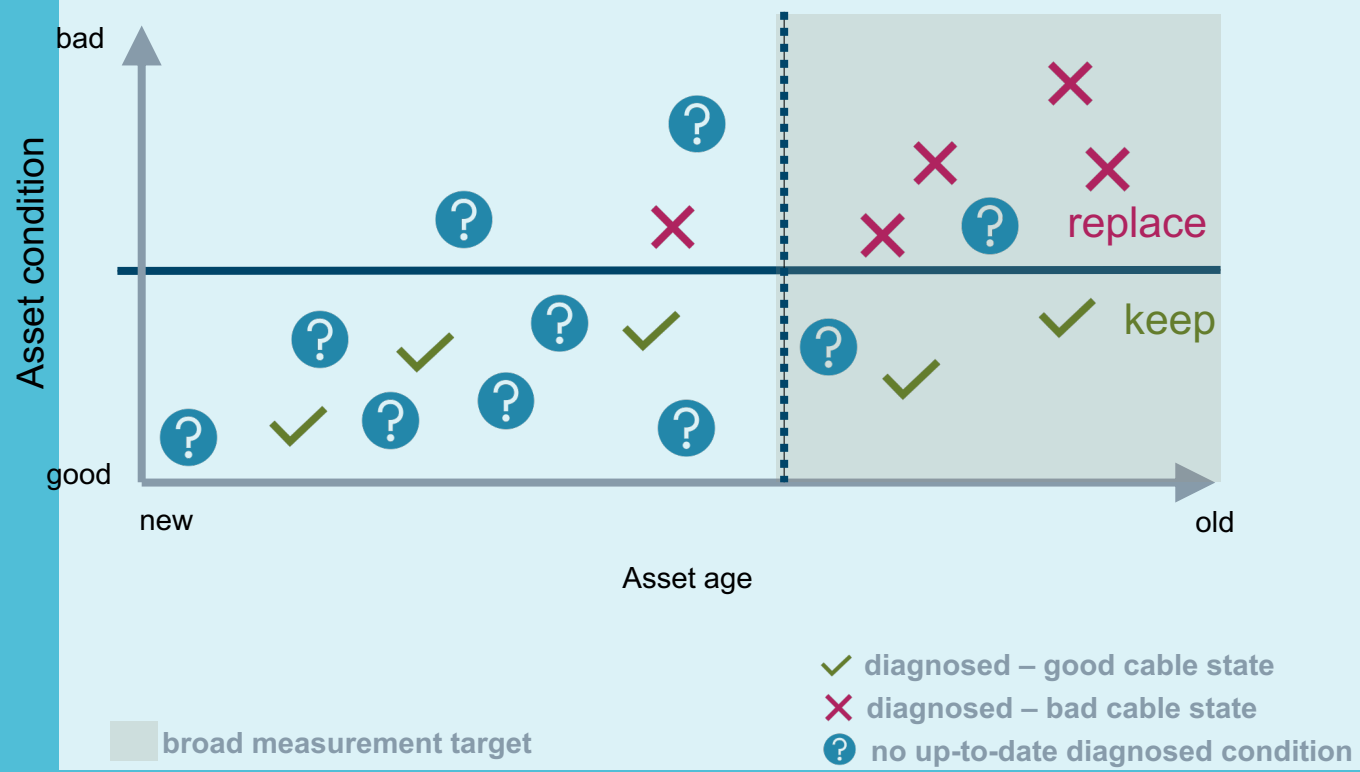✗ bad cable state by on definition

Pros & cons

- Simplest approach:
  - Minimal input data
  - Simple age threshold
  - No measurement needed
- Expensive:
  - Replacement of good cables just because of their age
- High risk:
  - Bad cables remain and fail in operation due to their youth
- Inflexible:
  - Investment based on cable age distribution

Source: Siemens Advanta

Condition-based Asset Management – Improved approach leveraging state-of-the-art cable diagnostics

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Overview

Two-dimensional classification by condition

- Asset condition: bad / good
- Asset age: new / old
- replace
- keep

✓ diagnosed – good cable state
✗ diagnosed – bad cable state
❓ no up-to-date diagnosed condition

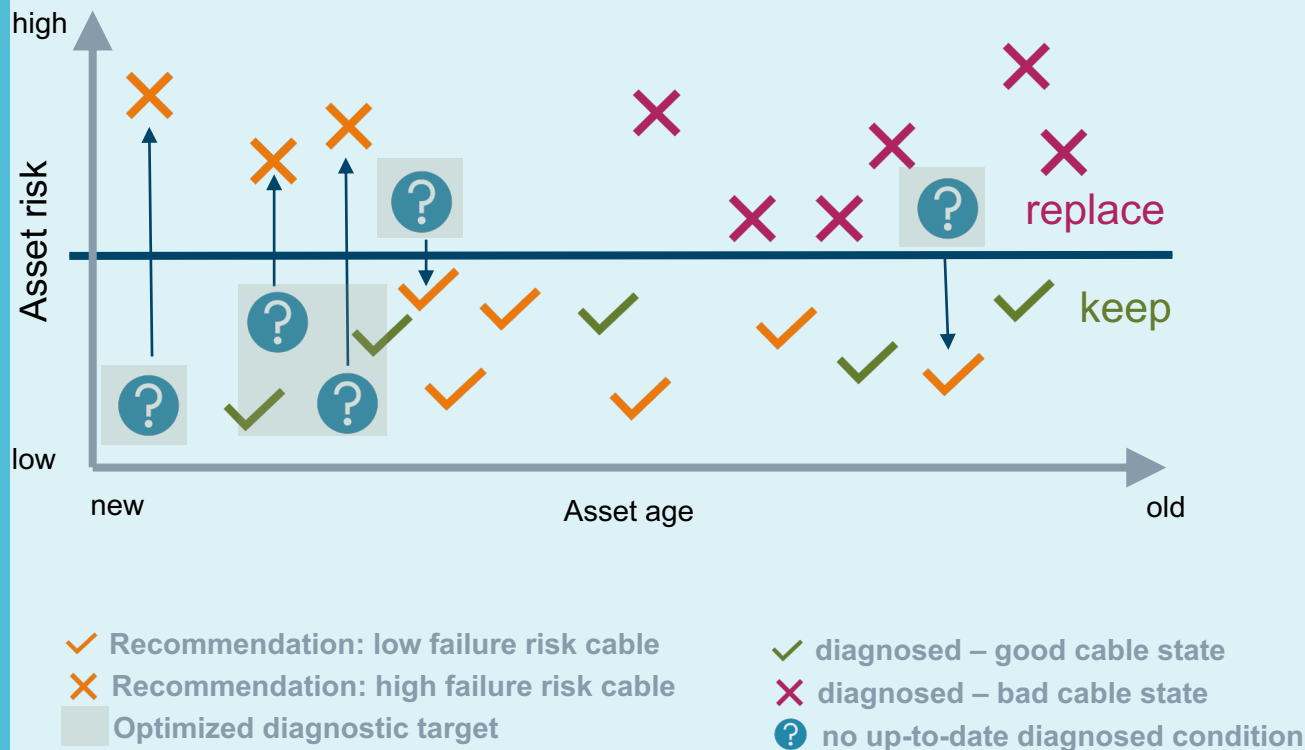▇ broad measurement target

Pros & cons

- ➢ Improved approach:
  - ➢ Use cable diagnostics to determine cable condition
  - ➢ Simple condition threshold
- ➢ Investment protection:
  - ➢ Good cables operate longer
- ➢ Reduced risk:
  - ➢ Bad cables are replaced even if they are quite new
- ➢ High diagnostics effort
  - ➢ to get complete picture
  - ➢ to keep it up-to-date
  - → remaining risk on blind spots

Risk-based Asset Management: Siemens Advanta's approach leveraging state-of-the-art cable diagnostics & AI model

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Overview

Multi-dimensional classification by risk

Asset risk (high / low) vs Asset age (new / old)

replace
keep

✓ Recommendation: low failure risk cable
✗ Recommendation: high failure risk cable
⬛ Optimized diagnostic target

✓ diagnosed – good cable state
✗ diagnosed – bad cable state
❓ no up-to-date diagnosed condition

Pros & cons

➤ Integrated approach:
  ➤ Leverage internal & external data incl. measured status
  ➤ Multi-dimensional risk profile
➤ Optimized investment planning:
  ➤ Long life of low-risk assets
➤ Optimized OPEX:
  ➤ Targeted diagnostics and maintenance measures
➤ Minimized risk:
  ➤ Up-to-date risk value for all cables
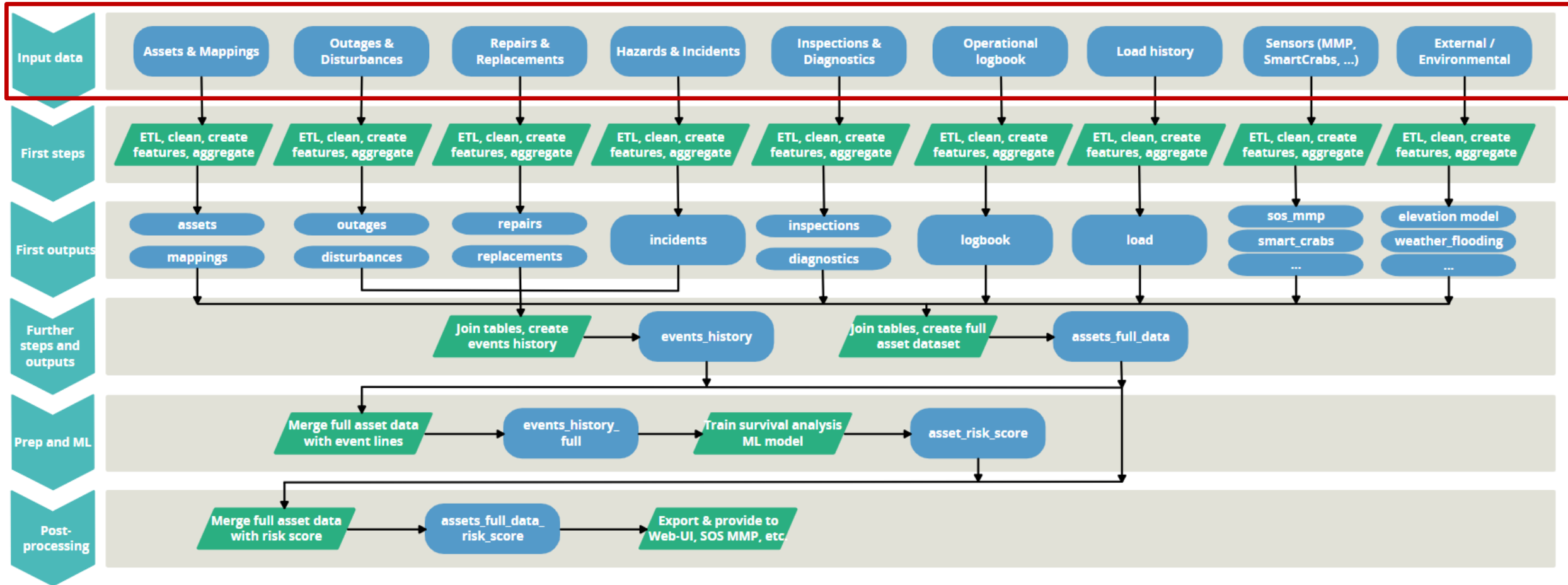 ➤ Bad cables are replaced before they fail

Source: Siemens Advanta

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DATA PROCESSING & SURVIVAL ANALYSIS

How we implemented cable analytics

Siemens-Advanta.com

Data aggregation – GIS data

Corridor along the cable sections
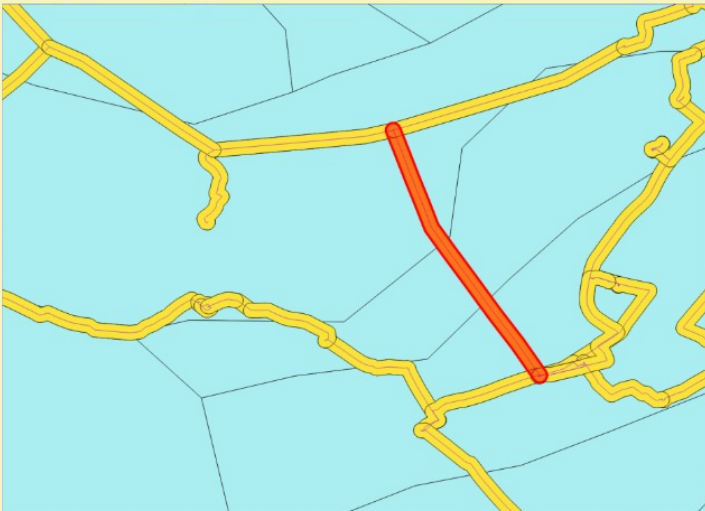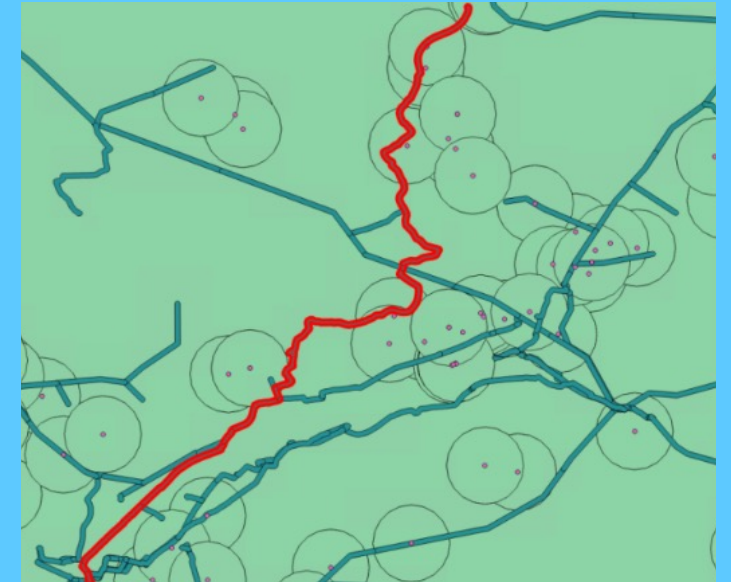
Integration along the corridor
- Land cover (city, forest, etc.)
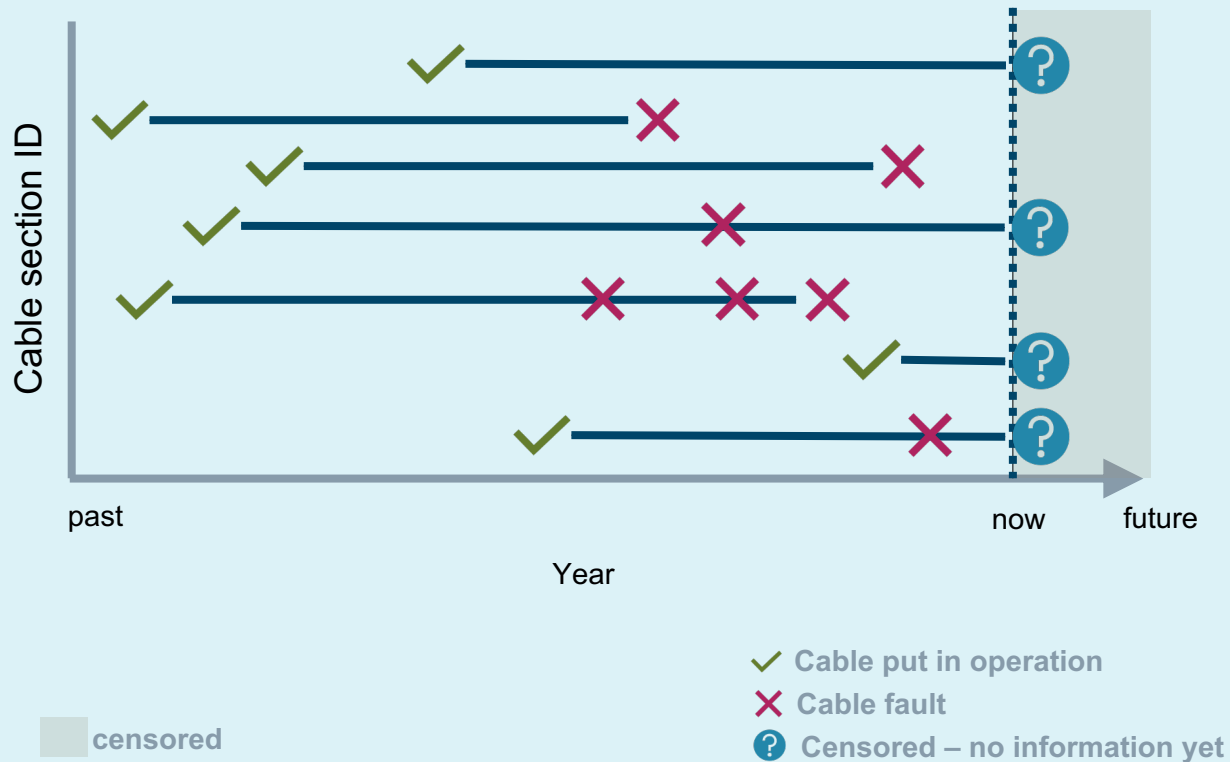- Flooding areas
- …

Events included within a radius
- Landslides
- Other natural disasters

Survival analysis model – input data

Event Timeline

Main input is the history of events for each cable

Cable section ID

past   now   future

Year

✓ Cable put in operation
✗ Cable fault
? Censored – no information yet

censored

Characteristics

➤ Most cables are censored

   ➤ Currently in regular operation or put out of operation without fault

   ➤ Might already have experienced faults

➤ Uncensored cables

   ➤ Put out of operation due to fault

   ➤ Often have experienced previous faults

➤ The covariates are a selection of the other aggregated features

Survival analysis model
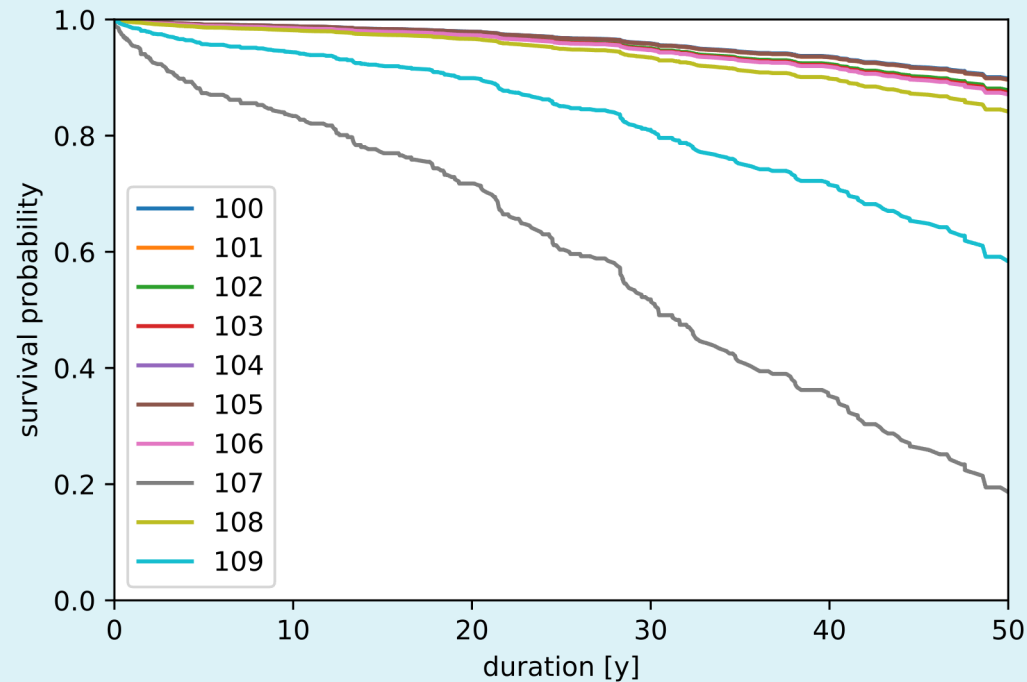
Survival curves

Typical survival curves for selected cables

Approaches

- ➤ Compared several approaches of survival regression
    - ➤ Accelerated Failure Time (AFT) model
    - ➤ Cox Proportional Hazard (CPH) model
    - ➤ Counting process
    - ➤ Stratified versions of above
- ➤ Details depending on individual customer data set
- ➤ Implemented in Spark / Python / R or pure Python
- ➤ CPH delivered good results

Survival analysis results
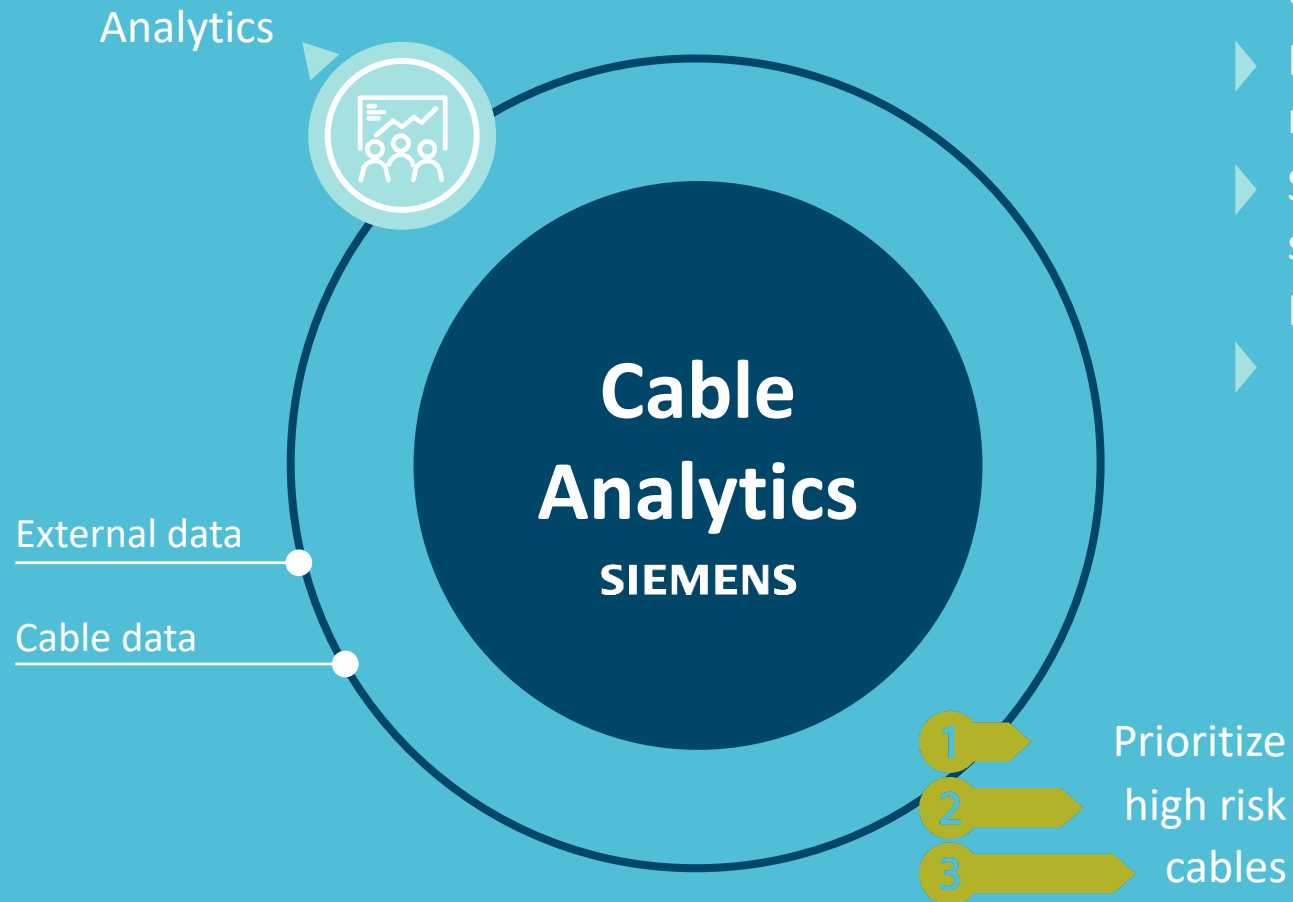
Model results

- Concordance index > 0.75
- Main influential parameters
  - Number of past events
  - Number of cable sections
  - Fraction of urban area
  - Material

Translation to results in the field

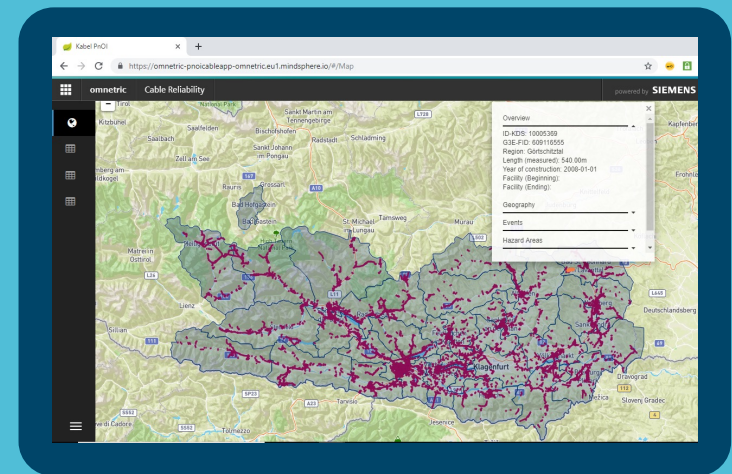- **Outage prevention:**
  - 80% of cable outages occurred in top <5% of cables (highest risk)
  - 90% of outages in <10% of cables (highest risk)
  - Replacing these few % of highest risk cables significantly reduces outages

- **Investment protection:**
  - Old cables with moderate risk can operate longer
  - Estimated lifetime extension of 10 years or more

Sources: Siemens Advanta, KNG

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Cable Analytics decision support system

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Analytics

Cable Analytics
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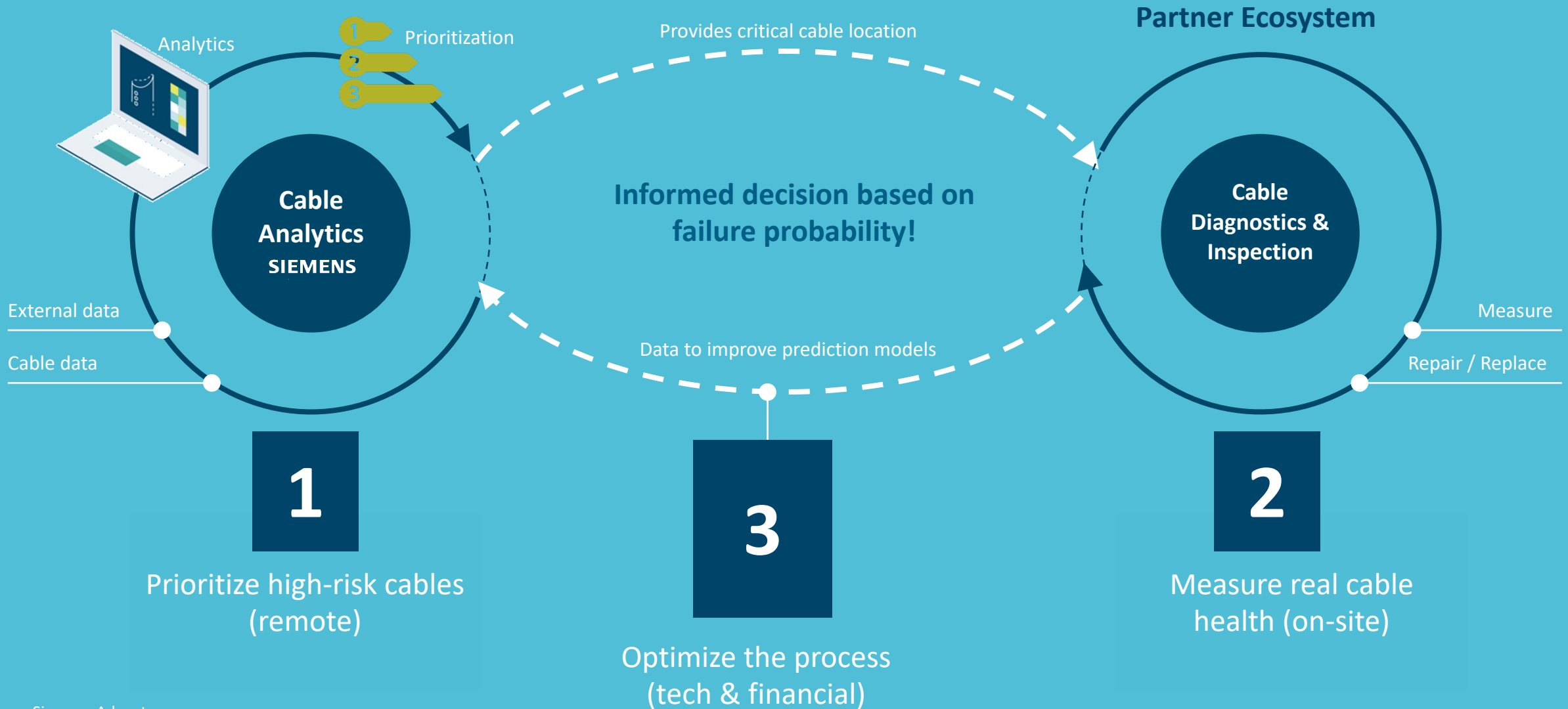
External data

Cable data

1
2
3
Prioritize
high risk
cables

- Provides a complete and up-to-date health status for each individual cable asset in the grid
- Risk score is predicted based on survival analysis model
- Serves as a decision support system for improving safety and optimizing maintenance & investments
- Provides a **web-app** for the end user

Combining Cable Analytics and Cable Diagnostics

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Analytics

① Prioritization
②
③

Provides critical cable location

Partner Ecosystem

Cable Analytics
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Informed decision based on failure probability!

Cable Diagnostics & Inspection

External data

Cable data

Data to improve prediction models

Measure

Repair / Replace

1

Prioritize high-risk cables (remote)

3

Optimize the process (tech & financial)

2

Measure real cable health (on-site)

Source: Siemens Advanta

Underground Cable Analytics
Key results

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on point
investment decision!

Analyzing your cables
based on already available data

Reducing cable outages by a factor of up to 10
by focusing inspections, repair and replacements on cables with high failure likelihood

Shifting investments and saving costs
based on survival analysis results

Increasing cable lifetime by more than 10 years
by extending lifetime of old assets that are still in good condition

Physical inspection of suspect cables by our partners
Leading cable diagnostics providers

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Advanced Cable Analytics

Questions & answers

Thank you for your attention!

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EXPLORE SOME MORE SLIDES IN THE

BACKUP

Cable Analytics – Success Story

- In 2016, one **DSO in Austria ("KNG")** was looking for a data-driven analytical solution to **predict and prevent outages** of **overhead power lines** due to atmospheric disturbances

- **Success** led to **ongoing innovation partnership** with KNG and another DSO ("Energy-Networks Styria"), for which several **other use cases** have been built:

  - **Optimization of inspection intervals** for better maintenance planning and lower OPEX
  - **Decision support system** for **cabling** of overhead power lines
  - **Decision support system** for maintenance of underground **cables** (repair vs. replace)
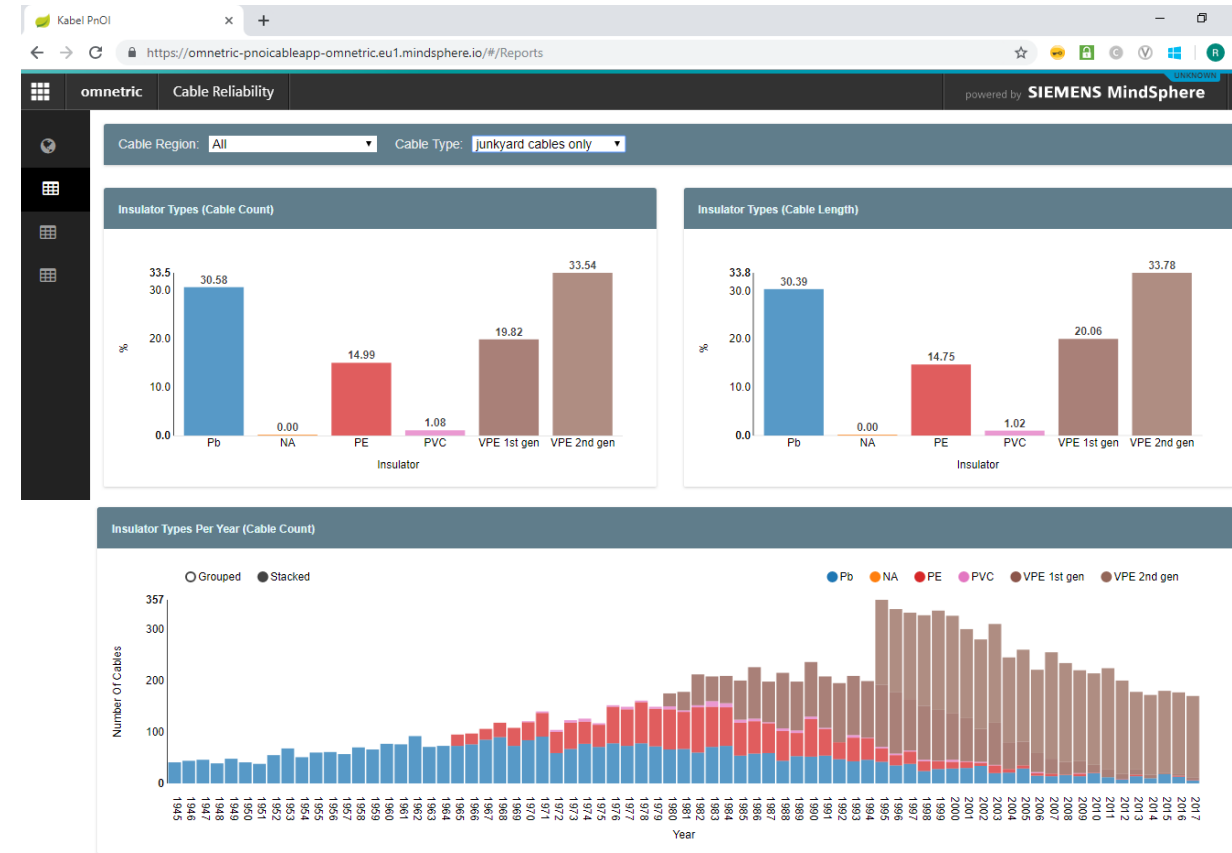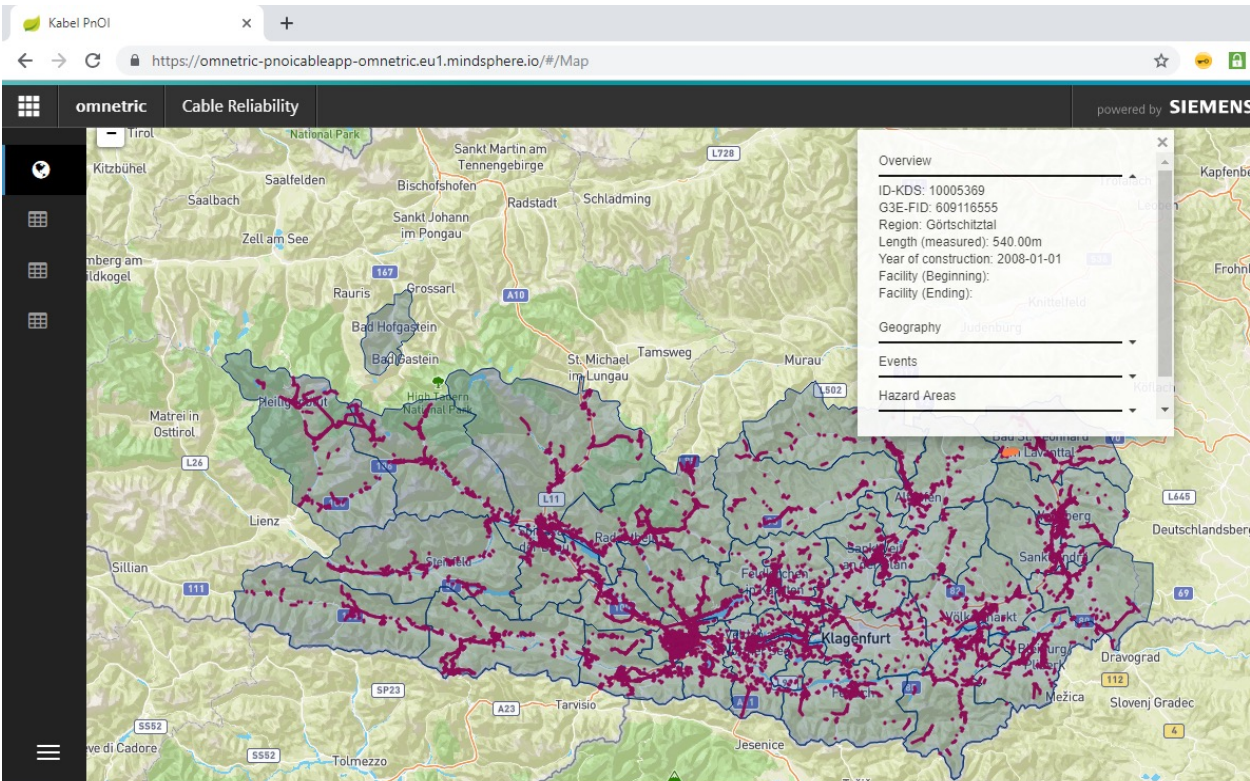

Grid Analytics
omnetric

Planning and Outage Int...
omnetric

CABLE Analytics

Cable Reliability
omnetric

PREVIEW

Cable Analytics Solution – Web App – Interactive Demo

Source Siemens Advanta

Advanced Analytics solution to optimize asset management

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Overview

➤ Data & analytics take asset management to the next level

➤ Recommendation for best resource usage to obtain maximal asset reliability at optimal OPEX

➤ Self-learning AI model calculates risk profile & shows multi-dimensional influences

➤ Uncover blind spots of rule based asset management

➤ Leverage internal & external data sources

➤ Integrate with existing asset management and WFM applications*

  ➤ The model output enriches conventional asset management rules based approach

➤ Cable analytics model insight dashboard

Solution Architecture

Applications

Asset management   WFM

Cable Analytics Engine

PnOI dashboard   Database   Analytics

Data Sources (selected)

Asset management | WFM | Scada | Diagnostics inspection | Weather / Climate | Landcover, soil, events

* on project base

Real world examples: Tangible benefits for grid operators

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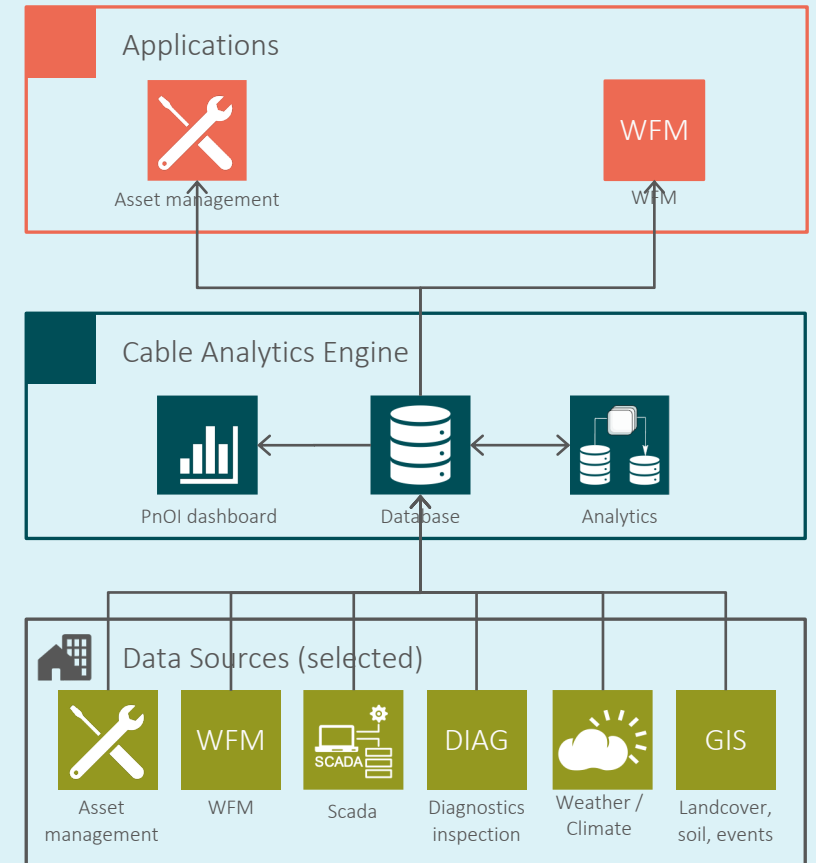
Outage Prevention

>10x

Real live projects at grid operators show that Cable Outages per 1.000 cable-kilometers can be reduced by 10x-20x by better understanding all available data and setting priorities right

Investment Prevention

>10yrs

Applying Advanced Cable Analytics techniques can avoid unnecessary investments and increase remaining lifetime of selected cables by more than 10 years

"Big Value with Bad Data"
Key is to integrate and understand *all* available data - the good, the bad, the ugly.