# Predictive Maintenance System Architecture

***Creating Value out of Asset Data***

# Camiel Oremus - Business Director Asset Management

2018-present

- **DNV GL Asset Management**
  - *Asset Management advisory: Condition Assessments, Power Failure Investigations, SCG, HI, Intelligent Network Communications*

2012-2018

- **Liander Asset Management**
  - *Manager Asset Lifecycle Policies and Standardization*
  - *Smart Grid, Cyber Security and Telecommunications*

2004-2012

- **Accenture Management Consulting**
  - *Manager, Program Manager*

Universiteit Utrecht

# A quality assurance and risk management company

STIFTELSEN
DET NORSKE VERITAS

*Stiftelsen Det Norske Veritas is a free-standing, autonomous and independent foundation whose purpose is to **safeguard life, property and the environment**.*

**MARITIME**

**OIL & GAS**

**ENERGY**

**BUSINESS ASSURANCE**

DIGITAL SOLUTIONS

**150+** years

**100+**
countries

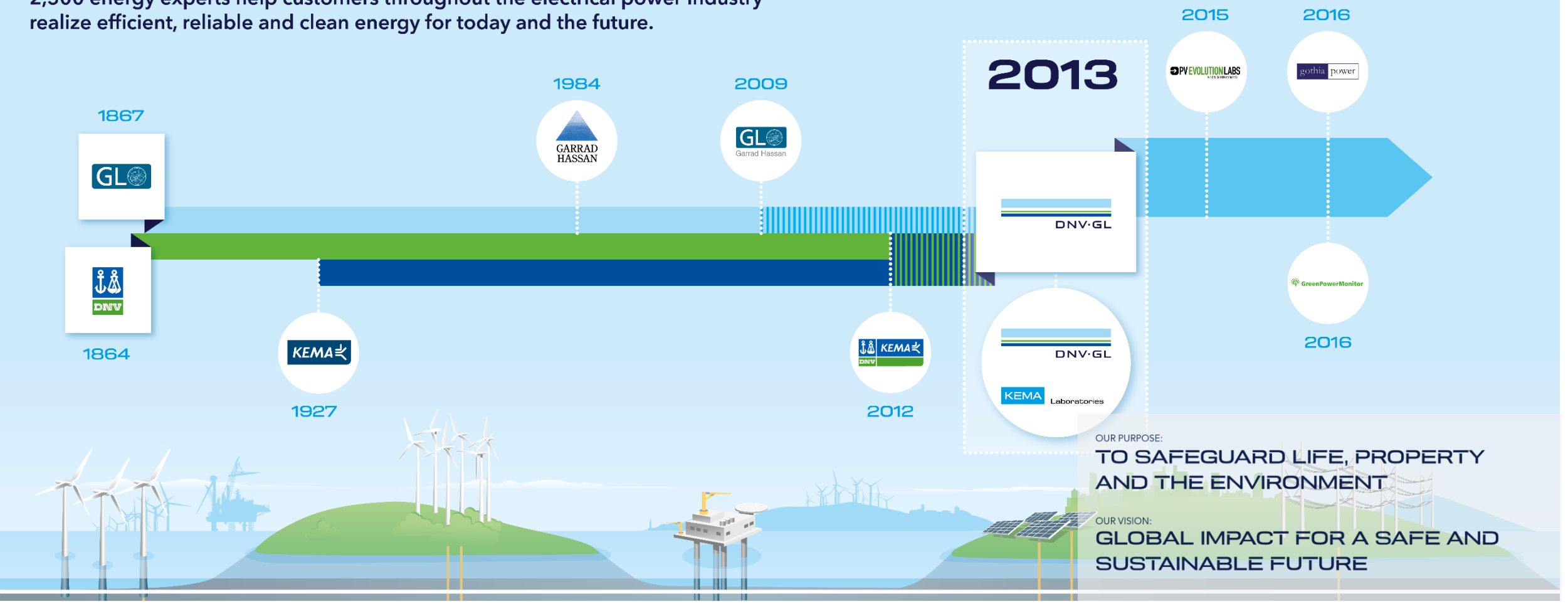
**100,000**
customers

**12,500**
employees

**5% R&D**
of revenue

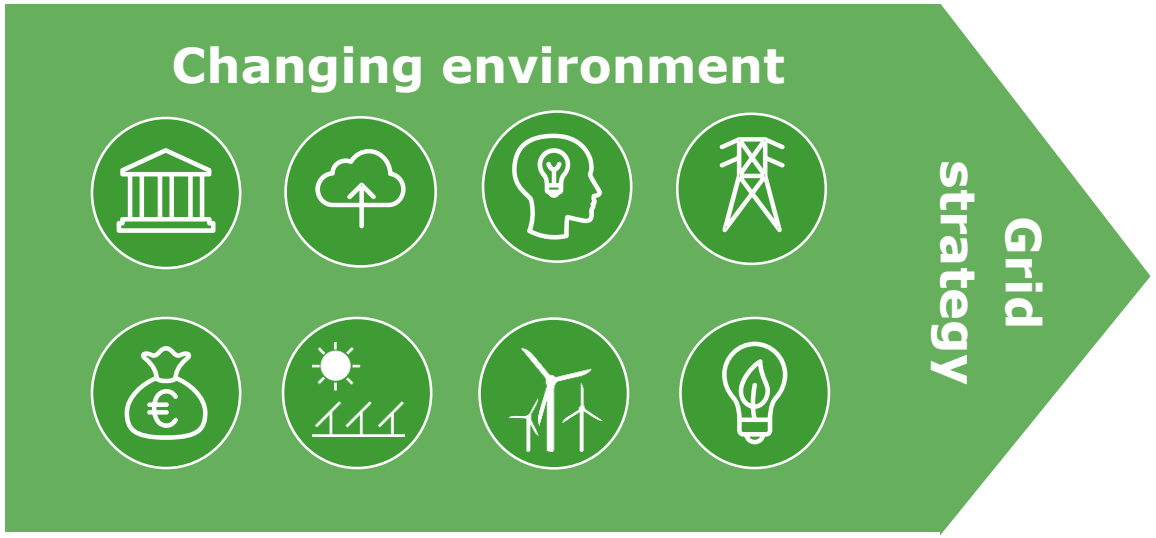
# Industry consolidation – strong brands

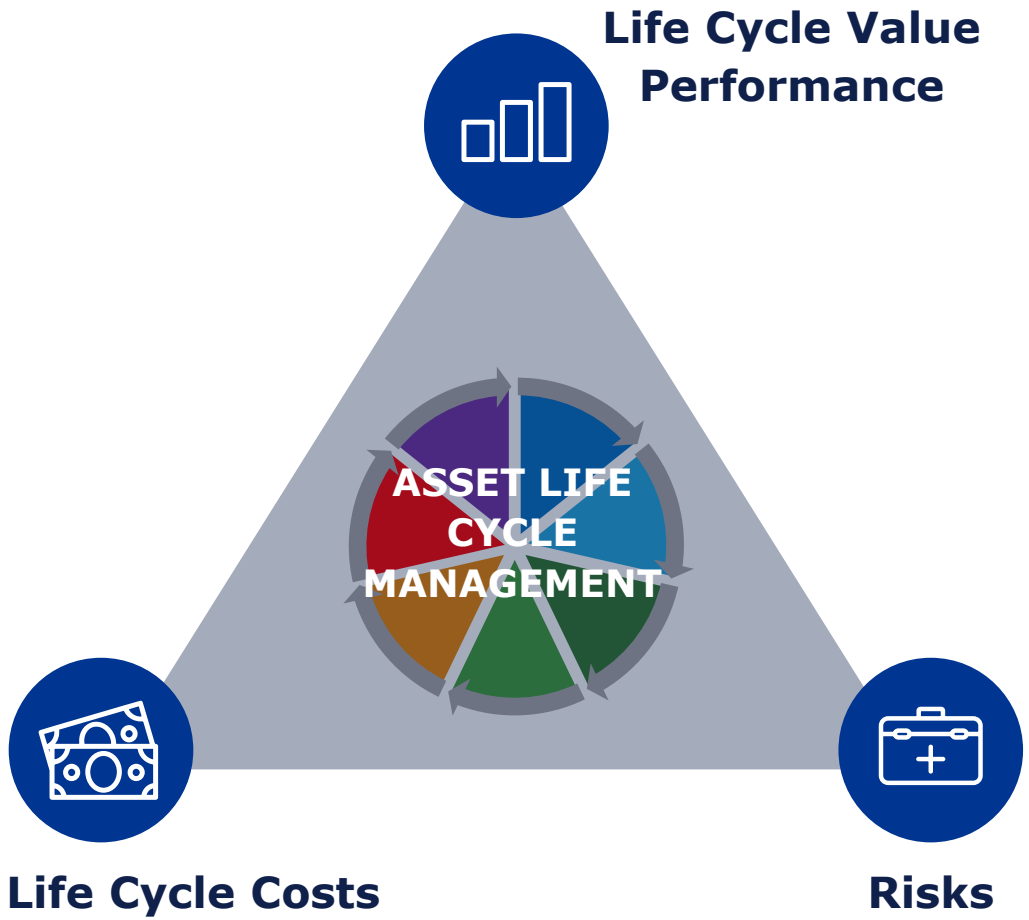
2,500 energy experts help customers throughout the electrical power industry realize efficient, reliable and clean energy for today and the future.



# External and internal challenges impacting Asset Management

**T&D are impacted by major external and internal challenges: introduction of renewables, energy transition, electrification, new regulations, aging assets, aging workforce, etc.**



# Where is the value?

| | | |
|---|---|---|
| Who knows the condition of my old assets? | What parts of my system is at risk? | How to minimize unplanned downtime? |
| How and when to use limited resources and budget? | ***Why*** to do ***what maintenance*** on ***which assets*** and ***when***? | Do we face a replacement wave? If so, when? |
| What asset data do we need to gather? Why? | | How do we make consistent decisions? |
| Do we have sufficient manpower, now and in the future? | Where do we need to focus, with thousands of assets? | How can asset data support our decision-making? |

# Advanced Asset Management: value driven & data enabled

**VALUE DRIVEN**

### Agile decision-making

**Asset Life cycle management Use Cases:**

- Condition management
- Risk management
- Policy & strategy development
- Replace and Maintenance Planning
- Portfolio management

### Data analytics

- Machine Learning
- Algorithms
- Platforms
- Digital Twins

### Data

- Loading
- Weather
- Soil
- Sensor
- Forecasting
- Temperature
- Conditions
- Outage
- Workforce
- Static
- GIS
- Maintenance
- Inspection
- Performance
- Financial
- Customer
- Application
- Social media

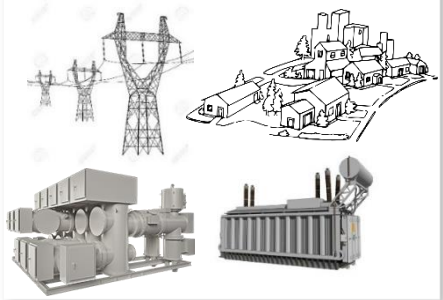
### Smart sensors

Digital substation

Smart meters

Digital workforce

### Grid, assets and customer connections



**DATA ENABLED**

| | | | |
|---|---|---|---|
| Optimization of decision-making processes | Real time insight in condition and performance | Integration of AM and operations | Making use of digitalization |

# *"What is Digitalization?"*

**DIGITIZATION**

Making things digital

**DIGITALIZATION**

Business opportunities created by digitization

**DIGITAL TRANSFORMATION**

Changing business models with digitalization


www.dnvgl.com/to2030

TECHNOLOGY OUTLOOK 2030

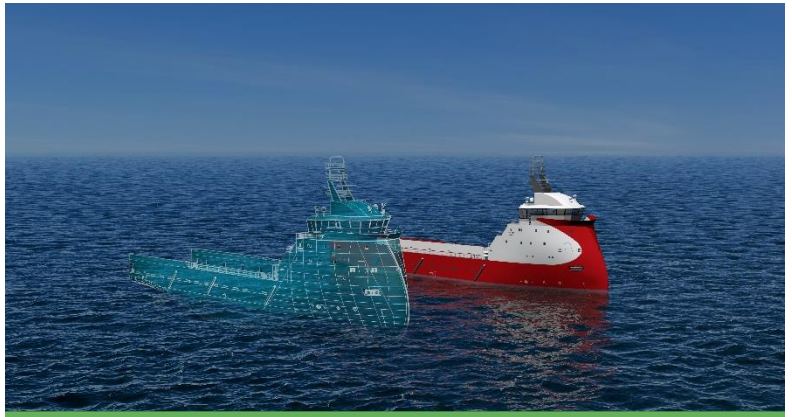


DNV·GL

# Enabling technologies

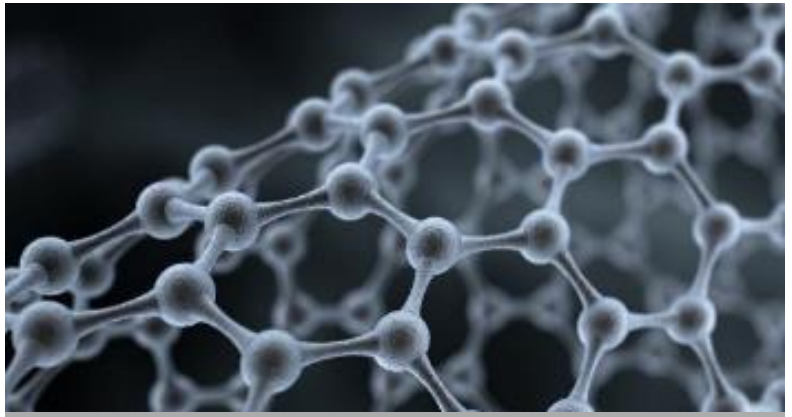
## Acceleration of digitalization

- Artificial Intelligence
- Internet of Things
- Distributed ledger technologies
- Augmented & virtual reality
- Quantum computing
- Everything as a service



## Virtualization and automation

- Prognostic maintenance
- Sensors
- Autonomous control
- Digital twins
- 5G communication networks



## *Towards precision materials*

- Holistic material selection
- Real time digital sensors
- New manufacturing processes
- Model based prediction tools
- Virtual material test labs

# Industry view on Digitalization

**1,919**

**respondents from across the power and renewables industry**

www.dnvgl.com/futureofenergy

**87%**

**have a digital strategy**

Digitalization is clearly important for the power and renewables industry

**89%**

**improving efficiency is the main goal for digitalization**

Digitalization is improving efficiency, reducing costs, enhancing customer satisfaction

**41%**

**lack of digital mind set**

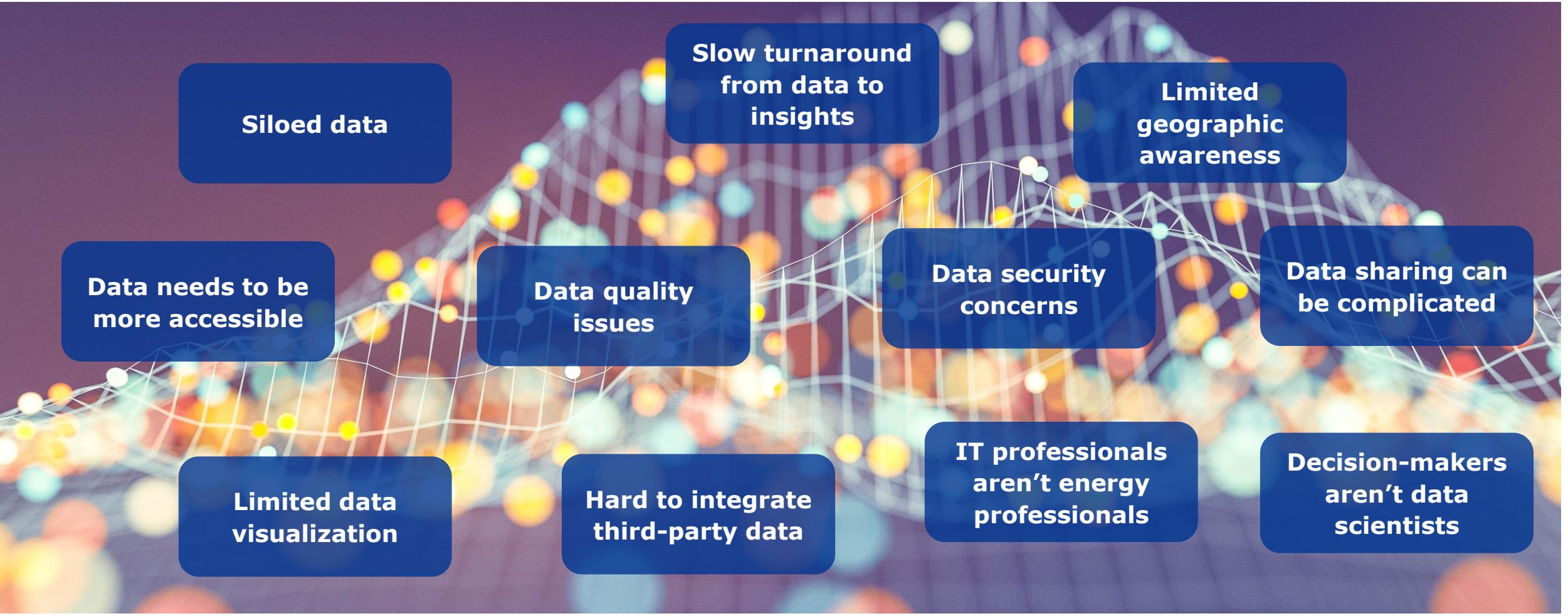
Digitalization requires digital technology skills, but human factors are crucial

**71%**

**need employees with combined data and domain knowledge**

Digitalization needs to be connected to engineering to make an impact

# Data challenges utility clients are facing



# Data journey

**Data made available**

**Data made usable**

**Data actually used for predictions**

**Predictions used for operational decisions**

## Getting the data

- Data ingest
- IoT Sensor data acquisition
- Streaming analytics
- API management
- Cloud storage
- User management
- Secure access

## Managing data

- Data quality management
- Data quality dashboards
- Asset modelling
- Contextualize data
- Risk assessment
- Data quality improvement

## Become Data-driven

- Data insights
- KPI dashboards
- Forecasting / trend analysis
- Predictive Maintenance
- Digital Twin, Analytics, AI/ML

## Towards actual Business impact

- Data maturity assessment
- QA, Testing and of Assurance of data driven models
- Moving from pilots/prototypes to operational systems

## Operational Deployment

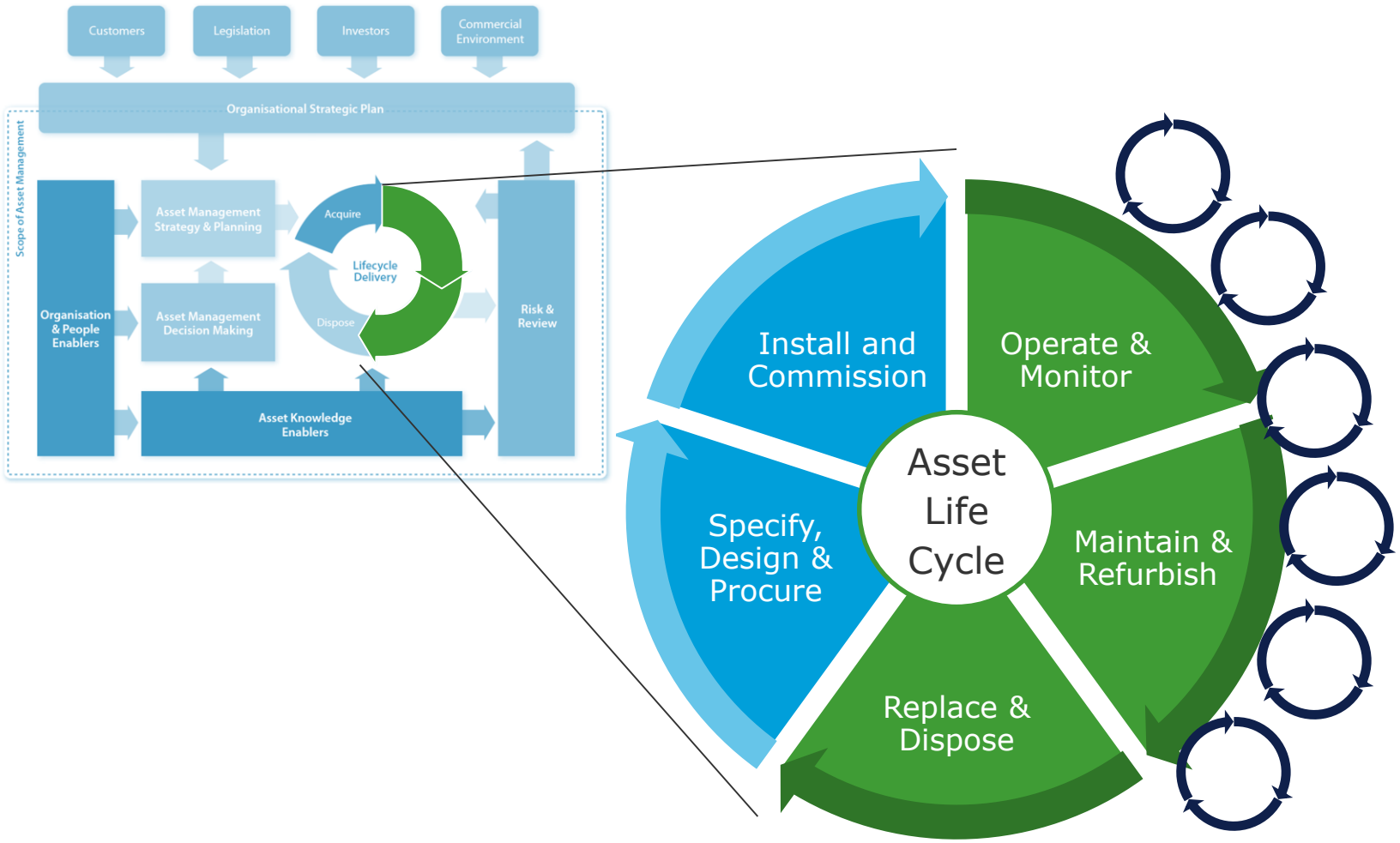
- Deployment & support
- Maintenance & SLA
- Evaluation of outcome and results
- Upgrades

**Improved efficiency, lower costs, higher user experience**



DNV·GL

# Asset Life Cycle Management – Grid assets vs. Digital assets




**Digital Life Cycle << Asset LC**

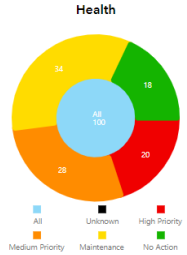
- Secondary Equipment
- Telecom
- Hardware
- Software
- Protocols
- Data & data models
- Cyber Security Compliancy
- Data migrations

# Digitalization in Asset Management – 4 DNV GL Examples

**VALUE DRIVEN**

Agile decision-making

4 **Software & Analytics**




**APM Foresight Health & Risk**

3 **Platform**

**Veracity**

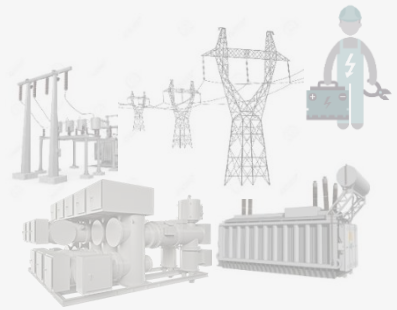
2 **Data**

**Architecture & Management**

1 **Sensors**

**Smart Cable Guard**

Grid, assets and customer connections



**DATA ENABLED**

| | | | |
|---|---|---|---|
| Driven by Business Value Creation | Focus on installed base & Aging Assets | Independent, transparent & flexible | Cross-Industry Best Practices |

# Smart Cable Guard on-line cable monitoring

1 Sensors

## Ambition

- Lower outage minutes (SAIDI)
- Lower outage frequency (SAIFI)
- Improved safety (avoid permanent and intermitting short circuits)
- Data Driven and Condition based asset management

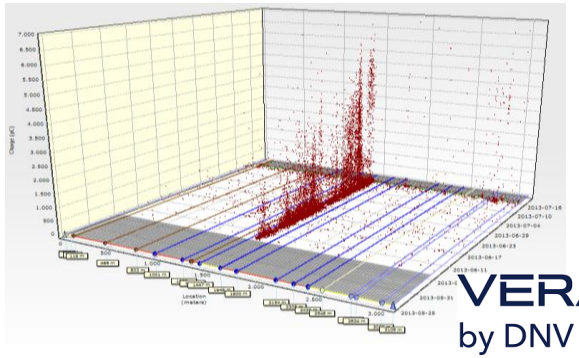
## Smart Cable Guard

**Accurate fault prevention, detection and localisation**

**On-line monitoring of partial discharges, short-circuit and earthing faults**

**Up to 15km cables**

**3-66kV (going up)**



VERACITY by DNV GL



DNV·GL

# Smart Cable Guard – End2End digital service

**VALUE DRIVEN**

**KPI**

- Risk reduction
- SAIDI reduction
- SAIFI reduction
- CAPEX reduction

**Use Cases (ex.)**

**Operations**
- Outage repair approach

**Asset Management**
- Condition management and risk management cables & joints
- Planning just-in-time replacement
- Replacement policy and portfolio optimisation

**Data & Analytics**

**Data lake**

**Asset data**

**Sensor data (PD)**

**Outage (FPL) data**

**Algorithms**

**Machine Learning**

**Infrastructure**

**DNV GL IT**

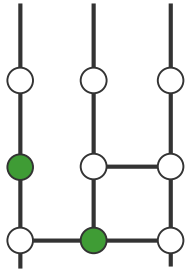
**3G**

**4G**

**Veracity**

**Smart Cable Guard**


**Grid & customers**

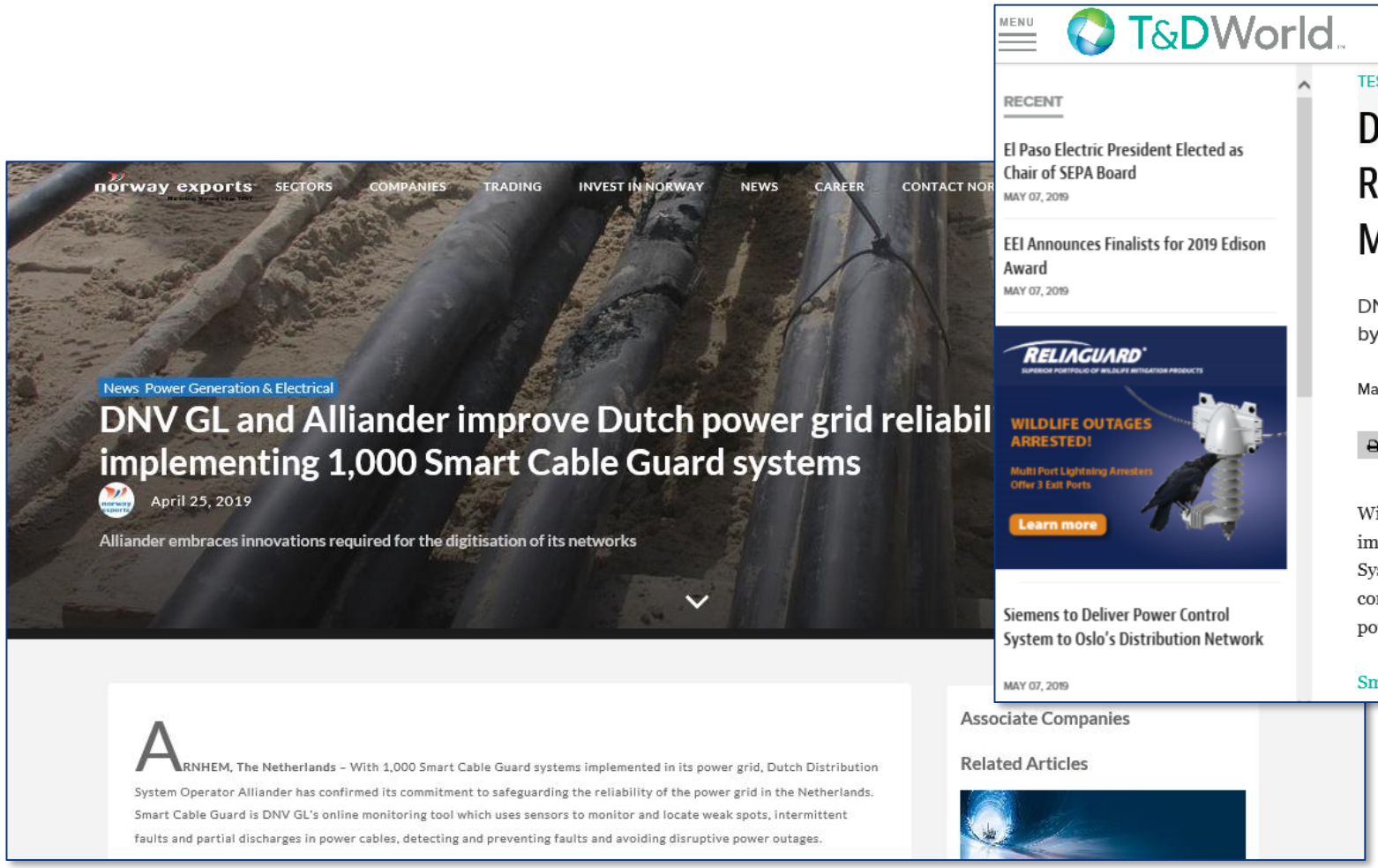


MV (HV) circuits (cables & sec. substations)

**DATA ENABLED**

# Large scale SCG roll-out of >1.000 systems (Global >3.000 planned)

1
Sensors



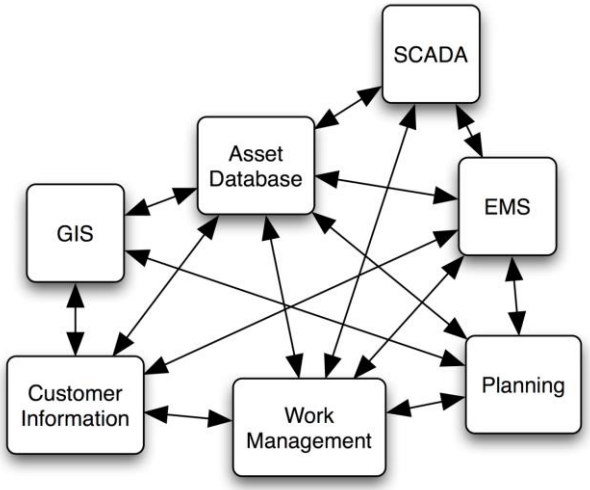

# Data governance and data exchange based on CIM & ESB



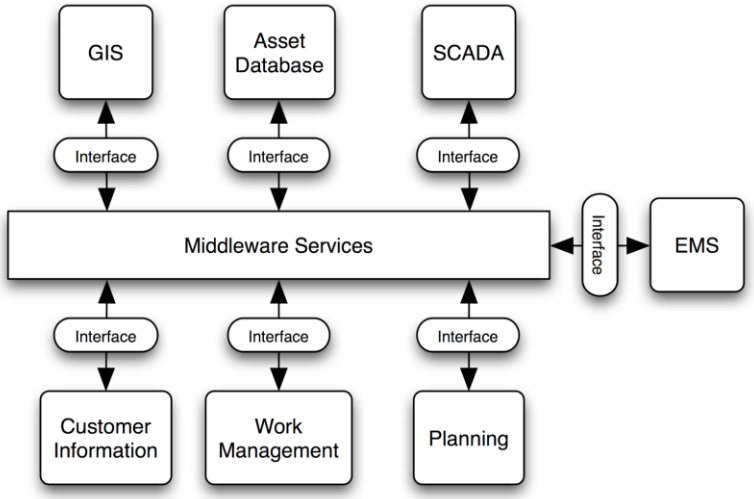
The CIM is an international IEC standard that models the information exchanges required in electric utilities. It is independent of any individual application, middleware, or message protocols used for data exchange.

**Benefits:**

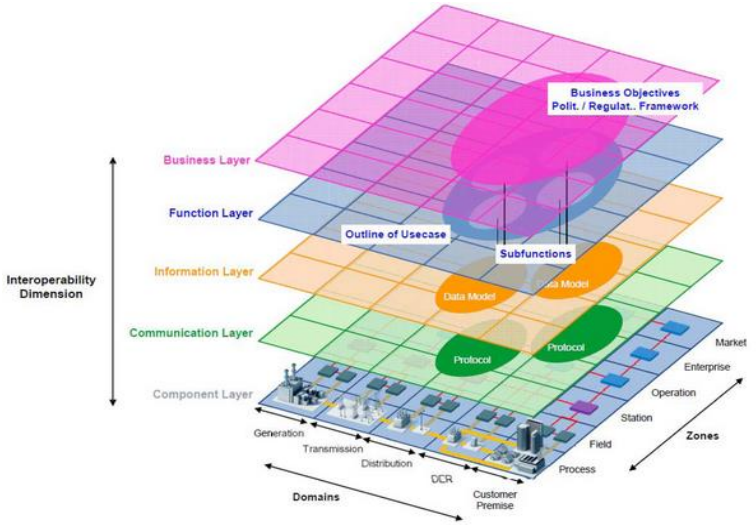
- One interface per application: less development/maintenance
- One asset definition: improved knowledge on assets, fewer errors




Point-to-point communication




Service Oriented Architecture
Enterprise Service Bus

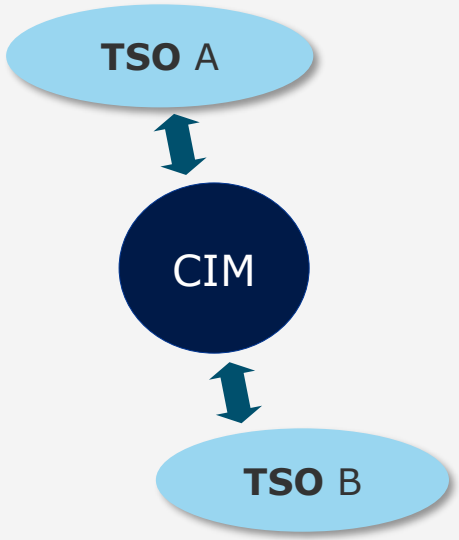



Smart Grid Architecture Model

# Standardized data exchange through Common Information Model

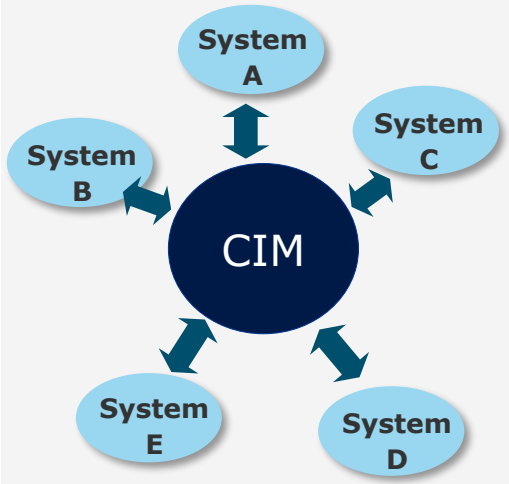


**Exchange of power system network data between organizations**



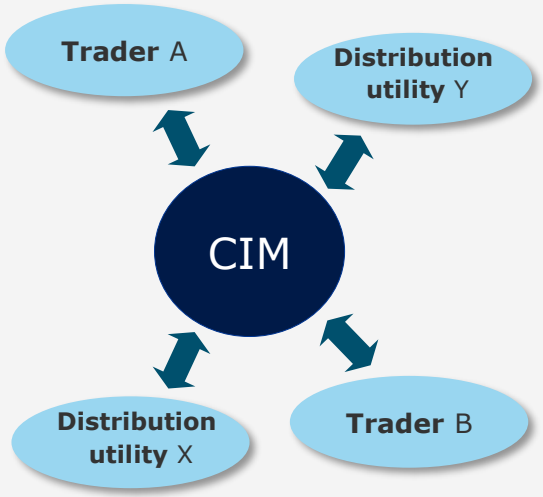

**IEC 61970-301**

**Exchange of data between applications within an organization**




**IEC 61968-11**

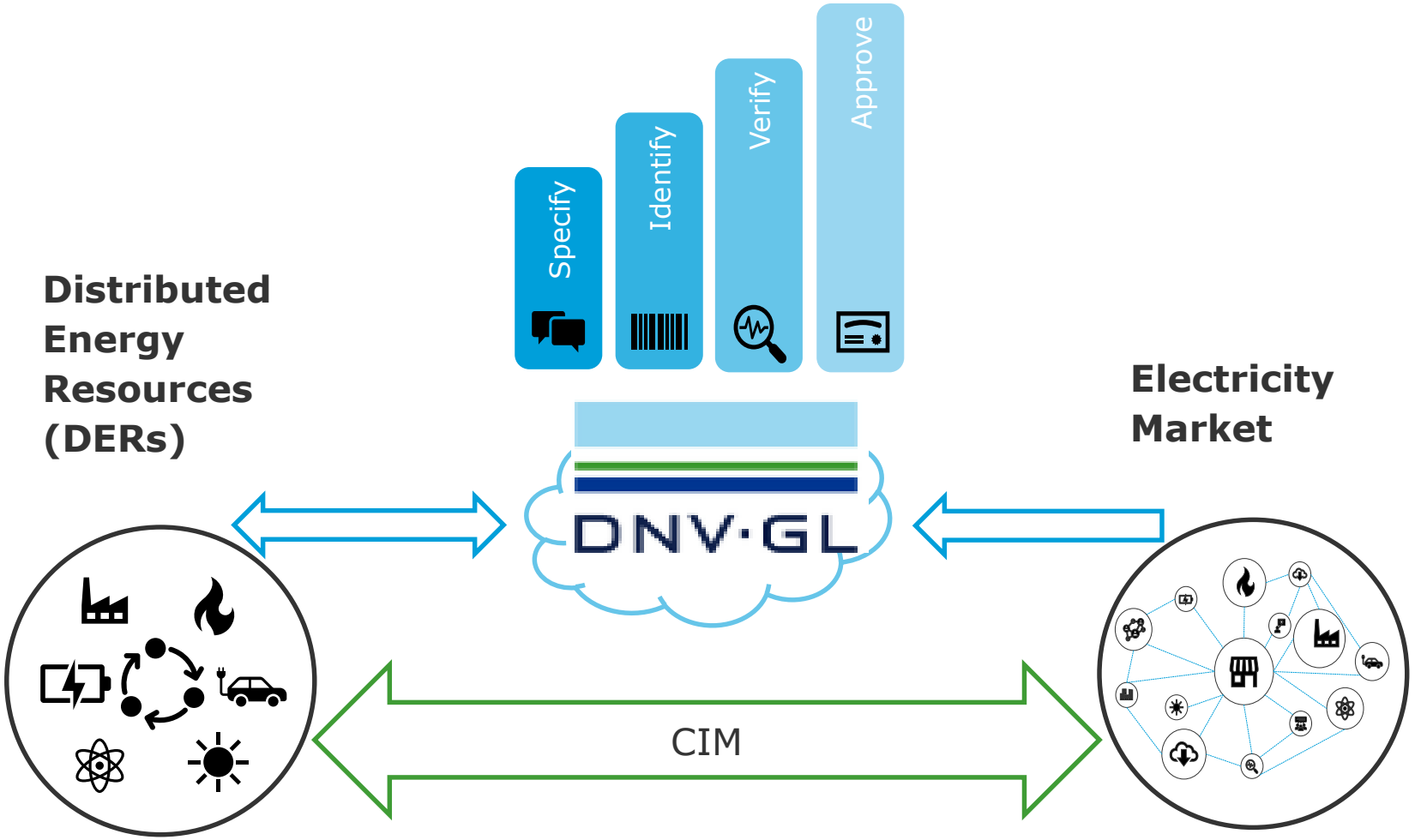
**Exchange of market data between organizations**




**IEC 62325-301**

# DNV GL CIMBION - online service for pre-approval and connection



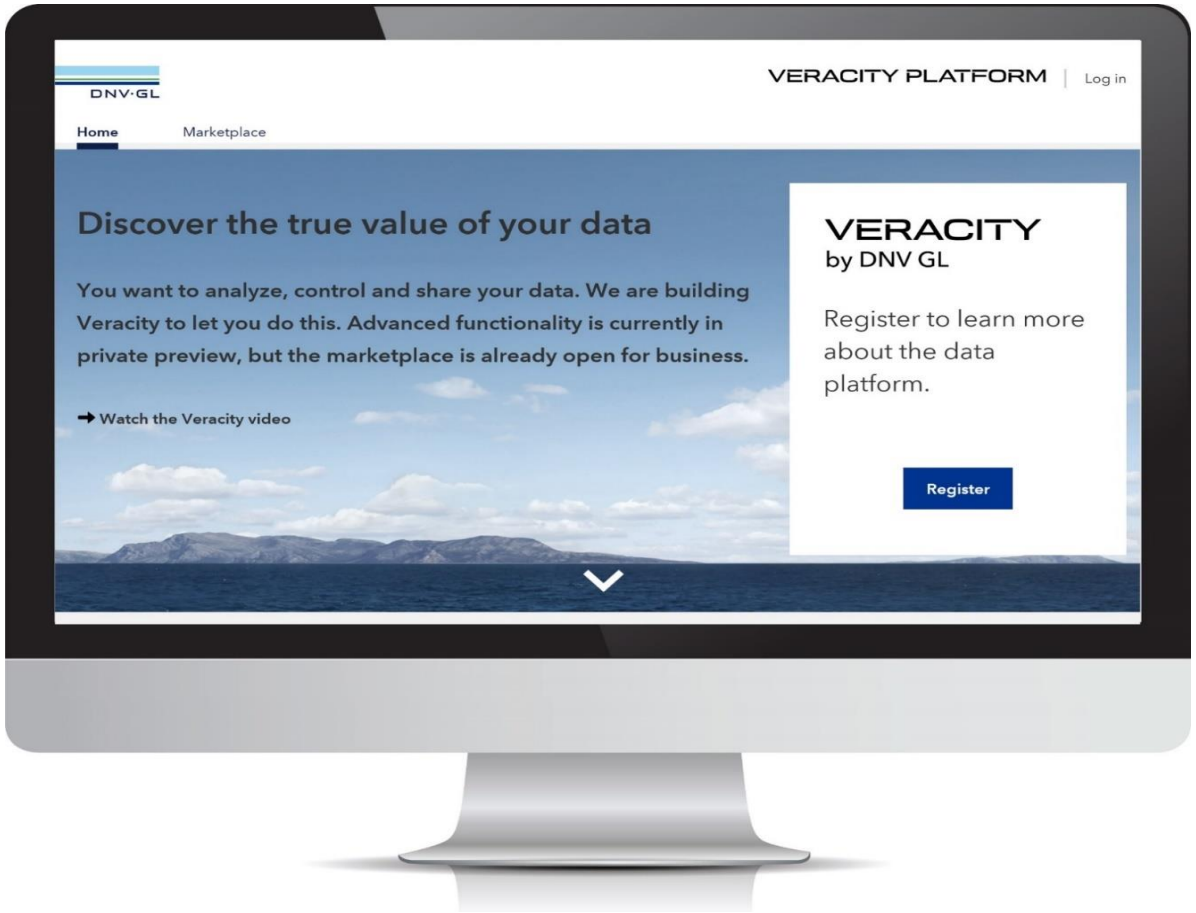



- Harmonization with majority of electricity
- Reduction of market entry barriers for DERs, BRPs, and BSPs
- Simplification of Business Processes
- Compliance with ENTSO-E
- Increased automation and security
- Management of future market business processes

# Insights by Veracity



Veracity is DNV GL's secure platform for digital innovation and industry collaboration



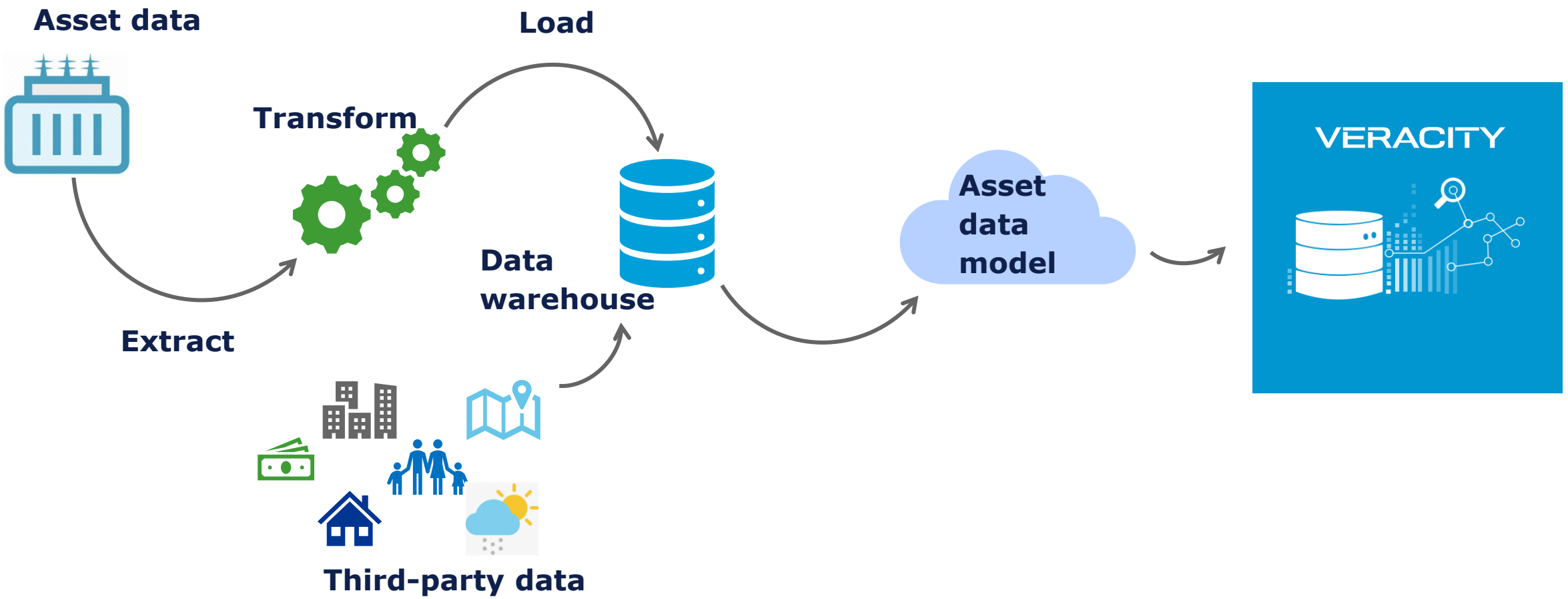

## Data insights

- Data ingest, modelling, transformation
- Data quality management, data cleaning
- KPI Dashboards
- Asset workbench

## Data-driven insights

- IoT/sensor data ingest
- Analytical models
- Forecasting and predictive maintenance
- Digital Twin

# Getting data on the platform

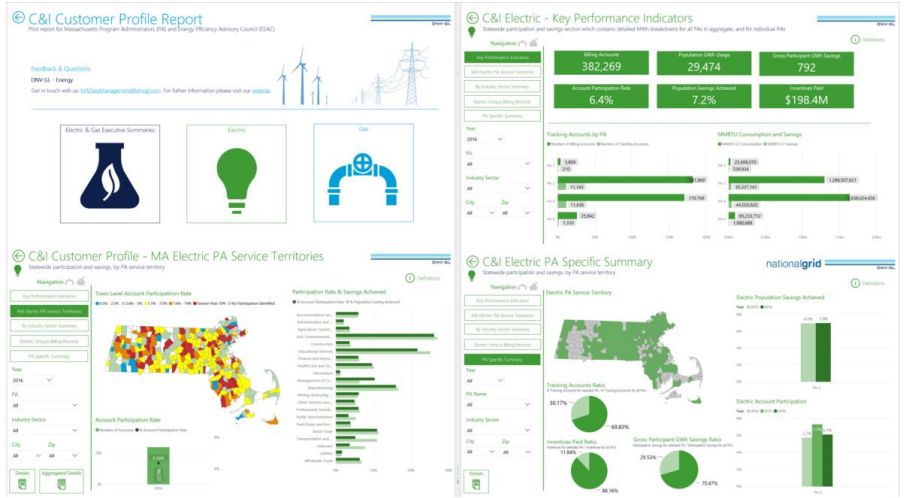


# Provide accessible insights

3
Platform

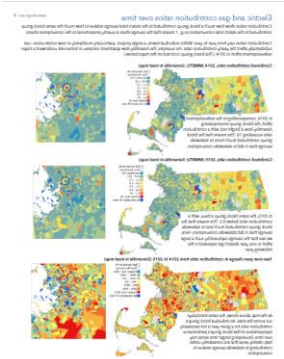
VERACITY

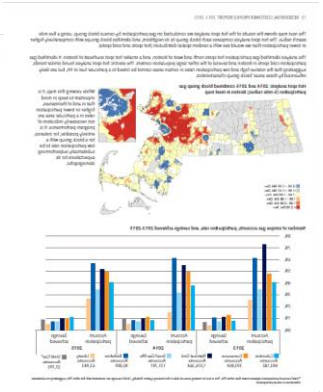
**Veracity dashboards**

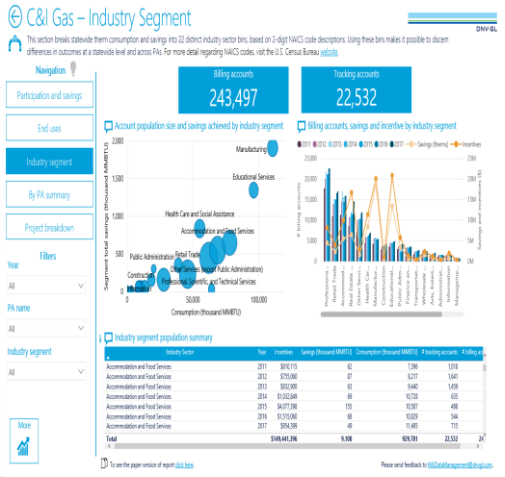



**Access to your data and our energy data scientists**

**Graphical summary reports**

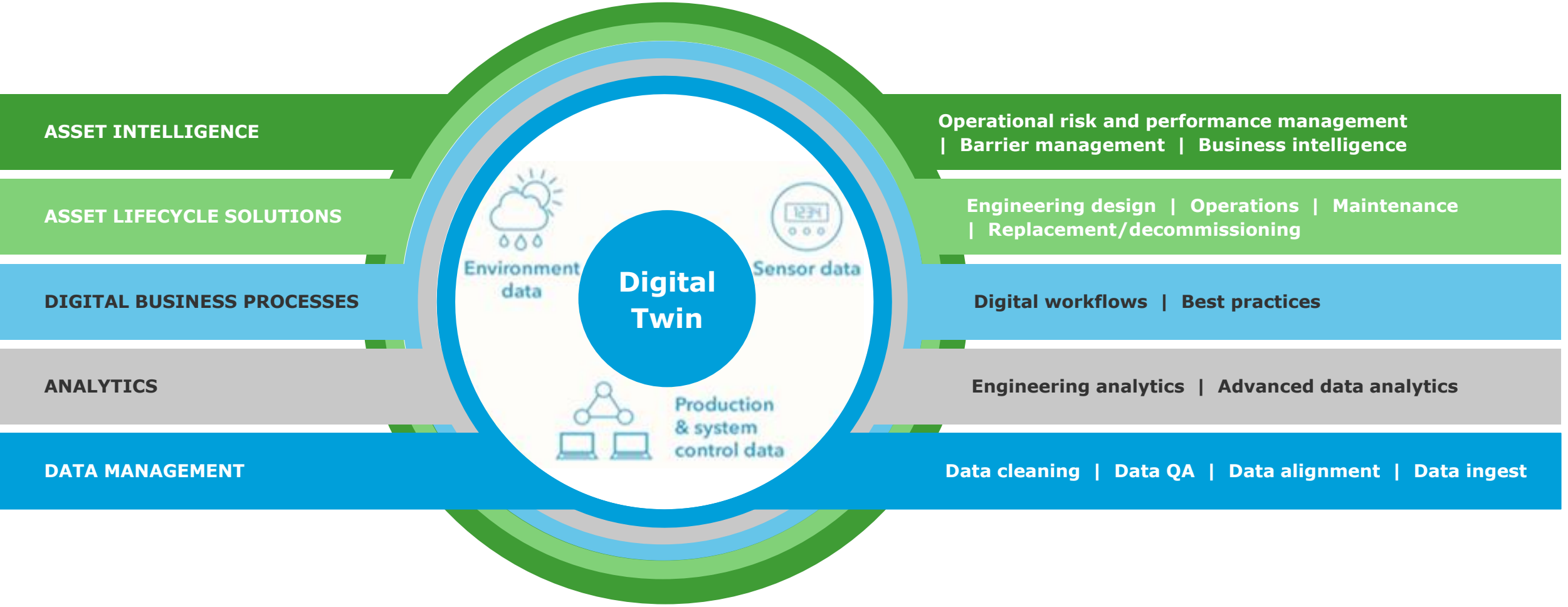






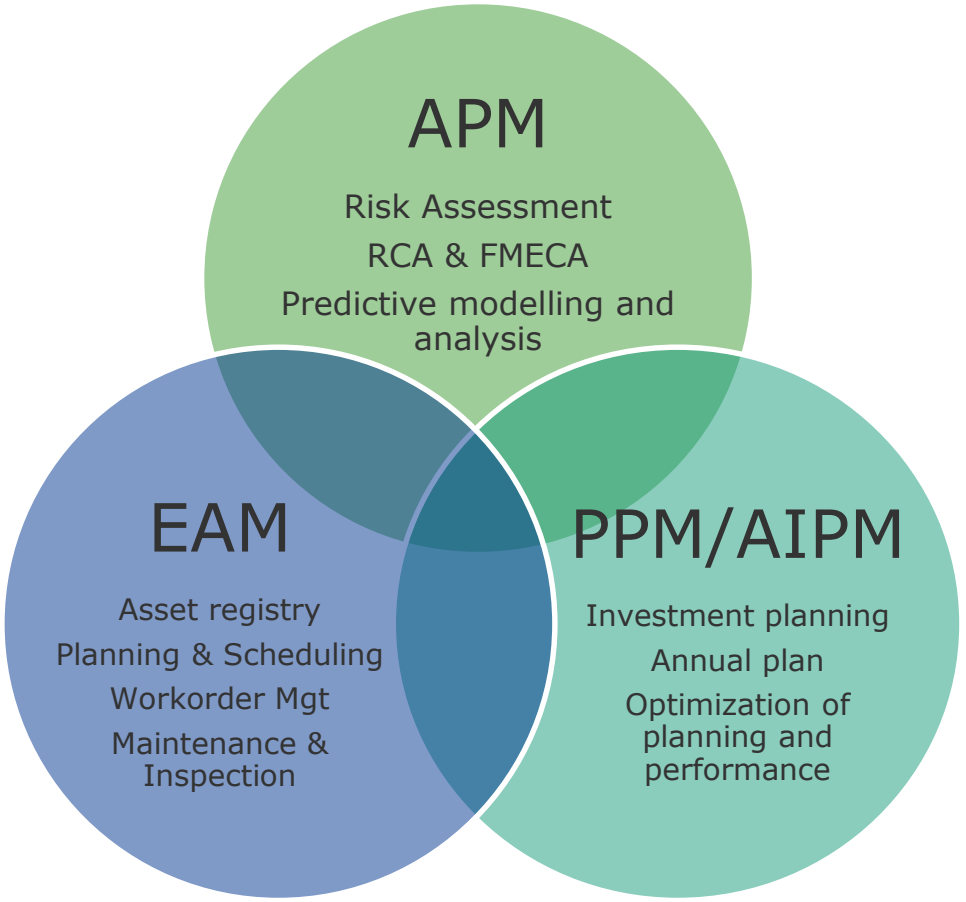
# The Digital Twin Ecosystem

3
Platform



# Gartner – Asset Management System Functions






**Enterprise asset management (EAM)**

- **EAM (or CMMS)** consists of asset register, work order management, inventory and procurement functions in an integrated business software package.

**Asset Performance Management (APM)**

- **APM** encompasses the capabilities of data capture, integration, visualization and analytics,

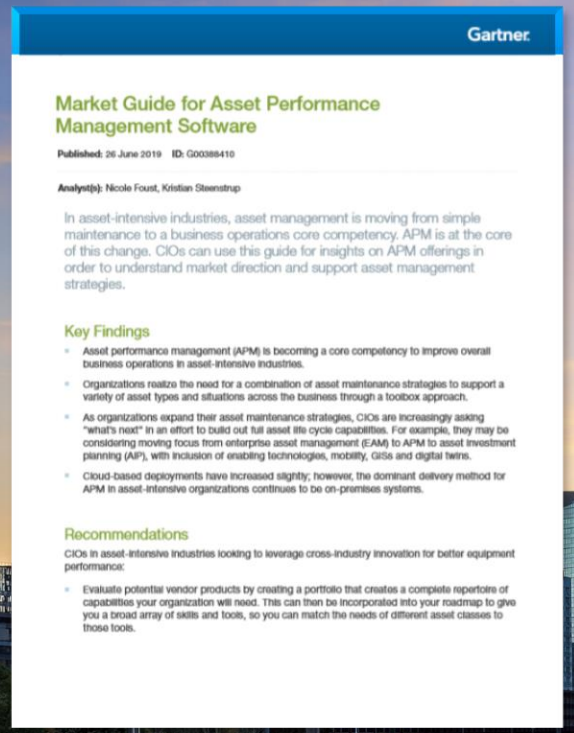
**Portfolio and Program Management (PPM) & Asset Investment Planning & Management (AIPM)**

- Software that supports portfolio management. Assists in analyzing and reporting risks versus opportunities.

# Market Guide Report for APM Software – June 2019



Asset management is moving from simple maintenance to a business operations core competency. Asset Performance Management (APM) is at the core of this change.



Gartner

Market Guide for Asset Performance Management Software

Published: 26 June 2019 ID: G00388410

Analyst(s): Nicole Foust, Kristian Steenstrup

In asset-intensive industries, asset management is moving from simple maintenance to a business operations core competency. APM is at the core of this change. CIOs can use this guide for insights on APM offerings in order to understand market direction and support asset management strategies.

Key Findings

- Asset performance management (APM) is becoming a core competency to improve overall business operations in asset-intensive industries.
- Organizations realize the need for a combination of asset maintenance strategies to support a variety of asset types and situations across the business through a toolbox approach.
- As organizations expand their asset maintenance strategies, CIOs are increasingly asking "what's next" in an effort to build out full asset life cycle capabilities. For example, they may be considering moving focus from enterprise asset management (EAM) to APM to asset investment planning (AIP), with inclusion of enabling technologies, mobility, GIS and digital twins.
- Cloud-based deployments have increased slightly; however, the dominant delivery method for APM in asset-intensive organizations continues to be on-premises systems.

Recommendations

CIOs in asset-intensive industries looking to leverage cross-industry innovation for better equipment performance:

- Evaluate potential vendor products by creating a portfolio that creates a complete repertoire of capabilities your organization will need. This can then be incorporated into your roadmap to give you a broad array of skills and tools, so you can match the needs of different asset classes to those tools.

**APM is becoming a core competency**

**Need for a combination of asset maintenance strategies**

**CIOs asking "what's next" to build out full asset life cycle capabilities**

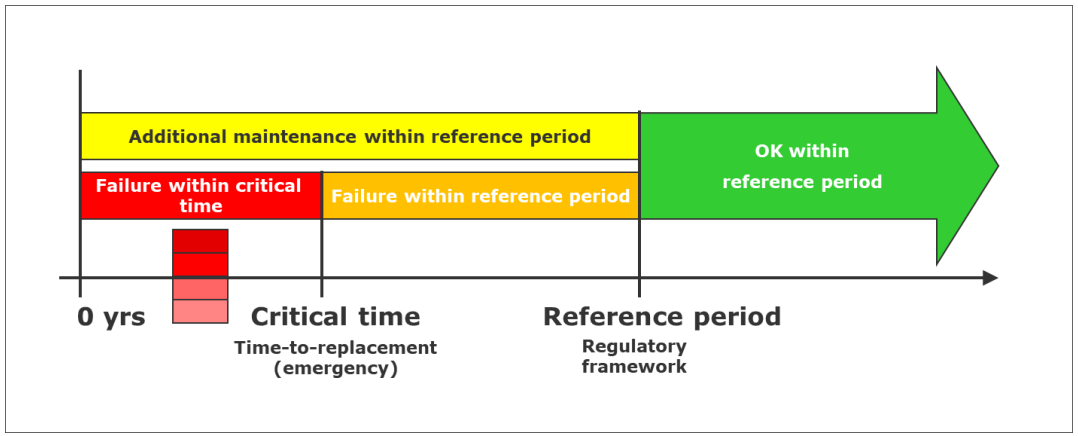
**Cloud-based deployments increase; on-prem still dominates**

# APM - Asset Health Index – Example failure modes & condition indicators



## TF Failure Modes

- Active part
- Tap changer
- Bushing
- Main tank

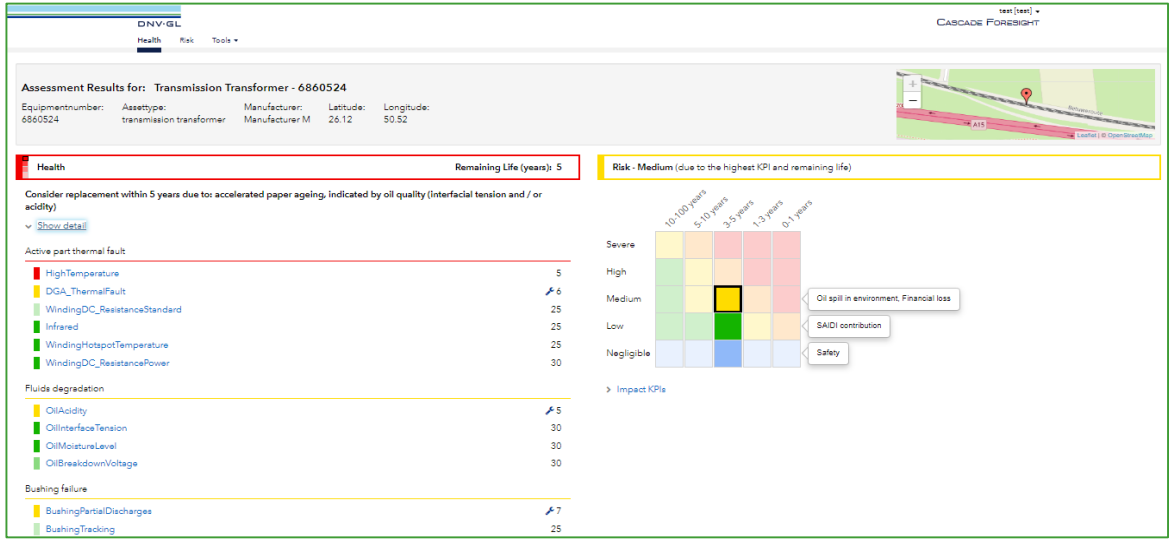


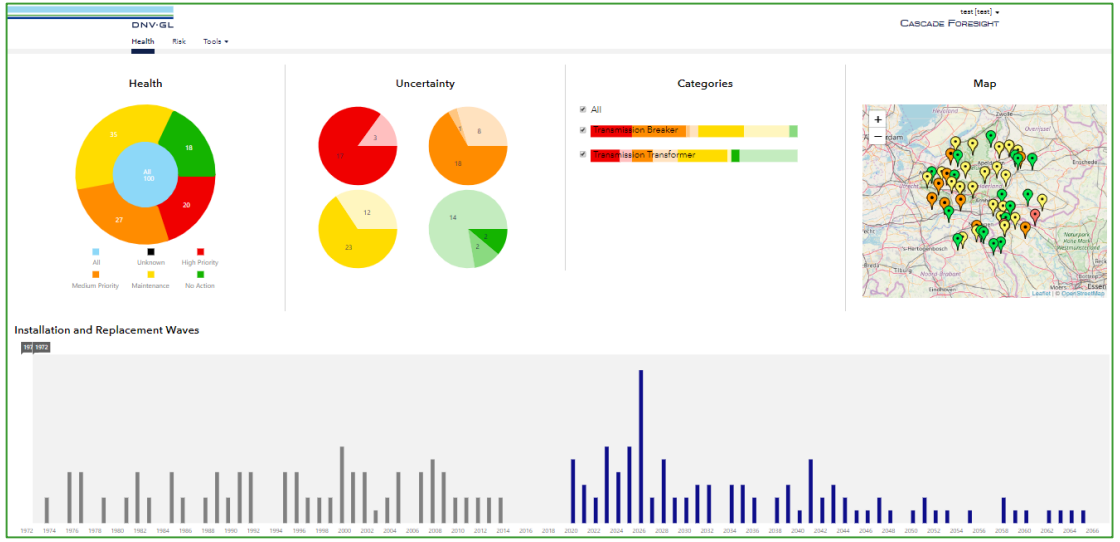

## Condition indicators

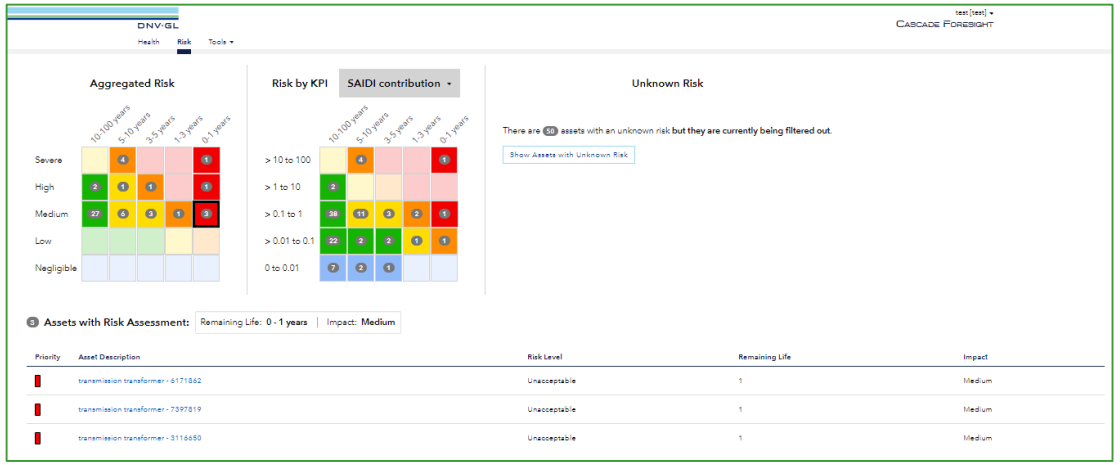
- Active part thermal failure
  - Paper degradation
  - Thermal fault
  - Overload

# Foresight Health & Risk – Asset Health Index & Risk Dashboard






All failure modes taken into account

Decision support tool for risk management and link to portfolio management

Supports condition-based strategy with prescriptive measures

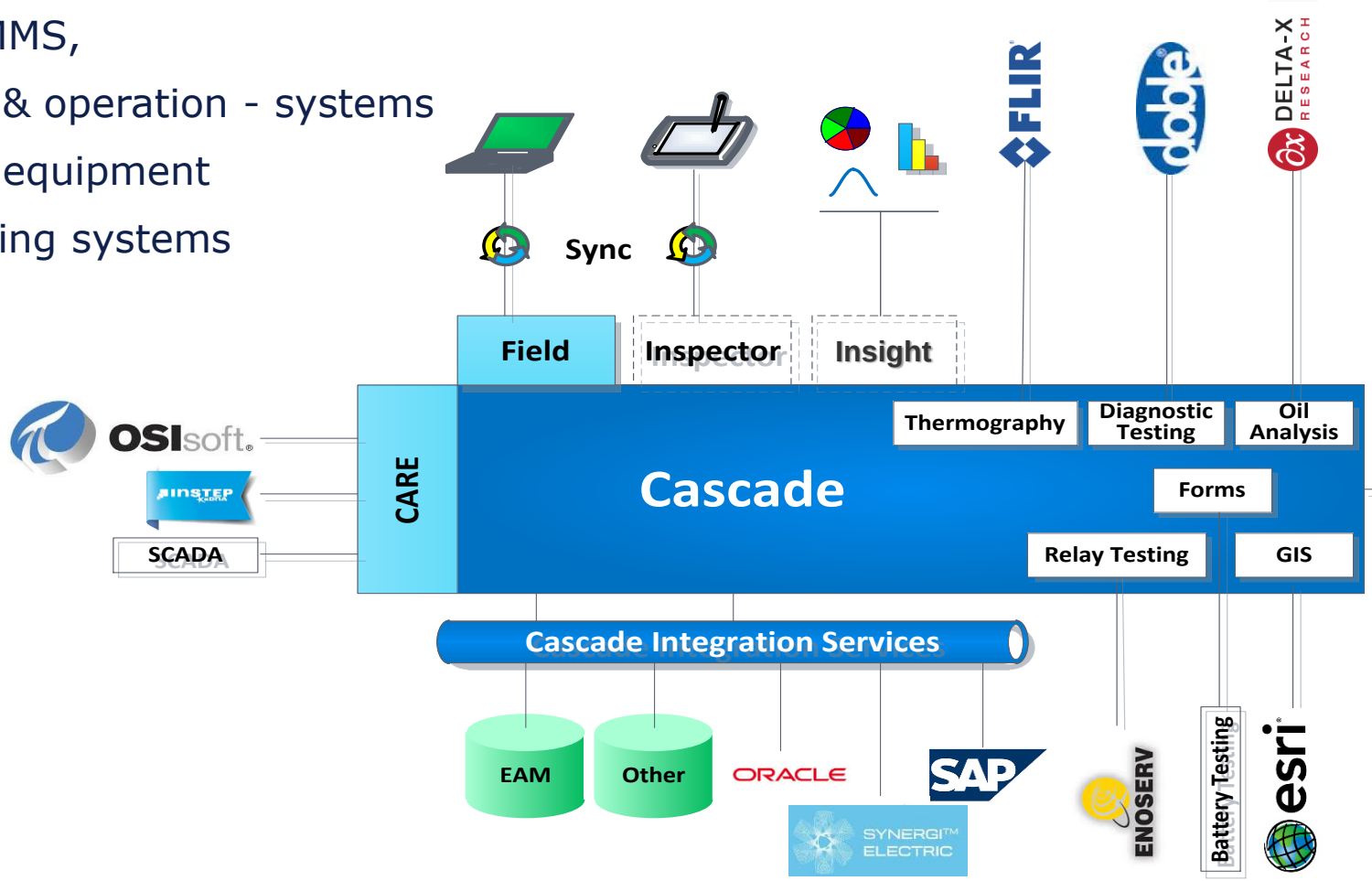
Both short-term- and long-term investment decisions

# EAM / APM Example architecture



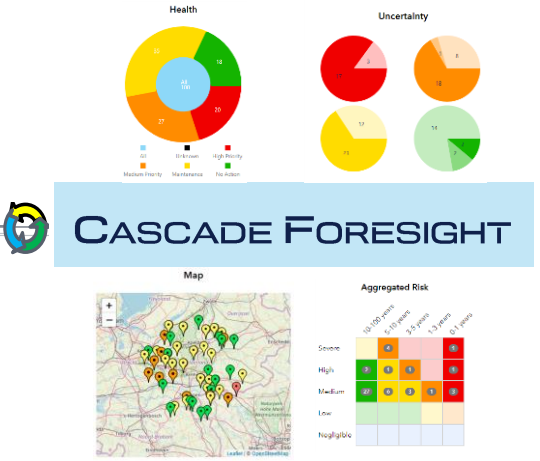
## Cascade Foresight Interfaces

- ERP, CMMS,
- SCADA & operation - systems
- Testing equipment
- Monitoring systems




## Cascade Foresight reports

- To CMMS Additional Maintenance
- To PPM Portfolio Tools



# Conclusions

- Current Asset Management practice needs to adapt to new and urgent challenges
- Use the potential of Digitalization: Smart Grid Sensors, Data Management, System Architecture and Advanced Data Analytics
- Create Business Value through Data enabled Asset Management:
  - Performance optimization: improve network reliability (direct reflection on SAIDI and SAIFI)
  - Risk reduction: reduction of failures through condition based maintenance and -replacements
  - Cost reduction: optimize asset management strategies and -plans

# Thank you

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**SAFER, SMARTER, GREENER**