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
A quality assurance and risk management company

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.

1867
1864
1927
1984
2012
2013
2009
2015
2016
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.

Changing environment

Grid strategy

Life Cycle Value Performance

Life Cycle Costs

Risks
Where is the value?

- Who knows the condition of my old assets?
- How and when to use limited resources and budget?
- What asset data do we need to gather? Why?
- Do we have sufficient manpower, now and in the future?

**Why to do what maintenance on which assets and when?**

- What parts of my system is at risk?
- How to minimize unplanned downtime?
- Do we face a replacement wave? If so, when?
- How do we make consistent decisions?
- 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

Smart sensors
- Static
- GIS
- Maintenance
- Inspection
- Performance
- Financial
- Customer
- Application
- Social media

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
Enabling technologies

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

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

Acceleration of digitalization

Virtualization and automation

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

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

www.dnvgl.com/futureofenergy
Data challenges utility clients are facing

- Siloed data
- Data needs to be more accessible
- Limited data visualization
- Slow turnaround from data to insights
- Data quality issues
- Hard to integrate third-party data
- Data security concerns
- IT professionals aren’t energy professionals
- Limited geographic awareness
- Data sharing can be complicated
- Decision-makers aren’t data scientists
- Slow turnaround from data to insights
Data journey

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
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 Compliance
- Data migrations
Digitalization in Asset Management – 4 DNV GL Examples

VALUE DRIVEN

1. Sensors
   Smart Cable Guard

2. Data
   Architecture & Management

3. Platform
   Veracity

4. Software & Analytics
   APM Foresight Health & Risk

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

**Ambition**

- Lower outage minutes (SAIDI)
- Lower outage frequency (SAIFI)
- Improved safety (avoid permanent and intermittent 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)
Smart Cable Guard – End2End digital service

**VALUE DRIVEN**

<table>
<thead>
<tr>
<th>KPI</th>
<th>Use Cases (ex.)</th>
<th>Data &amp; Analytics</th>
<th>Infrastructure</th>
<th>Smart Cable Guard</th>
<th>Grid &amp; customers</th>
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<tbody>
<tr>
<td>Risk reduction</td>
<td>Operations</td>
<td>Data lake</td>
<td>DNV GL IT</td>
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<td>MV (HV) circuits (cables &amp; sec. substations)</td>
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<td>SAIDI reduction</td>
<td>Asset Management</td>
<td>Asset data</td>
<td>3G</td>
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<td>SAIFI reduction</td>
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<td>Sensor data (PD)</td>
<td>4G</td>
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<td>CAPEX reduction</td>
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<td>Outage (FPL) data</td>
<td>Veracity</td>
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**DATA ENABLED**

- Operations
  - Outage repair approach
  - Condition management and risk management cables & joints
  - Planning just-in-time replacement
  - Replacement policy and portfolio optimisation

- Asset Management
  - Data lake
  - Asset data
  - Sensor data (PD)
  - Outage (FPL) data
  - Algorithms
  - Machine Learning
DNV GL and Alliander improve Dutch power grid reliability by implementing 1,000 Smart Cable Guard systems.

With 1,000 Smart Cable Guard systems implemented in its power grid, Dutch Distribution System Operator Alliander has confirmed its commitment to safeguarding the reliability of the power grid in the Netherlands.

Smart Cable Guard is DNV GL’s online monitoring tool which uses sensors to monitor and locate weak spots, intermittent faults and partial discharges in power cables, detecting and preventing faults and avoiding disruptive power outages.
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

![Diagram of data governance and data exchange based on CIM & ESB]
Standardized data exchange through Common Information Model

Exchange of power system network data between organizations

- TSO A
- TSO B
- CIM
- IEC 61970-301

Exchange of data between applications within an organization

- System A
- System B
- System C
- System D
- System E
- CIM
- IEC 61968-11

Exchange of market data between organizations

- Trader A
- Distribution utility Y
- Trader B
- Distribution utility X
- CIM
- 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

Distributed Energy Resources (DERs)

Electricity Market

CIM
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

Extract → Transform → Load → Asset data model → Asset data

Extract → Third-party data → Transform → Load → Data warehouse → Asset data model → Asset data

VERACITY
Provide accessible insights

- **VERACITY**
  - Access to your data and our energy data scientists
  - Graphical summary reports
  - Veracity dashboards
The Digital Twin Ecosystem

ASSET INTELLIGENCE
- Operational risk and performance management
- Barrier management
- Business intelligence

ASSET LIFECYCLE SOLUTIONS
- Engineering design
- Operations
- Maintenance
- Replacement/decommissioning

DIGITAL BUSINESS PROCESSES
- Digital workflows
- Best practices

ANALYTICS
- Engineering analytics
- Advanced data analytics

DATA MANAGEMENT
- Data cleaning
- Data QA
- Data alignment
- Data ingest

Digital Twin

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

APM is becoming a core competency

CIOs asking “what’s next” to build out full asset life cycle capabilities

Need for a combination of asset maintenance strategies

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