NEXANS STRATEGIC ASSET MANAGEMENT SOLUTION (SAMS): THE POWERFUL DECISON MAKING PLATFORM DEDICATED TO DSOs

Thomas LACROIX
Cosmotech – France
thomas.lacroix@cosmotech.com

Thierry DE LUMLEY
Cosmotech – France
thierry.de.lumley@cosmotech.com

Olivier PINTO
Nexans – France
olivier.pinto@nexans.com

Franck BLONBOU
Nexans – France
franck.blonbou@nexans.com

ABSTRACT

Many DSOs will face an investment wall in the near future. With an aging asset stock and the risk of failures and cascading effects, asset fleets need repair and replacement. What's more, the energy transition along with the exponential growth of DERs requires anticipating network outages and flat consumption constraints. Experienced workers are getting older and retiring in greater numbers. Maintenance and renewal policies might not be optimal, and there are increasingly stricter regulations and new tariff structures to comply with. All of these challenges result in more constraints than ever on DSO asset managers, strategic planners, decision makers, and specifically more pressure to make the optimal decision.

We introduce in this paper the world's most powerful decision management platform designed especially for the complex systems that DSO executives negotiate every day. Concretely, we will elaborate on how this platform helps decision makers extract the maximum value from their assets and make optimal decisions for their strategic sustainment plans and investments by considering their systems as a whole instead of locally or in silos.

INTRODUCTION

Finding an optimum balance between expenditures and quality of supply has become a tremendous challenge over the last years for DSOs. Furthermore, the proliferation of renewable energy sources on one side and new heavy energy consuming services such as electric vehicles on the other side is drastically changing the distribution network lifecycle and especially on critical components. Historically, DSOs have designed strategies consisting in addressing all aspects of network maintenance and renewal individually such as finance, quality of service, safety or human resources. However, all these strategic pillars interfere with one another in a very complex way that cannot be easily modeled and handled by asset managers. With the combination of Nexans technical knowledge of electrical assets and Cosmotech complex system modeling platform *ASSET*, we designed a solution capable of generating a digital model of the complete distribution network and consider all the constraints imposed by the regulatory environment, business rules, available financial and human resources, and any technical policy in place. We will elaborate in this paper how this model is built and then used by asset managers to make trade-offs across CAPEX and OPEX while mitigating risks and reducing intervention conflicts. Aligned with ISO 55000 international standard and compliant with the CNAIM[1] framework of principles and methods established by OFGEM[2], this platform provides asset managers with an unprecedented capacity to anticipate and assess the mid to long-term impacts of multiple scenarios on financial performance, network performance, regulatory alignment, and HSE indicators.

SYSTEM MODELING – ASSETS DIGITAL TWIN METHODOLOGY

Relevant modelling for critical components of a DSO network require to understand how external factors such as location, temperature, humidity, stable or transient current load affect the overall ageing speed and ultimately the probability of failure. To cover the vast majority of choices available today, we decided to implement the British DSO CNAIM framework and our own methodology called "apparent age". Although the CNAIM methodology gives the ability to measure probability of failure and measure its consequences, the pre-established values and statistics for each asset category and the calculation methodology is recognized by OFGEM as relevant only up to a 5 to 10 years horizon. SAMS apparent age methodology allows asset managers to compensate this limitation by using asset ageing profiles for each category and network operation simulation to reproduce weekly real activities, failures and associated repairs or replacement.

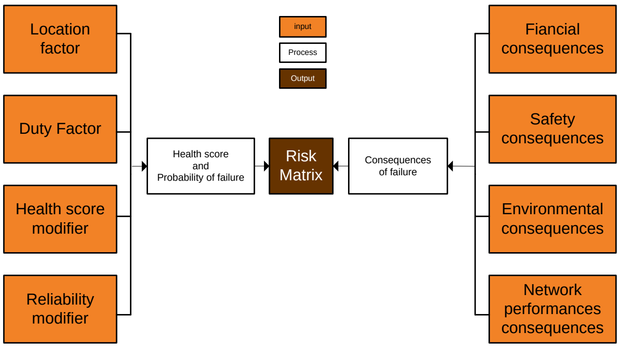
CNAIM framework [1]

CNAIM offers a comprehensive and ready to use framework to establish probability of failure (PoF) for all network assets. Starting with age and expected lifetime, a health score is generated then combined with external factors such as location, load and reliability information. CNAIM also gives the ability to assess consequences of

1 Office of Gas and Electricity Markets

2 Common Network Asset Indices Methodology

failure by monetizing financial, safety, environmental and network performances consequences. Ultimately, a risk matrix is built by plotting all assets condition and the consequences associated to failures. This process is illustrated in figure 1.



$$PoF = K * \left[1 + (C * H) + \frac{(C * H)^2}{2!} + \frac{(C * H)^3}{3!}\right]$$

Where :
H is a variable equal to Health Score
K and C are constants

Figure 1 : CNAIM risk matrix calculation based on probability and consequences of failure

SAMS/ASSET "apparent age" modelling

The ageing of a physical asset is a continuous and progressive phenomenon which is dependent on several actions. Those actions can either increase or decrease the degradation of the asset. We can group those actions in two major classes :

- Workforce actions (renewal, maintenance operations, etc…), made manually or automatically by a human or machines on the asset
- Environmental actions (corrosion, mechanical fatigue, etc…), made directly or indirectly by environment on the asset

All those considerations lead us to represent asset ageing using one or several variables which evolve dynamically with actions over the course of the network simulation. The global ageing model [2] is described below, with two inter-dependent variables evolving.

$$A(t + \delta t) = A(t)\big(1 - \alpha_A(t)\big) + \beta_A \delta t - \gamma(B(t))\delta t$$

$$B(t + \delta t) = B(t)\big(1 - \alpha_B(t)\big) + \beta_B \delta t$$

Where :

- A, B are state variables
- $0 \leq \alpha_A$, $\alpha_B \leq 1$, impact of workforce actions each state variable
- $0 \leq \beta_A$, $\beta_B \leq 2$, impact of environmental actions and/or operating conditions on each state variable
- $-1 \leq \gamma(B(t)) \leq 1$, function representing the coupling between state variables A and B.

To illustrate our methodology, we took the example of a DSO asset manager requested to reduce overall expenses by 8% (over the course of 40years of operation) to allocate toward new projects. Low voltage transformers have been identified as one of the main contributors to the maintenance plan, so condition-based maintenance is analysed with four different scenarios. Scenarios under analysis will be the following :

- Strategy #1 "Business as usual", to implement the DSO asset management strategy as it is currently
- Strategy #2 "Budget under cut", to evenly lower every pool of activities to reach the 8% savings globally
- Strategy #3 "Strategy 5-year inspection", to adapt the LV transformers inspection frequency from 1 to 5 years
- Strategy #4 "Strategy 10-year inspection", to adapt the LV transformers inspection frequency from 1 to 10 years

The first step is to replicate the DSO network with the asset relationship witnessed on the general electrotechnical architecture. This requires understanding the hierarchy from MV substations down to the delivery cable and circuit breakers. SAMS/*ASSET* modelled the impact of outages on one particular asset by defining "cutset" and "outage bags" which will trigger outage on directly related components whenever a central or critical asset is failing. Figure 2 illustrates several cases analysed with this model.

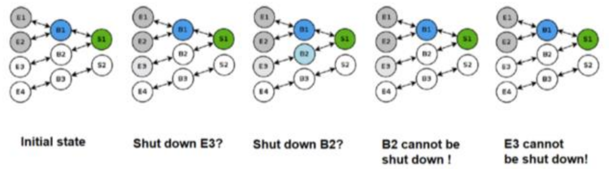


Figure 2 : topology digital clone modelling

The second step is to reproduce the actual ageing with altitude, corrosion, humidity and load variation into a model applied to all low voltage transformers of the dedicated territory under analysis. Figures 3 and 4 describe the probability of failure modelled, and asset health calculated to feed the simulation in the third step.

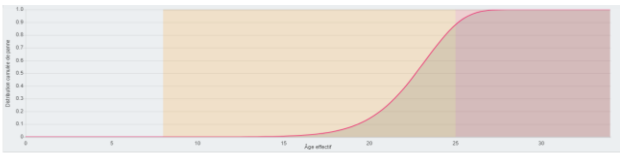


Figure 3 : Probability of failure for LV transformers of the example analysis

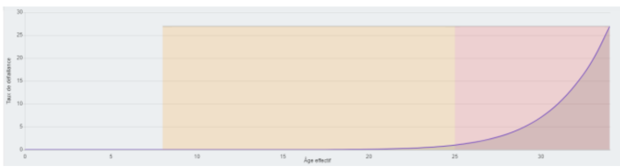


Figure 4 : Asset health calculated for low voltage transformers of the example analysis

SCENARIO SIMULATION – DECISION IMPACT ASSESSMENT

Four themes are analysed during our simulation, allowing us to measure the impact of one optimised parameter on the other themes thanks to dedicated KPIs for each category. Two questions are asked and answered as DSO asset managers when assessing the categories. First, “Why is this theme a constraint to take into account into the simulation?”. Second question is “what KPI will be displayed for analysis?”.

Quality of service – network performance

Network performance is critical at every point of energy distribution to ensure outage time remain as low as possible. However, planning maintenance for the same assets is mandatory to maintain PoF and asset health within desired range. A general measurement often used to measure the network performance is the SAIDI[3] KPI for a dedicated zone of the network.

In our example, the DSO asset manager decided to focus on asset health to measure the overall network performance for each scenario. Figure 5 and 6 illustrate that strategy #4 has a significant impact on average asset health which can be directly related with high probability of failure.

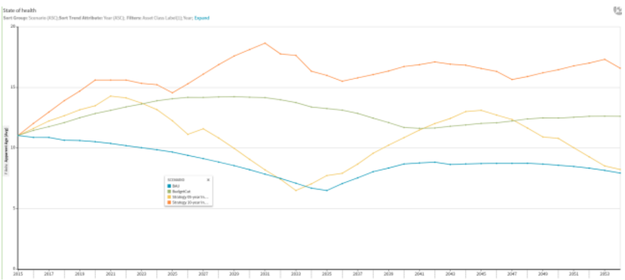


Figure 5 : Average asset health for LV transformers for each scenario

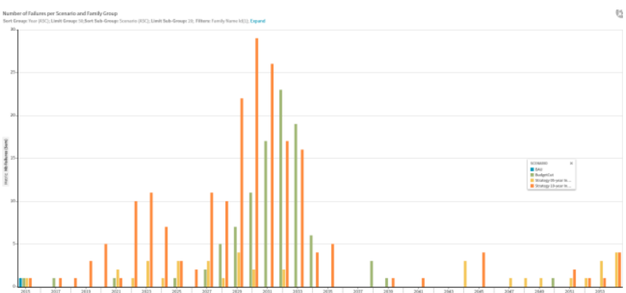


Figure 6 : Average number of failures for LV transformers for each scenario

Financial performance

Financial performance usually means analysing how much CAPEX or OPEX is spent to execute an asset management strategy. However, efficiency of the distribution network has become a target for DSO. Indeed, energy conveyed but not sold is lost revenue for the operator and will indicate poor network quality if this reaches high rates. DSOs have named this KPI “Non distributed energy” (NDE).

In our example, Our DSO asset manager decided to compare financial performance by adding CAPEX, OPEX and a monetization of NDE (triggered by outages, planned maintenance or renewal) for each scenario. Figure 7 illustrates that strategies #2 and #4 generate higher NDE losses over the course of the complete simulation.

Figure 7 : Financial performance comparison and NDE monetization for each scenario (all assets included)

Safety performance

Safety performance can be related to several topics such as operations accidents if number of repairs rise, or non-distributed energy causing major trouble to population or industries. Therefore, it is important for DSO to measure the impact of increased failure rate on the network. The number of failures per year is one major KPI allowing DSO to ensure that asset maintenance and renewal strategies in place remain within safety limits judged acceptable either by regulators and the internal maintenance teams.

In our example the DSO asset manager wants to ensure that every scenario will maintain the failure rate as low as possible on LV transformers. Figure 8 illustrates that strategy #1 and #4 do not comply with that objective.

3 System Average Interruption Duration Index

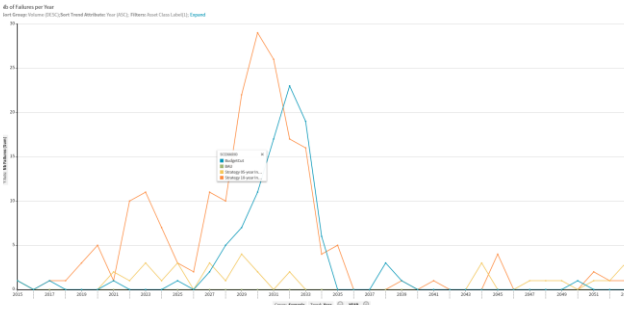


Figure 8 : Safety performance comparison with focus on number of failures per year for each scenario

Key HR availability

As proficient human resources for critical maintenance are getting older, key competences for repairs and renewal are increasingly harder to secure when establishing long term strategies. Maintenance technicians and engineers availability is a tremendous KPI followed by DSO to avoid multiple postponing of operations which implies longer failures and outages on the network.

In the example, the asset manager is focusing on necessary resources to execute each strategy every year and figure 9 illustrate that a rise in number of delayed interventions will happen on repair and replacement of LV transformers with all strategies. This indicates that the HR renewal plan has to be reinforced.

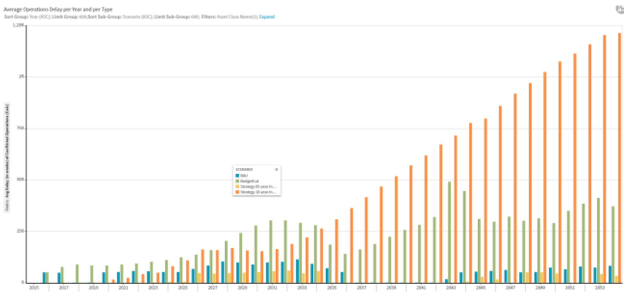


Figure 9 : Key HR availability for maintenance and renewal of LV transformers for each scenario

OPTIMIZATION – DECISION MAKING PROCESS

Assessing all interactions between individual parameters described before is giving a complete understanding of the global performance of asset management strategy. However, optimizing one parameter without jeopardizing all the others requires fine optimization to identify the right balance. Manual optimization is one possibility but the complexity of asset management strategies often necessitates digital tools to give relevant orientations.

Manual optimization of dedicated parameters

Manual optimization implies defining budget limitations on CAPEX or OPEX, setting maximum outages for subnetworks or any combination of these limitations to meet corporate objectives.

In our example, all strategies have met the goal of lowering expenses by 8% with different methodologies (see fig 7). Strategy #3 has been identified as the most relevant scenario when comparing financial, safety, HR and network performance. It is important to note that the nature of the simulation implies an error rate to take into account, but the high-fidelity simulation-based analysis has given the opportunity to decide with higher accuracy for maintenance or renewal plans.

During the strategy definition process, asset managers may require exploring multiple directions to assess the value generated on the network. Given the large number of iterations needed for this exploration, semi-automatic calibration is a unique feature.

Semi-automatic calibration

By focusing on one high priority parameter, asset managers are usually able to gather domain experts and define a specific target to reach on one particular KPI. However, they also set the maximum order of magnitude other KPIs can reach. These requirements feed the SAMS/ASSET parameter exploration feature, able to iterate multiple scenarios each with automatically proposed values for the peripheral parameter (within a predefined range) and targeting the desired value for the main KPI.

By exploring trends with the parameter exploration feature, DSOs will go faster into establishing a strategy with the best balance between corporate objectives and operational, financial, safety or HR constraints.

CONCLUSION – FUTURE DEVELOPMENTS

Strategic asset management methodologies can now benefit from powerful digital tools to go faster and deeper into maintenance and renewal plans definition. CNAIM methodology is a relevant starting base for 5 to 10 years analysis horizon but dynamic ageing modelling and high-fidelity topology simulation provided by SAMS/ASSET bring complementary understanding to design efficient plans for the future.

One key ongoing development is the ability to model asset grouping to enable planning operations such as maintenance or renewal on a macro asset (a complete substation for example) with the same flexibility as an individual asset and with the same level of impact assessment for optimal planning. Such feature is expected in 2019 in SAMS/ASSET.

REFERENCES

[1] OFGEM, 2017, *DNO Common Network Asset Indices Methodology – Health and Criticality – Version 1.1*, United Kingdom.

[2] T. Lacroix, P. Stevenin, 2018, "A Digital Model of Physical Assets for Long Term Network Resiliency", WCEAM conference, Norway