FINAL REPORT

SSEN NAIM Intervention Evaluation

ea technology

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EA Technology Limited, Capenhurst Technology Park, Capenhurst, Chester, CH1 6ES;
Tel: 0151 339 4181 Fax: 0151 347 2404

http://www.eatechnology.com

Registered in England number 2566313

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1. Background and Introduction

EA Technology have implemented Condition Based Risk Management (CBRM) approaches with more than 60 organisations globally. These approaches define and implement methodologies to help organisations with the following:

- Understand the condition of their assets using a health score scale of 0.5-10, where 0.5 is an asset in new/excellent condition and 10 for an asset in very poor condition.
- Determine probability of failure (PoF) by linking the asset health to likelihood of failure, and then determining what this means for an asset population.
- Calculating the consequence of failure (CoF) by determining the monetary cost of asset failure considering four categories, asset service (network performance), safety, financial (OPEX/CAPEX) and environment. This process accounts for the fact that some assets will have a higher cost than others of the same type and are therefore more critical.
- Determining the risk of failure for each asset by combining the PoF and CoF so that each asset has its own measure of risk which is an indication of its condition and criticality.
- Predicting asset health into the future and therefore being able to calculate the probability of failure, failure rate and risk into the future.
- Devise investment plans that implement a defined logical process to determine assets which should be replaced or refurbished and the impact of these plans in terms of asset and fleet health, failure rate and risk. Such plans can be compared against plans using a different process and a ‘no intervention’ base case to determine the effectiveness of any given plan.

Like all distribution network operators in Great Britain, SSEN uses the Common Network Asset Indices Methodology (CNAIM) which was derived from CBRM. This methodology precisely defines the calculation of asset health, PoF and CoF for 25 asset categories (Health Index Asset Categories) and 61 asset subcategories (Asset Register Categories).

CNAIM v2.1 has recently been approved by Ofgem for use in RIIO-ED2 (2023-2028). To produce their business plan for this forthcoming price control, SSEN have developed a Network Asset Intervention Methodology (NAIM) that describes the approach taken to produce their investment plans.

SSEN have invited EA Technology to review their RIIO-ED2 NAIM and provide some comment on the validity of the approach. To do this, EA Technology have considered the available documentation to determine if the approach seems reasonable, practicable and represents an optimal investment strategy – maximising the lifespan of an asset without incurring significant risk.

This report comprises of commentary of our findings and evaluation of the SSEN NAIM approach.

2. Scope of Review Materials

During the review process, EA Technology have used the following SSEN documents:

- TG-NET-ENG-026 - Network Asset Intervention Methodology (NAIM)_Rev 0.01 Draft.docx
- A_06_Safe-Resilient_MICROSITE.pdf
- 308_SSEPD_NLR_HV_TRANSF_FINAL-MOVED.docx

We have also referred to the CNAIM Methodology:

- dno_common_network_asset_indices_methodology_v2.1_final_01-04-2021.pdf

And to the implementation documentation for the CNAIM solution, produced by EA Technology:

- SSEN NAIM Methodology Investment Model Guide v1.0.docx

As a long-term project partner, EA Technology supply SSEN with the software system used for CNAIM and have amassed experience and knowledge of processes, system usage and intervention modelling design. In this document we will be clear about any sources and assumptions.

During this review we have not reviewed OFGEM publications, guidelines or other documents pertaining to the development of the DNO investment plans.

3. Review Observations

SSEN are required to maintain a highly reliable network whilst minimising cost. This means maximising the lifespan of the asset whilst proactively undertaking replacements and refurbishments and avoiding disruptive failures. As the condition of assets deteriorate over time and the probability of failure increases, SSEN must carefully judge when it is the most appropriate time to undertake investment. This is the point at which the risk of failure becomes unacceptable.

Through the NAIM methodology, SSEN have determined the level of risk that they feel is appropriate for their business and they have used criticality to set the criteria of acceptability. For most asset types, SSEN are willing to accept a higher probability of failure for assets which are less critical.

The following sections provide some commentary on the detail of the methodology that SSEN may consider as they improve and evolve their NAIM and business as usual asset management.

3.1 Data Assurance

CNAIM produces outputs for each asset under the Network Asset Risk Methodology (NARM) mechanism. Each asset must therefore have its own data that feeds into the methodology. The basis of the NAIM is on CNAIM outputs. This relationship ensures traceability from asset data through to investment decision. It is of critical importance then, that data management processes ensure:

- Accuracy
- Timeliness
- Completeness

3.1.1 Accuracy

As SSEN move to reporting further asset categories for ED2, there will be a requirement to ensure that all data is placed in core systems, such as Maximo, and that there is a single source of truth. Process should be established and validated to provide data to further systems without human interaction. This will remove the possible introduction of errors inadvertently introduced through incorrect handling and ensure that data held at source will match relevant data stored elsewhere.

We understand that, through the publication of the forthcoming Good Practice Guide, a visual reference and data guidance will be used for guidance on each data input into CNAIM. Where SSEN choose to collect different data points for mapping into CNAIM, care needs to be taken to retain consistency and accuracy to ensure compliance with the guide.

3.1.2 Timeliness

Each network operator is free to choose their own inspection, test, and maintenance intervals. Like other network operators, some assets, such as EHV/132kV plant are visited frequently while other assets, such as overhead line assets, have long cycles.

Within the NAIM commentary (see sections 5.8.1/5.8.2 in TG-NET-ENG-026), fitting inspections are performed over 8 years so the outputs of the CNAIM model may not accurately reflect the current condition. Once an asset sees signs of moderate degradation the probability of failure increases quite rapidly, so with fewer opportunities to re-evaluate the condition of the assets, fitting intervention criteria are much lower, across all criticality bands, than they are for other assets.

It is possible to understand the impact of long inspection cycles, and this is something the EA Technology have built into some CBRM models, though it is not part of CNAIM. SSEN could consider applying the process as an 'offline' exercise.

Health Score Correction Process:

- Determine the age of the inspection (current date - date of inspection)
- Subtract the Inspection Age from the Asset Age to give a Modified Asset Age
- Calculate Initial Health Score using the standard calculation and the Modified Asset Age
- Calculate the Health Score as normal to give a 'Health Score at Date of Inspection'
- Using the ageing process, 'age' the Health Score to the current date based on the inspection age.

Such a refinement could be considered as part of any future CNAIM version and is particularly useful for OHL assets where there is a reliance on data from a particular inspection with a long interval between inspections. SSEN could use the process to determine how much difference it would make to their fitting's investment plan based on the current 8-year cycle, this may help with prioritisation and enable the setting of the Health Score Intervention Criteria to align more closely with the other asset categories.

3.1.3 Completeness

The availability and completeness of data being processed by the CNAIM methodology is highly important. Without sufficient specific data, assets will be limited to a health score of 5.5 and will not appear on the radar for investment, regardless of criticality. SSEN should ensure that their process includes the checking of assets and work to backfill missing data to establish accurate condition.

This process will be especially important for 33kV Tower Line conductors where data from Cyber Hawk has not been incorporated into the models used for ED2 planning. SSEN could improve on the current process which uses the expected lifespan of conductors to determine replacement levels. This could be extended to consider the assets limited to a Health Score of 5.5 due to lack of condition data, and reflect the duty and location.

For link boxes (asset category LV UGB) there are significantly different end of life ratios per inspection between the SEPD and SHEPD licence areas. The reasons for this are not clear in the NAIM methodology, however it may be useful to see how these ratios align to other attributes, such as age or location, to increase confidence in the assets predicted to be at end of life during ED2. (It is understood that this may be due to the lack of historical data and where SSEN is within the collection of this data across the inspection cycle which is not scheduled to be completed until 2024).

3.1.4 Information Gathering Plans

The ED1 regulatory requirement to produce an Information Gathering Plan (IGP) to document how DNOs gather and record information, is a useful exercise helping them to consider their business processes and progress to better quality and complete data sets. Regardless of the regulatory obligation, it is in the DNOs best interest to consider these processes and produce models with the most accurate results to avoid over or under investing in the network that may compromise affordability, reliability, or safety.

The requirements for ED2 are still to be determined and we understand this is a topic discussed within the Network Output Measures Electricity Distribution Working Group (NEDWG). Any such discussion will be limited to what can be achieved for collective benefit. SSEN may wish to adopt a similar process for their more granular data that is collected, rather than the processed inputs provided to the CNAIM models. SSEN have engaged EA Technology in providing proposals of how this could be achieved and considered by NEDWG for inclusion within the CNAIM models for Ofgem regulatory reporting as well as the more DNO specific granular detail. The former could provide additional benefit to the regulator in data completeness, and quality but not timeliness.

3.2 Health Score Intervention Criteria - Replacement

The significant part of the NAIM Methodology involves the identification of Health Scores at which assets become eligible for intervention, which is most often replacement, where generally the more critical the asset, the lower the Health Score.

Within the methodology there is consistent scaling and terminology across all asset classes, however SSEN have chosen different Health Score values for the different asset types. By using sensitivity analysis, SSEN have examined a range of scenarios for each asset type and pursued the ones that have given the right balance between affordability and reliability.

EA Technology agree that setting intervention criteria by criticality provides a useful mechanism for balancing reliability and risk. We agree that a proactive approach to asset investment to avoid unplanned failures aligns with stakeholder requirements. We accept that asset classes have nuances in the data and that some engineering judgements have been made to determine the intervention criteria for each asset class. These engineering judgements have involved SSEN's own experience, and knowledge whilst benefiting from work previously undertaken across the industry shared in the original production of the CNAIM.

3.2.1 Methodology Consistency

The CNAIM methodology uses consistent methodology, terminology and scaling across the asset classes. It may be a desirable goal to align the intervention criteria for all asset classes. Whilst the NAIM currently documents some of the differences, there is the potential to resolve some of these challenges in the long term (such as with additional data or process) but in the short term, SSEN have engaged EA Technology's services to standardise this methodology into their CBRM investment modelling to ensure consistency and replication of their NAIM configuration. This makes it possible to review and repeat the outputs from the models utilising the Health Score Intervention Criteria and provides documentation of decision making, aids traceability and allows for different scenarios. Parameters that are used include:

- Asset complexity – the lack of moving parts for HV Transformers has been a factor in the setting of higher threshold values than for other plant assets
- Obsolescence – this is not considered a criticality factor within CNAIM, however it is considered a driver for asset replacement. This may include long lead times for spares or replacements.
- Limitations of CNAIM methodology – Steel towers and Submarine cables are examples where there the CNAIM methodology outputs require further analysis and investigation and simply setting the criticality points is not sufficient to determine the whole life plan for the asset.
- Limitations due to data quality – where a risk averse approach may be taken for assets such as the EHV conductors, there are challenges with the completeness of data. There may be other instances where other quality attributes may affect the results.
- Additional benefits – there may be other desirable benefits for asset replacements that are not considered as part of the CNAIM methodology but would be considered as part of a full cost benefit analysis. Examples of these may be reduced maintenance and inspections requirements for the new

asset or non-like-for-like replacements that include flexibility benefits or help with the reduction of consumption. Such options are currently documented in Engineering Justification Papers.

As mentioned previously, it would be an interesting exercise to see if applying a slightly refined process for OHL assets, in particular fittings, could be used to avoid differences due to long inspection cycles.

There is significant emphasis on Safety within the SSEN documentation and the proximity of LV poles to people is cited as the reason for all intervention criteria being set to 8 across all criticality consequences. The CNAIM methodology includes a safety location factor for poles so this could be reflected in the criticality. For LV Poles this may be difficult because the criticality compares each asset against an 'average' asset of the same type and an 'average' LV pole is already most often close to people. Since DNOs specify the location as 'Low', 'Medium' or 'High' within the methodology, this is not very helpful. Safety risk is also very low and generally contributes only a small value towards the consequence of failure for an asset. Therefore, there is an imbalance between safety drivers for replacement within SSEN and the CNAIM methodology.

Regardless of this, it may be possible to refine the approach taken for poles by considering Location Safety Rating, or the ESQCR data that drives this rating. Using this input data, assets that are in areas away from people could have an increased health score replacement point in line with their criticality index.

3.2.2 Using Engineering Judgement

EA Technology accepts that some engineering judgement is required when setting the Health Score Intervention Criteria. CBRM and CNAIM are both based on engineering judgement to set expected lives and factors to give the expected results. The longevity of these methodologies has been due to the accuracy with which they give predictable results. They contain the collective judgement of many organisations who understand how the methodology works.

Engineering judgement can be backed up by reviewing failed assets and assets removed from service. By assessing the condition of such assets and comparing them with their health scores, it may be possible to determine if the right balance between risk and affordability is being met.

If SSEN have not done so already, it would be useful to consider what data values an asset would be required to have to meet the replacement criteria and ensure this passes the 'engineering judgement test'. For example, for a pole to meet the intervention criteria of 8, it would either need several defects and to be old or it could be any age but look like it has substantial deterioration (see Observed condition: Visual Pole Condition Collar within the CNAIM methodology). Using these combinations, it would be possible for engineers to determine if the risk of leaving the asset in such a condition was acceptable or not.

This same process is performed for CBRM models as part of the calibration process where example assets are considered, and their results reviewed. This enables the calibration to be adjusted until consensus is agreed. Scenarios for CBRM models include considering young assets in poor health, old assets in reasonable health, mid age assets in poor health etc.

3.2.3 Methodology Considerations

The use of the pole condition example in the previous section, where an asset meets the intervention criteria based only on the Visual Pole Condition being classified as 'Substantial Deterioration', occurs due to CNAIMs use of 'Collar' values. The use of the collar value of 8 indicates a significantly increased probability of failure. In all such cases, SSEN would need to determine if this was indeed an 'end-of-life' condition and included in forthcoming replacement plans.

For fittings and pole assets, the current intervention criteria is less than or equal to collar values set within CNAIM. SSEN will need to be very confident of the data quality and ensure assessment of the asset condition aligns with criteria that drives these results. Other assets are less likely to be impacted by collar values since the intervention criteria are generally higher so there would need to be a combination of recorded tests or observations that lead to investment.

Multi-component assets, such as steel towers and transformers are also a special case. CNAIM defines the methodology for each component which results in a component health score. These component health scores are combined, by taking the highest value to produce a health score for the 'asset'. Components for the same asset will often have different health scores, especially for towers, and the health scores advance at different rates to create future health scores. The NAIM methodology for towers includes refurbishments and acknowledgment of the challenges of using CNAIM for replacement.

There may be limitations on how the CNAIM models enable the identification of cables for proactive replacement. This is because, particularly for solid cables, there are limited model inputs and those that exist are most often determined at circuit level rather than at section level making it difficult to isolate individual sections for replacement. Replacement plans would more likely consider multiple sections, rather than replace individual ones.

For submarine cables, there is an observed condition, 'external condition armour' with a collar of 8 for a cable classified as 'critical'. There are three measured conditions, notably Fault History with a cap of 5.4. The cap feature limits the health score for the asset. SSEN have found that some assets look in extremely poor condition, visually but they have no faults. Therefore, the cap and collar are working against each other within the methodology and the collar is taking priority. Additionally, there have been concerns for some very long cables with high PoF values attributed, because the data points relate to the whole length and not just the part with some condition concerns. These issues suggest that the CNAIM submarine cables may need to be revised before it can be used as a single basis for investment decision making.

3.3 Risk Mitigation

The outputs from the CNAIM models can be used to help set the inspection, maintenance, and test cycles. For example, where fittings are inspected every 8 years, once signs of some deterioration are detected, the interval may be reduced to ensure more timely results were collated. Where there is no deterioration detected on an inspection, the interval could be increased. This would improve the data quality for assets with the greatest requirement. It is not just health that could be used for this purpose, the transformer Oil Test process detects change between results which could be used as a driver for more or less frequent testing, even if the results themselves show no significant sign of concern currently. Safety inspections could use the high/medium/low criteria, perhaps combined with asset health. It is our understanding the SSEN do currently adjust some intervals, but it is not known how this is achieved. The use of the CNAIM outputs for this purpose makes sense because there is a clear line of sight between data and investment decision making.

There are a significant number of non-NARMs assets that are not represented in CNAIM. It would be useful for these to be represented by some form of asset model in software that was tested and known to be reliable as a useful mechanism for quantifying and managing risk, especially where there are known legal and compliance issues, such as the issues associated with Rising Lateral Mains. These may be simplified population-based models that do not necessarily identify individual assets but calculate based on units and known parameters, such as age. Such models may be useful in advance of full exploration by NEDWG since it will take some time for the design of any such model to be agreed. If SSEN already have working models that produce the correct outputs, they will be in a strong position to move this design forward with the other DNOs and therefore avoid a situation where the design may be compromised to achieve commonality.

3.4 Refurbish vs Replacement

Within the write up for the NAIM methodology, other than for Steel Towers, there is little mention of refurbishments, however these may be useful for some assets, particularly where there are younger assets with fixable issues that are perhaps being assigned higher health scores due to the CNAIM collar process.

SSEN should make use of the processes built into their software investment models to identify refurbishment candidates. This would then allow them to introduce an additional Health Score Intervention Criteria for refurbishment specifically in line with the guidance in CNAIM as a set for refurbishment intervention.

3.5 Deliverability of the Program

SSEN will need to plan for the deliverability of the program. The application of the new methodology will result in an uneven investment program requiring more assets to be replaced in some years than others. In some cases, there may be a large backlog that will need to be addressed or a future spike in the number of investments that will need to be smoothed out into a program of works that is deliverable.

With any smoothing or phasing process, it will be necessary to shift assets from their desired year of investment to another year (forwards or backwards), this means that there needs to be a tolerance in the intervention criteria and a prioritisation of assets. Assets can be shifted based on a ranking devised using a combination of ageing rate, health score or PoF and CoF. The volumes to be delivered can be based on capped values (maximum number per year) or percentage values (deliver no more than x% in a year) or smoothed over period averages.

EA Technology has recently delivered updates to the Intervention Software Models that includes the phasing of replacements. Resulting models provide SSEN with the mechanism to configure optimum intervention phasing based on one of three scenarios:

- % replacement – providing a smooth investment profile;
- Rolling average profile – considering the historic, current and future requirements and
- Future average profile – considering the current and future requirements.

SSEN can consider the shape of the asset health profile and determine the best scenario for each asset class and adjust the settings within it to produce the best match to the intervention criteria. By adjusting the settings, the tolerance for changes in investment volumes year by year can be reflected in the phasing profile.

In Figure 1, the year-on-year replacements created by the NAIM methodology can be seen in dark blue. The other colours represent different phasing approaches that smooth out the profiles.

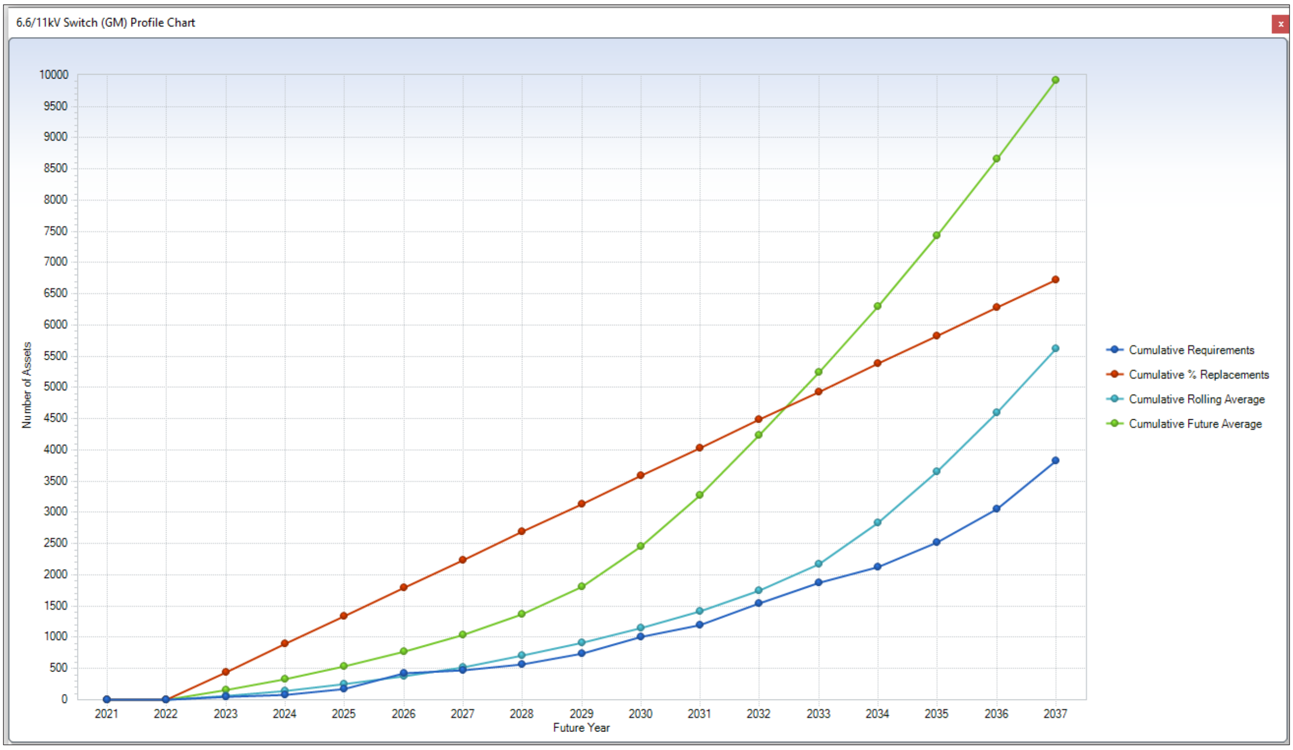

Figure 1: Phasing Model Example

The phasing mechanism is modelled for 16 years into the future and has the capability to delay the profile for the next two years to ensure it starts at the beginning of the ED2 period.

3.6 Cables

Cable assets are not included within the main NAIM TG-NET-ENG-026 document and so assumed to not be subject to the same process of investment based on the health score/criticality criteria. ED2 volumes have been derived for LV and HV cable based on the assessment of fault rates and tested through various scenarios documented in the EJPs.

It is not understood presently how volumes for EHV/132/submarine cables are determined or how proactive investments may be considered. There is reference to Annex 11 regarding submarine cables however this document has not been reviewed. SSEN have also indicated further development of enhanced subsea cable modelling is something they wish to progress to assist with future intervention considerations as they are a leading authority in this asset type management.

3.7 Other Notes

- 5.5.4 in the TG-NET-ENG-026/CNAIM example is possible to model within the software using the variants and units
- A_06_Safe-resilience – Safety is highlighted and mention of the injurious claims. Other than poles intervention criteria being 8 for all CI bands, and a passing reference to safety blankets, there is not much in the methodology to tackle safety explicitly in the commentary of TG-NET-ENG-026.

- A_06_Safe-resilience – mentions that core investment in RIIO ED2 (5-year period) is lower than in RIIO ED1 (8-year period) with capital investment reducing from £755m to £732m, however there is a significant increase from £94.37m per annum in ED1 to £146.4m per annum in ED2.

4. Conclusions

The CNAIM methodology, and the CBRM methodology that preceded it, has a long history of evolution built upon years of work by many network operators, both in the UK and overseas. The CNAIM methodology is trusted and accurate and been used by the network operators in Great Britain since 2016, so SSEN have built up significant experience using it for regulatory reporting and in the wider role of asset management. For ED2 they have created a new intervention methodology based on this experience.

The CNAIM methodology is designed to support medium to long term strategic decision making. With the use of quality data, the outputs and predictions are reliable and consistent. The methodology tracks assets as they move through their life, however with lifespans of 50+ years for most assets, this movement is quite slow, especially in the early years. By producing health scores of 8 or more, whilst there is a prediction that the asset is more likely to fail that lower health score assets, it does not mean that the asset is necessarily at end of life, but that the asset owner should be determining what to investment needs to be made to avoid failure.

There are many investment methodologies that could be applied to the outputs of the CNAIM model, however SSEN have been given the steer from their stakeholder engagement that the first priority is affordability and then reliability. This guides SSEN to the position of investing in assets at the point in which they feel maximised the asset lifespan but without significant risk of failure. The 'asset point of failure' cannot be precisely defined and so engineering judgement has been used to set a point of acceptability for the health score within each criticality band. The intervention criteria have been guided by the available data, obsolescence, safety, and technical aspects of specific assets.

SSEN acknowledge where the CNAIM methodology does not lend itself to setting the intervention criteria in this manner, such as in the case for Steel Towers, and have used experience to guide the principles that will be used during ED2. Submarine, and possibly other cable models will also use an alternative mechanism to create investment plans that are practicable.

EA Technology broadly agree that the SSEN NAIM is a sensible and practical way of determining and prioritising asset investments for the RIIO-ED2 period. The 'optimum time for replacement' method maximises lifespan whilst creating a buffer between automatic HI5 replacement and end of life which increases with criticality. This aligns to stakeholder requirements without compromising reliability of the network or safety. The NAIM approach is supplemented by EJPs that provide additional asset class specific guidance and NPV based costing. These are comprehensive and account for any nuances and special cases. EA Technology are therefore happy that SSEN acknowledge some challenges with their data or shortcomings of CNAIM to support a singular replacement approach for all asset classes and that different approaches have been considered and evaluated.

technology

Safer, Stronger, Smarter Networks

EA Technology Limited
Capenhurst Technology Park
Capenhurst, Chester CH1 6ES

t +44 (0) 151 339 4181
e sales@eatechnology.com
www.eatechnology.com