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Integrated Substation Life Management and Asset Information Strategy

J.J. SMIT *) (convener), N. BARRERA(CH), A. WILSON(UK), R. MEHAIRJAN (NL), P. LEEMANS (BE), N. FANTANA (DE), P. MYRDA (US), I. PORTUGUES (UK), J. BEDNAŘÍK (IE), N. KAISER (DE), B. BAKKA (NO), G. BALZER (DE), T. KOBAYASHI (JP), A. MACKRELL (UK), S. LÄDERACH (CH)

On behalf of CIGRE WG B3.06-B3.34

Delft University of Technology *)
The Netherlands

ABSTRACT

For some 15 years a group within the B3 CIGRE substations committee has been tracking changes in management of maintenance activities. The first activity of the group (then a joint SC 23/39 group was a major international survey. It was completed in 2000 and identified several key trends in the management of maintenance tasks (1). Respondents identified key drivers. These were to seek “efficiencies” to manage asset care, introducing tighter controls of budgets, and most importantly processes for managing business risk exposure. For its subsequent work B3-06 decided to look at some of these changes in greater detail. Three topics were pursued in task forces- TF01 outsourcing of maintenance, TF04 decision processes for asset replacement and thirdlyTF-05 information strategy for asset management. Each involved further surveys, and for the outsourcing group further brochures and papers at Paris sessions followed (2,3,4,5). After a break for some years further surveys were undertaken using Doble clients both in USA/ Canada and in Europe (6). This section in this paper is intended as a review of this activity.

Results from the WG investigations will be presented in three sub-areas of substation management in the subsequent sections, together with new work of WG 34 investigating changes brought about by future developments of the grid.

KEYWORDS

Substation Equipment Asset Management, Maintenance Organisation, Replacement Strategy, Information Strategy, Maintenance Outsourcing

INTRODUCTION

The next sections describe how the work of WG B3.06 task forces TF04, TF05 and TF01 interrelate and are based on practical experience in the current substation management. Finally an outlook on how substation asset management develops from existing to future grid concepts (WG B3.34).

WG B3.06, TF-04: INTEGRATED DECISION PROCESS FOR SUBSTATION EQUIPMENT REPLACEMENT

In Technical Brochure TB-486 (5) we described the current practice of an integral decision process for asset replacement purposes, as applied to substations. Instead of focusing solely on asset condition, a top-down approach is adopted by incorporating general business drivers. The brochure provides examples of relevant experience and lessons learned from the field and can serve as an implementation guideline for the asset manager when defining the process dealing with equipment replacements. The integral nature of the decision process described in this technical brochure results from the consideration of both the maintenance needs of existing assets (due to aging), as well as of the requirements by the capacity plan (due to grid enlargement of structural changes). This integral approach to substation asset replacement is necessary so as to ensure that high-level, general business drivers are systematically applied to all levels of individual replacement projects.

For substation asset replacement decisions it is necessary to adopt a general point of view, as non-high-voltage infrastructures (e.g. secondary systems, support structures, buildings etc.) are also included in substations. It is therefore necessary to not only evaluate the status of the equipment, but also to assess the overall condition of substation infrastructure.

This decision path should be incorporated into an overall asset management concept such as described in other available Publications, e.g. the Publicly Available Specification PAS 55.

Proposed Decision Process Flowchart

The proposed decision process for asset replacement is organized into ten steps, as shown in figure 1.

Step 1 – Business drivers: Business drivers address the values that a power utility wants to put in the foreground. Unless business drivers serve as starting point for further decisions, it will not be possible to integrate asset replacement within the overall business of a utility. Therefore, business drivers have to be clearly identified first. Examples for common business drivers of power utilities include personal safety, legal compliance, security of supply, power quality, financial and socio-economic issues, reputation, environmental care and sustainability.

Step 2 – Policies: Once the aforementioned general business drivers have been identified, appropriate asset replacement policies will have to be established. Such policies involve existing know-how of a utility and define a general perspective for asset replacement decisions, which usually comprises of standard decision making procedures. Well-defined policies provide general guidelines which ensure consistent decision making.

Step 3 – Decision criteria: For the assessment of decision alternatives on asset replacement, decision criteria are necessary. Such criteria evaluate and quantify the performance of the alternatives with respect to the general business drivers. In the technical brochure, risk indicators are proposed as decision criteria: for example personal safety is measured by the risk of personal injury.

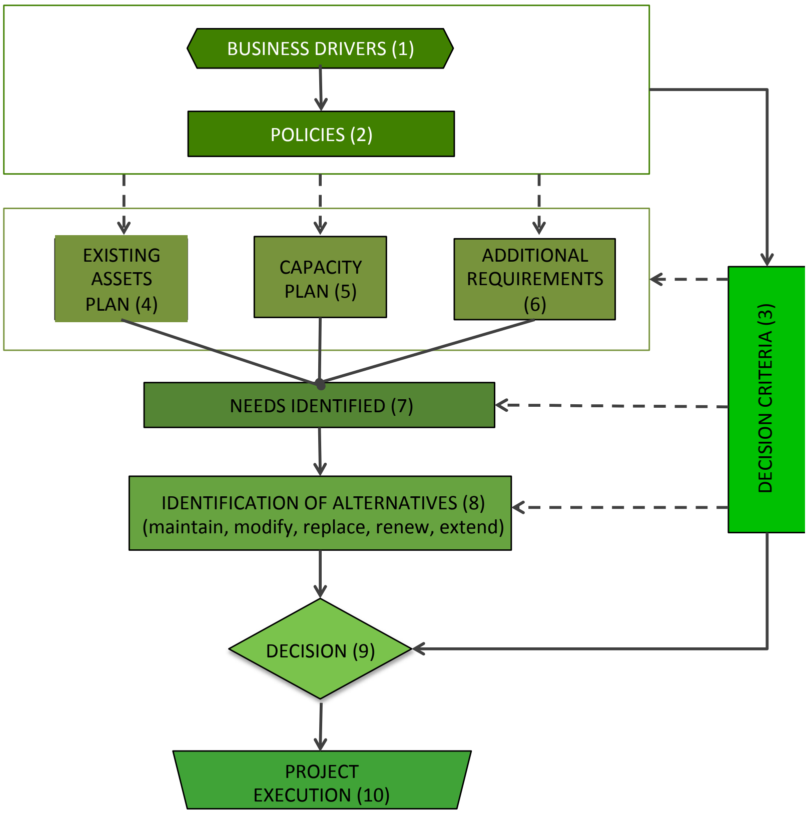


Figure 1: The proposed decision process for asset replacement, which is organized into ten steps.

Step 4 – Existing Asset plan: The existing asset plan (renewal, replacement, long overhauls, etc.) comprises of all investigations, decisions and processes with a view to maintaining assets already installed. Although it mainly results from the technical condition of the equipment in the grid, the power utility's ability to maintain existing assets also plays an important role. The latter is influenced by factors such as technical obsolescence or general in-house technical competence regarding training, maintenance skills and workforce developments. As an example, figure 2 gives the relative age distribution of the work force of an European utility. This age distribution will have a major impact on decision making process.

However, asset condition is still the main drive behind an existing asset plan. In order to provide information on asset condition, a systematic, up to date register containing data about installed assets regarding ratings and operating and maintenance history has to be maintained. Appropriate diagnostic techniques and respective interpretation schemes should further be applied in accordance with the specific asset type.

It must be an asset manager's goal to keep track of the coverage of asset replacement needs in the project portfolio. To support this, IT tools are needed to manage the needs on a daily base and the long term realisation of the targets. An example is given in figure 3.

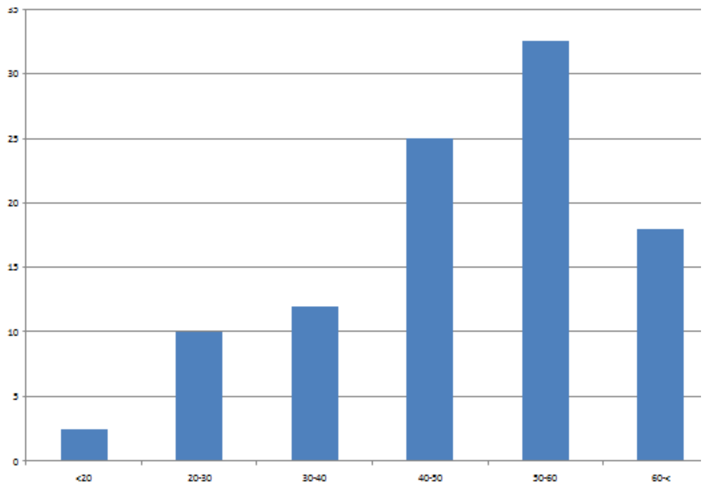
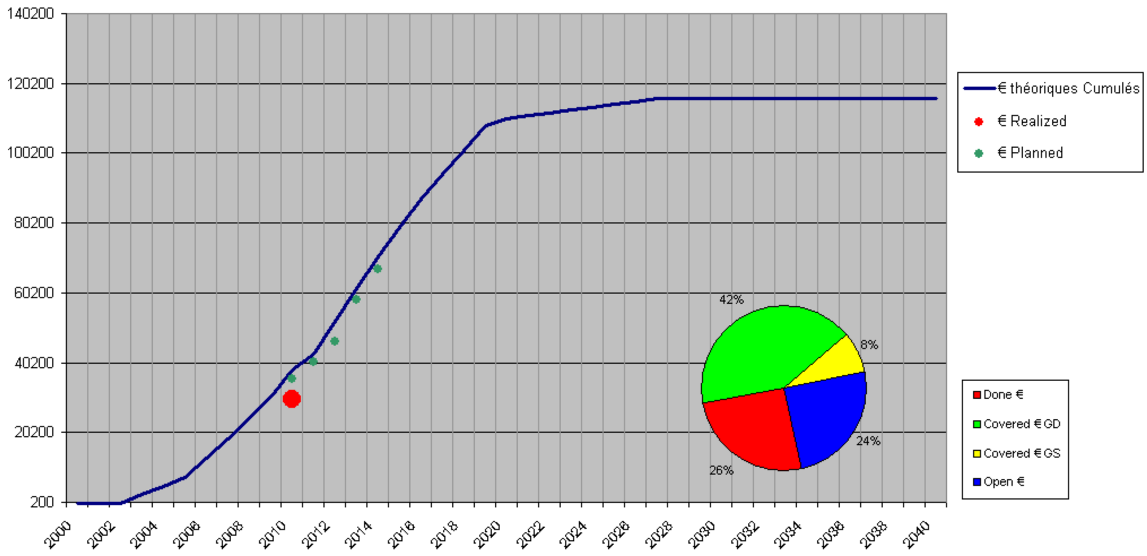


Figure 2: Relative age distribution of the work force of a European utility.



	2010	2011	2012	2013	2014	Portfolio coverage
Planned	93,4%	94,2%	88,7%	95,1%	94,8%	94,8%
Realized	77,7%					

Figure 3: Illustration of an existing asset project portfolio, tracking accumulated costs for replacements: realized (red), planned (green), and targeted (blue line).

Step 5 – Capacity plan: The capacity plan results from middle and long term grid planning and investigates situations beyond "business as usual". Integration of the capacity plan into asset replacement decisions is an important feature of the proposed decision process. The most obvious impact of changed capacity requirements is on equipment ratings: higher short circuit capacity of circuit breakers or higher rated power of transformers are typical examples of drivers for asset replacement due to increased capacity requirements.

Step 6 – Additional requirements: Additional requirements can also act as external drivers for asset replacement in substations. One example of such additional requirements is infrastructure work (e.g. construction of a new highway) affecting an existing substation. Figure 4 illustrates another example of a needed GIS extension, which triggered the earlier replacement of the substation automation system as well.

Step 7 – Identifying needs: The next step in the decision process is the identification of individual needs of each asset as per both the maintenance and the capacity plan as well as any additional requirements. In order to ensure transparency of all risks within the utility, an easily accessible, systematic register of needs should be designed and kept up to date.

Step 8 – Identifying alternatives: The aforementioned register of needs forms the basis for the development of decision alternatives by the engineering asset management department. Each alternative should be defined as a project with a clear scope and budget along with assumptions made.

Step 9 – Decision making: Prior to decision making, the performance of each alternative with regard to the decision criteria has to be evaluated. Comparing the respective risk indicators with and without project execution demonstrates the compliance of an alternative with the general business drivers. Moreover, risk exposure due to postponement of decision making should be taken into account in order to identify urgency.

In order to ensure that the decision process is always followed, decisions on asset replacement should be well documented and approved by an entity with sufficient authority within the utility. The documentation should include all considered alternatives along with their performance indices.

Figure 4: Early Control & protection system replacement, performed together with the GIS extension as one large project.

Step 10 – Project execution: After a decision on asset replacement has been made, the project should be assigned to a team for execution. The project leader is usually responsible both for budget planning as well as for technical supervision. It is also advisable for a utility to implement a planning and control system for the development phase, the annual plans and for any internal contracting mechanisms (service level agreements).

WG B3.06, TF-05: GENERAL PRINCIPLES FOR ASSET MANAGEMENT INFORMATION STRATEGY

The importance of setting up a well-considered information strategy within transmission and distribution utilities as a basis for decision-making was early recognized by CIGRE (7). This section describes an information strategy pertinent to the asset management decision-making process (for instance as shown in figure 1. The emphasis is principally on substation level asset management; however, the discussed information strategy can also be seen in a broader context.

Risk Management as Guiding Principle for Asset Management

According to CIGRE WG C1-01, asset management involves the centralisation of key decision-making for the network business to maximise long term profits, whilst delivering high service levels to customers, with acceptable and manageable risk (8). In this context, risk management is seen as a mainstream regime to enable asset managers to translate corporate business values and requirements into a comparable, measurable and manageable dimension namely *Risk*. Although the concept of asset management has been around for over twenty years, utilities asset managers still have to settle for less than ideal condition regarding asset information to support risk-based decision making. A part of this WG work shows that this is mainly due to the, still existing, strong focus on technical data and less on economical and social data. Risk-based decision making, however, requires data in mixed strategies and matching technical, economical and social requirements from a holistic point of view. Succeeding in filling this gap is the first step in obtaining better decisions in the field of asset management.

Hourglass Model

The work of JWG B3/C2-14 followed by WGB3.06 instigates in filling the gap between data management, through information strategies, and the link with risk based decision-making. For this purpose, our work describes an information strategy, named the *“hourglass model”*: it essentially, consists of two parts. These are:

- The risk management in a business relevant environment: this helps in utilizing and addressing the requirements on asset data
- The data management: this supports the decision making process through constructing a system to acquire, warehouse and transmit data.

The link of the above mentioned two parts is the critical connection. This connection, named *“intelligent hub”* in our work, aligns the translation of the information requirements from a “risk management side” to the requirements understandable by the “data management” side. The concept of the “hourglass model” is illustrated in figure 5.

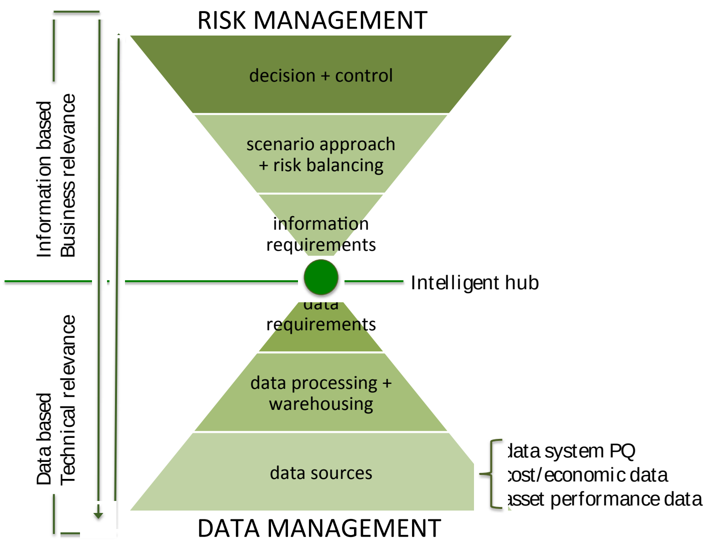


Figure 5: Illustration of the “hourglass model”, which expresses the need to align the translation of data into information according to the risk based decision process.

The “intelligent hub” shown in figure 5 is a method and approach to transform information requirements into data requirements. This transformation process can be regarded as one of the most important features for asset managers. Related to the data requirements data processing methods, such as data warehousing, are described that provide data extraction from existing databases.

Decision Process & Information Requirements

Organisational differences and differing asset management philosophies and priorities have resulted in significant disparity across different companies with respect to asset management strategy and implementation. This diversity makes it difficult to analyse and compare asset management implementations and their relative efficiencies. Therefore, to support the understanding of asset management implementations, a generic functional model for asset management containing three domains is used. These domains are: (1) operation, (2) maintenance and (3) management. Accordingly, these domains are used to structure the asset management decision process. In such decision processes the best option, when presented with a number of alternative options, in a decision-making environment should be chosen. This can effectively be viewed as a continuously running decision process based upon matching technical, economic and social information. In figure 6 the asset management decision process is illustrated.

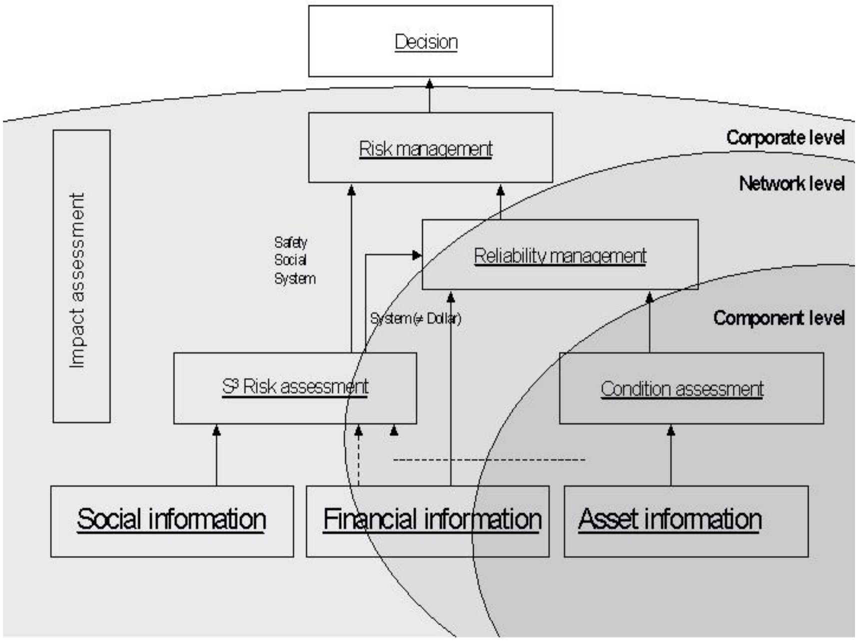


Figure 6: Asset management decision process, which shows the different levels of information requirements to ultimately make decisions in a risk management regime. (Note S^3 stands for Safety, Social and System oriented risks).

Moreover, from figure 6 we show that decisions are supported by information in three categories, which are:

- the technical category, which specify the condition for individual component and offers solution scenarios;
- the economical category, which assesses the benefit of technical scenarios on reliability;
- the social category, which assesses the benefit of technical scenarios on risks and make the final decision.

Information Pyramid

Hence, from the previous section, that the information requirements for asset management decision-making comprise multilevel information flows. Besides the information requirements at different levels, there is also a need for data processing systems. This is often provided by a plethora of existing IT (Information Technology) systems. During the last decade many commercially available IT tools have been developed and may, generally, be grouped in: (1) Enterprise Asset Management (EAM), (2) Enterprise Resource Programmes (ERP) and (3) Asset Operation Systems. High end transactional information processing tools such as data warehouses and expert systems are also available. These can provide support in the area of gathering and processing data in order to provide decision support. The practical implementation of IT tools to support the decision-making process is a challenging problem as the final architecture of information systems can strongly influence the processes and organisation of a utility.

A generic information processing architecture to support decision processes can be identified. This is referred to as the "Information Pyramid" and is presented in figure 7. This architecture allows open use of data together with high stability and a high degree of integration. It reflects the descriptions of the decision-making processes (figure 6), and information requirements as described in this paper. Different levels of the pyramid correspond to appropriate parts of the decision process.

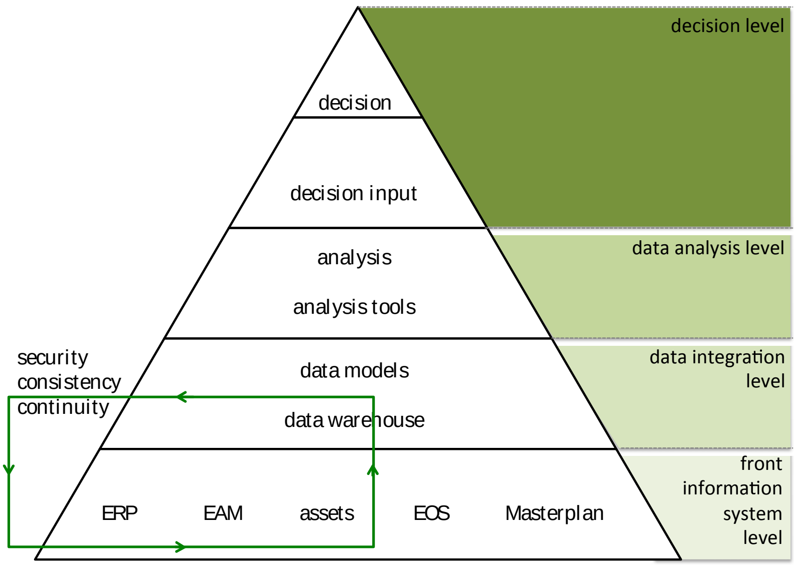
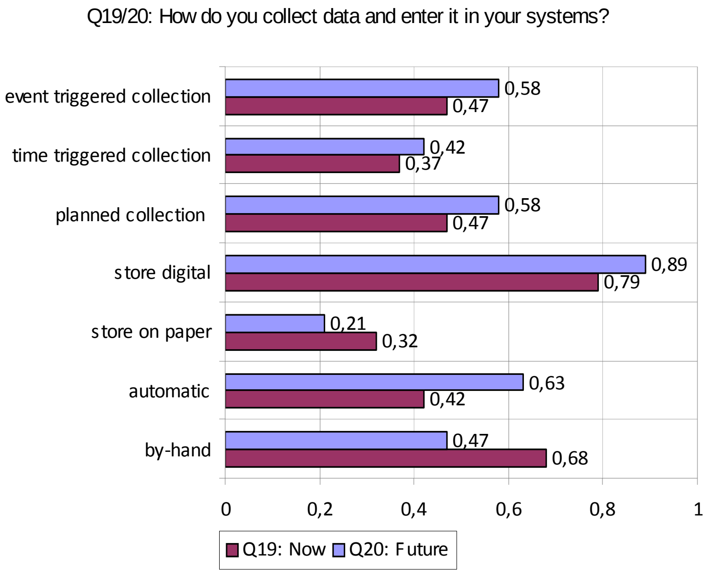


Figure 7: Information pyramid representing the data input level, data integration level, data analysis level and finally the decision level

International CIGRE Survey

With the goal to find out the status of current information strategy practises and to assess the future information strategy necessities, an international survey was carried out in the year 2006/2007 by the WG. This survey comprises 19 utilities from Europe, North America, Middle East and Australia. The questionnaire was focused on elucidating the current experiences, practices, support of information technology tools, and applied data management methodologies. In general, the results indicate that a majority of utilities own a large volume of digital records regarding daily operation and maintenance on a wide range of substations components. However, when it comes down to data processing the focus is mainly on technical aspects. Consequently, decisions on maintenance strategies are much better supported than those on replacement.

Survey results for data collection and systems used: According to the survey results hand-based data collection is still common practise nowadays (68% of respondents). This is definitely going to change according to the respondents. As can be expected, there will be an increased automatic collection and storage in digital format. Added to this, most respondents intend to increase their data collection actions in several ways, namely planned actions, time- and event triggered actions. Subsequently, questions were also asked on the usage of systems. The questions where focused on which systems utilities use nowadays and which systems utilities plan to implement. Answers show that the whole range of (systems) functions commonly needed in the field of asset management are used or are planned for. Since some utilities indicate that they plan to add some of the systems it can be concluded that not all the utilities own the complete range. Answers also indicate that systems for Enterprise Asset Management, planning/scheduling systems (not ERP), MS office and specific systems and proprietary databases are most commonly (> 50% of the respondents) used. On Enterprise Resource Planning (ERP) a significant increase on adding those to the existing system landscape can be seen. A portion of the, above mentioned, survey results are presented in figure 8.



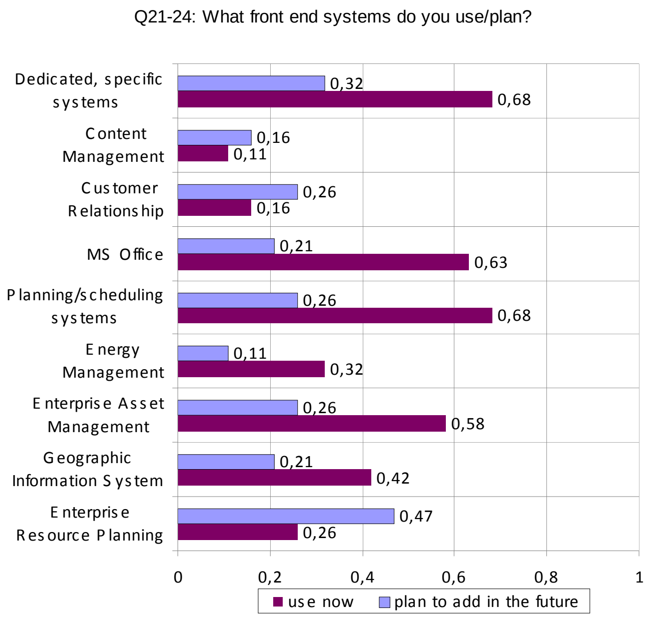


Figure 8: International survey results for data collection and systems used, now, and expected to be used in future.

The WG would like to stress that the integration of technical and non-technical systems is not common in the power sector. Evidence of this is also found in the widely used dedicated systems and proprietary databases. At the same time, we see that Enterprise Asset Management systems urge the need of data integration and most utilities are at the threshold of this integration. Which is why, the focus should be on “on single version of the truth” for the most important business objects (e.g. customer, substation, transformers, outage, etc.). In the end, the asset manager is responsible for the processes and IT systems requirements. This calls for collaboration between business and IT departments.

WG B3-06, TF-01: CONTRACTING OF MAINTENANCE OUTSOURCING

The key driver for change in the way the work force is managed, including the use of external contractors, has been the liberalization of global power markets that has taken place over the last 25 years. Various surveys have tracked these changes.

The 2000 Survey

Traditionally maintenance groups had been site-based teams, providers of a service, keeping the assets operational. They were responsible for maintenance for all assets in their own local area and undertook as much as possible within an allocated budget. This first survey identified a move to what is now described as a “network manager”. This allowed some degree of contractor use to undertake low risk routine tasks in order to achieve some cost saving. The more radical types of organisation changes came as companies attempted to control costs and network performance by introducing centralised decision making- the essence of an asset management organisation. With centralised decision making and centralised data management it became natural to define work programmes then to be undertaken by site located staff. At this point the topic of “outsourcing” of any, or all, site work becomes a natural discussion point. But importantly the processes for identifying work, prioritising tasks, managing effectiveness are the same- whether the team undertaking the tasks are internal or external- all are in effect contractors for the asset managers.

One chapter in this survey was devoted to outsourcing. Typically, the level throughout the world reported was between 30 and 35% of budget. This represented an increase from the 26% reported in a 1991 pilot survey. The exceptions were North and South Americas, where the survey reported outsourcing to be only 5%. The traditional kind of activities being outsourced there were the lower skilled areas such as tree pruning, tower painting, grass cutting, etc. But elsewhere there was also a major change towards outsourcing of specialist activities as utilities are increasingly focused their activities on core business.

The 2002 CIGRE/ Doble survey

This particular but small survey was completed by members of the B3 CIGRE group and some attendees at the September Doble Clients meeting in USA. This confirmed that at that time there was little activity (<10% budget) being spent in US/ Canada on outsourcing- the exceptions being the industrial respondents. The B3 group with respondents from Europe and two from Australia and New Zealand mainly replied with outsourcing budgets in the 25-75% range. Three companies listed more than 75% outsourcing claimed 10, 15 and 30 years satisfactory experience of outsourcing. One company had multiple suppliers and did not use an incentive based payment, instead had the incentive of an extension to the contract. For 15 years this company had used a 3-year contract with a 3 year extension. They were about to increase the duration to a 5+5 year contract. The other two had mixtures of single and multiple service providers, a mixture of 1, 3 and 5- year contracts, all with incentive payments. However, a trend noted, particularly with European utilities was that they had separated off their maintenance department as an independent company wholly owned by them. This allowed them to specify the work, prioritise what work was being undertaken and control costs. It also allowed the maintenance company to seek unregulated income- and to demonstrate to a regulator that they were cost effective by being able to win external contracts.

2011 CIGRE/ Doble survey

It is in this more recent survey that greater changes may be seen. The main respondents here were utilities attending two Doble events in 2011. The first was in San Diego in September where the 58 respondees were mainly from USA and Canada. The second was at the EuroDoble Colloquium in Stockholm in October where 18 European utilities contributed. Later that month there was a B3-06 meeting and 5 extra European utility members contributed. The first set of questions was intended to identify to what extent management of asset care was being centralised and the extent to which it had led to outsourcing of work. Here the two categories were (1) low risk site facilities- such as vegetation control and tower painting and (2) skilled care of assets.

These replies showed that in both continents centralisation of work management had taken place to a considerable extent. In Europe the changes had started 20 years ago and so the extent of outsourcing is more mature, with smaller increases indicated for the future. The enquiry attempted to identify what are the most important features to be sought when outsourcing. There are no clear conclusions. Clearly the company will seek cost savings but in US these are considered to be only secondary to allowing internal resource to be directed at core activities. In Europe there was more confidence that real cost savings was achieved.

The groups were much clearer about what they did not like about outsourcing. But in both surveys there are concerns that quality is less than delivered by internal teams and fears for long term continuity exist. As long as contract departments insist on lowest cost tendering for even the higher skilled work category then on-going recruitment and innovation will suffer. There was significant concern about the loss of technical skills from the company- and then being hostage to providers who retain the skills. Emergency restoration is a key requirement in any utility and flexibility will be lost using a third party. This could be addressed using a small in-house team who retain all necessary skills and can be used for this purpose. Both groups accept the need for the utility to assume the risks- and the consequences in term of management of contractors.

Decision Processes Influencing Outsourcing

The maintenance department is often the largest within a utility. To outsource their activities to an outside company can be cataclysmic for both the company and staff. It needs full endorsement by the executive. If handled badly it can affect company image, performance and motivation throughout the whole company, and for the staff involved the loss of their jobs. In some cases staff may transfer to the provider, but for many vendors the cost of assuming the past pension provision may be too high to recover within the contract. Any incident on site involving in-house staff is attributed to the utility, and it is up to the management to identify and control risks. This is a more difficult situation when the work is done by contractors only indirectly under management control. This means significant attention is needed to decide what to outsource, how contractor are selected, and how they are managed subsequently.

What to outsource- Competency mapping

Decisions as to whether to outsource all or only some activities will depend on the degree of risk a company will accept. Selection is through “competency mapping”. Some of the activities undertaken by utilities are low risk. Spill-over competencies allow a utility to obtain profits through external sales. Parasitic activities waste organizational resources. Tower painting would be an example. These are activities that may be managed with cost–driven “adversarial” contracts- since cost and performance can be identified fairly easily and consequently the risk of poor performance is less. However, essential competencies are those needed for an organization to operate. In the case of a transmission utility this could be the competency of post fault restoration of demand. Switching, maintaining safety from system dangers and emergency repairs may be outsourced only if a risk analysis had been undertaken and that level of risk was acceptable to the company. Whilst adversarial relationships might deliver the lowest price for these services, they are unlikely to deliver best value or indeed the lowest overall costs, when transactional and other possible costs are accounted for. Very close collaboration and mutual trust is necessary if the relationships are to generate the scale of benefits needed to justify a decision to outsource.

Risk management

One of the most important trends in maintenance is the management of risk. The common risks relate to business interruption through poor performance, safety to workers and public, health exposure, and environmental damage. Most tasks will involve data entry using an access into the utility servers. Some will use a secondary firewall allowing contractors into only part of the company data base. Supervisory staff needs to be trained to monitor risks and mitigation. All staff will need adequate and up-to-date training and certification for their tasks- and this can be quite an expensive process. No assessment of an outsourcing opportunity should proceed without an appropriate risk exposure analysis. Here the three overriding issues of importance to outsourcing decisions are: risk, cost and quality/effectiveness.

Financial Assessment

For many the cost saving is seen as the major driver. But for rigorous outsourcing evaluation it is important that costs should be compared on a like for like basis, including overhead allocation. It is vital that all costs associated with in-house provision are captured. In addition to direct costs e.g. labour costs, the assessments should also include training and development, tools and equipment and all management costs. It also needs the cost of increased overhead cost (buildings, HR, pensions etc.) It is essential that outsourcing cost components should include both on-going direct and transaction costs. This should also include training, certification of workers. Some will also include provision for innovation development to lead to a total reduced cost of the activity. To complete the picture, one-off costs, e.g. market development costs, or switching costs associated with transferring the activity to an external supplier should also be taken into account.

OUTSOURCING, SOME CONCLUSIONS

Centralisation of decision making within an asset management model is clearly the widespread response to business drivers introduced into utilities. This has led to increased contracting of work to external groups. The use of external service providers is a long established feature of life in Europe, Asia and Australasia and a growing trend in North America. However, maintenance outsourcing is not a simple task, particularly in core areas. In most instances it can be successful provided goals are not unrealistic, obstacles minimised and suitable management controls established. The surveys indicate significant concerns remain within utility engineers relating to flexible working, loss of skills and knowledge. Current work of the group is to prepare a final brochure describing the contracting framework.

WG B3-34: SMART ASSET MANAGEMENT IN FUTURE GRID CONCEPTS

The organisation of asset management for existing substations as described by WGB3.06 gradually develops in order to match with future grid concepts (see figure 9). It is expected that substations in future grids will be equipped to operate in a more complex ICT supported environment. Many utilities are considering the introduction of substation architecture with subsystems employing intelligent interface technologies. In this regard CIGRE working group B3.34 is investigating the *"Expected Impact of Future Grid Concept on Substation Management"*. In future substations real-time monitoring will require the embedding of sensors in primary plant together with the provision of associated intelligent hardware and ICT. The integration of secondary sensing/actuating technologies into primary equipment remains a big challenge particularly from the reliability viewpoint. Typically, the secondary devices are less robust and have shorter lifetimes than primary equipment. An important consideration will be the feasibility to extend the lifetime of interface devices between the primary plant and modern digital secondary systems. In addition, a model-based framework to optimize usage of power equipment should be implemented using a predictive health indexing model. Besides the issues relating to the normal flows of power and information the data management aspects are also of concern such as data security, data ownership, data storage, retention etc. The amount of data transfer at both local and central level will increase so rapidly that agent technologies will be required for processing the growing data streams in the autonomous grid sections. The WG should assess the benefits, if any, of introducing intelligence into the substation management methods.

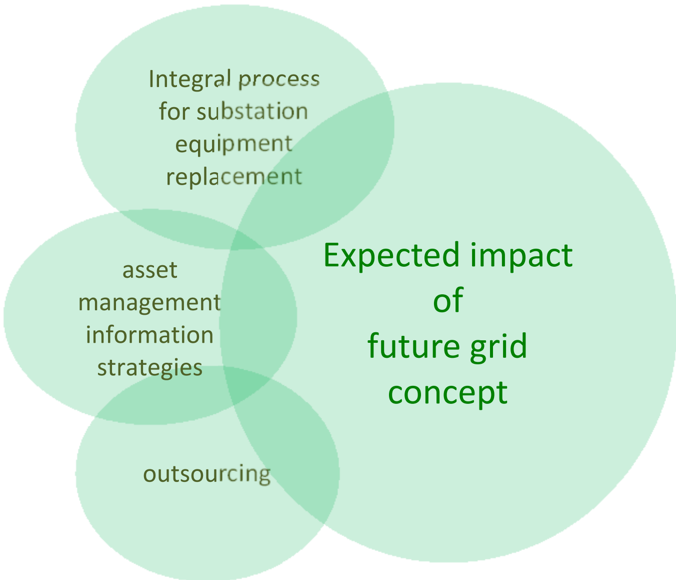


Figure 9: Presents the organisation of asset management for existing substations as described by WGB3.06 (shown in the left three conceptual areas and as described in this paper). On the right side the gradual development in order to match with future grid concepts that will be investigated by CIGRE WG B3.34 is shown. These investigated areas closely interact with each other.

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Biographical details of Authors:

Johan J. Smit received his Ph.D. at the State University of Leiden in 1979. Since 1996 he is fulltime professor at the Delft University of Technology (NL) for High Voltage Technology and Management. He chairs the foundation for Knowledge Sharing and Research on Asset Management of Electrical Infrastructures. Earlier he was employed at KEMA T&D for 20 years, and member of the supervisory board of the power transmission company of South Holland. Also he is IEC-TC112 WG6 convener on Electrical Insulation Systems Evaluation, and for CIGRE TC-honorary member, past SCD1 chairman on Materials & Emerging Technologies, convener of D1 advisory bodies and WG B3.34.

Nhora Barrera has worked in different areas of Project Management in high-voltage substations for over fifteen years, including five years at ABB GIS Manufacturer, four years at the IFC - World Bank Group in project financing, two years on site and most recently, at Axpo AG managing large high-voltage substations projects. Education includes an Electrical Engineering degree with major in Power Systems, post-graduate studies in Business Economics and MSc in Project Management. She has been an active member of the PMI since 2004.

Alan Wilson has been with Doble Engineering for the last 14 years and is currently director of Global Strategy. Before that he worked for 34 years in National Grid, and its fore-runner Central Electricity Generating Board. This involved being research programme project manager, technology manager responsible for cable and transformer technologies, a research manager and earlier a research scientist. He has a BSc, PhD; is a chartered engineer and fellow of IET.

Ravish P.Y. Mehairjan is with Stedin B.V. in the Netherlands involved in various roles, especially on maintenance management, condition monitoring, statistical life data analysis and risk-based management. He also works part-time towards a PhD degree at Delft University of Technology at the High Voltage & Asset Management group on the topic of risk-based maintenance within asset management. He has a BSc (2008) and MSc (2010), both cum laude, in electrical power engineering from University of Suriname and Delft University of Technology, respectively. He is secretary of CIGRE WG D1.39 "Guidelines for the Use of Statistics on Failure Data".

Paul Leemans is Expert Manager Substations with Elia for the last 5 years. His main responsibility is the asset management of primary substation equipment of the Elia Grid in Belgium. Before, he was working 8 years as technical expert within the maintenance division of Elia. He started his career 25 years ago with Laborelec in the field of diagnostics and failure analysis on HV equipment.

***Nicolaie L. Fantana**,* graduated 1974 in Electrical Engineering and received 1985 his Ph.D. from University Politehnica Timisoara Romania, where he was an associate professor until 1991. He received an European Grant and was visiting Karlsruhe Institute of Technology, KIT, Germany form 1991 to 1992. Since 1992 he has been with ABB Corporate Research Germany. He was involved in various projects and international working groups on condition monitoring, life assessment, power equipment maintenance, lifetime data management for power equipment and substation management as well as using mobile, ICT and internet technologies for field service activities. He has been convener of CIGRE working groups A2.23 Lifetime data management, Secretary of B3.10, Obtaining value from substation on-line condition monitoring, task force leader and member in working groups in the area of transformers and substations. He has over 30 years of research, engineering and university experience. He has published papers including CIGRE Technical reports as co-author and author, has multiple patents. Also he has initiated and chaired IEEE-CIGRE expert meetings and panel session on on-line condition monitoring for substations during 2011, 2012, 2013.

P. Myrda is a Technical Executive with the Electric Power Research Institute working in the Power Delivery and Utilization Sector. Currently he is program manager for the transmission portion of IntelliGrid and the Smart Transmission coordinator at EPRI. Previously, Paul was Director of Operations and Chief Technologist overseeing planning and asset management functions for Trans-Elect's operating companies. Paul has over 30 years of experience that includes planning, engineering, information systems and project management. He has an MBA from Kellogg and MSEE and BSEE from Illinois Institute of Technology. He is a licensed professional engineer, and a member of the IEEE and CIGRE.

Iliana Portugues is the director of the Power Networks Demonstration Centre. Before then she worked as a Senior Project Manager for the Electric Power Research Institute where she was in charge of researching and implementing novel technologies in substations and transmission networks. Before then, she founded, Elimpus Ltd, a company dedicated to providing condition monitoring solutions to the electricity industry and novel web-based solutions. Iliana Portugues holds a MEng degree from the University of Bath in Electronics and Communications Engineering and a PhD from the same institution.

N. Kaiser is an Expert Manager in the field of Power Transmission and Distribution Systems Services and is in his role coordinating the R&D activities of this Business Segment. He has experience as R&D Project Manager developing an Reliability Centred Asset Management Service, RCAM®, for power transmission and distribution systems at Siemens. Currently he is the project manager to link the above mentioned Asset Management Services with online condition monitoring systems for a big customer project.