A FRAMEWORK TO EVALUATE A FUNCTIONAL REFERENCE MODEL AT A NORDIC DISTRIBUTION UTILITY

Authors: Dinusha Gunaratne[1], Moustafa Chenine[2], Mathias Ekstedt[2], Per Närman[2],
Company: [1] Vattenfall Research and Development AB
[2]Industrial Information and Control Systems,
School Of Electrical Engineering
KTH – Royal Institute of Technology
Telephone number: + 46 (0) 70 329 89 81
E-mail address: dinusha.gunaratne@vattenfall.com

SUMMARY

Distribution utilities have found IT systems to be indispensable for competition in the deregulated electricity market. But in order to be highly efficient, a distribution utility ought to essentially maintain a correlation between IT systems and business processes. A Functional Reference Models (FRM) is one way to achieve this correlation.

A FRM is a versatile and multidisciplinary tool that could be used to create alignment between business processes and IT-systems by describing what a "business is" and in terms of business functions that are carried out. There are many utility standards and system vendors claiming to offer complete FRMs for the utility domains. In addition, of course there exist implicit FRMs in the company in terms of existing processes and IT-systems. Thus there is a growing need among distribution utilities for a method to evaluate the quality and suitability of a FRM for a given enterprise.

This paper will describe the development of a framework that has been used to evaluate the quality of a FRM in a Nordic distribution utility by benchmarking against the IEC 61968-1, UCA 2.0, IFS and Oracle FRMs for the utility domain. The framework cross reference a FRM with other FRMs to get a *Coverage* of all the business functions used in the utility business and eliminate vendor dependence and it analyze the strengths and weakness of the FRM and what amendments to be included. Finally it evaluates the *Suitability* of the FRM to the utility by aligning with the IT systems. The evaluation also helps to identify redundant IT systems and maximize the IT usage in a distribution utility. This paper concludes with a motivation to distribution utilities to adopt a FRM discussing its business values.

1 INTRODUCTION

IT systems for the power industry have been evolving extremely fast. The technological advancement constantly initiates new applications and changes to the utility business operations. Technology and IT systems are often forced upon and embraced by companies without a proper definition of new objectives [1]. If IT systems are viewed as "costs" that manage the "utility assets" then it is essential to define and identify proper objectives for the current and potential IT systems and maximize the IT usage. A *Functional Reference Model (FRM)* represents the functionality needed by a functional area and can be used to identify the degree to which the application suits the business needs of the utility [11]. *"A Function is any set of actions performed in the course of conducting business"* [2].

An FRM is a versatile and multidisciplinary tool that could lay a corner stone in Enterprise Architecture Planning (EAP). A FRM can be used to understand the business through functional definitions in order to define the Enterprise Architecture (EA) [2]. An IT application portfolio can be defined mapping all business functions to the IT applications which will maximise the usage of the current application portfolio, optimise application integration and changeover and allow benchmarking IT applications in future procurements. Derived from the FRM Long term Information Systems (IS). strategic plans can be defined including architectures for data, applications, and technology [2]. Apart from EAP, the common vocabulary for the business established by the FRM boost the knowledge sharing among different stakeholders.

Developing a customized FRM from scratch is time consuming. Therefore is it more desirable for a company to adopt an industry standard or a vendor FRM that is developed for the domain of interest. Some examples of such industry standards and vendor FRMs are: International Electrotechnical Commission (IEC) 61968-1[3] and Utility Communications Architecture (UCA) 2.0 [6] international standards and Industrial & Financial Systems (IFS)[5], ORACLE [12] and Systems Applications & Products (SAP) [4]

The need to understand and evaluate the quality of the FRM and the suitability for the company business processes initiate the development of the framework to compare and evaluate a FRM by cross-referencing it with other FRMs in the industry. This paper describes a suggestion for an updated FRM for Vattenfall Distribution and Generation. This project was done as Master Thesis project cooperation between Vattenfall and the department of Industrial Information and Control System at KTH [13].

The rest of the paper is structured as follows. Chapter 2 provides a description of the business map of a large energy utility Vattenfall AB. Chapter 3 gives a short introduction to FRM evaluation criteria and proposed evaluation framework for developing the new enhanced Vattenfall FRM. Chapter 4 will discuss the benchmark and evaluation of Vattenfall's existing FRM with other international standards and vendor FRMs. finally, the paper concludes with giving recommendations for the improvement of the utility business map and thereby proposing a FRM that can be used by any utility company.

2 FUNCTIONAL REFERENCE MODEL AT VATTENFALL

Vattenfall is a producer and a provider of electricity and heat to private households and industrial customers in Europe. Vattenfall is currently using a modified version of SAP Business Map called *Vattenfall Business Map (VBM)* as the company FRM. The SAP Business Map is a representation of different business functions and their supporting sub-functions developed by SAP and its partners for different industries.

The VBM is currently used to categorize the applications used by Vattenfall in the *Vattenfall Application Catalog (VAC).* VAC is a framework for managing application portfolio data in Vattenfall. The vendor dependence of the VBM can make the model biased, making SAP-applications appear better than they actually are when compared with applications from other vendors. There is a limitation of background information available about the SAP Business Map and therefore the business map could be tailored towards business processes dissimilar with those processes at Vattenfall.

However SAP claims to offer a complete FRM of all the functionality present in IT-systems at electrical utilities, which are continuously updated to incorporate state-of-the-art functionality, and their use is free of charge. Figure 1 below is a high level view of the Vattenfall Business Map. The VBM is based on the SAP Industry Solution Maps designed for Utilities [8] and Mining [7].

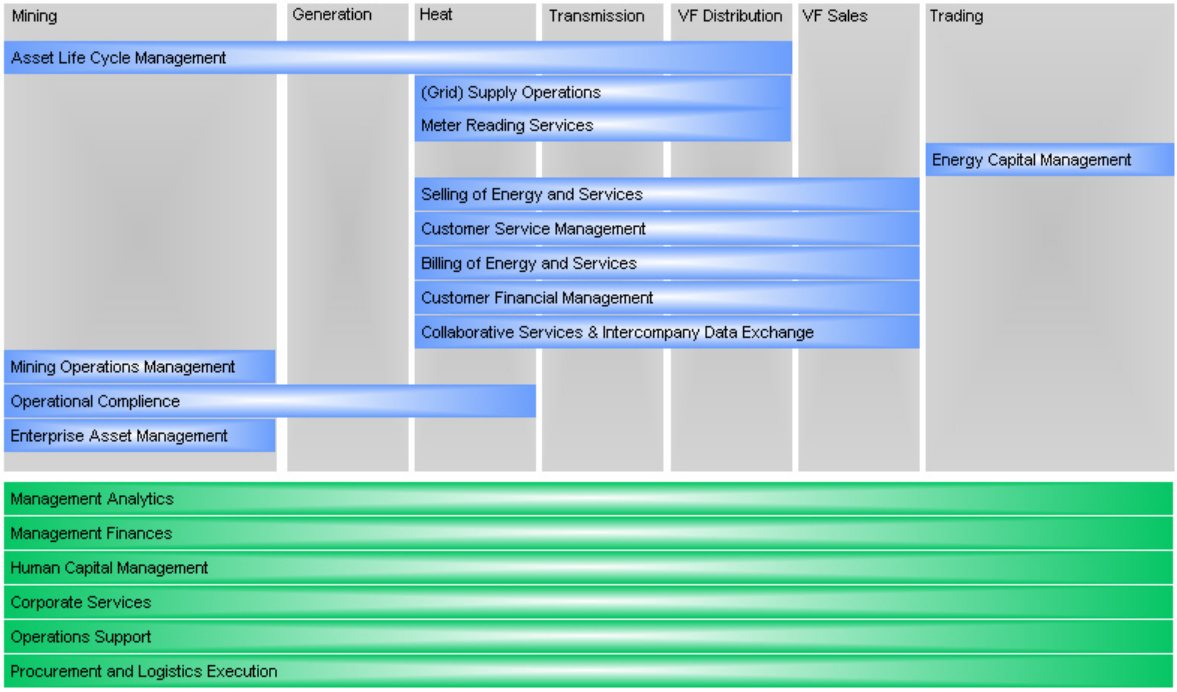

Figure 1: Vattenfall Business Map

Generally, a FRM is organized in several levels of abstractions with increasing details going further down in the model. Typically the Level 1 refers to a larger functional area and level 2 deals with a more specific business function. The level 3 is a more specific abstract components or specific functions. The VBM is depicted in figure 2 below.

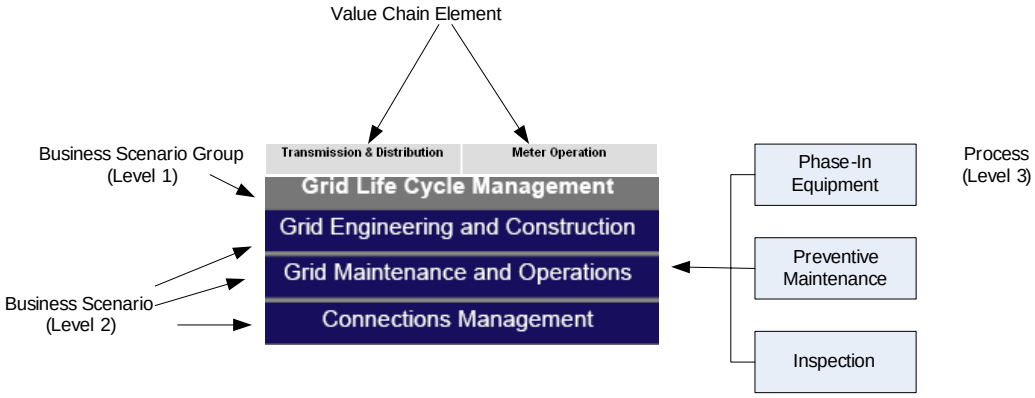

Figure 2: Structure of the Vattenfall Business Map

In certain functional areas such as Asset Life Cycle Management, the VAC categorizes many applications under the same level 1 component indicating that they have the same purpose although in reality they can be identified as different applications. This is proof of the fact that a proper organization of a VBM is required for optimal usage.

As the VBM is solely based on the existing system functionality of SAP applications the value of information represented in the VBM was questionable. Thus in order to use the VBM as a FRM for Vattenfall, there was a need to evaluate the overall quality and the suitability. There was a need to eliminate the vendor dependence of the VBM, furthermore, there was also a need to increase the level of concentration for technical areas that is utilized within Vattenfall.

3 FRM EVALUATION FRAMEWORK

In order to evaluate the quality of the FRM the following evaluation criteria and method were deduced.

3.1 FRM Evaluation Criteria

Coverage – Coverage of a FRM depicts the functional areas and functions covered by a given model. Lack of coverage can be depicted as incompleteness in a FRM meaning the absence of some functional areas in one model that is found in another model. Figure 3 illustrate the high coverage of model 1 compared to the model 2.

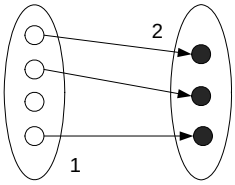

Figure 3: Coverage [9]

Resolution **-** The granularity or the level of detail of each business functional in a given model. A model is said to be lack in resolution when a business function is overloaded combining several functions together when the same business function is depicted in another model with sufficient details separating different sub functions as shown in figure 4. The model 1 has more components compared to model 2 due to the high resolution.

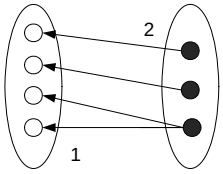

Figure 4: Resolution [9]

Uniqueness **-** There cannot be multiple components with the same functionality in a given domain/sub domain.

Industry and Standard Compliance **-** To what extend a model comply with industry standards and with other vendor requirements.

3.2 The Evaluation Framework

Based on the above evaluation criteria, the framework depicted in Figure 5 was developed to evaluate a FRM.

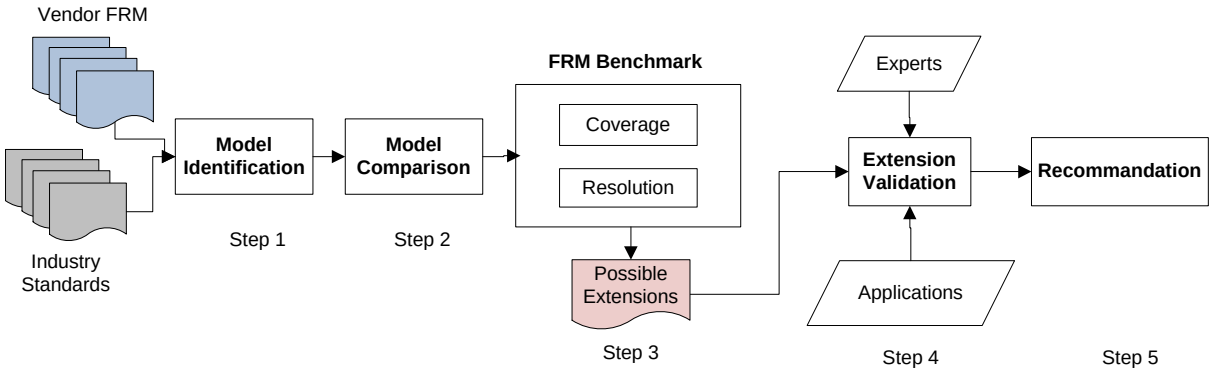

Figure 5: Proposed Evaluation Frameworks

Step 1 of the framework is the *Model Identification.* This involves the identification of suitable models from vendors and international standards to be compared to the FRM in question. In the domain of energy utilities IEC 61968-1 and UCA international standards and IFS and oracle vendor business maps were identified as potential candidates to be benchmarked against the SAP-based Vattenfall Business Map.

Step 2 involves extracting business functions from each model and mapping them to the business functions of the FRM in question. As depicted in figure 2, a FRM has different levels of abstraction in describing the functionality used within the functional area. Therefore it is desirable to use level 2 business functions to perform the model comparison in order to have a good comparison of the models.

During *step 3* the FRMs are benchmarked based on the finding in step 2 looking at which model is better in the evaluation criteria *Coverage* and *Resolution* for the domain. Each business function that was not covered by the FRM in question are extracted and added as proposed extensions to the original model and a proposed FRM is created.

Step 4 involves evaluating the suitability and the *uniqueness* of the proposed extensions and FRM in question for the business. All the applications used in the company related to the domain are categorized under the proposed FRM. The original categorization of the applications before adding the proposed extension is compared with the categorization after adding the extension. If there are no two-business functions to which an application can be categorized for the same functionality then the business functions are said to be unique. After the categorization, the application under each business function is compared for similarities and if similarities are found the component is identified as a suitable recommendation.

The advantage of this method of validation is that the recommendations are unbiased and they are not subjective to any external conditions, as it has been tested in its actual business environment.

4 FRM EVALUATION

The framework proposed in figure 5 was deployed at Vattenfall to benchmark the SAP Based Vattenfall Business Map against the IEC 61968-1, UCA 2.0, IFS and Oracle FRMs.

4.1 Coverage of the Vattenfall Business Map

The IEC 61968-1 is the first in a series that defines interfaces for the major elements of an interface architecture for *Distribution Management Systems* (DMS) [3]. The requirements and standards in IEC 61968-1 are defined based on the *Interface Reference Model* (IRM). The IRM model recommends a set of *business functions* that are found to be desirable for a DMS. The business functions are sub divided into *sub-functions* and them in to *abstract components* that are portions of a software system that supports functions of one or more interfaces. The narrowed focus of the IEC provides a very high resolution of the functionality within Distribution in comparison to the other models with a broader focus. The coverage and resolution of the SAP Based VBM in the core business areas such as Network Operations, Network Extension and Operational Planning and Asset Management was very low. In contrary the functional areas Customer Support, Energy Capital Management, Collaborative Services and Intercompany Data Exchange, Finance and Human Resource has a very good coverage in the SAP Based VBM in comparison to the IEC.

The UCA model developed by the Electric Power Research Institute (EPRI) gives an overview of the business functions used in an entire electric utility [6]. The UCA model has identified functional areas based on the major operating components Transmission, Distribution, Power Plant, Control Centers and Corporate. The VBM has no coverage of Control Center functionality but covered the majority of the other functional areas.

IFS is a provider of business applications to many industries. Today, the operations of IFS are in two areas: Asset and Product Lifecycle management and mid market ERP covering midsize distribution and manufacturing companies. The IFS component chart is a form of a FRM in which IFS depict the functionality provided for different functional areas. [5] The VBM covers all IFS functional areas except Asset Data Management.

Oracle is also a provider of ERP applications for many industries. The Oracle Solution Footprints provide separate FRMs for power generation and transmission and distribution.

The VBM has no coverage of Fuel Management in power generation and no coverage of Asset Management and Network Operations in distribution in comparison to the Oracle model.

As a result of the benchmarking the following findings were observed related to the *coverage*, *resolution* and industry standard compliance of the SAP Based Vattenfall Business Map.

It was apparent from all the model comparisons that the SAP Based VBM has a good coverage in common in Maintenance and Engineering, Meter Reading, Customer Support, Energy Capital Management, Collaborative Services and Internal Data Exchange, Finance and Human Resource.

It was visible that the VBM has no or very poor coverage of the technical business functions Network Operations, Fuel Management, Asset Data Management, Plant Operations, Network and Plant Extension Planning, Operational Planning and Optimization that are highly used in the core utility business.

4.2 Resolution of the Vattenfall Business Map

It was apparent from the coverage analysis that majority of the technical components found in other FRMs could be mapped to a Level 3 process in Plant Maintenance and Operations, Grid Maintenance and Operations or Energy Capital Management components of the VBM. As described in the framework these two Level 2 components (Plant Maintenance and Operations, Grid Maintenance and Operations) are overloaded with the level 3 components and therefore the resolution of Level 1 components Grid Supply Operations and Asset Life Cycle Management is very low.

The Energy Management has a very high resolution in the VBM when compared to the IEC and UCA standards. The resolution is confirmed to be valid by the Oracle model giving the same resolution for energy management.

The resolution of the non-technical components is very high in the VBM. The separate operations selling, billing and customer service are divided in to different level 1 components providing a very good resolution. Industry standards IEC and UCA models provided a very low resolution for areas such as Customer Service, Human Resource, Financials, and Energy Management by locating all the functionality in few level 2 components.

4.3 Industry and Standard Compliance

Total of 29 extensions to the VBM were found out of which 22 originated from IEC 61968-1 and UCA 2.0 and 14 originated from vendors IFS and Oracle. Thus there is a lack of coverage of 75% of the business functions from standards and lack of coverage of 48% components from vendors. Although VBM has poor compliance to Industry Standards the compliance to other vendor FRMs is fairly acceptable.

5 SUGGESTION FOR IMPROVEMENTS TO FRM

Considering the low coverage and resolution of technical components in the VBM, it was suggested to increase the resolution by including the components that were identified during

the model comparison. Two separate FRMs were developed for distribution and generation. The separation of the functionality for generation and distribution gives the advantage of easily identifying the specific functionality and common functionality used for each area. The separation also allows finding if there is any difference in the systems used within the common business functions for distribution and generation.

5.1 Distribution Related Functions Improvements

Figure 6 depicts the proposed FRM for distribution. Control Centers work as the heart of the distribution process. They are responsible for constant monitoring of the network, gather real time data and provide high degree of security and reliability to the network. The Supervisory Control and Data Acquisition (SCADA) system work as the backbone in control centers automating all the network operations. But unfortunately the VBM does not cover the network operations. Having considered the importance of network operations in the utility business Network Operations business functions and its sub functions are suggested to be added to the VBM based on the IEC and UCA standard and Oracle model.

The *Network Operations* functional area, therefore, is concerned with real-time operations of an electrical distribution network. This functional area covers SCADA (Supervisory Control and Data Acquisition) systems functionality is utilized to control and monitor the performance of the network as well as to manage and analyze faults. Also, SCADA training of dispatchers in included.

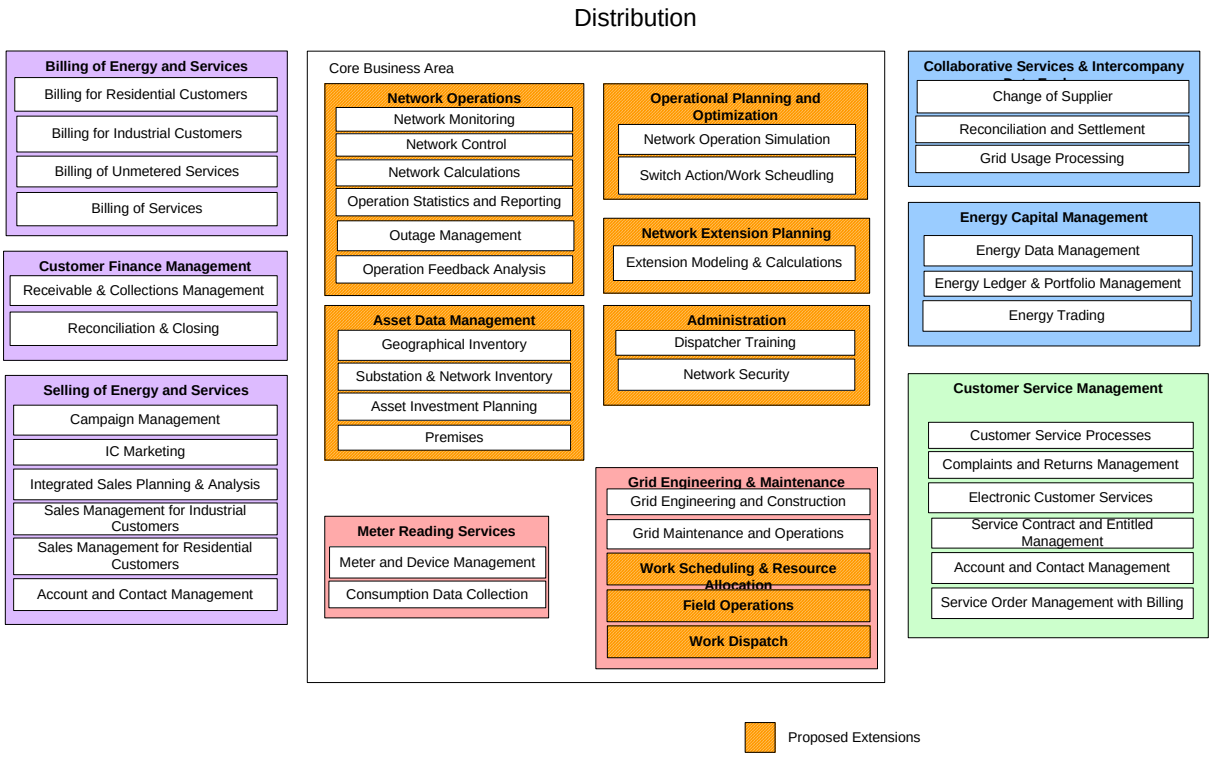

Figure 6: Proposed FRM for Distribution

The electric utility industry is a capital-intensive industry and therefore it is important to manage the asset data and thereby make optimal investments. GIS/NIS is an important tool used to maintain the electrical models and show the connectivity and special model for spatial analysis [10]. The VBM has no coverage for GIS or Network Inventory therefore the Asset Data Management business function is suggested to be added.

The *Asset Data Management* functional area is concerned with the collection and storage of information regarding all assets in the network in an asset repository. The information is used as basic data when making decisions regarding investments and maintenance activities in the network.

It is very important for a utility to manage a constant supply of power to its customers and also maintain the cost of production at the least to maximize the profit margin. Thus the Operational Planning and Optimization functions are suggested to the VBM based on IEC, UCA standards and Oracle model.

These functions are classified in the *Operational Planning and Optimization* functional area. This functional area is concerned with the preparation of decision support for the Network Operation (NO) business function to ensure that the grid is utilized in an optimal manner (this also includes network simulations).

VBM has a very strong coverage in Grid Engineering & Maintenance covering planning and organizing the construction and maintenance work. The VBM has covered Work Management under the Maintenance. On the other hand, management of the workforce and the field is an important part of the maintenance process it was therefore suggested expand on this function with additional detailed function that cover Work **Scheduling & Resource Allocation, Field Operations, Work Follow-up.** This suggestion is based on similar coverage and resolution in the IEC, UCA, IFS and Oracle models.

From the model comparison it was found that the extension planning business functions are somewhat covered under planning and optimization and maintenance and engineering components. But the validation with the experts showed that it is necessary to add a separate component for extension planning to capture the functions that deal with modeling and calculation of extensions to plants and network. Therefore, as requested by the experts and by the recommendation of the IEC model it is proposed to add the Extension Planning function to the VBM. *Extension Planning* is a Functional area concerning expansion of the electrical network and simulating extensions.

Finally, *Network Administration* was also suggested to cover functions in **Network Security** and **Dispatcher Training.** This business function was suggested to be included in the VBM by experts.

The other business functions in the FRM are based on the original SAP business functions and definitions.

5.2 Power Generation Related Functions Improvement

Figure 7 depicts the proposed FRM for distribution. Similar to the distribution business, the Control Centers work as the heart of the power generation process providing similar operations in managing generation plants. Some of the power plants are controlled solely by the control centers without any human intervention. Having considered the importance of plant operations in the power generation process the business function *Plant Operations* is added based on the UCA standard.

Power generation economists simulate future scenarios and make long-term optimization plans. The cost of generation of power is balanced by deciding what the optimal energy form is for a given period of time. On plant level, optimizations plans and simulations are carried out to make the maximum utilization of the energy and minimize cost of the production. The yield and cost both is controlled and maintained by this functional area but it has not been covered by the VBM. Therefore is recommended to add the function *Operational Planning and Optimization* based on UCA and Oracle models.

Dispatch Training is one important function in power plants. Simulating different scenarios and training the staff. **Plant Security** is one very important function which is often overlooked by models. Therefore a business function *Plant Administration* is added to cover this functionality.

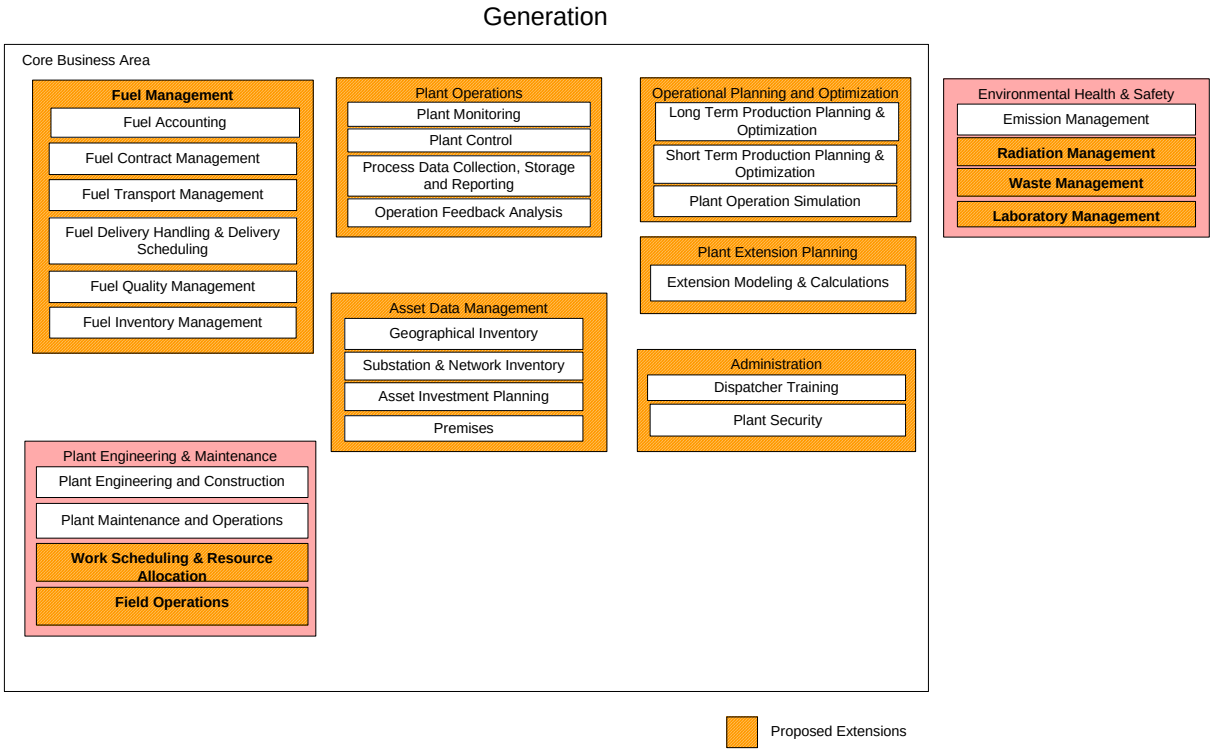

Figure 7: Proposed FRM for Generation

Unlike water and wind power fuel such as coal, oil and uranium need to be procured and managed within the power plants. The VBM has no coverage for fuel management and the Fuel management applications of Vattenfall are listed under the Plant Maintenance and Operations. Therefore it is suggested to add the business function *Fuel Management* based on the Oracle model.

Power plants are usually differentiated by the type of fuel used in the electricity generation. It is mandatory that the power plants maintain the health and safety of the employee especially in nuclear plant it is very important to monitor the impact of radiation. The VBM provides a component for Environmental, Health & Safety but its coverage is limited to incident management and emission management. Therefore it was decided to add **Radiation Management, Waste Management and Laboratory Management** under the Environmental, Health & Safety to increase its resolution.

5.3 Suggested Improvement Validation

As described in the step 4 of the figure 5 (Evaluation framework) the proposed extensions were validation by categorizing the IT applications from the VAC (IT Application inventory of Vattenfall) in the area of distribution and generation. There was a drastic drop in the number of applications categorized under the Grid Maintenance and Operations and Plant Maintenance and Operations components. The difference in the new and old classifications of the applications displayed that the new classification provides a better categorization of the applications. The *uniqueness* of the FRM was observed and controlled during the application categorization. To further increase the acceptance of the proposed extensions, a few interviews were carried out with selected domain experts in the area of distribution and generation.

The existence of at least one application and in many cases more than one application in the new component boxes show that the proposed components represent functionality used with in the enterprise.

6 CONCLUSION

As described earlier, a FRM is a versatile tool for any enterprise. But in order to gain all the business values of having a FRM is it important to select a suitable FRM with reasonable coverage and resolution.

This research explored the use of international standards for system integration and vendor business maps as a FRM. Although the research framework was deployed in one large Nordic power utility the findings are generalized and can used by any utility. The results of the model comparison and evaluation between different standards and vendors is a good starting point for utility companies to adopt a complete vendor independent FRM for distribution and generation.

It was a good choice for the utility to use the SAP business map as the base model. But in order to cover technical areas where SAP has low coverage it is recommended to add the proposed extensions and create a model that covers the entirety.

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