Extending the SGAM for Electric Vehicles

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Summary

Within this contribution, the authors introduce the so called Smart Grid Architecture Model (SGAM) which has been developed anin the European Commissions' M/490 mandate. After having proved successful in day-to-day projects and especially standardization, the SGAM should be considered as state of the art to document smart grid architectures. However, as electric mobility and vehicles is considered a part of the overall Smart Grid, a better fit to this special domain can be achieved with tailoring the SGAM to an so called Electric Mobility Architecture Model (EMAM). This paper outlines the needed transfer process, provides an overview on standards to be applied and aligned, and a final recommendation how to use the EMAM in the very context with existing SGAM methodological processes.

1 Introduction to M/490 Results

Need for ICT use for the data exchange btw various components in the different processes.

A future smart grid is a complex system-of-systems or often also called a cyber-physical system. One particular important aspect in such distribution and transmission grids is the growing need for using information and communication technologies (ICT) for the needed data exchange between various components involved in processes [18]. Particular goals to be achieved by the smart grid may be related to aspects like the optimization and coordination of various elements and their operation in the power grid. For instance, for aspects of critical infrastructure protection, the level needed for different protection scenarios of components involved is rather ambitious and elevated. Also, the importance of the aspect of (system) availability and uptime for the electric power distribution system is considered high.

Additionally, the dependability of the Smart Grid infrastructure and its basic components highlights the focus of system and interface design even at design-time, before actual deployment. At design-time stage, interoperability and interchangeability have to be seriously taken into account to ensure a meaningful analysis of both technical and non-technical requirements [19]. To achieve this goal, one particular way is to standardize the needed technical solutions at international and national level to constitute dependencies between the various Smart Grid components.

To fulfil the imposed interoperability requirements in a more holistic way and to enable a smarter, ICT-controlled transmission and distribution grid, openness as well as the necessary amount of data exchange between participating parties and components inside a smart grid ecosystem has to rely on an agreed set of formal and meaningful concepts. This will lead to the standardization of data models, interfaces, processes, and communication protocols. Without standardization (e.g. in terms of data models and interfaces), the overall costs for integrating (distribution automation) components as well as applications would increase heavily due to the large number of new interfaces and processes involved in the critical infrastructure. After the first initiatives were raised by IEC (International Electrotechnical Commission) and NIST (Northern American's National Institute of Standards and Technology), the idea that standards do answer all those questions became apparent. The NIST framework and roadmap for interoperability as well as the European initiatives from the M/490 Smart Grid mandate focus on properly using, expanding, and adopting the IEC core standards as well as various related ones at second level.

The objective of the M/490 [1], [2] mandate has been developing and/or updating a set of needed and consistent standards from a common European perspective as well as integrating a large variety of digital computing and communication technologies and electrical architectures, their associated processes, and, finally, services. Business models are considered out of scope for standardization but have been included in the very foundational and methodological work of the mandate as well. The consistent set of standards shall achieve interoperability between them, and, thus, will enable and facilitate the implementation of different high-level Smart Grid services and functionalities in Europe as defined by the Smart Grid Task Force.

This set should be flexible enough to accommodate future developments from both utilities and OEMs. Building, Industry, EVs, Appliances (White Goods), and Home Automation are out of the scope of the M/490 mandate; however, their interfaces with the Smart Grid and related services have to be treated under this mandate as well.

The M/490 initiative was a huge leap forward in Smart Grid standardization for Europe in the first time after the

Joint-Working-Group (JWG) Smart Grids report. Within the M/490 mandate, the communication (ETSI), electrical engineering (IEC), and automation (ISO) organizations worked hand in hand for a common storyline and understanding to cover the integration of their best-practices using shared grid technologies and ICT. In addition, a link to the NIST initiatives was built with the Smart Grid Advisory Committee (SGAC) groups, regular discussions, and round-tables about architectures, roles, actors, domains, and use cases. One of the main items developed is the so-called Smart Grid Architecture Model SGAM [3] enabling a holistic architecture definition. The SGAM wil be in the very core of this contribution.

The remainder of this ETG paper is organized as follows: based on the Smart Grid Architecture Model SGAM overview in the section 2, section 3 outlines the urgent need for a transfer of the general design principles for new use cases like the Smart City Infrastructure Architecture Model SCIAM suggested by the German Standardization roadmap for Smart Cities as well as problems occurring when design principles are violated. For the German funding schema *"IKT für Elektromobilität II"*, we propose a possible solution for a better architectural modelling of aspects of electric vehicles and mobility concepts and their connection to the smart grid in Section 4. Section 5 concludes the paper with an outlook on future work and preliminary results from our projects dealing with the EMAM.

2 Smart Grid Architecture Model - SGAM

In the context of the European Commission's standardization mandate M/490 a general reference of an overall Smart Grid infrastructure named Smart Grid Architecture Model (SGAM) has been developed [21]. This work bases heavily on existing approaches and, thus, subsumes the different perspectives and existing methodologies of Smart Grid concepts.

In general, the SGAM comprises five basic viewpoint layers, which address different concerns in terms of interoperability issues, also addressing business aspects which are usually considered out of scope for the standardization but can be regarded as regulatory issues. These layers are named *Business, Function, Information, Communication, and Component*. They were adopted from the existing Gridwise Alliance Architecture Council (GWAC) stack and its so called context-setting framework (CSF). Therefore, the eight layers of the GWAC stack can be mapped onto the distinctive layers of the SGAM for needed backward compatibility of US approaches, like the NIST Conceptual (Cloud) Model or the context-setting framework of the Gridwise Alliance. Read more on this...

The *Business Layer* shows a Business viewpoint focusing on both strategic and tactical goals, business processes and business services as well as the aforementioned regulatory aspects. For standardization purposes, this layer could be considered out of scope. The *Function Layer* includes IT-oriented, technology independent descriptions of vague Smart Grid use cases, their functions and implemented technical services. The *Information Layer* provides information about data and information models to support the exchange of business objects and data models of the Function Layer to enable interface interoperability. The *Communication Layer* makes for modeling protocols and procedures for the data exchange between components based on the Information Layer. The *Component Layer* provides a way to cover a physical and technical view on Smart Grids components. Besides power-system related infrastructure and equipment, ICT-infrastructure and -systems are also considered as possible items.

Each of the layers consists of the five domains are subdivided into six zones. Domains are constituted according to organizational cohesion to allow for a simpler identification of organizational boundaries to identify inter-organizational interfaces. The domains are in particular made up from the supply chain of the energy sector in their order from generation to use. Accordingly, they are named Generation, Transmission, Distribution, DER, and Customer Premises.

The zones are defined according to zones of automation, i.e. from enterprise-level automation down to the process level. This is essential to distinguish between different types of used technologies and standards. The zones are named Market, Enterprise, Station, Operation, Field, and Process.

An overall graphical representation of the SGAM (the so called SGAM 3D cube) can be found in Figure 1.

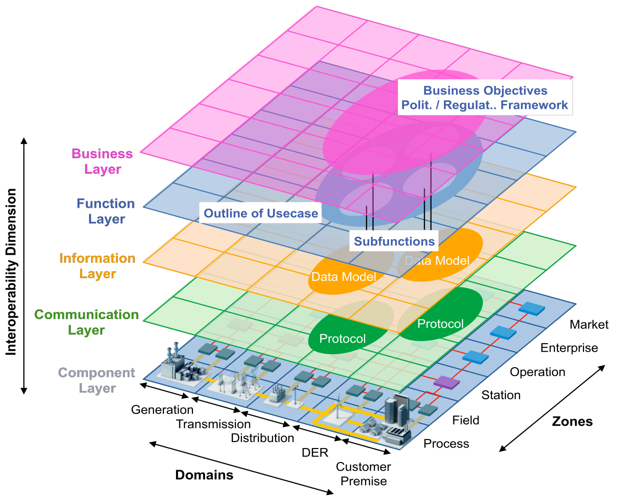

Figure 1: The SGAM reference designation model from the M/490

3 Design Principles for *AM frameworks

One of the original modeling paradigm aspects, also to align with the existing NIST work, was the use of a slightly compressed GridWise Architecture Council Interoperability [20] stack for the SGAM layers. It covers various aspects of interoperability between systems on individual levels. Figure 2 shows those adaptions made in order to reduce the complexity within the SGAM. This stack is also based on NEHTA Australian health-care models, re-using SGAM model paradigms shall also work with the more complex stack as well as in the health-care domain. These aspects shall be considered when derivatives of the original model are constructed.

If the stack can be agreed upon, the main challenge for adoption is the change of the domain and zone axis as well as the needed modelling granularity. Certain methods to be used in context with SGAM only work if the bag principle is not applied. The aspect of the axis is discussed in the next subsection.

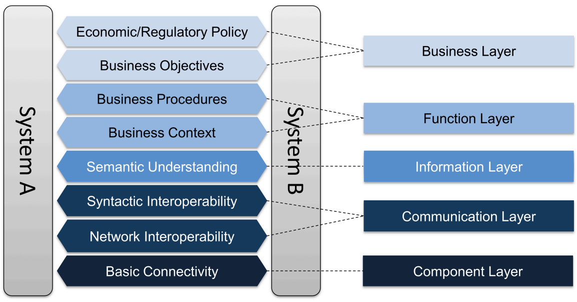

Figure 2: GWAC stack mapped onto M/490 levels

The SGAM provides a much needed tool for a static analysis of systems, their interdependencies as well as their context in the electricity value chain and the utilities' organizational dimension and structure [5]. Yet, no formal model has been defined to properly assess the semantics of the graphical elements to be painted on the SGAM canvas, however, some recommendations from the enterprise architecture context exist in the mandate work and other early approaches exist [4]. Prerequisites for filling out the SGAM model by standardized use case and user story descriptions have been evaluated and put in the very context of the SGAM meta-model in [6], [7].

The SGAM shall be used to create a description of static architecture states, i.e. of a current infrastructure, the possible data flows, the status of a (future) architecture envisioned, standards to be applied in the individual layer, domains and zones, and documenting overlap between standards. It has been solely developed with the focus given as in [5]. One of the key aspects is the visualisation of complex system-of-systems from a holistic perspective to show heterogeneous stakeholders, if they have to interact, and with whom [24].

Based on the original scope, the SGAM can be considered as a reference designation system from a modelers perspective.

The designation concept is derived from the original physical hardware design process in order to allocate certain parts and functions. As per definition, a reference designator unambiguously identifies a component in an electrical schematic or on a printed circuit board PCB. The reference designator usually consists of one or two letters followed by a number, e.g. R13, C1002. A letter sometimes follows the number, indicating that components are grouped or in relation with each other, e.g. R17A, R17B.

The so-called IEEE 315 series contains a list of Class Designation Letters to use for electrical and electronic assemblies. For example, the letter R is a reference prefix for the **r**esistors of an assembly, C for **c**apacitors, K for relays. Those schemes can be found in the power grid as well, e.g., in the IEC 61850 LN naming and definition rules.

The ISO/TS 81346-10:2015 [22] contains sector-specific stipulations for structuring principles and reference designation rules for technical products and technical product documentation of power plant, and therefore, it is applied within a lot of standards for finding MRIDs (Master Resource Identifier) with semantic background. It is applied in combination with the IEC 81346-2, ISO/TS 81346-3, VGB-B 101, and VGB-B 102 for the classification of systems and objects, and for function-, product-, and location-specific designation of technical products and their documentation for power plants and -systems.

The SGAM can be seen as a higher-level concept with a three-dimensional visualisation on top of those designators. The three dimensions of function-, product-, and location-specific can be re-visited in the SGAM in terms of the domains, zones, and layers. In general, due to its component-based approach, the location of a smart grid system can be seen in the domains and zones, making it possibly to take a value-driven as well as an automation-driven point of view on an asset. As the Smart Grid solutions or composed on individual systems making the solution up from a technological portfolio, the product viewpoint can be derived from those layers. Individual communication stacks as well as communication technologies can be assessed for CAPEX and OPEX costs. For the functional viewpoint, the function layer directly does the job. Therefore, the experts agreeing on using the SGAM can discuss various viewpoints and align their view on possible technical solutions using this reference designation approach.

Additionally, services can be made more transparent to show which devices at field level finally contribute in which way to the overall business function and result. Creating an SGAM model always leads to one system being exact at one place and layer [8]. Communicating about SGAM models has proven to be a useful solution in several EU FP 7 projects and national roadmaps [9]. Due to its success, different initiatives have tried to re-use the use case process and the system documentation process suggested by the SGAM.

Tools, like the SGAM toolbox [7], implemented in Sparx Enterprise Architect as a UML profile have proven to be useful to start a holistic requirements engineering [10] process and trying to re-use model-driven architecture engineering principles.

The most prominent adaptions are the Smart City Infrastructure Architecture Model (SCIAM) [11], [26], the DKE Smart Home Architecture Model (SHAM) [27], and the RAMI 4.0; the SCIAM can be seen in Figure 3.

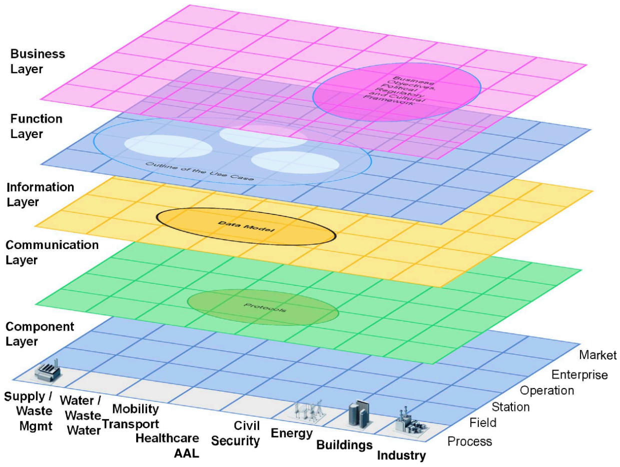

Figure 3: The Smart City Infrastructure Architecture Model

However, in the *SCIAM* there is a violation of the general SGAM principle in terms of the value chain for the domains [23]. The domains are in no particular, logical order, leading to the fact that systems which are used on a plane for, e.g., energy as well as AAL (e.g., Smart meter and Home Gateway) have to be put into the graphical representation twice, due to the fact, that the domain Civil Security is in between them in terms of the graphical representation. Similar problems exist for the SHAM with its zones; therefore, one main aspect of re-using SGAM modelling visualizations is the aspect of insisting on ordered items for domains and zones.

The Reference Architecture Model for Industry 4.0 *(RAMI 4.0)* is the most sophisticated derivative of the SGAM as of today, developed by ZVEI in Germany.

Based on the German Industrie 4.0 concept, the main aspect is the re-use of the GWAC interoperability stack. In addition to business, function, information, communication, and asset representing component, a new layer called integration is introduced. The domain and zone axis are not custom taxonomies but are based on the IEC 62890 value stream chain or the IEC 62264/61512 hierarchical levels, respectively.

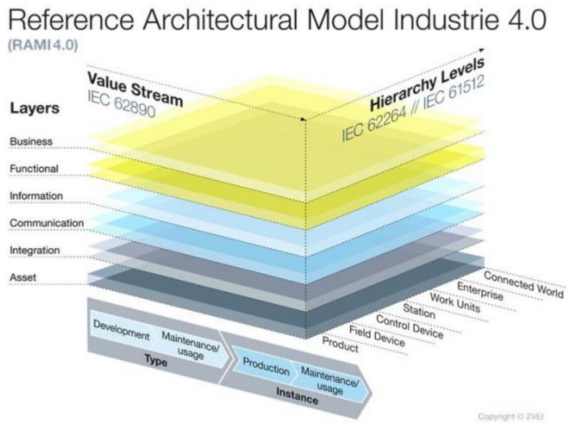

Figure 4: RAMI 4.0 by German ZVEI

The main purpose of the model is defined by ZVEI as follows: The model shall harmonize different user perspectives on the overall topic and provide a common understanding of the relations between individual components for Industrie 4.0 solutions. Different industrial branches, like automation, engineering, and process engineering, have a common view on the overall systems landscape. The SGAM principle of having the main scope of locating standards is re-used in the RAMI paradigm, also using it as a reference designation system.

The next steps for proceeding with the modelling paradigm is to come up with “101 Examples” for Industrie 4.0 solutions in the RAMI, provide proper means for the devices to be identified, and provide discovery service modelling for those devices, harmonize both syntax and semantics, and focus on the main aspect of the integration layer which was introduced in order to properly model the communications requirements in factory automation. The proposed EMAM shall adhere to the principles depicted.

4 The EMAM – Developing the Domain and Zone Model

Recent work [28] has been done to transfer the overall SGAM concept to deal with electric vehicles and charging infrastructure, thus, making all analyses functions and modelling for the SGAM-like standards assignment, technical migration paths, risk assessment to technical components, and reliability calculation also available for this sub-part of the smart grid domain. Previous work has been done by [12], proposing the re-use of SGAM with no emphasized focus on the design principles and use cases for SGAM communication. This contribution will elaborate more on this issue.

The German DKE originally pointed out the following focus in their electric vehicles roadmap:

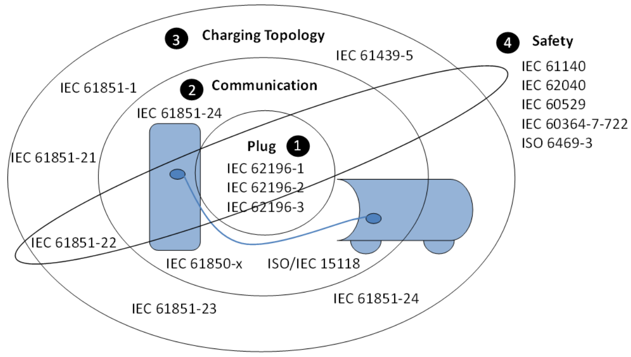

Figure 5: View from German DKE on needed standards

The main focus is on car inlet, cable, plug, pole, and safety as crosscutting issues. Aspects of billing, roaming, etc. were not originally seen as core problems (but have been ever since). But still, those aspects, extended by the physical parking situation or the enterprise level can make a good zone axis.

A meaningful morphological analysis on EV integration into the grid is provided in [13] to outline scenarios for EV to derive an architecture for information systems and the corresponding communication requirements.

Later work of the authors [14] proposes to adapt the SGAM for EV purposes shortening the zonal dimension by field and process, renaming its scope and distinguish in the domain character between moving infrastructure and immobile infrastructure.

Still, the SGAM is considered a good base. As the German standardization roadmap points out, the following interfaces are the most important ones from their point of view:

- vehicle – charging infrastructure
- vehicle – user
- vehicle – energy trade
- charging infrastructure – grid
- charging infrastructure – energy trade
- charging infrastructure – charging infrastructure operators
- charging infrastructure operators – billing and payment services
- user – billing and payment services
- user – charging infrastructure (e.g. reservation of publicly available charging stations)
- charging infrastructure operators – user
- vehicle – service
- vehicle – billing and payment services

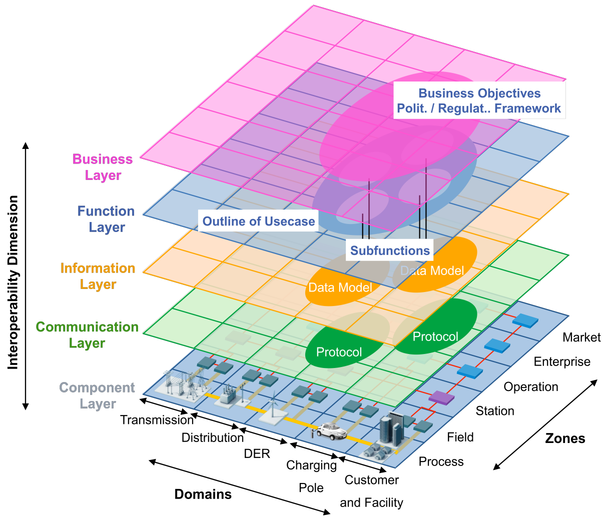

Figure 6: First Draft of the EMAM [28]

From the view of the final report of the M/468 EV mandate, the following overall systems (or: rather role) architecture has been derived/ identified:

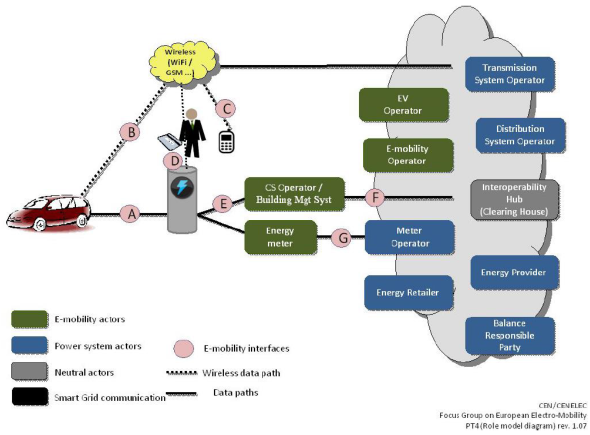

Figure 7: M/468 role model diagram and interface classes

One of the most important aspects of changing the SGAM towards a new or different domain is the proper application of defining a meaningful for the domain and zone axis. Domain and zone are normally defined from the reference designation point of view just like domain and range in the W3C RDF standards. The domain typically covers the coarser granularity with less details and the zone implementation aspects for the individual organizations in scope with the overall model and how the act in the different domain facades. The next subsection discusses briefly what has to be focused on when defining domains and zones.

When deriving new models, it is sometimes tempting to fill up the three axes with all envisioned entries. This is often due to the fact that a four-dimensional model would be harder to handle. This approach often leads to two effects that are detrimental to the usability: (i) The axes are overloaded with too many entries, and (ii) the entries along the axes are organized in a non-contiguous manner, i.e., adjacent entries are not connected in a geographical, hierarchical, or logical sense. In the original SGAM, the contiguity along each axis is an important factor in the usability of the model: the domains reflect the domains of energy generation, transmission, and distribution in this order, the zones are reminiscent of the hierarchical SCADA pyramid ranging from a wide scope to a narrow scope, and the layers are organized from abstract business goals to concrete physical components. In derived models, this contiguity is often weakened or completely broken.

We suggest changing the SGAM as little as possible to get the highest compatibility with existing methods, metamodels, and tooling, and changing only limited aspects of the domain value chain. The aspect for immobile assets and mobile assets is taken into account, but it has to be kept in mind that SGAM has no dimension of time, so all aspects shall be treated static. This and the aforementioned aspects lead to the following proposal for the EMAM in a first edition to be put into evaluation in day-to-day projects just like the SGAM.

As figure 5 and 7 have pointed out, other perspectives can be taken when discussing the domain and zones for an EMAM model. The communication requirements can be fulfilled by the IOP layers from the perspective of the electric vehicle domain. As for the zones, we suggest an approach taking into account the DKE and M/468 by using the following physical perimeters at the zonal axis.

The order of the zones shall be as follows: *In-Car, Plug, Cable, Pole, PCC (point-of-common coupling), Grid*, always starting at the right lower level. Those levels pretty much set the communications flow between the needed interfaces at a semantic level, also making it possible to align with in-car models like AUTOSAR.

The plug level shall to used to provide a view on external information to the car (like, e.g. providing a possible state-of-charge), the cable zone shall represent to communication path to the pole and the pole the connections to the electrical grid. At PCC zone, the home or microgrid is connected to a larger distrubution grid, either at MV or LV. This level shall be used to communicate about services needed from the communications perspective at this level. The sixth zonal level is the grid level, where e.g. aggregators to communicate to use car pools like a virtual power plant.

As for the domain dimension or axis, we suggest the following starting on the left hand side of the domain axis. Here the axis shall resemble the energy distribution chain, but in a finer way from the granularity perspective. *Distribution, DER, Building, HEMS/HMI and EV battery* from the 5 needed axis. One could argue, whether they shall be extended like the SGAM by transmission and generation, we we argue that then an EV use case would be subject to SGAM rather than EMAM if those domains were of higher importance. Also, the interfaces for the services can be aligned to the individual responsibilities on the domain axis. The distribution grid or the DER provides the energy, the building can act as a hub and distribute through the HEMS to the battery. This could make for a meaningful axis of electricity flow.

5 Conclusions

This contribution presents the SGAM as a standardized, accepted way to describe smart grid architectures in the form of models and visualization in the SGAM cube. Additionally, extensions based on the SGAM were presented as well as design and use principles were discussed. Based on previous work, we proposed to adhere to those principles creating a so-called Electric Mobility Architecture Model (EMAM) which has been discussed beforehand.

The EMAM is still work in progress and future work will elaborate formal models supporting the definition of EMAM architectures and analyses based on that foundation.

As discussed before, the SGAM is not only transferred to different application domains, but also for the Smart grid, new scopes have been defined. One particular aspect in the integration of the SGAM with the IntelliGrid 62559 template in terms of UCMR applications, making documented use cases to be meaningful to be used in context with SGAM, re-using functions, actors and non-functional requirements. In addition, tooling, like the SGAM toolbox or EdFs Modsarus implemented in Sparx Enterprise Architect [25], visualising and manipulating SGAM graphical models to the individual needs of highest interest as SGAM is used to communicate about Smart Grid solutions

Furthermore, the EMAM will be checked for modelling all scenarios described in [15], [16], and [17] in the context of the IKT-EM II program and the M/490 mandate. New visualisations, like the ones developed in 3D for the RAMI 4.0, can be used to properly interact with the reference designation models at operational level in projects. Figure 8 shows a current demonstrator, which can interactively be changed to highlight layers, systems and use tool-tips to show meta-data of the individual systems shown in the example loaded.

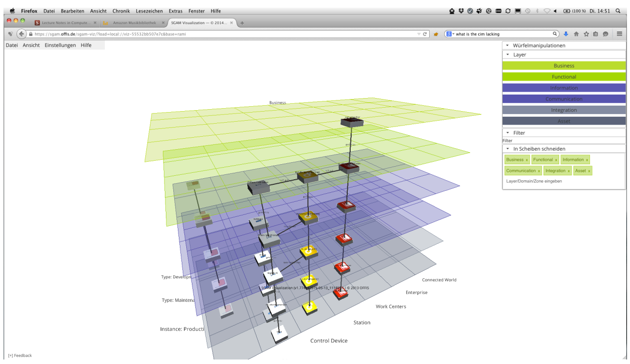

Figure 8: RAMI 4.0 Yoghurt filling example in 3D and browser plugin

We plan to extend our RAMI work to the proposed EMAM model and discuss our proposed domains and zones with the projects form the IKT EM II funding schema.

6 References

[1] CEN, CENELEC, and ETSI, "Final report of the CEN/CENELEC/ETSI Joint Working Group on Standards for Smart Grids," May 2011.

[2] European Commission, "M/490 Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment," March 2011.

[3] Uslar, M., Specht, M., Dänekas, C., Trefke, J., Rohjans, S., Gonzalez, J.M.,Rosinger, C., and Bleiker, R. Standardization in Smart Grids. Berlin, Germany: Springer-Verlag, 2013.

[4] Santodominigo, R., Uslar, M., Göring, A., Gottschalk, M., Nordström, L., Saleem, A., & Chenine, M. : SGAM-based Methodology to Analyse Smart Grid Solutions in DISCERN European Research Project. In: Proceedings of the IEEE EnergyCon 2014.

[5] Englert, H., & Uslar, M.: Europäisches Architekturmodell für Smart Grids - Methodik und Anwendung der Ergebnisse der Arbeitsgruppe Referenzarchitektur des EU Normungsmandats M/490. In VDE-Kongress 2012 - Intelligente Energieversorgung der Zukunft, Stuttgart, 2012.

[6] Trefke, J., Rohjans, S., Uslar, M., Lehnhoff, S., Nordstrom, L., & Saleem, A.: Smart Grid Architecture Model use case management in a large European Smart Grid project. In: *Innovative Smart Grid Technologies Europe (ISGT EUROPE)*, 2013 4th IEEE/PES (pp. 1–5). doi:10.1109/ISGTEurope.2013.6695266.

[7] Dänekas, C., Neureiter, C., Rohjans, S., Uslar, M., & Engel, D.: Towards a Model--Driven--Architecture Process for Smart Grid Projects. In: *Digital Enterprise Design and Management DED&M 2014* (pp. 47– 58). Springer International Publishing. doi:10.1007/978--3--319--04313—55.

[8] Kellendonk, P., Kiessling, A., Uslar, M., Trefke, J., Gonzalez, J., & Stein, J. : Definition von Use Cases in der Normung - Basis für eine aktive Beteiligung privater Haushalte im Smart Grid. In *Internationaler ETG-Kongress 2011 in Würzburg*.

[9] Apel, R., Benze, J., Eger, K., Fries, S., Harner, A., Hemberger, K., et al: Normungsroadmap Smart Grid /E-Energy 2.0: Status, Trends und Perspektiven der Smart Grid-Normung. DKE, 2012.

[10] Rohjans, S., Danekas, C., & Uslar, M. (2012). Requirements for Smart Grid ICT-architectures. In: *Innovative Smart Grid Technologies (ISGT Europe), 2012 3rd IEEE PES International Conference and Exhibition on* (pp. 1–8). doi:10.1109/ISGTEurope.2012.6465617.

[11] DKE: Die deutsche Normungs-Roadmap Smart City, 2014.

[12] EU FP7 project FINSENY D5.3: Electric mobility functional ICT architecture Description, 2013.

[13] Fluhr, J. and Lutz, T.: Use Case Types for Communication with and for Electric Vehicles (EV), 17th International Conference on Concurrent Enterprising ICE 2011.

[14] Schuh G.; Fluhr, J.; Birkmeier, M.; Sund, M.: Information System Architecture for the Interaction of Electric Vehicles with the Power Grid, IEEE Publishing 2013.

[15] Mayer, C., Suding, T., Uslar, M., & Weidelt, T.: IKT-Integration von Elektromobilität in ein zukünftiges Smart Grid. In *VDE-Kongress 2010 - E-Mobility: Technologien - Infrastruktur - Märkte in Leipzig*. VDE Verlag, Berlin, 2010.

[16] Mayer, C., Tröschel, M., & Uslar, M. (Eds.). : *Elektromobilität: Geschäftsmodelle, Kommunikation und Steuerung*. VDE Verlag, Berlin, 2012.

[17]Arnold, G., Bülo, T., Bukvic-Schäfer, S. A., Degner, T., Nauck, E., Schütte, S., Weidelt, T. et al.: Studie Markt-übersicht Kommunikation/Steuerung im Auftrag der Initiative Elektrofahrzeuge intelligent am Netz (ELAN 2020). (M. Landau & C. Mayer, Eds.). Bdew, 2010.

[18] Rohjans, S., Dänekas, C., Uslar, M.: Requirements for smart grid ICT-architectures. In: *3rd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies (ISGT Europe)*, IEEE, 2012.

[19] Postina, M., Rohjans, S., Steffens, U., and Uslar, M.: Views on Service Oriented Architectures in the Context of Smart Grids. In: *First IEEE international conference on Smart grid communications (SmartGridComm),* IEEE, 2010.

[20] Uslar, M.. Semantic interoperability within the power systems domain. Proceedings of the First international workshop on Interoperability of heterogeneous information systems, ACM Sheridan Publishing, 2005.

[21] Bruinenberg, J. Colton, L. Darmois, E., Dorn, J. Elloumi, O., Englert, H. Forbes, R. Heiles, J. Hermans, P. Kuhnert, J., Rumph, F. J., Uslar. M., and-Wetterwald, P.: Smart grid coordination group technical report reference architecture for the smart grid version 1.0. Technical report to CEN, CENELEC, ETSI, 2012.

[22] ISO and IEC. IEC 81346-1:2009- Industrial systems, installations and equipment and industrial products Structuring principles and reference designations Part 1: Basic rules , ISO, 2009.

[23] IEC SEG 1. Report of SEG 1, Smart Cities to the IEC SMB, 2015.

[24]Andren, F., Strasser, T., Rohjans, S., and Uslar, M.. Analyzing the need for a common modeling language for Smart Grid applications. 11th IEEE International Conference on Industrial Informatics (INDIN), 2013, IEEE Publishing.

[25] Uslar, M., Rohjans, S., Specht, M., and Gonzalez,J. M.. What is the CIM lacking?. Innovative Smart Grid

Technologies Conference Europe (ISGT Europe), 2010 IEEE PES.

[26] DKE/DIN and VDE. The German Standardization Roadmap Smart City: a Concept , Version 1.0, 2015.

[27] DKE/DIN and VDE. The German Standardization Roadmap Smart Home and Building , Version 1.0, 2015.

[28] Uslar, M and Trefke, J.: Applying the Smart Grid Architecture Model SGAM to the EV Domain. EnviroInfo 2014: 821-826