Fergal McCaffery
Rory V. O'Connor
Richard Messnarz (Eds.)

Communications in Computer and Information Science 364

Systems, Software and Services Process Improvement

20th European Conference, EuroSPI 2013
Dundalk, Ireland, June 2013
Proceedings

Springer

SPI and Measurement

Customer-Driven Software Product Development Software Products for the Social Media World – A Case Study 300
Thomas Fehlmann and Eberhard Kranich

Risk Management and Functional Safety Standards

Framework to Assist Healthcare Delivery Organisations and Medical Device Manufacturers Establish Security Assurance for Networked Medical Devices 313
Anita Finnegan, Fergal McCaffery, and Gerry Coleman

Implementing Functional Safety Standards – Experiences from the Trials about Required Knowledge and Competencies (SafEUr) 323
Richard Messnarz, Christian Kreiner, Ovi Bachmann, Andreas Riel, Klaudia Dussa-Zieger, Risto Nevalainen, and Serge Tichkiewitch

Automotive Knowledge Alliance AQUA – Integrating Automotive SPICE, Six Sigma, and Functional Safety 333
Christian Kreiner, Richard Messnarz, Andreas Riel, Damjan Ekert, Michael Langgner, Dick Theisens, and Michael Reiner

Experience with an Integrated Risk Management Process in the Medical Regulatory Environment 345
Botond Tényi, Adrien Csík, Ibolya Monoki, and Ferenc Tegzes

Author Index 355

Automotive Knowledge Alliance AQUA – Integrating Automotive SPICE, Six Sigma, and Functional Safety

Christian Kreiner[1], Richard Messnarz[2], Andreas Riel[3], Damjan Ekert[2], Michael Langgner[4], Dick Theisens[5], and Michael Reiner[6]

[1] Graz University of Technology, Austria
christian.kreiner@tugraz.at
[2] ISCN LTD/GesmbH, Ireland and Austria
rmess@iscn.com
[3] EMIRACLE Association, Belgium
[4] Automotive Cluster Austria, Austria
[5] Symbol BV, Netherlands
[6] European Certification and Qualification Association, Europe

Abstract. This paper discusses (based on the EU project AQUA) how the core elements of three complementary approaches and standards can be integrated into one compact skill set with training and best practices to be applied. In this project experts from Automotive SPICE (ISO 15504), Functional Safety (ISO 26262) and Lean Six Sigma collaborate. In a first analysis the experts identified an architecture of core elements where all three approaches fit together and where a holistic view about improvement is needed. The Automotive Clusters from Austria and Slovenia are trial partners and will roll out this knowledge in pilot courses to the industry. Other Automotive Clusters showed interest and will join the trial phase.

Keywords: Automotive SPICE, Functional Safety, Lean Six Sigma, Integrated View.

1 Introduction

Electronics and software control 70% of modern cars' functionality; studies predict 90% and more tomorrow. The induced system complexity makes it increasingly difficult for automotive companies to master interdisciplinary, horizontal issues such as quality, reliability, and functional safety.

Moreover, the ISO 26262 reference standard for road vehicles has been released only very recently. Consequently, existing knowledge is rare, and highly specialised on teaching the standard rather than its practical implementation. This is where competition is happening in automotive worldwide, and where Europe can create a competitive advantage.

In the Automotive Cluster Austria they currently discuss "Can we still manage the complexity of software and electronics in cars?" [1], and come to the conclusion that such integrated automotive and safety engineering best practices are needed.

F. McCaffery, R.V. O'Connor, and R. Messnarz (Eds.): EuroSPI 2013, CCIS 364, pp. 333–344, 2013.

Key Notes about Functional Safety at EuroSPI 2012 illustrated that functional safety is increasingly important for the success on the market:

The EuroSPI 2012 key note from the KTM quality head stated: “It is important to show a way of effective integration of the process and the methods of functional safety for a medium-sized business based on pilot projects. The principle of these projects is to acquire expert knowledge via practical execution of the work products and simultaneous training.”

The EuroSPI 2012 key note from a Magna program manager of a highly safety critical product line states that “for Tier 1 suppliers of mechatronic systems it is inevitable today to comply with standards like Automotive SPICE and ISO 26262 (Functional Safety for Road Vehicles). This can lead to substantial on-top costs and a lot of additional effort if especially requirements management is not implemented in a smart way."

A group of industry partners from Automotive and medical device industry joined a workshop series at EuroSPI and collaborate in task forces since 2003 which was kick-off financed for one year by the Bavarian software initiative. This group published a number of papers about their integration of Automotive SPICE and Functional Safety in an integrated approach [2], [3], [4].

The Lean Six Sigma Academy published papers about EuroSPI emphasising the implementation of Lean Six Sigma in Europe applying the Toyota success story in Europe. They presented different levels of six sigma experts (yellow, orange, green, black belt) and contributed examples of success stories.

Automotive SPICE, Functional Safety standards, and Lean Six Sigma in a way form the quality backbone of the automotive industry. Only such common standards enable highly integrated supply chains as we find them in automotive industry. For a participating company this means competence and ability in all these areas is a priority.

Also the Automotive Clusters reported that - while there is a limited number of Tier 1 companies in the market - there are hundreds of Tier 2 and Tier 3 small and medium sized companies. They do not have the time to invest in each of the three approaches separately and they need an integrated compact view which can be implemented (as much as possible related to real practice).

The EU project AQUA proposes such a compact integration of core elements and will create training which is delivered through the Automotive Clusters.

2 Modular Integration Strategy

We illustrate the AQUA architecture in Fig.1 below. In AQUA a base layer of core modules will be established which allow an integrated and complementary view about the three approaches, including Automotive SPICE, Functional Safety, and Lean Six Sigma. Integrated means, the base layer modules extract and teach common paradigms and principles - “the essence” - from the latter, and the link layer expresses the mapping or translation to Automotive SPICE, Functional Safety, and Lean Six

Sigma. In this way, the complexity of learning and mastering all three standards can be significantly reduced.

From the core modules AQUA also develops a linking layer which references the parts addressed in the existing and established approaches, such as Automotive SPICE, Functional Safety, and Lean Six Sigma.

Also the AQUA project maps the key words which the partners in the Automotive clusters need to address onto the core modules which we propose in AQUA.

The Automotive Clusters stated that these core modules must contain enough best practice examples so that based on the core modules an implementation in the projects can be done. A selected set of experts in the company will be recommended to the full courses (see link to existing and established approaches and courses (= layer of existing courses on the market).

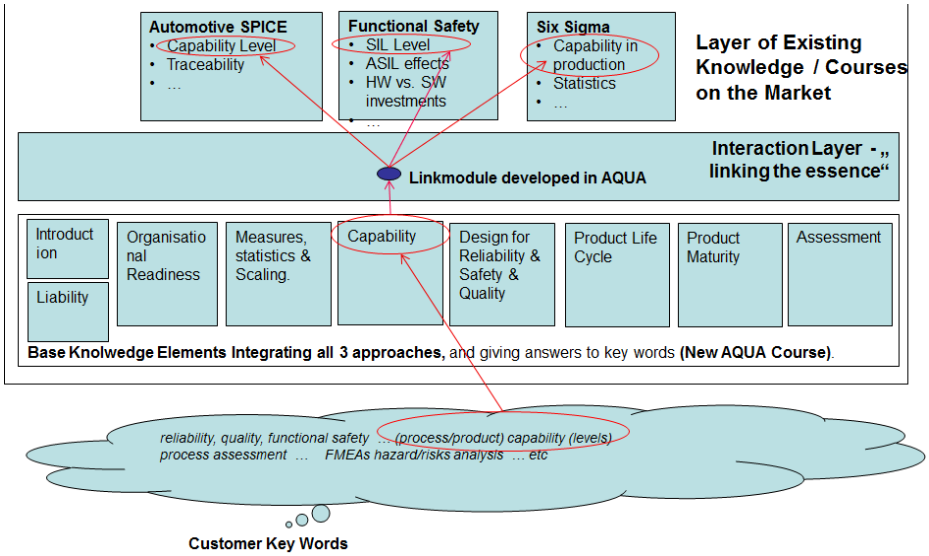

Fig. 1. Integrated Base Modules Concept of AQUA and Linking Strategy

The functionality of this architecture in Fig.1 can be illustrated based on a key word based “signal” flow (see the arrows in Fig.1).

If you take the key word “capability” it has three different meanings although it is used by all three approaches. Thus in a core module the concept of capability is explained from the three perspectives. In Automotive SPICE [5] the capability levels are derived from process capability levels based on ISO 15504 (the capability of an engineering process such as ENG.5 Software Design). In ISO 26262 the Safety Integrity Levels ASIL-A to ASIL-D are originally derived from IEC 61508 and represent a specific redundant hardware design and hardware FIT rate (1 FIT is equal to a probability of 10-9 that an error occurs in an hour) and corresponding diagnostic coverage by software to avoid that failures of the electronic lead to hazardous situations for the driver. So this SIL is a kind of product maturity level. And in Six

Sigma the capability relates to the production capability which means that by statistical quality control the number of faults in introduction is reduced to achieve 6-sigma deviation. This is also needed in Automotive because the contracts in Automotive mention ppms (Parts per Million Errors) which need to be achieved and contracts contain less than 100 ppm.

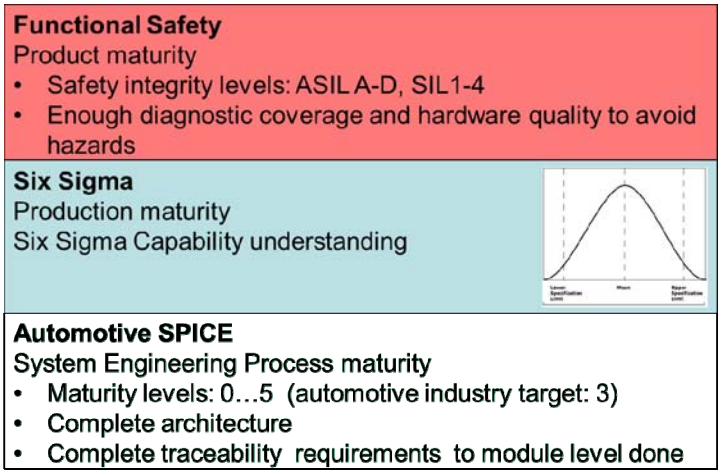

Fig. 2. Example Skill Element – AQUA Module – U2.E2 – Capability

As outlined in Fig.2, AQUA will create a three dimensional view on key terms, broadening the mind set of Automotive companies to understand and implement capability from three angles: process capability, product capability, as well as production capability. It is obvious that it would be best to cover all three aspects at once in a holistic quality and engineering approach.

3 Overview of the Proposed AQUA Core Modules

The following module architecture for AQUA (see the base layer in the architecture in Fig.1 above) has been elaborated in a kick off workshop with experts from Automotive SPICE, Six Sigma, and functional safety.

Each module fulfills the following criteria:

- The module addresses key words which the Automotive Clusters addressed as a requirement for the members
- The module integrates the view of the three approaches in one holistic concept for process capability, product capability, and production capability
- The module can be linked to specific content in the established certification and course programs of Automotive SPICE, Functional Safety, and Lean Six Sigma

Also the modules are mapped onto the skills set definition standards of ECQA [7] (European Certification and Qualification Association). ECQA established Europe wide standards for skills definitions, skills assessment, online teaching and Europe wide exams following standard procedures. In ECQA the competencies are structured in so called skills sets (see Fig. 3 and Fig.4)

A **DOMAIN** contains
JOB ROLES, which contain
UNITS, which contain
ELEMENTS, which contain
PERFORMANCE CRITERIA, which must be proven by
EVIDENCES.

Fig. 3. Standard Skills Set Architecture (ECQA)

- Introduction
  - U1.E1: Overview of Standards and Norms
  - *U1.E2: Liability*
  - U1.E3: Organisational readiness (&continuous improvement)
- Measurement
  - U2.E1 Measures/Statistics/Scaling
  - U2.E2 Capability in 3 dimensions (metrics)
- Engineering
  - U3.E1: Design for Reliability & Safety & Quality (Structure)
  - U3.E2: Design for Reliability & Safety & Quality (Tools)
- Product lifecycle
  - U4.E1: Life cycle (V-model (VDA 6.1), traceabilty, methods, sfty LC, APQP)
  - U4.E2: Product maturity (traceabilty, DC+V&V methods, APQP DVP&P (18)
- U5.E1: Assessment

Fig. 4. AQUA Skills Set Architecture (ECQA compliant)

Each AQUA module has been assigned to a specific unit and skills element based on an overall skill set architecture. For each module three complementary views of knowledge are considered, looking at the topic based on Automotive SPICE, functional safety, and Six Sigma.

Here is a list of the core modules and the main content topics.

All three approaches help to avoid costs related to liabilities / penalties (see Fig.7). While functional safety addresses liabilities due to injuries and casualties due to hazardous errors of the electronics, the Six Sigma helps to avoid penalties due to not reaching specific ppm rates or start of production milestones. Automotive SPICE assures that you can demonstrate capability needed to get the contracts with customers. Failing in one of these three perspectives can cause a lot of costs for the company.

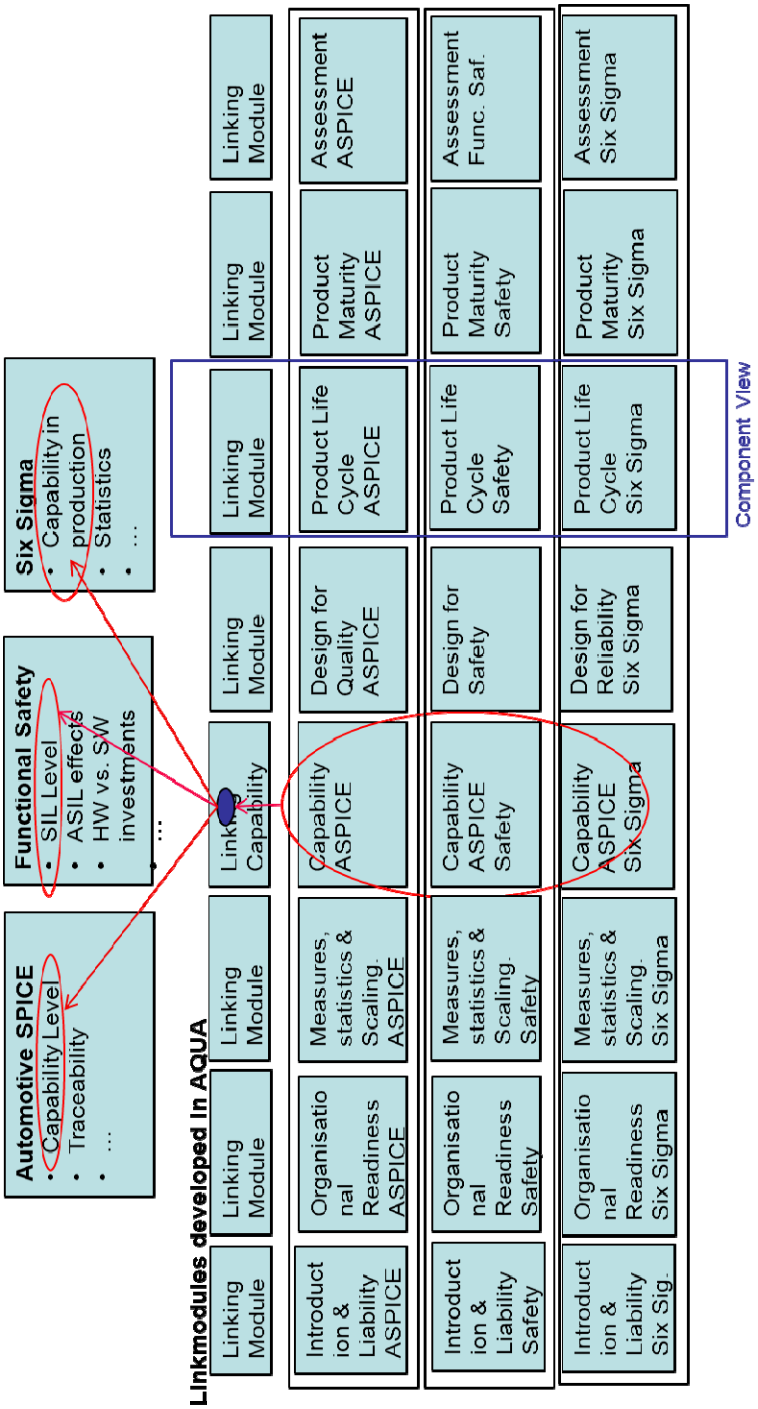

Fig. 5. AQUA course structure: each component (an ECQA element) consists of core modules from ASPICE, Safety, Six Sigma, plus a linking/consolidation module

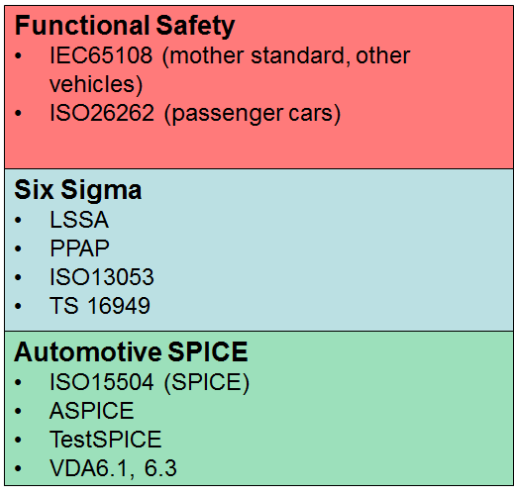

Fig. 6. Integrated View – U1.E1 Introduction/ Overview of Standards

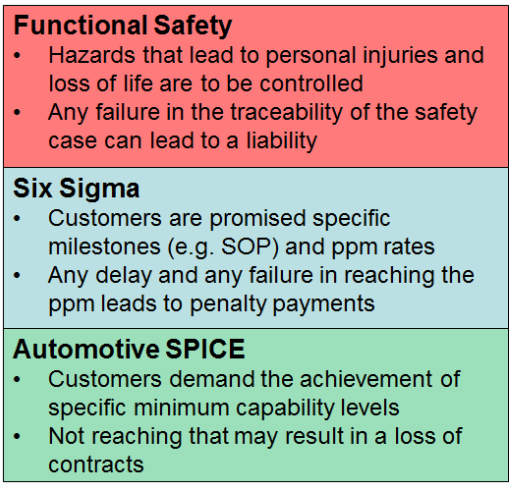

Fig. 7. Integrated View – U1.E2 Introduction/ Liability

Each of the three approaches (see Fig. 8) has a specific understanding of a required organizational structure. In Six Sigma improvement projects are managed for improving the production capability helping to avoid cost of errors, A Green Belt manages improvement projects, a Black Belt managers the team of Green belts and organizes larger scale improvement projects. Yellow Belts are staff which understand statistical basics and apply the measures in the production (help to gather the data). In

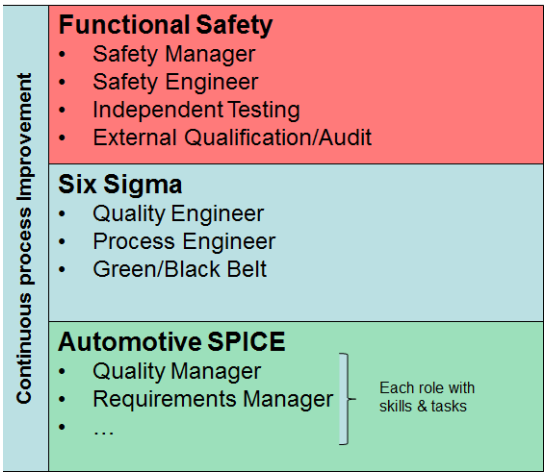

Fig. 8. Integrated View – U1.E3 Introduction/ Organisational Readiness

functional safety management there are safety managers who are responsible for the safety plan, the safety life cycle, and managing the safety case (starting from a hazard and risk analysis). And the functional safety engineers are experienced architects who are responsible for the functional safety requirements, the technical safety concept, etc. In Automotive SPICE there are different management, supporting and engineering processes and each process requires specific roles (e.g. a requirements manager, a configuration manager, a software tester, etc.).

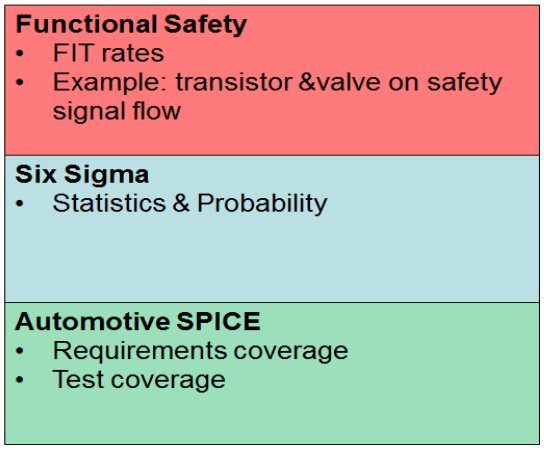

Fig. 9. Integrated View – U2.E1 Measures / Statistics / Scaling

All three approaches demand the use of statistical measures (see Fig.9), but all three use metrics on a different level. In Automotive SPICE the metrics are used to prove that the engineering is complete, e.g. coverage of all requirements in the specification, coverage of all requirements in the test, coverage of all requirements in the design, etc. In functional safety the hardware metrics are used to evaluate the probability per hour that the hardware fails (FIT=10^{-9} probability that the hardware fails per hour) and the required coverage of hazardous error by software diagnostics (in percent). And in Six Sigma the probability theory and statistical process control are used to predict the number of errors in production.

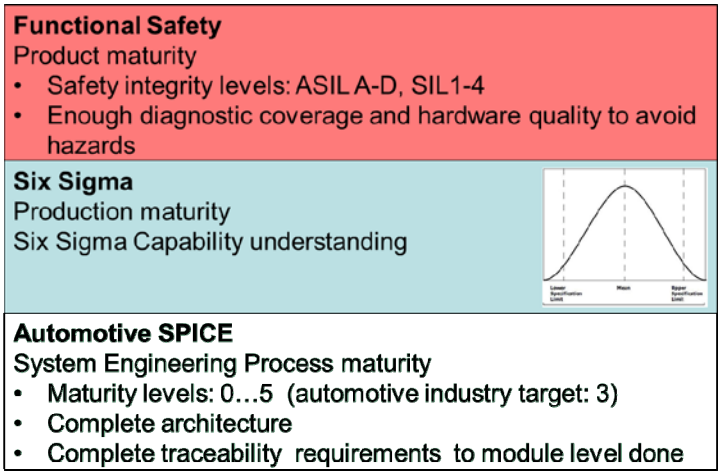

Fig. 10. Integrated View – U2.E2 Capability in 3 dimensions

All three approaches (see Fig. 11) demand a specific set of processes and methods to be implemented. In functional safety the safety critical path (from sensors to electronics / software to actuators) is analyses in an item definition and depending on the safety integrity level the redundancy of hardware and diagnostic capability of software is derived. Tools used are H&R (hazard & risk analysis), FMEDA (Failure Modes, Effects and Diagnostic Coverage Analysis), Signal Flow Design, Technical Safety Concept, HSI (Hardware Software Interface), etc. In Automotive SPICE assessment tools are used to determine capability levels and derive improvement actions. The Automotive SPICE model emphasizes the use of tools to establish traceability throughout the engineering (e.g. traceability of requirements to design). In Six Sigma tools are used to preventively identify weaknesses (e.g. DOE – Design of Experiments, e.g. DFMEA – Design FMMEA), and a cluster of statistical tools to control the production, as well as tools to analyse the production flow / optimization (CTQ flow).

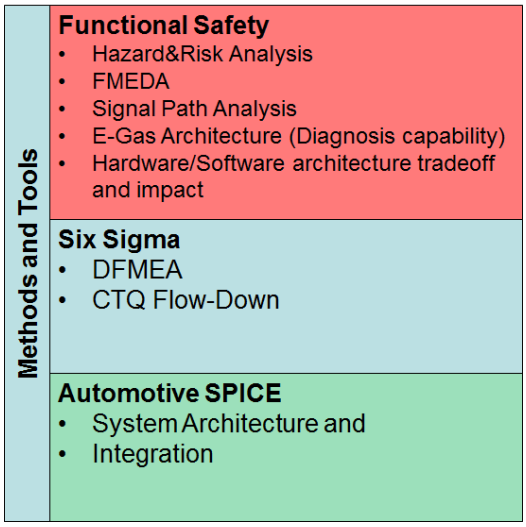

Fig. 11. Integrated View – U3.E1 Design for Reliability & Safety & Quality ("Design for 0 Errors") & U3.E2 Tools

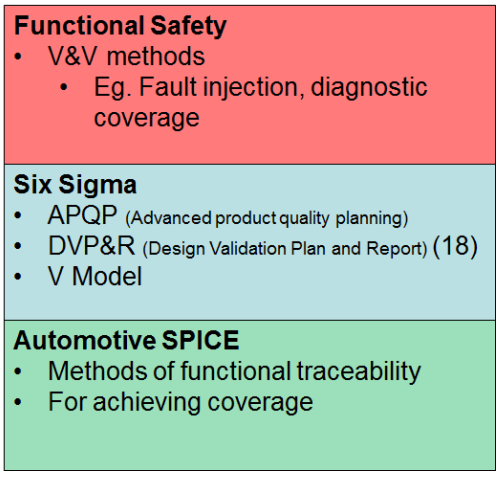

Fig. 12. Integrated View – U4.E1 Product Lifecycle

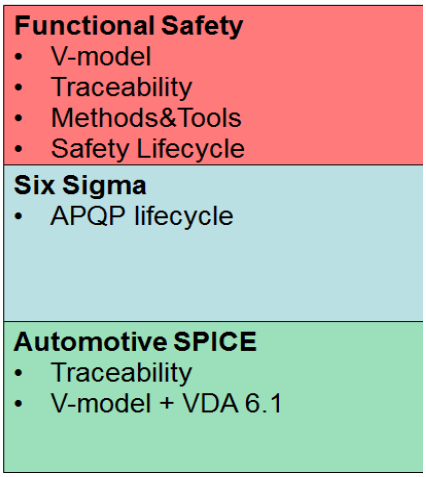

Fig. 13. Integrated View – U4.E2 Product Maturity

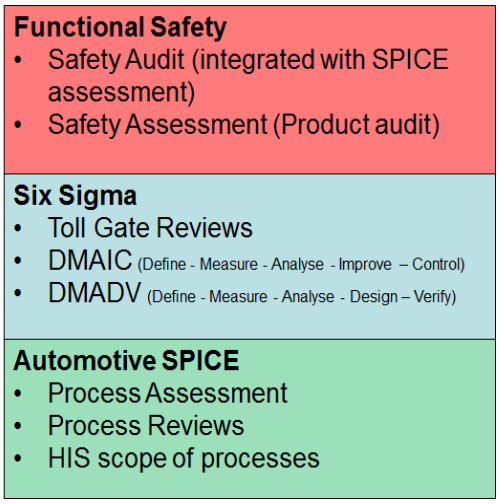

Fig. 14. Integrated View – U5.E1 Assessment

4 Conclusion and Outlook

The Automotive Knowledge Alliance (AQUA) was formed to bring together Automotive SPICE (ISO 15504), Functional Safety (ISO 26262) and Lean Six Sigma under one skills framework. The architecture of this modular framework is symmetric, that means, skills, methods, and practices from all three areas are not only offered in isolated skill sets and courses, but also in a synoptic way organized and linked by common concepts across all three areas. From that we expect better integrated understanding and practicing Automotive SPICE, Functional Safety, and

Lean Six Sigma within one organization, as well as more effective learning by offering a new paradigm of course structuring.

Furthermore a Europe-wide recognized certification scheme will be offered via the European Certification and Qualification Association (ECQA).

The modular AQUA architecture will be reviewed by industrial partners and based on this feedback the structure will be refined. The development of knowledge modules as course modules starts in the mid of 2013 and by end of 2013 a first version of elaborated materials will be available for interested partners of Automotive Clusters across Europe.

Acknowledgement. The AQUA project is financially supported by the European Commission in the Leonardo da Vinci part of the Lifelong Learning Programme under the project number EAC-2012-0635.

This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

References

[1] Automotive Cluster Austria. AC Quarterly Magazine (February 2012)
[2] Riel, A., Bachmann, V.O., Dussa-Zieger, K., Kreiner, C., Messnarz, R., Nevalainen, R., Sechser, B., Tichkiewitch, S.: EU Project SafEUr – Competence Requirements for Functional Safety Managers. In: Winkler, D., O'Connor, R.V., Messnarz, R. (eds.) EuroSPI 2012. CCIS, vol. 301, pp. 253–265. Springer, Heidelberg (2012)
[3] Messnarz, R., König, F., Bachmann, V.O.: Experiences with Trial Assessments Combining Automotive SPICE and Functional Safety Standards. In: Winkler, D., O'Connor, R.V., Messnarz, R. (eds.) EuroSPI 2012. CCIS, vol. 301, pp. 266–275. Springer, Heidelberg (2012)
[4] SOQRATES Safety Team, Messnarz, R., Ross, H.-L., Habel, S., König, F., Koundoussi, A., Unterrreitmayer, J., Ekert, D.: Integrated Automotive SPICE and safety assessments. Wiley SPIP 14(5), 279–288 (2009)
[5] Automotive SPICE, an international standard used in Automotive industry, http://www.automotive-spice.com
[6] Theisens, D.: How Green is your Black Belt. In: Riel, A., O'Connor, R., Tichkiewitch, S., Messnarz, R. (eds.) EuroSPI 2010. CCIS, vol. 99, pp. 257–267. Springer, Heidelberg (2010)
[7] Messnarz, R., Sicilia, M.A., Reiner, M.: Europe wide Industry Certification Using Standard Procedures based on ISO 17024. In: Proceedings of the TAEE Conference in Vigo Spain. IEEE (June 2012)
[8] ISO 26262, Road vehicles — Functional safety
[9] SOQRATES Initiative, http://www.soqrates.de
[10] HIS, http://www.his-automotive.de