Chapter 5
Effective Approaches to Training CPS Knowledge and Skills

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ABSTRACT

Training of skills for engineering CPS systems requires to convey deeper understanding of complex and multidisciplinary processes and products. Companies are facing complex challenges and encounter demands for specialized skills and interdisciplinary collaboration to achieve dependable mass products for end customers. Furthermore, industry demands flexibility, effectiveness, and efficiency in qualifying trainees. Usually they ask for: deliver yesterday, no time committed to training, and perfectly qualified trainees as outcome. The modular matrix course architecture is described for those in need to devise a complex training for industry. It is complemented by best practice recommendations for course development, delivery, and certification. The training and certification toolbox of the AQUA Knowledge Alliance for Automotive has fully implemented the described approach, and serves as a case study.

INTRODUCTION

Nowadays electronics and software control take over functionality at a tremendous rate - we are heading for software-defined anything. This leads to a level of complexity that has never been experienced before - both of the (connected!) CPS itself, and the related development processes. There is a strong common agreement that interdisciplinary expertise is indispensable. It is a fundamental basis for being able to tackle this complexity under the heavy pressure of shorter development and innovation cycles. Moreover, this demand is reinforced by the necessity of mastering essential horizontal topics such as product and lifecycle process quality, reliability/resilience, functional safety, security.

Looking at the example of the automotive industry, e.g. international standards on development quality like Automotive SPICE, ISO/ IEC 15504 (The SPICE User Group, 2015), functional safety according to ISO 26262 (ISO, 2011), and Design for Six Sigma methods (ISO, 2011) for production and process quality have to be mastered. Only together, they ensure both the successful integration of all parts and subsystems, and smooth cooperation in the modern automotive supply chains. These quality aspects need to be implemented in an integrated way because of their holistic nature as such, but also due to shorter and shorter product development cycles that pushes development steps to overlap each other.

This leads to a strong need for qualified specialists and even more for interdisciplinary allrounders. Such people are sometimes referred to as T-shaped people, able to drill deep in one (or more) of their specialized areas, and having a broad "integration T roof" to understand and effectively integrate the expertise and skills of specialists from other areas in the overall CPS development team.

The modular matrix approach for a course architecture is described for those in need to devise a complex training for industry, and universities in turn. In particular, this often requires to convey deeper understanding of complex processes and products. Companies are facing complex challenges and encounter demands for specialized skills and interdisciplinary collaboration to effect a dependable mass product for end customers. Furthermore, industry demands flexibility, effectiveness, and efficiency in qualifying trainees. Usually they ask for: deliver yesterday, no time committed to training, and perfectly qualified trainees as outcome.

Methodically, the approaches described support and incorporate many well-known pedagogical patterns in both course architecture, and use cases of training delivery.

Among others, the presented course architecture has been implemented in the course of the European Commission supported Sector Skills Alliance project AQUA for the Automotive domain (Kreiner, et al., 2013). A training toolbox like AQUA allows to be reconfigured according to the needs of in-house company trainings and university courses. This leads to effective and quick proliferation of "young" state of the art knowledge and skills across universities and industry. Throughout the chapter AQUA will serve as reference implementation and example.

CONTEXT AND CHALLENGES OF TRAINING CPS SKILLS

Mastering a whole bunch international standards in addition to state of the art technologies is key for being able to place a competitive product on the market. In Automotive system development, standards like Automotive SPICE (The SPICE User Group, 2015) for development process quality, ISO 26262 for functional safety (ISO, 2011), and Design for Six Sigma for production and process quality (ISO, 2011) have to be implemented in one integrated, multi-disciplinary, seriously complex product development lifecycle. See Figure 1 for a typical high-level view of an Automotive development process – based on the well-known "V" model covering all development phases, augmented with quality gates as mandated by IATF 16949:2016 (Automotive Industry Action Group (AIAG), 2016), mandatory safety activities, and best-practice method selection for Design for Six Sigma. Each method is complex by itself to understand and implement. Successful Automotive product development requires all, in an integrated way. While specialized courses are available, training leading-edge integration is a major challenge – because of an ever-moving target of state-of the art knowledge, and the sheer organizational complexity of integration.

Figure 2 illustrates the cognitive complexity as encountered by an engineering team during product design. It just schematically focuses on the intricate relationship of tasks and methods to be executed.

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