**Back to the future! Designing a future oriented Systems Engineering based on agile product development and good practices from different industries.**

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New and digital business models, highly interrelated system networks (e.g. Internet of Things), mechatronic and software-intensive products, demanding certification requirements (ISO26262, ARP4754, Automotive SPICE, etc.) pose very high challenges for established as well as new companies in all industries. With the previous, sometimes “hero-based” approaches of single experts and formalities between “silos”, today's complexity can no longer be mastered. Systems engineering (SE) as originally developed in the space industry, e.g. by the Apollo program in the 1960s, contains various helpful approaches to systematically structure large and new projects (e.g. functional analysis, architecture, trade-off decisions) and to implement them in interdisciplinary teams in accordance with requirements and standards.

In the early 2000s the methodology found its way into other industries. Mechatronic systems were on the advance, the interaction of mechanics, electrics/electronics and software found its way into many of the traditional mechanical engineering companies. Due to the current trends in industry 4.0, IoT or networked high-tech topics such as autonomous driving, this trend towards SE is even more pronounced in large and medium-sized companies. Companies from a wide variety of sectors such as the automotive, agricultural engineering, medical technology and shipbuilding industries are setting up programs to anchor SE in order to get a grip on the new complexity and market dynamics and to remain capable of acting. The SE methodology has developed in many facets to meet the specifics of these industries, such as design to value, modularization, variant management and reuse. On top it was amended by modern, agile working methods such as scrum, kanban and design thinking. Agile product development is currently moving towards scaled agile approaches incorporating project portfolio, organization and leadership [1]. An agile R&D provides a highly productive and consistent way to focus on value-creating opportunities.

Especially in the space industry, SE is an established and effective approach to systematically mastering complex challenges. Depending on the individual goals, business model, context and history, a space company can benefit adapting its SE approach and supplementing it with agile methods. This is especially true in areas where the countless start-ups are bringing a breath of fresh air to the scene or in strongly scaling areas such as upcoming "mega" satellite constellations. New approaches are currently emerging. For example, many components, such as in electronics, do not have to be developed from scratch, but can be purchased as COTS from e.g. automotive suppliers and then adapted and tested. It is no longer necessarily a question of the most sophisticated technology, but of developing smaller systems more cost-effectively and faster and thus getting them into operation. An agile approach contributes with 15-30% shorter time to market, 40-60% less risk of missing deadlines and up to 45-60% technical risk reduction [2]. The pure "classic" SE processes are no more sufficient for the new challenges. A refresher and pragmatic interpretation are needed for today's companies. Systems Engineering needs modern components, such as agile methods, in order to be fast and flexible enough in the market. Modularization, reuse approaches and value engineering are needed to deliver best customer value and individual solutions economically. At the same time, approval-relevant consistency, verification and documentation must be ensured without paralyzing the organization. Successful SE requires more than “just” processes. For an effective anchoring, however, further dimensions are needed that interact equally well. 3DSE has combined these dimensions in a Best Practice SE reference model. For a successful and sustainable optimization of Systems Engineering the combination of the following 8 dimensions have proven to be effective: (1) target system, leadership model and incentives, (2) organization and x-functional SE roles, (3) system architecture, (4) systems thinking, change and engagement, (5) system competence, career path and qualification, (6) development logic and SE processes, (7) SE and agile methods, (8) digital skills and tools. The 9th dimension requires the coherence of the reference dimensions to each other.

The lecture will use these dimensions to identify the areas where and how space companies can especially benefit from an agile development approach complementing their SE approach and optimize their product development with best practices from other companies.

[1] Atzberger, A., Nicklas, S.J., Schrof, J., Weiss, S., Paetzold, K. (2020), Agile Entwicklung physischer Produkte, Universität der Bundeswehr München, Neubiberg, Deutschland.

[2] Referring to project results generated by 3DSE and Studies of Jacob Creech and Dean Leffingwell, 2019