Application of the V-Model in Assessing the Feasibility of Complex Multimodal Projects under Educational Limitations

Piotr Grzybowski

Abstract. The V-Model constitutes one of the fundamental frameworks in systems engineering and is widely applied in high-complexity domains, including the aerospace sector. In educational practice, however, its use is often limited to fragmented examples that omit the complete cycle of requirements definition, implementation, verification, and validation. As a result, students are rarely exposed to the actual workload and integrative nature of real-world engineering projects.

This paper presents a research-oriented educational project aimed at conducting both quantitative and qualitative analyses of the workload required at individual stages of the V-Model. The proposed design task involved the development and implementation of a complex multimodal device integrating mechanical, electronic, and software components. The project was treated as a representative didactic scenario enabling estimation of the actual time demand and identification of the competencies required throughout the entire project lifecycle—from requirements specification and conceptual design to detailed design, system integration, and validation.

The implementation phase incorporated modern rapid prototyping manufacturing technologies as well as artificial intelligence tools supporting concept generation, software development, and project documentation. A structured decomposition of project activities made it possible to determine the temporal distribution of effort and to identify critical stages affecting feasibility within the constraints of a standard semester-based educational cycle.

The results indicate that implementing the full V-Model in engineering education is feasible; however, it requires precise scope definition, deliberate complexity management, and alignment between project autonomy and students' entry-level competencies. The proposed framework provides a structured basis for designing realistic yet ambitious educational projects aligned with contemporary systems engineering practice.