Applying systems engineering (SE) and life cycle management (LCM) principles to protection systems

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NEW ENGINEERING APPROACHES FOR COMPLEX PROTECTION SYSTEMS

A notable number of natural hazard-related protective infrastructures or systems in the Alps will reach the end of life span within the next years. Therefore it is essential to assess how these systems can be optimized or adapted. Furthermore in the light of the increasing complexity of protection systems, innovative planning paradigms are required to overcome the deficiencies of classical approaches in construction engineering. Modern protection systems embrace not only technical structures, but incorporate also assemblies of mechanical, mechatronic and digital elements with unequal ruggedness, service life, maintenance requirements and risk of failure. In order to increase their functional performance these- systems are organized in functional units or elements in sequences/functional chains and closely interact with other planning, legal and organizational measures (e.g. combining permanent structures with mobile elements and flood warning/alert systems). While the function of the single elements has to be ensured at every time, the conditions of the single elements change and so the time perspective becomes more and more important. Another characteristic of complex protection systems is the multidisciplinary competence necessary to plan, design, construct, operate and maintain them as well as the multitude of responsibilities bringing about a high demand for coordination among planning engineers, approving authorities, operating institutions and beneficiaries of protection.

Protection Systems Engineering (PSE) and Life Cycle Management (LCM) represent new approaches in natural hazard engineering to better manage the increasing complexity of protection systems.

PRINCIPLES OF PROTECTION SYSTEMS ENGINEERING

Systems Engineering (SE) is by definition an interdisciplinary field of engineering that focuses on how to design and manage complex systems over their service life. When applying SE to protection system against natural hazards, a fundamental principle is the compliance of the functionality of the protection system with the „customer expectation", in concrete terms the congruence of protection effects with the protection needs of the beneficiaries. In general the fulfillment of protection goals is the most important benchmark for the quality of a protection system (structure). Protection System Engineering comprises several essential methods:

- Project Management (PM) is an essential function to steer complex and multilayered planning, creation and operation processes of protection systems with a multitude of actors in the project.
- Requirement Analysis (RA) and Systems Design (SD) aims at the design of robust, efficient and less failure prone protection systems.
- Engineering Change Management (ECM) is applied to adapt and reconfigure protection systems to changing framework conditions.
- System Integration (SI) serves the reconfiguration, enhance or realign of existing systems at the end of the first life cycle or after extreme events.
- Risk management (RM) for protection systems to timely identify potential hazards and risks for the stability, serviceability and durability of the system (structures) and prevent system failures or total breakdown by safety reserves and redundancies.

LIFE CYCLE MANAGEMENT (LCM) FOR PROTECTION SYSTEMS

The necessity to optimize the functional performance and the operational reliability over the entire life cycle of the envisaged protection system is mandatory. Following the comprehensive systems engineering approach, integral protection

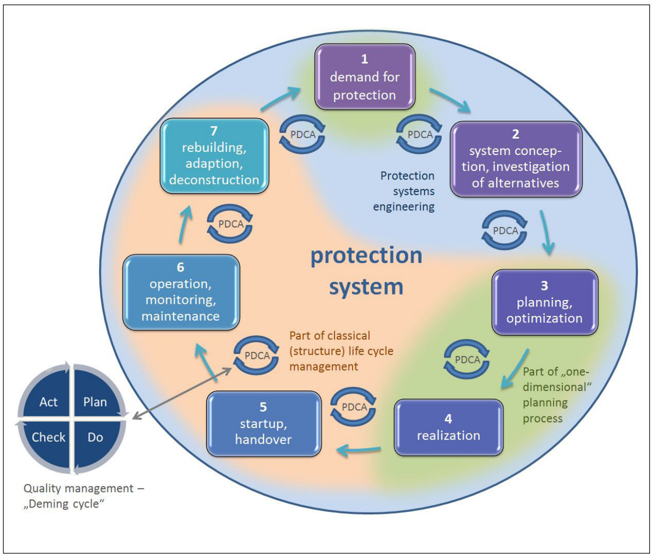

Figure 1. System Engineering Cycle

concepts have to be elaborated in a structured manner according to the „system life cycle" (Fig. 1), aiming to fulfill the requirements of effectiveness and efficiency.

ADDED VALUE IN APPLYING PROTECTION SYSTEMS ENGINEERING

The planning, design, operation and maintenance of complex protection systems involves as a rule a multitude of actors and decision makers with different levels of competences and capacities. This unbalanced situation requires the creation of protection systems that are oriented to the capacity of the holders or beneficiaries (as a rule lay-person) who carry the load of liability as well as in case of failure or breakdown the risk of compensation of damages to third parties. The sustainable serviceability of protection systems that need recurrent supervision, adjustment, inspection or maintenance by the operator (holder) presupposes standardized operation procedures, regular instruction and training.

Traditionally the cost calculation for protection systems (structures) is limited to the planning and construction phase, while operating expenses or maintenance costs are not - or just rudimentary - taken into account. In fact the latter costs may clearly exceed the costs of production over the lifetime (service life) of a protection system (structure) and exponentially increase with growing complexity. Considering these shortcomings, Life Cycle Costing (LCC), a cost calculation method that takes into account all phases of service life (Fig 1), should be applied.

EXAMPLES OF APPLICATION OF CONCEPT

Galina torrent (Vorarlberg/AT) - Redevelopment of historic protection systems

Habichtgraben torrent(Bavaria/G)- Change of protection system

Gadria torrent (Alto Adige/IT) - Reconfiguration of protection works

CONCLUSIONS AND RECOMMENDATIONS

Systems engineering includes many valuable elements, which can promote an improved, sustainable and integrated approach for protection systems. Already during preparation and preplanning of these systems aspects of functionality, stability, serviceability and durability have to be assessed. An early consideration of life cycle-based costs facilitates the search of optimized and cost-effective protection solutions.

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KEYWORDS

Protection systems engineering; Life Cycle Management; stability; serviceability; system life cycle

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