# PRAGMATIC SYSTEM ENGINEERING FOR CVIS POSITIONING & MAPPING

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The Cooperative Vehicle Infrastructure Systems (CVIS) (1) project's Positioning and Mapping (POMA) group developed a pragmatic system engineering methodology to capture requirements and structure the subsequent architecture, development and test phases in the project. This methodology provided a focused approach for the multidisciplinary team consisting of university groups, public authorities, and commercial companies. The roots of the used methods are in IEEE and engineering industry standards and best practices. The method provides control by consistency and traceability, whereas the diverse group can work with it. Interfacing to the other CVIS sub projects and outside world has been supported by solid justifications.

## SYSTEM ENGINEERING IN CVIS CONTEXT

Coordinated by Ertico, CVIS is a major ITS project in Europe partly funded by the EU with the goal of demonstrating the cooperation of vehicles and infrastructure systems at six test sites located all over Europe. The CVIS consortium consists of 63 parties with a diversity of backgrounds, e.g. commercial companies, car manufacturers, public authorities, universities, research institutes, etc. The main objective of CVIS is to develop core technologies (i.e. communication infrastructure, architecture framework, positioning and mapping) and applications (i.e. for urban traffic, interurban traffic, traffic monitoring, and freight & fleet applications).

This paper addresses the system engineering for the CVIS subproject aimed at positioning and mapping features. The architecture of CVIS includes on-board as well as road side systems with service center support using a new versatile communication infrastructure. Localization of vehicles and infrastructure looks for lane level (~1 m) accuracy leading to developments for integration of positioning systems and upgrading map accuracy and details. The local cooperation foreseen for the participating vehicles and infrastructure requires provider independency of data and information, e.g. leading to map independent location referencing. CVIS applications have liability requirements, e.g. paid location dependent services. Hence accuracy and integrity of the localization data needs to be available.

The POMA group develops the positioning and mapping core technologies. The diversity in background (and the respective development methodologies and communication habits) of this group poses the challenge to setup documentation and communication that sustains the effective development of the products needed.

The requirements development for POMA within CVIS had to take into account:

- the above background diversity, and common development competences of the people,
- effective development of the products,
- interfacing to the other parallel CVIS development groups, and CVIS external context,
- matching the overall CVIS requirements development planning and budgets

The requirement development process tailored for these needs was based on standards (2) commonly applied to system engineering in telematics, military, railway, space and aviation industries. Considerable tailoring minimized training and education effort in the respective standards without compromising the product performance for the proof of concept demonstrations. The interfacing aspects for the products as well as the process received special attention to maintain overall alignment with the project. This paper describes the tailoring, the criteria, justifications and benefits and risks from this system engineering.

## PRAGMATIC SYSTEM ENGINEERING METHODS

Many definitions for system engineering exist. However, the result of system engineering is alignment between the processes, documentation, quality assurance and acceptance of products tailored for the applied projects or product development. System engineering differs explicitly from architecture. Architecture defines, designs and discusses the technical aspects within a project, whereas system engineering details the aspects mentioned above without directing the technical aspects.

The challenge for system engineering in the CVIS project is that the available resources for tailoring are minimal, whereas the diversity of parties in the consortium allows only limited processes to be implemented that can be justified by straight common sense. A tailoring by slight modification to the described standards was hence not in scope of this project. This implies that for every system engineering aspect a pragmatic choice of principles was selected and justified to guide the system engineering (see Table 1). This approach enables one-off deliveries as envisaged for CVIS, but this approach will not cope with the rigors needed for commercial product development (especially under stringent quality and mission criticality or safety requirements).

| ***Engineering aspect*** | ***POMA tailoring guiding principle*** |
|---|---|
| Context | CVIS application area/technology support center driven |
| Concept justification | SWOT analysis for requirement development and prioritization |
| Life cycle | along CVIS project, waterfall with early V&V aspects/review |
| Documentation | CVIS project, selecting IEEE-J-STD016 topics for content |
| Design process | align to CVIS UML based process |
| Requirements | GST like, but strict J-STD016 formulation and selection of topics |
| Assurance | 2-phases review process: group, external;<br>in line with project process |
| Configuration control: | Web portal based file structure |
| Team skills | chapter captains, but redaction/harmonisation of final deliverables |
| Engineering control | External interface driven |
| Process | enable incremental external interface development/design |
| Project control | design to cost |

**Table 1** POMA tailoring principles for system engineering aspects

The applied method uses three Excel tables as tool that document the main features and justifications. The first table provides a SWOT (strengths, weaknesses, opportunities and threats) analysis of the envisaged telematics applications with respect to the four POMA functional domains: positioning, mapping, map-matching, and location referencing. From here the interface parties in the application areas are identified with the respective data needs. The second excel sheet deduces the capabilities (features) that POMA provides explicitly scoping the interface data. The third sheet contains the deduced requirement list extended with verification by the applications that they need the requirement, the requirement allocation towards the POMA components, and the requirement verification matrix.

## BENEFITS AND RISKS

The system engineering model for POMA resulted in the following benefits:

- A structured development model was available that enabled autonomous development of components by the POMA companies
- The focus on agreed capabilities directed development effort efficiently towards the needed innovation
- Considerable interface design smoothed and guided discussions with the POMA context providing clear justifications for changes
- Requirements traceability & early verification descriptions minimized late defect detection with corresponding cost and planning consequences

Here we present risks of the used system engineering approach that have been identified during the POMA development:

- Ahead of the troops; the system engineering approach provided an efficient way to develop the system, but care was taken stay aligned with the other CVIS development teams by the flexibility POMA provided.
- Having competitors together in a strategic project leads to the risk on blocking issues. However, strengthening common interests provided for needed progress.
- A risk exists that partners not used to system engineering approaches drop out of the process. Mitigation by specific coaching proved successful.
- A communication risk exists that team members new to the approach need to discuss the approach or its consequences outside the POMA development team. Simple coaching during sessions provided them with enough skills to act professionally.
- A well described system asks for thorough justification if changes are due. Risk is that flexibility with respect to the requirements in the development phase is not optimized. Regular requests for improvements to the requirements proved to be helpful.

## CONCLUSIONS

The POMA development within the CVIS project uses the pragmatic system engineering approach described here. The current development state shows that it supports efficient development within reasonable budget and planning constraints. The POMA group operates with a common language and sound knowledge supported by the structures provided with the system engineering approach. Hence, the system engineering approach contributes significantly to the success of POMA within the CVIS project.

## REFERENCES

(1) See www.cvisproject.org
(2) Standards: IEEE-J-STD016, MIL-STD-498, ECSS-E-010
(3) POMA group: Navteq, Teleatlas, Mizar, Mapflow, UTC, DLR, LCPC, Thales-Alenia Space, Logica, Volvo, ISMB, and Intempora.