POLITEHNICA UNIVERSITY TIMIŞOARA
The PhD School of Engineering Sciences
PhD. Field: Engineering and Management

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Considerations on Models Used in the Development of Radio-Navigation Software Projects

- PhD Thesis Summary -

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CONTENT

CONTENT OF PHD THESIS

1. SUMMARY OF PHD THESIS

The purpose of this research is to identify practical solutions on organization- and project development issues in automotive industry. Increasingly higher complexity of automotive projects and customer expectations has led the author to the elaboration of ways to adapt current software processes, by inserting flexible methodologies into traditional development models.

Certain specification change during development of automotive projects and mandatory project completion into the initial planned schedule, often constrain project managers to reduce project scope without considering the effects of such decisions. Thus automotive companies feel compelled to focus their attention on function prioritization which must be met, at the expense of implementing new technologies.

The elaboration of new development models implies detailed project management knowledge and analysis of current development processes used in the area or environment in which the new development model will apply.

The advantages resulted from the analysis of agile methodologies and the development models used in the automotive industry, ensured the necessary tools to conceive a new development model.

Applying established management methodologies, like EM Goldratt's "The Theory of Constraints" [1] or the hazard theory (HAZOP) [2], did not fully solve the problem, more precise the attenuation of effects of changing requirements on project milestones. The two theories applied to the radio-navigation automotive projects bring advantages, but do not solve the problem of changing requirements during development of complex automotive projects. Applying the Theory of Constraints on the traditional V-cycle would alter its structure, which proved to be necessary. The altered V-cycle will keep the interfaces to the environment stable, which is very important in the development of projects in automotive industry.

The data collected after analyzing the impact of requirement changes on project schedule and the analysis of different development models, led to the author's conclusion that a new development model has to be implemented. The new development model is the result of inserting agile methodologies into the structure of traditional development models. The insertion of agile methodologies into the traditional development models brings the advantage of flexibility, which is needed in the development of innovation products.

The usage of the new development model (2JCS), designed in this research, will allow the project team to keep initial planned project milestones. Applying the new model is recommended especially because of its flexible approach on changing requirements. Validation of the development model conducted to the conclusion that besides time saving, the 2JCS development model brought financial advantages to the automotive companies. By keeping initial project milestones and by saving costs by not initiating a new project update (as it certainly happens by using the V-cycle model), the 2JCS model assures time and financial benefits as also benefits related to marketing activities.

2. OVERVIEW OF PHD THESIS

People's mobility, as also holding and spreading information, became essential elements in society evolution. As a consequence, the development of radio-navigation systems became a necessity, being a medium which combines the mobility and information environments. The newest evolution of in car radio-navigation systems revealed integrative- and connectivity elements with car external systems, more concrete smartphones or IT components.

The research question was defined by requirement changes in automotive projects and the resulted time constraints, because of implementation of requirement changes during project development. The main goal of this research is to identify practical solutions for the organizational and development issues of automotive projects. The usage of traditional development models does not allow the implementation of many new defined requirements during project development. Project managers often decide to reduce project scope in order to achieve the objective *time* of the project. Even if at first look it seems to be the right decision, as the immediate project objectives are reached, the companies will have supplementary costs because of not fulfilling all project goals. The companies have to organize and start a new project to complete the past projects with requirements which are not implemented yet. These arguments defined the main goal of this thesis, namely, the presentation of correct exploitation of time resource, objective concretized by conceiving a new development model, which is flexible to requirement changes and which should correspond to the requirements of automotive industry.

The PhD Thesis is structured in 6 chapters, in which the author's goal is to treat in detail the intermediate thesis objectives, which together will lead to the solution of thesis's objective. Each chapter ends with solutions and specific conclusions; the last chapter of this thesis presents the final conclusions, solutions and author's personal contributions of this paper. The thesis is organized as follows:

Chapter 1 presents the research actuality and motivates the research topic, thesis objectives and its structure.

Chapter 2, structured in two parts, systemize project management and customize specific project management aspects of radio-navigation automotive projects.

Following important aspects resulted from the critical analysis of project management in general, and project management of radio-navigation systems in particular:

- Reaching project goals implies detailed knowledge of project phases and steps, and the order in which they should be conducted, as well as the project specific critical factors, synthesis realized in the first part of the chapter;
- The importance of the critical factors underlying project success resulted through literature review which addresses deeper aspects of project management;
- Standardization of processes used in automotive projects in form of Spice processes, helps project leaders in the organization and decisions related to the command and control methods- issue addresses in the last part of the chapter;

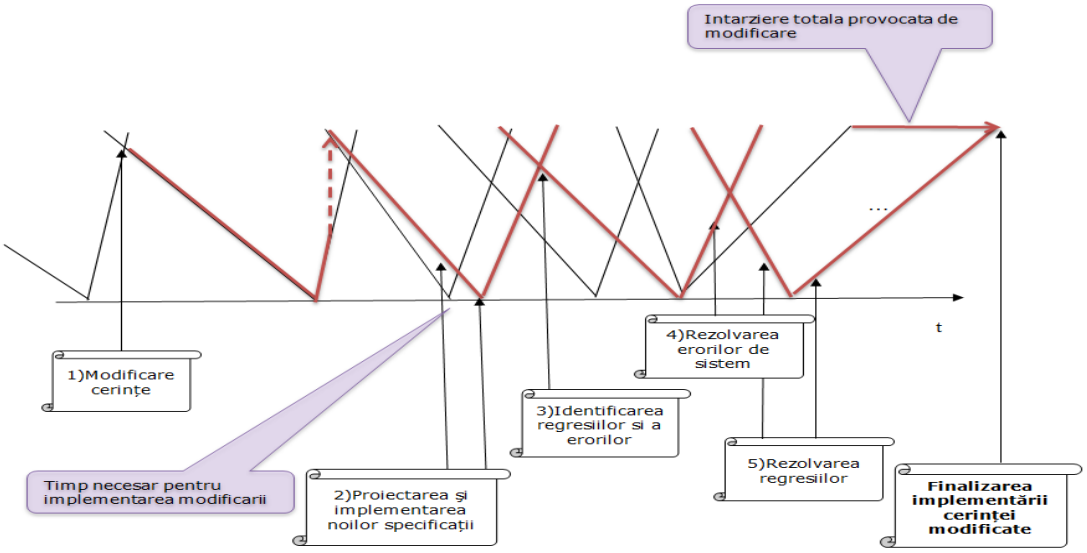
Chapter 3 presents general characteristics of software development project. The chapter begins with the description of the traditional V-cycle, specific to automotive software development projects. The V-cycle represents a superior approach to other traditional development model, waterfall. Traditional development model used in software project management does not differ in essence, these differs in detail. The inflexibility of traditional development models led to the development of AGILE methodologies.

The second part of the chapter analysis the main AGILE methodologies, as follows: Adaptive Software Development (ASD), Crystal, Feature Driven Development (FDD), Agile Model Driven Development (AMDD), SCRUM, Dynamic System Development (DSDM), Lean Development and Extreme Programming. The critical analysis performed on development models revealed that the AGILE methodologies manage to eliminate the weaknesses of traditional methods, focusing on communication and team harmonization whenever there is a disturbance in the project, introducing thus a real flexibility in the change management approach;

The chapter ends by fleshing out its main objective, more concrete, detailed highlighting of the particular aspects of development models of automotive projects and the effects on project schedule in case of implementing changed requirements during different phases of the project.

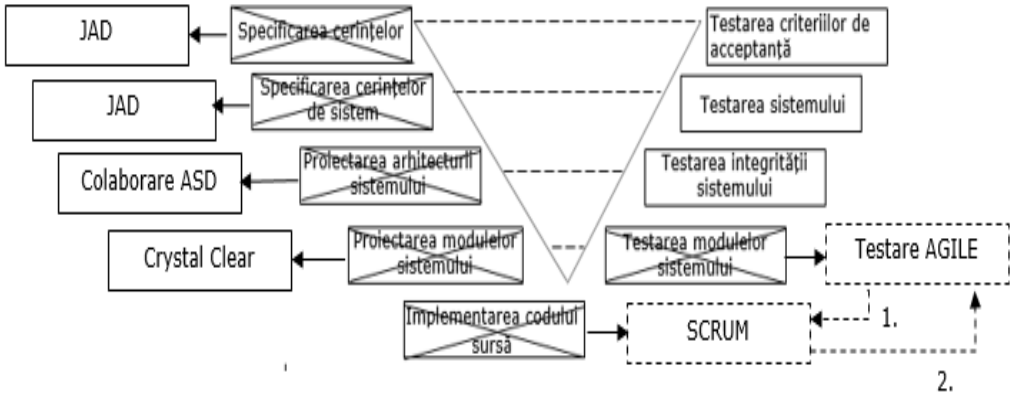
Chapter 4, through its declared aims, follows the conception of a new development model which shall meet high technology automotive project development requirements. Three essential factors in radio-navigation project success stays at the basis of implementing new development model. The first factor is given by the decision to create new high technology products by keeping project schedule. Second factor is the continuous analysis of traditional development models in case of changing requirements. The third factor is the continuous optimization of software project lifecycle by applying modern methods like 'The Theory of Constraints' by E.M. Goldratt. This method explains the shortcomings of traditional processes in software development models. The explanation for the shortcomings of traditional software development processes can be altered by the risk and decisional factors which lead to the implementation of new or changed requirements with the goal to propose a new solution so that the project schedule is not affected;

Further the author presents a calculation method to validate the implementation decision of a requirement change, by integrating all decision factors. The organization of projects in the phase of requirement change is also presented, being identified the effect of requirement changes on project schedule in the different phase of the project.



Requirement change effect on project schedule in the bug fixing phase

At the end of the chapter the author conceives and elaborates a new development model (2JCS) for the development of software for radio-navigation projects, based on the analysis result of different traditional development models and agile methodologies.



2JCS model

Chapter 5 performs the validation of the new developed model on two directions. The first direction aims keeping the project schedule while the second direction concerns the validation from economic point of view.

The validation criteria are inspired from the main project success criteria, time and financial performance.

The validation of the 2JCS model was achieved through comparative analysis between two companies: company A in which the model 2JCS was used and company V in which the traditional v-cycle was used. By keeping initial planned project schedule, company A yielded a better organization of teams. Although some phases exceeded the planned budget, a benefit was achieved by completing the project in the initial project schedule and by saving costs through not starting a new update project(as it is surely done when using the V-cycle).

Chapter 6 presents the conclusions and personal contributions of the author. Future work directions are listed, using the development model proposed by this research.

3. CONCLUSIONS

The rigidity of the V-cycle lifecycle used in the development of automotive projects proved the actuality of this thesis, as the V-cycle always expresses low capacity of all types of resources involved in projects. Intact reputation of companies producing new technologies, because of not holding project milestones, has led to the research of new methods for project development, which can be applied to automotive projects. High pressure for keeping project milestone conducted to the analysis of processes used in the development of automotive products. The identification of the weaknesses of established development models used in automotive industry, guided the author in the design of a new development model (2JCS), which helps to eliminate inconsistencies which are expressed in current automotive projects. The usage of the 2JCS model allows time savings in projects, bringing financial advantages on long term.

The new development model (2JCS) was validated on the two axes, time and financial axis. The validation included a comparison of the traditional model and the 2JCS model.

The objectives of this thesis resulted from the complexity of radio-navigation systems in combination with processes and methods used in their development.

Following intermediate objectives have been highlighted in the thesis:

- Definition of project management starting from its history to the definition of project management for radio-navigation systems;
- Advantages and disadvantages analysis of using traditional development models and AGILE methodologies in projects;
- Impact analysis of using the theory of constraints in automotive projects;
- Impact analysis of using the hazard theory (HAZOP) in automotive projects;
- Validation of the new designed model (2JCS) through comparative analysis of the traditional model and the 2JCS model.

Based on the declared objectives of this thesis, following main conclusions can be highlighted:

- Achieving project goals requires detailed knowledge of project phases and steps and the order in which they should be conducted, as well as the specific critical factors of projects;
- The understanding of the importance of critical factors stays at the origin of project success;
- Standardization of processes used in automotive projects, in form of Spice processes, helps project leaders in the organization and decisions related to the command and control methods in this kind of projects;
- Traditional development model used in software project management does not differ in essence, these differs in detail.
- The most used development model in automotive projects is the V-cycle model and it represents a superior approach to other traditional development model, waterfall;
- The usage of traditional development models in automotive projects is determined by historical reasons, more concrete, the production uses this kind of processes and the projects took over the same configuration of lifecycles;
- The usage of traditional development models in production, methods which are used also in the development of software automotive projects, does not permit relevant modification of requirements during project development;

- The inflexibility of traditional development model led to the integration of agile methodologies into its structure;
- AGILE methodologies manage to eliminate the weaknesses of traditional methods, focusing on communication and team harmonization whenever there is a disturbance in the project, introducing thus a real flexibility in the change management approach;
- Requirement changes in any phase of the project is a certitude in automotive industry projects;
- Modern methods like “The Theory of Constraints” by E.M. Goldratt offer explanations and solutions to the shortcomings of traditional processes in software development models. This method offers solutions which will accelerate the project schedule, but will not totally solve the problem of changing requirements during project development;
- The explanation for the shortcomings of traditional software development processes can be altered by the risk and decisional factors which lead to the implementation of new or changed requirements with the goal to propose a new solution so that the project schedule is not;
- Because of the automotive project structure, the 2JCS model will not save time, but brings the possibility to implement higher amounts of requirements, without endangering project schedule;
- From financial point of view, the 2JCS model will bring savings to companies on long term, by ensuring keeping project schedule in case of requirement changes.

4. AUTHOR’S PERSONAL CONTRIBUTIONS

- Summary of representative phases of projects in general with particular aspects of automotive projects;
- Summary of representative critical factors, based on comparative literature review;
- Description of representative and specific critical factors of automotive projects;
- Identification of a new critical factor characteristic to automotive projects, the innovative product.
- Analysis of main characteristics of traditional development models;
- Analysis of main agile methodologies which will eliminate the weaknesses of traditional methods;
- Justification for using the V-cycle in software automotive projects;
- Comparative analysis and synthesis between traditional development models and agile methodologies;
- Comparative analysis and -synthesis between the effects of requirement changes in different phases of the project;
- Presentation of the impact of requirement changes on project schedule;
- Identification of need to conceive a new development model specific to big automotive projects;
- Analysis and description of literature conclusions related to requirements stability in software projects;
- Conceiving a decision method based on mathematical formula on the opportunity to implement new requirements during development of automotive projects;
- Analysis of development processes and the influence of production processes on them;

- Analysis and description of the Theory of Constraints with the goal to validate the new conceived model;
- Analysis and elaboration of factors which determines the implementation of new requirements;
- Setting up a new development model, flexible on changes, with the goal to mitigate the effect of requirement changes during development of automotive projects (**2JCS model**);
- Summary of criteria which must be fulfilled by the software development model;
- Analysis of validation possibilities of the 2JCS model by literature review;
- Collecting information and data regarding development of radio-navigation projects in company A and V;
- Comparative analysis of the two projects in company A and V;
- Comparative analysis of traditional models and 2JCS model from time and financial point of view;
- The essential contribution of the 2JCS model is implementation of a higher amount of requirements, without delaying project schedule;
- The usage of the 2JCS model will bring economies to the companies on mid-term because of reaching project milestones even if requirements have been changed;
- Presentation of project development cost distribution;
- Design of validation process in terms of keeping initial project milestones of radio-navigation projects, regardless variation of initial specifications;
- Design of validation process from the perspective of economic efficiency through the combination of the two variables cost and time.

References

[1] Goldratt, E. M., 2004, The Goal, the North River Press Publishing Corporation, Great Barrington.

[2] Lawley, H.G., Operability studies and hazard analysis, Chemical Engineering Progress 70 (4), 1974