TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 64, Issue Special I, January, 2021

A DEVELOPMENT MODEL FOR RADIO-NAVIGATION SOFTWARE PROJECTS

Gabriela PROSTEAN, Andrei HUTANU, Cristian VASAR, Stephan VOLKER

Abstract: Todays Vehicle-Electronics or Automotive-Electronics engineering becomes increasingly complex due to rapidly changing customer expectations regarding comfort, convenience, safety and especially aftermarket driven communication features. Thus, to handle such variety of functions or requirements the development complexity is divided into several electronic control units (ECU) interconnected via automotive specific communication channels (i.e. CAN, MOST). This paper investigates automotive software development processes for a radionavigation or so-called infotainment unit. The research will mainly focus product requirement modifications on a fast-growing project, which generates the strong demand of evaluating and changing current applied implementation strategies and if they prove to be insufficient developing new tailored approaches.
Key words: *software automotive projects, changing requirements, agile methodologies, automotive industry.*

1. INTRODUCTION

In [1] is stated that the project management methodologies did not change in the past 40 years, except the spreading of these methodologies along the structures of entire companies. In the context of automotive projects, the authors identified the three most important project management organizations and their definition of project:

- ICB (IPMA Competence Baseline) [2]: the project is “a time and cost constrained operation to realize a set of defined deliverables (the scope to fulfil the project’s objectives) up to quality standards and requirements”.
- PRINCE2 (PRojects IN Controlled Environments) [3]: “a project is a temporary organization that is created for the purpose of delivering one or more business products according to an agreed Business Case”.
- Project Management Institute [4]: “a project is a temporary endeavor undertaken to create a unique product, service, or result”.

Reflecting the automotive area, the main objective of radio-navigation projects is the creation of unique high technology products by fulfilling the factors time, cost, quality and functionality.

Developing products considering these factors will bring an important competitive advantage to companies in comparison to competitors. The market acceptance of one product is heavily determined by time and quality factors.

The foremost factors that encourage customers to buy a product, are quality and functionality. The company which manages the factors time, cost, quality and functionality and launches the product at the right time to the market will win the position of leading benchmark company in the area. In automotive industry, delaying the launch of new innovative functions will generate the risk of losing customers as the product can miss the target of becoming the benchmark in that specific area.

Achieving the main project objectives are mainly hampered by the different opinion of project stakeholders. As the project “is a temporary endeavor undertaken to create a unique product, service or result” [4], the implementation of late change requests is often rejected by project supplier.

Table 1

Difference between traditional development model and agile methodologies (adapted from [6]).

Criteria	Traditional	Agile
Fundamental Assumptions	Systems are fully specifiable, predictable, and can be built through meticulous and extensive planning. In automotive projects the planning of full implementation has its roots in production processes.	High-quality, adaptive software can be developed by small teams using the principles of continuous design improvement and testing based on rapid feedback and change.
Control	Process centric	People centric
Management Style	Command-and-control. Every subarea of one automotive project has a leader whose responsibility is to plan, command and track the project.	Leadership-and-collaboration
Knowledge Management	Explicit	Tacit
Role Assignment	Individual—favors specialization	Self-organizing teams—encourages role interchangeability
Communication	Formal	Informal
Customer's Role	Important, still in automotive projects some decisions are taken even if customer does not agree to them.	Critical
Project Cycle	Guided by tasks or activities	Guided by product features
Development Model	Life cycle model (Waterfall, Spiral, or some variation). In automotive projects most often the V-cycle model is used.	The evolutionary-delivery model
Desired Organizational Form/Structure	Mechanistic (bureaucratic with high formalization)	Organic (flexible and participative encouraging cooperative social action)
Technology	No restriction. To radio-navigation system projects, the object-oriented technology is used.	Favors object-oriented technology
Acceptance of changes	*Rigid, requirement changes are hard to implement*	*Flexible, easy to implement changed or new requirements*

In radio-navigation projects the client is defined as the car manufacturer while the supplier is defined as the developer and provider of software and hardware deliverables. "This attitude is caused by the client's rigorous tracking of the defined milestones and implicitly the wish to comply with these milestones. On the other hand, the project sponsor/client is interested to implement the newest technology, as technology is advancing very fast" [5].

The management and traceability of achieved (software) project objectives are dependent on the development models applied, each company uses different development methods which, fits to its need. For example, in the automotive industry the most used organizational system engineering and verification model is the V-cycle. The decision to use the V-cycle development process model in automotive projects has its roots in the production processes used. The appearance of software development projects was much later than the production processes, which are based on the V-cycle. As no real alternative existed at that time, the software projects took over the processes used in the production and adapted them to their needs. IT projects uses mostly the agile methodologies as a response to the disadvantages of the V development model. Table 1 shows the main differences between the V development model (traditional model) and the agile methodologies.

In this context, the authors have developed a new conceptual model that facilitates the implementation of new or changed requirements and is presented later in the paper.

2. STATE-OF-THE-ART

The appearance of software projects in (the formerly purely hardware driven) automotive area later determined the managers to use in the development of automotive software projects adapted production processes, concretely the traditional V-cycle. Even if some researchers believe that the traditional development model do not have the necessary flexibility to achieve customer's needs, the traditional models provides stability and safety of implementing the initial system requirements. Larmann [7] and Martin [8] believed that the iterative methodologies can be used only in small projects, but in praxis, in big automotive projects the iterative model found their use on large scale.

Project success in the automotive area is dependent on the ability to track projects total development status of each agreed requirement (i.e. reject, planned (scheduled), implemented and quality). The need of high technology products and the short development cycles made of these main objectives of companies.

From authors practical experience the main factor in project success in automotive projects is keeping project milestones with the agreed deliverables since a radio navigation unit enjoys a multi-partner-relationships within the automotive network. Any deviation of agreed objects (i.e. new requirement, schedule, quality) will have side effect to network partner projects [9]. In addition, since automotive software development models rely on production processes all requirements must be defined at the very beginning of project. In most cases automotive projects will be developed by suppliers and delivered to OEM (Original Equipment Manufacturer). The need of conceptual work on OEM side will generate a delayed project start at supplier because the supplier cannot start any project without knowing its content.

The concept will generate a document, which describes on high level the product features and will have an impact on the project milestones. This concept-document is the requirement baseline of the supplier contract given to several prospective suppliers for quotation. Besides other success factors like costs, quality, customer satisfaction or content, the factor time is mentioned also by other researchers as one of the most important factors in project success [10; 11; 12]. As initial project specifications will change almost certainly [13], the use of traditional development model will lead to project delays. The requirement changes are cause mainly by [14]:

- Project has a big temporal pressure.
- Client does not want to inform all project details in the early phases of the project.
- Developing an innovative and complex system for the first time.

The project delays are caused mostly by the inflexibility of the V-cycle model. The path of one requirement change is presented in Figure 1 that presents the path of a generic requirement change. The angle of the V-cycle can vary depending on the project phase for new V-cycles, being bigger at the beginning of the project and smaller at the end of the project.

From authors experience in automotive industry the impact of project delays differs depending on the project phase in which the requirement change will be implemented. It is well known that projects developed using the traditional models are divided into two main parts: feature construction phase (Figure 2) and bug fixing phase (Figure 3). In case of any requirement modification in the phase of feature construction, the new or changed requirement will be implemented for the duration of four development cycles (Figure 2).

In Figure 3 the authors present the number of cycles needed to implement a changed requirement. The time needed to implement a new requirement differs depending on the project phase and cycle duration.

It is well known that the time duration of project cycles differs during the project lifetime, the cycles have longer duration at the beginning of the project (where a lot of conceptual analysis for the new model are made) and shorter during the final phases of the project (where just functional tests are made).

The total amount of development cycles needed to implement new or changed requirements, are explained by the number of work packages needed to fulfil the implementation:

1. Communication of requirement change.
2. Design, implementation and system testing.
3. Solving major errors.
4. Solving all regressions.

Concluding, the time needed for implementing a changed requirement will grow depending on the number of modules, which are affected by the modification. In practice of automotive projects, the dozens of unplanned requirement changes will endanger the project objectives.

The usage of the V-cycle model in an environment with a lot of requirement changes becomes inoperable without imposing the creation of a complex and adapted development model which can handle this kind of projects and specification changes.

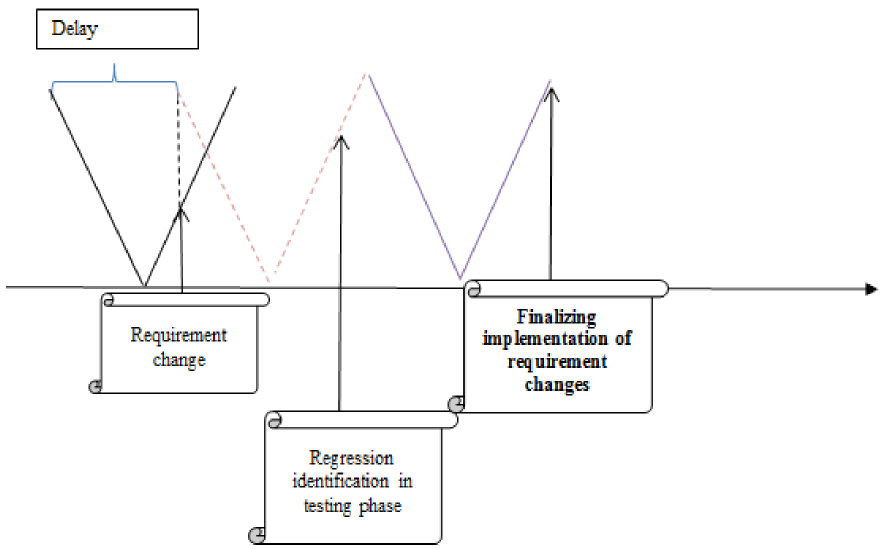

Fig. 1. Path of requirement changes along project using the V-cycle development model.

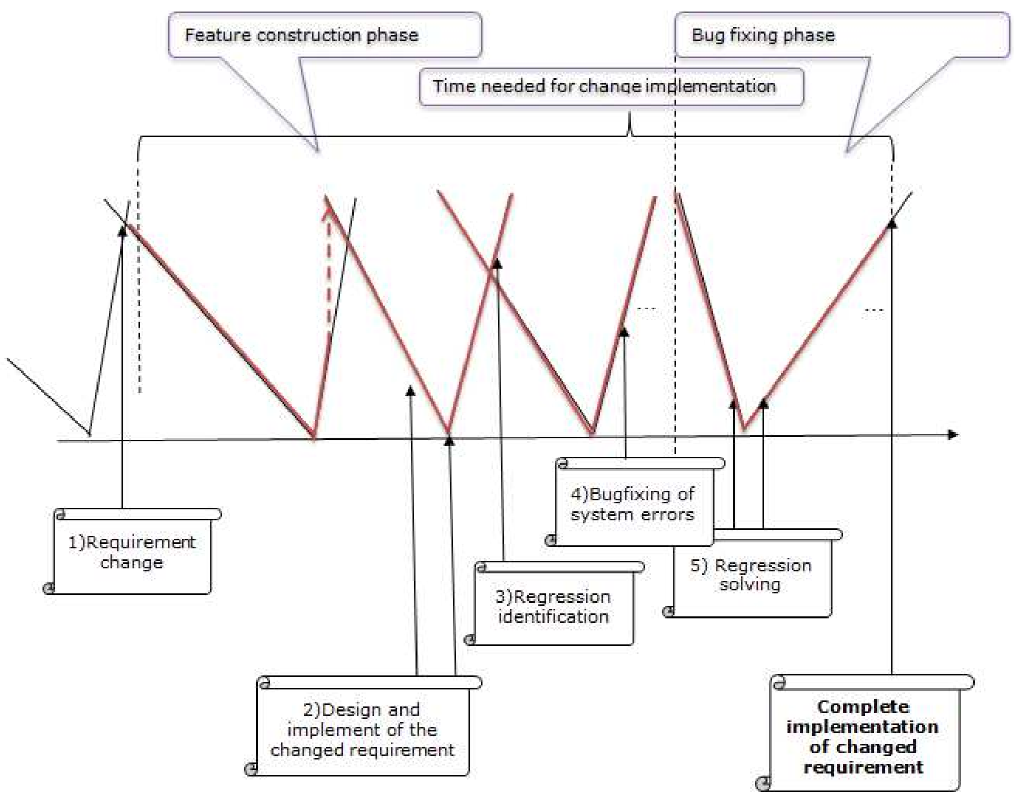

Fig. 2. Path of requirement changes in the feature construction phase of projects using the V-cycle development model.

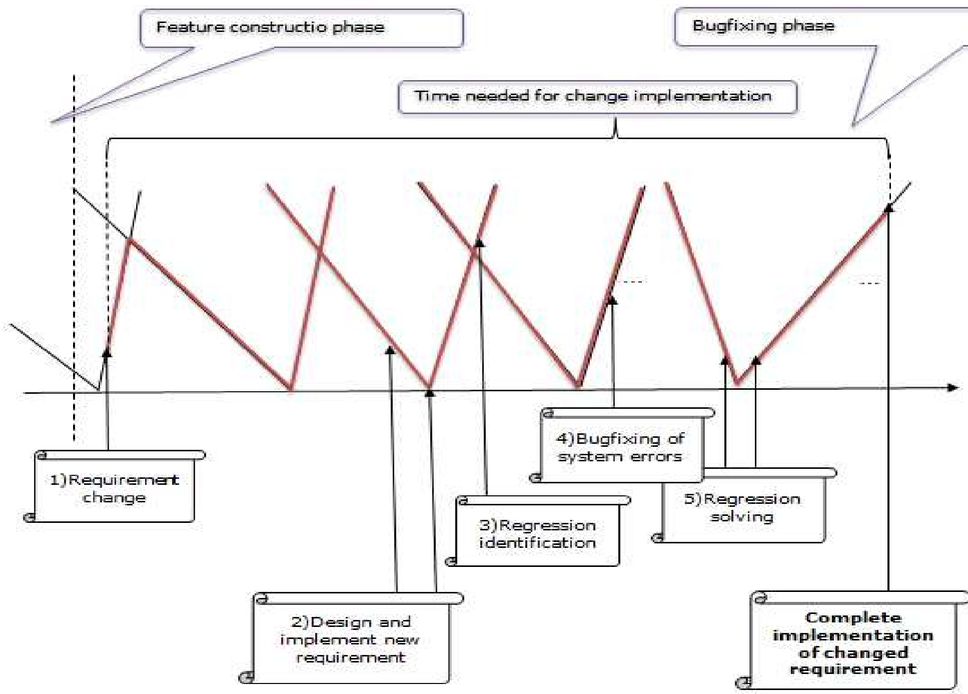

Fig. 3. Path of requirement changes in the bug-fixing phase of projects using the V-cycle development model.

3. INTEGRATING AGILE METHODOLOGIES INTO TRADITIONAL DEVELOPMENT MODELS

The traditional models used in the development of automotive projects proved their inflexibility regarding requirement changes. But continuous evolution of technology within one automotive project life cycle (which is at least 4 times longer than competing aftermarket state-of-the-art technologies) requires a flexible development model, which steered the authors to the analysis of possible solutions like inserting flexibility into the currently used development models. As automotive projects run as a part of other projects, all included into an overall project called system project, it is obligatory that the change of one development model will not affect the interfaces to other system projects. Any change brought to the phases of the development model will have to keep the delivery dates to other system components. For instance, radio-navigation projects accept as main target the delivery of hardware and software, but most important is to agree the date when the hardware has to be delivered to production.

The need to change to flexible development models and to keep the current structure of traditional models forced the authors to analyze the possibility to integrate agile methodologies into the traditional development models. The literature review and the analysis result of traditional development directed the authors to the required changes of the traditional development model used in the automotive projects. The disadvantages of every development phase of the V-cycle model were countered by agile methodologies with the aim to keep the delivery dates as defined.

The starting point of our solution is the left-hand side of the V-cycle model, where we changed the running processes of the phases with the intention to give the model the relevant flexibility. We started with requirement specification phase, where instead of changing requirement documents, we suggest to use direct communication. The JAD (Joint Application Development) [15] gives the supplier direct access to the needed information and customer requests. The very good communication between customer and supplier in the early phases of the project is the most important factor for project success.

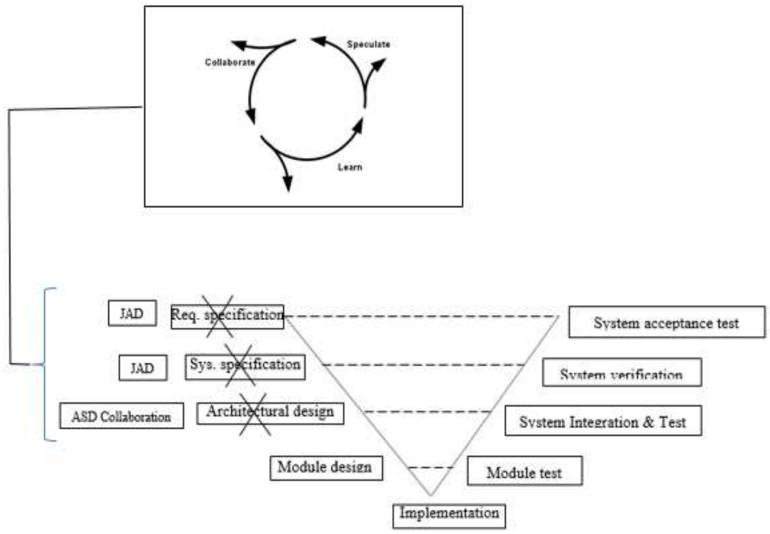

Fig. 4. V-cycle design after integrating agile methodologies in traditional model phases

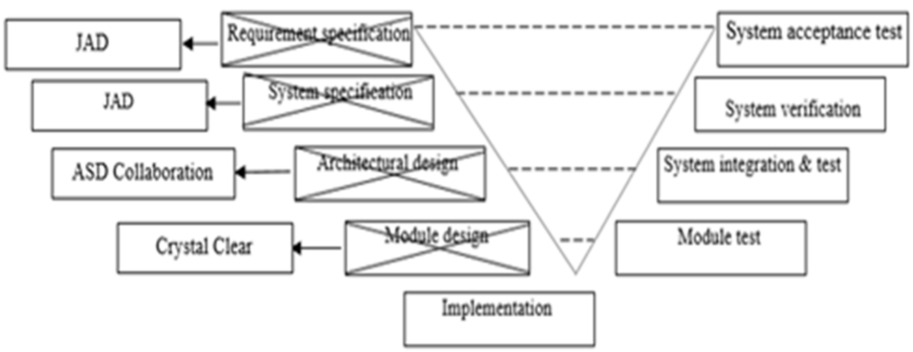

Fig. 5. V-cycle design after replacing the module design phase with agile methodologies (Crystal Clear)

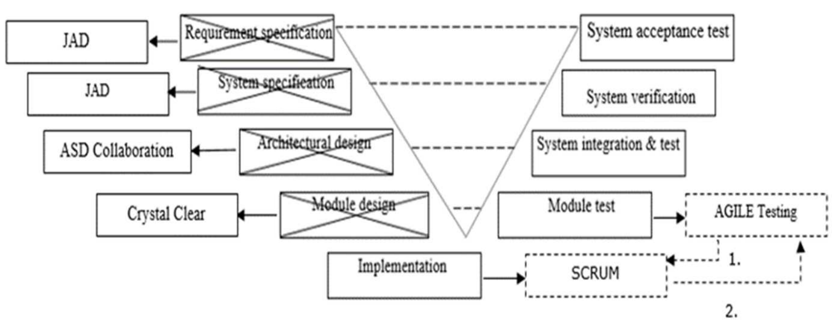

Fig. 6. V-cycle design after replacing the implementation and module test phases with agile methodologies (SCRUM)

The replacement of the V-cycle phases of system specification and architectural design agile methodologies based on JAD and ASD Collaboration [16] (Figure 4) will heavily increase the chances to achieve the project success criteria.

The main disadvantages of using the V-cycle model in large automotive projects are: (1) Client is not involved in architecture definition; (2) Supplier does not get in time the confirmation about final requirements; (3) Never ending discussions between system architects.

The advantages of using the JAD and ASD Collaboration methodologies are:

- Intense collaboration between client and development team in a project early phase;
- Ability to predict the influence of requirement changes over the project;

- Design system architecture as change tolerant;
- Improved collaboration between project teams through ASD Collaboration.

Descending further on the left-hand side of the V-cycle model, the authors identified the disadvantages using the traditional development models in the phase of module design:

- The absence of a prototype to confirm the correctness of the module design;
- The client does not get involved in this phase, which lead to the impossibility of confirmation of module design;
- Week communication between team members while designing the system modules.

Looking to neutralize the V-cycle disadvantages presented, the authors analyzed the properties of several agile methodologies which can help fulfilling these objectives. In the end we decided to replace the V-cycle phase of module design by applying the processes of Crystal-Clear methodology (Figure 5).

The advantages of using the Crystal Clear methodology are:

- Intermediate deliveries depending on project priorities;
- Continuous involvement of the client by organizing meetings with the objective of presenting the intermediate results;
- Adaptability of process and change flexibility. By gathering feedback from the client, it is possible to adapt the project requirements in the early phases. The small teams used in this methodology, facilitates the knowledge transfer and communication in project.

As there is the wish to not jeopardize the overall automotive system, the last phases of the V-cycle model, which we decided to analyze and adapt are the phase of implementation and module testing. From authors experience the main issues and delays are generated by:

- Rigid organization of project. The first 2/3 of the entire project time is spent on implementation of requirement. Only 1/3 of the remaining time is spent on debugging (bug-fixing). These two phases are not mixed up while using traditional development models;
- The impossibility to prioritize function on short term;
- The testing of the implemented code can be tested only after a long period of time;
- Implementation of scrap software;
- Inflexibility on changes.

The analysis of SCRUM [17] defined the countermeasures, which must be taken to neutralize the negative effects described above. The advantage of incubating the module-testing phase into the phase of implementation will generate the necessary problem feedback, including the possible solution. The advantages of the SCRUM agile methodology are:

- Short term planning by using the sprint planning;
- Tracking of project status by also involving the project client;
- Flexibility on changes;
- Fast feedback on implementation errors;
- Fast reaction on requirement and priority changes;
- Possibility to report exact project status at every moment of the project.

Figure 6 presents the new development model after integrating the SCRUM methodology.

The AGILE methodologies inserted into the V-cycle determined the authors to name the new development model 2JCS (JAD, JAD, ASD Collaboration, Crystal Clear, SCRUM, SCRUM Testing).

4. ADVANTAGES BROUGHT BY THE 2JCS DEVELOPMENT MODEL

The conception of new development models implies the finding of relevant validation methods applied to a certain environment. ”The validation of design methods is important for (i) the continuing advancement of design theory for researchers, to guide the development and evaluation of new methodologies, and (ii) for the professional practice of engineering, to determine which methodology to employ as well as when and how to employ them” [18]. Even if after literature review it results that the validation of development models implies applying mathematical models, [19] there are situations where this is not possible. “Since much engineering research is based on mathematical modelling, this kind of validation has worked – and still works – very well. The main objective of development models is to guide the project so that it saves time and costs. The development models have to prove their efficiency from the point of view of the variable combination of "time" and "cost".

During author's research to validate the conceptual model 2JCS, we asked several companies to develop several projects using the 2JCS model. There have been more than five automotive projects in which the 2JCS model has been applied. Authors target was to validate the model by collecting empirical data from these projects. Based on the obtained data we could compare two similar projects using the traditional- and the 2JCS development model.

The authors decided for confidential reasons to name the companies in which the validation took place "A" (inspired from the use of agile methodologies in the model) and "V" (inspired from the use of V-cycle). The precondition was to compare similar projects, with appropriate number of requirements. The project of company "V" had 11000 requirements and the project of company "A" had 11700 requirements. The comparison of these two models is made only for the phases of the V-cycle model, which have been replaced by agile methodologies. The comparison duration of the two models in similar projects starts with the first two phases of the V-cycle and 2JCS model, requirement- and system requirement specification (Figure 7). The data collected from the two companies are presented in Table 2.

In large automotive companies' parallel projects will add delays in current projects. The activities of the requirement specification and system specification are composed of the sub-phases listed in Table 3. The sum of sub-phase duration of requirement specification generates the total time needed for the phase of requirement specification.

The main difference for the phases of architectural and module design (Figure 8) is given by the project organization. In the V company the two phases have a clear start and endpoint, while in the A company these two phases run during the whole project duration. After collecting the data from the two companies, the usage of ASD did not reduce the duration of these phases but improved the flexibility to implement new requirements during project development.

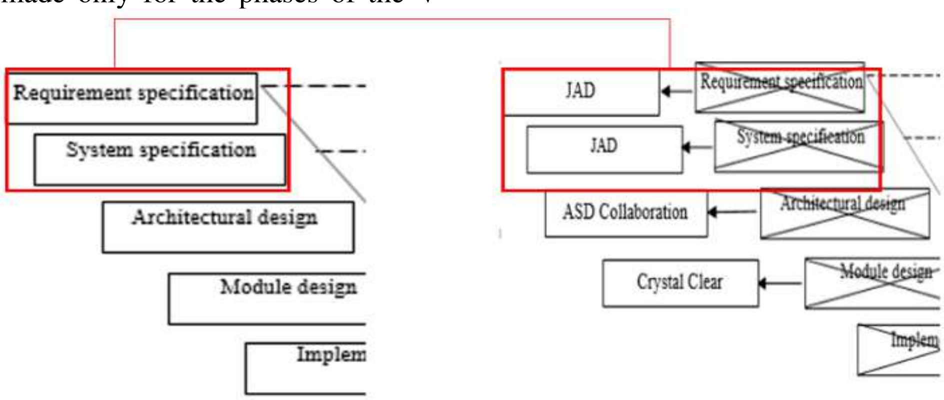

Fig. 7. Comparison of requirement specification phases of V-cycle and 2JCS model

Table 2

Comparison of characteristics of traditional development models vs. agile methodologies

	Activities of requirement specification phases	**Phase duration in company V(-cycle)**	**Phase duration in company A(gile)**
1	Creation of initial requirements	24	24
2	Specification review	5	5
3	Chose relevant requirements for project	6	6
4	Send requirements to supplier	1	0.5
5	Analyze requirements	6	1
6	Review requirements	2	1
7	Request of requirement modification	1	1

8	Review request of modification	1	0
9	Change requirements	2	0
10	Review changed requirements	1	0
11	Deliver changed requirement	1	0.5
12	Deliver requirement document to system architects	1	0
	Phase duration sum	**51**	**39**
	Transition time between phases	**2**	**3**
	Total duration time	**53**	**42**

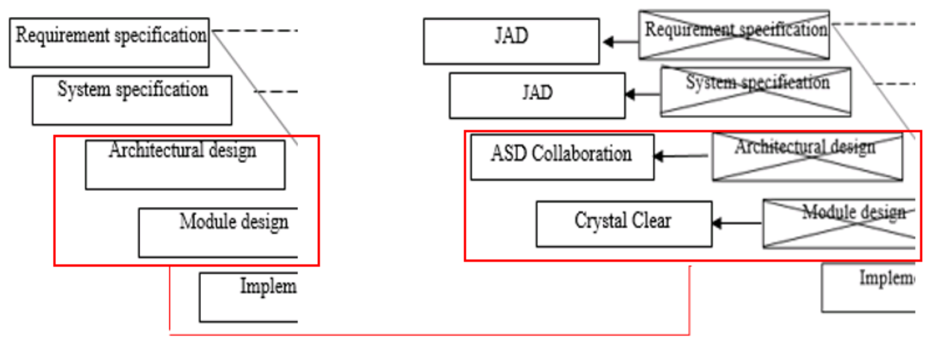

Fig. 8. Comparison of architectural and module design phases of V-cycle and 2JCS model

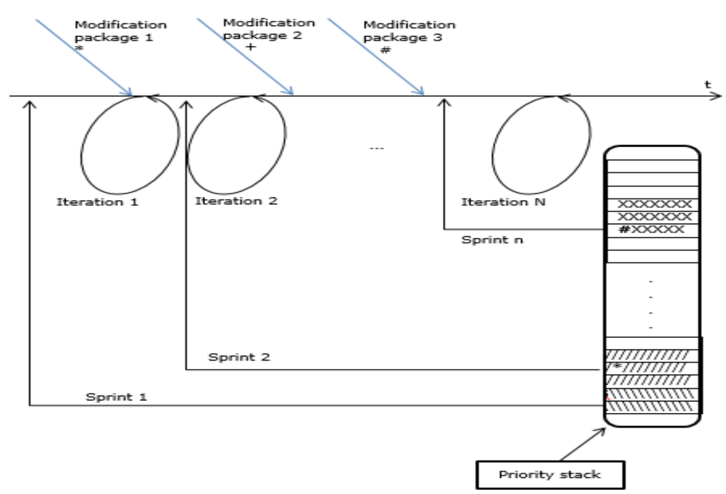

Fig. 9. Impact of requirement change in agile radio-navigation systems

The time spent for the implementation phase in the V company was one year for the construction phase and six months for the bug-fixing phase. The implementation sequence of requirements was not determined by the future grow of the system, but by the number of requirements which had to be implemented for different milestones.

In comparison, the agile methodologies used in the A company brought the needed flexibility to predict the grade of risk regarding future changes. The time reduction using the SCRUM methodology was won by reducing the implementation of unneeded software code. The requirements implemented at first in the project have been agreed with project customer, opposite to the project in the V company. Projects in V company did not have the necessary flexibility to implement additional requirements as the prioritization of requirement implementation did not involve the customer in order to predict (via client discussion) possible requirement changes (i.e. due to miss interpretations of the specification).

Developers who were involved in both companies defined as biggest advantage of agile projects the project structure. The first requirements implemented in the agile structured (infotainment) projects were the one of functions, which were already established in the market, like the radio or audio functions. Even if in case of projects developed in V company every requirement change brought milestone delays, the usage of agile methodologies leads to project content priority restructuring. Figure 9 shows the impact of requirement changes in radio-navigation projects using scrum methodology in the phase of code implementation. Because the modifications brought in the project have always big priority, these changes are planned in radio-navigation agile projects in the subsequent sprint. The changes "*" (modification package 1), "+" (modification package 2), "#" (modification package 3) were inserted in the project priority stack (product backlog) in agreement with the customer.

Depending on the position in product backlog the set of modification will be planned for sprint 1 to n. Developers of company A confirmed that using the scrum methodology instead of the implementation phase of v-cycle generated 20%-time economy. They explained that their tasks were not interrupted, and the implemented requirements were agreed with the customer, which brought the time management. The comparison for the module test phase was accomplished by interviewing the test managers of both companies. The main questions were: Q1: What was the advantage of using the agile testing methodology? And Q2: What is the risk of module testing only after complete software implementation of the modules?

The answers were: (A1) Identification and solving of errors in an early stage of the project; (A2) Errors found in any phase of the project will not be solved due to the accumulation of errors derived from all system testing phases. Concluding, the usage of agile methodologies in radio navigation systems will not save time but will keep project milestones and will allow implementing all requirements as planned initially in the project. In comparison to projects using traditional development models often had to remove initial planned functionalities as the quantity of task were compressed at the end of the project. The advantage of using AGILE methodology in the module-testing phase is quantified by achieving the expected results by meeting customer and end-user expectations.

A comparative analysis of the two models (V and 2JCS) for the phases of requirements specification, system requirements specification, architecture design and module design and the implementation phase showed that applying the 2JCS model, time management was improved even if the project duration remains the same: the phase of requirements specification lasts less; system specification phase lasts less; the implementation phase lasts less. Time saved in the three phases listed above is reallocated to the implementation phase of changed- and new-requirements. In conclusion, applying the model 2JCS does not shorten the project but avoids inherent delays, which incur by the application of V-cycle model due to requirement changes that occur in the current generation of projects.

As time economy directly flows into financial economy, we started discussions about financial impact using the 2JCS model. We identified 2 axes for financial analysis: (1) financial analysis during project development; (2) analysis of financial impact of project result. Table 2 displayed the time save applying the 2JCS. Still the financial economy is calculated dependent of project phase, number of experts involved in project phases and rating hour. The way to estimate the economy for every phase of the project is presented in (1):

$$C1 = NPF \cdot NOE2 \cdot VS \quad (1)$$

Where: NPF - number of persons involved in the development phase; $NOE2$ - number of saved hours using the 2JCS model, VS - corresponding hour rate.

Data collection of the two companies is shown in Table 3, where: HR- hours needed to run current phase, NP- number of persons involved in current development phase, SR - standard rate €/hour and monetary value MV is given by (2):

$$MV = HR \cdot NP \cdot SR \quad (2)$$

The advantage of the 2JCS model is shown in the last column of Table 3.

According to Table 3, a loss of money results by applying the 2JCS model, but in this table, the implementation of changed requirements was not included or calculated. The advantage of using the 2JCS model is that there are no intermediate phases for updating the project like in the case of V-cycle model. In case of using the V-cycle model the changed requirements cannot be implemented within given project schedule without throwing out of project scope initial planned functionalities. By changing requirements, the projects using the V-cycle model are forced to open an update project to implement the abandoned functionalities and finally complete the initial project mission. From data collection and author's experience, big radio-navigation projects have an average of 80 changed requirements or new functionalities.

The opening costs of a new project and the implementation costs of the requirements, which could not be implemented in the first phase of the project will generate the financial impact of project result.

Table 3

Financial data collection per project phase for the A(gile) company.

Development phase	*HR*	*NP*	*SR*	*MV*	Profit/loss in comparison to V(-cycle) company
Requirement specification	1.680	5	80	672.000	+176.000
Architectural design	720	4	100	288.000	0
Module design	120	10	90	108.000	0
Source code implemen-tation	3.240	250	80	64.800.000	-7.200.000
Module testing	600	10	50	300.000	-40.000
Total					-7.064.000

The average value of one not implemented function was 50.000€ and the costs of opening a new project was 5.000.000€. In conclusion, the advantage of using the 2JCS model is given by the sum of financial aspects during project development and financial impact of project result (3) in comparison to traditional development models.

$$C2 = PPD + PPR = -7.064.000 + \\ +(50.000 \cdot 80 + 5.000.000) = 1.936.000 \quad (3)$$

Where: PPD - profit during project development in comparison to traditional development models; PPR - profit of project result in comparison to traditional development models.

5. CONCLUSIONS AND FURTHER WORK

Practical background of the authors with radio-navigation projects led to the subject of this paper. The fast-growing area of information technology in the automotive industry demands the assessment of applied supporting engineering processes to improve or completely revise procedures. The study started with the comparison of different aspects regarding project success, opening with the enumeration of project critical factors and continuing with the opportunity of using traditional or agile development models in different projects. Solving the problem of changing requirements during development of radio-navigation systems assumes detailed knowledge about traditional development processes used in automotive projects. Any modified or added requirement to the initial project mission is implemented only after crossing four development cycles. The comparison of agile and traditional models delivered us the arguments of integrating agile methodologies into traditional development models. Keeping the structure of traditional development process models in radio-navigation projects is essential to integrate the methods used in the development of automotive software projects into the overall software and logistic processes used in producing the whole system or car. As external interfaces of the project must remain the same, we studied the possibility to encapsulate the fast agile methodologies into the phases of traditional models. We integrated the advantages of agile methodologies into the phases of the V-cycle model with the target of winning flexibility needed in software projects while changing or implementing new requirements. Finally, we started the discussion with the focus on addressing the time performance and financial advantages while using the 2JCS model. The advantages brought on the two axes are:

- Applying of the 2JCS model will allow the implementation of more changed or new requirements.
- The financial advantage during project development is negative, thus using agile methodologies will increase project expenses, but compared to the large number

of changed requests successfully implemented, the cost of completing the project by applying the 2JCS model becomes much smaller compared to projects, which used the traditional development V-cycle model.

- The financial consolidation between the financial outcome of project results and the financial result of project development will generate the complete picture of the budgetary advantage using the 2JCS development model.

Further research should focus on extending the 2JCS development model in all automotive areas, resulting in applying flexible methods in the development of all automotive projects and systems.

6. REFERENCES

[1] Kerzner, H. *Project Management Best Practices: Achieving Global Excellence*, New York, 2006.
[2] Caupin, G., Knoepfel, H., Koch, G., Pannenbäcker, K., Perez-Polo, F., Seabury, C, *ICB IPMA Competence Baseline Version 3.0*, page 13, 0-9553213-0-1, 2006.
[3] Hedeman, B., van Hemst, G., Fredriksz, H. *Project Management Based on PRINCE2®*, Van Haren Publishing, 9087534965, 2010.
[4] TenStep Inc., *TenStep PB PMBOK Framework Student Handbook*, 2005.
[5] Hutanu, A., Prostean, G., Mnerie, D., Badea, A. *Research of Requirements Constraints in Automotive Projects*, Procedia Technology, Vol. 9, pp 750-756, 2013.
[6] Nerur, S., Mahapatra, R., Mangalaraj, G. *Challenges of Migrating to Agile Methodologies*, Magazine Communications of the ACM - Adaptive complex enterprises, Volume 48 Issue 5, pp 72-78, 2005.
[7] Larman, C. *Agile and Iterative Development: A Manger's Guide*, Addison– Wesley, USA, 9–39, 0131111558, 2004.
[8] Martin, R.C., *Iterative and Incremental Development (IID)*, Engineering Notebook Column, C++ Report. 1999
[9] Prostean, G., Volker, S. *Research of Automotive Change Management and supportive Risk-Management*, International Symposium in Management, 2015
[10] Thomas, G., Fernandez, W. *Success in IT projects: A matter of definition?* International Journal of Project Management, 26(7), 733–742, ISSN: 0263-7863, 2008.
[11] Cohn, M., Ford, D. *Introducing an agile process to an organization*. IEEE Computer Society, 36(6), 74-78, ISSN: 0018-9162, 2003.
[12] Lindvall, M., Muthig, D., Dagnino, A., Wallin, C., Stupperich, M., Kiefer, D. *Agile software development in large organizations.* Computer, 37(12), 26–34, 2004.
[13] De Bakker, K., Boonstra, A., Wortmann, H. *Does risk management contribute to IT project success? A meta-analysis of empirical evidence.* International Journal of Project Management, 28(5), 493–503, 2010.
[14] Hoermann, K., Mueller, M., Dittmann, L., Zimmer, J. *Automotive Spice in Practice*, dpunkt.verlag GmbH, 1933952296, 2008.
[15] Rottman, D. *Information Systems Analysis, Joint Application Development,* 1999.
[16] Eberle, C. *Adaptive Software Development*, 2003.
[17] Schwaber, K., Sutherland, J. *The Scrum Guide. The Definitive Guide to Scrum: The Rules of the Game,* 2014.
[18] Du Bois, E., Horvath, I. *Operationalization of the quadrant-based validation in case of a designedly software development methodology*. International Conference on Engineering Design, Seoul, Korea, 2013.
[19] Rennung, F., Paschek, D., Dufour, C.M., Draghici, A. *Managing Complexity in Large-Scale Business Projects. A Theoretical Model*, Acta Technica Napocensis, 61(3), 169-178.

Model de dezvoltare pentru proiecte software de radio-navigație

Rezumat: Sistemele electronice utilizate astăzi in industria autovehiculelor devin din ce în ce mai complexe datorită schimbărilor rapide ale așteptărilor clienților. Astfel, pentru a gestiona o asemenea varietate de funcții sau cerințe, dezvoltarea este structurată pe mai multe unități de control electronice care sunt interconectate prin canale specifice de comunicații auto. Articolul prezintă procesul de dezvoltare software pentru radio-navigație dedicat autovehiculelor. Cercetarea realizată se axează în principal pe modificările cerințelor referitoare la produs, care au loc într-un proiect cu dinamica rapidă, ceea ce conduce la o nevoie puternică de evaluare și schimbare a strategiilor de implementare aplicate, iar dacă acestea se dovedesc a fi insuficiente chiar la dezvoltarea de noi abordări mai bine adaptate acestor modificări.

Gabriela PROSTEAN, Ph.D., Professor, Politehnica University Timisoara, Faculty of Management in Production and Transportation, 14 Remus str., 300191 Timisoara, Romania, gabriela.prostean@upt.ro, 0256 404039

Andrei HUTANU, Ph.D., Specialized Consultant, Politehnica University Timisoara, Faculty of Management in Production and Transportation, 14 Remus str., 300191 Timisoara, Romania, andreihutanu@yahoo.com, 0256 404039

Cristian VASAR, Ph.D., Lecturer, Politehnica University Timisoara, Department of Automation and Applied Informatics, Bd. V. Parvan no.2, Timisoara, Romania, cristian.vasar@upt.ro, 0256 403237

Stephan VOLKER, Ph.D. student, Politehnica University Timisoara, Faculty of Management in Production and Transportation, 14 Remus str., 300191 Timisoara, Romania, stephan-volker@htp-tel.de, 0256 404039