

# A Review of Software Development Methodologies in Software Engineering

Ms. I.G.U.Dilmini Rathnayaka<sup>1</sup>, Dr. BTGS Kumara<sup>2</sup>

<sup>1</sup> *Demonstrator, Department Remote Sensing & GIS,  
Faculty of Geomatics, Sabaragamuwa University of Sri Lanka 70100*

<sup>2</sup> *Senior Lecturer, Department of Computing and Information Systems, Faculty of Applied Sciences,  
Sabaragamuwa University of Sri Lanka 70100*

## ABSTRACT

*The software development life cycle (SDLC) is a framework depicting the gradual work flow of each step such as requirement gathering, analyzing, designing, implementing, testing and maintaining in the process of software development. Many companies and software developers want to increase the progress of software development by investigating the advanced techniques and methods to minimize the complicity of the development process. They are having difficulties when choosing an appropriate software development methodology. This is affecting to the failure of the software development process. There are several development models such as the Waterfall model, Iterative model, V-shaped model, and Agile methodology etc. These models have advantages and disadvantages. All the essential points and details about the software development methodologies are reviewed in this paper as well as the advantages and disadvantages of each model.*

**Keywords:** - *Software Development, Agile, Waterfall model, Iterative model.*

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## INTRODUCTION

According to the regular development and changes that happen today, it's no doubt that new problems and requirements arise not even biologically and chemically but rapidly in technological developments and innovations. From all these mentioned categories "Software development" is a significant area that is taking more attention. A software development process depicts as a cluster of procedures, actions, activities, and controls which are appropriate to obtain and assure the development process of the software and its associated products [1]. When handling software development, the customer requirements should highly consider and it is not so easy to manage those. New customer requirements are making a huge gap when software development is doing according to traditional development methods due to the modern world changes and new techniques. It could occur some issues in dependability, usability, availability as well as reliability of the software development outcome and that won't help to cover customer satisfaction.

A system should hold effective and efficient development for the reason of often modifications and requirements that arise in systems and functionality of the final outcome. As a suitable solution, new methods and pathways were software development pathways that are found basically to solve the issues above mentioned. The new methodologies include new moderations of the software development process that were introduced through this new methodology to make the software development process more fruitful and amendable. The new principles ensure that the development processes with new criteria are introduced to guarantee the software engineering principles and information technological standards are suitable to meet the needs and objectives of present software [2]. As it is mentioned here, the values of these methodologies are assisting to reach the goals and objectives of a process without hesitations. This paper includes with software development methodologies like scrum, agile, spiral, waterfall, etc., characteristics, advantages & disadvantages of software development methodologies, discussion and finally conclusion of the paper.

## 1. Waterfall Model

This method can be introduced as a traditional methodology in Software development. It is a sequence process of development and the development progress estimated according to consecutive phases which are showing an increment downwardly as a waterfall flowing. It emphasizes particular planning and comprehensive documentation as the outputs[3]. During this process, each and every initial stage begins after completion of the former stage and it is a linear sequential flow of activities. Due to this reason, the Waterfall model is recursive during each phase to get the perfect outcome and until it delivers a perfect outcome. After completion of each stage, that stage holds its own and specific deliverables. This is a software development procedure or architecture which possible to predict the forthcoming using the software development plan. The feedback of the project owner could collect after completion of development and testing stages. This methodology is applicable for slight software development projects which consists of undisturbed requirements with clear and easy planning.

### 1.1 Advantages of Waterfall Methodology

Simplicity and easiness in using and understanding is one advantage of using this methodology. Convenient management of methodology which helps to proper and specific deliverables at each phase as well as review the process when it's completed. This methodology is more productive when using for small projects which consist of clear and sufficient requirements. Each phase is completed within a given specific period before moving to the next phase which depicts a clear progression of the development project. Convenient implementation due to the linear flow of this methodology is another strength of this methodology. Implementation could proceed with the minimum amount of resources. Appropriate and proper documentation assist to enhance the quality of end result as well as the development procedure.

### 2.2 Disadvantages of Waterfall Methodology

Couldn't gain any working software until all the parts of the life cycle are completed. The availability of more risk and irresolution is a fact to consider here. This methodology is not suitable for large, complicated and object-oriented projects. This methodology could affect project failure if apply for the projects which consist of high-risk moderations. One phase of the development process starts after completion of the former phase and couldn't implement any changes after completion of a phase. This occurs for customer dissatisfaction

## 2. Agile Software Development Methodologies

A software development methodology can define as a proper guidance to maintain successive development process. In addition to that, it is a set of arranged tasks engaged with functions of software development process as well as it consists of structure to entire development activities. A software development methodology render the planning, analysis, design, development, implementation, testing and the maintenance of the process of software development by contributing suitable rules and guidelines. These methodologies help to manage a software project. There are no one and default methodology which suitable for every situation [4]. The reason for that is the software projects are different from each other as well as it's characteristics, resources that using, the development tools that use are slightly having variations. It's important to select the suitable and appropriate Software development methodology considering the attributes and nature of the project. The success and result of the project end product depends on choosing the appropriate software development methodology. And it helps to work before deadline, cost management, make a better client satisfactory, expenditure minimizing, etc. Considering these points, it's important to choose the best and most suitable software development methodology for the project. Some of the basic agile software development methodologies are discussed in this paper.

### 2.2 Agile Process

Agility in simply depicts to strip away the heaviness, usually associated with traditional software development methodologies, in order to accelerate the quick response for altering environments, modifications in user requirements, work before project deadlines.[5]. Agile methodologies give more attention to the development of the software than documentation. This methodologies trends to supply more work during its iterations and to use the feedback of the clients or customers to upgrade the software. This development methodologies way better suitable to enhance the ability to make changes in user requirements until the user or customer satisfaction about the final

product, rapid and effective development all over the development process as well as the incremental releases during a short time. This method usually applicable to law number of project teams, mostly for less than ten members. The reason for this is the team members must get tin to face to face interviews or discussions often. It's better to choose a team representative when using these methodologies. A disadvantage of agile methods is not applicable in large teamwork areas.

Followings are the different methods in agile methodologies

- Extreme Programming
- SCRUM
- Crystal family methodologies
- Feature-Driven Development
- Dynamic Systems Development Method
- Adaptive Software Development
- Open Source Software development
- Agile Modeling
- Pragmatic Programming

### **2.3 Extreme Programming**

Extreme Programming (XP) has gradually grown from the issues that occurred with the long development cycles of traditional development models [6]. This method began as a well-planned structure to finish the work with the successive and effective procedures all over the software development process. With the completion of remarkable experimental trials, this XP methodology was chosen to make "theorized" and usage. When using this method, the developers could work as pairs for the non-stop code segments. Using this method, it could gain robust final product with more quality as well as it could take double expenditure on the development process. This is a disadvantage of XP method.

### **2.4 SCRUM**

This is the most famous method in agile methodologies. It consists of small sprints (7-30 days) and the features could add during this sprint while conducting suitable meetings for better development. It's better to use a scrum board which helps to mention the tasks of the project. This method is ensuring the proper management in development process.

It is an innovative approach of industrial development process, applying development life cycles resulting reintroduction of more flexibility, adaptability and productivity [7]. Scrum depicts how to provide the functionality of team members to gain a flexible system. Scrum directs to magnify and strengthen the current engineering aspects (e.g. testing phase) of a software development process, allowing considerable management on privations or barriers all over the process and its utilization.

### **2.5 Crystal family methodologies**

This crystal family methodologies consists of various methods to choose the appropriate methodology for the selected project. Each and every team member of the crystal family, selecting different colors according to the workload assigned with. The dark colors were chosen for the heavier methodologies. Crystal family is gathering of agile software development methodologies which are possible use for diverse software projects depending on size, complexity, risk managing ability and number of people involved [8]. Crystal orange is aim for the projects which consisting maximum of 40 developers [9]. The project development period is last about two years. The project period is frequently about one to two years.

### **2.6 Feature-Driven Development**

It is an iterative development process. The FDD approach is not wrapping the whole software development process, but relatively aims on the design and building of phases [10]. FDD made to engage with co-operative activities during a software development process and avoid to utilize any significant process model. This approach involved for effective and efficient development of the project with better practices.

FDD contained five sequential processes while demonstrating the suitable methods, techniques, and guidelines which were useful for the stakeholders. The roles, artifacts, objectives, and goals were mentioned in this method. FDD depicts the most appropriate be for the development process of a project.

### **2.7 Dynamic Systems Development Method**

During this method, it settles the whole time it takes for the development, cost that would take and the quality. This method is allowing to take the project development to a finite and strong pathway. The basic view of DSDM is that when making the functions of the system, it increases the time period and resources to achieve that function. It is better to choose a fixed period and the required resources before adding more functions. This method suitable for projects when it considers the project time period, the cost for the development process, and the quality of the final product more specifically than the completion of the features of the project successively.

### **2.8 Adaptive Software Development**

Adaptive process model is a modified approach of XP model, which is the most widely used agile model [11]. ASD targets on the issues of the complex software development process mostly in the large systems. This method emphasizes the progressive and stage-wise development with stable prototyping. Furthermore, the ASD supply framework or an approach holding suitable enough guidance to avoid projects, but it should consider that it doesn't provide much guidance to trample the creativity.

### **2.9 Open Source Software development**

This is an innovative way of software development method. There are significant variations between this model and other respective models, about the flow of software development, adding modifications, reuse, and redistribute the software [12]. Open source developers are involved in a variety of activities such as designing, coding, debugging and utilizing [13]. This method defines as the traditional theoretical method that the programmers happy with writing, rectification and testing the software reducing the straight decrement. This method nominates free source code to be freely available for amendments and expanding the facility to modifications. Eventually, the developers who are using this methodology, won't gather and discuss the matters in the development process. This method can be named as a combination of distinct licenses for software development as well as a co-operation for the personals who develop software with regular progress. OSS doesn't hold the proper defined and expressed software development procedures with a formation of a written descriptive method. OSS consists of extensive testing which can be introduced as an advantage and it's due to the reason that the codes are examined by several developers. It's benefits for the developers who work in different locations in the same project. In this method, there is no project owner to give feedback. OSS methodology is applicable for slight, medium and wide-scale projects.

### **2.10 Agile Modeling**

Agile Modeling is an innovative method introduced by Ambler during 2002. It is a fresh pathway to accomplish the activities of the software development process. This method basically targets to procedures and traditional policies. This method focuses to minimize the documentation which involves the development process while inspiring developers to produce successive models and even in design parts of the process. The significant attention goes to proper communication with team members according to team structures with co-operative teamwork.

The basic element of agile modeling can be expressed as functioning the software. Agile Modeling is highly targeted towards to practices or procedures. It consists of basic eleven practices that are mentioned under four sections as iterative and incremental modeling, teamwork, simplicity, validation. These practices providing better ways to select an appropriate methodology for the development as well as for manageable teamwork. Moreover, eight additional were defined under three categories like productivity, documentation, and motivation.

This methodology introduces applications of solutions for the problems, support for traditional and organizational issues, way to maintain a better working environment with the help of tools and teamwork. Agile modeling depicts features like customer attendance, slight teams and very less or no communication. Agile modeling contributes to the illustrations about the way of agile principles influence for modeling. Agile modeling needs helping methods, due to the reason of it only covers modeling and not describing the way of creating, (Ex: UML models). This

Modeling only supports day-to-day software development activities and it should get a special attempt to illustrate the methodologies.

### **2.11 Pragmatic Programming**

Pragmatic programming is not consisting of any significant process, aspects, manifest roles or outcomes. It mainly targets towards day-to-day problems, but this method can be applied for any software development process.

However, it consists of a noticeable attempt to define the way of developing the design and implementation of software including reculant changes. The significant to providing solutions for maintaining software consistent among the changes is discussed in here. Pragmatic programming tests the actual code which is implemented, automatically. This can be more described as if the corrected problem codes are not adding for testing and if regression tests are not habitually run, the time and effort is wasting to find the same problem continuously, while the most unfavorable effect influence to the for codes that cannot be detected the issues early enough.

Automatization is emboldened in pragmatic programming during numerous activities. As an example, the creation of documentation drafts from source code, creation of code from database definitions can mentioned as things that should be automated. Pragmatic programming depicts easier, responsible and continence software practices. The approach of pragmatic programming to testing involves the test code being implemented alongside the actual code, and all tests being made automatic [14]. The procedures are almost written according to the view of a programmer, providing the way to resist certain coding and redesign issues, as well as to proper discussions of teamwork problems.

### **2.12 Advantages of Agile Methodologies**

Highly satisfied customers can be gained due to quick, nonstop development. The communication and stable interaction among each other of the development team and with the customers effect for a successive outcome reversely than maintaining interactions with process and tools. Fast delivery of software during a short time is one advantage of these methodologies. Communication between the customer and project team member is in the form of face to face conversation which makes easier for recognition of customer requirements and comments. Continuous and up to date cooperation and engagement of project activities help for a better development process. Nonstop consideration on good design and technical development which affects proper software output. Much easier to systematic adaptation for changes of conditions, requirements as well as features of the project. Allow to make changes in requirements of the project even it is late and while the development process is in action. Daily logs of work of the methodology, helps to keep the day today activities up to date during the project development process.

### **2.13 Disadvantages of Agile Methodologies**

First one is that agile methodologies are not suitable for green-field engineering and not suitable for maintenance, since there will be not much documentation for the systems [15]. During large scale projects, it is tough to estimate the effort essential for the entire software development procedure, at the beginning. It contained more documentation and designing during this methodology. Project development procedure could get away from the right path if the customer is not holding clear requirements and it could cause worse outcomes than the customer expected. Agile method subsists more on user involvement which can describe as poor user cooperation and communication could make project failure. Not proper methodology to develop a reusable software, for the reason of this methodology focus to provide solutions for distinctive issues and not for the general problems.

## **3. Prototyping**

Prototyping can be introduced as an innovative and evolved methodology which used to declare the specifications that used to develop a demo version of software outcome perfectly. During this methodology, the basic and inaugural specifications are declared due to the reason of distributing adequate information to establish a prototype. The prototyping methodology is highly targeted to clarify the specifications and it is the basic crucial part when considering the communication between project crew and project owner. Prototypes are used in numerous approaches, for example engineers fabricate prototypes of products to explore and control uncertainty in the design of a product, or in order to explore difficulties in the production process before the eventual large scale manufacture of the product [16]. Moreover, attention focuses on the functional issues as well as to user and usability issues

during the software development process. As a solution for that, the collectivization of knowledge of forthcoming users or straight engagement for the development process can be mention. Prototyping contributes shortened development cycle, in advance implementation, easy project management, less development expenses, enhanced user and developer communications, enhanced quality assurance, less maintenance costs, concentration of business functions and improved user satisfaction[17]. The feedback of project owner collected after completion of the prototype. This methodology is suitable for the wide-scale projects which are having difficulties to recognize the requirements for real coding functions. Moreover, Prototyping methodology is applicable for incomparable or modern projects which couldn't find any former illustrations.

#### **4.1 Advantages of Prototyping:**

This methodology is applicable for the projects which don't consist of clear requirements. Appropriate for large scale projects. Missing features, functions, issues, and errors can be identified easily. Users could gain a better knowledge and understanding of the project. It could get feedbacks soon. This is a rapid development process with progress in functional applications.

#### **4.2 Disadvantages of Prototyping**

Require immense effort for the programming. Enhanced complexity of the system effects for poor customer feedback. High cost if there are many iterations during the development process. Continual client feedback could badly effect for loss of management, scope, and control of the project. Nonfunctional requirements are not considered during this methodology which is effective for the performance of the development process.

### **4. Iterative and Incremental Model**

This is a methodology that perform the software development process step by step with entangling with expanding model. This model can be described as a substitution for the waterfall model. A primary model of application is developed according to the inaugural specifications. This model is expanded moreover than the prototype, which is effective for the initial application development. It is extended considering the project requirement, functionalities, and feedbacks. With the completion of testing part of this Model, feedback of the project owner is collected to add and regulate the specifications for extending the model. The above mentioned procedure is continuing till the model can appear a complete functional application which fulfilled all the client requirements. After completion of every iteration, project owner feedback could be gained. This method is applicable for wide-scale and medium scale projects. It depicts the significance of design than documentation by this model.

#### **4.1 Advantages of Iterative and incremental Model**

It repeats the overall application and functions until it gets the best and errorless outcome. Quick remittal of codes. It could arrive for the phase that the errors emerged and it is feasible to rectify the error. Repetition of phases until the project owner receives the expected requirements and until the user gain the expected needs. It's a good reason for this model to apply for wide-scale projects. The project owner or the client engages with the project activities directly which helps to progressive development and proper communication.

#### **4.2 Disadvantages of Iterative and incremental Model**

The necessity of heavy documentation is one weakness. Each iteration resembles and consists of a slight format of waterfall projects which is traditional and time-consuming. It could hold expenditure for management and maintenance.

### **5. Spiral methodology**

The Spiral Methodology built on the basis of an idea of a development project should be use a significant development, that can introduce as incremental and iterative. The spiral development model can be defined as a risk driven process model generator which helps to direct multi-stakeholder software systems. Spiral methodology target on recognizing the objectives and analyze the possible alternatives within the proper documented project procedures [18]. The Spiral methodology is consists of four main zones,

1. Planning,
2. Risk analysis
3. Development
4. Evaluation

The project will repeat the same zone multiple times according to the above-given order until the end product or the developed software application is fit for the market environment. If any risks are identified then alternative solutions are suggested and implemented [19]. The Spiral methodology specified to risk analysis and render numerous options before implementation procedure begins. Each cycle of this methodology could complete after the requirements of the given phase are totally designed and developed with the closure of the full testing part. This procedure repeats until it meets the requirements of the project owner or users. The large scale projects are divided into small phases and it makes easier to practice or develop small deliverables through the spiral model. The changes could make during the development process which renders a progressive working phase. The feedback of the project owner could be collected since the completion of the first iteration of the methodology. This methodology is applicable to medium and wide scale projects.

### **5.1 Advantages of Spiral Methodology**

Better to apply for wide-scale projects which consist of risky missions. The requirements could adjust with the stakeholder or client feedbacks. Consistency of control with the help of documentation. More features and functions can be added during the development process. More flexibility and allows to work with other development models. Convenience of adaptation which is helping for project requirements.

### **5.2 Disadvantages of Spiral Methodology:**

High expenditure to use the methodology. Distinctive experts are needed to analyze the risks of the project. Achievement of success based on the project's risk analysis session. Not suitable to apply for slight scale projects. Need an experienced project manager to handle, requirement changes of the project and who got proper understanding about amend of deadlines as well as adding milestones.

## **6. Rapid application development**

Rapid application development is introduced to gain an end product by rapid development with better quality which couldn't be accomplished with traditional methods. It designed to receive the uttermost benefit of development project. This method consists of more specialty and significance to the development than planning which is the most important part of the development project. In rapid application development, structured techniques and prototyping are especially used to define users' requirements and to design the final system [20]. The structural techniques begin the development procedure. As a support, the data models namely preliminary and business are entangling with this process. During the next phase, the collected requirements are confirmed by prototyping, to clear-out the data as well as the process models ultimately. These phases are repeating continuously until it meets a combination of technical and business requirements of the project owner which are the basic two factors totally effect for a successful outcome. With the completion of each phase, the project owner is able to provide feedback. This methodology is applicable for all wide, medium and slight scale projects.

### **6.1 Advantages of RAD Methodology**

Enhanced capability to reuse the components. Occurrence of fast fundamental reviews which is a remarkable benefit. Proper and easy changes of requirements by collecting customer and project owner feedbacks. Better support and good capacity for solving integration problems from the start.

### **6.2 Disadvantages of RAD Methodology**

Weak documentation is one basic disadvantage. High expenditure for the developments and problems could emerge in codes during integrations. More experienced developers and designers need for the development process. Based on modeling skills which are most effective for project and development process dependency. Not suitable for low budget projects due to the high expenditure for modeling as well as for automated code production.

## 7. V-Model methodology

V-model is dependent upon component-based programming methodology [21]. V-Model methodology can be named as a model that can verify and validate. This model depicts an expanded edition of the traditional waterfall model due to the flow of sequential phases. This model specifies the testing method which can be introduced as paring all phases of software development using a proper and appropriate division of testing. When the process of software development is finished, project owner feedback received as the approval testing of the project. This methodology is suitable for small and medium-scale projects.

### 7.1 Advantages of V-model methodology

Simplicity and convenient to use. Earlier completion of testing procedures like designing and planning tests before coding, which help to well management and save time with progressive success than the waterfall model. Shortcomings are prevented from downward flow and Minimized rate of errors.

### 7.2 Disadvantages of V-model methodology

Less flexibility and the test documents should update with requirement documentation when it occurs any changes during the development process. Simple change could lead to large changes. Needed clear requirements and difficult to process with unfixed and unclear requirements. Prototypes are not available. Consistency of high risk and Project scope could fail with requirement changes.

## DISCUSSION

Software development methodologies consist of two practices as heavyweight and lightweight. Heavyweight methodologies are worth for to apply for the projects which consist of proper requirements that no need of applying changes. Heavyweight methodologies provide convenient implementation and capable to get a better understanding. The documentation consists of clear and perspicuous and descriptive information about every phase of the development project. The project manager is capable of success and easy performance in tracking, valuating and making records with the use of heavyweight methodologies. To the planning and research phases, the project owner is entangling noticeably. Lightweight methodologies are appropriate for projects which consist of unstable specifications and mutable requirements due to the interior or exterior factors of development project. Lightweight methodologies flow according to incremental procedure which could deliver the software during sequential phases or iterations. After collection of all those deliverables, the final and complete functional version of the software could be gained. Better flexibility and smooth adaptation for changing requirements are the benefits of lightweight methodologies. These methods inspire the quick delivery of codes, proper planning with self-motivated and well-managed project teams. The project owner is highly engaged for all of the project development phases due to the reason of project input and feedback are more important and effective when using lightweight methodologies. The benefits and weaknesses of several methodologies are provided in this paper. Project owner profile, project complexity, technical expertise frequency of project developers, expected project budget and deadlines are the most important factors which should consider when selecting a software development methodology.

## CONCLUSIONS

Obviously, it doesn't have any methodology to fulfil all the requirements and satisfy to gain a perfect final project. After considering all the factors, the best and proper methodology should select with the help of experienced team members and project managers. Instead of selecting one methodology, a combination of software methodologies could choose for the development process to gain a better outcome. Modernized and recent software development projects need innovative methodologies. This is a caption that has to be considered for more research under the range of software development.

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## BIOGRAPHIES

	<p>Author 1- Ms. IGU Dilmini Rathnayaka - Currently working as Information Technology Demonstrator in Department of Remote Sensing and GIS, Faculty of Geomatics, Sabaragamuwa University of Sri Lanka. Graduated as BSc(Hons) Computer Science &amp; Software Engineering degree holder from University of Bedfordshire, United Kingdom. Currently, following MSc in Information Management at Sri Lankan Institute of Information Technology.</p>
	<p>Author 2 - Dr. BTGS Kumara – Former Department Head, Senior Lecturer at Department of Computing and Information Systems, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka. Followed PhD in Computer Science and Engineering, University of Aizu, Japan during 2015, MSc in Computer Science at University of Peradeniya, Sri Lanka during 2010, and BSc (Hons) in Computer Science and Technology, Sabaragamuwa University of Sri Lanka during 2006.</p>