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Scrumbanfall: A Hybrid Blend of Agile & Waterfall in IT Projects

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Abstract: The Software industry has been growing with the advent of automation technology and is looking for a change in their software development practices to reap the benefits of automated technology to achieve their business objectives. Agile Business Process Reengineering (ABPR) is a trending software for Engineering Management (SEM) in the software industry, which assists software development in the transformation of software development practices. Scrum and Kanban are popular Agile solutions acquired by Software Engineering Management staff. Scrumban, a combination of both Scrum and Kanban, has gained strength from both parties, building a strong framework that addresses the challenges of Agile Software Engineering (ASE) methods such as workflow control, lead time, unresolved product delivery by Scrum or Kanban as an independent framework. However, some of the challenges, outside of Scrumban such as project documentation, planning, planning, evaluation and clear product vision in the first phase of the project. Such issues have prompted an application for research by Software Process Reengineering (SPR) in Scrumban by customizing its design to build the next level of hybrid framework. The traditional SDLC 'Waterfall' approach has the answers to those problems. An artistic analysis, solution to these problems, with the help of 'Waterfall' and its life cycle processes is the main objective of this study by combining Scrum with Kanban and Waterfall to form the hybrid framework 'Scrumbanfall' which aligns Kanban's central integration under the Scrum rules.

Keywords: Scrum, Kanban, Scrumban, Scrum Challenges, AM - Agile Methodology, ABPR - Agile Business Process Reengineering, BPR - Business Process Reengineering, ESE - Empirical Software Engineering, SPR - Software Process Reengineering, SEM - Software Engineering Management.

I. INTRODUCTION

Scrumbanfall is the agile hybridization and integration of Scrum and Kanban with Waterfall in Software Engineering Management (SEM). Agile is the framework for software development practices, built on the principles of Agile Manifesto and various approaches have been developed as a standard SEM practice. Agile is changing the way we think about product vision as it follows the flow of external processes as a process of innovation, depending on customer number, product quality, product growth and roles in the software product development team. In all, Scrum and Kanban integrate and fulfil all of the core values of the software development organization. Scrum and Kanban are both fast-moving entities and find aspects of Agile Manifesto principles as a core concept. Scrum is the most popular Agile Software Engineering Management (ASEM) framework among all Agile Methodologies (AM) systems; due to its features such as artifacts, events, pillars, roles and values, which transformed the software operating systems in software development organizations by empowering organizations responsible for Agile Business Process Reengineering (ABPR). All important factors should be taken into account when choosing a framework as a standard procedure for how to improve software and management.

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Scrum framework faces some challenges with software development practices such as lead time and workflow control, direct participation of external stakeholders as a critical decision maker, team size and their specific role in the development of large software product in a distributed area, complete product evaluation and vague product vision. Scrumban can overcome a number of challenges such as job flow control, lead management time; continuous integration with software product delivery. However, Scrumban is unable to cover all the challenges of software development. The proposed Scrumbanfall will help solve some of the problems such as project requirements documentation, planning, planning, evaluation and a clear product vision in the first stage of the product. Software development evaluation ensures cost (budget) and time frame for building quality software as well as clarification of operational and operational requirements. ABPR requires the appropriate PLCF (Process Life Cycle Framework) in the organization building using automotive technological capabilities such as AI (Artificial Intelligence) and ML (Machine Learning) for Software Project Management (SPM) frameworks in software development organizations such as emerging of this automation technology has the ability to perform project tasks and business operations as required by the organization.

II. RESEARCH OBJECTIVES

Agile integration of Scrum and Kanban with traditional SDLC methodology 'Waterfall' to overcome challenges of Scrum using empirical analysis of Agile Business Process Reengineering (ABPR) practices; is the goal of this research study. Following are core objectives of this research study:

a) Conceptual vision about agile integration of Scrum and Kanban with Waterfall.
b) An empirical analysis on how Scrumbanfall can help in resolving challenges of Scrum and Scrumban.
c) Proposed structure of Scrumbanfall system flow and its lifecycle phases.
d) What can be next form of hybridization for the challenges that could not be covered by Scrumbanfall?

Effective use of SEM (Software Engineering Management) in achieving the desired outcome and production and product production objectives, by selecting sound framework solutions - Scrum, Kanban and Waterfall; it is the purpose of this study.

III. SCRUMBANFALL

Scrumbanfall is an agile integration of Scrum and Kanban with Waterfall model using the mixture of traditional SDLC protocols with the empiricism, agility and workflow management.

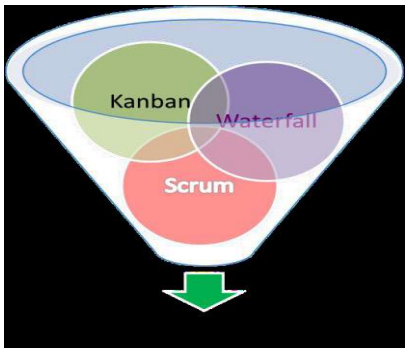

Figure 1: Scrumbanfall = Scrum + Kanban + Waterfall

Figure 1 depicts the amalgam of Scrum and Kanban with Waterfall for the optimized formation of Scrumbanfall. Scrum lies on the base of the Scrumbanfall Model, by keeping Kanban in the center of the Scrum and covering Waterfall prior to the Scrum Sprints.

A. Scrum

Scrum is an effective framework of empiricism, built on the basis of a control concept of empiricism under the framework of agility, which helps to address complex operations and improve productivity and quality of software product development. Scrum features that can be selected for Scrumbanfall formation are:

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a) Pull and push control system for workload control
b) Events, Artifacts, Pillar and Values of Scrum
c) Creativity and productivity
d) Self-organizations and servant leadership

B. Kanban

Kanban is value optimization theory based agile framework for the transparency of work flow movement and limited work in-progress. The Kanban features that can be selected for Scrumbanfall formation are:

a) Limited WIP system
b) Work item movement management
c) Little's law and Flow theory
d) Kaizen and JIT
e) Continuous integration and delivery

C. Waterfall

Waterfall was the first tradition SDLC, introduced in 1970 by Winston Royce, as linear sequential process flow model for the software product development. Process flow is divided into several SDLC phases like requirement analysis, planning and scheduling, system design, implementation, testing, deployment and maintenance. Waterfall features that can be selected for Scrumbanfall formation are

a) Requirement Analysis & Documentation
b) Project Planning and Charter

IV. SCRUMBANFALL LIFE-CYCLE MODEL

The Scrumbanfall life cycle model includes the following categories, based on Scrumban (Scrum + Kanban) and Waterfall as Scrumbanfall is a combination of them all.

1) Requirement Analysis
2) Project Planning
3) Sprint
a. Sprint Planning
b. Daily Scrum
c. Work Item Management (WIM)
i. To - Do
ii. In Progress
iii. Done
d. Continuous Integration and Continuous Delivery (CICD)
i. Sprint Review
ii. Sprint Retrospective
4) Product Release

A. Requirement Analysis

Requirement Analysis & Documentation is derived from the Waterfall model, during which the requirement specifications are analysed and documented using various standard project documentation procedure, whichever is applicable according to structure of the product, project and organization. It is essential for software project development to visualize the conceptual view of the product, project planning, estimation and prediction about risk in the project, if there will be any feasibility during the project process life cycle. According to rulebook of Waterfall model the output of RAD phase will be the input for the Project Planning & Charter phase. With the help of the needs analysis document, the Product Backlog Item (PBI) pool is created in the form of a User Story Document (USD) based on Scrumbanfall. The Product Backlog (PB) dam is the issuing phase for the need for analysis and documentation. Stakeholders who are required to participate in the required analysis and documentation are the Scrumbanfall product owner, business analyst,

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project coordinator, project manager, working group manager or team member, organizational management, external project (external) project stakeholders or other development-authorized stakeholders.

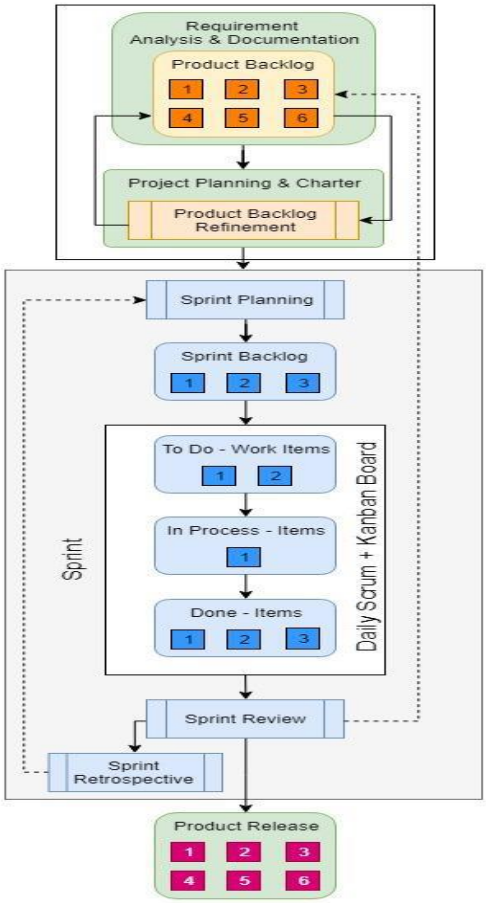

Figure 2: Proposed Scrumbanfall Process Flow

B. Project Planning

Project Planning and Charter is the second phase of Scrumbanfall, which uses the Product Backlog (PB) pool as a continuous input into the PBI editing process where each user issue is converted into multiple user stories, if an epic is created in PB; each user story is divided into Kanban cards in the form of a list of technical tasks. Each of the Kanban cards can have a list of technical tasks and all the PBI are sorted by order.

C. Sprint

Sprint is the next section of Scrumbanfall, featuring Scrum events and Kanban career trips; such as Sprint Planning, Daily Scrum, Sprint Review and Sprint Retrospective. Sprint Planning generates Sprint Backlog Pool (SBP) with the help of project planning and stock planning by maintaining PBI priorities within Sprint Planning.

DoD (Definition of Done) is the result of a Sprint Planning and Sprint purpose meeting, which will be investigated during the Sprint Review meeting, while DoW (Definition of Workflow) is a constructive process to be followed by the Scrumbanfall Team, which will facilitate discussion during of the Sprint Retrospective meeting.

Daily Scrum is a formal meeting every day in the beginning or end of the day, during which Kanban WIM is undertaken by the development team using Scrumbanfall board, by visualizing 'To-Do', 'In Progress' and 'Done' items on the board. CICD is an optional phase of the cycle that occurs when there is an urgent need for improved delivery, within the Sprint. The Sprint Review is an investigation of things that have been developed at the end of the Sprint. Completed items are submitted to the PRP (Product Release Pool) in the form of Product Extension (PI) and incomplete items are returned to

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the PBP. Sprint Retrospective is WIM flow investigation event, followed by Sprint Review, as an opportunity of ABPR for the upcoming Sprints.

D. Product Release

Product release is the delivery management of developed items, available in PRP (Product Release Pool) in form of PI (Product Increment). Any change request or bug reported post product release will be forwarded to PBP.

V. SCRUMBANFALL ARTIFACTS

Scrumbanfall artifacts are base of the framework in the form of customer value, documentation, workflow management, transparency, increment and opportunity for Scrumbanfall team and other stakeholders.

- Product Backlog Pool (PBP)
- Scrumbanfall Document (SD)
- Sprint Backlog Pool (SBP)
- Product Increment (PI)
- Product Release Pool (PRP)

A. Product Backlog Pool (PBP)

PBP is a cumulative core collection of requirements for product development and its documentation in form of BRS (Business Requirement Specifications), UCS (Use Case Specifications), FRS (Functional Requirement Specifications), SRS (System Requirement Specifications), USD (User Story Document) along with WMD (Wireframe Mock-up Designs) and SFD (System Flow Diagrams) etc. whichever is applicable according to project, product and organizational structure. Any change or amendment in PBP requires refinement of PBI and rearranged in PBP sequential order according priority.

B. Scrumbanfall Document (SD)

Scrumbanfall document consists of planning and scheduling information which helps in estimation of at project level with required level of accuracy. It's an epic collection of Sprint Planning describing time duration required based on information available in PBP. Any change in PBP results into redesigning Scrumbanfall document and results into recalculation of product estimation.

C. Sprint Backlog Pool (SBP)

Sprint Backlog Pool is the small chunk of PBP and follows Scrumbanfall document without any alteration. SBP is generated during Sprint planning and results into DoD and DoW. Product backlog reconsidered for refinement exact prior to Sprint planning meeting, if it is required. Items that should fall under CICD are also discussed and planned.

D. Product Increment (PI)

PI is the result of Sprint and outcome of Sprint Review meeting by keeping DoD in the center of the event. The developed items meeting DoD are investigated and forwarded to PRP as an increment of product.

E. Product Release Pool (PRP)

PRP is a collection item, for which development is completed, in the form of product increment and considered for deployment and delivery, as and when required, according to Scrumbanfall document plan.

VI. WHY SCRUMBANFALL?

As each path has its own characteristics and barriers; an independent framework Scrum or Kanban or a waterfall cannot provide complete solutions to all the challenges of Software Engineering Management (SEM) processes. Scrum and Kanban are the agile software project management teams while Waterfall is the first traditional SDLC and still exists in some of the software development organizations, which have not yet taken agile frameworks. Agile frameworks are best suited for large or medium-sized software projects, where project requirements and scenarios are frequently changed over time, while Waterfall is suitable for short-term projects with clear needs in the first phase of the project, predicting

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that project requirements may not change during its life cycle. final project delivery. According to the Waterfall rulebook, only one category can be considered an 'In-Process' at a time because the (output) result of one phase is for the next phase, which is the largest return of the Waterfall model to follow and use in modern software development practices but the same is the biggest advantage in Scrumbanfall as it benefits as the first two phases - Needs Analysis and Documents, as well as Project Planning and Charters from Waterfall. Complete documentation of project requirement descriptions and their planning is the largest Scrumban (Scrum + Kanban) distraction.

Project planning and scheduling help in cost estimation at project level, which is essential information for the management of development organization and other internal or external stakeholders in budgeting. An accurate estimation of assets and resources involved into software project has a great importance to measure the length (in terms of timeline duration) of the project and its cost calculation, which are critical factors for the project owners like client or the stakeholder's organization who will be going to bear the cost of software product development.

Scrum was introduced to deal with the challenges of complex projects having no straight forward requirement defined and the product requirement keeps changing very often. With the help of such characteristics, the requirement changes will go under requirement analysis as soon as product requirement changes and it will be pushed into PBP for the backlog refinement process. As PBP is the source of input for the project planning phase; any change or amendment in Project Requirement; results into additional cost to the software product owners and organizations, which needs redefinition of project estimation and budget. Scrumbanfall document improves accuracy level and decision-making capabilities of the organizations.

Transparency of each and every phase of the project is one of the pillars of the Scrum. WIM enables visibility of each state of work item and visualizes work in process report and helps in tracking progress of the project.

VII. EMPIRICAL ANALYSIS

The combination of empiricism and WIM with linear sequential procedures empowers the strength of software development organizations. Cocco et al developed a system dynamics model for the comparison of means of simulation techniques for prescriptive approach using Scrum and Kanban on Waterfall in 2011, and evaluated that each of them has their own strengths and weaknesses and proposed further research work on the combination of all them to resolve the agile software development issue. In 2011, Cuellar concluded that Kanban has very less detailed definition about processes and principles to be followed in the software development practices, compared to Scrum but it is less rigid in handling capabilities for the work flow of development practices.

In 2016, Taani and Razali analysed requirement prioritization process for the product backlog in agile software development practices and carried out factors like customer value and feedback, estimated process duration, dependencies, clarity on backlog item; which are indispensable and should be regarded. Ahmad et al conducted a survey in 2016 and thematically analysed challenges of Scrum like visibility of work flow, prioritization of work items, and failure of Sprints and evaluated that such challenges & obstacles could be minimised and reduced with the help of Kanban. In 2017, Alqudah and Razali performed a comparative analysis about the factors which are effective for software engineering practices from Scrum and discovered that user roles and responsibilities; team and batch size; lead and adoption time; cost and quality are appropriate. Due to the lack of statistical evidence comparisons that help address the challenges of traditional software engineering, Lei et al conducted a mathematical comparison in 2017, evaluating the performance of Scrum and Kanban in SEM (Software Engineering Management) operations and concluded that Kanban is better than Scrum for project flow management but depends on project planning and project planning. Traditional SDLCs like Waterfall while measuring project level. Dennehy and Conboy conducted a case study of 2018, on the challenges of a 'Flow' project management project in the world of Scrum and concluded that Scrum follows a box-time concept that may be different from the concept based on the Kanban flow. They suggested that project management practices lead to further integration and delivery of improved product that can be achieved through both Scrum and Kanban.

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In 2019, Averineni and Rama Swathi empirically explored and recommended the concept of Agile practices has been gaining potential in perception of people and it should be implemented in organization as an Agile HR practices also. In 2019, Singh et al argued that calculation of accurate estimation is the core activity for the software engineering projects and they proposed a PSOT (Particle Swarm Optimization Technique) which improves the results for estimation process using the calculation approaches based on SLOC (Source Line of Code) and FPA (Function Point Analysis) techniques. SLOC result shows 12.09% improvements per 733 SLOC while FPA shows 60.88% improvements. The summary of empirical analysis of this research represents requirement analysis, cost estimation, project planning, scheduling, quality measurement, error identification and error prediction at early stage of project are very critical factor and they have grate impact on success of the project.

TABLE I: LIMITATIONS OF SCRUM, KANBAN, SCRUMBAN, SCRUMBANFALL

Parameter	**Description**	**Scrum**	**Kanban**	**Scrumban**	**Scrumbanfall**
External Stakeholder	Restricted involvement of external stakeholders as a team member.	Yes	NA	Yes	No
Team Size	Restricted team size.	Yes	NA	Yes	Yes
Role	Limited roles in a team.	Yes	NA	Yes	Yes
Project Tracker	Progress view at project level.	Yes	Yes	Yes	No
Product Vision	Unclear product vision.	Yes	Yes	Yes	No
Estimation	Full product development estimation is not feasible.	Yes	Yes	Yes	No
Distributed Environment	Collaboration issue in distributed environment.	Yes	NA	Yes	Yes
Skill & Expertise	Unavailability of specific skilled resource.	Yes	NA	Yes	Yes
Documentation	No or minimum documentation.	Yes	Yes	Yes	No

VIII. RESULTS & RECOMMENDATIONS

Scrumbanfall is combination of characteristics of Waterfall, Scrum and Kanban, each of them having their own pros and cons that they can't resolve challenges of software development world, as a standalone framework. The strengths of all of them are inherited into Scrumbanfall to empower its capability towards achievement of Software Engineering Management (SEM) goals. Table I shows the result of the research against the limitations of Scrum and support from Waterfall, Scrumban and Kanban by indicating limitations of each framework using keyword 'Yes' and strength using 'No'.

A. Strengths of Scrumbanfall

Table I represents strength of Scrumbanfall against Scrum, Kanban and Scrumban, where 'No' keyword is marked again limitations of Scrum in the column titled 'Scrumbanfall' and described as follows:

- Documentation: Requirement Analysis and Project Planning are initial phases of Scrumbanfall, derived from waterfall, which supports documentation of the PBP and planning charters.
- Estimation: Project planning and scheduling charts along with task level of documentation with help of user story and Kanban card, provides accurate estimation which is essential for product owner in identifying risk with the project.
- Project Tracker: Project Planning helps in designing a tracker at project level, which is used by development team during the Sprint and updated as soon as work item state changes in a Kanban card.
- Product Vision: An accurate estimation of project requirement and its planning enables product vision and tracker which helps in progress report and risk identification.

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- External Stakeholders: Just like Scrum, Scrumbanfall does not allow direct involvement of external stakeholder into Project Planning.

B. Limitations of Scrumbanfall

The combination of Scrum and Kanban with Waterfall gives a great strength to Scrumbanfall but still it can't cover all the limitations, which are represented in Table I, using 'Yes' keyword in the column titled 'Scrumbanfall' and described as follows:

- Distributed Environment: Communication between team members in the distributed environment is still limitation and general issue.
- Roles: As there is no specification about roles of the team members in Kanban and Waterfall, they are inherited from the Scrum, which is limitation of Scrumbanfall.
- Team Size: Yet the Scrumbanfall follows Scrum, which limits between 3 to 9 team members, for each Scrum team. For large scaled project development, large team is required that cannot be fit according to Scrum rule.

C. Recommendations

The result of this research extensively recommends that Scrumbanfall is has a great strength compared to Scrumban, Scrum and Kanban as Scrumbanfall resolves challenging limitations with the power of Waterfall, Kanban and Scrum. Along with the strengths, Scrumbanfall derives few limitations of Scrum represented in Table I, that requires further research by integration of the robust framework, which can resolve such limitations. Software development organizations should consider such limitations and their impact on their projects prior to considering Scrumbanfall as a standard Software Engineering Management practices.

IX. CONCLUSION

Software development organizations have been seeking ABPR (Agile Business Process Reengineering) to optimize their SEM (Software Engineering Management) practices. Scrum and Kanban are trending agile methodologies for software project development and management. This research has concluded that the proposed integration of Scrum and Kanban with Waterfall in the form of hybrid framework for SEM (Software Engineering Management) practices, to overcome the limitations of Scrum] and Scrumban; and empower the strength of software development organization by combining required characteristics of Scrum, Kanban and Waterfall into Scrumbanfall which has a great strength compared to stand alone framework and capabilities to answer the challenges of software development and management practices like direct involvement of external stakeholder into project requirement and analysis documentation; project planning, estimation and tracker. An accurate estimation of complete project; prior to the development activities begins; is the biggest challenge for Agile methodologies and hybrid frameworks formed using pure Agile Manifesto principles like Scrumban, as they do not prioritize project documentation. Inaccurate estimation invites risks into project and unclear vision about software product, which result into unexpected cost in the project for the software project owners or software development organizations that bear the cost of project development.

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