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PRODUCT LIFE CYCLE BASED PROJECT MANAGEMENT MODEL

Dr. Haluk Altunel

Program Director at SoftTech, part-time faculty at METU
Ancara, Turquia
altunel@metu.edu.tr

ABSTRACT

Every product has a life cycle. Just as living beings, it is born, it grows/changes, matures, loses ground and completes its life. The stages that define the product life in this way were put forth in The Product Life Cycle Theory. One or generally more projects and various operational works accompany the product throughout the product life. The expectations from the projects also vary with respect to the stage of the product. In this study, project, operational work and product are related as Product Life Cycle Based Project Management Model. In order to receive effective results from the projects that accompany the product, propositions are made on how to handle them. The propositions are tested with the outcomes of projects implemented in the software development sector.

1. Introduction

Product is defined as anything presented to satisfy a requirement or fulfill a demand of a customer (Kotler et al, 2006). Even though concrete tangible objects are generally considered as products, intangible outcomes like computer software or insurance processes are also products. Products are classified in a wide spectrum foremost according to the area of usage and in relation with other products. There are a couple of widely accepted classification standards as North American Product Classification System (NAPCS, 2015), European Union Central Product Classification (EC, 2015) and United Nations Standard Products and Services Code (UNSPSC, 2015).

It was proposed in The Product Life Cycle Theory that like living creatures, products also have a life cycle (Vernon, 1966). Product life cycle is shown in **Figure 1**. According to this perspective, each product has a birth phase formally named as the development stage. After various preliminary works, the product starts its life with prototype(s). The following section is named as the introduction stage, where the product meets its customers. After a while of market introduction, the growth stage starts with a demand trend for the product, which is determined mainly by customer acceptance. Acceleration of demand is shaped by market, competitors, economic conditions and socio-cultural factors (Langerak et al, 2004). If the growth curve is below expectations, the product life is ceased. If the product draws enough attention of the customers and the growth curve is around or above expectations, then the maturity stage can be reached after a while (Thorelli & Burnett, 1981). At the maturity stage, it is observed that the product reaches a wide target customer group and at the same time, competition is higher than the previous stages. The product management team copes with the competitors by trying to add new features to make differences with the competitors? If the newly added features and expectations of the customer group overlap, then the growth curve can go higher and the product can survive (Gmelin & Seuring, 2014). At one point, extra features are useless and the product saturates, which means there is no possibility to go further. After saturation, the decline stage is probable and for some products it is unavoidable. The length of decline stage is determined by the power of the competitors in the market in terms of their technical capabilities and financial advantages. After the decline stage, at a point the product management team should decide to terminate the supply of the product. Subsequently the product disappears from the market.

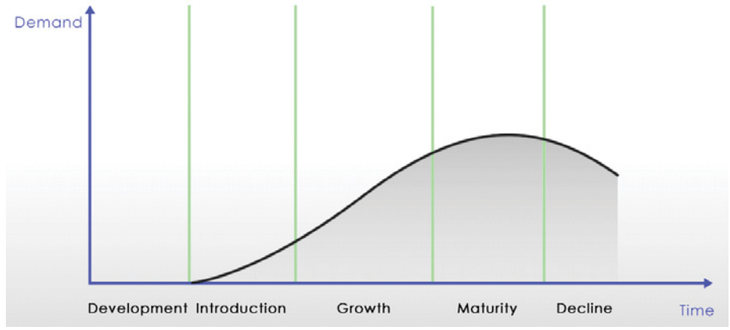

FIGURE 01. *Product life cycle stages.*

Most of the products start their lives with a project in development stage. Project is defined as a temporary endeavor designed to create a unique product, service or result (PMI, 2013). Project has its own life cycle which is defined as a set of phases that projects go through from initiation to closure. Project life cycle processes are grouped under Initiation, Planning, Executing, Monitoring & Control and Closing as overlapping executions (PMI, 2013). Based on the above definitions, project and product are not identical terms. Before the termination of a product, the relevant project can be closed successfully when the settled project scope is completed within the defined budget and time constraints. In product life cycle, generally some projects accompany the product together with operational work. Therefore, the management of project and product teams are generally different. Depending on the structure of the project, the product management team can be in the customer position in project organization.

Studies in literature are mainly focused on systematizing product development (Brown & Eisenhardt, 1995; Peng et al 2014; Cui et al 2014; Tekinerdogan et al 2014). As examples, two of them are explained briefly here. The first model was proposed as Stage-Gate Model (Cooper, 2001). In this model, product development is modeled under six stages and five gates. The stages are named as Discovery, Scoping, Business Case, Development, Verification & Validation and Launch. Gates are decision points before starting next stage and they are positioned between stages. However, this model does not combine product and project life cycles together with operational work.

The other model was suggested from industry as ABB Model (Wallin et al., 2002). ABB Model proposes six gates as decision points. An example is Gate0 whether agreement on starting project is ensured. Fulfilling required constraints opens Gate0 and in this way, the team starts realizing requirements for opening the next Gate. This model formulates development projects but does not include any connection with product life cycle.

Relating product and project in terms of work breakdown structure was studied for complex system projects (Sharon & Dori, 2014). As seen in the above theories and models, there is no study in literature conducted on product life cycle stages and project management. Thus, the clarification of project and product concepts, and their relation and differences carries importance. Another significant point is to manage projects by taking the product life cycle into account. In this way, project and product relation can be healthier. Moreover, product exploits project deliverables and customer can be satisfied with the project and the product.

The main focus of this study is to propose a complete model for project management from the product life cycle perspective. Based on this model, the second purpose is to put forth the idea of adapting project management perspective according to the related product's life cycle stage. In this way, projects can contribute more value to the success of products. For this purpose, in the following section, Product Life Cycle Based Project Management Model is explained, and the configuration of projects according to the product life cycle stages is proposed. In the third section, the outcomes of sample projects are examined together with the customer satisfaction surveys. The fourth section is reserved for comparing methodology and real life project outcomes as a discussion section.

2.Methodology:

Product Life Cycle Based Project Management Model is shown in **Figure 2**. Product, project and operational works are combined and related in this Model. The processes are grouped as

- **Initiation Step:** It is the starting point of a work stream. For product, it is product definition with basic features. For project, this part corresponds to Project Initiation Process Group (PMI, 2013). For operations, this step kicks-off working stream. This step finds an answer to the question "What will be done?"
- **Team Build-up Step:** Here people in charge of product, project or operational work are assigned as Product Manager, Project Manager and Operational Manager correspondingly. The project team is identified at this step. This step finds answer to the question "Who will do?"
- **Scope Definition Step:** At this point, the scope is clarified and related Statement of Work is exposed as requirements, constraints, assumptions, risks and issues. This step further clarifies the "What?" question.
- **Planning Step:** The planning part of Statement of Work is executed at this step. The following phases are planned and work packages are determined. This step answers "How it will be done" question.
- **Technical Step**: This part includes all related technical work. The details are not our interest, and they may change depending on product, sector,

methodology, and business culture. For operational work, this part means daily repetitive activities. For project, this part means development activities. During these activities, new requirements on product could appear. They should be recorded by Product Manager to take into account later.

- **Testing and Acceptance Step:** Deliverables of project are tested at this part. If the target product is not reached, the outcomes are feedback to Technical Step for necessary further developments. When operational works include enhancements, they are also controlled at this part.
- **Delivery Step:** Delivering product or its enhancements are executed at this step. After delivery, adequate time should be reserved for monitoring before releasing the project team.
- **Closure Step:** For project, this part corresponds to Project Closing Process Group (PMI, 2013). Closure of operational work is realized in this part. Product termination is also conveyed at this step.

Step relations in **Figure 2**, do not mean that when one step is completed the other is started immediately. Rather, it demonstrates the starting order of steps, but not ending. In other words, activities of a couple

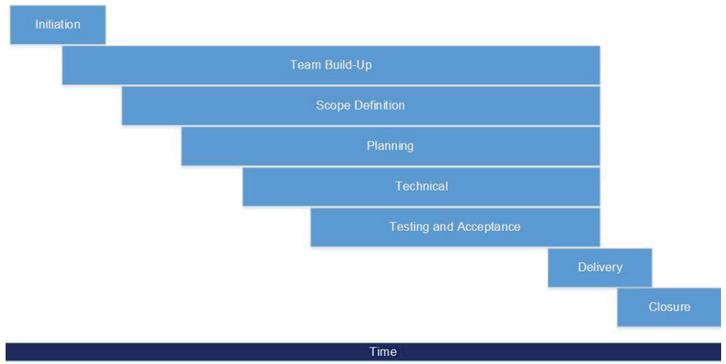

FIGURE 03. *Execution of steps with respect to time.*

steps can be realized simultaneous. The execution of steps with respect to time is shown in **Figure 3**. Team Build-up and Scope Definition should continue throughout the work stream, since team or scope may change at any point. Therefore, the plan should change in response to these changes and in response to risks and issues. Technical Step and Testing & Acceptance Step should be executed iteratively. Testing results should be fed back to Technical works for required corrections. Hence, these activities should continue to a point where they are no more required. Delivery Step preparations can start when Testing Step is coming to an end.

Based on the Steps, product, project and operational works are related in **Figure 2**. As the initial point, each product starts with an idea. After satisfying necessary feasibility and strategic criteria, the product definition triggers the development stage of the product. Before starting a project, product should have a manager who will follow and manage it throughout the product life cycle. Following step is to define the scope of the product in more detail and its alignment with the corporate's strategies. Roadmap of product is clarified before starting a project in Planning Step.

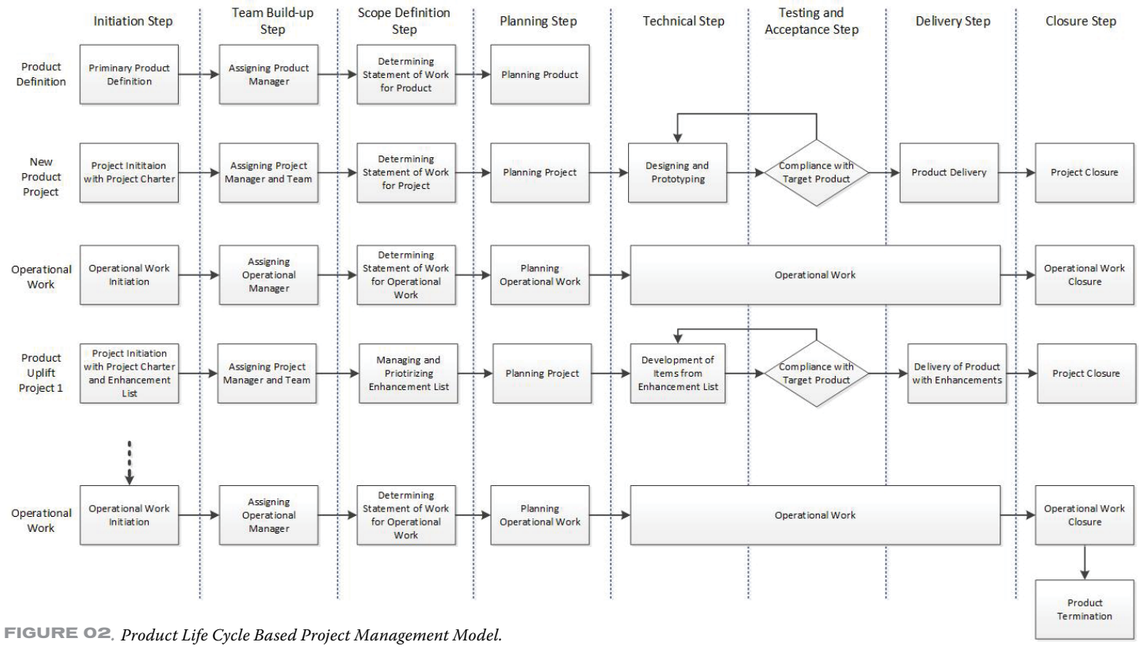

FIGURE 02. *Product Life Cycle Based Project Management Model.*

After defining product and clarifying its roadmap, a project should be started to realize the product. Then New Product Project (NPP) is started. NPP, as its name expresses, produces a new product. (Altunel, 2014). The main delivery of such a project is the new product such as a new automobile, building, software, electronic device or system. New Product Project covers the development stage of product life cycle. The success criteria should be described for product and project separately including both financial and other dimensions (Cooper & Kleinschmidt, 1987). Similar to other project types, it starts with project charter (PMI, 2013). Team building, starting from project manager, is the following step. Afterwards, Statement of Work (SOW) is defined to determine the boundaries of the project by including business need, product requirements, assumptions, risks and issues. Project planning is the following step to clarify consequential project activities. Product development is executed under Technical Step. The details of the Technical Step are different for diverse industries. Designing the product by taking into account both the current product goals and potential requirements that could appear throughout the product life cycle is crucial. The prototyping phase includes the implementation of the design, and it can be planned as a cyclic loop where the exit criterion is in compliance with the target product by testing results. Testing and Acceptance Step controls realized product and compares it with target product. When the prototyping and testing phases are operated without adequate details, undetected problems are likely to appear in the end product and fixing them is costly in most of the cases. (Segismundo & Miguel, 2008). After the completion of Testing & Acceptance Step of the project, the product can start its life in Delivery Step. When project targets are reached, then the project can be finalized with the Closure Step.

After completion of NPP, product related tasks can be transferred to the operation. Operational Work is defined as a set of repetitive organizational actions to produce the same outputs. (CSCMP & Sanders, 2013). Differences between project and operational works are highlighted mainly as the first being temporary and unique, while the latter being repetitive and ongoing (PMI, 2013). Operational Work (OW) starts with Initiation Step. Team Build-Up, Scope Definition and Planning Steps start afterwards as shown **Figure 2**. Under Technical Step, mainly operational tasks are executed. However, during OW, new features can be added to the product and evolution can continue, but this evolution is limited. During OW, new requirements should be collected in Product Enhancement List (PEL) which contains required but missing features of product with priorities. PEL may also contain some non-implemented or postponed items from NPP.

If new requirements are intensive, then Product Uplift Project could be started. Product Uplift Project (PUP), as its name indicates, adds new features to an existing product (Altunel, 2014). It starts with a project charter and PEL. Implementation of PUP follows the same steps with NPP with some adaptations. PEL is the driver of PUP. The relation between NPP, PEL, PUP and OW is shown in **Figure 4**. During Scope Definition Step, project scope is chosen from PEL starting from high priority items. Technical Step covers the implementation of chosen features which are controlled under Testing and Acceptance Step. Delivery Step introduces product with new features. Project Closure is executed under Closure Step. While the product is in the market, OW should continue during PUP on the same product. Therefore, new and unnoticed requirements can appear. They should also be added to PEL for PUP. Examples of PUP are face-lift projects in automobile industry, restoration project for buildings, improvement projects in information technology industry.

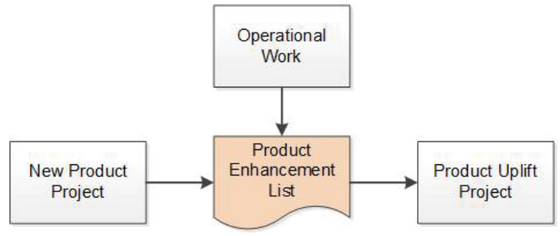

FIGURE 04. *Relation between PEL, NPP, PUP and OW.*

More than one PUP can be initiated for the same product. Such projects could be either successive or could be transferred to OW in between as shown in **Figure 5.a**. The fundamental target of the PUP is to append new valuable features to the product. Thus, acquiring advantages over competitors and keeping the demand for the product alive are intended. Positive effect of PUP appears after completion of it, during following OW period as seen in **Figure 5.a**. Here, first PUP accelerates growth stage and second PUP extends growth stage further.

When working on all items in PEL as a whole in one cycle is considered as lengthy and likely to diminish the competition advantages, the items can be grouped according to the priorities and costs and worked in phases as shown in **Figure 5.b.** Here, the contribution of phases on demand is clear after their Closure Step.

For both types of projects, product and project success criteria should be defined separately and clearly. Even if the project is completed successfully within the defined schedule and budget with promised scope and quality, product achievement is the final aim of the product manager (Ernst, 2002).

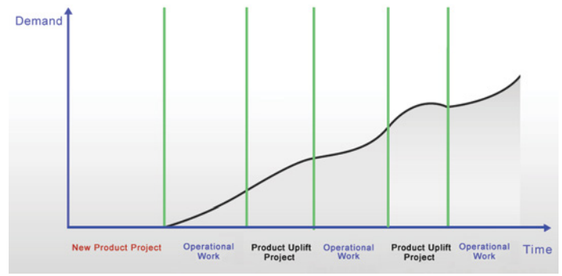

FIGURE 05A. *NPP, PUPs and OW in product life cycle.*

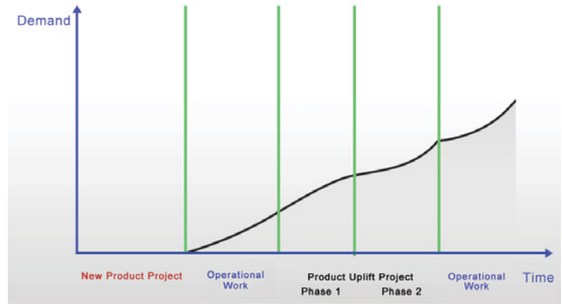

FIGURE 05B. *Phases of a PUP in product life cycle.*

Based on Product Life Cycle Based Project Management Model explained above, our propositions are as follows:

1. Projects actualized on products are part of product life cycle.
2. Product projects can be categorized as New Product Project (NPP) and Product Uplift Project (PUP).
3. Although NPP and PUP are both following the same project life cycle, they should be adapted by considering product's stage in its life cycle.
4. NPP should focus on producing fault free first prototypes within given constraints by exploiting adequate testing effort.
5. PUP should focus on adding highest priority additive values to product within given constraints.
6. Product Enhancement List (PEL) is the driver of PUP. PEL should be managed and prioritized by Product Manager by taking into account of end user' expectations.
7. Operational Work (OW) is part of product life cycle and should be managed by considering
8. Implementing PUP can increase the demand for product and hence can lengthen product's life.
9. Customers' perception of project success is related to end product success.

In the next section, above propositions are tested by utilizing real life products and projects.

3.Application and Results:

Product Life Cycle Based Project Management Model, New Product Projects and Product Uplift Projects were examined in software development industry. Projects were implemented by the same company for a private bank in Europe. Customers of the software products are different departments under the same Bank. The users of all software products are banking professionals. Due to confidentially issues, the names of the company and bank were masked for this study.

8 projects were chosen that were performed during 2010-2013 time period. Project monitoring results, project performance through customer eyes and product success data were collected and analyzed. Products that were handled via projects were dissimilar, and there was no relation between them. The customers of the projects were different. Projects were monitored with Earned Value Analysis which is a widely accepted project performance monitoring approach and produces comparable metric results independent of the project contents (Anbari, 2003).

Project	Product	CPI/SPI	Number of Survey Respondents (% of Total Users)	Mean of Project Success Rates	Standard Deviation of Project Success Rates	Mean of Product Success Rates	Standard Deviation of Product Success Rates
NPP1	P1	0.99/0.95	7 (%35)	3.91	0.25	3.25	0.49
NPP2	P2	1.13/1.00	8 (%38)	4.25	0.18	3.43	0.40
NPP3	P3	0.88/0.97	6 (%27)	4.10	0.20	3.60	0,50
NPP4	P4	0.95/0.95	12 (%24)	3.89	0.32	3.87	0,34

TABLE 01. *Performance of New Product Projects.*

Project	Product	CPI/SPI	Number of Survey Respondents (% of Total Users)	Mean of Project Success Rates	Standard Deviation of Project Success Rates	Mean of Product Success Rates	Standard Deviation of Product Success Rates
PUP1	P1	0.98/0.94	6 (%30)	4.47	0.15	4.33	0.19
PUP2	P2	0.97/1.01	9 (%42)	4.45	0.14	4.23	0.23
PUP3	P3	0.95/0.95	6 (%27)	4.54	0.10	4.21	0,29
PUP4	P4	0.99/0.99	14 (%28)	4.42	0.12	4.49	0,08

TABLE 02. *Performance of Product Uplift Projects.*

Earned Value Analysis calculates Schedule Performance Index (SPI) and Cost Performance Index (CPI) by utilizing Actual Cost, Planned Value and Earned Value of a Project (Marshall, 2007). When these values are equal to 1.00, the project realization is harmonious with the project plan. If SPI value is smaller than 1.00, the project is behind schedule plan. Opposite to this, if SPI value is greater than 1.00, the project is ahead of the plan. Similarly, CPI's being below 1.00 mimics the project has higher costs than the planned. If CPI value is greater than 1.00, then the costs are lower than the planned. Starting from these parameters, Cost Schedule Index (CSI) can be obtained as a unique indicator of the project status. If this value is equal to 1.00, the project is assumed as healthy and according to the plan. CSI lower than 1.00 indicates the project is behind the plan and CSI higher than 1.00 means the project is ahead of the plan.

Customer's perception of success was explored with surveys for product and projects separately. The surveys were accomplished after Closure Step of the projects by an independent quality team whose members did not participate in the projects. To take customer's impression exactly, a set of questions were prepared for projects and products. The answers were prompted with a scoring between 1 and 5 as Likert-type scale (Likert,1932). 1 point means "None of the expectations are satisfied" and 5 points means "The expectations are satisfied completely". Survey participants were chosen randomly from product users, who were also project customers. At least %20 of end users were included for each product. The mean and standard deviation values of the survey results were calculated for products and projects individually.

The project and product names were masked with abbreviations for New Product Projects as NPPx, Product Uplift Projects as PUPx and Products as Px. To realize each Px, firstly NPP was executed. Then Px was transferred to OW. When PEL were crowded enough, then PUPx was started. The effects of the size and complexity of products and projects were excluded for this study. To minimize the effects of them, similar scale products and same software development environment were chosen. The results are presented in **Table 1 and 2**.

In **Table 1**, the results for four different New Product Projects are presented. First two columns are reserved for project and product names respectively. In the third column, project monitoring metrics as CPI and SPI values are presented with project closure values. These values are between 0.88 and 1.13. That means cost and schedule overflows were limited and projects were performed relatively successfully in terms of timeline targets and budgets. In the fourth column, the number of respondents to surveys and their ratio with respect to the total number of end users are shown. The fifth and sixth columns indicate the success rates of projects as mean and standard deviation accordingly. The last two columns demonstrate the mean and standard deviation of product success. The first outcome of the data in the table is that the mean values of the product success rates are clearly lower than the mean values of the project success rates. This may point out that even though the customers' requirements are satisfied within projects, the customers do not have enough confidence and trust in products which are fresh to them.

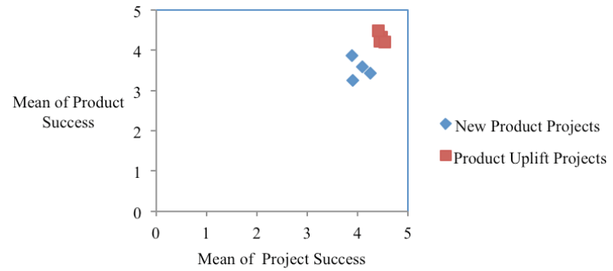

FIGURE 06. *Distribution of customer survey results.*

The same products were improved by Product Uplift Projects and results are demonstrated in **Table 2**. The number of survey respondents were similar, and some of them also participated in the NPP survey. This time, the project closure CPI and SPI values are between 0.95 and 1.01 indicating that projects were performed more effectively than New Product Projects in terms of the timeline targets and budgets. This can be elucidated with the fact that project teams were more experienced in Product Uplift Projects, and they were familiar with the product. The second point to express is that the mean of the project success is again higher than the mean of the product success grades, but this time the difference between them is lower than those observed in New Product Project cases. One of the underlying reasons for this improvement is that the products were in the development stage during PUP and customers' confidence with the products increased. In other words, the customers got used to products, and they had more trust in them. In order to analyze the distribution of the success grades for both type of projects, the results are sketched in **Figure 6**. Based on this illustration, upward convergence of the success rates after PUPs is noticeable when compared to NPPs. Thus, it is possible to express the positive contribution of PUPs on the products.

Another analysis was executed to observe whether Product Uplift Projects always make the same positive effect. As mentioned in the second section, more than one Product Uplift Projects can be executed for the same product either successively or Operational Work in-between. To analyze such projects, a product is chosen whose projects were fulfilled between 2009 and 2013 time period. Earned Value Analysis and customer surveys were applied as in the above projects. The results are displayed in **Table 3**. The Product was introduced by NPP, then 5 consecutive PUPs were performed. The very first outcome is that CPI and SPI values improved with each PUP. Another observation is that Product Uplift Projects enhanced the customer grades for the product and project success. The project success grades stopped their increment trend and saturated after a while. On the contrary, the product success outcomes decreased after the rising period. Especially the product success level degraded after PUP4. PUP4 was considered to correspond to the product's maturity stage. Decrement is more obvious with PUP5, which is in the decline stage of the project.

The trends of the project and product success rates with respect to projects are demonstrated in **Figure 7.** These results indicate that Project Uplift Projects contributes to product success prominently during the development stage of the product. However, the same project performances cannot stop saturation or decrement of the product during maturity and decline stages. This point can be considered as ideal for starting a New Product Project to produce a new product.

Project	Product	CPI/SPI	Number of Survey Respondents (% of Total Users)	Mean of Project Success Rates	Standard Deviation of Project Success Rates	Mean of Product Success Rates	Standard Deviation of Product Success Rates
NPP1	P5	0.86/0.97	22 (%37)	3.88	0.15	3.17	0.19
PUP1	P5	0.93/1.01	23 (%38)	4.11	0.14	3.53	0.23
PUP2	P5	0.96/0.98	20 (%33)	4.35	0.10	3.87	0,29
PUP3	P5	0.97/0.99	18 (%30)	4.40	0,12	3.98	0,20
PUP4	P5	0.99/1.03	17 (%28)	4.43	0,09	3.96	0,10
PUP5	P5	1.02/1.00	16 (%27)	4.43	0.12	3.88	0,08

TABLE 03. *Performance of consecutive Product Uplift Projects.*

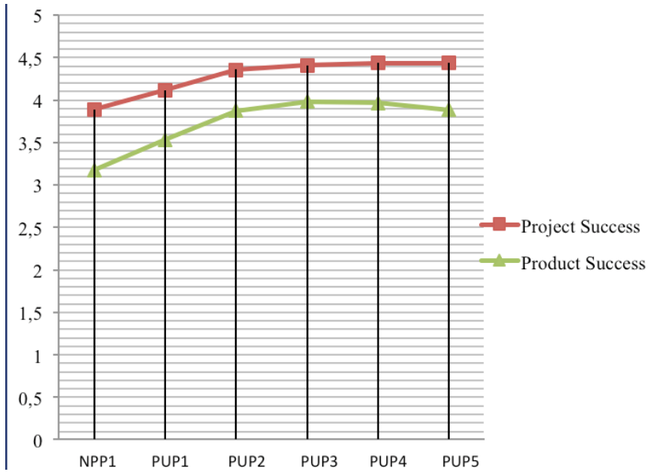

FIGURE 07. *The trends of product and project success after consecutive Product Uplift Projects*

Another point to check for successive PUPs is the correlation between parameters. Firstly, project monitoring CPI and SPI values are multiplied to calculate CSI parameter as explained. The correlation between CSI values and project success is computed as 0.2760, which points the low positive correlation. Another point is the correlation between project and product success rates. This value is calculated as 0.6228, which indicates the existence of positive correlation between them. Hence, the correlation between project and product success rates is stronger than the correlation between project and Earned Value Analysis parameters.

4.Discussion:

The propositions stated in Methodology Section and outcomes of Application and Results Section are compared here. The first five propositions are mainly on defining projects within product life cycle as New Product Project and Product Uplift Project.

The definition of Product Enhancement List is the subject of the sixth proposition. Due to scope of this article, the usage aim of PEL and prioritization information are presented here and other details and examples are excluded. The seventh item in the proposition list, touches on Operational Work. However, in this article, the main focus is on the project relation with product life cycle. Therefore, no application and results are presented in this article regarding Operational Work. The eighth and ninth propositions are tested with real life projects.

The effect of implementing PUP is demonstrated in **Figure 6**. PUPs increase project and product success rates relatively. Applying more than one PUP on the same product is shown in **Figure 7**. The consecutive utilization of PUP contributes positively during first four projects and lengthen product's life. However, their positive value is limited after the fifth and sixth projects. With this application, it is not possible to answer the question of how much product life cycle is lengthened. Designing a controlled experiment to compare two identical products one with PUP and other without PUP is not an easy task in real life due to the fact that products are not always the same and market conditions are also strong decisive on product's life. Therefore, this part is left open for future research. Briefly, the positive effect of the eight proposition is observed but the amount of contribution could not be measured at this study.

The relation between project and product success is tested with customer surveys in the previous section. Based on realized projects, the correlation between project and product success rates is calculated as 0.6228, indicating positive correlation between them. This value is even higher than 0.2760, which is the correlation between project closure CSI and project success rate. Hence, we have evidence for proving the ninth proposition. The ninth proposition reveals that project managers should take product life cycle and success of the end product into account throughout project life cycle.

5.Conclusion:

In this study, project management in product life cycle stages is explored and Product Life Cycle Based Project Management Model is proposed. The importance of adapting projects according to the stage of the product is underlined. New Product Project and Product Uplift Project are proposed for adaptation. New Product Project brings out the first version of the product. Therefore, the expectations from the product should be clarified with appropriate details. In addition to that, for designing, prototyping and testing phases of the project, sufficient schedule and budget should be allocated in order to reach the expectations, because tightening these phases could lead to reaching a premature product which probably contains costly bugs and/or misses some useful features. To sum up, effectively managed New Product Project gives birth to a healthy product that is ready to grow-up.

After completing New Product Project, product can be transferred to Operational Work. Another alternative is to start a Product Uplift Project immediately depending on necessity. It is also emphasized that planning the project in phases is beneficial in some cases. Since the product that is subject to project is alive, the importance of scope management in such projects are highlighted and using Product Enhancement List is suggested. Especially newly emerged requirements should be recorded in PEL and evaluated in terms of priority. Therefore, without disturbing the project success criteria, and requirements with higher priority should be handled primarily.

Newly defined project types are monitored with Earned Value Analysis and evaluated with customer surveys for software development projects. One of the main observations from this evaluation is that completing New Product Project is not enough for establishing customer's confidence in the product. Product Uplift Project helps to increase the trust of the customer. Another conclusion related to Product Uplift Projects is that their marginal contribution is obvious when the product is in its development stage. On the contrary, if product is in saturation or decline stages, Product Uplift Project cannot contribute much to product success.

In software development, agile approaches have been popular starting from 1990s with various practices (Shore & Warden, 2008; Abrahamsson et al 2003; Leyborune, 2009). Agile approaches are penetrating to other industries as well. These can also applicable to both New Project Projects and Product Uplift Projects.

In this study, trends or economic conditions are assumed to be stable during projects. Therefore, customers' perception of products is triggered only within product life cycle. Although the relation between project stakeholders are important (Bourne & Walker, 2008) especially the relation between project teams and customers are presumed as problem free for the simplicity of the analysis. Above factors have the potential of affecting customers' satisfaction; hence, survey participants are chosen as a widespread group. Additionally, institutional projects are chosen to minimize the effects of trends and economic fluctuations.

As a future study, this model will be applied to other industries to verify the relation between New Product Project, Product Uplift Project and product life cycle stages. In this way, propositions mentioned in Methodology Section will be tested whether adapting projects according to product life cycle stages contributes to products success. In a separate study, the above discussed relation will be extended to the markets' and competitors' effect on the project outcomes and product success.

author

Haluk Altunel Haluk Altunel has a BS and an MS, both in Electrical and Electronics Engineering from Bilkent University in Ankara in Turkey. He received a PhD in Biomedical Engineering subsection from Electrical and Electronics Engineering department of Middle East Technical University. Currently, he is a Program Director at SoftTech A.S in Turkey with a total 17 years of project management hands-on experience in a wide spectrum of information technology and automotive projects. He is a certified internal lecturer giving Project Management and Agile Methodologies courses at SoftTech. Together with his professional life, he is a part time faculty giving graduate level courses at Informatics Institute of Middle East Technical University. His research interests include project management, agile methodologies, and mobile health. He contributed into four project management books. He was ISITES 2015 conference mobile technologies chair.

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