Using Adapted Version of Hoshin Matrix for Selection of Agile Software Development Processes

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Abstract. According to Capability Maturity Model Integration for Development (CMMI-DEV), organizational process performance (OPP) area aims to establish and maintain a quantitative understanding of performance of selected processes. Many organizations have started their agile transformation to leverage the capabilities of their software development processes. In order to measure the effects of agile transformation, it is important to understand to what extent agile methods contribute to business objectives. Hoshin Matrix is a tool that provides a rationale for selecting processes identified for process performance analyses. Moreover, this rationale includes traceability from software development execution to business objectives. This study describes the implementation example of an adapted version of Hoshin Matrix at Huawei Turkey Research and Development Center which aims to establish its organizational quantitative quality and process performance objectives based on a set of business objectives. Our preliminary findings suggest that our OPP design may provide a guideline for software development organizations who are willing to adopt agile transformation and for those who would like to improve their software development processes.

Keywords: Software Development, Agile transformation, Organizational Process Performance, Hoshin, CMMI-DEV Level 5

Çevik Yazılım Geliştirme Süreçlerinin Seçimi İçin Hoshin Matrix'in Uyarlanmış Versiyonunun Kullanılması

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Özet. Bütünleşik Yetenek Olgunluk Modeli (CMMI-DEV)'e göre, organizasyonel süreç performansı (OPP) alanı, standart prosedürler dizisinden seçilen süreçlerin performansının niceliksel bir anlayışını oluşturmayı ve sürdürmeyi amaçlamaktadır. Pek çok kuruluş yazılım geliştirme süreç yeteneklerini geliştirmek için çevik dönüşümlerini başlattılar. Çevik dönüşümün etkilerini ölçmek için, çevik yöntemlerin iş hedeflerine ne ölçüde katkıda bulunduğunu anlamak önemlidir. Hoshin Matrix, süreç performans analizleri için belirlenen süreçleri seçme yöntemi sağlayan bir araçtır. Bu seçim, yazılım geliştirme uygulamasından iş hedeflerine kadar izlenebilirliği sağlayacak şekilde gerçekleştirilir. Bu çalışma, Huawei Türkiye Araştırma ve Geliştirme Merkezi'ndeki Hoshin Matrix'in uyarlanmış bir versiyonunun uygulama örneğini tanıtmakta olup, organizasyonel niceliksel niteliğini ve iş hedeflerine dayalı süreç performans hedeflerini oluşturmayı amaçlamaktadır. Ön bulgularımız, OPP tasarımımızın çevik dönüşümü benimsemeye istekli olan ve yazılım geliştirme süreçlerini iyileştirmek isteyen kurumlar için bir rehber olacağını göstermektedir.

Anahtar Kelimerler: Yazılım Geliştirme, Çevik Dönüşüm, Organizasyonel Süreç Performansı, Hoshin, CMMI-DEV Seviye 5

1 Introduction

A software development organization should strive a high productivity culture which delivers the desired high performance. Organizational process performance (OPP) derives to establish and maintain a quantitative understanding of the performance of selected processes in an organization's set of standard processes [1]. In implementation of Capability Maturity Model Integration for Development (CMMI-DEV) it is very important to assess the objectives to ensure that the business objectives are still

up to date and in line with business strategies [2]. In order to initiate pursuit of high performance gains, the first step is effective planning of the strategy and setting the goals based on this strategy. Each path of goals of a software development organization should ideally cascade through the enterprise even through small teams of development and testing. Many organizations have started their agile transformation to leverage capabilities of their software development processes [3]. ASD is part of the solution for an enterprise to adapt itself to fast changing business environment. However, Agile principles cannot help alone to achieve the goals of an organization if the objectives of the organization are not managed vertically and horizontally. There are literature about practicing implementation of agile methods along with plan-driven development processes (e.g. initiative based on CMMI-DEV) were also published [4]. Moreover, in a systematic review it is stated that agile cannot be used without being supplemented with other non-agile practices [5].

Lean approaches such as Hoshin, are gathering momentum for agile thinking and methods. Hoshin Planning (also known as Hoshin Kanri or Policy Deployment) is an inherited continuous improvement process that provides standardized tools for step by step organizational planning for strategy [6]. Hoshin Matrix (also known as the X-Matrix) aims to connect the top strategy to execution by using both horizontal and vertical alignment in an organization [6]. Hoshin Matrix tool visualizes a concrete picture of business objectives and its relation with processes and sub processes [7]. Therefore it invites individuals to understand how their individual efforts benefit the entire organization in meeting the business objectives. Also, it helps in defining the culture of the enterprise via supporting the key values of ASD such as visibility, transparency, continuous improvement and sustainability which should be placed at the core of an organization to make every employee to push forward to the same direction.

The primary aim of this paper is to describe the implementation example of an adapted version of Hoshin Matrix which aims to be a guide for software development organizations, particularly who are willing to adopt ASD and ultimately also for who would like to improve their software development processes. The remaining part of the paper proceeds as follows: Section 2 gives definitions for key process indicators and metrics. In Section 3, Hoshin Process and Hoshin Matrix are explained and steps of using a Hoshin Matrix is given. Section 4 gives an example of implementation of adapted version of Hoshin Matrix in ASD. In Section 5, we discuss the preliminary findings and its effects.

2 Key Performance Indicators (KPIs) & Metrics

Key Performance Indicators (KPIs) are a set of quantifiable measures that are used to evaluate the success of an organization and/or of projects, programs, products and other initiatives [8], [9]. Many organizations may desire to have the ability to measure a wide set of parameters. However, the main idea is not about broaden the things we measure. Yet, getting a meaningful insight without a distraction is very important. One of the famous quotes “if you can’t measure it, you can’t manage it” [10] might be understood in a way that lead organizations towards trying to measure everything. Deciding on what to measure depends on what the organization focuses and tries to

achieve. It is important to stay focused on what is important. That is why, KPIs and metrics should be selected very carefully. Moreover, how the selected metrics and KPIs would be interpreted should be analyzed. For an organization, common objectives (e.g. increasing product quality and decreasing costs) might be rather easy to agree on than agreeing on implementation methods to achieve these objectives. Yet, it might be a challenge for many organizations to convert strategic goals to tactical plans and metrics.

3 Hoshin Process And Hoshin Matrix Method

The Hoshin Kanri is a method which was developed by Akao [11]. It has been employed extensively by Toyota, as well as many other organizations known for their management prowess, including Hewlett-Packard [12], Intel, Milliken, Zytec, and Proctor and Gamble [13]. This management tool is a systematic approach that aims to make measures more visible to improve coordination and collaboration between teams. Moreover it provides more alignment from top to bottom throughout the organization to align the long-term goals with strategic projects. One of the most popular way of implementing Hoshin Kanri is applying the X Matrix. The Hoshin Kanri X Matrix is often used as the project plan for large organizations to achieve their mission and vision statements. The value in the Hoshin Matrix is in the relation between the quadrants. The interaction between these sections will lead to better decision making [14]. The Hoshin Kanri X Matrix is basically a document that includes long term goals, strategies, initiatives and responsibilities [15]. For linking strategy to execution a customized version of the Hoshin Kanri X Matrix is used at HTRDC.

3.1 Main Steps to Apply the Hoshin Process by Using Hoshin Matrix

The creation of the matrix can be done by organization leaders and/or any manager who is implementing it on a team level. The initial vision, goals, objectives, KPIs, and measures along with the processes used to realize them will be decided. The basic steps to set up a Hoshin Matrix are given as in the Figure 1. The steps are as in the following:

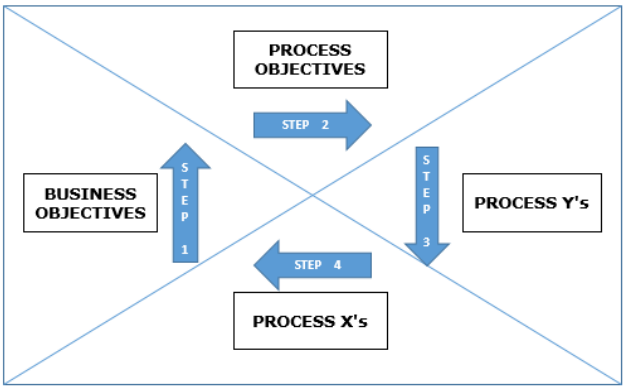

Figure. 1. The basic steps to construct a Hoshin Matrix

1. Step 1: Set the Strategic Vision & Define Business Objectives
2. Step 2: Define Key Mid-Term and Process Objectives which are top level improvement priorities
3. Step 3: Set Short-Term Actions and Process Output Metrics (KPIs)
4. Step 4: Agree on Key Sub Processes and Metrics

In order to select metrics that are driven from the high level business objectives, a rating of influence is given by voting of the workshop participants in following order:

1. Give rating of influence to each process objective against each business objective,
2. Give rating of influence to each sub process objective (process y's) against each process objective. The important process outcomes (Y) are a result of the drivers (x) (Y = f(x)),
3. Rated and eliminate controllable factors (process x's). Give rating of influence to the selected set of process x metrics against process y's,
4. Select the process x's with highest score.

The following part gives the steps to construct a Hoshin Matrix in detail.

Step 1: Set the Strategic Vision & Goals

At the left quadrant of the matrix identified business objectives are listed. Business objectives are the long or medium term goals of an organization in order to achieve the mission and vision. In the annual strategic planning phase, senior leadership sets objectives for the organization by assessing what has been done in the past, latest yearly plan and results, the challenges of the industrial/external factors, current business environment and short to medium term plans. Each business objective are voted for their relative importance. This is done by discussions and voting among workshop participants that are business leaders. The relative scale of rating has been considered based on the guidelines on Table. 1.

Table. 1. The relative scale of rating for influence levels

Influence Level	Scale
Low Influence	2
Medium Influence	5
High Influence	7
Highest Influence	10

Step 2: Define Key Mid-Term and Process Objectives

The next step is to identify key process objectives that will cause the organization to reach its strategic business targets. These process objectives are put in the top quadrant of the Hoshin Matrix. After the long-term goals are all set, list the most important process level objectives that you aim to achieve in a shorter time frame for example in one year. Provide rating of influence of process objective against each business objective. Voting members should consider what needs to be accomplished first to keep the processes on track. After the voting session each participant explains the reason of her vote and after a brainstorming session rating of influences are assigned. Subsequently, the sum product of the given rating of influence to the process objectives and business objectives needs to be calculated. If the selected product's value is the highest or very

close to the highest one, it is ranked as 10 (the highest influence). The influence reduces when the related process's rating reduces.

Step 3: Set Short-Term Actions and Process Output Metrics

The right quadrant will be filled with the process Y's on our customized Hoshin Matrix. In the Six Sigma methodologies process improvements are based on scientific and structured problem-solving approach $Y = f(x)$. This mathematical term is simply means that the process output measures (*Y*s) are a result of the drivers (*x*'s) within processes. Initially, we need to understand the process *Y*'s and how to measure them. These factors constitute the most important key process indicators (KPI) which are quantifiable measurements that reflect the critical success factors of an organization. The target for process Y's may differ depending on the organization's mission and products. On the Hoshin Matrix, the correlation between process objectives and process Y's are also highlighted by assigning the rating of influence that is calculated by the explained method to the sub process objective against each process objective.

Step 4: Agree on Key Sub Process Metrics

The lower quadrant is for selection of the process X's metrics. Process X's are the process inputs that are identified for arriving at process Y's. In order to select the potential controllable factors (process X), sub processes of a process (e.g. development, testing) are listed and process x's are prioritized and voted based on the following criteria and given rating scale on Table. 2.

Table. 2. Prioritization criteria for potential controllable factors for processes and the rating scale

Criteria	Rating Scale
Impact on Business Objectives & Project Success	5 - High Impact 3 - Medium Impact 1- Low Impact
Extent of Process Definition	5 - Well Established Process 3 - Process can easily be defined 1- Difficulty in Process Definition and implementation.
Extent of Data Availability	5 - Established Data Collection System 3 - Data Collection can easily be started 1- Difficulty in Data Collection/ It is not cost effective.

		Impact on Business Objectives & Project Success		
		1	3	5
Extent of Process Definition	5	5	45	**125**
	3	3	27	75
	1	1	9	25
		1	3	5
		Extent of Data Availability		

Figure. 2. The multiplication matrix for controllable criteria prioritization rates

Figure. 2 shows the multiplication matrix of the rated numbers. At the beginning of the workshop, a threshold value needs to be determined to eliminate the processes. For example if the grand total is equals to and above the determined threshold value, for instance 75, the sub-process/metric is selected. This prioritization technique or a simple offline multi-voting will help to achieve reducing potential *x*'s to a manageable and measurable few. The next thing to do is to define the relations of the controllable factors (process x) with selected sub processes. These controllable factors are the metrics that will help the company to keep track of the selected processes during execution for the company goals. Provide rating of the process X measures/metrics against each Process Y's. Total score implies the influence rating of process inputs/measures/metrics on process Y the process/sub processes. Together with the workshop participants the most crucial metrics that you need to select are agreed on. These metrics will be tracked and maintained to improve.
Lastly, complete the flow down picture by showing the relations between business objectives to process metrics and measures.

4 Application of Adapted Version of Hoshin Matrix by HTRDC on Agile Software Development

Historically, Huawei Turkey Research and Development Center (HTRDC) started its presence in Turkey with a strong Software Development & Testing under the framework of CMM. Subsequently over a period of years spreading its business capability and ownership several pioneering initiatives are implemented like CMMI. Within a few years, it has improved its software development process maturity and was certified with CMMI Level 3 and CMMI Level 5. It is also inevitable for HTRDC to get ASD's technical and commercial benefits. As HTRDC is an organization that has maturity level 5 of CMMI-DEV, it aims to get productivity gains and strengthen the culture of value focus by applying ASD. In HTRDC, quality and operations department is responsible for conveying a workshop to construct the matrix for organization level and selection of most critical process metrics for organizational improvement projects, and for constructing process performance model (PPM).

Step 1: Set the Strategic Vision & Goals
The business objectives are updated annually for HTRDC considering the long term strategic plans. The organizational leaders formulate strategic business objectives every year for achieving the mission for what the organization is working towards. These are set on the left quadrant of the matrix are as in the following:

1- Budget Optimization: Deliver projects within Budget and Usage Rate should be greater than 85%
2- Customer Satisfaction (CSAT) should be greater than 85%
3- Achieve Zero Critical Quality Accident

Relative Importance of the business objectives are voted by the workshop participants by considering their effects to process objectives. The voted annual business objectives are voted at HTRDC and the results are listed in the Table. 3.

Table. 3. Annual business objectives with decided relative importance

BUSINESS OBJECTIVES	Relative Importance
Budget Optimization: Deliver projects within Budget and Usage Rate should be greater than 85%	**7**
Customer Satisfaction (CSAT) should be greater than 85%	**10**
Achieve Zero Critical Quality Accident	**10**

Step 2: Define Key Mid-Term and Process Objectives

Process objectives are selected in consideration of the goals to achieve in a shorter time frame. These are sometimes called top level improvement priorities. The process objectives aligned to business objectives on the table X2 are listed as in the following:

1- Deliver with HTRDC Quality Standard
2- Improve Engineering Capability to deliver within budget and on time

Rating of influence of process objective against each business objective are voted by members by considering what needs to be targeted primarily to keep the processes on track. The calculated score of sum products of the given ratings and the relative importance set for the process objectives as explained on the Step 2 of the section 3.1. The relative importance is showed on the Figure. 3 which is showing the completed left and upper quadrants of the Hoshin Matrix.

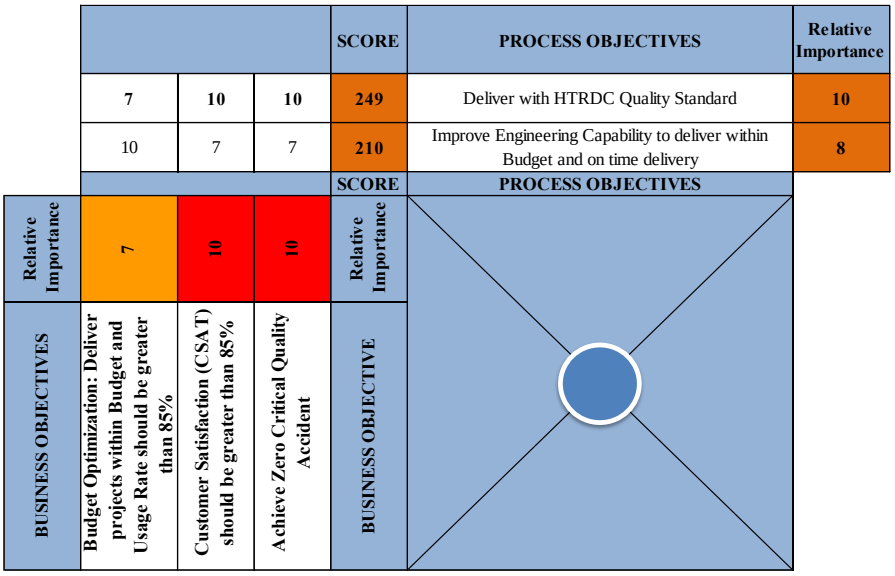

Figure. 3. The left and the upper quadrants of the Hoshin Matrix

Step 3: Set Short-Term Actions and Metrics

The process output metrics (*Y*s) of HTRDC for ASD are listed on Table. 4. These are the quantifiable results of the drivers (x's) within processes that reflect the critical success factors of an organization as explained on section 3.1 Step 3.

Table. 4. Agile Software Development process output metrics in HTRDC

Process Y's
Version Release Defect Index (DI)
Delivered Open Defect Density
Downstream Defect Density
End to end (E2E) Productivity
Workload Deviation
Schedule Slippage
Process Compliance

Rating of influence are assigned to each sub process objective against each process objective by votes of workshop members. This rating score defines the relative importance of process outputs (Ys). The right quadrant is filled with the process Ys and the ratings which can be seen on Figure. 4. The two process Ys that are highlighted with blue are selected to be used at Process Performance Model (PPM) for prediction and process control.

PROCESS OBJECTIVES	Relative Importance	RATING OF INFLUENCE <<Provide rating of Sub Process Objective against each Process Objective>>						
Deliver with HTRDC Quality Standard	10	10	10	10	7	7	7	7
Improve Engineering Capability to deliver within Budget and on time delivery	8	7	7	7	10	10	7	7
	SCORE	156	156	156	150	150	126	126
	PROCESS Y'S	Version Release DI	Delivered Open Defect Density	Downstream Defect Density	E2E Productivity	Workload Deviation	Schedule Slippage	Process Compliance
	Relative Importance	10	10	10	10	10	8	8

Figure. 4. The upper and the right quadrants of the Hoshin Matrix

Step 4: Agree on Key Sub Process Metrics

Potential controllable factors (process X) of development and testing processes are given on Table. 5 and Table. 6.

Table. 5. Controllable factors for development activity in HTRDC

Development: Controllable Factors (Process X):	
A	User Story Productivity
B	Us Dev Review Defect Density (DD)
C	Development Test Defect Density
D	Total Impediments Density
E	Specifications Stability
F	Number Of Network Defects
G	Size Deviation

Table. 6. Controllable factors for testing activity in HTRDC

Test: Controllable Factors (Process X):	
A	Sdv Test Defect Density
B	Total Internal Defect Density
C	Total Defects With Delivered Open Defect Density
D	Total Defects With Downstream Defect Density

E	Post Delivery Defect Density (System Integration Test+Customer Reported)
F	Base Code Testing Productivity
G	Base Code Quality Defect Density
H	Sprint Level Base Code Quality Delivered Open DD
I	Sprint Level Delivered Open Defect Density
J	Number Of Trouble Tickets Rejected In Regression Test

HTRDC Agile Software Development sub processes are analyzed and some of them are listed as in the Figure. 5. The determined threshold to select sub processes the Figure. 5 is decided as 75. If the grand total equals to 75 and above the sub processes are selected. The selected sub processes are namely; user story development, user story development review, user story development test, and user story system design verification (SDV) test. The relation of these sub processes are given on the right column of the Figure. 5.

Process Selection - Development Processes								
	No	Name of Sub Process	Process Selection Criteria - Quality & Ontime Delivery			Grand Total	Selected	Relation with Process X
			Impact on Business Objectives & Project Success	Extent of Process Definition	Extent of Data Availability			
DEVELOPMENT	1	User Story Development	5,00	4,50	3,50	78,75	Yes	A,H,I,J, K
	2	User Story Development Review	5,00	4,75	4,65	110,36	Yes	B,C,D
	3	User Story Development Test	4,85	4,50	4,71	102,96	Yes	E,F,G
	4	Other Proj. Mgt. Efforts	4,50	4,35	3,50	68,51	No	
	5	Configuration Management	3,86	3,57	3,29	45,26	No	
	6	Defect Prevention	4,33	3,00	2,33	30,33	No	
	7	Competency	5,00	4,14	3,00	62,14	No	
	8	Project Setup	4,00	4,33	3,67	63,56	No	
	9	Knowledge Management	4,00	4,33	2,67	46,22	No	
	10	Change Control/ Management	4,43	3,67	3,86	62,69	No	
	11	Build, Release and Deployment Mngmt	4,71	3,29	2,71	42,04	No	
	12	Communication & Collaboration	3,67	3,67	2,67	35,85	No	
TEST	1	User Story SDV Test	4,67	4,02	4,35	81,61	Yes	A,B,C,D,E,F,G,H,I,J,K,L,M
	2	Other Proj. Mgt. Efforts	4,00	4,00	3,67	58,67	No	
	3	Configuration Management	4,00	3,67	3,33	48,89	No	
	4	Defect Prevention	5,00	3,00	2,33	35,00	No	
	5	Competency	5,00	4,00	3,00	60,00	No	
	6	Project Setup	4,00	4,33	3,67	63,56	No	
	7	Knowledge Management	4,00	4,33	3,00	52,00	No	
	8	Change Control/ Management	5,00	4,33	3,33	72,15	No	
	9	Requirement Verification	5,00	5,00	2,67	66,75	No	
	10	Communication & Collaboration	3,67	4,00	2,33	34,22	No	

Figure. 5. Sub-Process Selection for Process Prediction Model and/or Statistical Control

The rating of influence of the process Xs against each Process Y's are given on Figure. 6. Total score is calculated based on the given influence rating of process X on process Y and relative importance of process Ys. The process X Metrics are agreed to be selected by the workshop participants if the total score is 300 or above. This threshold defined by the organization.

	PROCESS Y'S		Version Release DI	Delivered Open Defect Density	Downstream Defect Density	E2E Productivity	Workload Deviation	Schedule Slippage	Process Compliance	PROCESS Y'S
	Relative Importance		10	10	10	10	10	8	8	Relative Importance
PROCESS X Metrics <<Process Inputs / Measures / Metrics identified for arriving at Process Ys>>	**Processes X's Measured & Monitored**	**Total Score**	**RATING OF INFLUENCE**							**Selected**
User Story Productivity	User Story Development	522	7	7	7	10	10	7	7	Yes
Specifications Stability	User Story Development	522	7	7	7	10	10	7	7	Yes
US Dev Review Defect Density	User Story Development Review	462	7	7	7	7	7	7	7	Yes
Development Test Defect Density	User Story Development Test	552	10	10	10	7	7	7	7	Yes
Total Impediments Density	User Story Development	522	7	7	7	10	10	7	7	Yes
Size Deviation	User Story Development	522	7	7	7	10	10	7	7	Yes
SDV Test Defect Density	User Story Development SDV	552	10	10	10	7	7	7	7	Yes
Total Internal Defect Density	User Story Development SDV	522	7	10	10	7	7	7	7	Yes
Total Defects with Delivered Open Defect Density	User Story Development SDV	346	5	5	5	5	5	5	7	Yes
Total Defects with Downstream Defect Density	User Story Development SDV	346	5	5	5	5	5	5	7	Yes
Post Delivery Defect Density (SIT+Customer Reported)	User Story Development SDV	466	7	10	10	5	5	5	7	Yes
Base Code Testing Productivity	User Story Development SDV	522	7	10	10	7	7	7	7	Yes
Base Code Quality Defect Density	User Story Development SDV	522	7	10	10	7	7	7	7	Yes
Sprint Level Base Code Quality DO DD	User Story Development SDV	522	7	10	10	7	7	7	7	Yes
Sprint Level Delivered Open Defect Density	User Story Development SDV	522	7	10	10	7	7	7	7	Yes
Number of Trouble Tickets Rejected in Regression Test	User Story Development SDV	410	7	7	7	7	5	5	5	Yes
Number of Network Defects	User Story Development	546	7	7	7	10	10	10	7	Yes

Figure. 6. The right and the lower quadrants of the Hoshin Matrix

5 Discussion

The explained adapted version of Hoshin matrix is introduced to projects by the quality and operations department of HUAWEI Turkey R&D Center. HUAWEI Turkey R&D Center is a large software development company works in Turkey with around 500 engineers. With the CMMI Level 5 maturity lean methods are used in process management that are applied for controlling and monitoring the processes based on statistical data. Benefits of using Hoshin Matrix, in defining and mapping organizational goals has been observed at HTRDC. Since the business objectives are monitored and controlled by selected process x metrics that are mapped with the defined organizational goals, the risk to misinterpret the results and lose organizational alignment is decreased. This risk is manageable by the annual/half yearly evaluation of the process performances. This control mechanism has provided to be early in taking action and adjust the business goals and/or process improvements faster. Initial implementation of Hoshin Matrix was applied on traditional V-model Software Development Lifecycle at HTRDC. In the interest of improving business capability and productivity, agile transformation has been employed together with CMMI. As a result, Huawei Turkey made significant contributions as it has been managing its ASD processes and high product quality with lean management methods and CMMI Level 5, the highest level of maturity.

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