Schema Development for Integrating Environment of SE and EVM : Case Study

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Abstract. EVM(Earned Value Management) is applied to many large scale projects as one of project management techniques. But the measurements of the EV have been carried out by separated process with Systems Engineering processes, in separated tool environments. This separation caused the problem that EV does not show the exact value of the work accomplished. To overcome this separation and to solve the problems, this paper suggests an integrated computer aided tool environment and processes.

In this research, we defined data elements needed for systems engineering and project management. Those elements are WP(Work Package), WP_DETAILED_PLAN, WP_PROCEED_DPLAN and SYSTEM REQ. WP is the decomposition of the WBS element and the WP_DETAILED_PLAN contains PV information, the WP_PROCEED_DPLAN contains the AC information and the SYSTEM REQ contains the requirements which the WP should satisfy.

These elements were implemented using computer aided systems engineering tool(Cradle®). If this tool can be integrated with EVM tool, technical information related with EV can be traced efficiently. This paper describes the integration concept mentioned above and the implementation of the concept.

Introduction

The Problem. EVM(Earned Value Management) is applied to many large scale projects as one of project management techniques. Especially, in defence sector, it is mandatory to apply EVM to the projects which are over some predefined scale. But it is pointed out that there are some problems in applying EVM. Paul Solomon(2005) insisted that the EVMS standard states that EV is a measurement of the quantity of work accomplished and that the quality and technical content of work performed are controlled by other processes. He also asserted that EVMS addresses only the

project work scope and ignores the product scope and product requirements. His point is that it is needed to integrate EVM with Systems Engineering which deals with the scope, requirements, quality and technical maturity of the system.

Furthermore as EVMS and SE are managed by separate processes, the activities to acquire and input the information by EVM part and the works of SE part to provide the data to EVMS are carried out in a very inefficient way.

The Solution. One of the solutions to solve the problems mentioned above can be the environment which integrates the systems engineering processes and the EVM Processes.

These days, it is very common to use CASE(computer aided systems engineering) tool to apply systems engineering to projects. Especially, it is recognized that the use of CASE tool for the development of the large scale complex systems is essential. The EVM is also performed using computer software for analysis and anticipation of the project. So if the two tools (SE and EVMS) can be tailored and integrated to solve the shortfalls of EVMS, it would provide a very efficient environment for both systems engineers and EVMS managers.

This paper describes the SE process and the schema of the CASE tool for integration with EVMS tool. The feasibility and the efficiency of the integration are also discussed. This paper also contains suggestions on the performance based project management environment for the effective project management.

Related Standards

The standards related with systems engineering are MIL-STD 499B, IEEE 1220, EIA 632. And ANSI/EIA-748-A-1998 is a major standard for EVM. The CMMI model is used for process improvement and PMBOK is used for project management. The DoD acquisition guidebook and the SEP preparation guide book can be used as best practice for systems engineering. This study used these standards and guidebooks for the development of the schema of the CASE tool, so it can be argued that the schema introduced in this paper is compliant with those standards and guidebooks in a general framework point of view.

Schema for SE Process

Figure 1 show the schema for SE processes.

The REQUIREMENT is captured from various sources(NEED, ROC, OPERATION_CONCEPT), and the SYSTEM REQ is defined through functional analysis and architecting. The REQUIREMENT is traced to SYSTEM REQ. VERIFICATION is defined for each SYSTEM REQ and connected to it. SBS is developed based on system architecture and the traceability to the REQUIREMENT is established. Next, the PBS which satisfies the SBS is defined and the traceability is established. For each PBS and SBS, the VERIFACTION is defined and the traceability is established. Each VERIFICATION is connected to TEST EVENT, and the TEST EVENT is connected to RESULT.

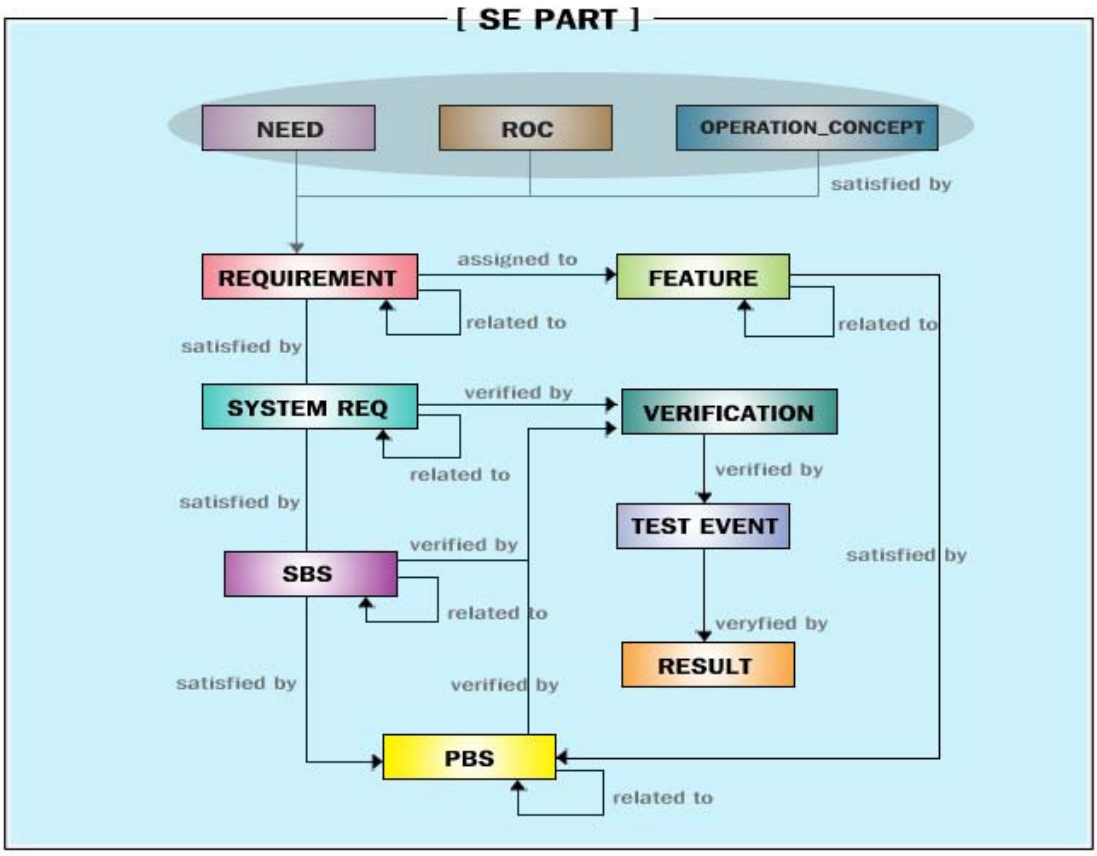


Figure 1. SE Schema

Table 1 shows descriptions on the elements of SE schema.

Table 1: Elements of SE Schema

Element Name	Description	Major Attribute
SOURCE	NEEDS , ROC , OPERATIONAL_CONCEPT	• Text
REQUIREMENT	REQUIREMENT contains the description of the behavior required for the system, or characteristics that the system required to posses	• Requirement Details • Acceptance Criteria • Req Category
SYSTEM REQ	SYSREQ records the functional and non-functional system requirements – what the system must do in order to meet the REQUIREMENT	• SYSTEM REQ Details

Element Name	Description	Major Attribute
SBS	SBS(System Breakdown Structure) is an alternative view of the architecture based on a hierarchical decomposition rather than modeling driven architecture analysis and design.	● SBS Details
PBS	PBS(Product Breakdown Structure) used in a hierarchy to depict the physical structure of a system.	● PBS Details ● Quantity ● Weight
VERIFICATION	VERIRICATION verifies one or more requirements.	● Verification Description ● Procedure
TEST EVENT	TEST EVENT contains the information on the testing	● Description
RESULT	RESULT is used to record the results of the TEST EVENT.	● Description ● Attached File

Schema for PM and EVM

Figure 2 shows the schema for project management and EVM .

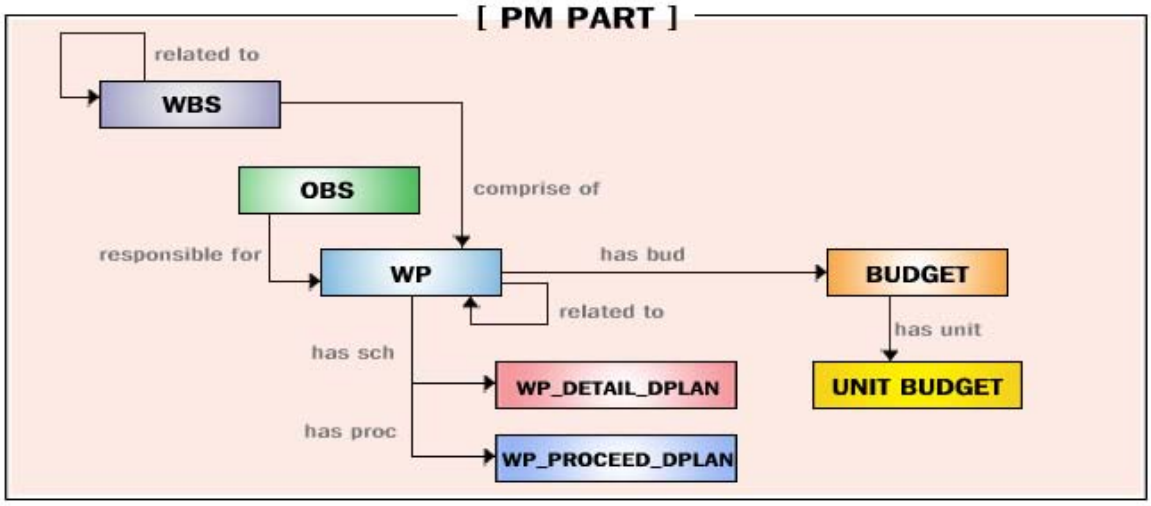


Figure 2. Schema for PM and EVM

The WBS(Work Breakdown Structure) forms the basis for planning the schedule, budget, and manpower of the Project. The WBS is comprised of WP(Work Package) which has its own budget and work plan. Each WP is allocated to OBS(Object Breakdown Structure) which means the

organization responsible for the WP. The BUDGET has UNIT BUDGET which decomposes the BUDGET according to the accounts.

Table 2 shows detailed descriptions for the elements of the PM schema.

Table 2. Elements of PM Schema

Element Name	Description	Major Attribute
WBS	Work Breakdown Structure shows product oriented structure of the project.	● WBS code ● WBS Level ● WBS description
OBS	Organization Breakdown Structure shows the information about the manager, coordinator, manpower, personnel of each component of the organization.	● Manager information ● Name of the organization ● System coordinator ● Manpower ● Personnel
WP	Work Package is a basic unit of the project.	● Development Plan ● SOW ● Output ● Budget for each year by accounts ● Weight Total ● Budget Total ● Man-Year
WP_DETAIL_DPLAN	Work Package Detail Plan shows cost and manpower plan of the related Work Package.	● Budget of each year ● Budget of each quarter of the year (PV : Planned Value)
WP_PROCEED_DPLAN	Work Package Proceed Plan shows actual cost and manpower of related Work Package.	Same as WP_DETAIL_DPLAN except for the data (AC: Actual Cost).
BUDGET	BUDGET shows the assigned budget of each account.	● Budget Item ● Contract Type ● Budget Type ● Budget of the year ● Budget of a quarter of the year
UNIT BUDGET	UNIT BUDGET is a decomposition of the BUDGET.	● Allocated Budget ● Number of components to be produced ● Budget Total ● Budget Type

Integrated Schema for SE and EVM

Figure 3 Shows the integrated schema for PM and SE. Each WP is connected to SBS for traceability between SE and PM. Each SBS has allocated requirements and related information of SE which can be regarded as the supporting information for calculation of EV. The PV and AC of each WP can be traced from WP_DETAIL_DPLAN(PV) and WP_PROCEED_DPLAN(AC). One remaining value, the EV comes from the EVM tool and integrated with the PM and SE schema as shown in Figure 4. All the information can be integrated in one database as in Figure 4 or the EVMS data can be imported to SE Tool. This way, we can see the evidence of the value of EV in systems engineering part so that the problems mentioned in the introduction of this paper can be solved.

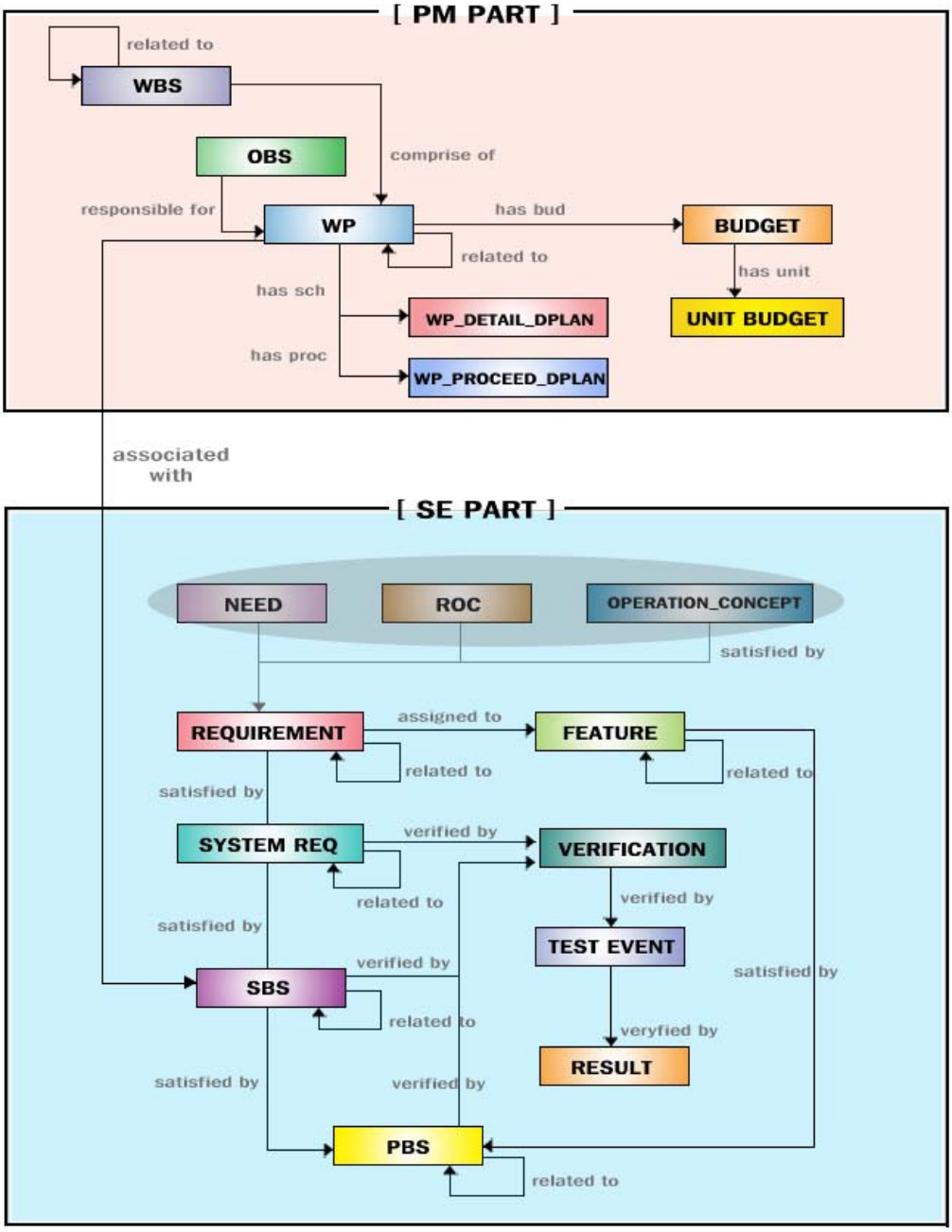


Figure 3. Integrated Schema of PM and SE

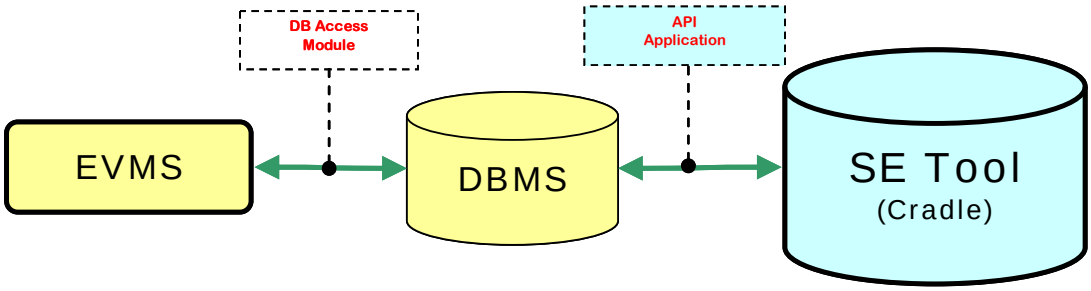


Figure 4. EVMS and SE Tool Integration Concept

Integration of PM and SE data

The Cradle® can be integrated with Oracle DB through API and Proc, an embedded language. The Oracle DB contains information about EVM. The SE and PM data (cost, metrics, etc) which are recorded in Cradle® can be transmitted to Oracle DB by three steps as shown in Figure 5

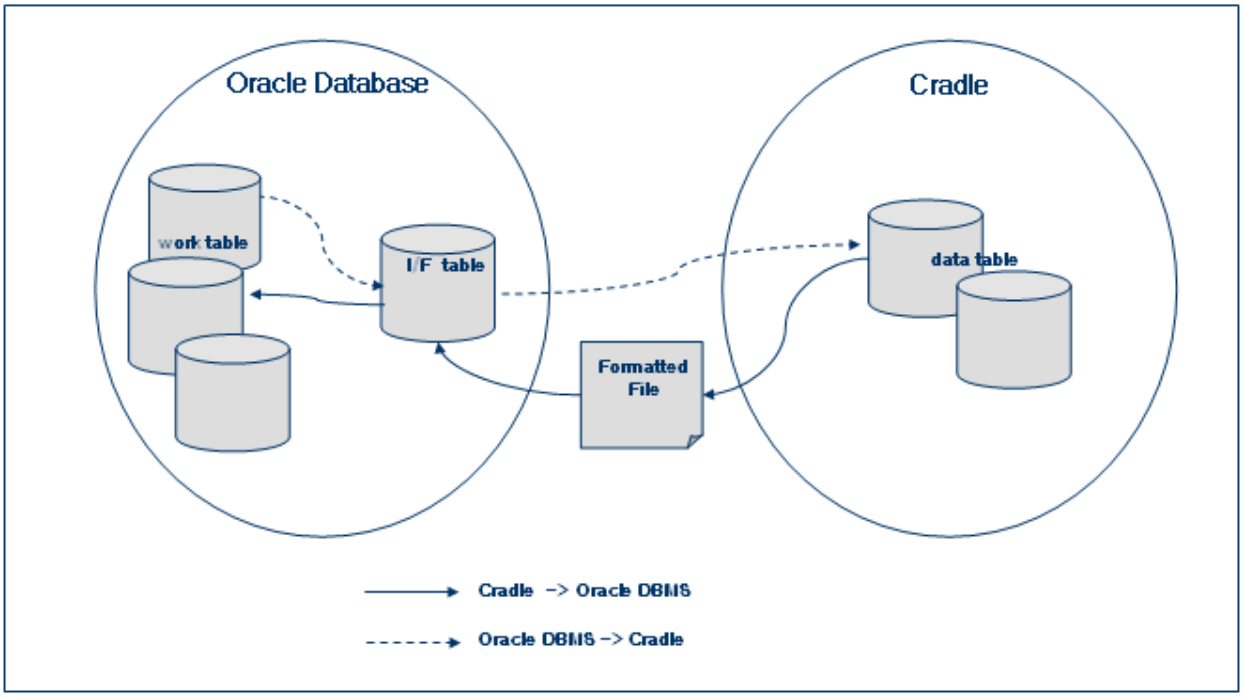


Figure 5. Integration of PM and SE data

- From Cradle® to Oracle® DB

The first step is to input the SE and PM data to the Cradle® and run a calculation program. Second step is to produce a predefined file and the third step is to transmit the data in the predefined file to the I/F(Interface) table.

- From Oracle® DB to Cradle®

The first step is to move the data in the work table to I/F table, and then transmit the data in the I/F table to Cradle® project data using Cradle API®.

Work Processes

The integrated work process concept for SE and EVM is shown in Figure 6. The project management team allocates the PV for each WP in CASE tool using PM schema. Systems Engineer performs systems engineering and inputs AC for each WP using CASE tool. The EVM team collects or receives the PM and SE data in order to analyze and output EVM data.

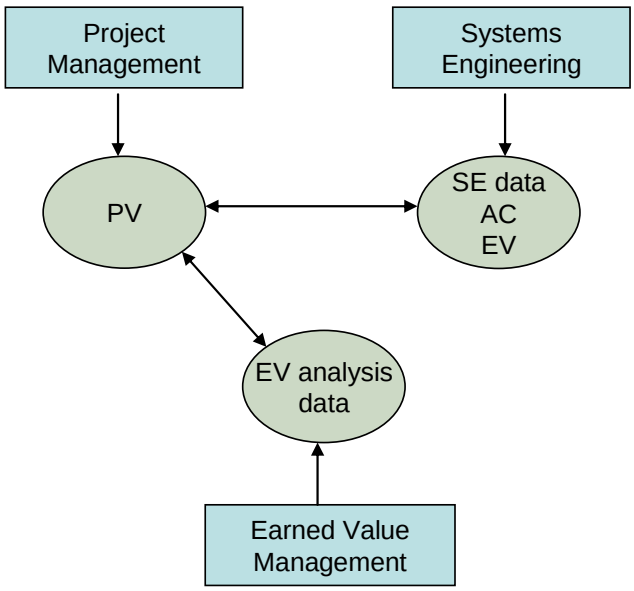


Figure 6. Integrated Process Concept

Example

Following figures show how the concepts mentioned above are implemented. The example was implemented using Cradle®. In this example, we illustrated traceability of WP, PV, AC and SBS and requirements.

Figure 7 shows the traceability of WP with BUDGET, SBS, WP_DETAIL_DPLAN and WP_PROCEED_DPLAN. SBS is connected to appropriate SYSTEM REQ which is one of the products of systems engineering. This traceability enables the project manager to identify what requirements are to be satisfied by the work package. And the project manager can identify the

budget allocated to the work package. The WP_DETAILED_DPLAN contains the PV information and the WP_PROCEED_DPLAN contains AC information. Because the WP is the basic unit of project management in this case study, WP is connected to the systems engineering and the EVM.

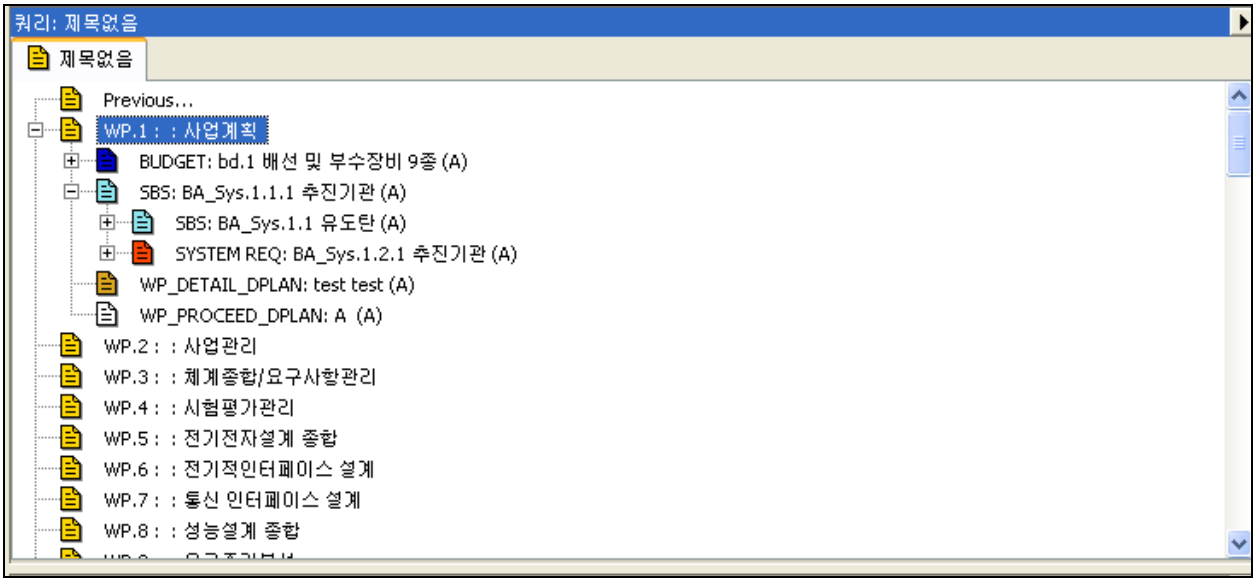


Figure 7. Traceability of WP with Other Elements

But the relationship between the WP and the SBS may be inappropriate if the levels of them are different. This means that, if the WP is very detailed and the SBS has very level of abstraction, one may not clearly identify what System Requirements are allocated to the WP. For this the System Requirement should have appropriate level of detail for allocation to SBS. And if the WP is directly related with PBS rather than SBS, it may appropriate to connect WP with PBS. But this can cause some traceability problem of requirements. As the System Requirement is allocated to SBS and the PBS is linked to SBS, one may not clearly identify what System Requirements are allocated to PBS. If the PBS is lower level than the SBS, this kind of traceability problem shall occur.

Figure 8 shows detailed attributes of WP. In Figure 8, the annual budget and quarterly budget are automatically calculated using all BUDGET related to WP. This automatic calculation function was implemented using Cradle API® .Figure 9 shows detailed information of the BUDGET. A WP can have many BUDGETs. The PV of WP comes from the WP_DETAIL_DPLAN as shown in Figure10 and the AC of WP comes from the WP_PROCEED_DPLAN as shown in Figure 11.

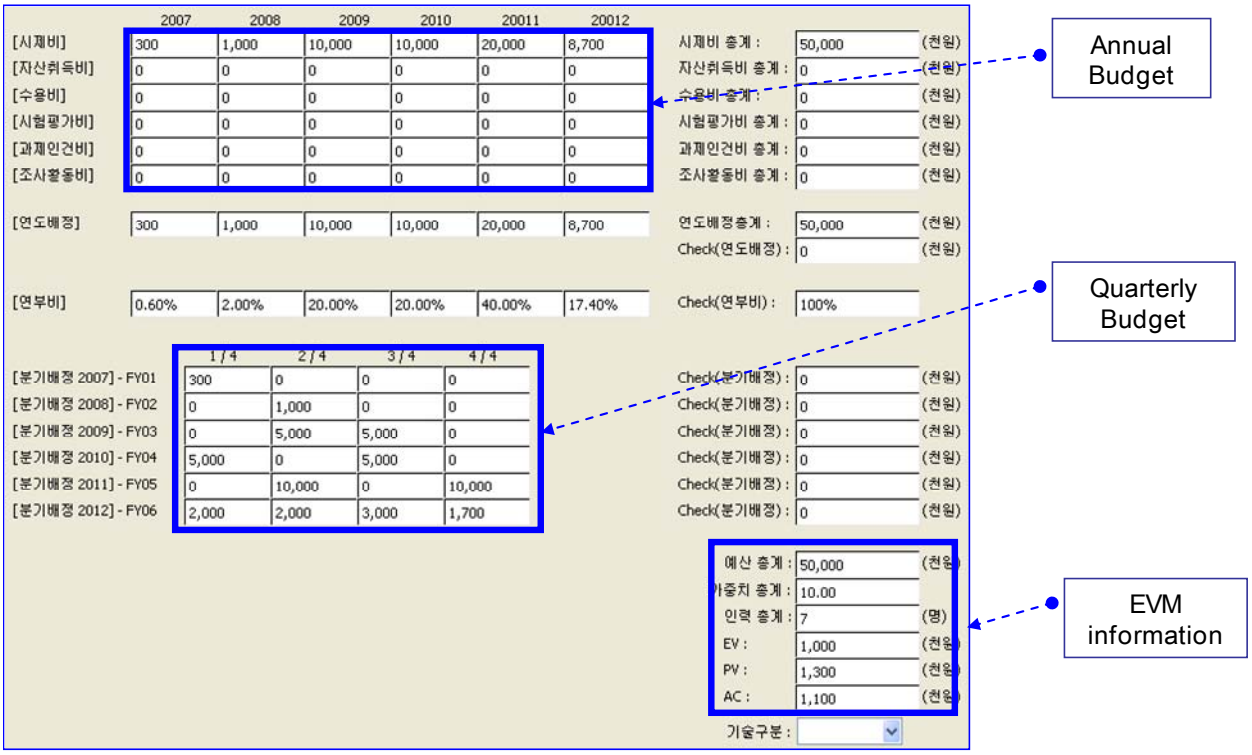


Figure 8. WP details

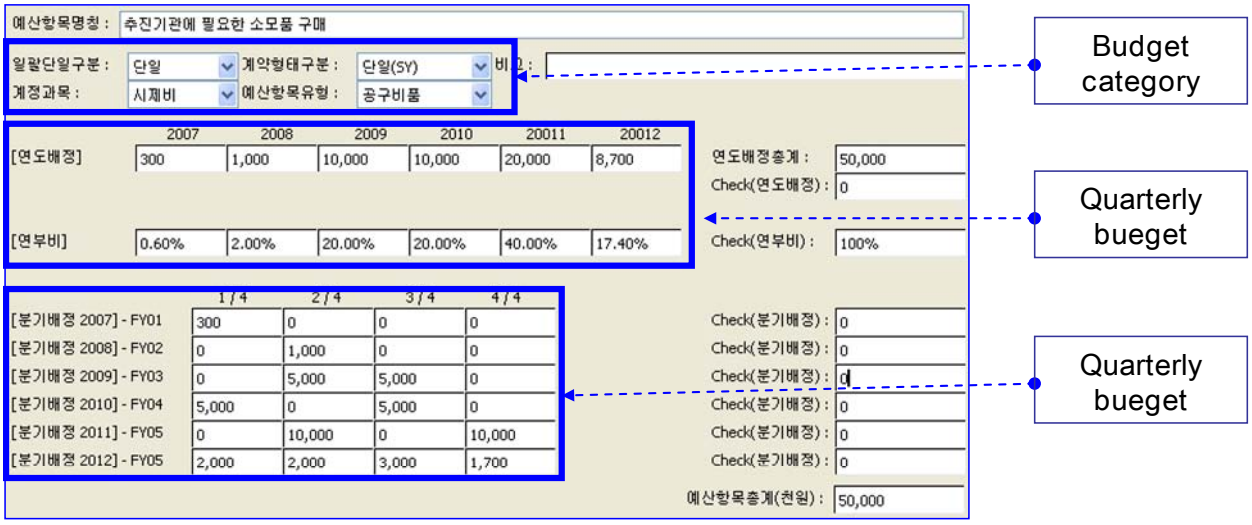


Figure 9. Budget details

Figure 10. WP_DETAIL_DPLAN

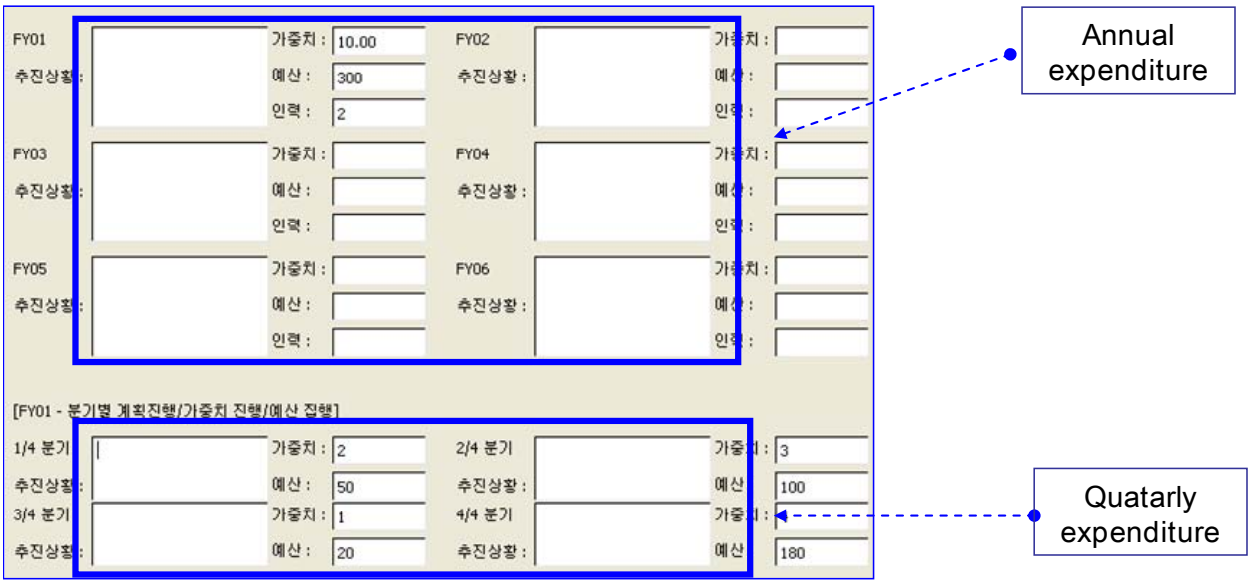
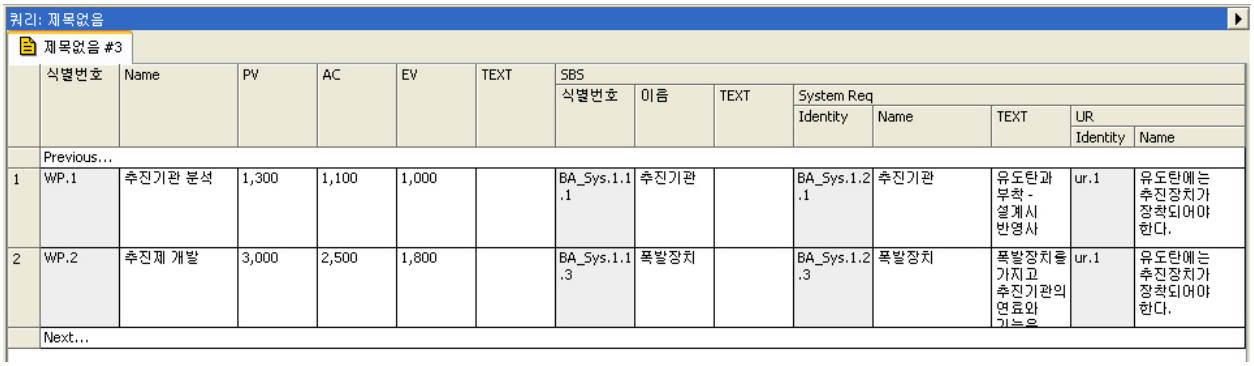


Figure 11. WP_PROCEED_DPLAN

Figure 12 shows the table view of the WP and related information. In Figure12 we can see the name, PV, AC, EV and text of a WP and the SBS related to the WP and the SYSTEM REQ related with the SBS.



쿼리: 제목없음

제목없음 #3

	식별번호	Name	PV	AC	EV	TEXT	SBS							
							식별번호	이름	TEXT	System Req			UR	
										Identity	Name	TEXT	Identity	Name
	Previous...													
1	WP.1	추진기관 분석	1,300	1,100	1,000		BA_Sys.1.1.1	추진기관		BA_Sys.1.2.1	추진기관	유도탄과 부착 - 설계시 반영사	ur.1	유도탄에는 추진장치가 장착되어야 한다.
2	WP.2	추진제 개발	3,000	2,500	1,800		BA_Sys.1.1.3	폭발장치		BA_Sys.1.2.3	폭발장치	폭발장치를 가지고 추진기관의 연료와 기능을	ur.1	유도탄에는 추진장치가 장착되어야 한다.
	Next...													

Figure 12. Table view of the WP and related information

Conclusions

EV is a very widely used technique to manage a project. But the EV can not tell anything about the quality of the achievement. To overcome this kind of problem EV should be integrated with SE which provides the evidence of the achievement.

We can expect the effects from integrated SE and EVM system as follow,

- It supports more reasonable EV calculation due to the possibility of evaluation of the work scope performed and the results or the quality of the works performed together.
- It enhances the work efficiency by integrating the SE and the EVM processes which have been performed separately.
- It improves the accuracy of EV by using consistent data between SE and EVM.
- It enables to identify and to mitigate project risks in advance by shortening the periods of EV evaluation.
- It provides a basis for practical performance-based project management in accordance with TPM management.

This study needs additional study in order to implement performance-based project management in connection with TPM management.

The linkage between the PM and SE are WP and SBS in this paper. But another linkage, for example WBS with SBS, WP with PBS may be reasonable for some projects or organizations.

References

ANSI/EIA-747-A. 1998. *Earned Value Management Systems*.

ANSI/PMI 99-001-2004. *A Guide to the Project Management Body of Knowledge*. Third Edition.

IEEE. 2005. IEEE Standard for Application and Management of the Systems Engineering Process. INCOSE 2006 *Systems Engineering Handbook* - a guide for system life cycle processes and activities, Version 3.

Paul J. Solomon. 2005. *Performance-Based Earned Value*. The Journal of Defense Software Engineering. 22-26.

Ronald S. Carson. 2008. *Using Performance-Based Earned Value® for Measuring Systems Engineering Effectiveness.* In Proceedings of the 18th Annual International Symposium of the International Council on Systems Engineering (Netherland).: INCOSE.

ThreeSL. Cradle® User Guide. (www.threesl.com)

US DoD, Defence Acquisition Guidebook, https://akss.dau.mil/dag/

BIOGRAPHY

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Dr. Youngwon Park is a professor of Systems Engineering at Ajou University in Korea since 1998. Prior to coming to AU, he served as a research director at Institute for Advanced Engineering in Korea for two years. He worked at McDonnell Douglas Aerospace for twenty years in the area of space system avionics.

Mr. Jongsun Park is CEO of SNS Eng Co. He is a Ph.D student of Department of Systems Engineering of Ajou University. He is interested in performance bases earned value management.