

Practical Issues of Earned Value Management Systems (EVMS) for Nuclear Power Plant (NPP) Construction

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Abstract: Cost, schedule, and quality are the three major performance indicators for any construction project. Under the globalized competition in the nuclear industry, researchers and practitioners have also explored a systemized and integrated management system for cost, schedule, and quality. In order to address this issue, the concept of earned value management system (EVMS) has been often utilized. However, implementing EVMS for a mega-project of nuclear power plant (NPP) construction requires extensive overhead efforts. Though previous studies proposed structures and methods for effective NPP EVMS, there has been no legitimate study for data collection strategy for practical implementation. In this context, the purpose of this paper is to develop an effective data collection strategy for NPP EVMS. Firstly, the barriers to practical NPP EVMS were identified based on literature review and expert interviews. Strategies for data collection were then developed based on different phases of project life cycle. This study focuses on the 'life-cycle integrated progress management system' for NPP construction from an owner's perspective. Therefore, results of this study can be used as a guide for preparing request for proposals (RFP) of an NPP owner organization.

Keywords: EVMS, Nuclear Power Plant (NPP), Data Collection, RFP

I. INTRODUCTION

The concept of earned value management system (EVMS) has been often explored in academia as well as in the industry in order to effectively integrate the management systems for cost, schedule, and quality in an integrated manner. Even though it is widely recognized that this integration offers significant benefits, implementing EVMS for a mega-project such as nuclear power plant (NPP) construction requires extensive overhead efforts to collect and organize data [1][2]. Nevertheless, there has been no legitimate study for data collection strategy for practical implementation.

In order to address this issue, the purpose of this paper is to develop an effective data collection strategy for NPP EVMS. EVMS requirements for project management organization (PMO) in NPP projects were identified first. Data collection strategies and methods were then developed focusing on the contractual relationships with engineers, equipment suppliers, and general contractors (GC). Finally, provisions for request for proposals (RFP) of an NPP owner organization were specified to collect general contractors' information during the construction phase for the purpose of NPP EVMS in an owner's organization.

II. REQUIREMENTS FOR NPP EVMS

In order to identify EVMS requirements, this study uses a case-company that constructs and operates nuclear power plants as an owner. The owner's PMO is specialized in managing NPP projects throughout the project life cycle including design, procurement, construction, operation, and decommissioning. This paper focuses on the construction phase.

A. EVMS Objectives

As the case-company has lately joined into international nuclear market as an EPC service provider, significant efforts to enhance PMO capability have been conducted. EVMS objectives were formulated to support this posture change. The objectives can be summarized into four major areas [1]; "integrating performance measures", "enhancing organizational capability" specifically in the planning phase, "optimizing EVMS workloads", and "augmenting cost engineering" processes.

B. EVMS Requirements for Data Collection

Based on the objectives identified above, EVMS requirements for data collection are defined. The first important requirement is to directly connect general contractors' (GCs') input with the owner PMO's systems in order to minimize the efforts in manipulating enormous data. It also requires to minimize the GC's data entry to PMO systems. The second requirement is to embed knowledge of previous projects into the database as much as possible. The form of knowledge could be either implicit or explicit. The last major requirement is to maximize the use of EVMS data not only for project control of on-going projects but also as the basis for scenario-based planning for the future projects.

C. EVMS Structure

An EVMS structure with a systematic numbering method was developed to meet these EVMS requirements. The entire EVMS structure for this case-study consists of about 18,000 activities, those are grouped into 1,400 EVMS packages (control accounts, CAs) [1].

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FIGURE I
 DATA STRUCTURE OF EVMS COMPONENTS

Example for AB FR&P Wall to BOS E.120

EVMS CA No.		EVMS CA Description						
CON20AUBA1		2-AUB-Major Building and Related Structures						
ACT No.		ACT Description						
23230C40		AB FR&P WALL TO BOS E.120 - LVL.3 AREA 1&2						
Scope of Work								
Work Item	Remarks	Required EWP Deliverables	Lead Time					
Formwork		99240C1183 FI-AB EL.120 CONC STRUC DWGS	60 days					
Formwork (Special)		99240C1183 FI-AB EL.120 EQUIPMENT FON DWGS	55 days					
Reinforcing Bar		99240C1183W FI-AB EL.120 WALL CONC STRUC DWGS	55 days					
Reinforcing Bar (Special)		99240C1183W FI-AB EL.120 EQUIPMENT FON REINFTL	40 days					
Concrete Pouring		99240C1253 FI-AB EL.120 MISC METAL DWGS	40 days					
Curing		99240C1253 FI-AB EL.120 L/B PIPE SUPPORT DWGS (A)	30 days					
Form Removal		X93110C4603 Special Instruction for RWGT Concrete	30 days					
Standard Productivity								
Desc	Unit	Value	Code	Desc	Unit	Qty		
Progress Measurement (진행 측정)	CY	5.600	X00350-00	콘크리트 하역	CY	5,600		
Standard Quantity	Day	140.0	X00352-00	Embedded Conduit	LF	2,000		
Standard Daily Output	M3	40.0	X00350-00	철근입	M2	10,000		
Man-days per Daily Output	M/D	3.5	X00350-00	철근	Ton	500		
Total Mandays	M/D	700	X00350-00	철근카	대입	50		
Required Crew	C201		X00350-00	크레인	대입	60		
C203			X00350-00					
Activity Relationships								
Relation	AWP ID	Type	Lead Time					
Preceding	99240C1183	FS	60 days					
Succeeding	23230C40	FF	10 days					
Actual Productivity								
Desc	Unit	Value	Item No.	Desc	Unit	Qty		
Reporting Date		2015-03-31	X00350-00	콘크리트 하역	CY	1,450		
Progress Measurement (진행 측정)	CY	5.600	X00350-00	Embedded Conduit	LF	1,300		
Total Quantity (Planned)	M3	5,600.0	X00351-00	철근입	M2	2,000		
Total Duration (Planned)	Day	140.0	X00352-00	철근	Ton	120		
Duration to Date	Day	34.0	X00353-00	철근카	대입	14		
Progress	%	25.9	X00354-00	크레인	대입	10		
Planned Value (PV)	CY	1,450.0						
Earned Value (EV)		1,450.0						
SPI (EV/PV)		0.967						
Actual Work Items and Resources (Sub-Activity)								
Sub-Activity No.	Sub-Act Desc	Mandays	E09010-00	X00350-00	X00351-00	X00352-00	X00353-00	X00354-00
23230C40.001	Wall 001	10	-	50	100	10	1	1
23230C40.002	Wall 002	20	-	120	200	12	1	2
23230C40.003	Wall 003	15	-	140	200	11	1	1
23230C40.004	Wall 004	10	-	160	310	20	1	1
23230C40.005	Wall 005	5	-	100	300	5	1	1
23230C40.006	Wall 006	5	-	60	200	3	1	-
23230C40.007	Wall 007	5	-	70	300	5	1	-
23230C40.008	Wall 008	8	-	40	200	4	1	-
23230C40.009	Wall 009	40	-	260	300	10	1	1
23230C40.010	Wall 010	20	-	165	300	17	1	1
23230C40.011	Wall 011	10	-	40	150	2	1	-
23230C40.012	Wall 012	20	-	50	200	4	1	1
23230C40.013	Wall 013	10	-	10	30	3	1	-
23230C40.014	Wall 014	10	-	185	20	14	1	1
23230C40.015	Conduit	22	1,300	-	-	-	-	-

III. DATA STRUCTURE AND COLLECTION STRATEGY

The 1,400 EVMS packages (CAs) with CPM activities were carefully organized to accommodate previously defined EVMS requirements, especially focusing on the data sharing with other management systems including scheduling, cost engineering, and scenario-based planning. Figure I illustrates one of the 18,000 activities for the purpose of discussing the practical issues for EVMS. Characteristics of the proposed data structure are briefly discussed.

A. Direct Integration with GC's Minimized Data Entry

The example shown in Figure I is a construction activity for a concrete work package (5,600 cubic yard of concrete pouring with reinforcing bars and forms). Even though this activity is sizable, data entry requirements are relatively simple. The general contractor (GC) is only required to input the quantities of major work items (form, rebar, pouring) for fifteen areas as shown in the block 'C' in Figure I. After GCs fill out the block 'C', the system automatically generate block 'A' (showing planned data) and block 'B' (analyzing progress and productivity). The input data from GC are also directly connected to the cost management system for progress payment. Due to the fact that many GCs' capability for EVMS has been significantly improved over the decade [3], more complex

data entry by GCs would make it possible to have highly sophisticated system. However, this study minimized the data entry in order to have the most efficient system.

B. Embedding Knowledge into EVMS Database

One of distinct features of proposed system is that the EVMS packages incorporate construction experiences from the historical database. Block 'A' in Figure I shows the 'scope', 'required documents', and 'standard productivity'. By combining block 'A' and block 'C', the system can analyze current status of this activity in terms of progress, productivity, variances, and indices.

C. Linking and Supporting Relevant Functions

The primary function of EVMS is to analyze the cost and time. In addition to this basic function, this study put an emphasis on accumulating historical data into the EVMS system. The accumulated historical database can automatically update critical information for future projects. In this sense, EVMS data structure and Block 'A' were designed. Thus, the proposed EVMS system directly provides historical experiences to the automated front-end planning systems [4][5].

III. CONCLUDING REMARKS

This paper addressed the issues of practical EVMS implementation in terms of effective data collection strategy. An organization-wide perspective for EVMS throughout the project life cycle was discussed first. A case-company with examples of its construction activities were introduced in order to explore the practical issues.

Three major requirements were discussed including 1) minimized and directly linked data entry from the contractors based on optimized objectives, 2) embedding experiences into the EVMS in a structured manner, 3) maximizing the use of EVMS database for relevant functions (e.g. preliminary estimating and scheduling). It is stressed that automated and systemized applications to attain EVMS objectives can be more viable by identifying practically feasible solutions from the organizational perspectives.

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