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A model for effective implementation of Earned Value Management methodology

EunHong Kim[a,*], William G. Wells Jr.[b], Michael R. Duffey[c]

[a]Department of Business Administration, Kyongju University, San 42-1 Hyohyun-Dong, Gyongju City, Kyong Buk, Republic of Korea
[b]Office of Chancellor, McHenry Library, University of California (Santa Cruz), Santa Cruz, CA 95064, USA
[c]Department of Engineering Management, School of Engineering and Applied Science, The George Washington University, 707 22nd Street, NW, Washington DC 20057, USA

Abstract

For better implementation of Earned Value Management (EVM) methodology in different types of organizations and projects (e.g. public and private; large and small projects), a model was developed based on a research effort over a 2-year period. The findings include: (1) EVM is gaining higher acceptance due to more favorable views related to both diminishing EVM problems and improving utilities; and (2) a broader approach considering four-factor groups (i.e. EVM users, EVM methodology, project environment, implementation process) together can significantly improve the acceptance and performance of EVM in different types of organizations and projects.

Keywords: Earned Value Management; Implementation

1. Introduction

Earned Value Management (EVM) methodology is commonly defined as a management technique that relates resource planning and usage to schedules and to technical performance requirement [1]. More specifically, EVM can be said to bring cost and schedule variance analysis together to provide managers with a more accurate status of a project. Historically, beginning in the 1960s, the methodology in a US Department of Defense sponsored format known as C/SCSC (Cost Schedule Control System Criteria) was applied extensively by a number of agencies of the US Federal Government, particularly for large-scale projects. However, it seems not to have been widely adopted by the private sector during the ensuing decades [2], although this situation is in the midst of rapid change. Increasing global competition and rapid technological developments are pushing many firms to give more attention to improving the control of both their in-house projects and those being done for clients or customers.

The main purpose of this paper is to report on a research effort aimed at developing an EVM implementation model (framework) to assist in applying EVM more efficiently to projects in various industries and government agencies. Another focus is to determine what differences, if any, exist between applying EVM in different types of projects and organizations in the United States.

2. Conceptual framework

2.1. Brief literature review

The EVM literature is largely anecdotal. The very few empirical studies on EVM implementation were found in the literature review. The National Security Industrial Association (NSIA) [3] estimated that about 32.8 million pages of papers were required annually for industry to achieve C/SCSC compliance. A subsequent study by Arthur D. Little [4] also noted serious problems with implementation such as too costly, too complex, and too much paper work, but identified EVM users' general agreement with C/SCSC principles. Also, a DOD/NSIA study [5] found that the majority of the cost driver procedures were not required by C/SCSC.

A recent study by the GAO (Government Accounting Office) [6] noted that significant changes underway in DOD's EVM implementation could have a potential

* Corresponding author. Tel.: +82-54-770-5340.
E-mail addresses: ehkim@kyongju.ac.kr (E. Kim), wwells1923@aol.com (W.G. Wells Jr), duffey@seas.gwu.edu (M.R. Duffey).

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positive impact on streamlining EVM processes. Some of these changes included reducing reporting requirements by replacing the C/SCSC with commercial industry criteria and using information technologies to enhance timely data transfer between government agencies and contractors.

While these empirical studies mainly identified EVM problems such as high-cost and suggested streamlining EVM processes, other literature—mainly practitioners' essays—have discussed diverse factors on why EVM was not widely accepted. Some of these factors include project managers' lack of understanding of EVM [7], government-led centralized EVM implementation and the resulting lack of user participation [8], political conflict between project managers and project consulting groups (i.e. groups that initiate the adoption of EVM) [9], distrust between government and contractors, and pressures to report only good news [2].

As pointed out in the EVM literature cited earlier, there are quite diverse factors that can impact EVM processes and successful implementation. Thus, it can be argued that, as a multidimensional issue in practice, achieving successful EVM implementation requires deeper and more systematic research and analysis. However, the EVM literature review did not reveal any comprehensive research studies on an integration or synthesis of the many EVM factors that have been identified. Even in implementation studies in other fields (e.g. total quality management, information technology, and production manufacturing technology), no consensus has been achieved even on what leads to implementation success and how to measure it [10].

2.2. An approach to a conceptual model

Given this uncertain state of affairs, an effort to develop a conceptual model (or framework) based on a pragmatic synthesis of the various factors identified in the literature became a focus for this research study. First, as groundwork for the synthesis, the model postulates multiple implementation outcomes (or dependent variables) as follows: acceptance, use, cost, schedule, and technical performance, and overall satisfaction with EVM use. These multiple outcomes imply that EVM will be successful to the extent that (1) it is accepted; and (2) used by project managers and team members; (3) it helps projects to be completed within time and cost constraints and with satisfactory performance and quality; and (4) it brings overall satisfaction to users of the methodology. In addition, the four outcome variables are postulated to be part of a causal chain that includes feedback loops.

Key independent variables (about 40 factors) were identified from the existing literature and then divided into four groups: EVM users, EVM methodology, project environment, and implementation process. The specific factors identified for inclusion in the model are shown in Table 1—for more detailed information on the list, see Kim [11]. The literature-derived factor list and model were subsequently examined using the findings obtained during this research.

3. Research methodology

A mail survey and six on-site case studies provide an empirical basis for the research. For the mail survey, a questionnaire instrument was sent to a total of 2500 individuals who were randomly selected from the approximately 30,000 membership list (as of 1998) of the Project Management Institute (PMI) and the former Performance Management Association (PMA). Two-hundred and seventy-two responses were received, leading to a return rate of about 11%.

The survey instrument consisted of questions about background information, EVM characteristics, implementation outcomes, project manager and environment, and implementation problems. Each respondent was requested to answer the questions based on a project on which he/she has applied or is applying EVM. Contract projects from the public sector (regardless of their performers) and in-house public sector projects were considered public projects. Private projects include contract projects from the private sector and in-house private sector projects. The main statistical methods employed in the analysis were multiple regression and correlation as well as frequency counts. For the multiple regression, stepwise regression was performed and the statistical significance of predictors was checked at $\alpha = 0.1$.

Case studies were conducted at six organizations. In choosing the case study candidates, 10 experts were asked to identify several possible organizations and any special contact points. Also, an on-site interview protocol was pre-tested with the ten experts either in person or by telephone. It should be noted that the survey instrument might have collected biased data due to personal biases or lack of knowledge of the respondents. Also, the study's external validity beyond the studied EVM systems cannot be confirmed. However, it is believed that the combined sets of data from the mail survey results and the on-site case studies have provided a reasonably reliable, current, and comprehensive view of EVM implementation in modern organizations.

4. The current status of EVM

First, however, to provide a basis for this examination of the EVM implementation model, research findings on the current status of EVM are now discussed. EVM is now highly accepted among many project managers. As shown in Table 2, the mail survey analysis indicates that

Table 1
Literature-Derived Factor List

Factor group		Detailed variables
EVM user		
•Experience/Training	1. Experience with EVM (years) 2. C/SCSC (or EVM) training at DSMC	3. Industry seminar/workshop 4. On the job training
•Power base of project managers	5. Technical expertise	6. Administrative expertise
•Responsibility change	7. Changes in work contents with the use of EVM,	8. Power shift
EVM Methodology		
•Use of methodology	9. Integrated Product Team, 10. PERT 11. CPM 12. Gantt Chart	13. Software programs 14. EVM measurement methods 15. Threshold 16. Report format
•Frequency in the use of EVM	17. Frequency of planning 18. Frequency of status review	19. Frequency of status report
•Levels of detail in the use of EVM	20. Levels of detail in planning 21. Levels of detail in status review	22. Levels of detail in status review
Implementation process		
•Unfreezing	23. Developing need for change, 24. Developing safety,	25. Participation, 26. Developing goal
•Moving	27. Management support, 28. Provision of resource, 29. Establishing transition management,	30. Communication, 31. Rational planning
•Re-freezing	32. Evaluation of the change 33. Rewards	34. Integration of change
Project environment		
•Types of project	35. Size of project, 36. Type of project (public and private),	37. Project risk (cost, schedule, and technical performance)
•Organizational structure	38. Functional, matrix, and project organization	
•Political and social environment	39. Risk-free environment,	40. Colleague-based/hierarchical work environment

Table 2
Acceptance of Earned Value Management (EVM)

	Do not accept	Mildly accept	Accept	Strongly accept	Total
Public	8 (7%)	10 (9%)	36 (32%)	60 (52%)	114 (75%)
Private	5 (13%)	5 (13%)	12 (31%)	17 (45%)	39 (25%)
Overall	13 (8%)	15 (10%)	48 (31%)	77 (51%)	153 (100%)

82% of project managers who have used and are using EVM accept or strongly accept the methodology. In five of the six case studies senior managers and project managers strongly accepted EVM. The mail survey also shows that this high acceptance has become increasingly common in both the public and private sectors, implying that EVM can be applied successfully in both sectors.

This high acceptance appears to be related to significant changes in the perception of EVM problems. As shown in Table 3, the mean ratings of the EVM problems range between 3.4 and 1.6, indicating that project

Table 3
Earned Value Management (EVM) problems

Problems	Mean rating (public/private)[a]	Problem source
Optimistic view of users in planning	3.4/3.2	User
Inaccurate assessment of EVM	3.3/3.2	User
Lack of understanding of EVM	3.2/3.3	User
Culture such as distrust	3.2/3.1	Culture
Poor image of EVM	3.0/2.9	Culture
Takes long time to train	2.9/3.0	System
Too much paper	3.0/2.8	Implementation
Lots of jargon	2.8/2.8	Implementation
Inaccuracy in high-tech projects	2.8/2.7	System
Too much rules	2.8/2.8	Implementation
Lack of user participation in designing EVM	2.7/2.6	Implementation
Projection based on historical data	2.6/2.6	System
Lots of costs	2.6/2.3	Implementation
Inconsistency between WBS and Org.	2.6/2.6	Implementation
Use of deterministic scheduling tech.	2.6/2.3	System
Need additional scheduling systems	2.6/2.3	System
Detailed WBS	2.2/2.1	Implementation
EVM weakens management power	1.7/1.5	Culture

[a] Ratings: 1: Not a problem, 2: Insignificant problem, 3: A minor problem, 4: Major problem, 5: Extreme problem

managers who use or have used EVM perceive most problems that have been reported in the existing literature as "minor" to "insignificant". Especially, frequently reported problems such as "cost too high" and "too much paperwork" are no longer perceived as significant. Rather, people problems (e.g. an overly optimistic view by EVM users in planning, inaccurate assessment of work performed, and lack of understanding of EVM) and organizational-culture-related problems (e.g., a culture of distrust and some pressures to report only good news) are perceived as being among those problems that persist.

Among the reasons for the changes to more favorable perceptions of EVM problems are many efforts to improve EVM processes during the past three decades. Also, it can be suggested that EVM itself and the technical and logistical implementation process-related problems noted earlier were dominant in the early years of EVM application, while some user-related and organizational culture-related problems have become more important in recent times. Comparison of EVM problems between the public and private sectors indicates no significant differences in terms of rating and ranking, implying that project managers in both sectors have similar perceptions toward EVM problems.

EVM users generally agree on high values for its utilities in improving project performance. As shown in Table 4, the mean rating on the utilities of EVM ranges between 5.1 and 6.0, meaning that EVM users "mildly agree" and "agree" on the utilities listed in the table. The most important utilities perceived are the capability of predicting time and cost to complete, and of identifying cost and schedule impacts of known problems. This indicates that EVM is perceived as being a good forecasting or an early warning tool that enables project managers to plan and control projects proactively. Table 4 also shows that EVM users in the public and private sectors give almost the same ratings on the utilities, implying that EVM can bring similar positive impacts to projects in both sectors.

In short, EVM is gaining high acceptance as both senior managers and project managers perceive that EVM problems are diminishing and utilities are improving. This high acceptance is found in both the public and private sectors, suggesting that EVM is no longer a tool only for large projects in the public sector. In the following section is a brief description of a model developed in this research to support wider implementation of EVM in various types of projects and organizations.

5. An EVM implementation model

Fig. 1 shows the EVM implementation model developed from the findings of this research. The subsections below discuss critical factors that emerged from this research study as being particularly important to each outcome of EVM implementation.

5.1. Factors for the better acceptance of EVM

From the survey analysis, as shown in Table 5, four factors were found as being important. These factors include providing sufficient resources, administrative expertise of project managers, experience with EVM use, and increases in work efforts devoted to EVM. The four factors model explains 35% (i.e. $R^2 = 0.35$) of the

Table 4
Utilities of Earned Value Management (EVM)[a]

Utilities of EVM	Public	Private
Estimate cost and time to complete	6.0	5.7
Identify cost and schedule impacts of known problems	5.9	5.5
Accurately portrays the cost status of a project	5.7	5.6
Can trace problems to their sources	5.3	5.1
Can portray the schedule status of a project	5.3	5.4
Can provide timely information on projects	5.3	5.4
Identify problem areas not previously recognized	5.1	5.4

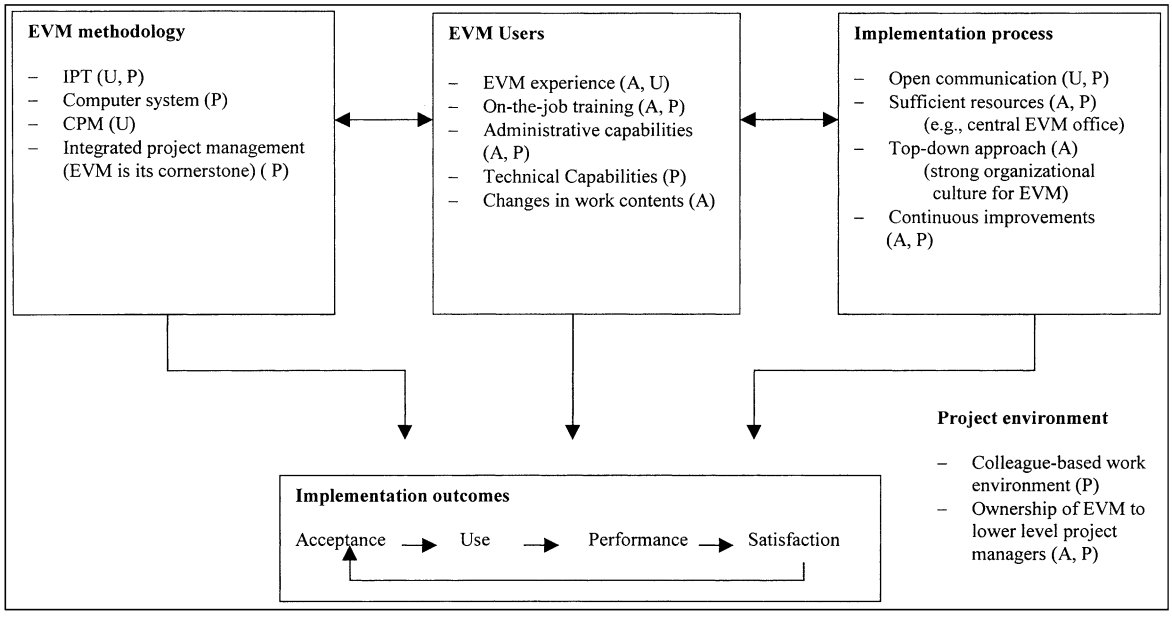
[a] Ratings: 1–3: disagree, 4: no opinion, 5: Mildly agree, 6: Agree, 7: Strongly agree.

variance in the acceptance of EVM and is significant at the level of $\alpha = 0.05$. Case studies also were conducted to help improve the validity of the findings. In addition, since the independent variables in the model have low *P*-values as shown in Table 5, multi-collinearity is not considered to be a significant problem in this study [12].

The case studies found similar critical factors: top management support (related to resource support as well), buy-in of EVM by project managers, flexibility allowed to lower-level project managers, and experience/training for EVM users. These two sets of findings can be integrated and interpreted as follows:

First, and probably most important, better acceptance of EVM depends highly on a "top-down approach" from senior management. More specifically, once top management becomes a true believer of EVM based on proven track records of EVM utilities in achieving project success, it embarks upon improving EVM processes patiently but firmly. At the same time, management builds a strong supportive culture in which EVM is perceived as a good way to do work in order to manage organizations' programs and projects effectively. In such a culture, EVM is not just forced on project managers. Instead, sufficient resources such as project administrative support, training, and automated computer systems are provided to facilitate better use and acceptance.

A second critical factor for the acceptance of EVM is "buy-in" by project and functional managers and their subsequent leadership to persuade project team members to use EVM. In this process, effective training is essential both for project managers and project team members to understand how to use EVM. Administrative and technical expertise of project managers were chosen as a factor for examination in



(A): Factors related to EVM acceptance
(U): Factors related to EVM use
(P): Factors related to EVM performance
Note: All factors are positively related to the implementation outcome variables

Fig. 1. The Earned Value Management (EVM) implementation model based on the research findings.

Table 5
Factors affecting the Earned Value Management (EVM) implementation outcomes coefficient (Prob. > F)

Major factors	Acceptance	Frequency	Level of detail	Cost performance	Schedule performance	Technical performance	Overall satisfaction
EVM user							
•EVM experience	0.05 (0.01)		0.08 (0.01)				
•On the job training					0.001 (0.07)		
•Technical expertise						0.16 (0.06)	0.19 (0.02)
•Administrative expertise	0.15 (0.09)			0.29 (0.01)	0.35 (0.01)		
•Changes in work contents	0.22 (0.09)						
EVM methodology							
•Integrated product team		0.16 (0.03)					
•Critical Path Method		0.21 (0.01)	0.28 (0.01)				
•Computer program							0.09 (0.06)
Implementation process							
•Sufficient resources	0.18 (0.01)			0.22 (0.01)	0.23 (0.01)	0.25 (0.01)	
•Communication		0.25 (0.02)	0.36 (0.01)				0.24 (0.01)
Project environment							
•Colleague-base work environment						0.19 (0.01)	
R^2 *of the model*							
(Prob. > F)	0.35 (<0.05)	0.26 (<0.05)	0.36 (<0.05)	0.25 (<0.05)	0.34 (<0.05)	0.25 (<0.05)	0.27 (<0.05)

this study because the analysis of the literature review suggested there is a tendency for some people with limited vision or capabilities to be afraid of accepting a new system or a methodology because it may change their power base. Thus, the findings from the survey and case study results can be interpreted as suggesting that especially administratively-capable project managers are more willing to understand, accept and buy-in to EVM, and to allow flexibility for lower level workers, thus improving the overall acceptance of EVM.

The third major factor is allowing flexibility to functional and project managers and workers or technical groups in selecting their own form of EVM use within a framework of general guidelines. This flexibility was found to enhance the ownership and buy-in of EVM by the programs, projects, and support units, thus improving the perception of EVM as a good business practice. Overall, as found in the case studies and the interviews with national experts, allowing flexibility has come to be seen widely as a "best practice" in industry.

The fourth factor is providing on-going training for EVM users. Over time, as experience builds in an organization, in combination with the requisite training, acceptance of EVM was found to be greatly enhanced.

In sum, as experience builds over time even if the level of work effort to use EVM increases, if there is top-management support, if the project managers have administrative expertise, and if requisite training is provided, then EVM acceptance is greatly enhanced.

5.2. Factors for the better use of EVM

From the survey analysis the following factors were found as increasing the frequency and the levels of detail in EVM use: (1) longer experience in using EVM, (2) use of integrated product teams (IPTs), (3) use of the Critical Path Method network techniques as a complementary scheduling tool, and (4) organizations having high levels of cross-organizational boundary communications (see Table 5).

Results from the case studies generally support the earlier findings from the mail survey. One additional finding from the case studies suggests that there is no fixed rule for deciding the level of detail and frequency in EVM use. Instead, flexibility is allowed to project managers to determine their own form of EVM use as long as they provide standard forms and reports under guidelines established by management.

5.3. Factors for the better performance of EVM

For better cost, schedule, technical performance, and overall satisfaction with EVM, the statistical analysis of the survey data found the following critical factors: (1) use of on-the-job training, (2) project managers' technical and administrative expertise, (3) use of automated computer programs, (4) provision of sufficient resources in the processes of EVM, (5) high levels of communications within an organization, and (6) a colleague-based work environment (see Table 5).

The case study results also identified several critical success factors generally similar to those in the survey

analysis. Among the factors that consistently received a special citation are (1) open communications among project team players and with customers, (2) strong support from top management, especially in providing sufficient resources including a central EVM support office, various computer programs, and other support services, and (3) the use of IPTs (Integrated Product Teams). Other critical factors include: (4) training on EVM use, (5) administrative and technical capabilities of project managers, (6) flexibility of EVM being allowed to lower level project managers, (7) the use of electronic data interchange, (8) a colleague-based project management environment (i.e. as opposed to hierarchical or bureaucratic culture), and (9) use of EVM as part of a so-called "Integrated Project Management System". Various dynamic interactions that seem to occur among these factors are as follows:

First, IPTs provide major communication channels, facilitating communication and collaboration among project players including customers. Especially, noteworthy is that close communication with customers provides a better opportunity to understand them, eventually improving the project performance of EVM and the competitive capabilities of an organization in the market.
Second, the use of IPTs in collaboration with the use of an EVM methodology also encourages a colleague-based culture that is of vital help in enhancing project performance. Especially, the use of IPTs results in the use of EVM as part of a so-called "integrated project management system;" a practice that has spread widely as an industry "best practice."
Third, a central EVM support office is an important way of providing enough resources for EVM application. Its major responsibilities entail providing a "seamless web of support" including training and consulting services for program managers.
Fourth, seamless electronic data interchange (EDI) allows project managers to achieve early recognition of problems and prompt and real-time action to solve them, eventually improving project performance through the better performance of EVM.
Fifth, strong support from top management is essential for providing sufficient resources including the central EVM support office and automated computer systems.
Finally, since EVM might be mistakenly perceived as a tool for scrutinizing worker performance, selecting administratively and technically capable project managers, training them on EVM, and allowing them flexibility to design the details of their own EVM system is considered one of the "best practices" for improving both EVM and project performance.

Overall, both the mail survey results and case study results generally agree on a cluster of major critical success factors, validating using a broad, four-factor grouping taken together for achieving better or more successful outcomes for EVM implementation in facilitating project success.

6. Modifications of the research-derived EVM implementation model

Neither survey nor case study results led to significant modifications being required for better application of the EVM implementation model in different types of organizations or in projects of different sizes and characteristics. Only a few different behaviors by project managers when they use EVM in projects of different sizes and types are as follows:

6.1. For projects of different sizes

- When they use EVM in smaller projects, project managers use simpler earned value measurement methods such as the fixed formula (i.e. 50/50 rule) and percent complete method.
- Smaller projects use EVM at less detailed levels than in larger projects.
- Successful project managers of larger projects tend to put more focus on enhancing communications among project team players and among different parts of the organization than do the ones of smaller projects.
- Larger projects tend to proportionally need more resources for EVM application than smaller projects.

6.2. For projects of different types

- Project managers in the private sector tend to keep increases in work effort arising from EVM application to a minimum.
- As a comparable pattern, projects in the public sector tend to require more EVM reporting.

7. Use of computer systems and software

The research indicated that the use of computer systems and software was both widespread and seen as a key element in successful EVM implementation. The survey results showed that a majority of EVM users (about 89%) either fully or partially have implemented an automated computer system as part of their EVM processes. While some organizations use internally developed software packages, most employ commercial packages; however, some users employ internally developed programs and commercial software.

While mainframe capabilities are still in use for some purposes (such as accounting and financial data), there has been a mass migration of computer system use from mainframes to a PC-environment—paralleling what has taken place generally within organizations during the past decade and especially within project management. Such use clearly has become a widespread best practice in both the public and private sectors.

The mail survey and the case studies showed that no single standard software program for EVM analysis has emerged. No program has captured more than 35% of users. Instead, combinations of programs are frequently in use, with Microsoft Project, MPM (Micro-Frame Program Manager), and wInsight being the most frequently cited of these.

8. Summary and conclusion

This research found that the acceptance and utility of EVM is being improved significantly. In addition, EVM users no longer consider previously reported EVM problems, especially problems such as costs too high and too much paperwork, as significant. Another finding is that a broader approach, as reflected in the model, to considering together the four-factor groups (i.e. EVM users, EVM methodology, implementation process, and project environment) can significantly improve the acceptance, use, and performance of EVM in facilitating more successful project outcomes. Finally, the research results suggest that the model can be applied without any major modification when implementing EVM in projects of different sizes or types.

A final and major conclusion arising from this research is that successful implementation of EVM, in terms of leading to better outcomes for projects, is not simply a matter of introducing the methodology into an organization. Instead, it must be associated with overall organizational approaches such as a colleague-based organizational culture, continuing top-level management attention; organizational integrating mechanisms (e.g. Integrated Product Team); effective training; and facilitating support systems (e.g. accounting, a project management office).

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