Models for Product Quality

The Capability Maturity Model Integrated for Development

CMMI-DEV, Version 1.2

Integrated Project Management (IPM): The CMMI and collaborative product development

Course Guide



Version 20 (Slides Version 21)

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About SSQC

William J. Deibler II and Robert Bamford founded SSQC in 1990 to support organizations in the definition and implementation of Software, Hardware, and Systems Engineering Practices, Software Quality Assurance and Testing, Business Process Reengineering, ISO 9000 Registration, and CMM/CMMI implementation. Their clients have successfully achieved ISO registration and advanced CMM and CMMI maturity levels.

Bob and Bill have developed and published numerous training courses, assessment and auditing tools, research papers, and articles on interpreting and applying the ISO 9000 standards and guidelines and the SEI Capability Maturity Model for Software. They were the principal authors and editors of **A Guide to Software Quality System Registration under ISO 9001**, and have served as active United States TAG members in the ISO/IEC JTC1 SC7 - Software Engineering Standards subcommittee, which is responsible for the development and maintenance of ISO 12207 and ISO 15504 (SPICE). Their latest book, **ISO 9001:2000 for Software and Systems Providers, and Engineering Approach,** was published in 2003 by CRC Press. The book joins their extensive portfolio of articles, which have appeared in McGraw Hill's **Quality Systems Update**, IEEE **COMPUTER**, McGraw Hill's **ISO 9000 Handbook**, **CrossTALK**, and **Software Marketing Journal**.

Since 1990, they have presented research papers and tutorials at over 50 national and international conferences, including those sponsored by the American Society for Quality (ASQ), the ESPI Foundation (ESEPG), Pacific Northwest Software Quality (PNSQC), the Software Publishers Association (SPA), Software Technology Support Center (STSC), the Software Engineering Institute (SEI) and Software Research Inc. Their courses have been offered through universities and professional associations, including the ASQ, the CSU Long Beach Software Engineering Forum for Training, Semiconductor Equipment and Materials International (SEMI), the Software Engineering Institute (SEI), UC Berkeley, and UC Santa Cruz.

William J. Deibler II has an MSc. in Computer Science and over 25 years experience in the computer industry, primarily in the areas of software and systems development, software testing, and software quality assurance. Bill has extensive experience in managing and implementing CMM-, CMMI-, and ISO 9001-based process improvement in software, hardware, and systems engineering environments. Bill is an SEI-authorized SCAMPI Lead Appraiser for CMMI.

Robert Bamford has an MAT in Mathematics. In a professional career spanning more than 30 years, he has taught secondary and university Mathematics, and has worked in and managed training development, technical publications, professional services, and third-party software development. His experience also includes implementing a Crosby-based Total Quality Management System, implementing CMM-, CMMI-, and ISO 9000-based systems, and developing and facilitating workshops and courses.





Project management: prioritized issues

- Develop an individual list of the challenges your organization needs to address in <u>managing projects</u> or programs
 - On-going problems
 - Impending needs
- Prioritize individual list
- Develop a single prioritized list of five items as a team
- Pick a representative to present team's list in 3 minutes
- Ensure your concerns are addressed to greatest possible extent

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About the rest of the presentation Brief orientation Structure of CMMI SE/SW v1.2 - Process Areas, Goals, Practices, and Process Categories • A warning: Chasing levels Integrated Project Management (IPM) - The Specific Practices • Metrics, models, Key Performance Indicators IPM and the Project Management Category Process Areas - Managing critical dependencies and risk - Project Planning (PP) - Process Monitoring and Control (PMC) - Team exercise: Case study Integrated Product and Process Development (IPPD) • IPM and the Support Process Category Process Areas IPM and the Generic Practices Tools, tips, checklists and implementation opportunities © SSQC All rights reserved Version 21 INTEGRATED PROJECT MANAGEMENT 4 <u>SS</u>

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The model

CMMI for Development, Version 1.2, CMU/SEI-2006-TR-008, Carnegie Mellon University, August 2006, available at: www.sei.cmu.edu/pub/documents/06.reports/pdf/06tr008.pdf

Capability Maturity Model Integration (CMMI), Version 1.1, CMMI for Systems Engineering, Integrated Product and Process Development, and Supplier Sourcing (CMMI-SE/SW/IPPD/SS, V1.1), <u>Continuous</u> Representation, CMU/SEI-2002-TR-011, Carnegie Mellon University, March 2002, available at: www.sei.cmu.edu/publications/documents/02.reports/02tr011.html

Capability Maturity Model Integration (CMMI), Version 1.1, CMMI for Systems Engineering, Integrated Product and Process Development, and Supplier Sourcing (CMMI-SE/SW/IPPD/SS, V1.1), <u>Staged</u> Representation, CMU/SEI-2002-TR-012, Carnegie Mellon University, March 2002, available at:

www.sei.cmu.edu/publications/documents/02.reports/02tr012.html

The CMMI Process Areas: Collections of Related Best Practices



A few words about Representations CMMI supports two approaches through representations Organizations diligently study both and pick one (see the Introduction) CONTINUOUS 4 **STAGED** REPRESENTATION REPRESENTATION **PRIORITY: Improve organizational PRIORITY:** Customer requirement for capability in specific process areas (like proving a standardized organizational CM, Requirements, and Verification) maturity level MEASURE OF SUCCESS: **MEASURE OF SUCCESS:** Implementation of individual process Implementation of pre-defined sets of areas process areas Core content is the same and there is a VI.1 = different way to convert: equivalent staging volumes v1.2 = rules of Assessed capability can be interpretation converted to an equivalent maturity 8

A few words about

- Staged supports organizational <u>maturity</u>
 Level 2 through 5
- Continuous supports process <u>capability</u>
 Levels 0 through 5
- Your organization diligently studied the current state of its practices and established a realistic target for capability or maturity level
- Each increase in level adds requirements

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Required, expected, informative

Required components describe

what an organization <u>must</u> achieve to satisfy a process area. This achievement must be visibly implemented in an organization's processes. The required components in CMMI are the <u>specific and generic goals</u>. Goal satisfaction is used in appraisals as the basis for deciding whether a process area has been achieved and satisfied.

Expected components describe

what an organization **may** implement to achieve a required component. Expected components guide those who implement improvements or perform appraisals. Expected components include the **specific and generic practices**. Before goals can be considered satisfied, either the practices as described, or **acceptable alternatives to them**, are present in the planned and implemented processes of the organization.

Informative components provide

details that help organizations get started in thinking about how to approach the required and expected components. Subpractices, typical work products, amplifications, generic practice elaborations, goal and practice titles, goal and practice notes, and references are examples of informative model components. CMMI V1.1 and V1.2, Section 2



| CATEGORY | Туре | | Process Area |
|--------------------------------|---------------|------|---|
| Process Management (PCM) | Basic | OPF | Organizational Process Focus |
| | | OPD | Organizational Process Definition |
| | | OT | Organizational Training |
| | Advanced | OPP | Organizational Process Performance |
| | | OID | Organizational Innovation and Deploymen |
| Project Management (PJM) | Basic | PP | Project Planning |
| | | PMC | Project Monitoring and Control |
| | | SAM | Supplier Agreement Management |
| | Advanced | IPM | Integrated Project Management for IPPD |
| | | RSKM | Risk Management |
| | | QPM | Quantitative Project Management |
| Engineering (ENG) | | RM | Requirements Management |
| | | RD | Requirements Development |
| | | TS | Technical Solution |
| | | PI | Product Integration |
| | | VER | Verification |
| | | VAL | Validation |
| Support (SUP) | Basic | MA | Measurement and Analysis |
| | | PPQA | Process and Product Quality Assurance |
| | | CM | Configuration Management |
| | A duran a a d | DAR | Decision Analysis and Resolution |
| | Advanced | CAR | Causal Analysis and Resolution |

Categories and interactions

CMMI V1.2, Section 4, Relationships Among Process Areas

Although we are grouping process areas this way to discuss their interactions, process areas often interact and have an effect on one another regardless of their defined group.

Being aware of the interactions that exist among CMMI process areas and which process areas are Basic and Advanced will help you apply CMMI in a useful and productive way.

See V1.1 Section 5

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Employ established principles

CMMI V1.2, Section 5, Using CMMI Models

Regardless of your type of organization, to apply CMMI best practices, you must use professional judgment when interpreting them for your situation, needs, and business objectives. Although process areas depict the characteristics of an organization committed to process improvement, you must interpret the process areas using an in-depth knowledge of CMMI, your organization, the business environment, and the specific circumstances involved. See V1.1 Section 1

As you begin using a CMMI model to improve your organization's processes, map your real-world processes to CMMI process areas. This mapping enables you to initially judge and later track your organization's level of conformance to the CMMI model you are using and to identify opportunities for improvement. See V1.1 Section 2

CMMI models do not explicitly prescribe nor imply particular processes that are right for any organization or project. Instead, CMMI describes minimal criteria necessary to plan and implement processes selected by the organization for improvement based on business objectives.





The intended scope of CMMI (cont.)

CMMI V1.2, Preface

CMMI® (Capability Maturity Model® Integration) is a process improvement maturity model for the development of products and services. It consists of best practices that address development and maintenance activities that cover the **product lifecycle** from conception through delivery and maintenance.

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Establish and Maintain

CMMI V1.2, *Glossary*, under "establish and maintain" In the CMMI Product Suite, you will encounter goals and practices that include the phrase "establish and maintain." This phrase means more than a combination of its component terms; it includes documentation and usage. For example, "Establish and maintain an organizational policy for planning and performing the organizational process focus process" means that not only must a policy be formulated, but it also must be documented, and it must be used throughout the organization.

CMMI V1.1, Section 3, Establish and maintain

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CMMI V1.2 Glossary and Part 2

A managed process

A performed process that is planned and executed in accordance with policy; employs skilled people having adequate resources to produce controlled outputs; involves relevant stakeholders; is monitored, controlled, and reviewed; and is evaluated for adherence to <u>its process description</u>.

A defined process

A <u>managed</u> process that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines; has a maintained <u>process description</u>; and contributes work products, measures, and other processimprovement information to the organizational process assets.

See CMMI v1.1, Chapter 3

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SEI commentary (and what appraisers look for)

The concept of documented procedure is handled by the generic goal that says that you perform a process according to a managed or defined process. The definition of a "managed process" includes documenting the process and procedures that you use. The term "according to a documented procedure" is not explicitly used in the model.

(CMMI FAQ, Feb. 2002, under "Model Interpretation"; for V1.1, true for V1.2)

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Chasing levels

Maturity levels are measured by the the achievement of the specific and generic goals that apply to each pre-defined set of process areas. [2000-TR-30, paragraph 2, p. 23]

Conformance with a process area means that in the planned and implemented processes there is an associated process (or processes) that addresses either <u>the specific and</u> <u>generic practices</u> of the process area <u>or alternatives</u> that clearly and unequivocally accomplish a result that meets the goal associated with that specific or generic practice. [2000-TR-30, paragraph 2, p. 26]

... trying to skip maturity levels is <u>usually</u> counterproductive. [2000-TR-30, paragraph 2, p. 24]

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Why Integrated Project Management (IPM)?

Shouldn't it wait until Level 3?

- For small organizations, small projects, level 3 PAs can be set as the initial goal
 - Support for cross-functional teams
 - Significant benefits in going beyond monitoring and control (Level 2)
- S/W CMM v1.1 transition, inspiration
- Because sometimes skipping levels is productive

Or, because sometimes not skipping levels is counterproductive

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Importance TO PROCESS IMPROVEMENT Support FOR VISION AND BUSINESS OBJECTIVES

The purpose of Integrated Project Management (IPM) is to establish and manage the project and the involvement of the relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes. [CMMI,V1.1 and V1.2, IPM, Purpose]

IPM is a cornerstone of process improvement. It enhances every Engineering, Support, and Project Management PA.

It <u>enables</u> continuous, systematic alignment of resources, activities, and business objectives converging on customer value.





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A critical specific practice SPECIFIC PRACTICE IMS, IMP, or ... New Product 1.5 Manage the project using the integrated plans Introduction Support WHY: product delivery is beyond any one group's capabilities, responsibilities Manufacturing SIGNIFICANT INDICATOR(S): Engineering SP1.4, SubPractice 5, peer reviews Training SP1.5, SubPractice 2, thresholds Technology Transfer AFFECTED STAKEHOLDERS: Project team (Mktg ... Mfg) Manufacturing Master **RESISTANCE:** Plan Accountability - being measured, reporting progress TIME TO SPECIAL APPRAISAL CONSIDERATIONS AND MARKET **CHALLENGES:** Prepare, prepare, and prepare - Ensure there is adequate preparation time to review the volume of documentation RISK PARALLEL **RECOMMENDATIONS:** Pilot - pick your project wisely ACTIVITIES © SSQC All rights reserved Version 21 INTEGRATED PROJECT MANAGEMENT SS 34

Specific practice 1.5, Subpractice 2

2 Monitor and control the project's activities and work products using the project's defined process, project plan, and other plans that affect the project.

This task typically includes the following:

- Using the defined entry and exit criteria to authorize the initiation and determine the completion of the tasks
- Monitoring the activities that could significantly affect the actual values of the project's planning parameters
- Tracking the project's planning parameters using measurable thresholds that will trigger investigation and appropriate actions
- Monitoring product and project interface risks
- Managing external and internal commitments based on the plans for the tasks and work products of the project's defined process

See CMMI V 1.1 SP 1.4

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Manipulating the estimates for software Myth 3: Reuse will save us

- To build in reusability: 2x effort
 - Per class library from 20 to 40 days
 - Design, inspection, documentation
- Library maintenance
 - Coordinating obsolescence
- Learning curve (6 to 12 months)
 - Library consultant per 4 projects
 - Maintain, communicate, advise, mentor









| Project Planning (PP) | | | | | | |
|---------------------------|--|--|--|--|--|--|
| SPECIFIC PRACTICES | | | | | | |
| | | | | | | |
| SPECIFIC GOALS | SP 1.1 Establish top-level Work Breakdown Structure (WBS) | | | | | |
| | SP 1.2 Establish and maintain estimates of | | | | | |
| SG 1 Estimates of project | attributes of the work products and tasks | | | | | |
| planning parameters < | SP 1.3 Define project life cycle phases | | | | | |
| are established and | SP 1.4 Estimate effort and cost for work | | | | | |
| | products and tasks | | | | | |
| maintained. | | | | | | |
| SG 2 A project plan is | SP 2.1 Establish and maintain budget and schedule | | | | | |
| | SP 2.2 Identify and analyze risks | | | | | |
| established and | SP 2.3 Plan for data management [documentation, all | | | | | |
| maintained as the | torms] | | | | | |
| basis for managing | SP 2.4 Plan for resources | | | | | |
| the project | SP 2.5 Plan for knowledge and skills | | | | | |
| | SP 2.6 Plan stakenolder involvement | | | | | |
| SG 3 Commitments to the | SP 2.7 Establish and maintain the overall project | | | | | |
| project plan are | pian | | | | | |
| ostablished and | SP 3.1 Review all plans that affect the project | | | | | |
| established and | SP 3.2 Reconcile plan to reflect available and | | | | | |
| maintained. | estimated resources | | | | | |
| ····· | SP 3.3 Obtain commitment from relevant | | | | | |
| V1.1 and V1.2 | stakeholders | | | | | |

Life cycles and life cycles

From Project Planning (PP), Specific Practice 1.3

Define the <u>project lifecycle phases</u> on which to scope the planning effort.

The determination of a project's lifecycle phases provides for planned periods of evaluation and decision making. These are normally defined to support logical decision points at which significant commitments are made concerning resources and technical approach. Such points provide planned events at which project course corrections and determinations of future scope and cost can be made.

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~V1.1 and V1.2

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Life cycles and life cycles (cont.)

More from Project Planning (PP), Specific Practice 1.3

The **project lifecycle** phases need to be defined depending on the scope of requirements, the estimates for project resources, and the nature of the project. Larger projects may contain multiple phases, such as concept exploration, development, production, operations, and disposal. Within these phases, subphases may be needed. A development phase may include subphases such as requirements analysis, design, fabrication, integration, and verification. ... Depending on the strategy for development, there may be intermediate phases for the creation of prototypes, increments of capability, or spiral model cycles.

Understanding the **project lifecycle** is crucial in determining the scope of the planning effort and the timing of the initial planning, as well as the timing and criteria (critical milestones) for replanning.

~V1.1 and V1.2

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Life cycles and life cycles (cont.)

Guidance from IPM Specific Goal 1

The project's defined process must include those processes from the organization's set of standard processes that address all processes necessary to acquire or develop and maintain the product. The product-related lifecycle processes, such as the manufacturing and support processes, are developed concurrently with the product.

From the Glossary, a product lifecycle is

The period of time, consisting of phases, which begins when a product is conceived and ends when the product is no longer available for use. ... A product lifecycle could consist of the following phases: (1) concept/vision, (2) feasibility, (3) See CMMI V1.1, Chapter 3

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Life cycles and life cycles (cont.)

From the Glossary, Integrated Product and Process Development is

A systematic approach to product development that achieves a timely collaboration of relevant stakeholders throughout the product lifecycle to better satisfy customer needs.

Guidance from RD Specific Practice 1.2

Relevant stakeholders representing all phases of the product's lifecycle should include business as well as technical functions. In this way, concepts for all product-related lifecycle processes are considered concurrently with the concepts for the products. Customer requirements result from informed decisions on the business as well as technical effects of their requirements.

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~V1.1 and V1.2

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Integrated Product and Process Development (IPPD)

With IPPD you get:

- Two new specific goals, one each for:
 - Integrated Product Management (IPM)
 - Organizational Process Definition (OPD)
- Amplification in various other Process Areas

Less

- Two fewer Process Areas (OEI and IT)
- Four fewer goals (OEI 2, IT 2, IPM 1, OPD + 1)

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| IPPD: Specific goals for Integrated Project Management (IPM) SPECIFIC PRACTICES | | | | | | |
|--|---|--------|---|--|--|--|
| | | SP 3.1 | Establish and maintain a | | | |
| SG 1 | The project is conducted using a defined process that | t | snared vision for the project. | | | |
| | is tailored from the organization's set of standard processes. | SP 3.2 | Establish and maintain the integrated team structure for the project. | | | |
| SG 2 SPECIFIC | Coordination and collaboration of the project with relevant stakeholders is conducted. | SP 3.3 | Allocate requirements, responsibilities, tasks and interfaces to teams in the | | | |
| GOALS | The project is managed using IPPD principles. | SP 3.4 | integrated team structure. Establish and maintain integrated teams in the structure. | | | |
| Fror <u> </u> <u> </u> com | n CMMI V1.1, <u>PM</u> SG 3 and SG 4 and <u>I</u> SG 1 and SG 2 are bined in V1.2 IPM SG 3 | SP 3.5 | Ensure collaboration among interfacing teams | | | |
| | | | | | | |


Integrated Product and Process Development (IPPD) - Beyond IPM

- New Specific Goal for OPD
- Implementation considerations and recommendations
 - Tools and techniques
 - A road map





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V1.1: Organizational Environment for Integration (OEI)

SPECIFIC GOALS

- SG 1 An infrastructure that maximizes the productivity of people and affects the collaboration necessary for integration is provided.
- SG 2 People are managed to nurture the integrative and collaborative behaviors of an IPPD environment.

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<u>V1.2</u>: Organizational Process Definition (OPD)

SG 2 Organizational rules and guidelines, which govern the operation of integrated teams, are provided. SPECIFIC PRACTICES

- SP 2.1 Establish and maintain empowerment mechanisms to enable timely decision making.
- SP 2.2 Establish organizational rules and guidelines for structuring and forming integrated teams.
- SP 2.3 Establish and maintain organizational guidelines to help team members balance their team and home organization responsibilities.





Suggestions and comments: tools and techniques for integrated teams

- Periodic project reviews
 The Key Deliverables Review (KDR)
- Milestone/Phase reviews
 - Checklists
- Earned Value as an approach
- Planning and replanning
 - Granularity

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| KDR REPORT - 01/14 - PHLM Project | | | | |
|---|-----------------|---------|------------|-------------|
| | | ST. | ART | |
| WBS/DESCRIPTION | ORIGINAL | LAST | CURRENT | ACTUAL |
| Requirements baselined | 01/07 | | 01/21 | 01/13 |
| 2 System design baselined | 01/31 | | 2/6 | |
| 3 Control subsystem | 7/4 | | | |
| 3.1 Design baselined | 3/07 | 3/21 | 3/14 | |
| 3.2 Prototype completed | 5/4 | | | |
| 3.3 Prototype concept test completed | 7/4 | | | |
| 4 Propulsion subsystem | 9/15 | | | |
| 4.1 Design baselined | 2/18 | | 2/25 | |
| 4.2 Prototype completed | 7/21 | | | |
| 4.3 Prototype concept test completed | 9/15 | | | |
| 5 Control/Propulsion Integrated | 12/01 | | | |
| 6 Control/Propulsion Integration Test | 12/31 | | | |
| COMMENTS | | | | |
| 2 Resources not available to take advanta | age of early co | npletio | n of 1 | |
| 3.1 Adjusted for 1 week slip in 1 | | | | |
| Expect to make up time and not slip subse | quent steps by | adding | 1 engineer | to project. |

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| | | | Two stages of training |
|-----|------|-----------------------|--|
| | 2.1 | Establish an | During implementation and roll-out |
| | | organizational policy | Address development and delivery of |
| | 2.2 | Plan the process | initial training in Integrated Project |
| | 2.3 | Provide resources | Management position of CMMI |
| | 2.4 | Assign responsibility | |
| | 2.5 | Train people | implementation plan |
| | 2.6 | Manage | Identify role-based skills needs |
| | 0.7 | configurations | Address development and piloting of |
| GG2 | 2.7 | Identify and Involve | on-going training capability as part of |
| | | stakeholders | implementation plan |
| | 2.8 | Monitor and control | |
| | | the process | Un-going, post-implementation delivery |
| | 2.9 | Objectively evaluate | Address in "operator" skills |
| | | adherence | requirements in <u>Project Planning</u> |
| | 2.10 | Review status with | procedures |
| | | higher level | • Add role-based skills peeds to |
| | | management | brooduroo Itaam related ekillel |
| | 3.1 | Establish a defined | procedures [reall related skills] |
| GG3 | 2.2 | Collect improvement | Identity sources of training |
| | 3.2 | information | Assign responsibility for providing |
| | | Information | (e.g., immediate manager) |
| | | | See Organizational Training |
| | | | 8 8 |

| GG2 | 2.5 2.6 2.7 | Assign responsibility Train people Manage configurations Identify and involve | Identify, control [revise, update], status audit Configuration management of planning work products Examples of the work products of the |
|-----|--------------------|---|---|
| | 2.8 2.9 2.10 | relevant stakeholders Monitor and control the process Objectively evaluate adherence Review status with higher level management | Examples of the work products of the project planning process include: Estimates and assumptions Historical data Models WBS Plans Schedules |
| GG3 | 3.1 3.2 | Establish a defined process Collect improvement information | <u>Team charters</u> <u>IPT processes</u> <u>IPT hierarchy (SEIT, IIPT) – responsibilit</u> and authority |

| | 2.1 2.2 2.3 2.4 2.5 | Establish an organizational policy Plan the process Provide resources Assign responsibility Train people | ☑ Address in tasks for planning, review and approval in <u>Project Planning</u> procedures (change requests, artifacts) |
|-----|---------------------------------|---|---|
| GG2 | 2.6 2.7 | Manage configurations Identify and involve relevant stakeholders | ☑ Address as tasks in <u>Project Planning</u> procedures for planning the planning and |
| | 2.8 2.9 | Monitor and control the process Objectively evaluate adherence | replanning process (GP 2.2) and reporting (phase dependent) Based on selected product life cycle |
| | 2.10 | Review status with higher level management | Consider whether planning tools can automatically produce relevant |
| 663 | 3.1 | Establish a defined process | Change requests - status, progres |
| 663 | 3.2 | Collect improvement information | Plan content - per cent complete Effort expended in planning and replanning activities |

| GG2 | 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.7 2.8 2.9 | Establish an organizational policy Plan the process Provide resources Assign responsibility Train people Manage configurations Identify and involve relevant stakeholders Monitor and control the process Objectively evaluate | ☑ Address as tasks in <u>Project Planning</u> procedures (phase dependent, periodic) and as part of the Process and Product Quali Assurance (PPQA) process(es) Provide checklists to support objective evaluation of Project Planning work products and activities – <u>as augmented by IPM work</u> <u>products and activities</u> |
|---------|--|---|--|
| | 2.10 | adherence Review status with higher level management | ☑ Address as tasks for review of activities by |
| 663 | 3.1 | Establish a defined higher-le process | higher-level management in <u>Project Planning</u> procedures |
| 663 | 3.2 | Collect improvement information | and as part of the standard reporting in the <u>Project Monitoring and Control</u> (PMC) Process |
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| | 2.1 | Establish an organizational policy | |
|-----|------|--|---|
| | 2.2 | Plan the process | _ [™] Define in scope statement in the <u>Proj</u> |
| | 2.3 | Provide resources | <u>Planning</u> policy or procedures |
| | 2.4 | Assign responsibility | 🗹 Tailoring |
| | 2.5 | Train people | Include a tailoning agation in the |
| | 2.6 | Manage configurations | Project Planning procedures |
| GG2 | 2.7 | Identify and involve relevant stakeholders | Options Eligibility or selection criteria |
| | 2.8 | Monitor and control the process | Include as "it" statements in procedure |
| | 2.9 | Objectively evaluate adherence | Allow for substitutions and exemptions |
| | 2.10 | Review status with higher level management | Contract or business requirements |
| 663 | 3.1 | Establish a defined _ | |
| 005 | 3.2 | Collect improvement information | |
| | | | |













- Define product life cycles
 - Define and align subordinate life cycles and functional area processes

② Define interfaces with internal organizations

- Establish risk management process (critical dependencies)
- Establish change management process
- Apply appropriate metrics
- Align organization with life cycle
- Align working environments and collaboration tools
- Ensure training takes place



Typical implementation opportunities -Business acquisition and proposal

- Define interfaces with internal organizations
- 2 Requirements analysis capability
- Requirements definition
- **4** Requirements change management
- S Estimation



Typical implementation opportunities - **Development**

- Engineering lifecycle definition
- Requirements management
- Planning and project management
 - Estimation
 - Verification and validation



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- Define interface with Engineering/Development
- Planning to ensure capability to meet commitments
 - New business (resources and training)
 - New types of product (process engineering)
- Integrate quality functions
- Automate systems to greatest extent practical



Typical implementation opportunities -Services and Support

- Define interfaces with internal organizations
- Planning to ensure capability to meet commitments
 - New business (resources and training)
 - New types of service (process engineering)
- Automate systems to greatest extent practical

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Vignettes

| 1. The Devil's Advocate | MOTIVATION of Senior Engineer | IMPACT of Senior Engineer's Actions | YOUR ACTION (Project Engineering Manager) |
|---|----------------------------------|--|--|
| There is a senior engineer who is well-respected by his peers for his technical acumen, but who raises objection after objection to any proposed course of action. His objections are always supported by an overwhelming army of facts. | | | |
| His background and experience make him essential to the project team. | | | |
| You are a Project Engineering Manager, to whom the senior engineer reports. What can you do? | | | |

| MOTIVATION | IMPACT | YOUR ACTION (Project |
|------------|---------------------------|--|
| | | |
| | | |
| | | |
| | | |
| | | |
| | MOTIVATION of Engineer | MOTIVATION of Engineer IMPACT of Engineer's Actions |

| 3. Teflon | MOTIVATION of Engineers | IMPACT of Engineers' Actions | YOUR ACTION (Project Manager) |
|--|----------------------------|---------------------------------|----------------------------------|
| Engineers immediately label any schedule slippage or cost overrun as due to changes over which they have no control. | | | (110)000 managory |
| Requirements changed. The design evolved based on experience with the product. People resigned and were replaced with less experienced engineers. People were added. Resources were temporarily reassigned to emergencies. Assigned resources were not available when they were supposed to be. They were held up on other projects that were (also) running longer than anticipated. | | | |
| You're the Project Manager, to whom the engineering project managers come with their explanations. What can you do? | | | |
| | | | |
| | | | |

| 4. Sinatra | MOTIVATION | IMPACT | YOUR ACTION (Project |
|---|-------------|-----------------------|----------------------|
| | of Engineer | of Engineer's Actions | Engineering Manager) |
| Based on a flash of inspiration, the software engineer saw a better way to implement the requirement. Not only was less code required, the code was less complex, more maintainable, offered better exception handling, and seemed to represent a more effective basis for any future enhancements that might be required. The simplicity of the new solution made it appear feasible to scrap what had been done and still finish the new code on time, by | | | |
| the end of the week. | | | |
| And he did. | | | |
| You are a Project Engineering Manager, to whom the engineer reports. What can you do? | | | |
| | | | |
| | | | |

| 5. Cleo - the view from the top | MOTIVATION | IMPACT | YOUR ACTION |
|--|---------------------|-------------------------------|---------------------|
| | of Software Manager | of Software Manager's Actions | (VP of Engineering) |
| The software manager told the Vice-President (VP) of Engineering that, after some investigation, it appeared the software could not be ready as early as the new hardware. The software manager proposed an alternative date for system test that would slip the product release by 2 months (on a 9 month project). The VP's response was that a two month slip was unacceptable and that the software manager needs to find a way to bring his part of the project in line with the hardware schedule. You are the Vice-President of Engineering What also cap | of Software Manager | of Software Manager's Actions | (VP of Engineering) |
| you do? | | | |

| 6. Cleo - the other side | MOTIVATION | IMPACT | YOUR ACTION |
|--|-------------------|-----------------------------|--------------------|
| | of VP Engineering | of VP Engineering's Actions | (Software Manager) |
| The software manager told the Vice-President (VP) of Engineering that, after some investigation, it appeared the software could not be ready as early as the new hardware. The software manager proposed an alternative date for system test that would slip the product release by 2 months (on a 9 month project). The VP's response was that a two month slip was unacceptable and that the software manager needs to find a way to bring his part of the project in line with the hardware schedule. | | | |
| Manager. What can you do? | | | |

| 7. Cleo, Part II - no problem | MOTIVATION | IMPACT | YOUR ACTION |
|--|---------------------|-------------------------------|-------------------|
| | of Software Manager | of Software Manager's Actions | (Project Manager) |
| The software manager told the Vice-President (VP) of Engineering that, after some investigation, it appeared the software could not be ready as early as the new hardware. The software manager proposed an alternative date for system test that would slip the product release by 2 months (on a 9 month project). | | | |
| The VP's response was that a two month slip was unacceptable and that the software manager needs to find a way to bring his part of the project in line with the hardware schedule. | | | |
| The software manager went back and did some backward planning. By overlapping previously sequential activities and replacing some estimates with the best case numbers, the software manager was able to tweak Microsoft project into producing a plan that ended close enough to the hardware date to satisfy the VP of Engineering. | | | |
| You are the Project Manager (responsible for delivering the hardware and software). What can you do? | | | |

| 8. | MOTIVATION | IMPACT | ACTION |
|------------------|------------|--------------|--------|
| | of | of's Actions | of (x) |
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| You are the (x) | | | |
| What can you do? | | | |
| | | | |

Risk Scenarios

The Forbes Project

The Forbes Project is developing a new product, which the VP of R&D promised the User Group as being available by the end of the year. It is now March 1st.

The Forbes Project requires the development of an algorithm which is based on a branch of Mathematics that is understood by only one engineer in the company. That engineer is currently developing an algorithm for another project and is committed full time to that other project for the next 4 months.

Development of the algorithm for the Forbes Project is planned to start in 4 months, so it will be ready for integration in 6 months.

The Port

To ensure the viability of its popular, cutting-edge product, MicroTome, the company has set up a project to port MicroTome from the DOS operating system to Windows NT. The project's charter is to duplicate the functionality exactly, but incorporate a real GUI, and make a few minor (well-defined) enhancements.

The charismatic project manager, Paul Miller, (PM) also plans to deliver a well-documented, object-based product that will be easily maintainable. The PM has set an aggressive schedule for the team, starting with training in Object-Oriented Techniques, C++, and GUI design. The team is made up of senior engineers who are familiar with the domain and the current product and who have excelled in maintaining the structured code in the DOS-based product.

Risk Taxonomy (see CRL1)

| | | CLASS | |
|-----------------------|---|--|--|
| | A. Product Engineering | B. Development Environment | C. Program Constraints |
| ELEMENT ATTRIBUTES | 1. Requirements a. Stability b. Completeness c. Clarity d. Validity e. Feasibility f. Precedent g. Scale | 1. Development Process a. Formality b. Suitability c. Process Control d. Familiarity e. Product Control | 1. Resources a. Schedule b. Staff c. Budget d. Facilities |
| ELEMENT ATTRIBUTES | 2. Design a. Functionality b. Difficulty c. Interfaces d. Performance e. Testability f. Hardware Constraints g. Non-Developmental Software | 2. Development System a. Capacity b. Suitability c. Usability d. Familiarity e. Reliability f. System Support g. Deliverability | 2. Contract a. Type of Contract b. Restrictions c. Dependencies |
| ELEMENT ATTRIBUTES | 3. Code and Unit Test a. Feasibility b. Testing c. Coding/Implementation | 3. Management Process a. Planning b. Project Organization c. Management Experience d. Program Interfaces | 3. Program Interfaces a. Customer b. Associate Contractors c. Subcontractors d. Prime Contractor e. Corporate Management f. Vendors g. Politics |
| ELEMENT ATTRIBUTES | 4. Integration and Test a. Environment b. Product c. System | 4. Management Methods a. Monitoring b. Personnel Management c. Quality Assurance d. Configuration Management | |
| ELEMENT ATTRIBUTES | 5. Engineering Specialties a. Maintainability b. Reliability c. Safety d. Security e. Human Factors f. Specifications | 5. Work Environment a. Quality Attitude b. Cooperation c. Communication d. Morale | |

Case Study – AJ Oy

BACKGROUND

Arvid Johnson Oy (AJ) is a large, established, and well-respected company based in Finland. One of AJ's products is KAL2 (for *Kalevala 2*), a system for automated inspection of discrete parts for form and finnish. KAL2 includes a highly-efficient and intelligent robotic feeder and handler that selects and orients the part, a multi-mode holographic scanner, and PC-based analytical software that interprets the scanner data. The division of AJ responsible for KAL2 has pioneered and its employees hold numerous patents in robotics, in thermal and optical imaging, in ultrasonography, and in the pattern recognition algorithms embedded in the feeder, handler, and scanner firmware.

KAL2 is a worldwide product marketed and supported by sales subsidiaries responsible for a country or major market.

HARDWARE

KAL2 hardware design and manufacturing are in Finland. Major hardware projects may take from 18 to 30 months. Once the hardware detailed design is done and an accurate availability date is determined (typically at least 12 months in the future), the software organization is notified to begin analysis and planning. AJ's goal is to ensure that any required software or software changes are planned for the quarterly release that will correspond with the hardware availability date. Defects in released hardware are rare and are the responsibility of the Hardware Engineering organization in Tampere, Finland. AJ's strategy is to address hardware defects through software changes whenever practical.

SOFTWARE AND SERVICE

For software, AJ KAL2 Division Engineering has established Centres of Software Engineering Excellence (CSWEE) in major technology centers around the world. The CSWEEs range in size from 30 to 230 software engineers and test personnel and 10 to 20 telephone support engineers. In almost all cases, these software development centers have been created and staffed through the acquisition of subcontractors and competitors. Software releases for KAL2 occur four times each calendar year. Software releases typically alternate between maintenance releases and releases with new functionality. If necessary, this pattern is adjusted to accommodate new hardware availability.

In the United States, the sales subsidiary, responsible for the Americas, and the CSWEE are collocated in Costanoa California.

MANAGING KAL2

Changes to the core software and hardware product for KAL2 are approved by a KAL2 R&D Board of Governors that meets quarterly in Helsinki. The Board includes the Directors of the Engineering Centres of Excellence, of the Hardware Engineering organization, and of the sales subsidiaries. New core development projects are typically planned and funded at the January meeting. The other three meetings deal with reviewing proposals for consideration at the next January meeting, monitoring progress on approved programs, and setting priorities for approved programs based on changes in the marketplace.

Software bug fixes are handled by a technical committee made up of the Directors of the Engineering Centres of Excellence. Lately, the field organization (and some customers) have discovered that enhancements can be processed quickly if they are approved as bugs.

THE CSWEE'S

Each CSWEE receives funding from three sources:

- AJ KAL2 R&D funds core product development.
- AJ KAL2 sales subsidiaries fund projects to develop *minor*, market-specific features.
- Customers fund the development of special features for KAL2, which may include the integration of third-party hardware.

At each CSWEE, a team of software engineers, headed by a senior software engineer, is formed for each project, which may last from 1 to 9 months. Each project begins with the current version of KAL2 (or with the version the customer currently has installed). The team leader works with the funding sales subsidiary, and, as appropriate, with customers to complete the project and to secure any add-on work that might be identified in the course of the project.

The US-CSWEE currently has 2 core development projects and 16 non-core projects in progress. The largest project in the US CSWEE is jointly funded by the Americas and the Mediterranean sales subsidiaries. This project grew out of a proposal that was rejected for inclusion in the core product.

THE QUESTION

You are an internal process consultant from AJ OY. Relate the goals of Integrated Project Management (IPM), Project Planning (PP), and Process Monitoring and Control (PMC) to opportunities, situations, or potential problems you might encounter at the Costanoa CSWEE. How could implementing practices to satisfy a goal address the associated situation or problem or seize the associated opportunity to benefit the organization? The audience for your comments is senior management.

For your convenience, worksheets, with the goals and specific practices - and with room for recording potential issues and benefits - are found starting on page 63.

HUOM - WARNING - ATTENTION - ACHTUNG

Do not overtighten. Not all goals necessarily offer benefits to AJ OY. If, after a reasonable amount of individual reflection and team discussion, there does not appear to be a benefit worth presenting, move on.

Integrated Project Management (IPM)

| | Specific Goals (SG) and Practices (SP) | Opportunity, Situation, or Potential Problem | Benefit |
|------|--|--|---------|
| SG 1 | The project is conducted using a defined process that is tailored from the organization's set of standard processes. | | |
| | SP 1.1 Establish and maintain the project's defined process.SP 1.2 Use the organizational process assets and measurement repository for estimating and planning the project's activities. | | |
| | SP 1.3 Integrate the project plan and the other plans that affect the project to describe the project's defined process. | | |
| | SP 1.4 Manage the project using the project plan, the other plans that affect the project, and the project's defined process. | | |
| | SP 1.5 Contribute work products, measures, and documented experiences to the organizational process assets. | | |
| SG 2 | Coordination and collaboration of the project with relevant stakeholders is conducted. | | |
| | SP 2.1 Manage the involvement of the relevant stakeholders in the project. | | |
| | SP 2.2 Participate with relevant stakeholders to identify, negotiate, and track critical dependencies. | | |
| | SP 2.3 Resolve issues with relevant stakeholders. | | |
| SG 3 | The project is conducted using the project's shared vision. | | |
| | SP 3.1 Identify expectations, constraints, interfaces, and operational conditions applicable to the project's shared vision. | | |
| | SP 3.2 Establish and maintain a shared vision for the project. | | |
| SG 4 | The integrated teams needed to execute the project are identified, defined, structured, and tasked. | | |
| | SP 4.1 Determine the integrated team structure that will best meet the project objectives and constraints. | | |
| | SP 4.2 Develop a preliminary distribution of requirements, responsibilities, authorities, tasks, and interfaces to teams in the selected integrated team structure. | | |
| | SP 4.3 Establish and maintain teams in the integrated team structure. | | |

Project Planning (PP)

| | Specific Goals (SG) and Practices (SP) | Opportunity, Situation, or Potential Problem | Benefit |
|------|---|--|---------|
| SG 1 | Estimates of project planning parameters are established and maintained. | | |
| | SP 1.1 Establish a top-level work breakdown structure (WBS) to estimate the scope of the project. | | |
| | SP 1.2 Establish and maintain estimates of the attributes of the work products and tasks. | | |
| | SP 1.3 Define the project life-cycle phases upon which to scope the planning effort. | | |
| | SP 1.4 Estimate the project effort and cost for the work products and tasks based on estimation rationale. | | |
| SG 2 | A project plan is established and maintained as the | | |
| 002 | basis for managing the project. | | |
| | SP 2.1 Establish and maintain the project's budget and schedule. SP 2.2 Identify and analyze project risks | | |
| | SP 2.3 Plan for the management of project data. | | |
| | SP 2.4 Plan for necessary resources to perform the project. | | |
| | SP 2.5 Plan for knowledge and skills needed to perform the project. | | |
| | SP 2.6 Plan the involvement of identified stakeholders. | | |
| | SP 2.7 Establish and maintain the overall project plan content. | | |
| SG 3 | Commitments to the project plan are established and maintained. | | |
| | SP 3.1 Review all plans that affect the project to understand project commitments. | | |
| | SP 3.2 Reconcile the project plan to reflect available and estimated resources. | | |
| | SP 3.3 Obtain commitment from relevant stakeholders responsible for performing and supporting plan execution. | | |
| | | | |
| | | | |

Process Monitoring and Control (PMC)

| | Specific Goals (SG) and Practices (SP) | Opportunity, Situation, or Potential Problem | Benefit |
|------|--|--|---------|
| SG 1 | Actual performance and progress of the project are monitored against the project plan. | | |
| | SP 1.1 Monitor the actual values of the project planning parameters against the project plan. | | |
| | SP 1.2 Monitor commitments against those identified in the project plan. | | |
| | SP 1.3 Monitor risks against those identified in the project plan. | | |
| | SP 1.4 Monitor the management of project data against the project plan. | | |
| | SP 1.5 Monitor stakeholder involvement against the project plan. | | |
| | SP 1.6 Periodically review the project's progress, performance, and issues. | | |
| | SP 1.7 Review the accomplishments and results of the project at selected project milestones. | | |
| | | | |
| 362 | project's performance or results deviate significantly from the plan. | | |
| | SP 2.1 Collect and analyze the issues and determine the corrective actions necessary to address the issues. | | |
| | SP 2.2 Take corrective action on identified issues. | | |
| | Sr 2.5 Manage corrective actions to closure. | | |
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The Key Deliverables Review

An extract from the Product Development Incorporated Engineering Handbook.

Key Deliverables Review (KDR)

The Key Deliverables Review is held monthly. It is chaired by the Chief Operating Officer (COO) and is attended by the heads of the site Engineering organizations, Operations, and Technical Support and Services. Each project is allocated a half-hour during which the project manager presents the progress of the project against standard, high-level milestones. Dependencies, issues, and risks are reviewed. In addition, each presentation may be attended by the project managers for any projects that are dependent on the project being reviewed. Each project manager provides a presentation for the meeting. Each month's presentations, along with any action items developed in the review meeting are maintained in the Project Tracking Book by the COO Project Administrator.

A template for the presentation is provided on the next page.

Key Deliverables Review Project Presentation Template

| Date | | | |
|-----------------|------|----------|--|
| Project | | | |
| Project Manager | | | |
| | | MARK ONE | |
| | 1 1 | | |

| WBS | | | Completion | Date | |
|------|-----------------------------------|----------|------------|---------|--------|
| ltem | Description | Original | Last | Current | Actual |
| | Project PRD and PP | | | | |
| | OEM Qualification COMPLETE | | | | |
| | Major Sub-System 1 DTD | | | | |
| | Major Sub-System 2 DTD | | | | |
| | Major Sub-System 3 DTD | | | | |
| | Hardware Specification | | | | |
| | PIP | | | | |
| | Prototype test | | | | |
| | Software Integration START | | | | |
| | Validation START | | | | |
| | Manufacturing Pre-Production Plan | | | | |
| | Regulatory COMPLETE | | | | |
| | RTM | | | | |
| | Beta START | | | | |
| | RTS – LA | | | | |
| | RTS – GA | | | | |

▲ = Mark if change from last KDR

Move Current to Last before changing Current

Changes

| WBS Item | Justification |
|----------|---------------|
| | |
| | |
| | |
| | |

Issues

Previous Actions

| Action | Progress | Target |
|--------|----------|--------|
| | | |
| | | |
| | | |

Acronyms

| GA | General Availability | LA | Limited Availability |
|-----|-------------------------------|-------|---------------------------|
| DTD | Detailed Design | KDR | Key Deliverables Review |
| PP | Project Plan | PIP | Product Introduction Plan |
| PRD | Product Requirements Document | RTS | Release to Ship |
| RTM | Release to Manufacturing | START | Start |
| WBS | Work Breakdown Structure | | |

Sample Phase Completion Checklists

The following are selected, sample phase completion or milestone checklists.

Alpha Test Readiness Review Checklist

- Manufacturing Pre-Production Plan complete
- □ Validation Testing has confirmed:
 - Operation of new features, enhancements, and specified bug fixes
 - □ All identified operational defects are documented
 - □ Interoperability with previous releases, all identified interoperability exceptions are documented.
 - All identified performance shortfalls against the performance criteria in the Design Specification are documented

Approval

- Validation Manager
- Beta site coordinator(s)
- Manufacturing Manager

Beta Test Readiness Review Checklist

- □ Validation Testing has confirmed:
 - □ Features targeted for Beta are implemented and have been tested
 - □ No open Class A defects in the portion of the product to be exercised in the Beta Test
 - Established performance targets have been reached
 - All identified performance shortfalls against the Design Specification are documented
- Dereliminary user documentation is available
- □ Preliminary release description is available
- Beta test planning complete (i.e., functionality to be exercised specified; agreements on file)
- Manufacturing Production Plan complete

Approval

- Product Manager
- Software Engineering development lead(s)
- □ Hardware development lead
- Validation Manager
- Beta site coordinator(s)
- Manufacturing Manager

Release to Ship (RTS) Readiness Review Checklist - for Limited Availability (LA)

- □ Validation has confirmed:
 - □ 100% of the features for the identified market/customer/etc. are implemented and tested
 - □ All performance targets are met
 - No open Class A defects
 - □ Four or less Class B defects
 - Load testing completed; report available
- □ Final user and field service documentation are available and reviewed.
- □ Release Description is complete and available
- Planned Beta Tests successfully completed
- Order Processing trained; order processing procedures, pricing, and part numbers are complete and available
- □ Sales trained; supporting external literature is complete and available
- □ Technical Support is trained on the new features
- Product Introduction and Support Services Plan approved
- Customer training is available for the new release
- Any approved waivers are documented with appropriate risk assessment and corrective action plans

Approval

- Product Manager
- □ Marketing (representing Sales)
- Project Manager
- Publications
- Manufacturing
- □ Regulatory compliance engineering
- Software Engineering development lead(s)
- □ Hardware development lead
- Validation Manager
- Legal
- Technical Support
Key Performance Indicators (KPI)

Key Performance Indicators are metrics, attributes or dimensions, of products and processes which, when measured, provide information to support project planning and management. Historical measurement data forms models for predicting performance and for establishing thresholds for taking action. Current measurement data enables management to monitor performance and make appropriate adjustments to ensure that results comply with planned arrangements. As project management skills and resources mature, plans are more accurate and adjustments are less frequent. When adjustments are necessary, they are typically less disruptive, since problems are identified as or before they occur.

The goal of a metrics program is to continuously measure selected product and process attributes and provide a flow of information that is consistent in granularity, volume, and frequency with management's decision making capacity. Too much information, too little information, and information received too late all result in ineffective decision making.

Consider the following metrics, presented in no particular order, as key performance indicators, appropriate for various levels of management.



Metric 1: Estimation Accuracy - The Cone of Variability

The Cone of Variability models the performance of the organization's estimation processes. The X axis represents points in the life cycle at which the balance of the project is replanned. The Y axis is calibrated for cost, schedule, or, as illustrated, for both. The Y axis is the ratio of planned values to actual values, as determined at project completion.

In the example, for Cost, at <u>Initial Project Definition</u>, the historical data from completed projects demonstrates that estimates of total project cost are off by a factor of 4. At <u>Requirements Specification</u>, estimates from replanning are from 1.5 times actuals (50% high) to .50 times actuals (50% low).

In the example, for Schedule, at <u>Initial Project Definition</u>, the historical data from completed projects demonstrates that estimates of the project schedule range from 1.6 times the actual schedule (e.g., estimated 12 months, completed in 7.5 months) to .60 times the actual schedule (e.g., estimated 12 months, completed in 20 months). At <u>Requirements</u> <u>Specification</u>, estimates from replanning are from 1.15 times actuals (e.g., estimated 12 months, completed in 10.4 months) to .85 times actuals (e.g., estimated 12 months, completed in 14.1 months).

It is typically appropriate to maintain models for different technologies or types of projects.

Suggested Application

During planning, the model supports establishing realistic expectations, realistic schedule buffers, and realistic budgetary reserves. As part of lessons learned, it allows the organization to identify opportunities and techniques for improvement. During the execution of the plan, the model provides thresholds that flag activities for management attention.

In the example, activities that take place between <u>Approved Product Definition</u> and <u>Requirements Specification</u> are monitored against a plan that historically ranges from 1.15 times the actual schedule to .85 times the actual schedule. An

activity planned for completion in 20 days may extend to 24 days before management intervention is appropriate. Or, if it is completed in 17 days, there is no reason for management to be concerned that something is not done - or to reward the team for beating the clock.

Comments

The values in the example represent the results of large systems projects performed under government contracts. Such projects are required to prepare detailed plans as part of the proposal process; they also tend to have significant costs in hardware components. In commercial organizations, while time to market makes maintaining schedules the highest priority, effort is underestimated by a factor of 1.9 and schedules are maintained by removing 25% to 50% of the committed features (see The Standish Group, **Chaos**, 1995, available at www.standishgroup.com).

Metric 2: Defects

Defects can be measured within design and development (e.g., from first integration to release) or the measurement activity can extend across the product life cycle, to include post-release defects.



In this example, all defects are counted equally. The historical data on defects is used to establish a baseline. Any significant deviation from the baseline signals a need for management attention. In the example, Project 3 and Project 4 both require attention. Is Project 4 in trouble or has it instituted a more rigorous inspection or testing strategy, which should result in much lower numbers in the future? Or is Project 4 addressing a legacy component that is virtually unmaintainable? Is Project 3 an example of exceptional quality? Or has inspection and testing been deferred? Or are the inspection and testing inadequate?

Once again, separate models may be appropriate for projects categorized by size or technology.

Since not all defects are equal, the same approach is taken for modeling and monitoring defects by severity.



In this example, cumulative reported defects and remaining open defects are represented. Labels on the open defect line provide precise counts of the Level A and Level B defects remaining open. Spreadsheet-style captions below the X axis provide complete detail on the number of new defects added to the counts.

Suggested Application

During planning, an accurate defect model enables management to predict and plan accurately for rework. During the execution of the plan, comparing defect levels to the plan (or model) identifies potential problem areas. As part of lessons learned, comparing defect levels to the plan (or model) identifies product components that are candidates for reengineering. Monitoring defect find and closure rates without a plan or model is common and useful, but without any historical reference, it promotes unnecessary stress.

(The argument about not being able to afford to reengineer is most effectively countered by providing actual data on the cost of not reengineering.)

Metric 3: Project productivity

Since engineering work is rarely completed at a predictable, steady rate, measuring actual productivity enables management to identify potential problems without having to rely on questionable estimates of "per cent complete".



In this example, *time*, on the X axis, is the time remaining in the plan and *product per cent complete*, on the Y axis, is based on modules checked into the configuration management system as *ready to release*. The three segments of solid line that are circled represent the highest rates of productivity achieved by the project team, as they sprinted to the various intermediate release milestones. The circled, dotted line segment represents the rate of productivity that is required to complete the project on time (100% of product complete when 100% of the time is reached). By inspection, based on the productivity rates that have already been achieved, the amount of product to complete and the time available represent a reasonable goal. Unless, of course, the last five percent of the product is the part that no-one knows how to do.

Suggested Application

Because productivity is influenced by a number of variables and is highly dependent on the team make-up, an effective use of project productivity is during execution of the later parts of the plan. Management can monitor progress against time to ensure that expectations of heroic last minute efforts are reasonable.

Metric 4: Verification activities

Comparing the completion of verification activities, like reviews, to the availability of the target work products allows management to ensure that those activities take place and that, when other organizations are involved, plans are being effectively coordinated. Any significant deviation from the plan is a signal to management to investigate.



In this example, the number of modules that have completed code review is measured against the number of modules coded (e.g., ready for review). The number of coded modules is represented by the solid line. The assumption is that 100% of these modules undergo code review. In Example 1 (the lower, dotted line), the backlog of modules that are ready for code review is fairly constant for three time periods and then appears to start increasing, as the dotted line moves further from the solid line. Management attention is indicated. Why is the project falling behind?

In Example 2, the backlog decreases dramatically. Management attention is indicated. Is the project doing an exceptional job of completing reviews? Are participants given adequate time to prepare? Or are reviews considered an academic exercise, to be disposed of with minimum effort and attention?

Metric 5: Requirements stability

Requirements changes (as recorded by the change approval process) represent a significant risk to the project. Too many can negate even the best engineering and project management processes. Too few indicate that the project may not be hearing about needed changes in a timely manner. This pent up demand inevitably surfaces late in the project (e.g., beta test) when it poses the greatest risk to the project.



In this example, there are approximately 80 requirements, as indicated by the dotted line and the scale on the right. The relatively high rate of change (6% to 10%) appears to have stabilized in the 2 to 3% range.

Metric 6: Earned value

Earned value measures performance against schedule and against budget. The cost performance index compare the actual cost of work completed to the amount budgeted for that work. The schedule performance index compares the actual amount of work completed to the amount of work planned to be completed. Earned Value allows management a view of schedule and budget performance independent of the shifts in order and priority that are managed on a daily basis at the team level. With the tools currently available for data capture and reporting, Earned Value can be considered to supplement Key Deliverables Reviews in smaller organizations.



Each index is constructed so that a value of "1" indicates "on schedule" or "on budget". Below 1 is "bad"; above 1 is "good". By monitoring late starts, which can be used to hide problems by shifting activities to the end of the project, management can monitor the overall health of a project. A wealth of additional information is available to support managers who need to look at the causes of potential problems identified by the indexes.

In the example, the Cost Performance Index, consistently above 1, shows that the project is spending less than budgeted; the problem is that the Schedule Performance Index shows that the project is behind schedule.

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| OSD1 | http://www.acq.osd.mil/pm/ | Program Management homepage of the Office of the Secretary of Defense. See http://www.acq.osd.mil/pm/paperpres/paperpres.html for a wealth of information. |
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| ROE1 | Roetzheim, William H., <i>Estimating Internet</i> Development, Software Development , August | http://www.sdmagazine.com/articles/2000/0008/0008d/ 0008d.htm |
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| | | A project schedule can be compressed or expanded within a range of 75% to 200%. |
| SDM1 | http://www.sdmagazine.com/supplement/ppm/ | Software Development Magazine Project Management home page |
| SEI1 | http://www.sei.cmu.edu/psp/psp.html | For PROBE: The Personal Software Process (PSP) home page at the Software Engineering Institute |
| SEP1 | http://sepo.spawar.navy.mil/docs.html or http://sepo.nosc.mil/docs.html | A complete set of downloadable documents for all KPAs from the Software Engineering Project Office (SEPO), Space and Naval Warfare Systems Center, San Diego, (SSC SD) |
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Partial List of Tools and Contacts

| | | | Resource | Risk | |
|----------------------------------|----------------------------|------------------------------------|--------------------------|------------|--|
| Provider | Planning | Tracking | Management | Management | Contact |
| ABT Corporation | Planner™ Workbench™ | Publisher™ Team™ Connect™ | Repository™ Resource™ | | ABT Corporation 361 Broadway New York, NY 10013 Tel: (212) 219-8945 www.abtcorp.com |
| Artemis Management Systems | Views 4 | | | | Artemis Management Systems 6260 Lookout Road Boulder, Colorado 80301 Tel: (800)477-6648 www.artemispm.com |
| Computer Associates | CA SuperProject | SuperProjectNet | CA SuperProject | | One Computer Associates Plaza Islandia, NY 11749 631-Dial CAI (342-5224) Fax: 1-631-342-5329 www.cai.com |
| Microsoft Corporation | Project™ | Project Central/ Project Server | Project™ | | Microsoft Corporation One Microsoft Way Redmond, WA 98052- 6399 (800) 426-9400 www.microsoft.com |
| Nikū | Portfolio Manager Suite | | | | Appears to include Bridge Modeler and Project Manager's Work Bench formerly from Applied Business Technology (ABT), which was acquired by Nikū in August 2000. World Headquarters 305 Main Street Redwood City, CA 94063 Tel: +1 650 298 4600 Fax: +1 650 298 4601 |
| PlanView Inc. | PlanView | | | | PlanView Inc. 7320 North MoPac #300 Austin, TX 78731 Tel: (512) 346-8600 www.planview.com |
| Primavera Systems, Inc. | TeamPlay™ | | | | Primavera Systems, Inc. Three Bala Plaza West Bala Cynwyd, PA 19004 Tel: (800) 423-0245 www.primavera.com |
| Scitor Corporation | Project Scheduler | Project Communicator | | | Scitor Corporation 256 Gibraltar Drive Sunnyvale, CA 94089 Tel: (800) 533-9876 www.scitor.com |

| Provider | Planning | Tracking | Resource Management | Risk Management | Contact |
|--|---------------|--------------------------|------------------------|--------------------|---|
| Software Program Managers Network | | Project Control Panel | | Risk Radar | SPMN 4600 N. Fairfax Drive Arlington, VA 22203 (703) 521.5231 www.spmn.com (both products are available for download at no cost) |
| Time Line Corporation | Time Line 6.5 | | | | Time Line Solutions Corp 1020 Railroad Ave. Suite D Novato, CA 94945 (415) 898-1919 www.tlsolutions.com |
| | On Target | Project Updater | | | |

| Provider | Cost/Size/Metrics | Contact |
|----------------|-------------------|---|
| Galoreth, Inc. | SEER | Galoreth Incorporated |
| | | 100 North Sepulveda Boulevard Suite 1801 |
| | | El Segundo, CA 90245 |
| | | Phone 310-414-3222 |
| | | Fax 310-414-3220 |
| | | http://www.gaseer.com |
| Marotz, Inc., | Cost Xpert | Marotz Inc. |
| Cost Xpert | | Cost Xpert Group |
| Group | | 13518 Jamul Drive |
| | | Jamul, CA 91935-1635 |
| | | (619) 669-3100 |
| | | http://www.costxpert.com |
| Quantitative | SLIM | QSM |
| Software | | 2000 Corporate Ridge |
| Management | | Suite 900 |
| | | McLean, Virginia 22102 |
| | | TEL: 800-424-6755 |
| | | FAX: 703-749-3795 |
| | | http://www.qsm.com |
| Software | KnowledgePLAN | Software Productivity Research |
| Productivity | | Inree Betnesda Metro Center |
| Research | | Suite 700 Betheada, Mandand 20014 |
| (SPR) | | Delitesua, Maryianu 20014 |
| | | Tel. 301.037.0200 |
| | | FdX 301.942.4301 |
| | | http://www.spr.com |
| DSC (Dr. Barry | | |
| Boenini) | | USC Center for Software Engineering, free, downloadable tools, including COCOMO II |
| | | The main address for COCOMO tools is |
| | | http://sunset.usc.edu/research/cocomosuite/suite_main.html |

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