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

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Version 20 (Slides Version 21)

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.

Integrated Project Management (IPM)

The CMMI V1.2 and collaborative product development

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Getting started

- About the presenters
- Audience
  - Some level of familiarity with the Software CMM Version 1.1 or CMMI Version 1.1 (Staged or Continuous)
  - Maintaining SW CMM 1.1, finishing CMMI V 1.1, starting CMMI V 1.2
- Experience breeds … , well, opinions, concerns, etc.

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Project management: prioritized issues

- Develop an individual list of the challenges your organization needs to address in **managing projects 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

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

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Orientation to the CMMI v 1.2

(with references to V1.1)

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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), Continuous 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), Staged 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

CAR	Causal Analysis and Resolution	**OT**	Organizational Training
CM	Configuration Management	**PI**	Product Integration
DAR	Decision Analysis and Resolution	**PMC**	Project Monitoring and Control
IPM	Integrated Project Management +IPPD	**PP**	Project Planning
MA	Measurement and Analysis	**PPQA**	Process and Product Quality Assurance
OID	Organizational Innovation and Deployment	**QPM**	Quantitative Project Management
OPD	Organizational Process Definition +IPPD	**RD**	Requirements Development
OPF	Organizational Process Focus	**REQM**	Requirements Management
OPP	Organizational Process Performance	**RSKM**	Risk Management
		SAM	Supplier Agreement Management
		TS	Technical Solution
		VAL	Validation
		VER	Verification

V1.1 not in V1.2

ISM Integrated Supplier Management

OEI Organizational Environment for Integration

IT Integrated Teaming

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A few words about

Representations

- CMMI supports two approaches through representations
- Organizations diligently study both and pick one (see the Introduction)

CONTINUOUS REPRESENTATION	STAGED REPRESENTATION
PRIORITY: Improve organizational capability in specific process areas (like CM, Requirements, and Verification)	PRIORITY: Customer requirement for proving a standardized organizational maturity level
MEASURE OF SUCCESS: Implementation of individual process areas	MEASURE OF SUCCESS: Implementation of pre-defined sets of process areas

- Core content is the same and there is a way to convert: equivalent staging
- Assessed capability can be converted to an equivalent maturity

V1.1 = different volumes
V1.2 = rules of interpretation

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A few words about

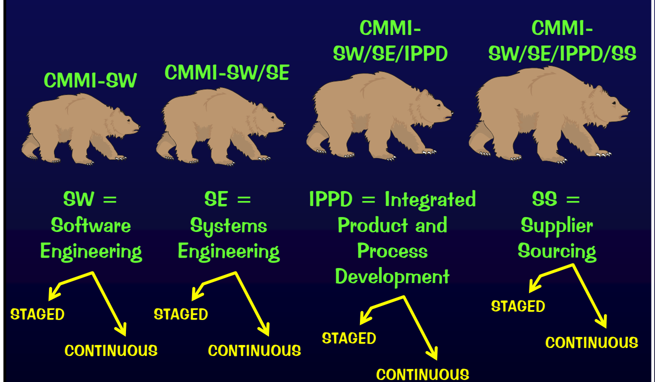
Levels

- Staged supports *organizational* *maturity*
  - Level 2 through 5
- Continuous supports *process* *capability*
  - 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

A few words about

Disciplines

- **V1.1**: Each CMMI representation is provided in four versions based on disciplines



- Your organization diligently studied the four versions and picked one
- Each discipline adds requirements and/or clearly labeled guidance

- Single book approach (CMMI-DEV+IPPD)
- **V1.2** CMMI has clearly labeled guidance for SW, HW, SE and additions for IPPD
- Your organization carefully considered the current state of its processes and determined

  (1) what engineering disciplines and functions to involve in the implementation

  (2) whether to include IPPD

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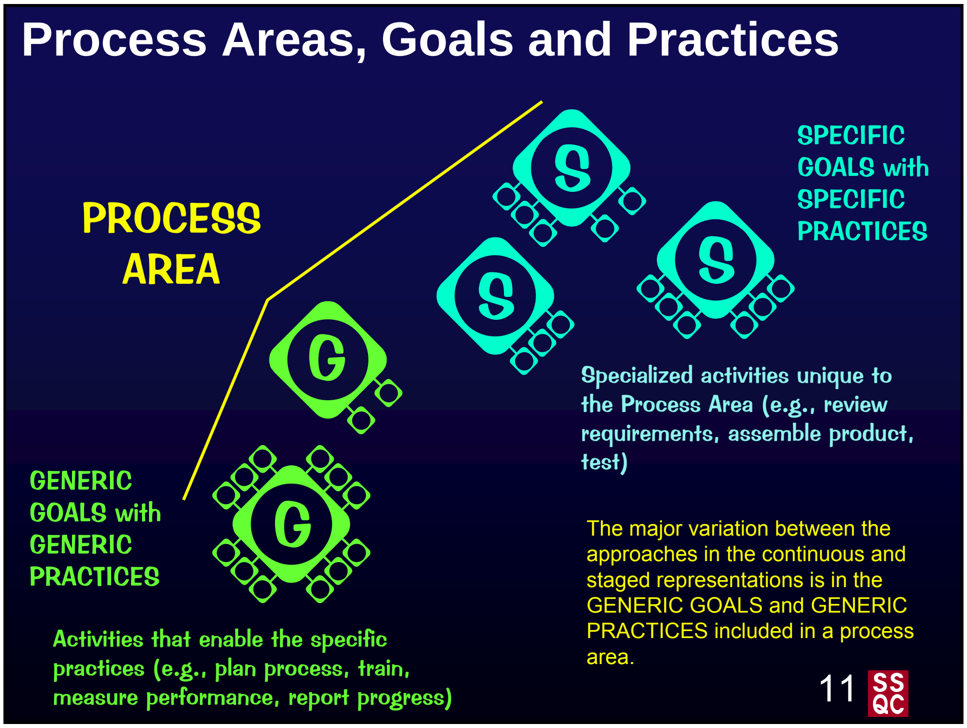

Required, expected, informative

Required components describe

what an organization **must** achieve to satisfy a process area. This achievement must be visibly implemented in an organization's processes. The required components in CMMI are the **specific and generic goals**. 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*

… and the Glossary

The CMMI glossary of terms is not a required, expected, or informative component of CMMI models. You should interpret the terms in the glossary in the context of the model component in which they appear. (CMMI V1.2, Section 2 *Process Area Components*)

To find out what the authors of the CMMI had in mind, look up:

- Familiar terms that don't seem to fit or that are interpreted differently by members of the team
- Unfamiliar terms

Be aware of "must"s in the Glossary ("establish and maintain")

CMMI Process Areas by Category

CATEGORY	Type	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 Deployment
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
	Advanced	DAR	Decision Analysis and Resolution
		CAR	Causal Analysis and Resolution

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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

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.

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Employ established principles (cont.)

CMMI V1.2, Glossary, in three places: under “adequate” and “appropriate” and “as needed”

When using any CMMI model, you **must** interpret the practices so that they work for your organization.

See V1.1, Section 3

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The intended scope of CMMI

CMMI V1.2, Section 1, *The Scope of CMMI for Development*

CMMI for Development is a reference model that covers the **development** and **maintenance** activities applied to both **products** and **services**.

Models in the CMMI for Development constellation contain practices that cover **project management, process management, systems engineering, hardware engineering, software engineering**, and other supporting processes used in development and maintenance. The CMMI for Development +IPPD model also covers the use of **integrated teams** for development and maintenance activities.

See CMMI V1.1, Chapter 5

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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.

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*

Processes: managed and defined

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 its process description.

A **defined** process

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

See CMMI v1.1, Chapter 3

Processes and process descriptions

CMMI V1.2, Part 2, *Generic Goals and Generic Practices*

A defined process clearly states the **purpose, inputs, entry criteria, activities, roles, measures, verification steps, outputs, and exit criteria**.

A critical distinction between a managed process and a defined process is the scope of application of the process descriptions, standards and procedures. … Another critical difference is that a defined process is described in more detail and is performed more rigorously than a managed process.

- Scope, detail, and rigor
  - Managed – project-unique processes developed independently
    - May be successfully implemented with less detail and less rigor (more professional judgment … *"we all understand what to do"*)
  - Defined – project's processes are tailored from the organization's standard processes
- Use the same template at Level 2 and Level 3
  - Facilitate migration and reuse

Process description defined

The level of detail is not specified. Consider process complexity, operator skills and training, frequency of execution, and risk.

Process description

A documented expression of a set of activities performed to achieve a given purpose.

A process description provides an operational definition of the major components of a process. The description specifies, in a complete, precise, and verifiable manner, the requirements, design, behavior, or other characteristics of a process. It also may include procedures for determining whether these provisions have been satisfied. Process descriptions may be found at the activity, project, or organizational level.

CMMI V1.2 and V1.1, Glossary

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 the specific and generic practices of the process area or alternatives 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 usually counter-productive. [2000-TR-30, paragraph 2, p. 24]

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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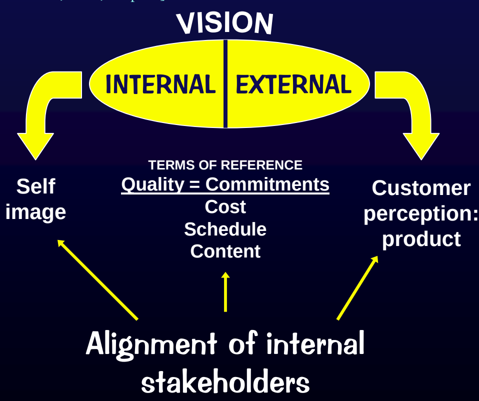
Importance TO PROCESS IMPROVEMENT
Support FOR VISION AND BUSINESS OBJECTIVES

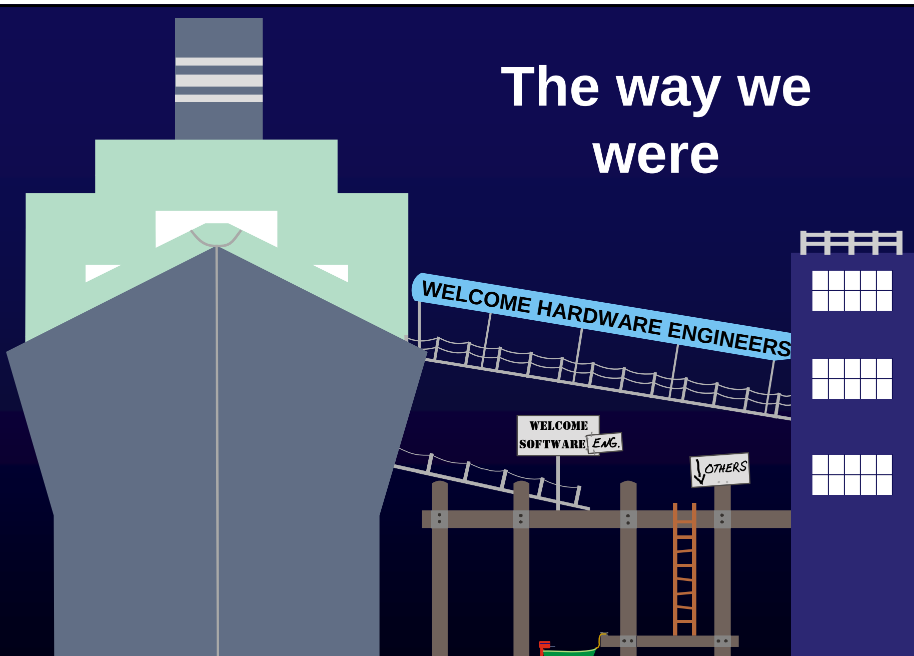
The purpose of Integrated Project Management (IPM) is to establish and manage the project and the involvement of the relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes. [CMMI,V1.1 and V1.2, IPM, Purpose]

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

It enables continuous, systematic alignment of resources, activities, and business objectives - converging on customer value.



The way we were



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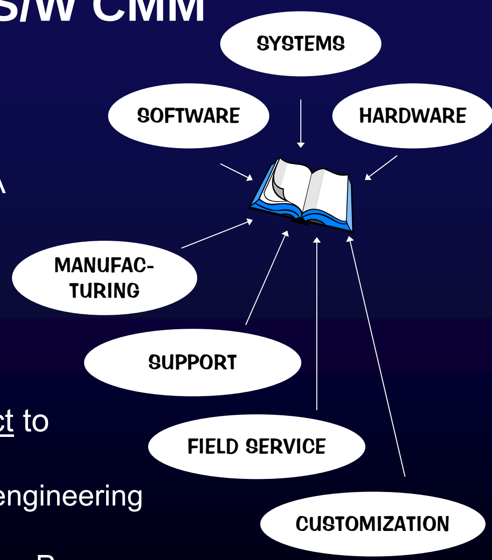
CMMI V1.2: Continues the evolution beyond S/W & the S/W CMM

Integrate engineering disciplines - one "book"

- Reduce influence and language of MIL-STD-2167A
- Appears more flexible, life cycle independent
- V1.2: More explicit content for engineering disciplines



IPPD - Expands scope from (software) engineering project to product delivery

- Inclusion of groups outside engineering is explicit
- V1.2 integrates IPPD into core Process Areas (IPM and OPD)

Benefits TO THE ORGANIZATION

Since the defined process of each project is tailored from the organization's set of standard processes, variability among projects is typically reduced and projects can more easily share process assets, data, and lessons learned.

[CMMI v1.1 and V1.2, IPM, Introductory Notes]

Reduced variability and a systematic multi-discipline view of product delivery translates directly into satisfying commitments to all stakeholders, including customers.

Enforced reuse of assets minimizes the cost of reinvention and lays a stable foundation for continuous improvement.

Relationships and dependencies

WITHIN THE PROJECT MANAGEMENT CATEGORY

Integrated Project Management (IPM) ...

- Relies on Project Planning (PP) and Project Monitoring and Control (PMC) for basic project planning and management
  - Adds basic requirements for systematic coordination
  - Adds IPPD requirements
  - Incorporates data to drive decisions

- Integrates Supplier Agreement Management (SAM) to support outsourcing development

IPM: The Specific Goals

SPECIFIC GOALS

SG 1 The project is conducted using a defined process that is tailored from the organization's set of standard processes.

SG 2 Coordination and collaboration of the project with relevant stakeholders is conducted.

SG 3 The project is managed using IPPD principles. ← +IPPD

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IPM: SG 1 Specific practices

SPECIFIC GOAL

SG 1 The project is conducted using a defined process that is tailored from the organization's set of standard processes.

SPECIFIC PRACTICES

From OPD

SP1.1 Establish and maintain the project's defined process from project startup through the life of the project.

SP 1.2 (Add to PP) Use the organizational process assets and measurement repository for <u>estimating</u> and <u>planning</u> the project's activities.

SP 1.3 Establish and maintain the project's work environment based on the organization's work environment standards

SP 1. 4 (Add to PP) <u>Integrate</u> the project plan and the <u>other plans</u> that affect the project to describe the project's defined process.

SP 1.5 (Add to PMC) <u>Manage</u> the project using the project plan, the other plans that affect the project, and the project's defined process.

SP1.6 <u>Contribute</u> work products, measures, and documented experiences to the organizational process assets.

Send to OPF

A critical specific practice

SPECIFIC PRACTICE

1.5 Manage the project using the integrated plans

<u>WHY:</u> **<u>product delivery</u>** is beyond any one group's capabilities, responsibilities

<u>SIGNIFICANT INDICATOR(S):</u>
SP1.4, SubPractice 5, peer reviews
SP1.5, SubPractice 2, thresholds

<u>AFFECTED STAKEHOLDERS:</u>
Project team (Mktg … Mfg)

<u>RESISTANCE:</u>
Accountability - being measured, reporting progress

<u>SPECIAL APPRAISAL CONSIDERATIONS AND CHALLENGES:</u> Prepare, prepare, and prepare - Ensure there is adequate preparation time to review the volume of documentation

<u>RECOMMENDATIONS:</u>
Pilot - pick your project wisely

- IMS, IMP, or …
- New Product Introduction
- Support
- Manufacturing Engineering
- Training
- Technology Transfer
- Manufacturing Master Plan

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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

Project management

- Models - predict
- Metrics - track
- Key performance indicators

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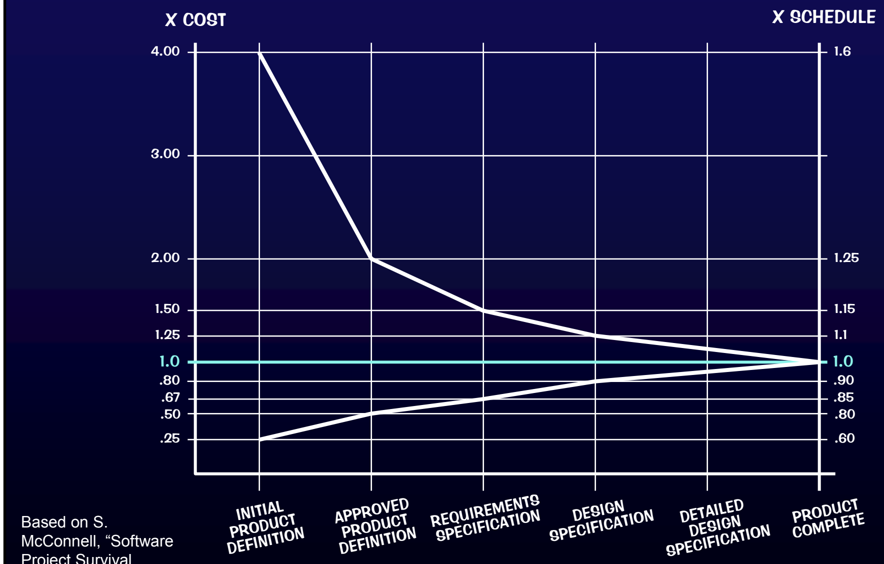
SP 1.2 Use the organizational measurement repository

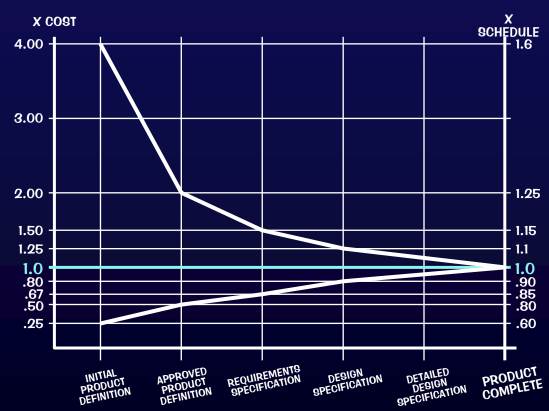
Model variation: set management expectations

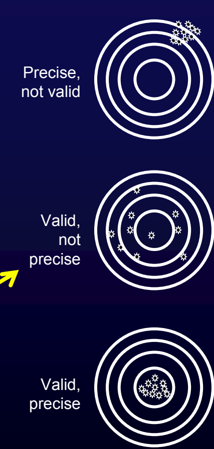


Based on S. McConnell, "Software Project Survival Guide", page 7, MCC2

Manipulating the estimates for software

Myth 2: There is a way to get <u>precise</u>, <u>valid</u> estimates





valid = predictive value
precise = repeatable

What is possible: defined variance

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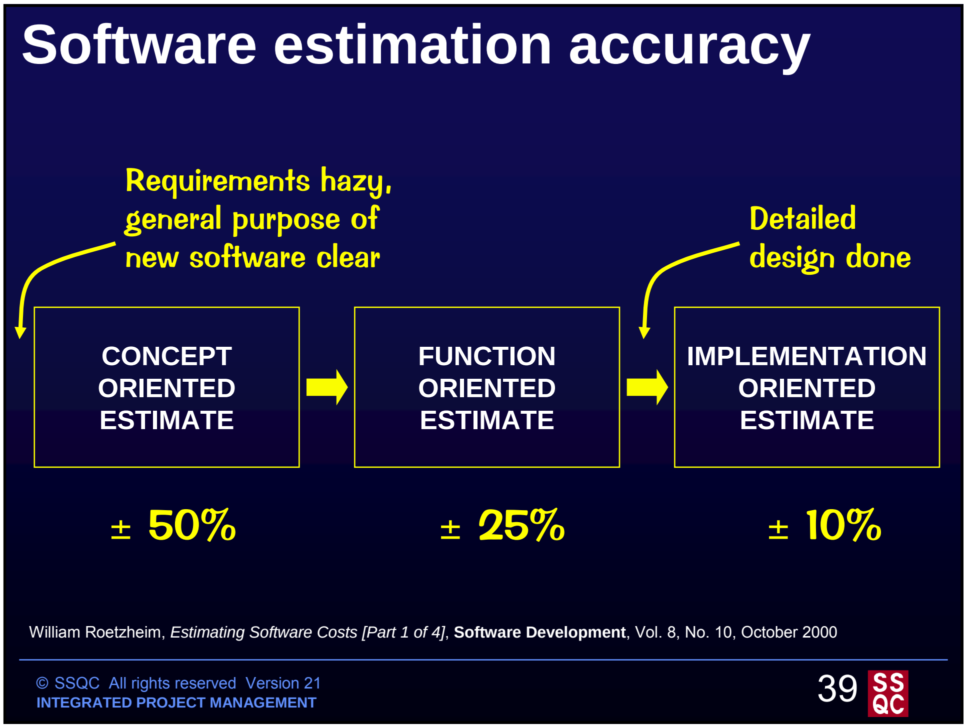
Software estimation accuracy
Requirements hazy, general purpose of new software clear
Detailed design done
CONCEPT ORIENTED ESTIMATE
FUNCTION ORIENTED ESTIMATE
IMPLEMENTATION ORIENTED ESTIMATE
± 50%
± 25%
± 10%
William Roetzheim, *Estimating Software Costs [Part 1 of 4]*, **Software Development**, Vol. 8, No. 10, October 2000
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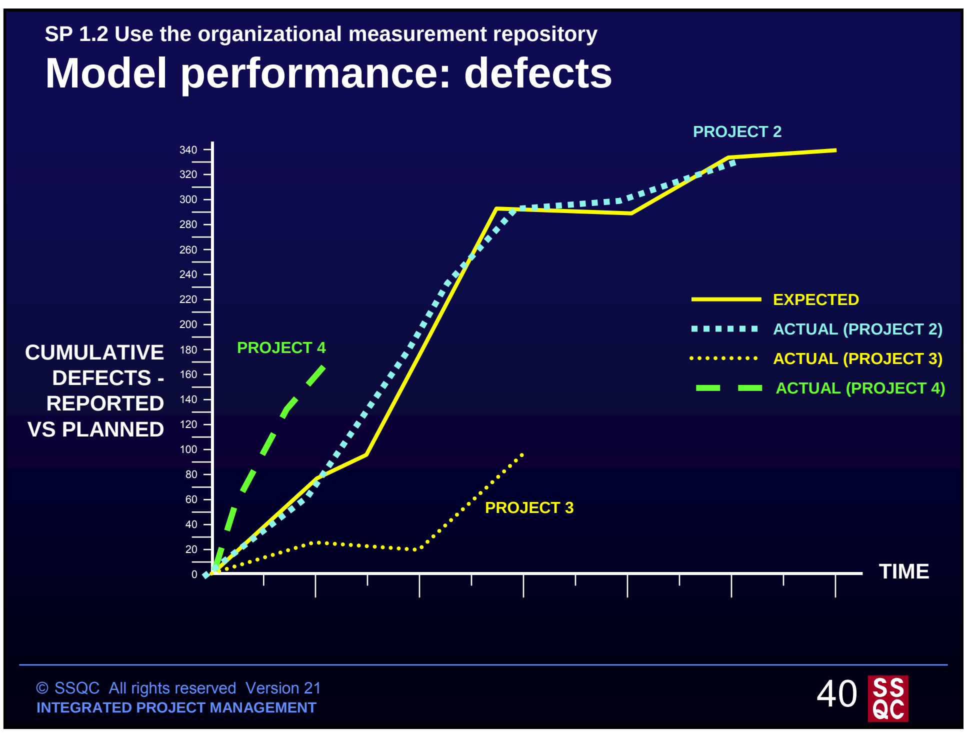
SP 1.2 Use the organizational measurement repository
Model performance: defects
PROJECT 2
PROJECT 4
PROJECT 3
CUMULATIVE DEFECTS - REPORTED VS PLANNED
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TIME
EXPECTED
ACTUAL (PROJECT 2)
ACTUAL (PROJECT 3)
ACTUAL (PROJECT 4)
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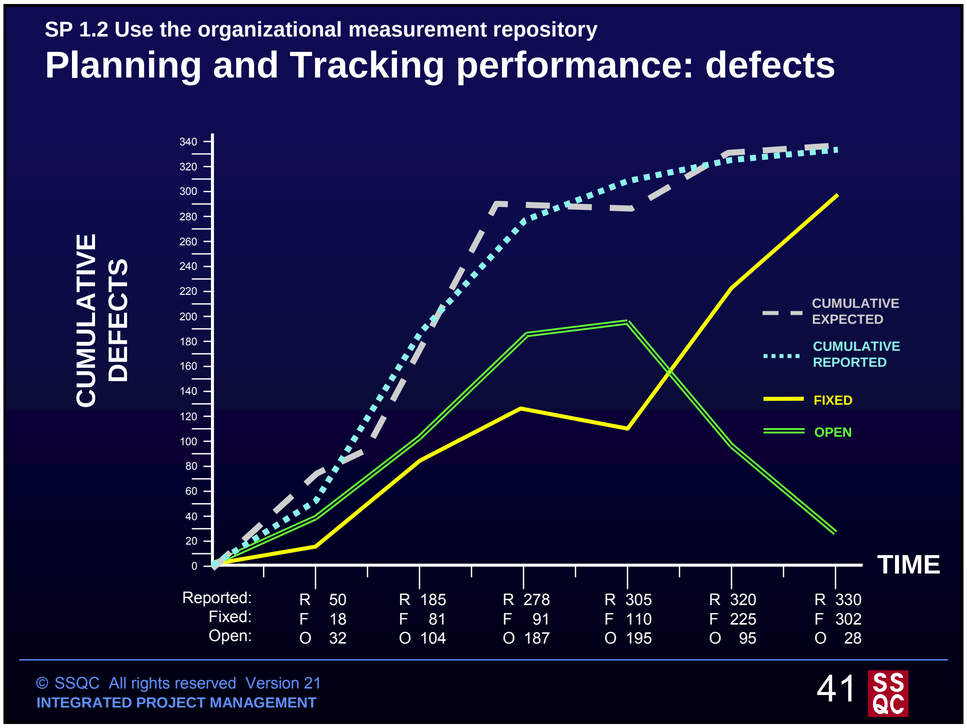

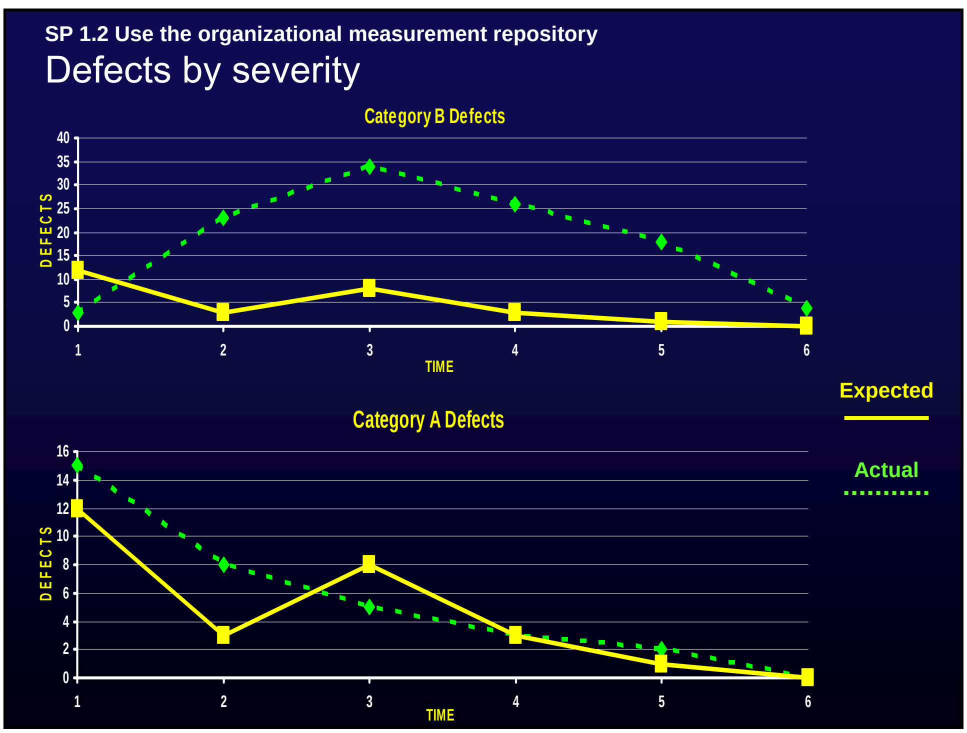

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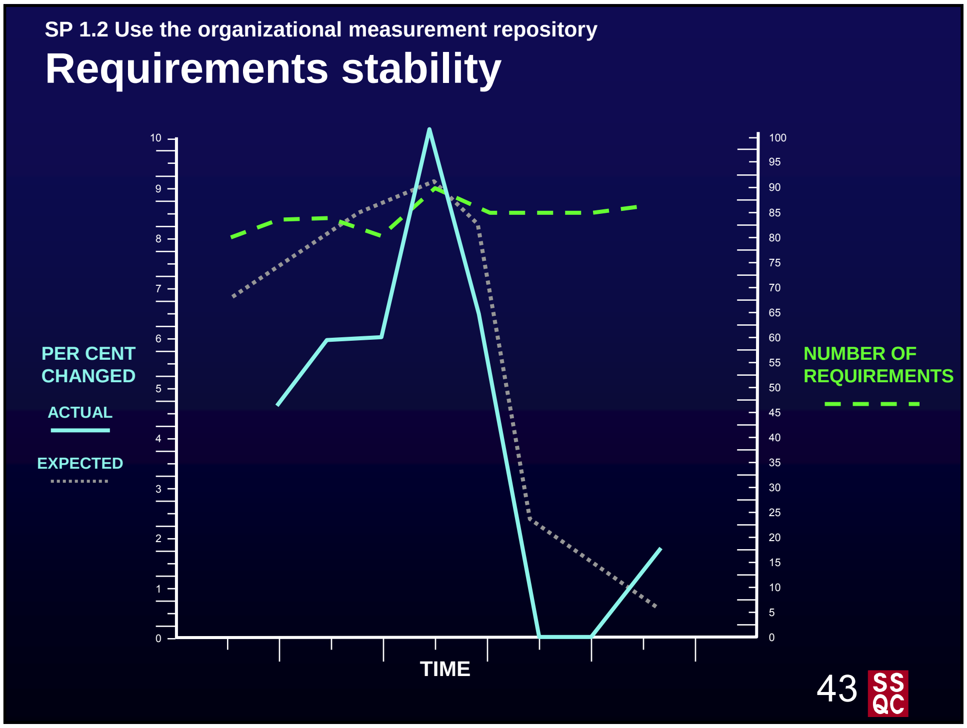

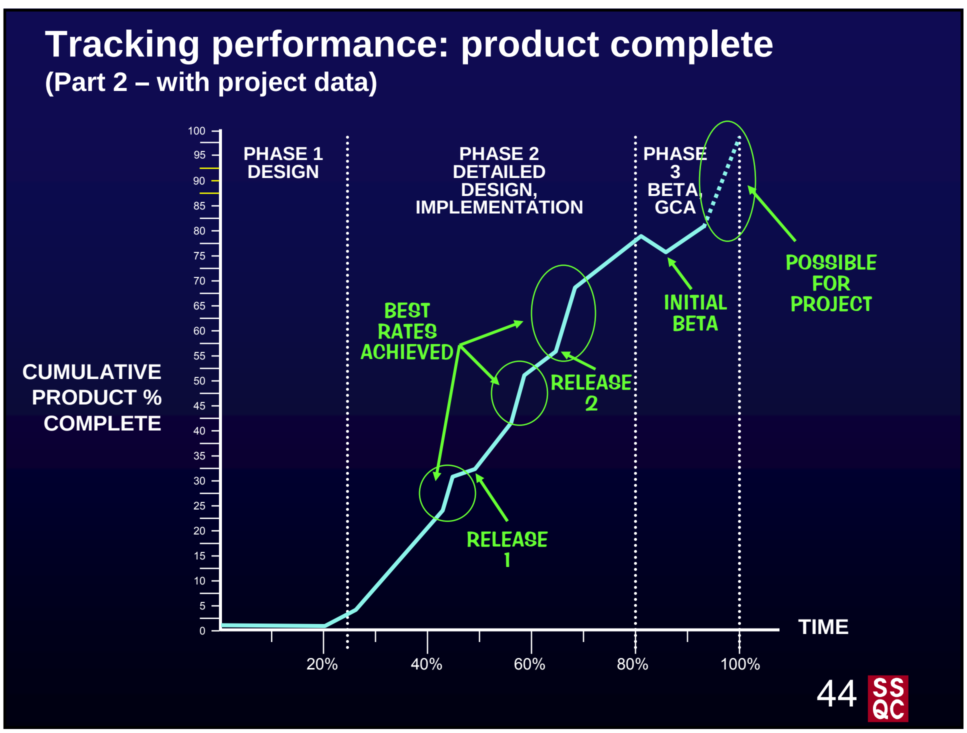

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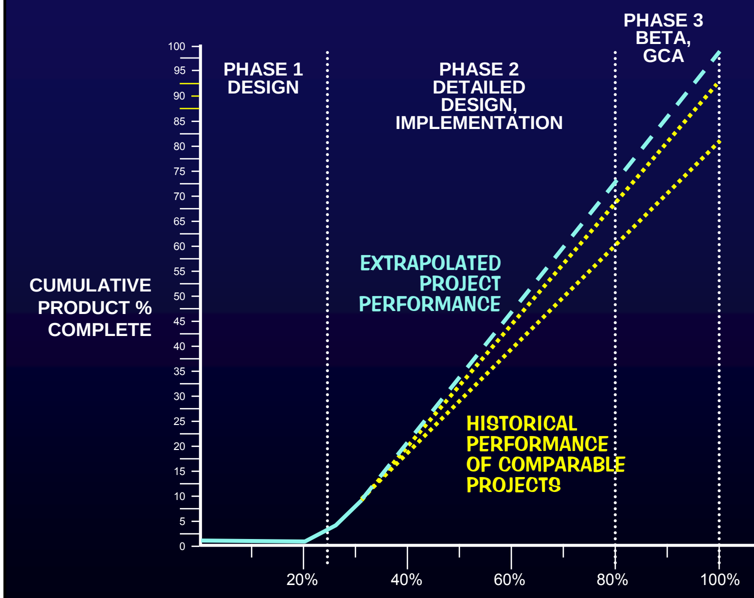
Tracking performance: product complete
(Part 1 – early in the project)



The goal:
Decision support and data-driven management

Cautions:
(1) Managing a project using only historical data is like driving a car using only the rear view mirror.
(2) Managing a project without historical data is like trying to arrive at an appointment in a strange city on time – without asking anyone for help.

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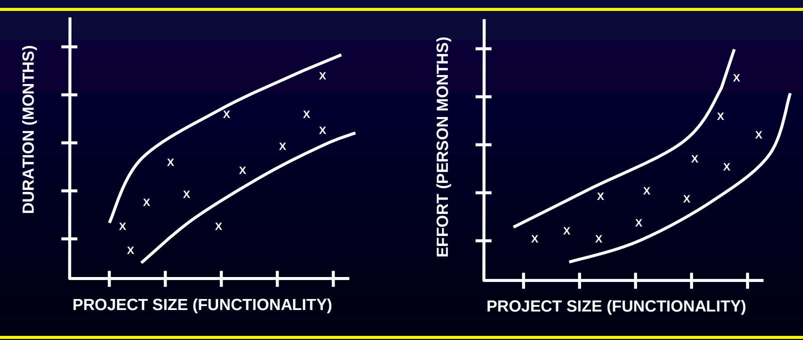
Manipulating the estimates for software

Myth 1: Add staff, compress the schedule

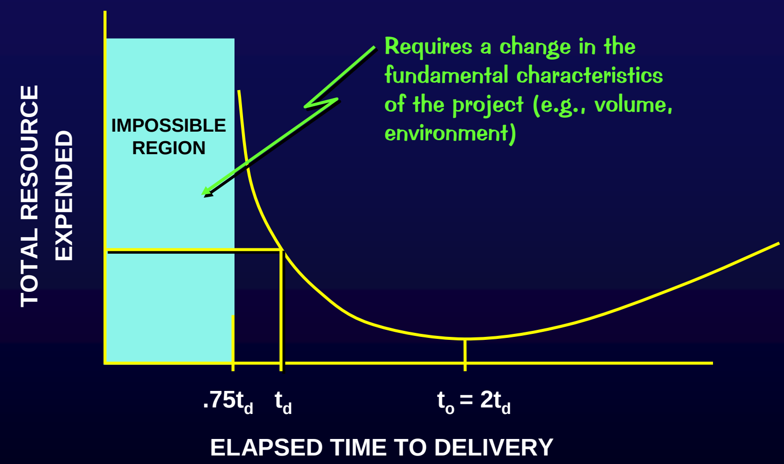
- Brooks' Law: manpower and time not interchangeable
- Based on a nominal schedule, 2x staff:
  - 20% faster
  - 6x defects
  - Coordination complexity = $(n^2-n)/2$
- Supported by core metrics: Size, Time, Effort, Defects (Anita Carleton, CAR1)
- GATHER DATA - Measure, learn from experience

Representing Experience



Michael Mah, MAH1

Myth 1: Add staff ... (cont.)



Roetzheim, ROE1; DOD1;
DeMarco, Controlling Software Projects, Yourdon Press, New York, 1982

t_d = Calculated time of first delivery (from selected Rayleigh Curve or Boehm formula)

t_o = Cost optimal time (least effort and cost)

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

PAG1, Meilir Page-Jones

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Manipulating the estimates for software

Myth 4: Assume we'll make it up later (somehow)

Arbitrarily cut time from activities that are further out (and for which estimates are inherently less accurate and defensible)

- Projects over budget when only 15% complete usually complete with overruns
- Actual completion costs will not improve by more than 10% of the current percent overrun
- For commercial projects
  - 10% late ~ 30% loss in profit
  - 50% cost overrun ~ 3% loss in profit

IPM: Specific goals and practices (cont.)

SPECIFIC GOALS

SG 2 Coordination and collaboration of the project with relevant stakeholders is conducted.

SPECIFIC PRACTICES

SP2.1 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.

V1.1 and V1.2

A critical specific practice

2.2 Manage [critical] dependencies

WHY: make dependencies continuously visible, mitigate or prevent impact

SIGNIFICANT INDICATOR(S):
SP2.2, SubPractice 5 - document the critical dependencies and commitments

AFFECTED STAKEHOLDERS:
Project team (Mktg … Mfg)

RESISTANCE:
Exposure - versus milestone chicken (*or* R = v / π)

SPECIAL APPRAISAL CONSIDERATIONS AND CHALLENGES: Look carefully at SubPractice 6 - track and take action

RECOMMENDATIONS: Pick a pilot project with a strong manager who understands the big picture; ensure team focuses on critical dependencies - avoid blame, focus on solutions

- Identify
- Inform
- Manage - SP 2.2 Subpractice 6
  - On or near critical path; or risk
  - Track and take corrective and preventive action
  - Evaluate the effects of late and early completion for impacts on future activities and milestones

I wish someone had told me …

V1.1 and V1.2

Specific practice 2.2, subpractice 5

5. Document the critical dependencies and commitments.

Documentation of commitments typically includes the following:

- Describing the commitment
- Identifying who made the commitment
- Identifying who is responsible for satisfying the commitment
- Specifying when the commitment will be satisfied
- Specifying the criteria for determining if the commitment has been satisfied

V1.1 and V1.2

Project Planning (PP)

SPECIFIC GOALS

SPECIFIC PRACTICES

SG 1 Estimates of project planning parameters are established and maintained.

- **SP 1.1 Establish … top-level Work Breakdown Structure (WBS)**
- **SP 1.2 Establish and maintain estimates of attributes of the work products and tasks**
- **SP 1.3 Define project life cycle phases …**
- **SP 1.4 Estimate … effort and cost for work products and tasks …**

SG 2 A project plan is established and maintained as the basis for managing the project.

- **SP 2.1 Establish and maintain budget and schedule**
- **SP 2.2 Identify and analyze risks**
- **SP 2.3 Plan for data management** [documentation, all forms]
- **SP 2.4 Plan for … resources**
- **SP 2.5 Plan for knowledge and skills**
- **SP 2.6 Plan stakeholder involvement**
- **SP 2.7 Establish and maintain the overall project plan**

SG 3 Commitments to the project plan are established and maintained.

- **SP 3.1 Review all plans that affect the project …**
- **SP 3.2 Reconcile plan to reflect available and estimated resources**
- **SP 3.3 Obtain commitment from relevant stakeholders**

V1.1 and V1.2

Life cycles and life cycles

From Project Planning (PP), Specific Practice 1.3

Define the project lifecycle phases 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.

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

INTEGRATED PROJECT MANAGEMENT

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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) design/development, (4) production, and (5) phase out.

See CMMI V1.1, Chapter 3

INTEGRATED PROJECT MANAGEMENT

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Life cycles and life cycles (cont.)

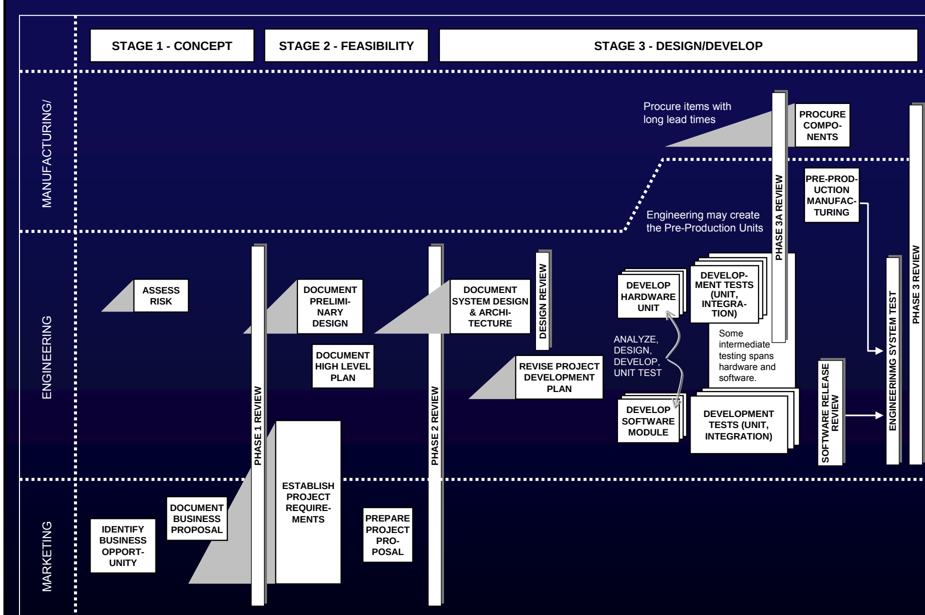
From the Glossary, Integrated Product and Process Development is

> 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.

~V1.1 and V1.2



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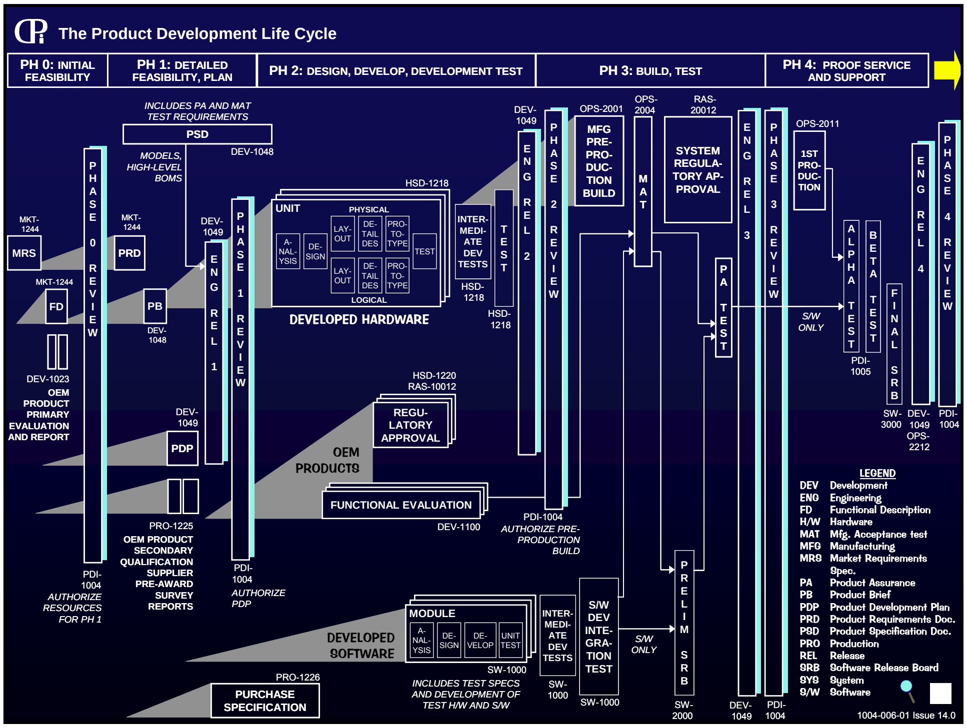
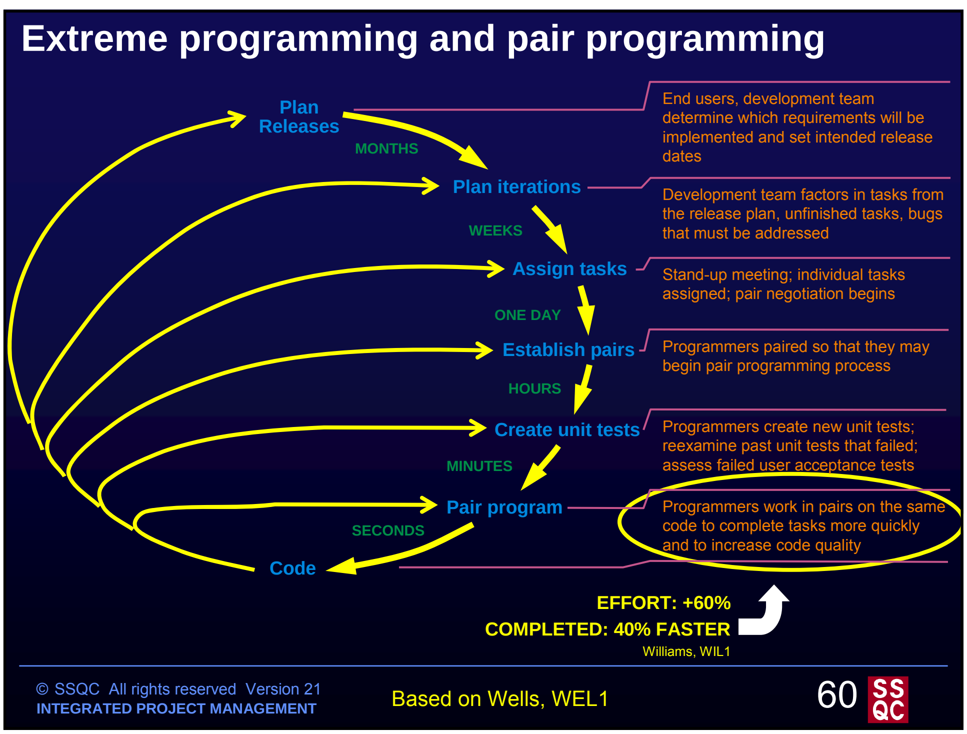

The Product Development Life Cycle
PH 0: INITIAL FEASIBILITY
PH 1: DETAILED FEASIBILITY, PLAN
PH 2: DESIGN, DEVELOP, DEVELOPMENT TEST
PH 3: BUILD, TEST
PH 4: PROOF SERVICE AND SUPPORT
INCLUDES PA AND MAT TEST REQUIREMENTS
PSD
DEV-1048
MODELS, HIGH-LEVEL BOMS
MRS
PRD
FD
PB
PDP
PHASE 0 REVIEW
PHASE 1 REVIEW
PHASE 2 REVIEW
PHASE 3 REVIEW
PHASE 4 REVIEW
ENG REL 1
ENG REL 2
ENG REL 3
ENG REL 4
DEV-1023
OEM PRODUCT PRIMARY EVALUATION AND REPORT
PRO-1225
OEM PRODUCT SECONDARY QUALIFICATION SUPPLIER PRE-AWARD SURVEY REPORTS
PDI-1004
AUTHORIZE RESOURCES FOR PH 1
AUTHORIZE PDP
UNIT
PHYSICAL
LOGICAL
DEVELOPED HARDWARE
HSD-1218
INTER-MEDI-ATE DEV TESTS
TEST
HSD-1220
RAS-10012
REGU-LATORY APPROVAL
OEM PRODUCTS
FUNCTIONAL EVALUATION
DEV-1100
AUTHORIZE PRE-PRODUCTION BUILD
OPS-2001
MFG PRE-PRO-DUC-TION BUILD
OPS-2004
MAT
RAS-20012
SYSTEM REGULA-TORY AP-PROVAL
PA TEST
OPS-2011
1ST PRO-DUC-TION
ALPHA TEST
BETA TEST
FINAL SRB
S/W ONLY
PDI-1005
MODULE
DEVELOPED SOFTWARE
SW-1000
INCLUDES TEST SPECS AND DEVELOPMENT OF TEST H/W AND S/W
S/W DEV INTE-GRA-TION TEST
PRELIM SRB
SW-2000
PRO-1226
PURCHASE SPECIFICATION
LEGEND
DEV Development
ENG Engineering
FD Functional Description
H/W Hardware
MAT Mfg. Acceptance test
MFG Manufacturing
MRS Market Requirements Spec.
PA Product Assurance
PB Product Brief
PDP Product Development Plan
PRD Product Requirements Doc.
PSD Product Specification Doc.
PRO Production
REL Release
SRB Software Release Board
SYS System
S/W Software
1004-006-01 Issue 14.0


Extreme programming and pair programming
Plan Releases
MONTHS
Plan iterations
WEEKS
Assign tasks
ONE DAY
Establish pairs
HOURS
Create unit tests
MINUTES
Pair program
SECONDS
Code
End users, development team determine which requirements will be implemented and set intended release dates
Development team factors in tasks from the release plan, unfinished tasks, bugs that must be addressed
Stand-up meeting; individual tasks assigned; pair negotiation begins
Programmers paired so that they may begin pair programming process
Programmers create new unit tests; reexamine past unit tests that failed; assess failed user acceptance tests
Programmers work in pairs on the same code to complete tasks more quickly and to increase code quality
EFFORT: +60%
COMPLETED: 40% FASTER
Williams, WIL1
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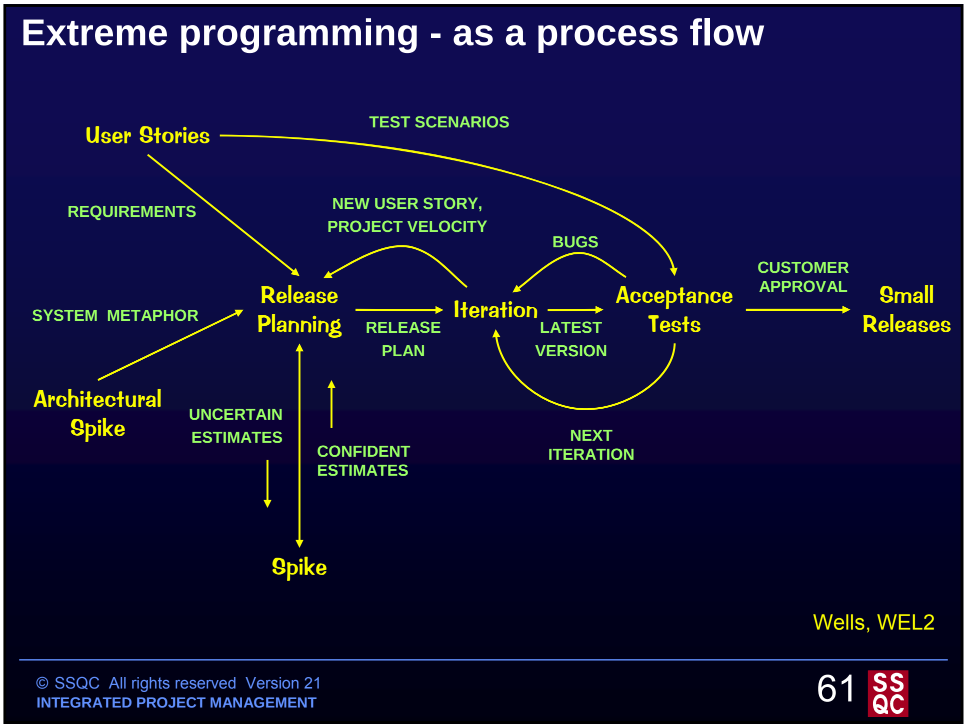
INTEGRATED PROJECT MANAGEMENT
Based on Wells, WEL1
60


Extreme programming - as a process flow
User Stories
TEST SCENARIOS
REQUIREMENTS
NEW USER STORY,
PROJECT VELOCITY
BUGS
CUSTOMER
APPROVAL
Release
Planning
Iteration
Acceptance
Tests
Small
Releases
SYSTEM METAPHOR
RELEASE
PLAN
LATEST
VERSION
Architectural
Spike
UNCERTAIN
ESTIMATES
CONFIDENT
ESTIMATES
NEXT
ITERATION
Spike
Wells, WEL2
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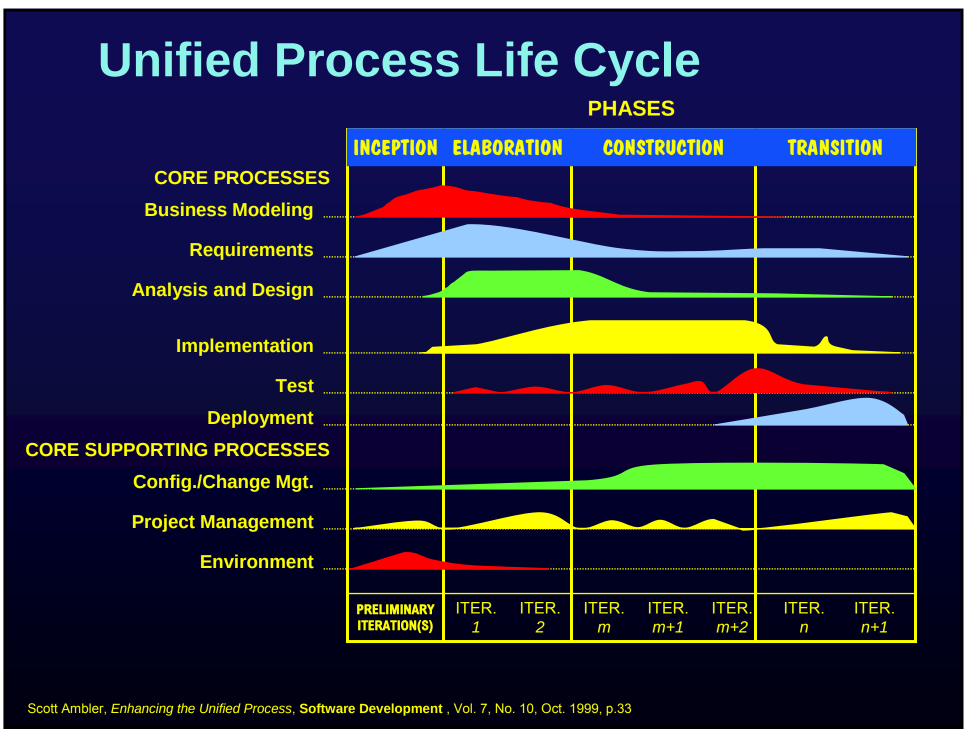
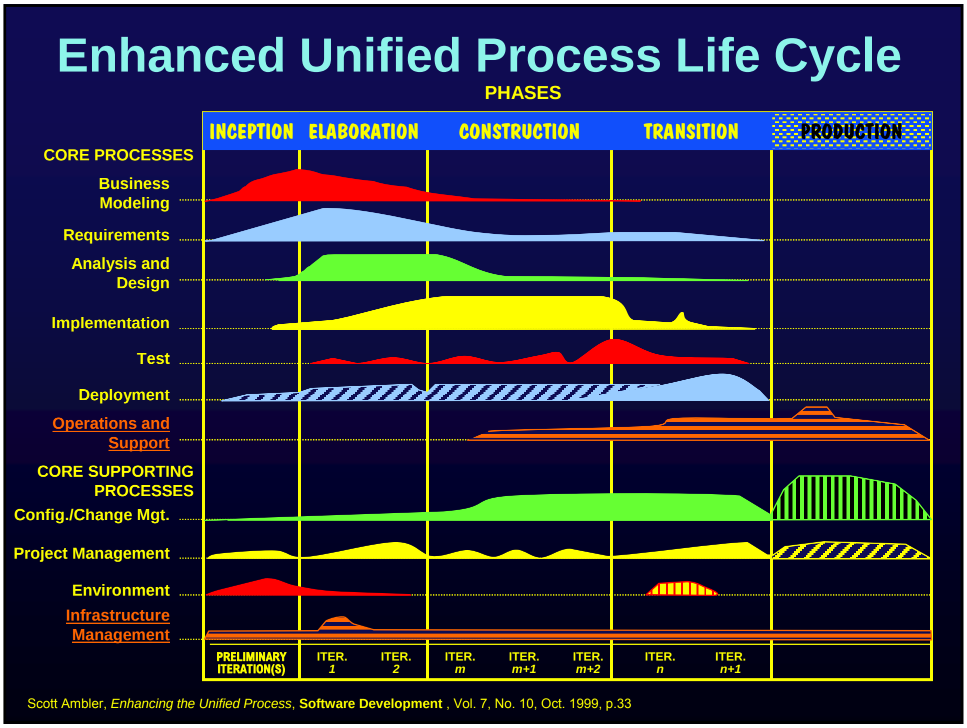
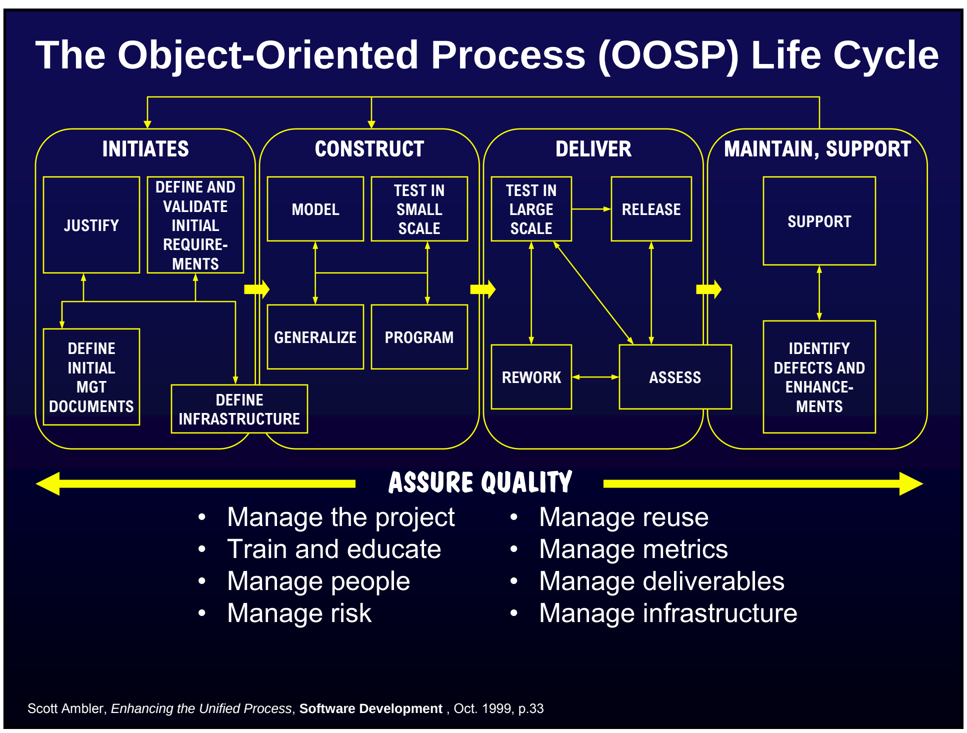
INTEGRATED PROJECT MANAGEMENT
61
SS QC


Unified Process Life Cycle
PHASES
INCEPTION
ELABORATION
CONSTRUCTION
TRANSITION
CORE PROCESSES
Business Modeling
Requirements
Analysis and Design
Implementation
Test
Deployment
CORE SUPPORTING PROCESSES
Config./Change Mgt.
Project Management
Environment
PRELIMINARY ITERATION(S)
ITER. 1
ITER. 2
ITER. m
ITER. m+1
ITER. m+2
ITER. n
ITER. n+1
Scott Ambler, Enhancing the Unified Process, Software Development , Vol. 7, No. 10, Oct. 1999, p.33


Enhanced Unified Process Life Cycle
PHASES
INCEPTION
ELABORATION
CONSTRUCTION
TRANSITION
PRODUCTION
CORE PROCESSES
Business Modeling
Requirements
Analysis and Design
Implementation
Test
Deployment
Operations and Support
CORE SUPPORTING PROCESSES
Config./Change Mgt.
Project Management
Environment
Infrastructure Management
PRELIMINARY ITERATION(S)
ITER. 1
ITER. 2
ITER. m
ITER. m+1
ITER. m+2
ITER. n
ITER. n+1
Scott Ambler, Enhancing the Unified Process, Software Development , Vol. 7, No. 10, Oct. 1999, p.33


The Object-Oriented Process (OOSP) Life Cycle
INITIATES
JUSTIFY
DEFINE AND VALIDATE INITIAL REQUIRE-MENTS
DEFINE INITIAL MGT DOCUMENTS
DEFINE INFRASTRUCTURE
CONSTRUCT
MODEL
TEST IN SMALL SCALE
GENERALIZE
PROGRAM
DELIVER
TEST IN LARGE SCALE
RELEASE
REWORK
ASSESS
MAINTAIN, SUPPORT
SUPPORT
IDENTIFY DEFECTS AND ENHANCE-MENTS
ASSURE QUALITY
• Manage the project
• Train and educate
• Manage people
• Manage risk
• Manage reuse
• Manage metrics
• Manage deliverables
• Manage infrastructure
Scott Ambler, Enhancing the Unified Process, Software Development , Oct. 1999, p.33

Project Monitoring and Control (PMC)

SPECIFIC GOALS

SG 1 Actual performance and progress of the project are monitored against the project plan.

SPECIFIC PRACTICES

Monitor actuals against the plan:

- SP 1.1 Parameters
- SP 1.2 Commitments
- SP 1.3 Risks
- SP 1.4 Data management
- SP 1.5 Stakeholder involvement
- SP 1.6 Periodically review progress, performance, issues
- SP 1.7 Review accomplishments and results at selected milestones

SG 2 Corrective actions are managed to closure when the 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.
- SP 2.3 Manage corrective actions to closure ... *complete ... effective*.

NOTE The word *dependency* does not appear in Project Monitoring and Control.

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 than in V1.1
  - 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 GOALS

SG 1 The project is conducted using a defined process that is tailored from the organization's set of standard processes.

SG 2 Coordination and collaboration of the project with relevant stakeholders is conducted.

SG 3 The project is managed using IPPD principles.

From CMMI V1.1, IPM SG 3 and SG 4 and IT SG 1 and SG 2 are combined in V1.2 IPM SG 3

SPECIFIC PRACTICES

SP 3.1 Establish and maintain a shared vision for the project.

SP 3.2 Establish and maintain the integrated team structure for the project.

SP 3.3 Allocate requirements, responsibilities, tasks and interfaces to teams in the integrated team structure.

SP 3.4 Establish and maintain integrated teams in the structure.

SP 3.5 Ensure collaboration among interfacing teams

Case Study: AJ OY

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Integrated Product and Process Development (IPPD) - Beyond IPM

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

IPPD addition

~~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.~~

SP 1.2 – "same rigor"

Core Model Content – not IPPD addition

V 1.2

Integrated Project Management (IPM)

SP 1.3 Establish and maintain the project's work environment based on the organization's work environment standards (NEW)

Organizational Process Definition (OPD)

SP 1.6 Establish and maintain work environment standards (NEW)

All PAs

GP 2.3 Resources

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NEW

~~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.

V1.2: 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.

~~V 1.1 Integrated Teaming (IT)~~

SPECIFIC GOALS

SG1 A team composition that provides the knowledge and skills required to deliver the team's product is established and maintained.

SG2 Operation of the integrated team is governed according to established principles.

V 1.2: Integrated Project Management (IPM)

SPECIFIC GOALS

SG 3 The project is managed using IPPD principles.

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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

KDRs - The simple truth

KDR REPORT - 01/14 - PHLM Project

WBS/DESCRIPTION	START ORIGINAL	START LAST	START CURRENT	START ACTUAL
1 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 advantage of early completion of 1

3.1 Adjusted for 1 week slip in 1

Expect to make up time and not slip subsequent steps by adding 1 engineer to project.

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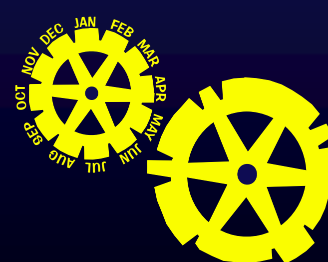
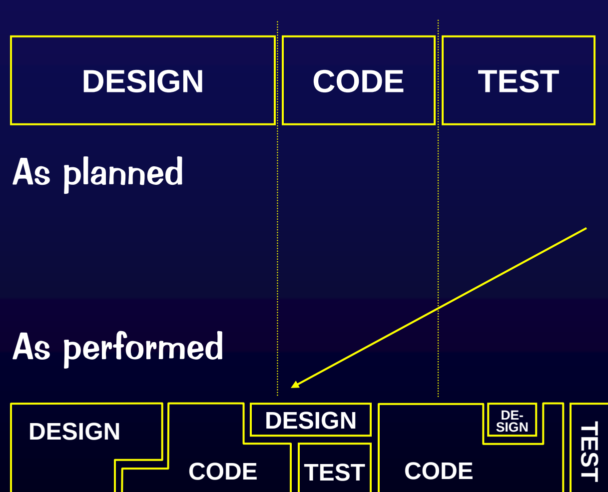
Tracking performance against the plan: Earned Value

- Assumes regular time or effort reporting
  - Sufficient detail to identify work product and activity
- System(s) to report
  - Cost or effort against plan
  - Completion of work against plan



Planning versus reality



Q May I please see the design.

A Well, we just pulled it back to do some more work on it, but we're way ahead of schedule on the code and we're about to start some testing.

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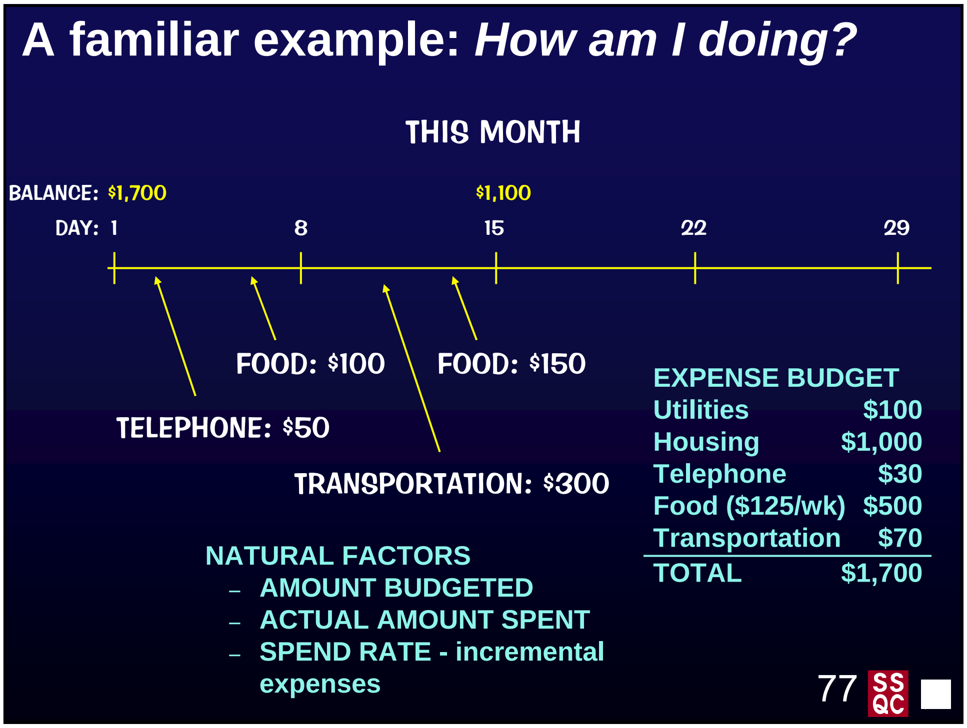
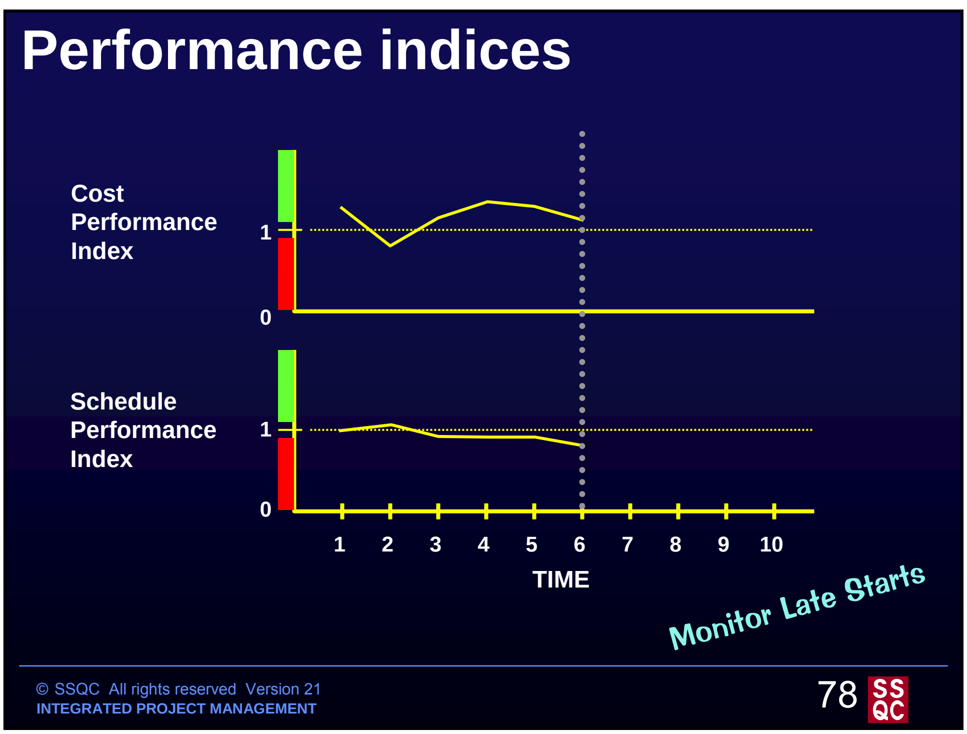

A familiar example: How am I doing?
THIS MONTH
BALANCE: $1,700
$1,100
DAY: 1
8
15
22
29
FOOD: $100
FOOD: $150
TELEPHONE: $50
TRANSPORTATION: $300
NATURAL FACTORS
– AMOUNT BUDGETED
– ACTUAL AMOUNT SPENT
– SPEND RATE - incremental expenses
EXPENSE BUDGET
Utilities $100
Housing $1,000
Telephone $30
Food ($125/wk) $500
Transportation $70
TOTAL $1,700
77


Performance indices
Cost Performance Index
1
0
Schedule Performance Index
1
0
1 2 3 4 5 6 7 8 9 10
TIME
Monitor Late Starts
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INTEGRATED PROJECT MANAGEMENT
78

Monitor late starts to detect *figuring*

DEFERRED START REPORT - 01/14

WBS	DESCRIPTION	ORIGINAL	START LAST	START CURRENT	ACTUAL	RISK
12.1	Beta Algorithm Detailed Design	01/07		01/21		HI
15.1	Alpha Algorithm Test Specification	01/07		01/14	01/13	
15.1	Fault Tree Test Specification	01/07	01/14	01/21		LO
19.1	High Performance Beta Plan	12/01	01/14	01/21		HI

COMMENTS ON HIGH RISK ITEMS

12.1 The assigned engineer has still not been released from the previous assignment. Current release date is 1/15. Another engineer has been assigned as a back up, but is just starting to learn the class library.

19.1 Marketing has still not identified a target customer. This is not a significant issue since the generic high-performance beta plan only needs to be tailored for the specific customer's configuration.

IPM: Required ordering? *No, but …*

TIME

- SP1.1 Establish the project's defined process
- SP1.2 Use organizational process assets for planning project activities
- SP1.3 Integrate plans
- SP1.4 Manage the project using the integrated plans
- SP1.5 Contribute to the organization's process assets

- SP2.1 Manage stakeholder involvement
- SP2.2 Manage dependen-cies
- SP2.3 Resolve coordina-tion issues

There is a natural, logical ordering.

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Examining the Generic Practices through 3.2

GG2 The [Integrated Project Management] process is institutionalized as a managed process	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3 The [Integrated Project Management] process is institutionalized as a defined process	3.1	Establish a defined process
	3.2	Collect improvement information

V1.1 and V1.2

Examining the Generic Practices through 3.2

GG2	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3	3.1	Establish a defined process
	3.2	Collect improvement information

☑ Address in Project Planning policy: require processes be followed

… or in a general policy that requires that processes be followed

☑ Address as tasks in Project Planning procedures for planning and re-planning throughout life cycle – augmented for Integrated Project Management activities

MORE ON GP 2.2 LATER

Examining the Generic Practices through 3.2 (cont.)

GG2	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3	3.1	Establish a defined process
	3.2	Collect improvement information

Two stages of training

- During implementation and roll-out
  - Address development and delivery of initial training in Integrated Project Management portion of CMMI implementation plan
  - Identify role-based skills needs
  - Address development and piloting of on-going training capability as part of implementation plan
- On-going, post-implementation delivery
  - Address in "operator" skills requirements in Project Planning procedures
    - Add role-based skills needs to procedures [team related skills]
    - Identify sources of training
    - Assign responsibility for providing (e.g., immediate manager)
- See Organizational Training (OT) Process Area

Examining the Generic Practices through 3.2 (cont.)

GG2	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3	3.1	Establish a defined process
	3.2	Collect improvement information

☑ Address as tasks in the Project Planning procedures

- Identify, control [revise, update], status, audit
- Configuration management of planning work products
- Examples of the work products of the project planning process include:
  - Estimates and assumptions
  - Historical data
  - Models
  - WBS
  - Plans
  - Schedules
  - Team charters
  - IPT processes
  - IPT hierarchy (SEIT, IIPT) – responsibility and authority
- See the Configuration Management (CM) Process Area

Examining the Generic Practices through 3.2 (cont.)

GG2	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3	3.1	Establish a defined process
	3.2	Collect improvement information

☑ Address in tasks for planning, review and approval in Project Planning procedures (change requests, artifacts)

☑ Address as tasks in Project Planning procedures for planning the planning and replanning process (GP 2.2) and reporting (phase dependent)

- Based on selected product life cycle
- Consider whether planning tools can automatically produce relevant measures
  - Change requests - status, progress
  - Plan content - per cent complete
  - Effort expended in planning and replanning activities

Examining the Generic Practices through 3.2 (cont.)

GG2	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3	3.1	Establish a defined process
	3.2	Collect improvement information

☑ Address as tasks in Project Planning procedures (phase dependent, periodic)

... and as part of the Process and Product Quality Assurance (PPQA) process(es)

- Provide checklists to support objective evaluation of Project Planning work products and activities – as augmented by IPM work products and activities

☑ Address as tasks for review of activities by higher-level management in Project Planning procedures

... and as part of the standard reporting in the Project Monitoring and Control (PMC) Process Area

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Examining the Generic Practices through 3.2 (cont.)

GG2	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3	3.1	Establish a defined process
	3.2	Collect improvement information

- ☑ Define in scope statement in the <u>Project Planning</u> policy or procedures
- ☑ Tailoring
  - Include a tailoring section in the <u>Project Planning</u> procedures
    - Options
    - Eligibility or selection criteria
  - Include as "if" statements in procedure
  - Allow for substitutions and exemptions
    - Contract or business requirements

Examining the Generic Practices through 3.2 (cont.)

GG2	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3	3.1	Establish a defined process
	3.2	Collect improvement information

- ☑ Define output and tasks in the <u>Project Planning</u> procedures
  - Process change requests
    - Submission (how, who to?), evaluation, approval
    - Identify process owner(s)
  - Ensure that the Project Planning processes and, if appropriate, the tool <u>automatically</u> generate suitable data to support management's information needs
    - Change requests - status, progress
    - Plan content - per cent complete
    - Effort expended in Project Planning (and replanning) activities
  - Integrated Project Management (IPM) SP 1.5: contribute work products and measures ...

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Generic Practice 2.2 Revisited

GG2 The [Integrated Project Management] process is institutionalized as a managed process

GP 2.2 Establish and maintain the plan for performing the process.
The plan typically includes the following:

- Process description[s]
- Standards and requirements for the work products and services of the process[es]
- Specific objectives for the performance of the process (quality, time, etc.)
- Dependencies
- Resources
- Responsibility and authority
- Training needed
- Work products to be placed under configuration management, level of management
- Measurement
- Involvement of stakeholders
- Activities for monitoring and control
- Objective evaluation activities of the process
- Management review activities for process and work products

- GG 2 and GP 2.2 apply to and appear in every Process Area
- For Project Planning, GP 2.2 addresses PLAN THE PLAN
  - May not be a project yet
  - Incorporate planning for IPM tasks and activities

~V1.1 and V1.2

Schedule: when in life cycle and what level

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GP 2.2 and the other GPs

GP 2.2 Establish and maintain the plan for performing the process.
The plan typically includes the following:

- Process description[s]
- Standards and requirements for the work products and services of the process[es]
- Specific objectives for the performance of the process (quality, time, etc.)
- Dependencies
- Resources
- Responsibility and authority
- Training needed
- Work products to be placed under configuration management, level of management
- Measurement
- Involvement of stakeholders
- Activities for monitoring and control
- Objective evaluation activities of the process
- Management review activities for process and work products

GG2	2.1	Establish an organizational policy
	2.2	Plan the process
	2.3	Provide resources
	2.4	Assign responsibility
	2.5	Train people
	2.6	Manage configurations
	2.7	Identify and involve relevant stakeholders
	2.8	Monitor and control the process
	2.9	Objectively evaluate adherence
	2.10	Review status with higher level management
GG3	3.1	Establish a defined process
	3.2	Collect improvement information

~V1.1 and V1.2

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Generic Practice 2.2 Revisited (cont.)

Generic Practice 2.2, Subpractice 1

1. Define and document the plan for performing the process.

   This plan may be a stand-alone document, embedded in a more comprehensive document, or distributed across multiple documents. In the case of the plan being distributed across multiple documents, ensure that a coherent picture of who does what is preserved. Documents may be hardcopy or softcopy.

Subpractice 3 in V1.1

Tools and tips

- No shortage of tools (free and otherwise) for collaboration,
- BUT ...
  - Process first
  - Tools second

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Start-up checklist for Integrated Project Management

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

➋ Define interfaces with internal organizations
  - Establish risk management process (critical dependencies)
  - Establish change management process
  - Apply appropriate metrics

➌ Align organization with life cycle

➍ Align working environments and collaboration tools

➎ Ensure training takes place

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Typical implementation opportunities - Business acquisition and proposal

➊ Define interfaces with internal organizations

➋ Requirements analysis - capability

➌ Requirements definition

➍ Requirements change management

➎ Estimation

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Typical implementation opportunities - Development

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

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❹ Configuration management
- Controls for change

❺ Maintenance
- Lifecycle scaleability
- External problem resolution

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Typical implementation opportunities - Manufacturing

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

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Typical implementation opportunities - Services and Support

➊ Define interfaces with internal organizations
➋ Planning to ensure capability to meet commitments
  - New business (resources and training)
  - New types of service (process engineering)
➌ 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?**			

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2. The Pressure Cooker	MOTIVATION of Engineer	IMPACT of Engineer's Actions	YOUR ACTION (Project Engineering Manager)
There is an engineer who dependably produces world-class work products, but who works best under pressure. He spends a great deal of time thinking about the assignment, working on problems, helping other people. As a result, the bulk of his truly brilliant work is produced just before the deadline. **You are a Project Engineering Manager, to whom the engineer reports. What can you do?**			

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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. 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?**			

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4. Sinatra	MOTIVATION of Engineer	IMPACT of Engineer's Actions	YOUR ACTION (Project 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?**			

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5. Cleo - the view from the top	MOTIVATION of Software Manager	IMPACT of Software Manager's Actions	YOUR ACTION (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 else can you do?**			

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6. Cleo - the other side	MOTIVATION of VP Engineering	IMPACT of VP Engineering's Actions	YOUR ACTION (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. **You are the Software Manager. What can you do?**			

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7. Cleo, Part II - no problem	MOTIVATION of Software Manager	IMPACT of Software Manager's Actions	YOUR ACTION (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?**			

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8.	MOTIVATION of ____________________	IMPACT of _________________'s Actions	ACTION of (x)______________________
You are the (x)__________. What can you do?			

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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.

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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	

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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.

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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.		

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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 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.		

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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.		
SG 2 Corrective actions are managed to closure when the 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. **SP 2.3** 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.

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Key Deliverables Review Project Presentation Template

Date	
Project	
Project Manager	

MARK ONE

PROJECT STATUS ☐ **GREEN** ☐ **YELLOW** ☐ **RED**

▲	WBS Item	Description	Completion Date: 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
DTD	Detailed Design
PP	Project Plan
PRD	Product Requirements Document
RTM	Release to Manufacturing
WBS	Work Breakdown Structure
LA	Limited Availability
KDR	Key Deliverables Review
PIP	Product Introduction Plan
RTS	Release to Ship
START	Start

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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
- ❑ Preliminary 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

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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

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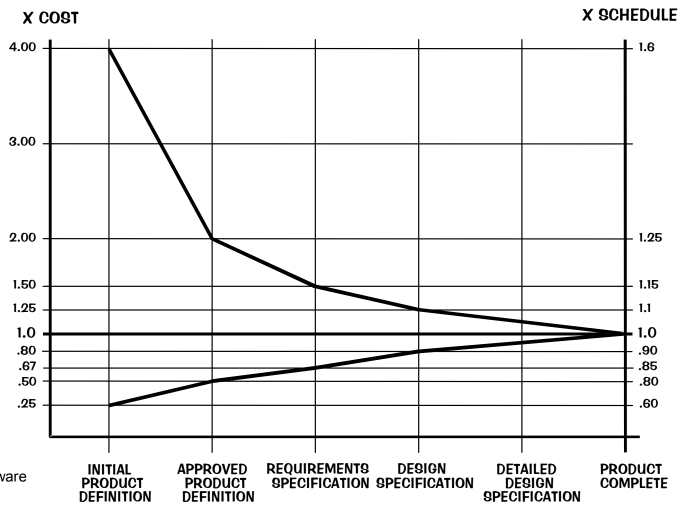
Key Performance Indicators (KPI)

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



Based on S. McConnell, "Software Project Survival Guide", page 7

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

In the example, for Schedule, at Initial Project Definition, 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 Requirements Specification, 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.

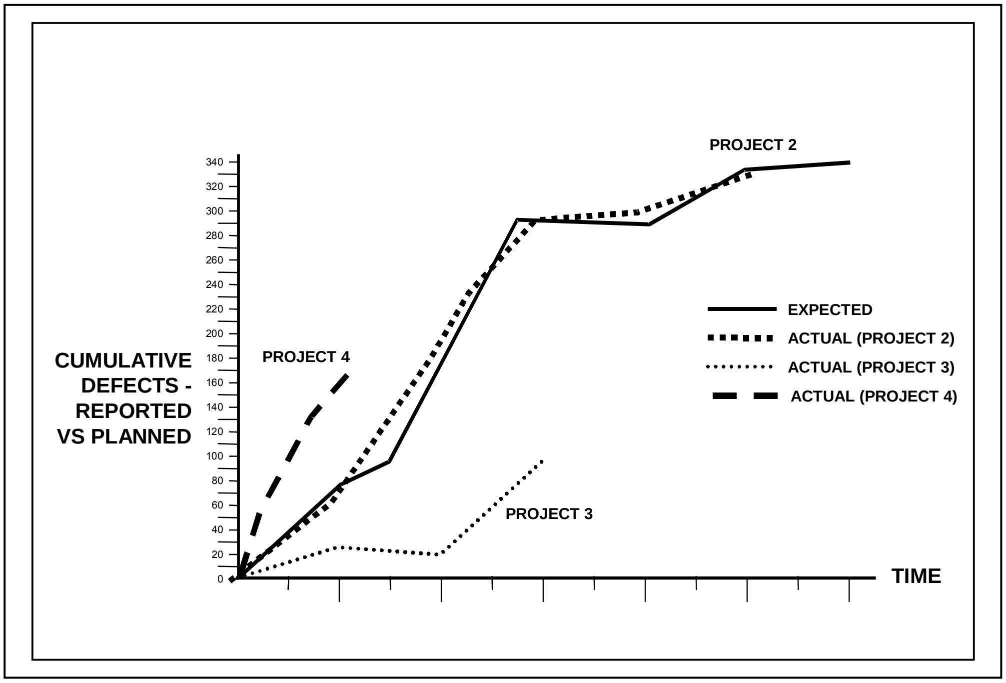
In the example, activities that take place between Approved Product Definition and Requirements Specification are monitored against a plan that historically ranges from 1.15 times the actual schedule to .85 times the actual schedule. An activity planned for completion in 20 days may extend to 24 days 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.

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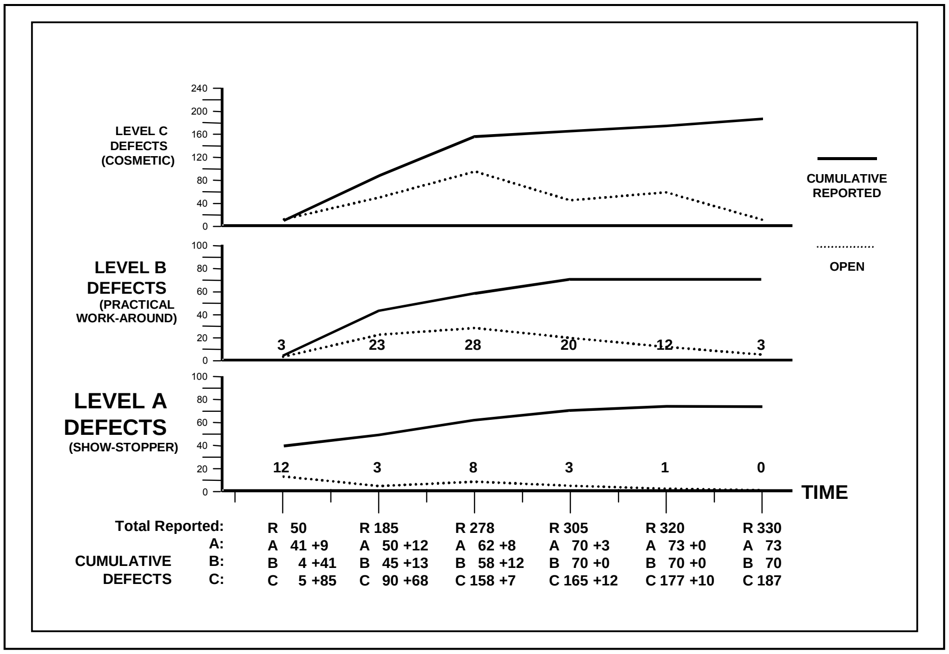


In this example, cumulative reported defects and remaining open defects are represented. Labels on the open defect line provide precise counts of the Level A and Level B defects remaining open. Spreadsheet-style captions below the X axis provide complete detail on the number of new defects added to the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

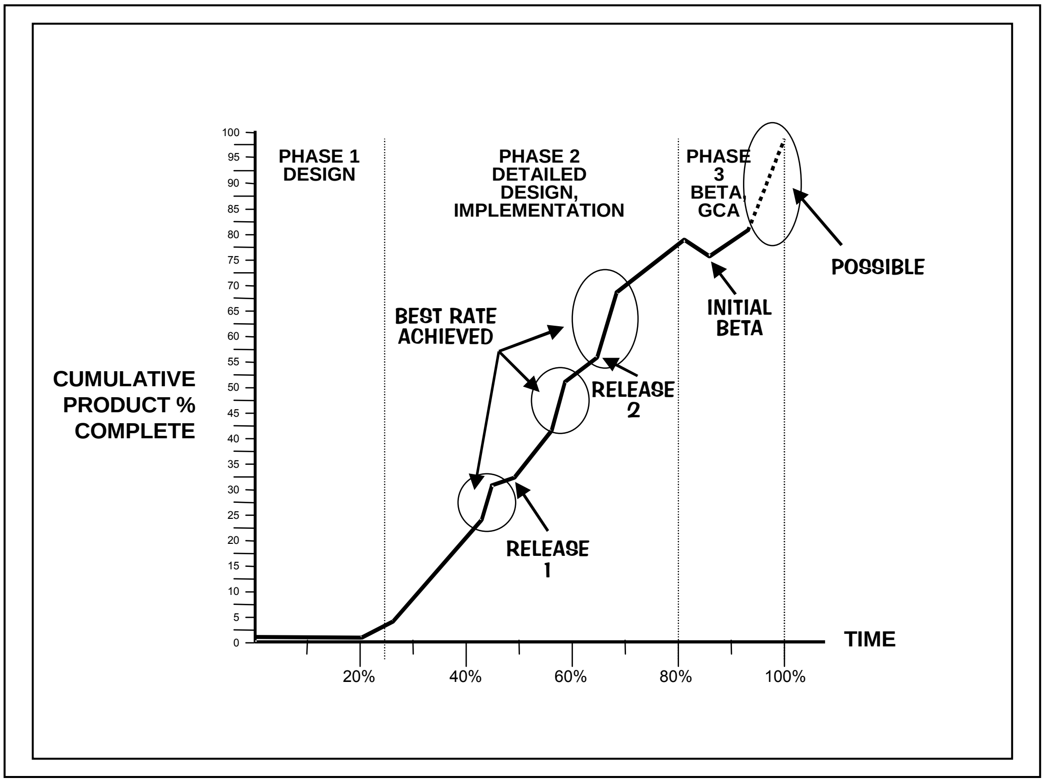
Suggested Application

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.

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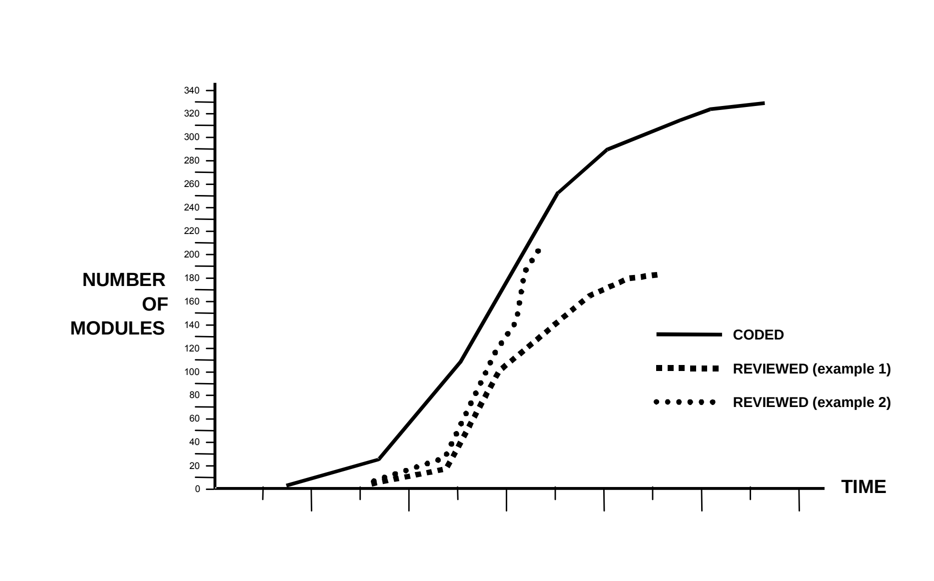
Metric 4: Verification activities

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.

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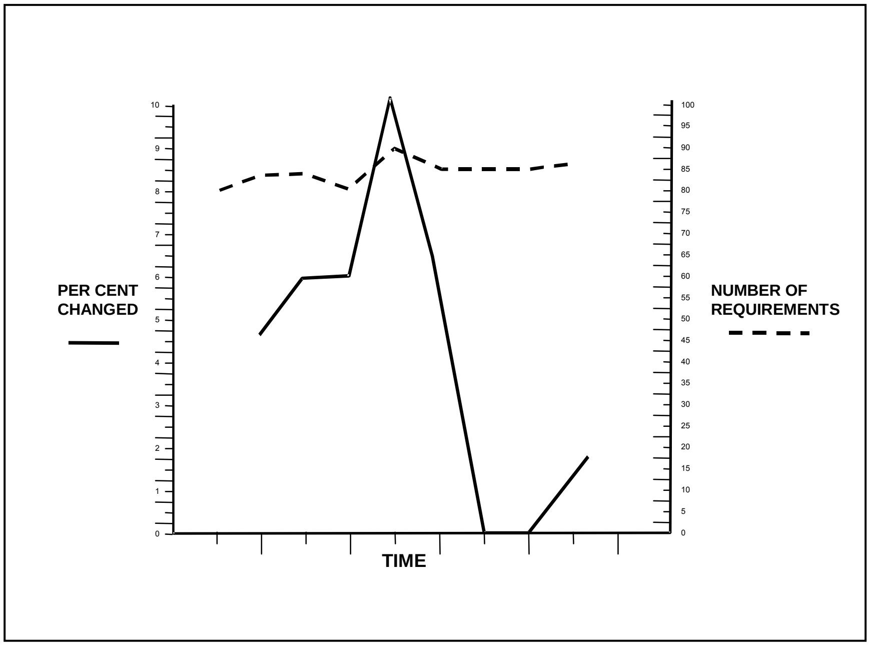
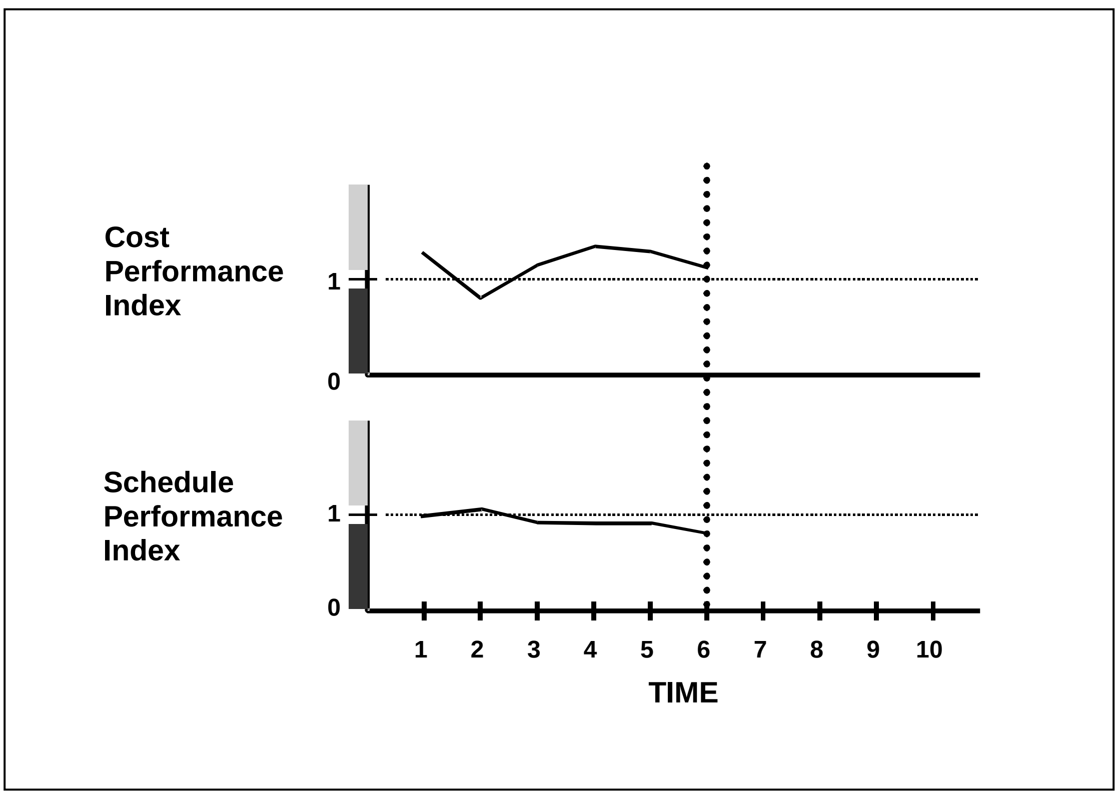


In this example, there are approximately 80 requirements, as indicated by the dotted line and the scale on the right. The relatively high rate of change (6% to 10%) appears to have stabilized in the 2 to 3% range.

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.



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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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References and Contacts

Ref	Item or Location	Description
BOE1	Boehm, Barry, **Spiral Development: Experience, Principles, and Refinements**, CMU/SEI-2000-SR-008, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, June 2000	**For Spiral Model and Win-Win Elaboration** http://www.sei.cmu.edu/ Key Concepts: Spiral Model implementation problems, anchor points (life cycle objectives [LCO], life cycle architecture [LCA], initial operational capability [IOC]), win-win elaboration of spiral model
BUR1	Burton, Dan; Over, Jim, **PSP Tutorial SEPG '98**, provided at the SEPG '99 Conference, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, 1998.	**For PROBE**
CAR1	Carlton, Anita, Park, Robert, Goethert, Wolfhart. *The SEI Core measures*, **Journal of the Quality Assurance institute**, July 1994	Key Concepts: Size, Time, Effort, Defects See also MAH1.
CRL1	Carr, Marvin J., Konda, Suresh L. , Monarch, Ira, Ulrich, F. Carol, Walker, Clay F. , **Taxonomy-Based Risk Identification**, CMU/SEI-93-TR-6, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, June 1993	Available at http://www.sei.cmu.edu/
DOD1	**Parametric Estimating Handbook**, 2nd Ed., Spring 1999	Available at http://www.ispa-cost.org/PEIWeb/newbook.htm
FIS1	Fisher, Roger; Ury, William. **Getting to Yes, Negotiating Agreement without Giving in,** (2nd ed.), Penguin Books, 1991; ISBN 01401.5735 2	Key Concepts: Arriving at mutually-acceptable agreements – without voting, compromise, or dictate
HAD1	Hadden, Rita, *Credible Estimation*, **Proceedings of the Software Engineering Process Group (SEPG) Conference, 2001**	Held from March 12 – 15, 2001, New Orleans, co-sponsored by the Software Engineering Institute, Carnegie Mellon University
HAR1	http://www.nnh.com/ev/perform.html	**For Earned Value**: Excellent papers from Noel N. Harroff Enterprise (NNH)
HUM1	Humphrey, Watts S., **Managing Technical People,** Addison Wesley, 1997	
IFP1	www.ifpug.org	**For Function Points**: Homepage of the International Function Point Users Group
JON1	Jones, Capers. **Assessment and Control of Software Risk**, Prentice Hall, 1994	
JON2	Jones, Capers, *Sizing up Software*, **Scientific American**, December 1998, 104-109	**For Function Points**: Article available for a fee from www.sciam.com (To purchase and download, select Archive, select Log on, proceed to browse December 98.)
JON3	Jones, Capers, *Why Software Fails*, **Software Development**, July 1996, page 49	This article is not available on line. Key Concepts: Careful cost estimating and schedule planning are critical success factors for software projects. The larger the project, the more important [they are]."
KAT1	Katzenbach, Jon R., Smith, Douglas K.; **The Wisdom of Teams**, HarperBusiness (A Division of HarperCollins), 1993	Originally published in 1993 by the Harvard Business School Press; the book is copyright by McKinsey and Company, with which Katzenbach is and Smith was associated.
KAY1	Kayser, Thomas A.; **Mining Group Gold**, Serif Publishing (A Division of Xerox Corporation), 1990; ISBN 1-878567-02-0	Managing group interaction in meetings
LEW1	Lewis, James P., **Fundamentals of Project Management**, AMACOM (A Division of the American Management Association), 1997	
LEW2	Lewis, James P., **The Project Manager's Desk Reference: A Comprehensive Guide to Project Planning, Scheduling, Evaluation, and Systems**, McGraw-Hill; ISBN: 007134750X; 1999	

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Ref	Item or Location	Description
LEW3	Lewis, James P., **Project Planning, Scheduling & Control : A Hands-On Guide to Bringing Projects in on Time and on Budget** (2nd edition), Probus Publishing Company; ISBN: 1557388695 ; 1995	
MAH1	Mah, Michael, *High-Definition Software Metrics*, **Software Development**, May 1999, page S9	Available on-line without the graphics at http://www.sdmagazine.com/articles/1999/0005/0005e/0005e.htm See also CAR1. Key Concepts: Discussion of core metrics (Size, Time, Effort, Defects) at end of article.
MCC1	McConnell, Steve, *Software Quality at Top Speed*, **Software Development**, August 1996, page 38	http://www.sdmagazine.com/articles/1996/0008/0008a/0008a.htm Key Concepts: "[While] Some project managers try to shorten ... schedules by reducing quality assurance practices such as design and code reviews ... [studies show that] projects that achieve the lowest defect rates also achieve the shortest schedules." (page 39) The figures are not included in the online version, but the verbal description of Figure 1 identifies the 95% defect removal level as optimum for reducing development time. (page 40) "Reworking defective requirements, design, and code typically consume 40% to 50% of the total cost of software development." (page 41) "Every hour you spend on defect prevention will reduce repair time from three to ten hours." (page 41) "Reworking a ... requirements problem once the software is in operation typically costs fifty to two hundred times what it would take to rework the problem in the requirements stage." (page 41) "... about 60% of all defects usually exist by design time." (page 41) See the section on "Additional Reading" in the side bar at the end of the article, on page 42.
MCC2	McConnell, Steve, **Software Project Survival Guide: How to Be Sure Your First Important Project Isn't Your Last**. Microsoft Press, 1997, Redmond WA. ISBN: 1-57231-621-7	
NASA1	**NASA Parametric Cost Estimating Handbook**	http://www.jsc.nasa.gov/bu2/PCEHHTML/pceh.htm
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.
PAG1	Page-Jones, Meilir, *Seduced by Reuse*, **Software Development**, September 1998, page 80	Impact of reuse, available at www.sdmagazine.com
PHI1	Phillips, Dwayne, *Proxy-Based Estimation*, **Software Development,** July 1998	**For PROBE**: Available through SD Magazine Online at http://www.sdmagazine.com/breakrm/features/s987f3.htm. [NOTE: While the formulas and method appear to be sound, the actual data reported is suspect.]
PMI1	http://www.pmi.org/	Homepage of the Project Management Institute (PMI)
POT1	Potter, Neil, Sakry, Mary, *Keep Your Project On Track*, **Software Development**, April 2001	Risk management; available at www.sdmagazine.com/articles/2001/0104/0104g/0104g.htm
PRE1	**General Information Resources**	An excellent set of references related to estimation techniques and various models is found at: http://www.premia.com/support/starestimator/weblibrary/resource.html

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Ref	Item or Location	Description
PRS1	Pressman, Roger, **Software Engineering A Practitioner's Approach, 3rd ed.**, McGraw Hill, Inc., New York, 1992, ISBN 0-07-050814-3	
PSM1	**Practical Software Measurement, A Foundation for Objective project management**, Office of the Undersecretary of Defense for Acquisition and Technology, 1998	www.psmsc.com Homepage of the Practical Software Measurement Support Center (PSMSC). Download the PSM Guide, Guidebook, and Insight Tool
ROE1	Roetzheim, William H.**,** *Estimating Internet Development*, **Software Development,** August 2000, page 70	http://www.sdmagazine.com/articles/2000/0008/0008d/ 0008d.htm Key Concepts: Parameters for estimation can include function points (for data-driven applications), GUI metrics (menus, dialogs, windows), and object metrics. 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)
THI1	Thielen, David, *The Commando Returns*, **Software Development**, March 1999, page 80	Not available on line. Key Concepts: "As projects get larger and more complex, projects get larger and more complex, good practices, design, and planning are the best approaches to project management."
WEL1	Wells, J. Donovan, *Planning Feedback Loops*	**For Extreme Programming** http://www.extremeprogramming.org/map/loops.html Key Concepts: Time frames between phases; phase activities
WEL2	http://www.extremeprogramming.org	**For Extreme Programming** J. Donovan Wells Extreme programming home page Key Concepts: Detailed descriptions of activities, tools, references to articles, etc.
WIE1	Wiegers, Karl, *Know Your Enemy*, **Software Development**, October 1998, page 38	http://www.sdmagazine.com/articles/1998/0010/0010a/ 0010a.htm Key Concepts: Structured risk management
WIL1	Williams, Laurie, Kessler, Robert R, Cunningham, Ward, Jeffries, Ron, *Strengthening the Case for Pair Programming*, **IEEE Software**, July August 2001, pp 19 - 25	www.objectmentor.com/s4williams.lo.pdf Key Concepts: pairs spent 60% more time on project; completed tasks 40% faster

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Partial List of Tools and Contacts

Provider	Planning	Tracking	Resource Management	Risk 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 Group	Cost Xpert	Marotz Inc. Cost Xpert Group 13518 Jamul Drive Jamul, CA 91935-1635 (619) 669-3100 http://www.costxpert.com
Quantitative Software Management	SLIM	QSM 2000 Corporate Ridge Suite 900 McLean, Virginia 22102 TEL: 800-424-6755 FAX: 703-749-3795 http//www.qsm.com
Software Productivity Research (SPR)	KnowledgePLAN®	Software Productivity Research Three Bethesda Metro Center Suite 700 Bethesda, Maryland 20814 Tel. 301.657.6266 Fax 301.942.4361 http://www.spr.com
USC (Dr. Barry Boehm)	COCOMO II	http://sunset.usc.edu/available_tools/index.html 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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