



**Embedded Computer Resources (ECR) Support Improvement Program**

## **Collaborative Support for Process Improvement: Measurement in Capability Maturity Model Integration**

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## Why Have a PSM Users' Group Conference?

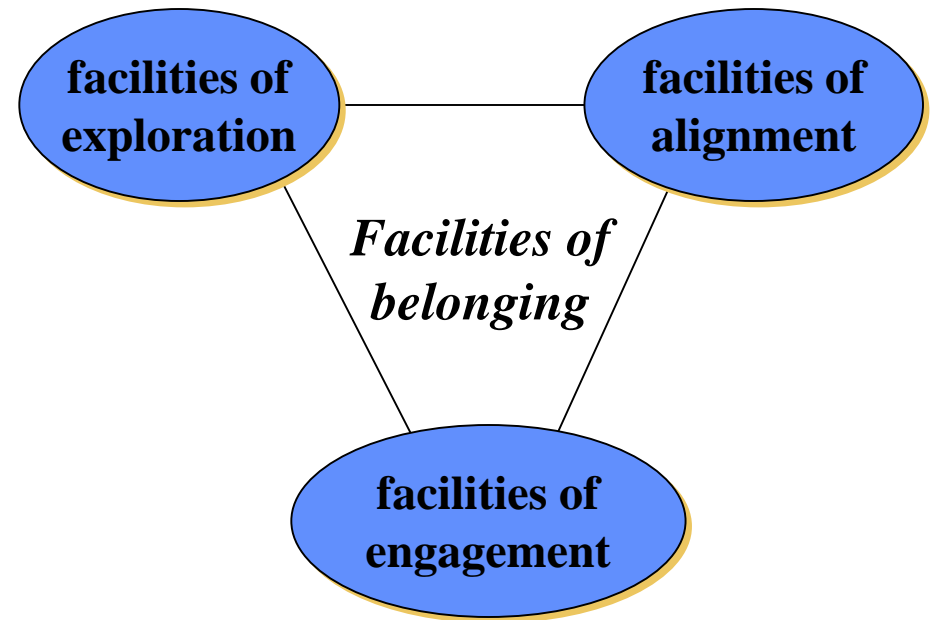
### Facilitates Communications

- Sharing Solutions
- Sharing Lessons Learned
- Networking with Professionals
- Exploring New Technologies

Directly Serves Multi-discipline Needs of the DoD support community (govn & industry)



Measurement Mafia



When we do something together over time, we create shared practices:

we learn to do what needs doing;  
we learn about each other, and  
we developed shared ways of  
doing things

***We form communities of practice.***

# National Security System Challenges

## Mission Critical Software in National Security Systems

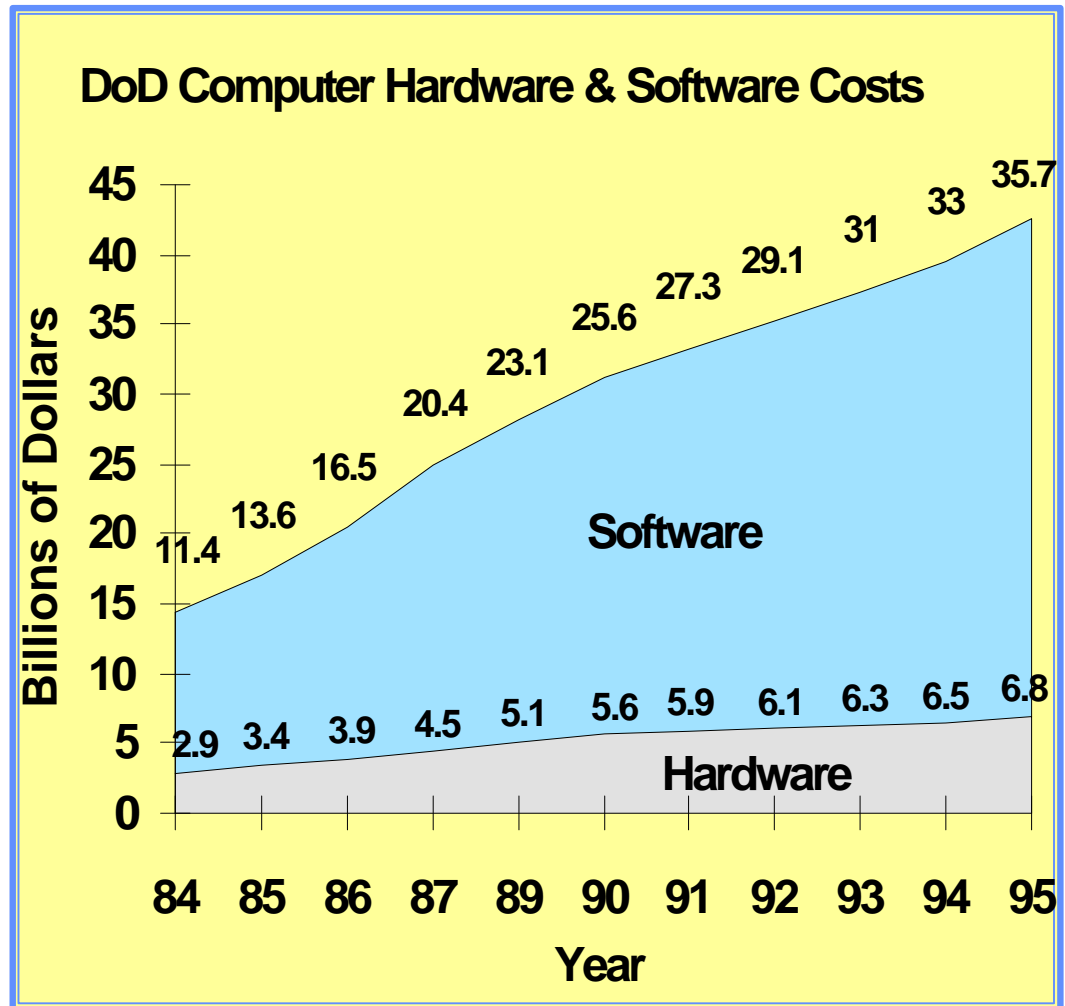
Information Technology is vital to mission effectiveness for operations involving national security systems

Software provides increased system capability & flexibility



# National Security Systems Challenges

- The quantity of software in national security systems is increasing dramatically
- Increases in program schedules & cost (both in acquisition & sustainment) prompt need for software solutions in Information Technology (IT) in National Security Systems (NSS = MCCR)



## The Software Challenge & Potential

### The Challenge

#### Poor Success Rate

- 1% projects on time, on budget, and meet expectations
- 33% never finish

#### Unacceptable Schedule Variance

- Average is one year behind schedule
- Average schedule missed by 50%

75% are “Operational Failures”

### The Potential

1% improvement saves \$300M+  
CMM-based improvement shows a 4  
- 19% potential gain \*

Sources: The Healthy Software Project,  
Mark Norris, Wiley: 1995

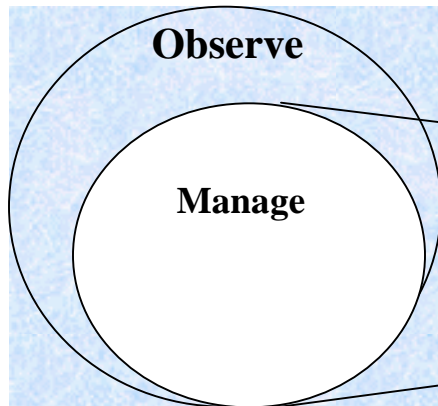
Guidelines for Successful Acquisition and Management of  
Software-Intensive Systems, Version 2.0, STSC,1996

*\* Depends on amount of reuse*

*\* CMM Level 5 findings as reported  
in May 99 CrossTalk*

# US Government Acquisition Role: Evolving from Oversight to Insight

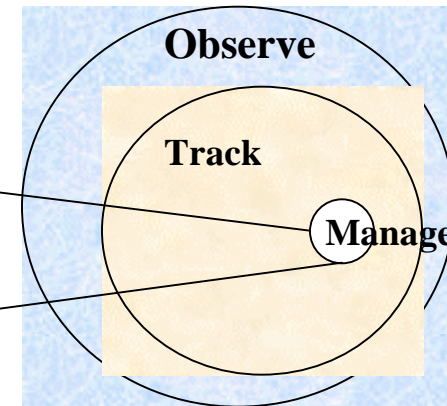
## Where we've been:



### **Risk Avoidance**

- System Specification
- Mil Spec/Standards
- Government in design
- Government Baseline
- Design-to-Cost/Life Cycle Cost
- Program Control
- CDRLs (Contract Deliverables)
- SOW (Statement of Work)

## Where we're going:



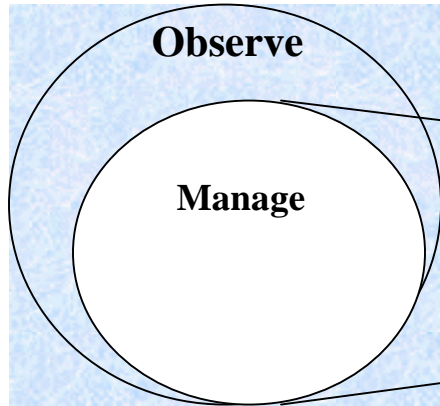
### **Risk Management**

- Performance Based Contracting
- Best Practices not Mil-Specs
- Bilateral Technical System Baseline
- Cost as an Independent Variable (CAIV) and Cost-Risk
- IPTs and IMP/IMS/EVMS Control
- Metrics and TPMs
- Data availability - minimize CDRLs
- SOO (Statement of Obj) -- CSOW

Reduction of  
Government  
Resources

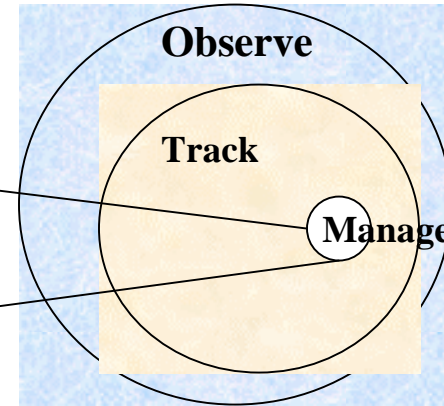
# Coping with Business Challenges & Need for Performance Improvement

Where we've been:



Reduction of Government Resources

Where we're going:



**Risk Avoidance**

**Risk Management**

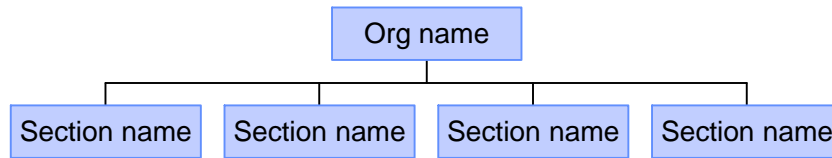
A cartoon illustration of a man in a suit running quickly, looking stressed. He is surrounded by several thought bubbles containing business-related questions.

- How do I measure, monitor and manage program risks?
- Which technologies should I adopt now or track for future investment?
- How do I recruit and retain technical expertise on my staff?
- How effective is my organization in meeting business & mission objectives?
- How do I prioritize and fund competing projects and improvements?
- How do I remain cognizant of changes to laws, directives & policies? What's the impact of complying with them?

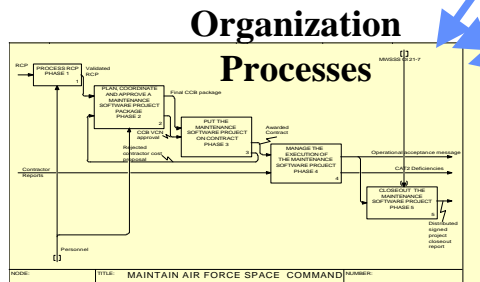
# Measurement in CMMI

## Steps to Enterprise-wide Organizational Maturity:

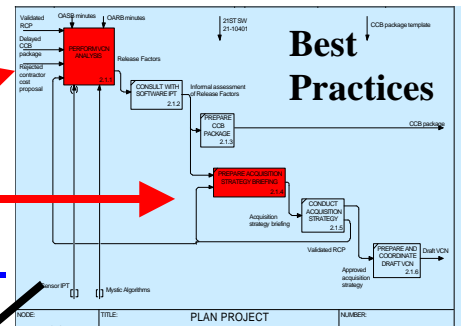
### 1. Vision, Goals, Buy-in



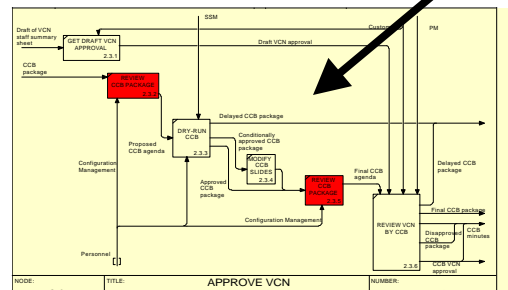
### 2. Process Capture



### 3. Gap Analysis



### 4. Process Transformation



From Process, all good things flow!





## Process Improvement Business Case

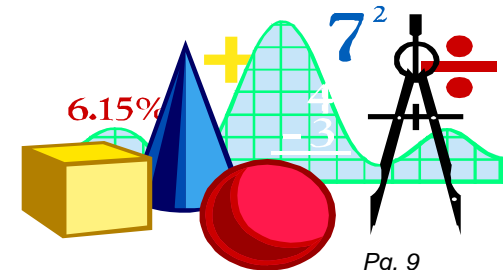
### Software Process Improvement (SPI) Demonstrated Return on Investment (ROI)

**SPI efforts quantifiably justify funding (based on several projects)**

- **Demonstrated Return on Investment** of 4:1 - 19:1
- **Earlier detection of software defects** from 22% - 90%
- **Reduction in post-release defects** from 39% - 84%
- **Reduction in schedule time** from 19% - 23%
- **Reduction in projected schedule variance** down to 2%
- **Increased productivity (less rework)** of 35% - 75%
- **Reduced sustainment costs** by 30% - 55%

**Several programs have improved their capabilities based on the Software Capability Maturity Model (CMM)**

- **Enabled effective communication between separate business units;**
- **Reporting improved customer satisfaction**



## The Current Situation

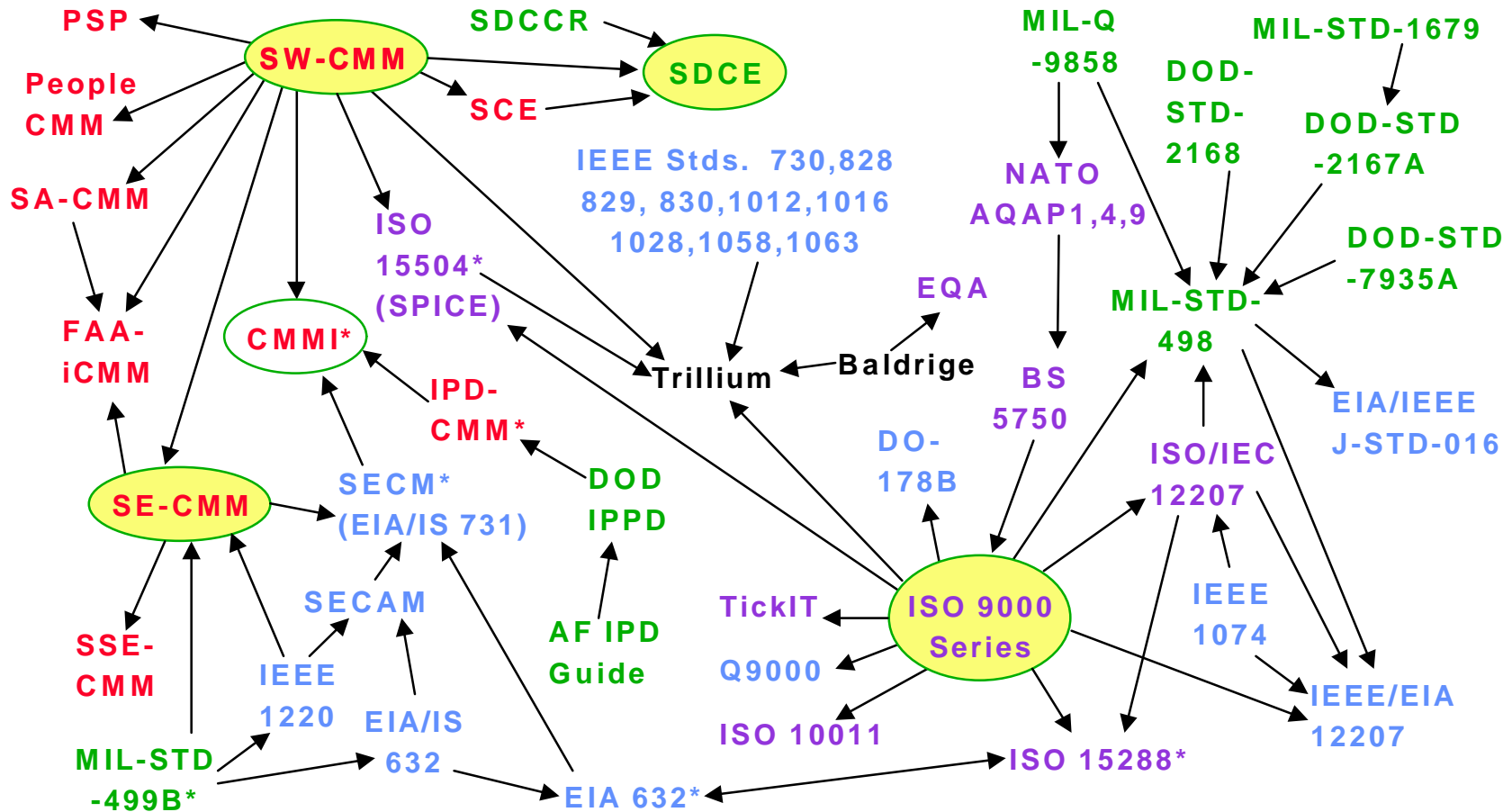
**Explosion of CMMs  
and CMM-like models  
Multiple models within  
an organization**

**Multiple assessments  
Multiple training  
Duplicated expenses**





# The Frameworks Quagmire



\* Not yet released

Courtesy Sarah Sheard, SPC  
 Documented in CrossTalk, the Journal of Defense Software Engineering



## **Why is this a problem?**

**Similar process improvement concepts, but...**  
**Different model representations (e.g. staged, continuous, questionnaire, hybrid)**  
**Different terminology**  
**Different content**  
**Different appraisal methods**  
**Different conclusions**



## Common Basis for Model-based Process Improvement

Improvement in any discipline is a function of performing:  
***implementing practices*** that reflect the fundamentals of a particular topic (e.g. configuration management)  
***institutionalizing practices*** that lead to sustainment and improvement of an implementation



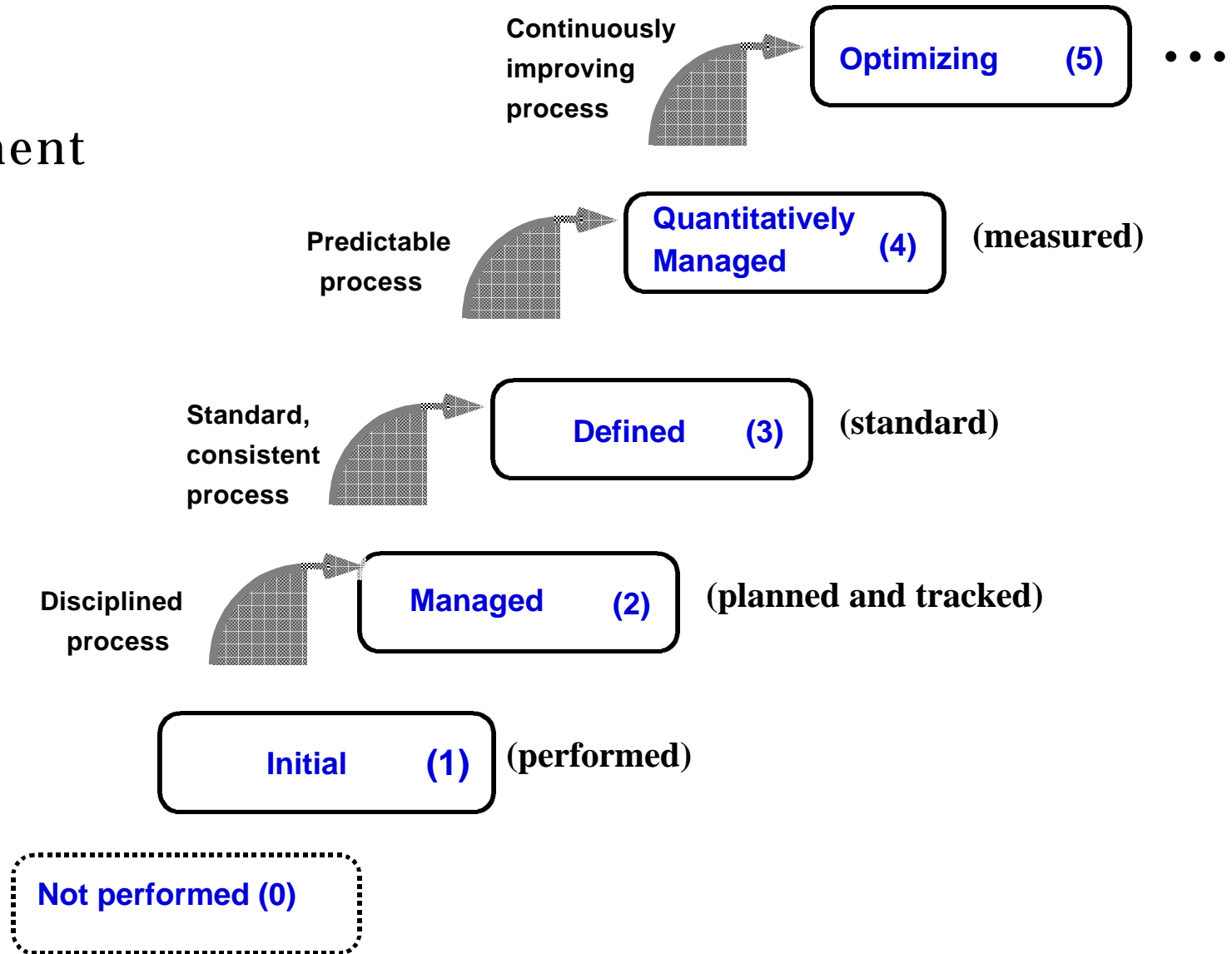
**Thus all CMMI source models contain:**

***Implementing practices*** grouped by affinity

***Institutionalizing practices*** that vary from model to model, however all models specify ***levels*** that describe increasing capability to perform

# Measurement in CMMI

## Improvement Levels





## **CMMI Design Goals**

**Eliminate inconsistencies**

**Reduce duplication**

**Reduce the cost of implementing model-based process improvement**

**Increase clarity and understanding**

- **Common terminology**
- **Consistent style**
- **Uniform construction rules**
- **Common components**

**Minimal impact on legacy efforts**





## **Benefits**

**Efficient, effective assessment and improvement across multiple process disciplines in an organization**

**Reduced training and assessment costs**

**A common, integrated vision of improvement for all elements of an organization**

**A means of representing new discipline-specific information in a standard, proven process improvement context**



## The Challenge

**Given the input models, extract the common and/or best features**

**Provide users the ability to produce single or multiple discipline models, both continuous and staged, tailored to their organizations needs.**

**Provide users the ability to assess and train based on these output models.**





## **CMMI Source Models**

**Capability Maturity Model for Software V2, draft C (SW-CMM V2C)**

**EIA Interim Standard 731, System Engineering Capability Model (SECM)**

**Integrated Product Development Capability Maturity Model, draft V0.98 (IPD-CMM)**



## Source Models

<b>SW-CMM V2C</b>	<b>EIA IS 731 SECM</b>	<b>IPD-CMM V0.98</b>
Staged	Continuous	Hybrid
Maturity Levels	Capability Levels Categories	Maturity and Capability Levels
Key Process Areas	Focus Areas	Process Areas
Key Process Area Goals	Themes	Capability and Process Area Goals
Activities Common Feature	Specific Practices	Base Practices
Common Features	Generic Practices	Generic Practices
	Generic Attributes	

## Example Map of Input Process Areas To Source Models

<b>CMMI PA</b>	<b>SW-CMM V2C</b>	<b>EIA SECM V1.0</b>	<b>IPD-CMM V0.98</b>
Requirements Management	X	X	
Supplier Agreement Management	X	X	X
Configuration Management	X	X	X
Data Management		X	
Training	X	X	X



## Staged Representations

**Key Process Areas are grouped in the stages (levels) from 2 to 5**

**A Key Process Area contains specific practices (activities) to achieve the purpose of the process area.**

**For a Key Process Area at a given stage, institutionalization practices are integral to the process area.**



# Staged Model

Level	Focus	Key Process Areas
5 Optimizing	<i>Continuous process improvement</i>	Org Improvement Deployment Org Process and Tech Innovation Defect Prevention
4 Quantitatively Managed	<i>Quantitative management</i>	Organization Process Performance Statistical Process Management Org Software Asset Commonality
3 Defined	<i>Process Standardization</i>	Peer Reviews Project Interface Coordination Software Product Engineering Organization Training Program Organization Process Definition Organization Process Focus
2 Repeatable	<i>Basic Project Management</i>	Software Configuration Management Software Quality Assurance Software Acquisition Management Software Project Control Software Project Planning Requirements Management
1 Initial	<i>Competent people and heroics</i>	



## Continuous Representations

**A process area contains specific practices to achieve the purpose of the process area.**

**Generic practices are grouped in Capability Levels**

**Generic practices are added to the specific practices of each process area to attain a capability level for the process area.**

**The order in which Process Areas are addressed can follow a recommended staging.**





# Continuous Model

CL5	GP												
	GP												
	GP												
CL4	GP												
	GP												
	GP												
CL3	GP												
	GP												
	GP												
	GP												
	GP												
CL2	GP												
	GP												
	GP												
	GP												
	GP												
Implemented													
Process Area		NE	RQ	OS	TR	PM	KM	QA	VS	...	SR	FD	IN

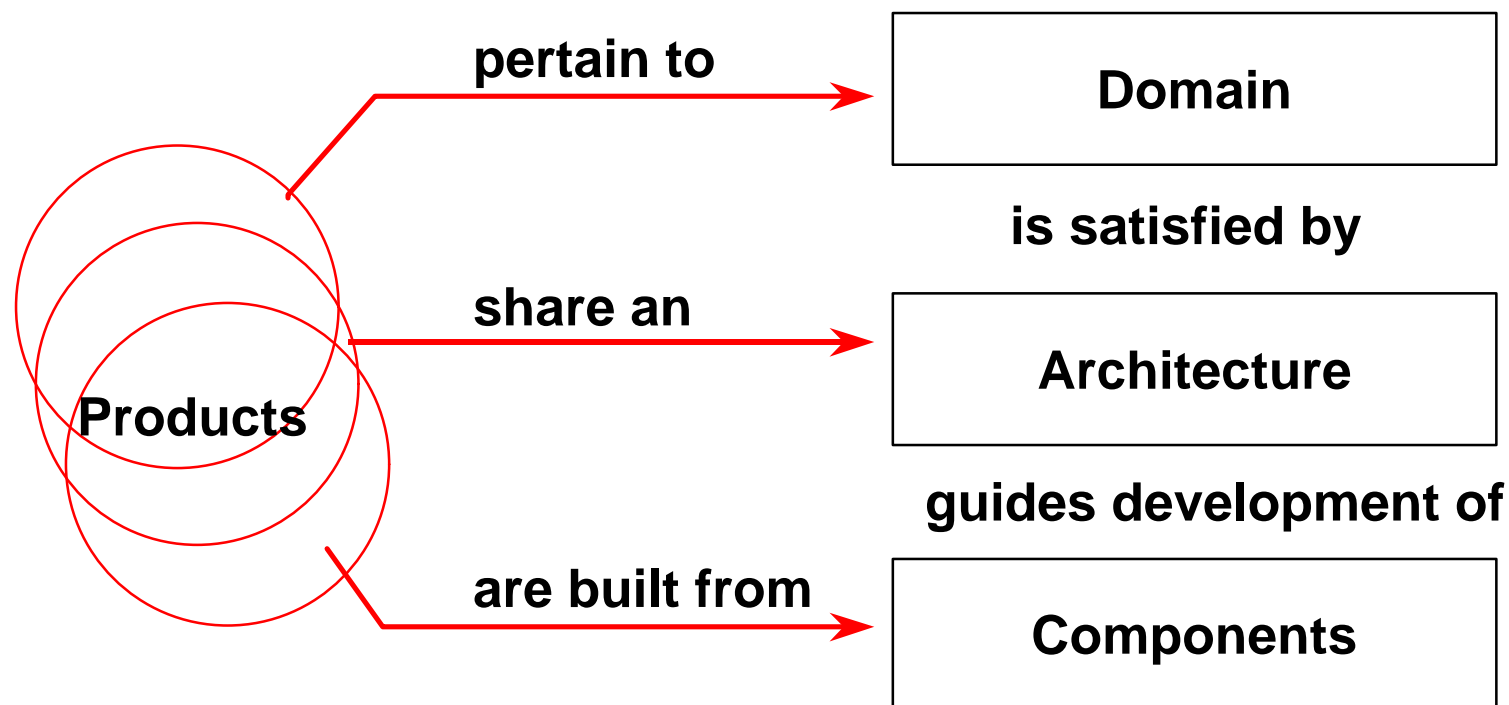
PA - Process Area  
 CL $n$  - Capability Level  $n$  institutionalized  
 (Level  $n$  GPs satisfied for PA)

GP - Generic Practice  
 Imp - Implemented Base Practices  
 NI - Not Implemented  
 NA - Not Applicable  
 NR - Not Rated



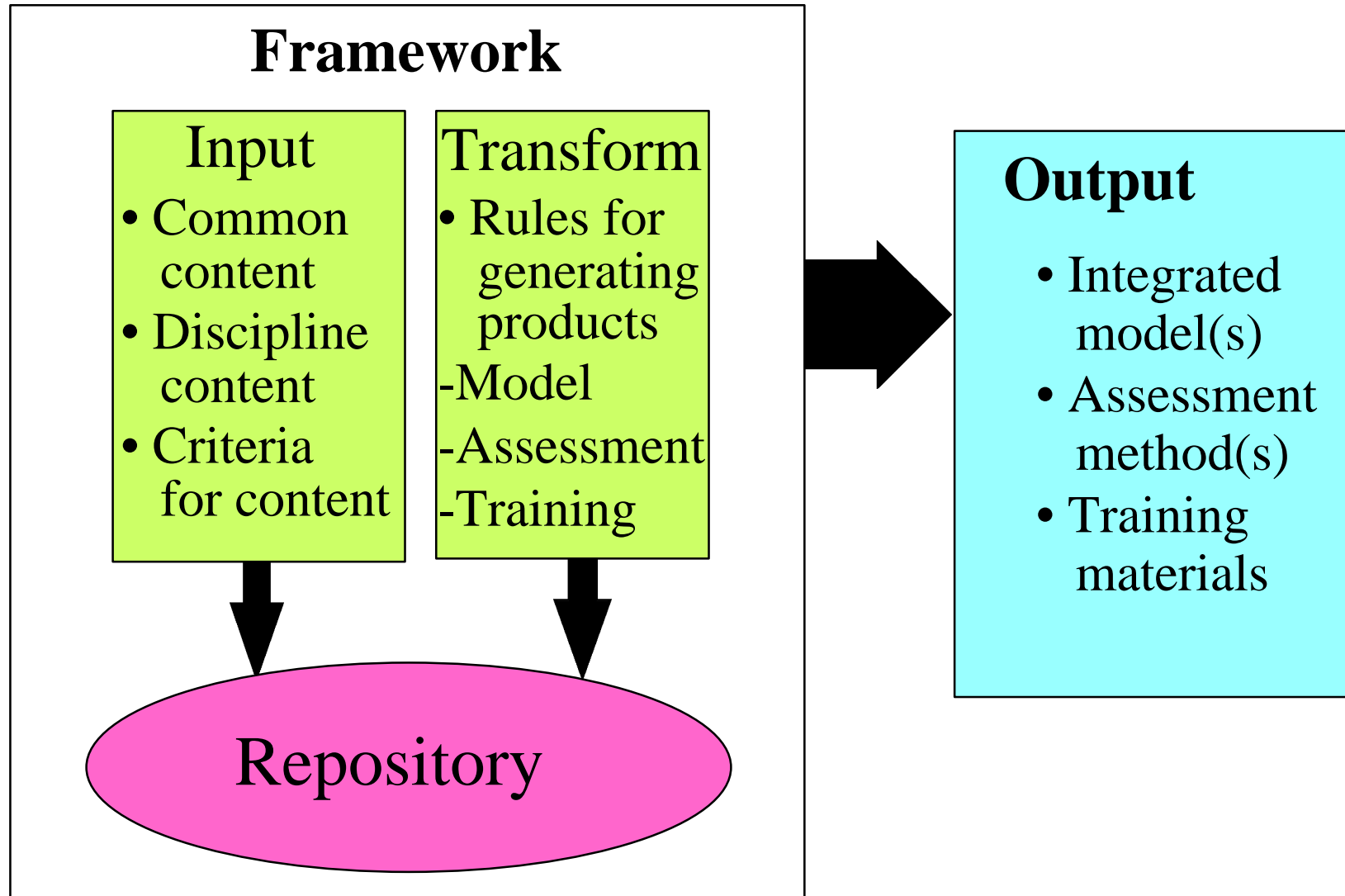
## The CMMI Product Line

The CMMI product line is a product suite sharing a common, managed set of features that satisfy specific needs of a selected domain.





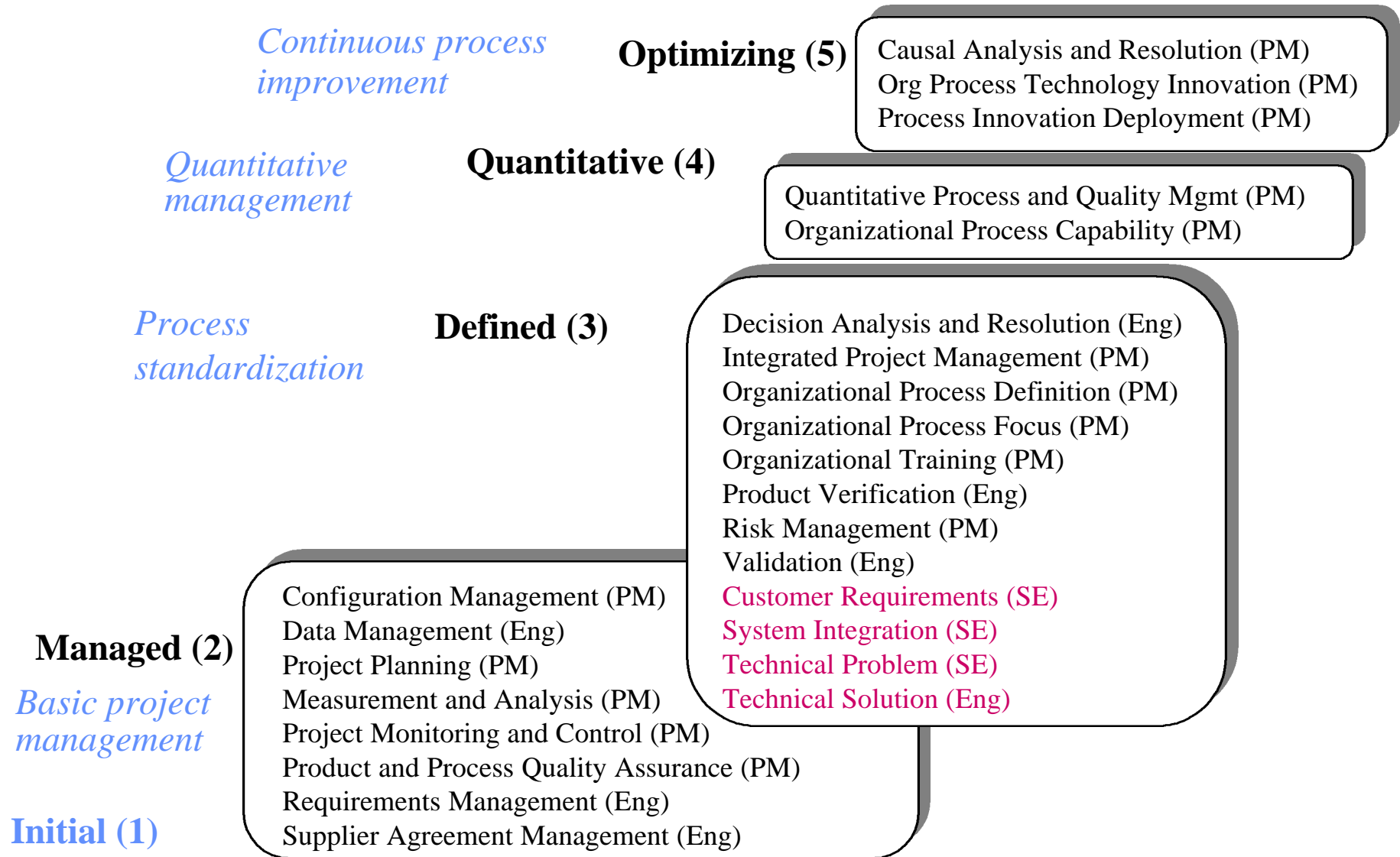
# CMMI Product Suite





# Draft CMMI-SW/SE

## Process Areas Listed by Levels



## **Harmonization with ISO Standards**

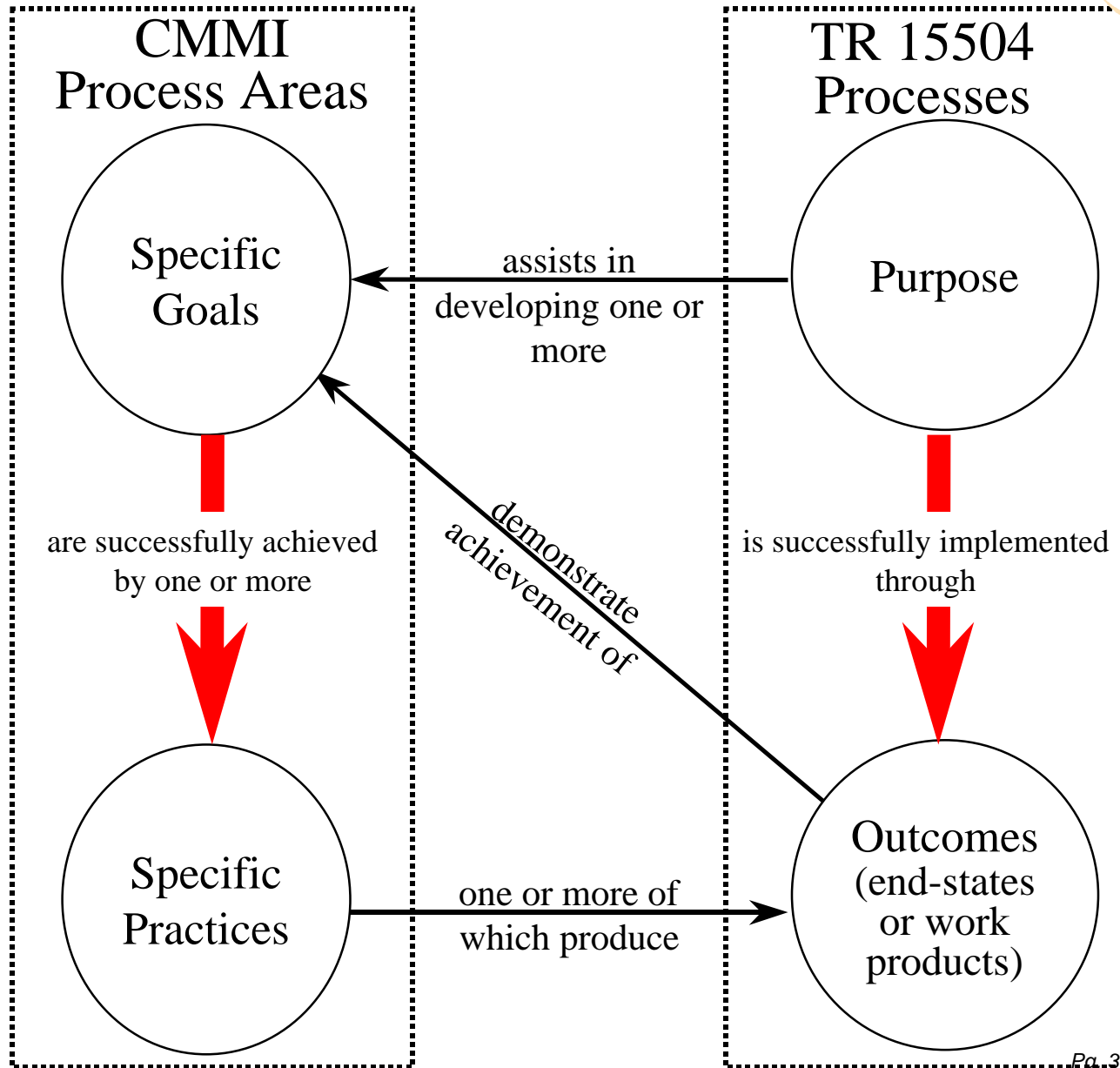
**15504 is reviewed prior to each draft release by authors and an ISO IPT within CMMI PDT**

**For CMMI Measurement & Analysis Process Area, 15939 & 15504 were used as the primary source inputs in addition to the Measurement & Analysis Common Feature of the Software CMM**

## **ISO 15504 / CMMI-SW/SE V0.1 Alignment**



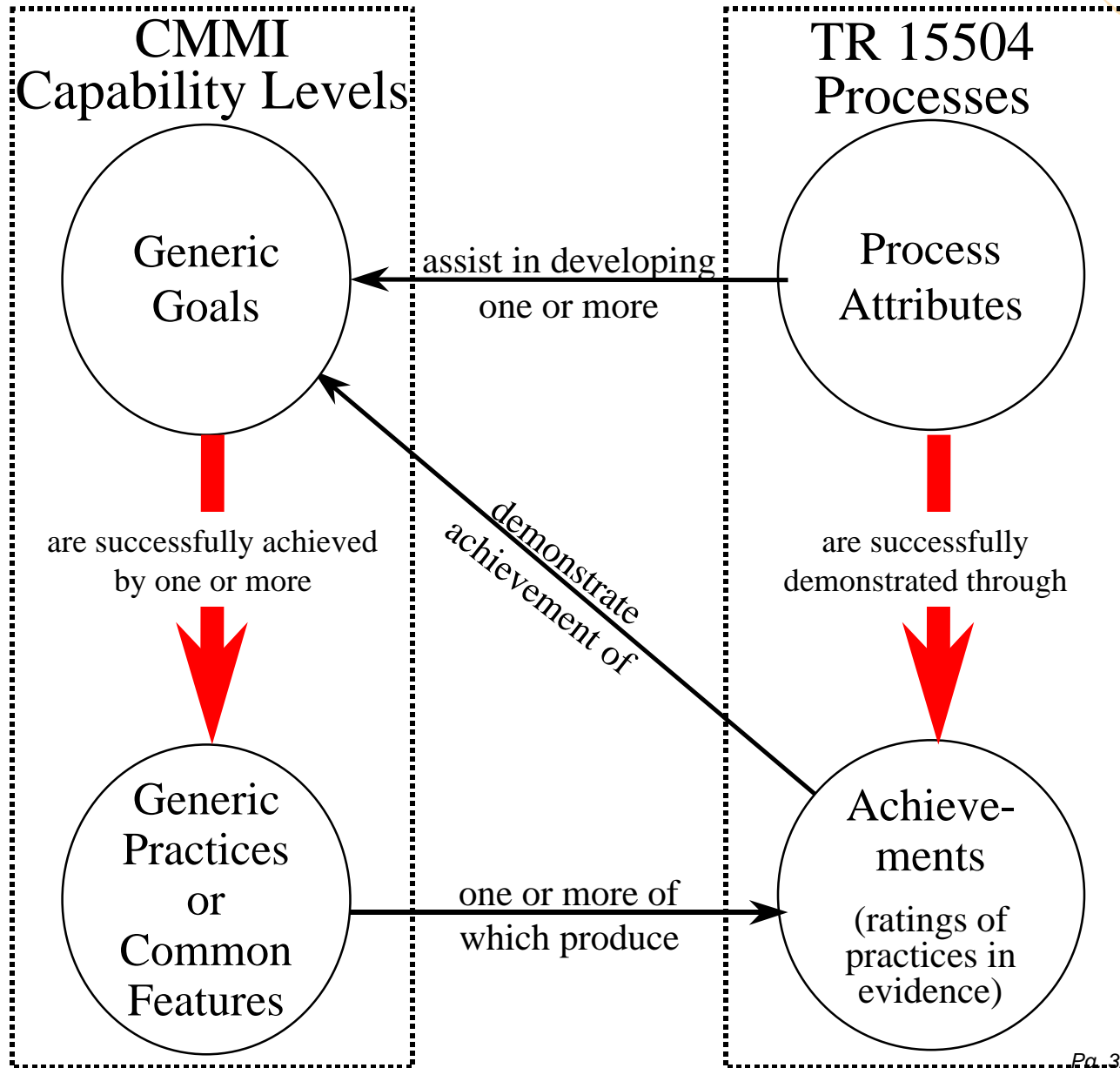
Assuring  
Compatibility  
between  
CMMI and  
ISO/IEC  
TR15504





# Process Capability Relationships

Assuring  
Compatibility  
between  
CMMI and  
ISO/IEC  
TR15504





## ISO 15504 / CMMI V0.1 Map-1

<b>15504 Process ID</b>	<b>15504 Process Name</b>	<b>CMMI V0.1 Process Area</b>
CUS.1	Acquisition	
CUS.2	Supply	
CUS.3	Requirements Elicitation	Requirements Development and Management
CUS.4	Operation	

## ISO 15504 / CMMI V0.1 Map-2

<b>15504 Process ID</b>	<b>15504 Process Name</b>	<b>CMMI V0.1 Process Area</b>
ENG.1	Development	Software Product Engineering
ENG.2	System and Software Maintenance	Software Product Engineering

## ISO 15504 / CMMI V0.1 Map-3

15504 Process ID	15504 Process Name	CMMI V0.1 Process Area
MAN.1	Management	Organizational Process Focus
		Organizational Process Capability
MAN.2	Project Management	Project Planning
		Project Monitoring and Control
MAN.3	Quality Management	Quantitative Process and Quality Management
MAN.4	Risk Management	Risk Management

# ISO 15504 / CMMI V0.1 Map-4

15504 Process ID	15504 Process Name	CMMI V0.1 Process Area
ORG.1	Organizational Alignment	
ORG.2	Improvement	Organizational Process Focus
		Organizational Process Definition
		Defined Project Management
ORG.3	Human Resource Management	Organizational Training
ORG.4	Infrastructure	
ORG.5	Measurement	Measurement and Analysis
ORG.6	Reuse	

## ISO 15504 / CMMI V0.1 Map-5

<b>15504 Process ID</b>	<b>15504 Process Name</b>	<b>CMMI V0.1 Process Area</b>
SUP.1	Documentation	Data Management
SUP.2	Configuration Management	Configuration Management
SUP.3	Quality Assurance	Process and Product Quality Assurance
SUP.4	Verification	Product Verification
SUP.5	Validation	Validation
SUP.6	Joint Review	Validation
SUP.7	Audit	Product Verification
SUP.8	Problem Resolution	Casual analysis and Resolution

## **CMMI Schedule**

<b>Release CMMI SW/SE V0.2 for Public Review</b>	<b>Aug '99</b>
<b>Pilot CMMI products</b>	<b>Nov '99-May '00</b>
<b>Publish CMMI SW/SE V1.0</b>	<b>Jun '00</b>
<b>Publish CMMI SW/SE/IPPD V1.0</b>	<b>Aug '00</b>

## **Need for a Measurement Process Area**

**Recognition by Congress through law for the need for measurement across software-intensive systems**

**Need for performance based management specified in the Information Technology Management Reform Act (ITMRA)**

**Need for more explicit measurement guidance recognized by lead assessors in organizations using existing CMM to guide process improvement**

## **Measurement and Analysis - Summary**

**Measurement and Analysis involves :**

- **Selection and documentation of measures and indicators that meet organizational unit needs.**
- **Collection, analysis, and management of measurement data is conducted according to a measurement plan.**
- **Output of the measurement and analysis process is communicated to users in a timely and usable fashion.**



## Measurement & Analysis Process Area– Level 2

### PA Purpose

The purpose of Measurement and Analysis is to develop and sustain a measurement capability in support of management information needs.

Measurement involves:

- identifying the goals and issues regarding the scope of measurement and analysis such that it is aligned to the business goals of the organization
- defining the measures to be used, the collection process, the storage mechanism, the analysis process, the reporting process and the feedback process
- collecting and storing data
- analyzing the data
- presenting the data

# Measurement & Analysis Process Area

**Integration of Measurement and Analysis activities into the project's life cycle processes supports the project to:**

- plan and estimate, at the project and organizational level, in an objective manner
- track actual project and organizational performance against established plans and objectives, and identify and resolve process-related issues.

The terms "measure" and "measurement" are used here in a manner consistent with the definitions of these terms found in ISO 15939 working draft, Software Measurement Process Framework.

## **Measurement & Analysis Process Area**

***Goal 1. Measurement components are established in alignment with information needs and objectives.***

- ***SP 1.1. Establish and maintain measurement objectives.***
- ***SP 1.2. Identify and define measures and indicators.***
- ***SP 1.3. Define how primitive and derived measures will be obtained (produced and collected) and stored.***
- ***SP 1.4. Define how measures will be analyzed and reported.***

## Measurement & Analysis Process Area

### Goal 2. Measurement results that fulfill information needs are available.

- ***SP 2.1. Obtain measurement data in accordance with the plan.***
- ***SP 2.2. Manage and store data, indicators, and results.***
- ***SP 2.3. Analyze measurement data according to plans and refine or derive additional indicators as necessary.***
- ***SP 2.4. Report results of measurement and analysis activities to appropriate users to support decision making and assist in taking corrective action.***

## **Maturing the M & A Process Area**

CMMI Process Management  
Capability Level Descriptions,  
Generic Goals, And Generic Practices  
*(Draft Version in development for Public  
Review Package)*  
*(6 July 1999)*

## Maturing the M & A Process Area

### Capability Level Descriptions, Generic Goals and Generic Practices

#### Capability Level 0 Description:

- **(Level 0 PcM, Incomplete)** An *incomplete* process is a process that is not performed or only performed partially. One or more of the specific goals of the process area are not satisfied.

#### Capability Level 0 Generic Goal:

- (None.)

#### Capability Level 0 Generic Practices:

- (None.)

## Maturing the M & A Process Area

### Capability Level 1 Description:

- **(Level 1 PcM, Performed)** A *performed* process is a process that completes the needed work and transforms the identified input work products to produce identified output work products. The definition, planning, monitoring, or controlling of the process may be incomplete, thereby resulting in an unstable and inconsistently implemented process.

### Capability Level 1 Generic Goal:

- (Level 1 PcM-GG 1.1) (Achieve Specific Goals) The in-use process achieves the specific goals of the process area.

### Capability Level 1 Generic Practices:

- (PcM-GP 1.1) (Perform Basic Activities) Perform the basic activities of the process.

## Maturing the M & A Process Area

### Capability Level 2 Description:

- **(Level 2 PcM, Managed)** A *managed* process is a process that is planned, documented, performed, monitored, and controlled at the level of an individual project, group, or standalone process to achieve a given purpose. Management of the process is concerned with both the achievement of the specific goals of the process area and the achievement of other specific objectives for the process, such as cost, schedule, and quality objectives.

### Capability Level 2 Generic Goal:

(Level 2 PcM-GG 2.1) (Institutionalize a Managed Process)  
The process is institutionalized as a *managed* process.



## Maturing the M & A Process Area

### Capability Level 2 Generic Practices:

- (PcM-GP 2.1) (Establish Organizational Policy) Establish and maintain a written organizational policy for planning and performing the process.
- (PcM-GP 2.2) (Plan the Process) Establish and maintain the plan for performing the process.
- (PcM-GP 2.3) (Provide Resources) Provide adequate resources for performing the planned process.
- (PcM-GP 2.4) (Assign Responsibility) Assign responsibility and authority for performing the planned process.
- (PcM-GP 2.5) (Train people) Train the people performing or supporting the planned process as needed.

## Maturing the M & A Process Area

### Capability Level 2 Generic Practices (cont.):

- (PcM-GP 2.6) (Perform Managed Process) Perform the process as a *managed* process.
- (PcM-GP 2.7) (Monitor and Control the Process) Monitor and control the performing of the in-use process against the planned process, and take appropriate corrective action.
- (PcM-GP 2.8) (Manage Configurations) Place the designated work products of the in-use process under appropriate levels of configuration management.
-

## Maturing the M & A Process Area

### Capability Level 2 Generic Practices (cont.):

- (PcM-GP 2.9) (Objectively Verify Adherence) Objectively verify adherence of the planned process, in-use process, and their work products to the applicable requirements and standards, and address non-compliance.
- (PcM-GP 2.10) (Review Activities and Results with Management) Review the activities, status, and results of the in-use process with management and resolve issues.

## Maturing the M & A Process Area

### Capability Level 3 Description:

- **(Level 3 PM, Defined)** A *defined* process is a *managed* process that is tailored from the organization's set of standard processes. Tailoring the organization's set of standard processes yields a *defined* process that is specifically suited for the circumstances in which it will be performed.

### Capability Level 3 Generic Goal:

- (Level 3 PcM-GG 3.1) (Institutionalize a Defined Process)  
The process is institutionalized as a *defined* process.

## Maturing the M & A Process Area

### Capability Level 3 Generic Practices:

(PcM-GP 3.1) (Establish Defined Process) Establish and maintain the description of the *defined* process to meet specific local and organizational needs.

(PcM-GP 3.2) (Perform Defined Process) Perform the process as a *defined* process.

(PcM-GP 3.3) (Collect Improvement Information) Collect work products, measures, and improvement information derived from planning and performing the process to support the future use and improvement of the organization's process assets.

## Maturing the M & A Process Area

### Capability Level 4 Description:

**(Level 4 PcM, Quantitatively Managed)** A *quantitatively managed* process is a *defined* process that is controlled using statistical and other quantitative techniques. The product quality, service quality, and process performance are understood in statistical terms and are controlled throughout the life of the process.

### Capability Level 4 Generic Goal:

(Level 4 PcM-GG 4.1) (Institutionalize a Quantitatively Managed Process) The process is institutionalized as a *quantitatively managed* process.

## **Maturing the M & A Process Area**

### **Capability Level 4 Generic Practices:**

(PcM-GP 4.1) (Establish Quality Goals) Establish and maintain quantitative goals for product quality, service quality, and process performance.

(PcM-GP 4.2) (Quantitatively Manage Process Performance) Quantitatively manage the performance of the process to satisfy the established quantitative product quality, service quality, and process performance goals.

## Maturing the M & A Process Area

### Capability Level 5 Description:

- **(Level 5 PcM, Optimizing)** An *optimizing* process is a *quantitatively managed* process that is improved based on an understanding of the common causes of variation inherent in the process. An *optimizing* process focuses on continually improving the range of process performance through both incremental and innovative improvements.

### Capability Level 5 Generic Goal:

- (Level 5 PcM-GG 5.1) (Institutionalize an Optimizing Process)  
The process is institutionalized as an *optimizing* process.



## Maturing the M & A Process Area

### Capability Level 5 Generic Practices:

- (PcM-GP 5.1) (Establish Process Improvement Goals) Establish and maintain quantitative process improvement goals that support the organization's business objectives.
- (PcM-GP 5.2) (Address Common Cause of Problems) Identify and address common causes of actual and potential defects and other problems in the process.
- (PcM-GP 5.3) (Identify Process and Technology Improvements) Identify process and technology improvements that would result in significant and measurable improvements to process performance.
- (PcM-GP 5.4) (Deploy Improvements) Manage the deployment of the selected process and technology improvements based on the quantified expected benefits and the estimated costs and impacts.

## **CMMI Measurement Workshop**

### **PSM Workshop Purpose:**

**Develop a draft Measurement Plan Template that can serve as a basis to guide an organization in implementing a CMMI-compatible Measurement Program**

### **PSM Workshop Process:**

- 1. Review CMMI measurement-related practices in Process Areas and Generic Practices**
- 2. Recommend structure and content of a Measurement Plan template**

# **BACKUP MATERIAL**



# Framework

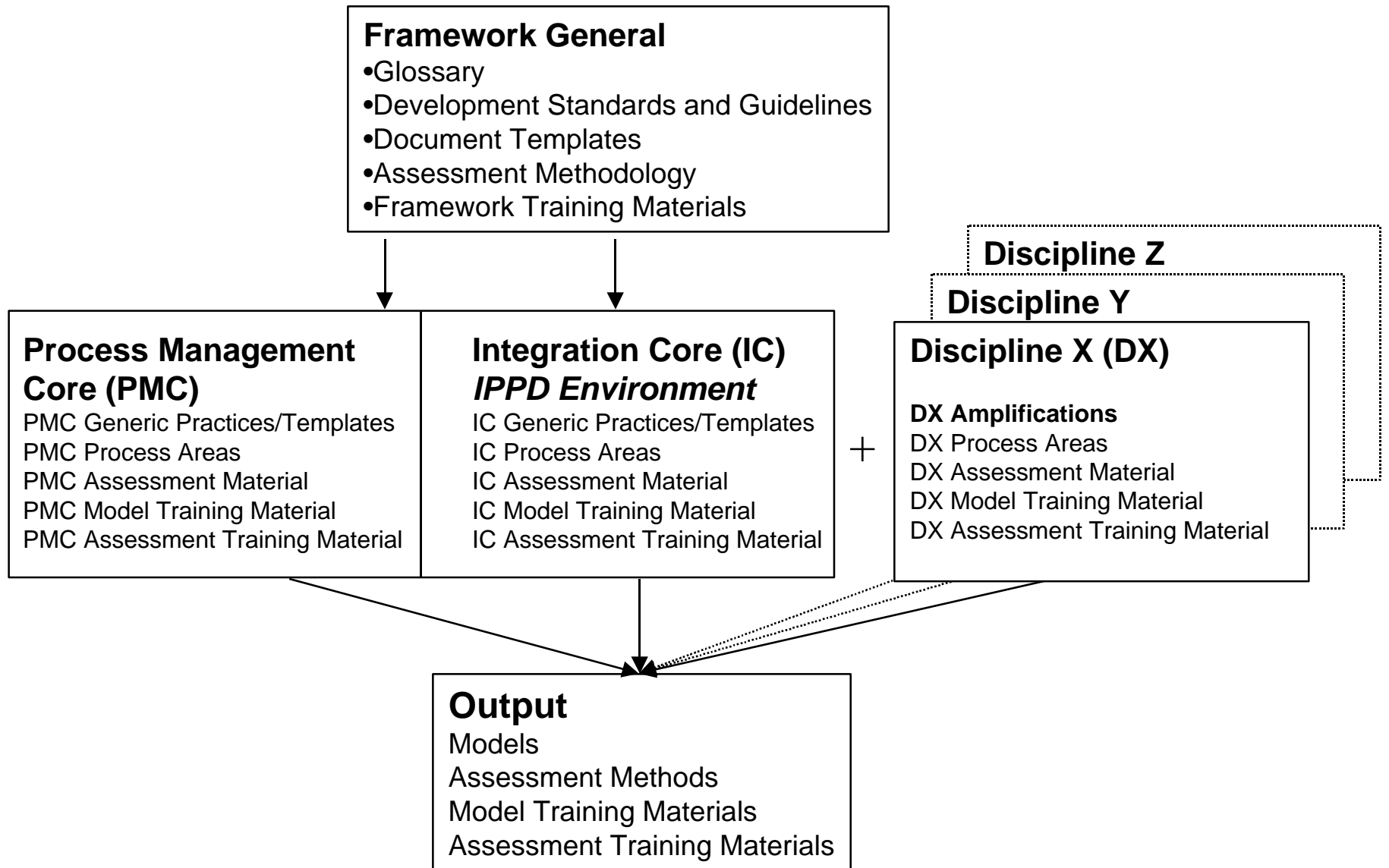
**Components**

**Construction rules**

**Conceptual architecture**



# The CMMI Framework





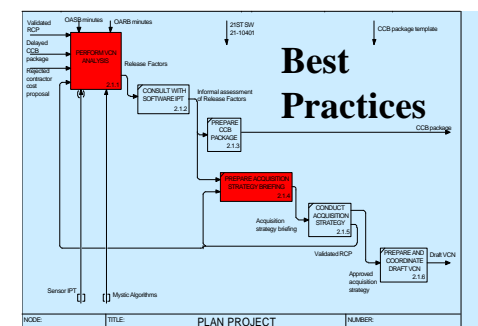
## **CMMI Products**



# CMMI Models

**Staged and Continuous Representations (with recommended staging) of:**

- **Software Engineering**
- **Systems Engineering**
- **Software+Systems Engineering**
- **Software+Systems Engineering with IPPD**



## Assessment Material



- **Assessment requirements**
- **Assessment methodology**
- **Assessment data collection methods and tools (e.g., questionnaires, interviews)**
- **Assessment Team qualifications**



## Training Material

- **Model Training**
- **Assessment Training**





## **Developer Material**

- **Glossary**
- **Framework and model content criteria**
- **Framework Training**