
# The Software Engineering Institute and Process Management for Software Development

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# What I will cover in this presentation

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- The Software Engineering Institute
  - Mission, Organization, Technical Programs
  - SEI's Work Model, Strategy, Vision
- The central role of Process in Software Development
- Simple Improvement Processes
- The Capability Maturity Model® for Software (SW-CMM®)
- ISO/IEC 15504
- CMM Integration (CMMI)
  - CMMI transition status
- What is CMMI
- CMMI Model Representations
- Benefits of CMMI
- Conclusions

# Software Engineering Institute

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DoD R&D laboratory federally funded research and development center (FFRDC)

Awarded to Carnegie Mellon University in 1984 based on competitive procurement

Sponsored by Office of the Under Secretary of Defense (Acquisition, Technology, & Logistics)

Contract administered by USAF Electronic Systems Center (ESC)

Offices in Arlington, VA, Huntsville AL, Pittsburgh, PA and Frankfurt, Germany

# Federally Funded Research and Development Centers (FFRDC)

Carnegie Mellon

- Address complex technical problems of critical importance to sponsors with a breadth and depth of expertise beyond that available inside the government
- Have access, beyond that which is common to the normal contractual relationship, to Government and supplier data, including sensitive and proprietary data, and to employees and facilities
- Conduct business in a manner befitting its special relationship with the Government
- Operate in the public interest with objectivity and independence
- Free from organizational conflicts of interest
- May not compete with the private sector

# Mission

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The SEI provides technical leadership to advance the practice of software engineering so the DoD can develop, acquire and sustain its software-intensive systems with predictable and improved cost, schedule, and quality.

# SEI[SM] Organization

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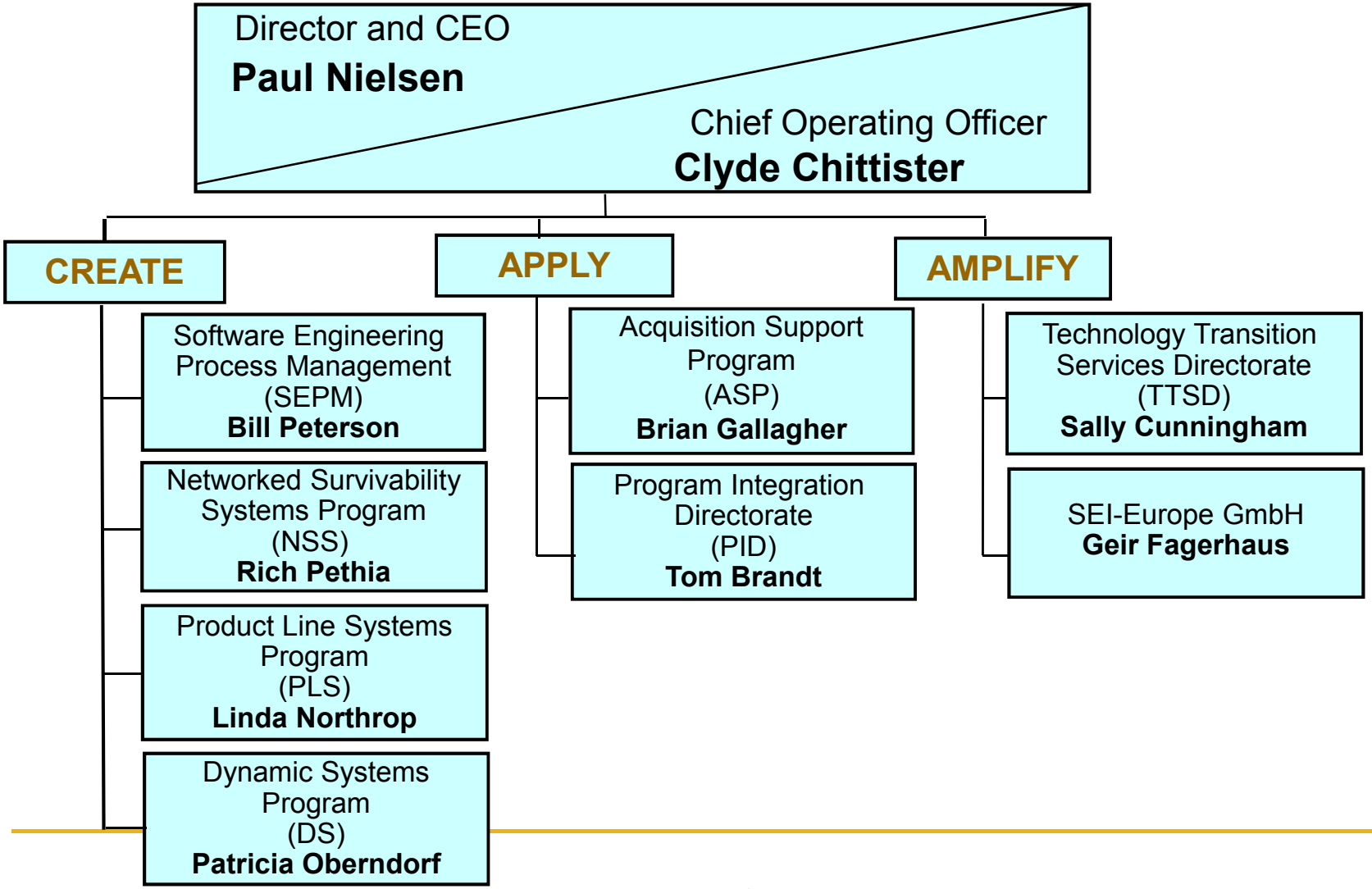

# SEI Technical Program

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*The right software delivered defect free, on cost, on time, every time*

*High-confidence, evolvable, product lines*

**Integration Software Intensive Systems**

**Performance Critical Systems**

**Software Architecture Technology**

**Survivable Systems (CERT)**

**Product Line Practice**

**Predictable Assembly with Certifiable Components**

*with predictable and improved cost, schedule, and quality*

**Capability Maturity Model® Integration**

**Team Software Process℠**

**Software Engineering Measurement & Analysis**

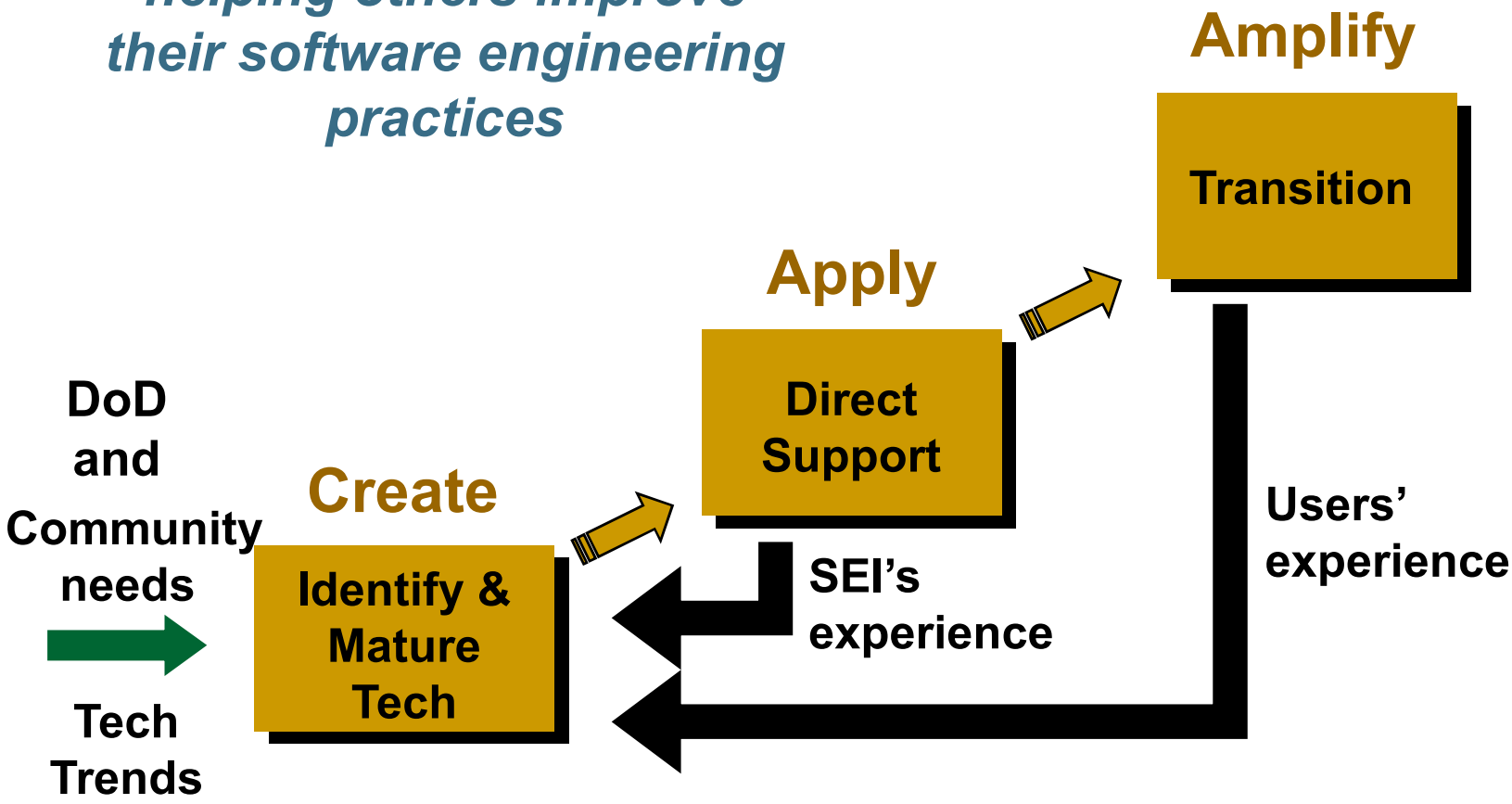
Technical Practice Initiatives

Management Practice Initiatives

# SEI Work Model

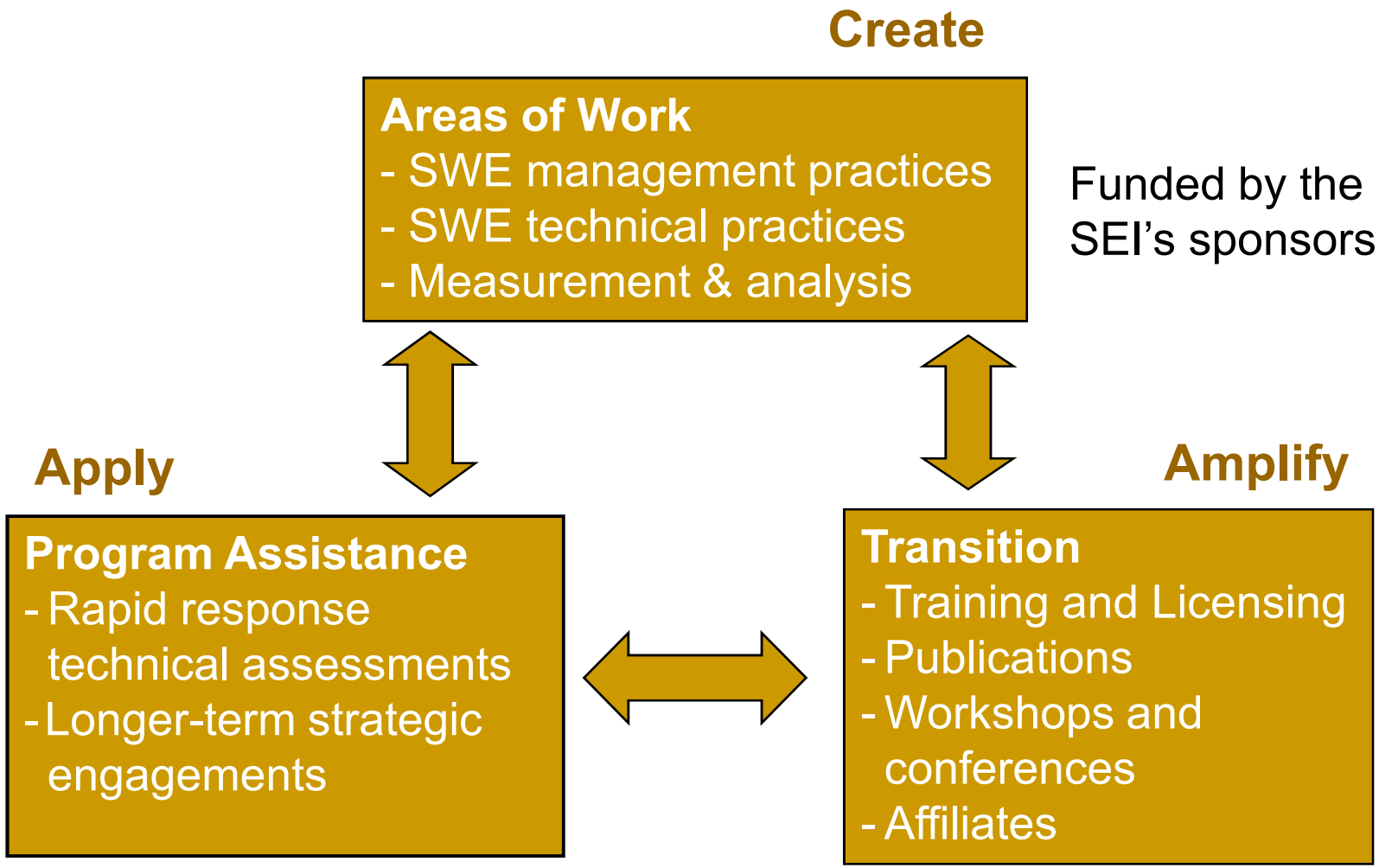
Carnegie Mellon

*helping others improve their software engineering practices*



# SEI Work Model

Carnegie Mellon



# SEI Strategic Themes

- Predictably better, faster, and cheaper by -

- Moving to the left
- Embrace a systems engineering approach and make better decisions before coding to predictably improve quality, cost, and schedule.

- Reusing everything
- Reuse code, but also the architecture and knowledge from building similar systems.

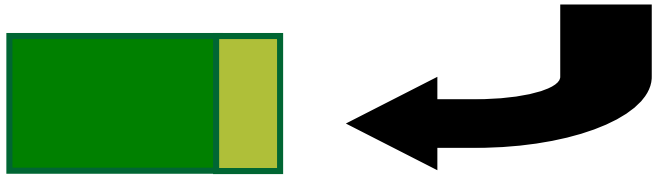
- Never making the same mistake twice
- Leverage lessons learned.

# State of Practice Versus SEI's Vision

***Software state of practice ("test in" quality)***


Development Integration and System Test

***World-class developers "design in" quality***



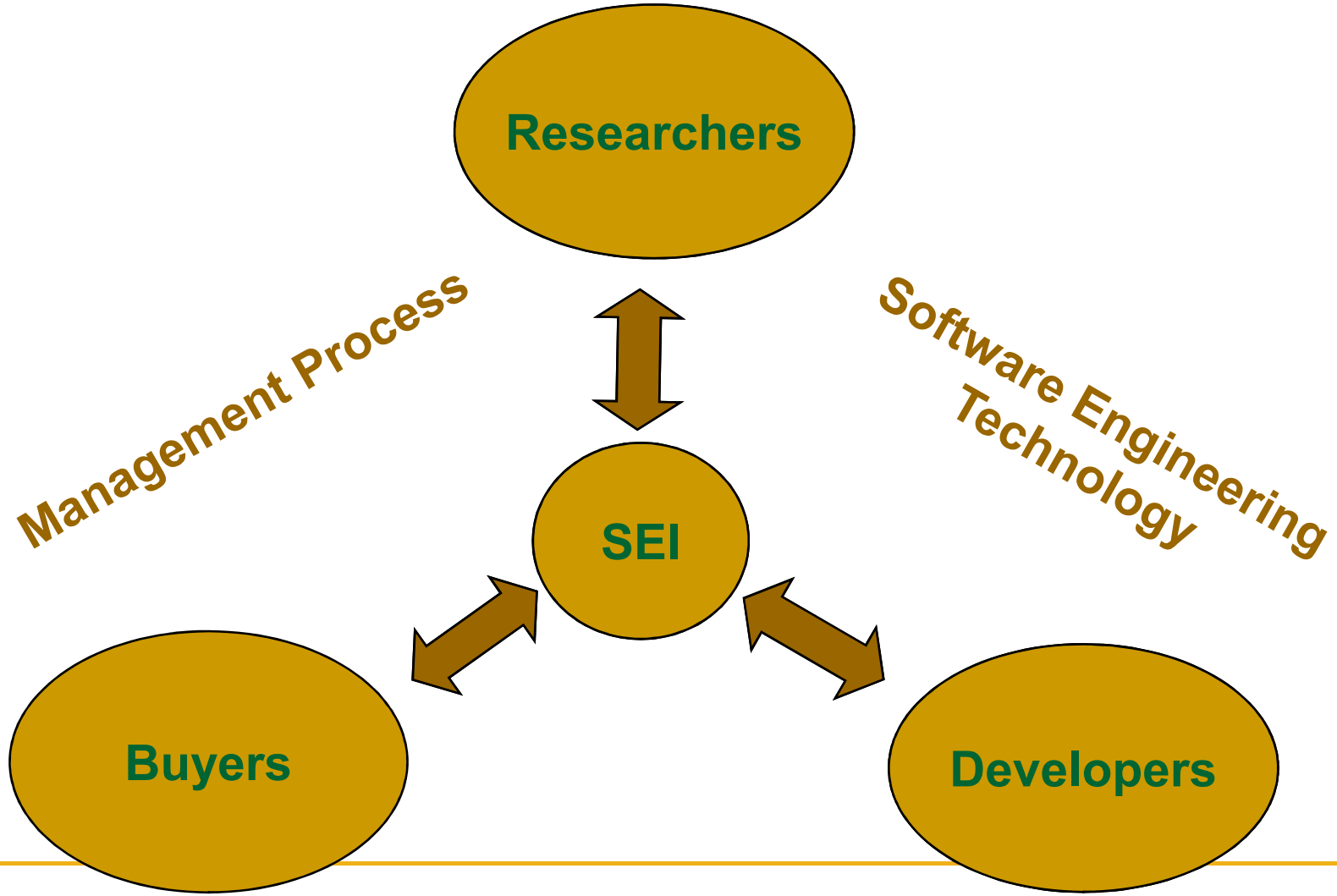
*Ref: Standish Group, www.standishgroup.com, 1999

*** move to the left !**

*** reuse <u>everything</u>**

*** never make the same mistake twice**

# The SEI Communities



# Vision

Right software delivered defect free, on time, on cost, every time

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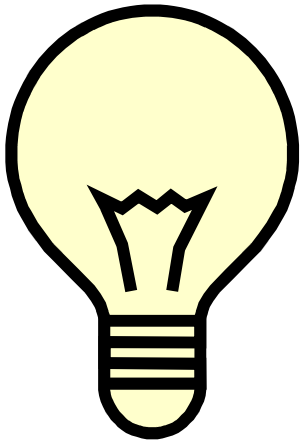
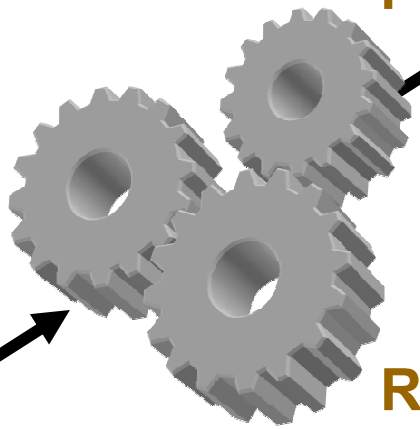


High-performance teams using best practices

**Developers**

**Buyers**



*An integrated engineering and manufacturing paradigm: systems assembled from certifiable components leveraging commonalities across families of similar systems*

Integrated systems and software engineering, but …

**Researchers**

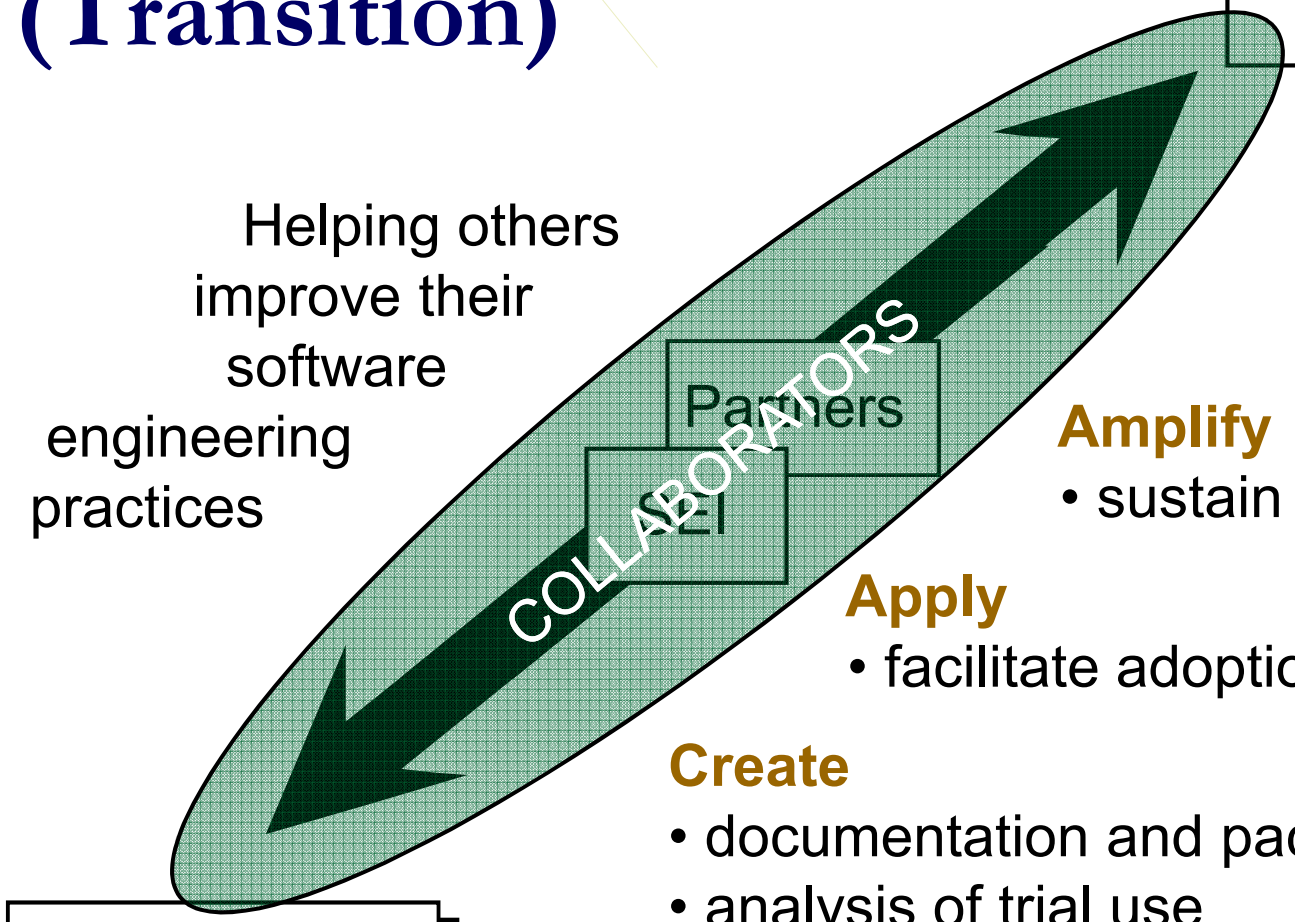
*Focusing on high-impact challenges (survivability, interoperability, predictability, evolvability, etc.)*

Each project is a new invention

*Programmed (and reprogrammed) line by line, frequently with unpredictable cost and schedule*

# SEI's Strategy (Transition)






**Amplify**
- sustain what is adopted

**Apply**
- facilitate adoption and use

**Create**
- documentation and packaging
- analysis of trial use
- identify and mature new practices

# The Software Life Cycle

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- Starts when application is conceived and ends when it is no longer in use. It includes:
  - Initial concept
  - Requirements analysis
  - Functional design
  - Internal design
  - Documentation planning
  - Test planning
  - Coding
  - Document preparation
  - Integration
  - Testing
  - Maintenance
  - Updates
  - Retesting
  - Phase-out

# SEI Strategic Themes

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- Predictably better, faster, and cheaper by -

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- Never making the same mistake twice
- Leverage lessons learned.

# General Definition of Process

- A process is a set of practices performed to achieve a given purpose; it may include tools, methods, materials, and/or people.

# Quality Leverage Points

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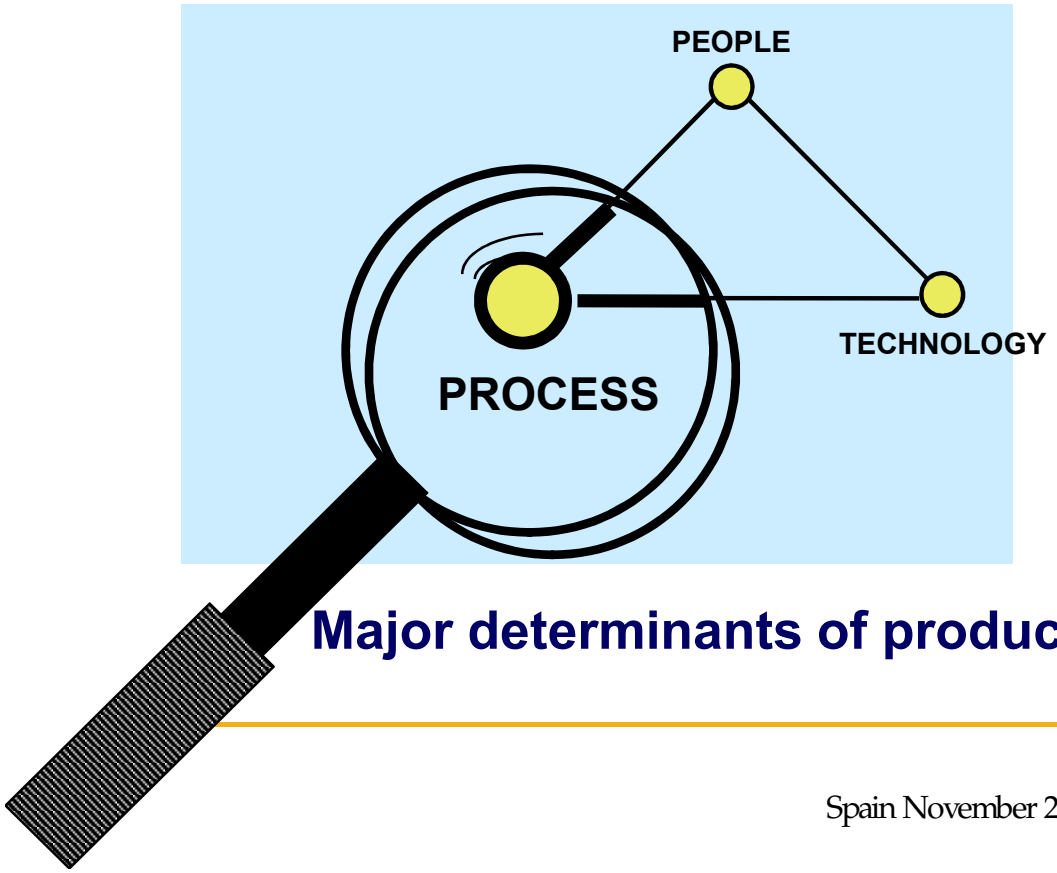
- While process is often described as a leg of the process-people-technology triad, it may also be considered the "glue" that unifies the other aspects.




Everyone realizes the importance of having a motivated, quality work force but even our finest people can't perform at their best when the process is not understood or operating "at its best."

Major determinants of product cost, schedule, and quality

# Why Focus on Process?

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- **Process provides a constructive, high-leverage focus...**

- **as opposed to a focus on people**
  - **The experience and training of your work force is not always enough.**
  - **Working harder is not the answer.**
  - **A well defined process can provide the means to work smarter.**
  - **Shifts the "blame" for problems from people to the process**
- **as opposed to a focus on technology**
  - **Technology, by itself, will most likely not be used effectively.**
  - **Technology, in the context of an appropriate process roadmap, can provide the most benefit.**

# The Process Management Premise

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- The quality of a system is highly influenced by the quality of the process used to acquire, develop, and maintain it.
- This premise implies a focus on processes as well as on products.
  - This is a long-established premise in manufacturing.
  - Belief in this premise is visible worldwide in quality movements in manufacturing and service industries (e.g., ISO standards).

# Simple Improvement Processes

- Make a plan.
- Execute the plan.
- Learn lessons and do it again.
- Determine where you want to be.

- IDEAL℠
  - Initiating, Diagnosing, Establishing, Acting & Learning

# The IDEAL℠ Model

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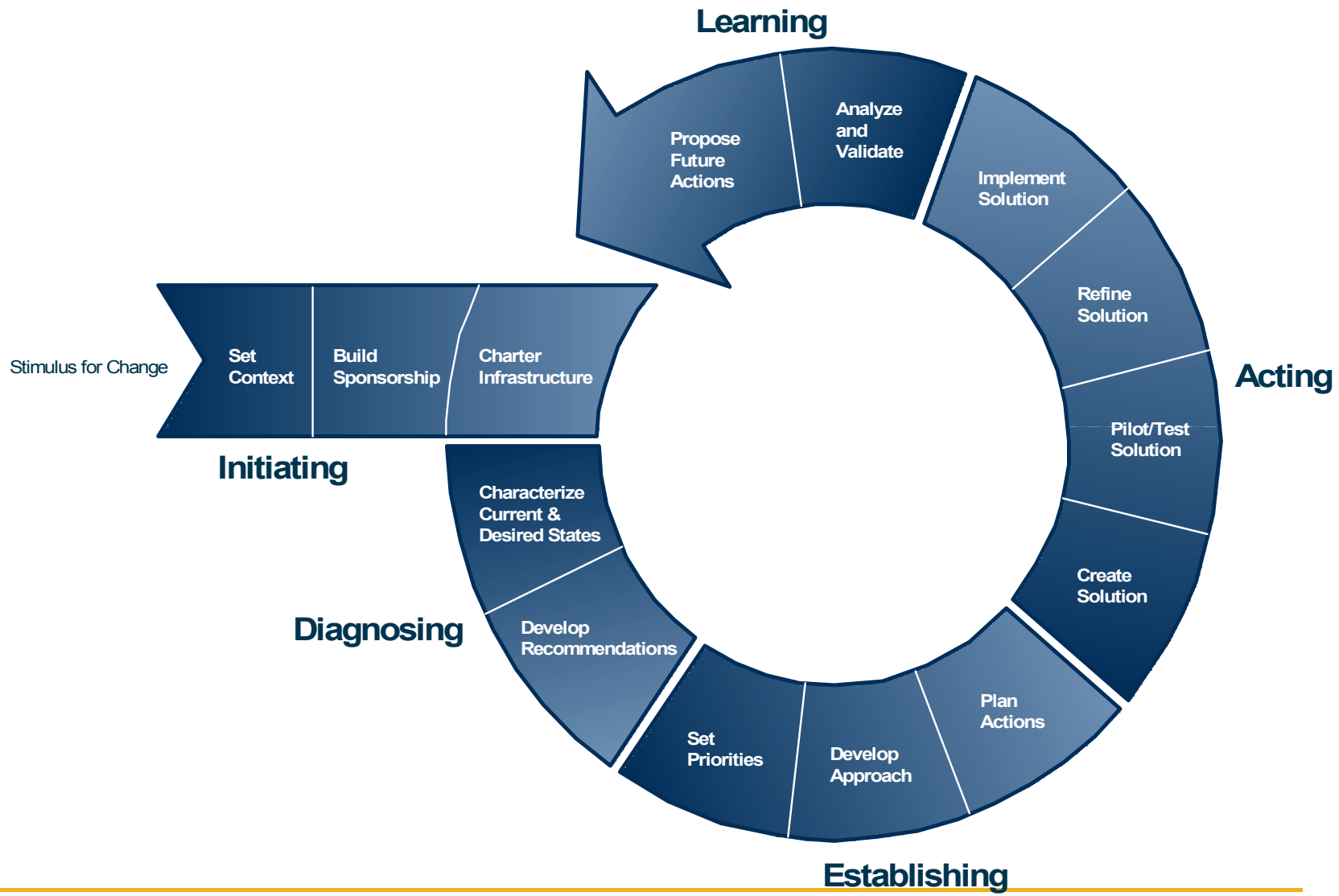


℠ IDEAL is a service mark of Carnegie Mellon University.

# The Capability Maturity Model® for Software (SW-CMM®)

A common-sense application of the concepts of Total Quality Management to software projects

A community-developed guide with descriptions of good engineering and management practices

A five-level prescriptive model for organizational transformation

The basis for reliable and consistent CMM-based appraisals

*Mark C. Paulk, Charles V. Weber, Bill Curtis, and Mary Beth Chrissis, The Capability Maturity Model: Guidelines for Improving the Software Process, 1995.*

# Software CMM v1.1

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| Level | Focus | Key Process Areas |
|---|---|---|
| 5 Optimizing | *Continuous process improvement* | Defect Prevention<br>Technology Change Management<br>Process Change Management |
| 4 Managed | *Product and process quality* | Quantitative Process Management<br>Software Quality Management |
| 3 Defined | *Engineering processes and organizational support* | Organization Process Focus<br>Organization Process Definition<br>Training Program<br>Integrated Software Management<br>Software Product Engineering<br>Intergroup Coordination<br>Peer Reviews |
| 2 Repeatable | *Project management processes* | Requirements Management<br>Software Project Planning<br>Software Project Tracking & Oversight<br>Software Subcontract Management<br>Software Quality Assurance<br>Software Configuration Management |
| 1 Initial | *Competent people (and heroics)* | |

# ISO/IEC 15504
## (Software Engineering – Process Assessment)

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- Continuous representation
  - processes (purpose + outcomes)
  - capability dimension (six levels)
- Process Reference Models
  - ISO/IEC 12207 (Software Life Cycle Processes)
  - ISO/IEC 15288 (Systems Life Cycle Processes)
- Process Assessment Models
  - ISO/IEC 15504-5 exemplar (under development)

- *Terence P. Rout, "ISO/IEC 15504 – Evolution to an International Standard," Software Process Improvement and Practice, January/March 2003, pp. 27-40.*

# Improvement and Impacts

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## Improvement per level

- Quality (reliability, defects) improves by roughly a factor of 2 (or more)
- Effort for a given product decreases 15-21%, productivity increases, cycle time decreases

## Impact of Software CMM and ISO 9001

- Certified firms indicate better product attributes and return on quality than non-certified firms
- CMM highly rated firms (levels 4 and 5) are better than ISO 9001 certified firms with respect to product attributes and return on quality

- *George Issac, Chandrasekharan Rajendran, and R.N. Anantharaman, "Do Quality Certifications Improve the Software Industry's Operational Performance?" ASQ Software Quality Professional, December 2003.*

# CMM Integration (CMMI)

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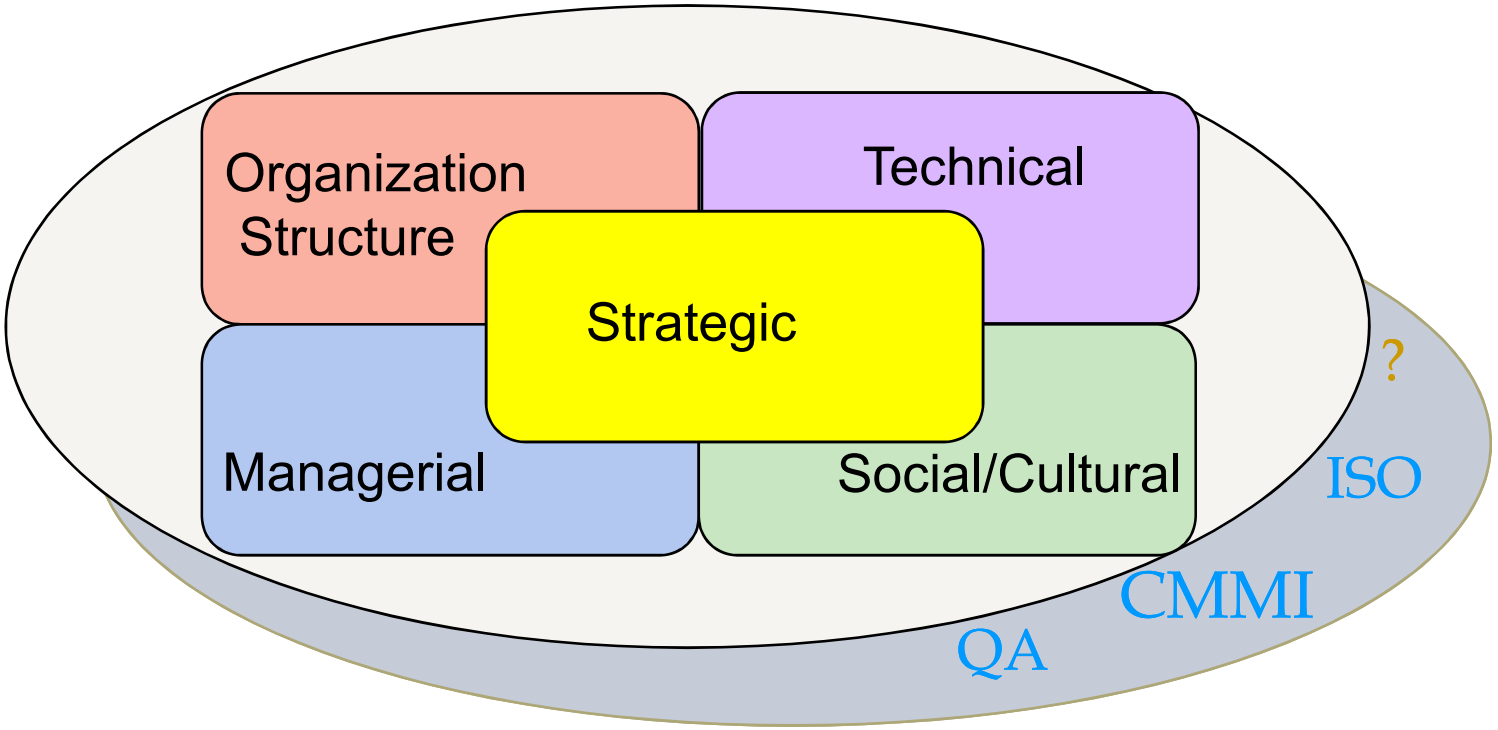
- The Software CMM is being superseded by CMMI.

- CMMI addresses
  - systems engineering
  - software engineering
  - integrated product and process development
  - sourcing selection
  - *acquisition module for government acquisition organizations*

- *Mary Beth Chrissis, Mike Konrad, and Sandy Shrum, CMMI: Guidelines for Process Integration and Product Improvement, 2003.*
- *http://www.sei.cmu.edu/cmmi/*
- *http://www.sei.cmu.edu/cmmi/adoption/sunset.html*

# Process Improvement Involves Dealing with Multiple Dimensions at One Time




CMMI based improvement is Much More than simply asking people to use a different template.

# CMM Integration (CMMI-SE /SW/IPPD /SS V1.1)

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| Level | Process Characteristics | Process Areas |
|---|---|---|
| 5 Optimizing | *Focus is on quantitative continuous process improvement* | Causal Analysis and Resolution<br>Organizational Innovation and Deployment |
| 4 Quantitatively Managed | *Process is measured and controlled* | Quantitative Project Management<br>Organizational Process Performance |
| 3 Defined | *Process is characterized for the organization and is proactive* | Requirements Development<br>Technical Solution<br>Product Integration<br>Verification<br>Organizational Process Focus<br>Integrated Project Management<br>Integrated Teaming<br>Organizational Environment for Integration<br>Integrated Supplier Management<br>Validation<br>Organization Process Definition<br>Organizational Training<br>Risk Management<br>Decision Analysis & Resolution |
| 2 Managed | *Process is characterized for projects and is often reactive* | Requirements Management<br>Project Planning<br>Project Monitoring and Control<br>Supplier Agreement Management<br>Product and Process Quality Assurance<br>Configuration Management<br>Measurement and Analysis |
| 1 Initial | *Process is unpredictable, poorly controlled, and reactive* | |

# Documented Results of CMM-based PI

- Process improvement benefits fall into one or more of these general categories:
  - improved schedule and budget predictability
  - reduction of rework
  - improved cycle time
  - increased productivity
  - improved quality (as measured by defects)
  - increased customer satisfaction
  - improved employee morale
  - increased return on investment
  - decreased cost of quality
- All this is in addition to meeting your customer's requirement....

# CMMI Transition Status

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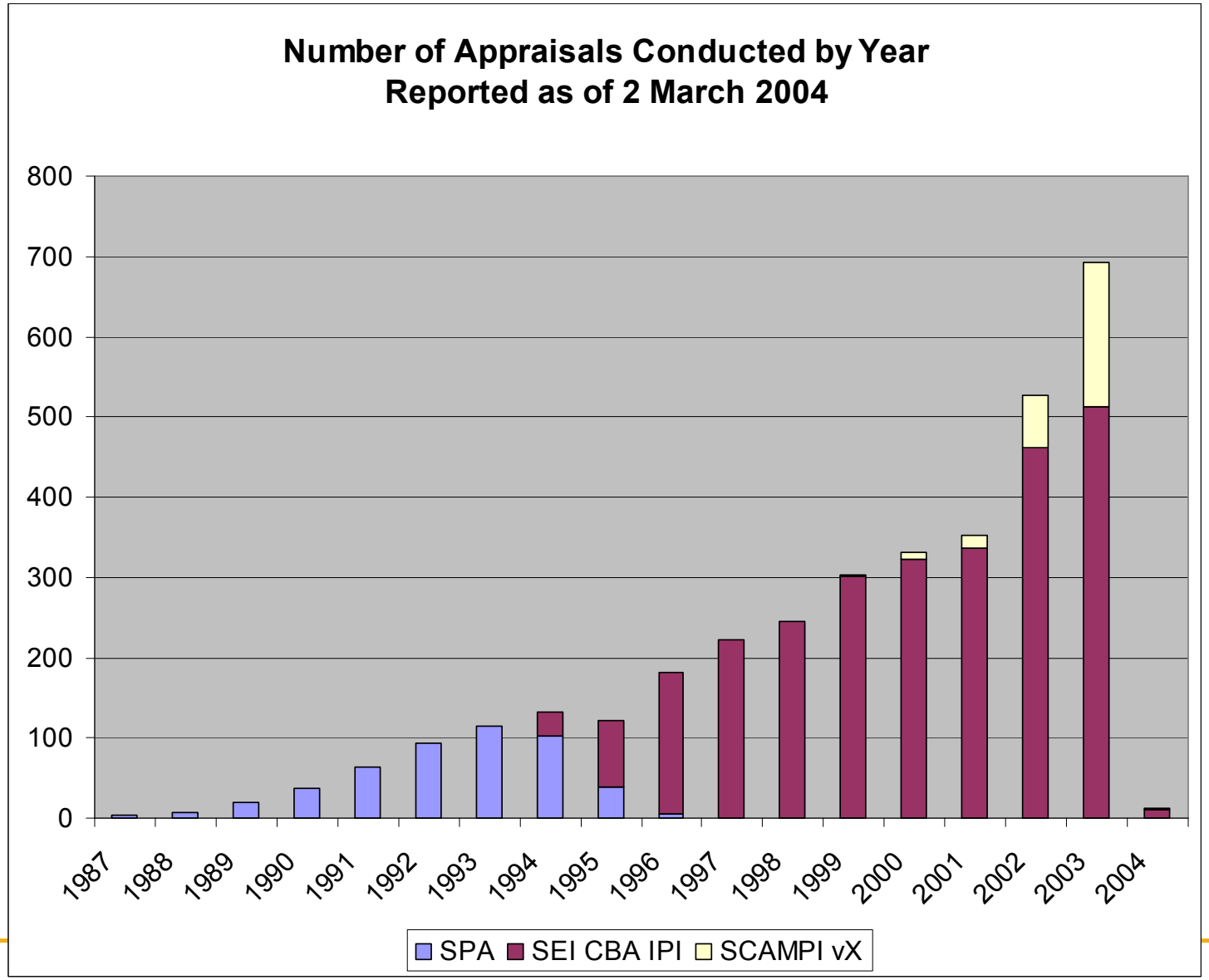
- 234 Introduction to CMMI instructors trained
- 402 SCAMPI Lead Appraisers trained
- 830 students trained in Intermediate Concepts of CMMI
- 179 Introduction to CMMI instructors authorized
- 16,161 students trained in Introduction in CMMI
- 293 SCAMPI Lead Appraisers authorized
- 80 active transition partners that offer Introduction to CMMI training
- 147 active transition partners that offer SCAMPI appraisal services


Number of Appraisals Conducted by Year
Reported as of 2 March 2004
800
700
600
500
400
300
200
100
0
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
SPA
SEI CBA IPI
SCAMPI vX

# What is CMMI?

- CMMI
  - is not a process; does not tell you How to do your work
  - is a model of best practices in systems and software development and in product development
  - does tell you What to do
  - is based on the process management premise

# CMMI Model Representations

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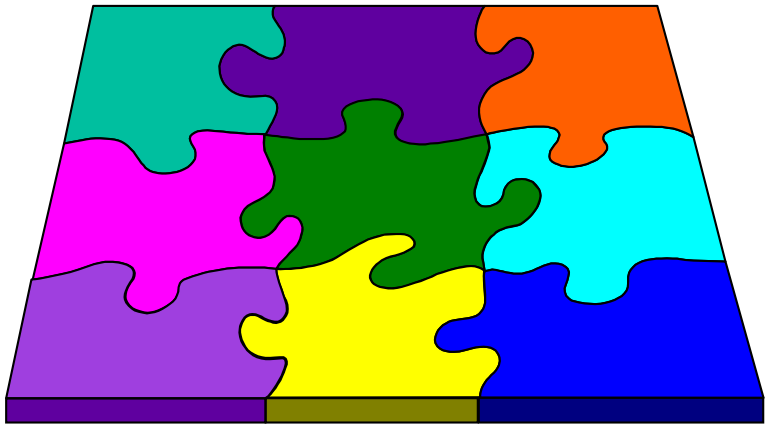
An organization may choose an approach to process improvement from either of the following:

- process area capability
- organizational maturity

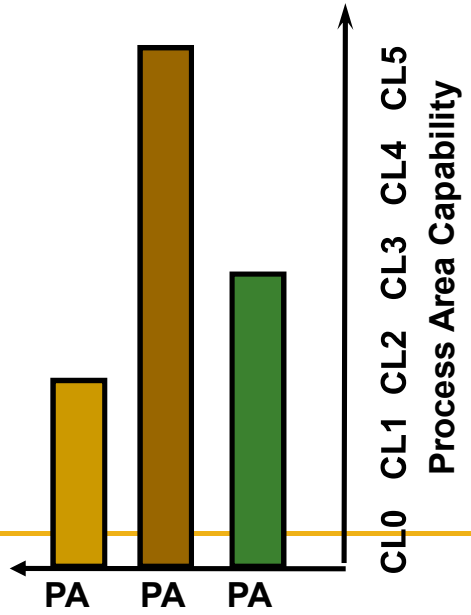


CMMI models support each approach with a *representation.*

- process area capability - continuous representation
- organizational maturity - staged representation

# Continuous Representation

- Some benefits of choosing the continuous representation are
  - It allows you to select the order of improvement that best meets your organization's business objectives and mitigates your organization's areas of risk.
  - It enables comparisons across and among organizations on a process area by process area basis.
  - It provides an easy migration from EIA/IS-731 to CMMI.



| Category | Process Areas |
|---|---|
| Process Management | Organizational Process Focus<br>Organizational Process Definition<br>Organizational Training<br>Organizational Process Performance<br>Organizational Innovation and Deployment |
| Project Management | Project Planning<br>Project Monitoring and Control<br>Supplier Agreement Management<br>Integrated Project Management for IPPD<br>Risk Management<br>Integrated Teaming<br>Integrated Supplier Management<br>Quantitative Project Management |
| Engineering | Requirements Management<br>Requirements Development<br>Technical Solution<br>Product Integration<br>Verification<br>Validation |
| Support | Configuration Management<br>Process and Product Quality Assurance<br>Measurement and Analysis<br>Decision Analysis and Resolution<br>Organizational Environment for Integration<br>Causal Analysis and Resolution |

# Capability Levels

- **Capability levels, used in the continuous representation, describe a sequential order for approaching process improvement within each process area.**

- **Capability levels build on each other, providing a recommended order for approaching process improvement within a selected process area.**

- **Capability levels enable you to track, evaluate, and demonstrate your organization's progress as you improve processes associated with a process area.**

# Staged Representation

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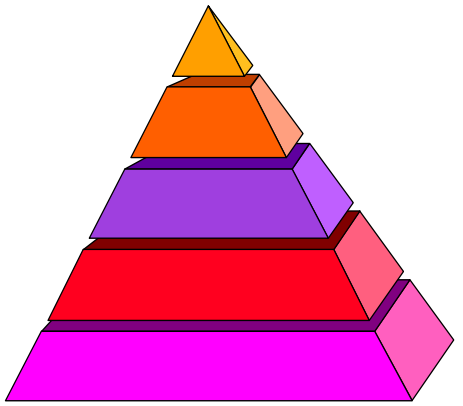
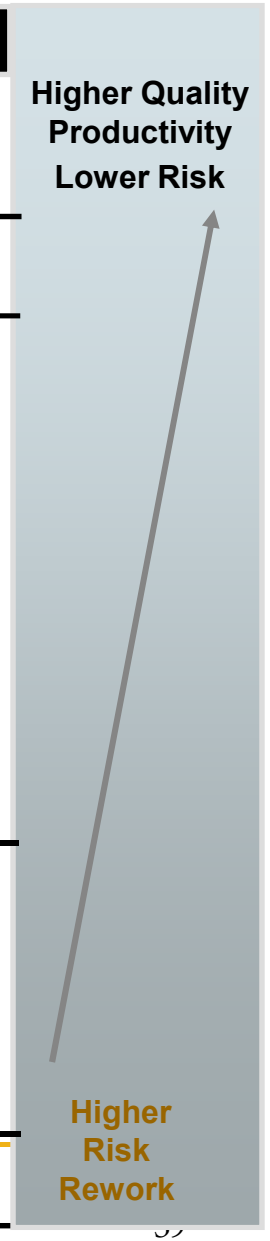
- Some benefits of choosing the staged representation are
  - It provides a proven sequence of improvements, each serving as a foundation for the next.
  - It permits comparisons across and among organizations by the use of maturity levels.
  - It provides an easy migration from the SW-CMM to CMMI.
  - It provides a single rating that summarizes appraisal results and allows comparisons among organizations.



| Level | Focus | Process Areas for SE/SW/IPPD/SS |
|---|---|---|
| 5 Optimizing | *Continuous Process Improvement* | Organizational Innovation and Deployment<br>Causal Analysis and Resolution |
| 4 Quantitatively Managed | *Quantitative Management* | Organizational Process Performance<br>Quantitative Project Management |
| 3 Defined | *Process Standardization* | Requirements Development<br>Technical Solution<br>Product Integration<br>Verification<br>Validation<br>Organizational Process Focus<br>Organizational Process Definition<br>Organizational Training<br>Integrated Project Management for IPPD<br>Risk Management<br>Integrated Teaming<br>Integrated Supplier Management<br>Decision Analysis and Resolution<br>Organizational Environment for Integration |
| 2 Managed | *Basic Project Management* | Requirements Management<br>Project Planning<br>Project Monitoring and Control<br>Supplier Agreement Management<br>Measurement and Analysis<br>Process and Product Quality Assurance<br>Configuration Management |
| 1 Initial | | |



# Maturity Levels-$_1$

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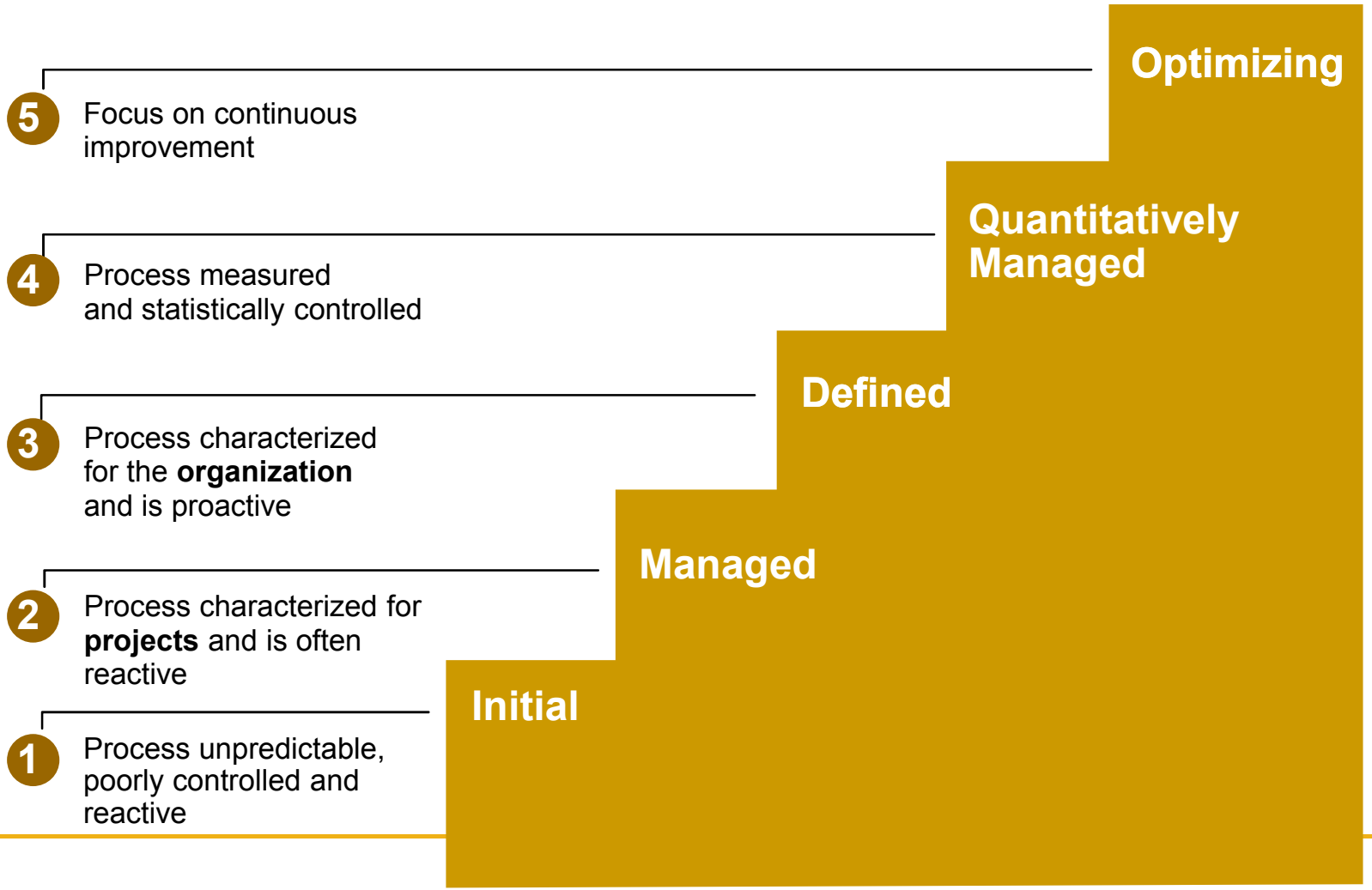
- **Maturity levels, used in the staged representation, organize selected process areas into five evolutionary plateaus to support and guide process improvement across the organization.**

- **Maturity levels are defined evolutionary plateaus of process improvement, in which each level is supported by the characteristics of the process areas implemented within the lower levels.**

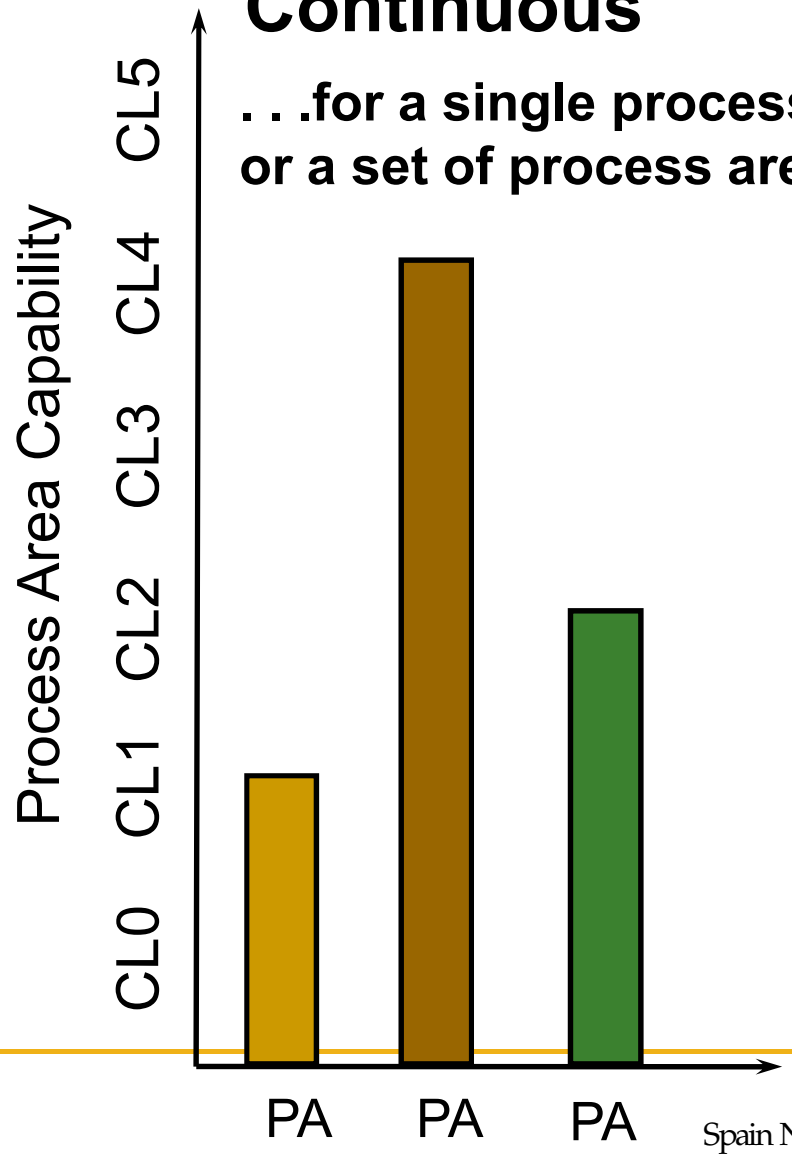
- **Maturity levels represent a process improvement evolution for the entire organization.**

# Maturity Levels-$_2$

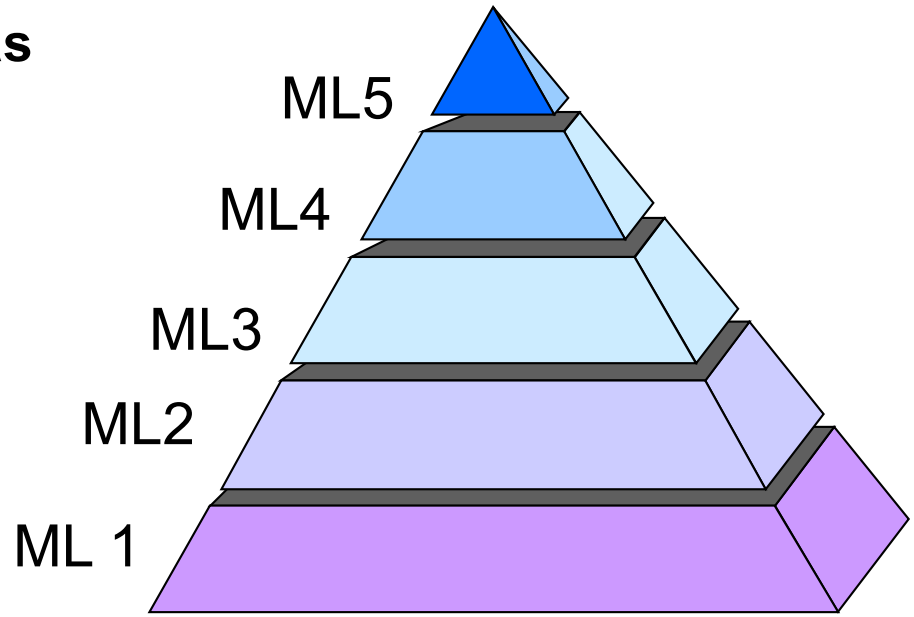


## Continuous

. . .for a single process area or a set of process areas




## Staged




. . .for a specified set of process areas across an organization

# Comparing the Different Representations

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- Both representations provide ways of implementing process improvement to achieve business goals.
- Both representations provide essentially the same content but are organized in different ways.
- There is nothing that requires that you use one or the other representation – you can use them both concurrently if that suits your business needs.

# Representation Synergy

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- The continuous representation provides additional *de facto* granularity in support of a staged-focus initiative:
  - as a guide for detailed tactical planning
  - to demonstrate intermediate progress short of process area or maturity level
  - to allay concerns and build support among stakeholders

- The staged representation can provide structure for a continuous-focus initiative:
  - as a guide for big picture "strategic" planning
  - to "chunk" higher-granularity activities for senior management
  - as a means for representing high-level success in "industry standard" terms key stakeholders will more readily understand

# Benefits of CMMI

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- CMMI provides
  - Efficient, effective assessment and improvement across multiple process disciplines in an organization
  - Improvements to best practices incorporated from the Software CMM
  - 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

# Conclusions

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- The Software Engineering Institute at Carnegie Mellon has met its Vision and fulfilled its Mission as an FFRDC
- The SEI has made an impact in a number of technical programs transitioned to the DoD and Industry
- From the beginning the SEI placed great emphasis in the improvement of the Software Process and its Management
- Among the flagships of the SEI are CMM and its successor CMMI
- Certified firms indicate better product attributes and return on quality than non-certified firms


# Questions?
# Comments?