Process Assessment

- Motivation
- SEI Capability Maturity Model
- Assessment process
- Case studies
- Critique

Motivation

- Risk reduction
- Quality improvement
- [Productivity increase]

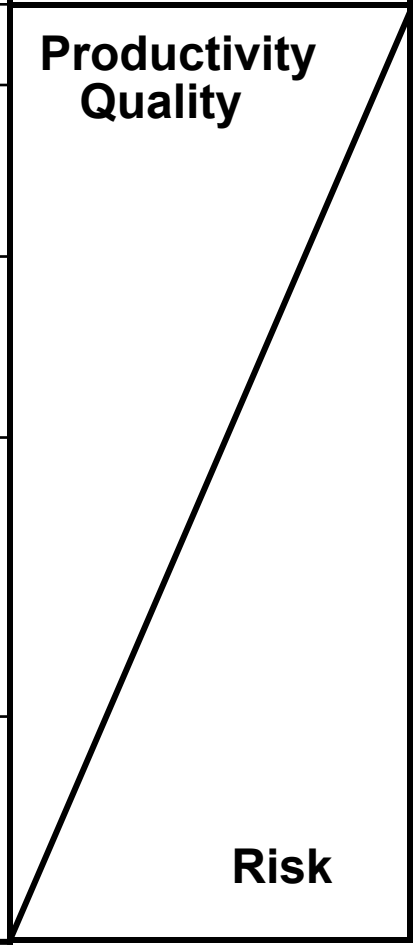
Capability Maturity Model (CMM)

- Developed by the Software Engineering Institute (SEI) with DoD funding
- Designed for large organizations doing routine development
- Assessment *and* evaluation
  - What's the difference?
- Five levels of maturity
- Key processes
- Extended to CMMI
  - Capability Maturity Model Integration

CMM . . .

- CMM
  - Original maturity model
- CMMI
  - CMM Integration
  - Generalization of CMM to different kinds of products and activities (services, acquisitions, etc.)
- *CMMI for Development*
  - Evolution of original CMM wrt software

The SEI Process Maturity Model

Level	Characteristic	Key Problem Areas	Results
Optimizing	Process improvement	Automation	
Managed	(quantitative) Process Measured	Changing technology Problem analysis Problem prevention	
Defined	(qualitative) Process defined and institutionalized	Process measurement Process analysis Quantitative quality plans	
Repeatable	(intuitive) Process dependant on individuals	Training Technical practice reviews, testing Process focus standards, process groups	
Initial	(ad hoc / chaotic)	Project management Project planning Configuration management Software quality assurance	

(source : SEI)

Levels

- Level 1: Initial
  - Instable; dependent on individuals
- Level 2: Repeatable
  - Policies; use of experience in planning; discipline
- Level 3: Defined
  - Documented process; process group; readiness and completion criteria
- Level 4: Managed
  - Quantitative goals; data collection
- Level 5: Optimized
  - Continuous process improvement

Level 1: Initial Process

- Ill-defined inputs; cost and schedule overruns
- Undefined process; no repeatability
- Simple metrics of size, staff effort
- Baseline for later comparison

Level 2: Repeatable Process

- Identified process inputs, outputs, and constraints
- No knowledge of how outputs are produced
- Measures of size:
  - Lines of code (LOC), function points, object and method counts
- Requirements volatility
- Extent of personnel experience determines success
  - Domain / applications, development architecture, tools / methods, overall years of experience, turnover
- Key areas
  - Requirements, management, project planning, project tracking, subcontract management, QA, change Management

Level 3: Defined Process

- Activities with definitions and entry / exit criteria
- Measures of requirements complexity, design modules, code complexity, test paths, pages of documentation
- Software Engineering Process Groups (SEPGs)
- Quality metrics
  - Defects discovered, error density for each activity area
- Key areas
  - Organizational process definition, training program, integrated management, product engineering, intergroup coordination, peer reviews

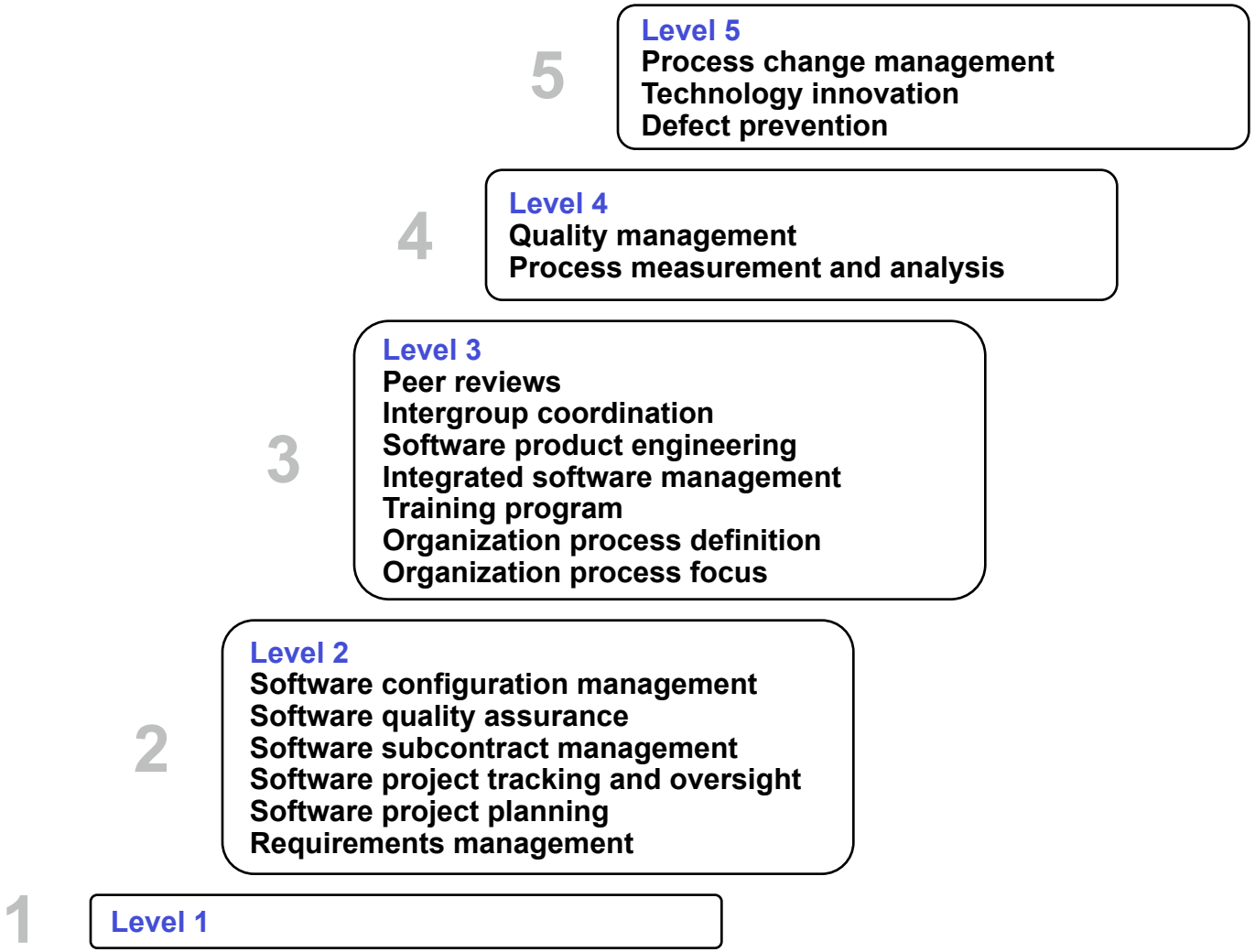
Level 4: Managed Process

- Feedback from early activities is used to set priorities for later stages
- Data collected
  - Process type, extent of reuse (production and consumption), when are defects detected, testing completion criteria, configuration management, change control, traceability links, module completion rate
- Key areas
  - Process measurement and analysis, quality management

Level 5: Optimizing Process

- Measures of activities are used to change the process
- Analogy with Statistical Process Control (SPC)
- Key Areas
  - Defect prevention, technology innovation, process change management

Key Practices



Assessment Process

- Selection of assessment team
- Management commitment
  - Assessment agreement
- Preparation
  - Training, survey questionnaire
- Assessment
  - Questionnaire analysis; discussions with projects and functional area representatives; findings; feedback; presentation
- Report
- Follow Up
  - Action plan, reassessment after 18 months

Assessment Details - 1

- Assessment team has 6-8 members, some internal, some external
  - Either SEI or a vendor
- Team members have > 10 years experience; team leader has > 20 years experience
- Assessment itself takes 3-5 days
- 78 YES / NO questions
- *Hurdle* scoring (binary)

Assessment Details - 2

- Four or five projects are examined per organization
- Interviews with 8-10 functional area representatives (FARs) from each area
  - QA, integration testing, coding and unit test, requirements and design
- Implementation process takes 12-18 months
- Follow-up at the end of this time

Example Questionnaire Item

2.3 Data Management and Analysis

Data management deals with the gathering and retention of process metrics. Data management requires standardized data definitions, data management facilities, and a staff to ensure that data is promptly obtained, properly checked, accurately entered into the database and effectively managed.

Analysis deals with the subsequent manipulation of the process data to answer questions such as, "Is there a relatively high correlation between error densities found in test and those found in use?" Other types of analyses can assist in determining the optimum use of reviews and resources, the tools most needed, testing priorities, and needed education.

Questionnaire - 2

2.3.1 Has a managed and controlled process database been established for process metrics data across all projects?

2.3.2 Are the review data gathered during design reviews analyzed?

2.3.3 Is the error data from code reviews and tests analyzed to determine the likely distribution and characteristics of the errors remaining in the product?

2.3.4 Are analyses of errors conducted to determine their process related causes?

2.3.5 Is a mechanism used for error cause analysis?

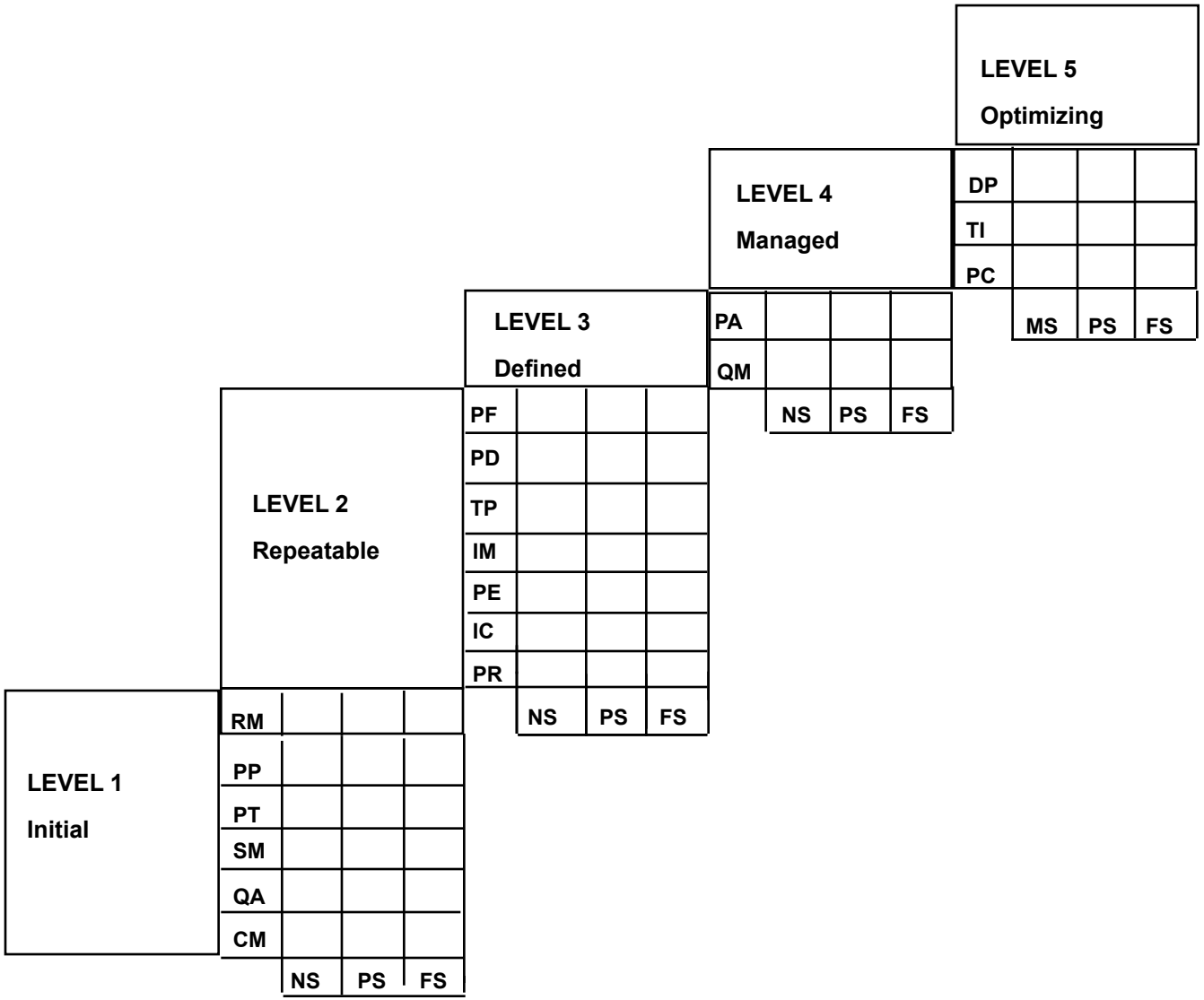
2.3.6 Are the error causes reviewed to determine the process changes required to prevent them?

2.3.7 Is a mechanism used for initiating error prevention actions?

2.3.8 Is review efficiency analyzed for each project?

2.3.9 Is software productivity analyzed for major process steps?

Key Process Area Profile Template



Case Study: Hughes Aircraft - 1

- 500 people in part of one division
- 1987: Level 2; 1990: Level 3
- Cost-Benefit
  - $45K assessment cost
  - $400K improvement cost
  - $2M savings
  - 2% increased overhead
  - 18 months implementation (78 staff months)
  - 5x improvement in expenditure estimation

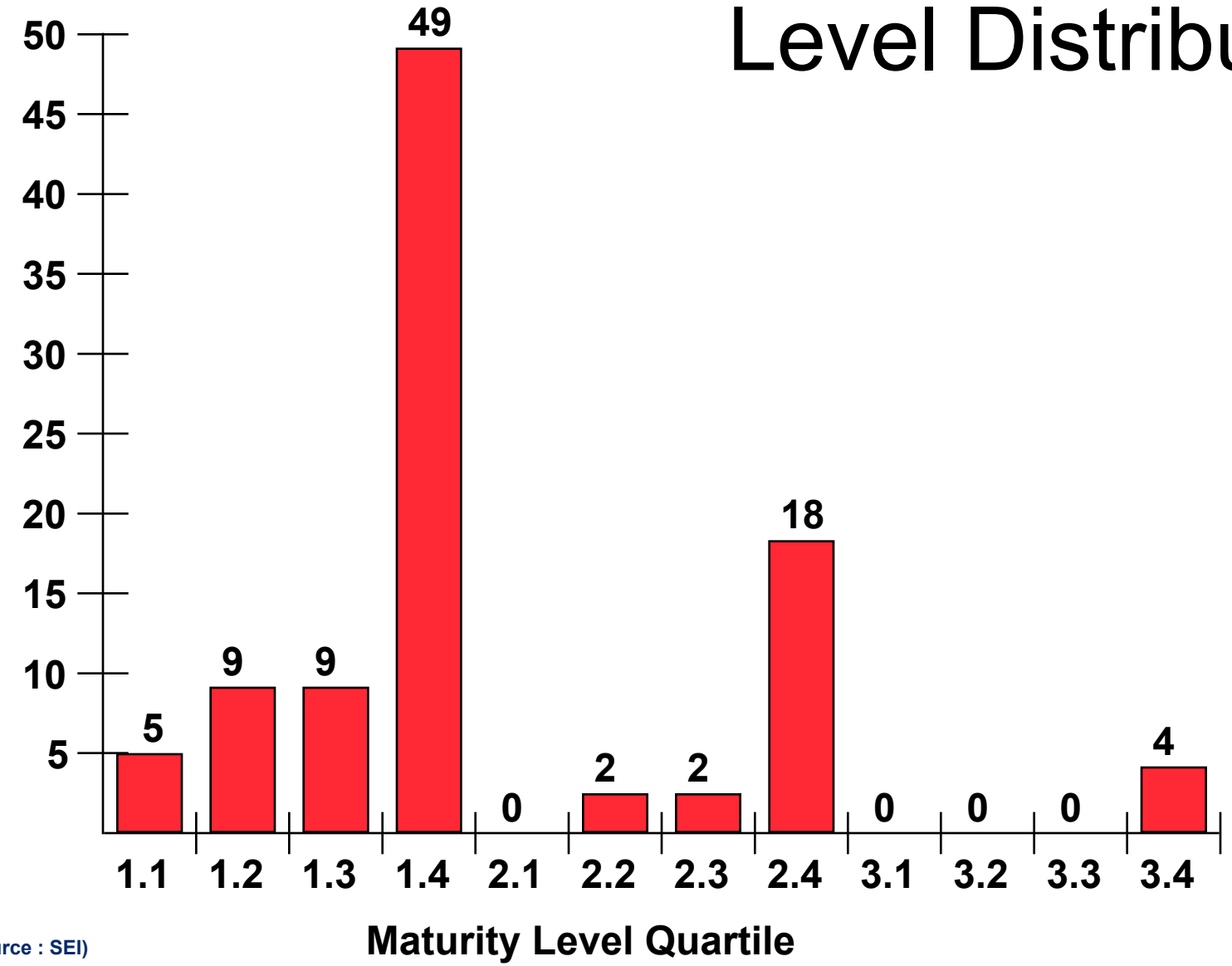
Case Study: Hughes Aircraft - 2

- Major 1987 recommendations
  - Central data repository
  - Process groups
  - More involvement in requirements process
  - Technology transition organization
- Major 1990 recommendations
  - More division-wide data analysis
  - Opportunities for automation

SEI Survey of Organizations

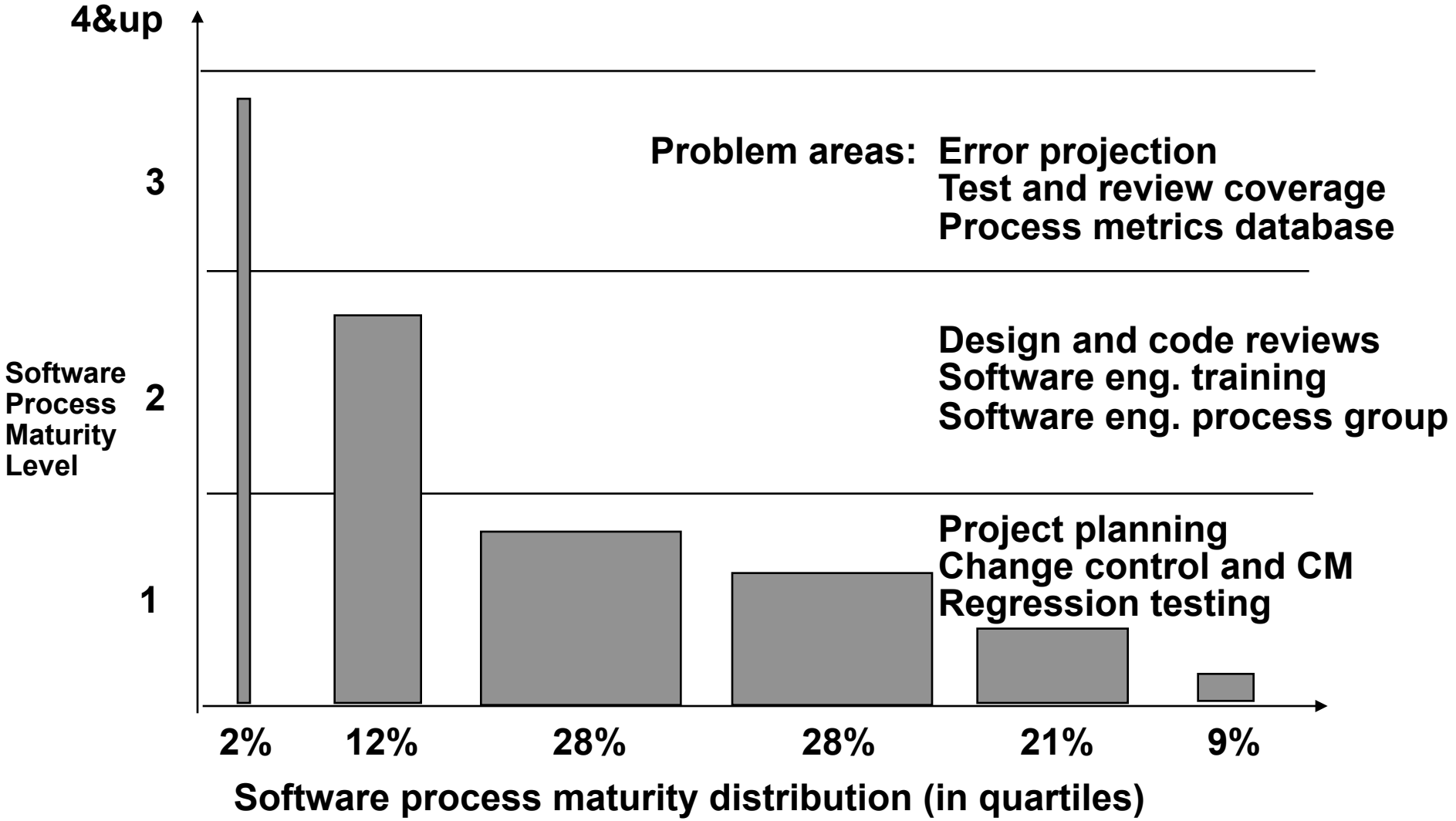
- 1990: 113 Projects
  - 85% At Level 1
  - 14% At Level 2
  - 1% At Level 3

Software Process Maturity Level Distribution



(Source : SEI)

Early Results



(Source: IEEE Software)

More Recent Results
CMMI - 2005

Performance Category	Median	Number of Data Points	Low	High
Cost	20%	21	3%	87%
Schedule	37%	19	2%	90%
Productivity	62%	17	9%	255%
Quality	50%	20	7%	132%
Customer Satisfaction	14%	6	-4%	55%
Return on Investment	4.7 : 1	16	2 : 1	27.7 : 1

CMMI

- Integrated framework for maturity models
- Structured by Process Areas

CMMI Process Areas

Category	Process Area	Level
Process Management	Organizational Process Focus (OPF)	3
	Organizational Process Definition +IPPD (OPD+IPPD)	3
	Organizational Training (OT)	3
	Organizational Process Performance (OPP)	4
	Organizational Innovation and Deployment (OID)	5
Project Management	Project Planning (PP)	2
	Project Monitoring and Control (PMC)	2
	Supplier Agreement Management (SAM)	2
	Integrated Project Management +IPPD (IPM+IPPD)	3
	Risk Management (RSKM)	3
	Quantitative Project Management (QPM)	4
Engineering	Requirements Management (REQM)	2
	Requirements Development (RD)	3
	Technical Solution (TS)	3
	Product Integration (PI)	3
	Verification (VER)	3
	Validation (VAL)	3
Support	Configuration Management (CM)	2
	Process and Product Quality Assurance (PPQA)	2
	Measurement and Analysis (MA)	2
	Decision Analysis and Resolution (DAR)	3
	Causal Analysis and Resolution (CAR)	5

Process Management

- Organizational Process Focus
  - Identified person or group
- Organizational Process Definition
  - Assets and standards
- Organizational Training
  - Processes, skills, knowledge
- Organizational Process Performance
  - Quantitative expectations; data; support
- Organizational Innovation and Deployment
  - Identification, evaluation, selection and deployment of improvements

Project Management

- Project Planning
  - Activities, estimates, schedule, resources
- Project Monitoring and Control
  - Tracking, corrective action
- Supplier Agreement Management
  - Status checking and corrective action
- Integrated Project Management
  - Inclusion of stakeholders, integration
- Risk Management
  - Cost, schedule, quality, functionality
  - Anticipation, monitoring, mitigation, prevention
- Quantitative Project Management
  - Link to performance, data intensive, predictions

Engineering

- Requirements Management
  - Allocation, component definition, consistency checking
- Requirements Development
  - Identification, analysis, documentation, agreement
- Technical Solution
  - Design, development, implementation
- Product Integration
  - Assembly, validation
- Verification
  - Reviews, inspections
- Validation
  - Satisfaction in customer environment

Support

- Configuration Management
  - Integrity of work products; versions and changes
- Process and Product Quality Assurance
  - Standards, audits
- Measurement and Analysis
  - Definition, storage, reporting, analysis
- Decision Analysis and Resolution
  - Established evaluation criteria; adequacy, relevance; alternative
  - {Criterion, measurement, threshold}
- Causal Analysis and Resolution
  - Correction, prevention; causal analysis

Generic Practices for Establishing Managed Processes

- Establishing policy
- Process planning
- Providing resources
- Assigning responsibility
- Training
- Controlling changes to the process and its work products
- Identifying and involving (process) stakeholders
- Monitoring and control
- Compliance checking
- Reviewing status with higher-level management

Adoption and Deployment

- Management buy-in
- Compliance vs. performance drivers
- Incremental adoption
- Identified resources and responsibilities
  - Engineering process group
  - Management steering committee
- Baseline measurements
- Deficiency identification
- Action plan
- Training

Generic Practices for Optimizing Processes

- Establishing a defined process
- Collecting improvement information
- Setting quantitative objectives
- Stabilizing subprocesses
- Ensuring continuous process improvement
  - {*metaprocesses*}
- Analyzing and correcting root causes of process problems

CMM Benefits

- CMM encapsulates industry best practices
- DOD sponsorship has enforced process improvement throughout Defense community
- Quality movement has led to CMM being quite widely used in other sectors
- Enhanced understanding of the development process
- Increased control and risk reduction
- Even Level 2 leads to superior product quality

Benefits - 2

- Migration path to a more mature process
- More accurate cost estimation and scheduling
- Objective evaluations of changes in tools and techniques
- Standardized training
- Marketing

CMM Criticisms

- Lots of room for interpretation of assessment rules
- Purpose and potential misuse of model
  - Originally for self-assessment and organizational learning
  - Increasingly used by DoD for contractor evaluation and qualification
- Tends to ignore different needs of different development environments
  - Emphasis on DoD contractual development
  - Emphasis on big, mission-critical projects
- Deemphasis of design risk
- Deemphasis on satisfaction of customer requirements