Outline

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

Motivation

- Risk reduction
- Quality improvement
- Productivity increase

Capability Maturity Model (CMM)

- Developed by the Software Engineering Institute (SEI) with Department of Defense (DoD) funding

- Designed for large organizations doing routine development

- Assessment *and* evaluation
  - What is the difference?

- Five levels of maturity

- Key processes

The SEI Capability Maturity Model

Level	Characteristic	Key Problem Areas	Results
Optimizing	Process improvement	Automation	**Productivity Quality**
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	**Risk**

(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
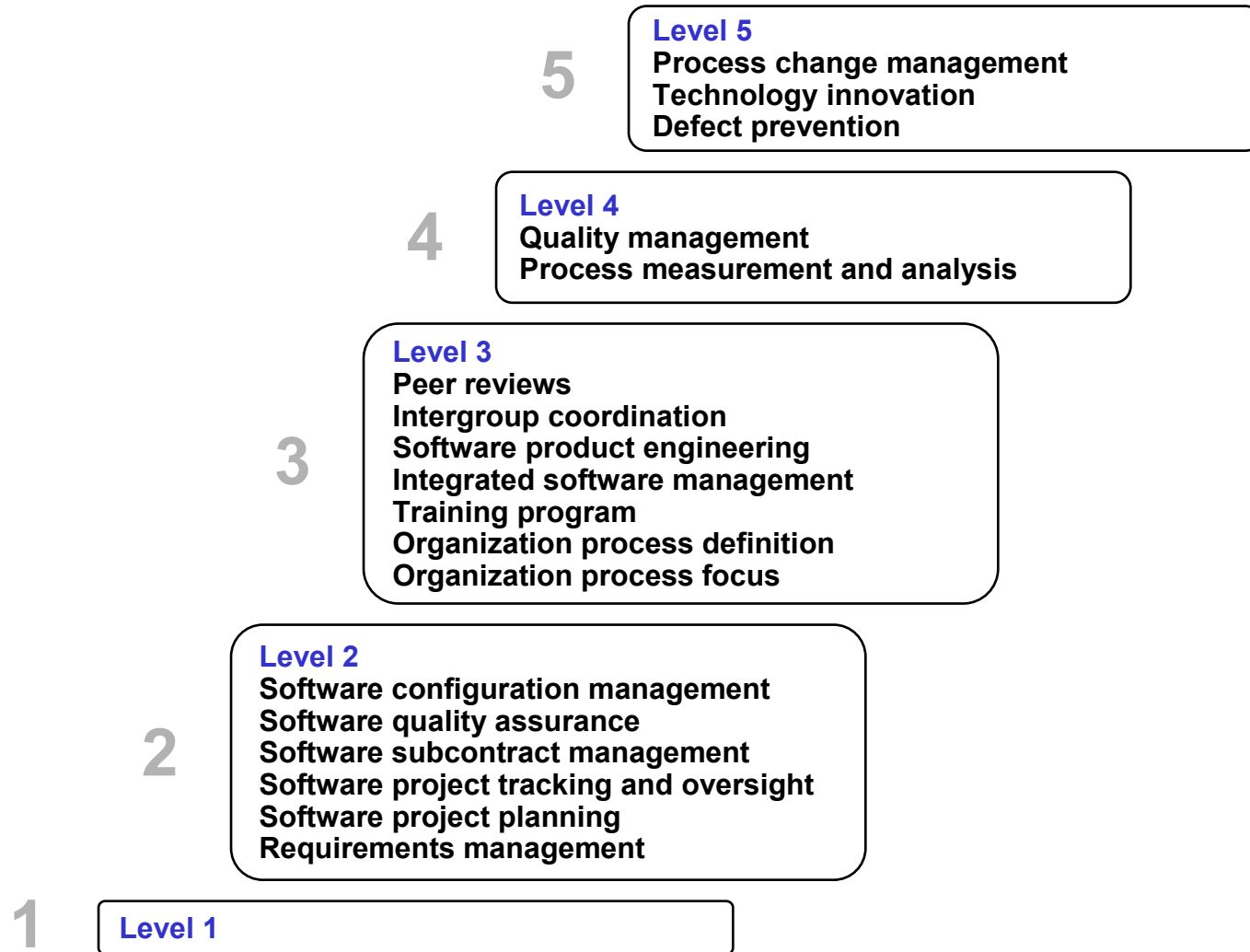
Level 4: Managed Process

- 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, use of 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

CMM Key Practices

5

Level 5
Process change management
Technology innovation
Defect prevention

4

Level 4
Quality management
Process measurement and analysis

3

Level 3
Peer reviews
Intergroup coordination
Software product engineering
Integrated software management
Training program
Organization process definition
Organization process focus

2

Level 2
Software configuration management
Software quality assurance
Software subcontract management
Software project tracking and oversight
Software project planning
Requirements management

1

Level 1

Assessment Process

- Selection of assessment team

- Management commitment
  - Assessment agreement

- Preparation
  - Training, survey questionnaire of key practices

- 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)

© 2007, Spencer Rugaber

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

© 2007, Spencer Rugaber

Example Questionnaire Area

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.

Example Questions

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?

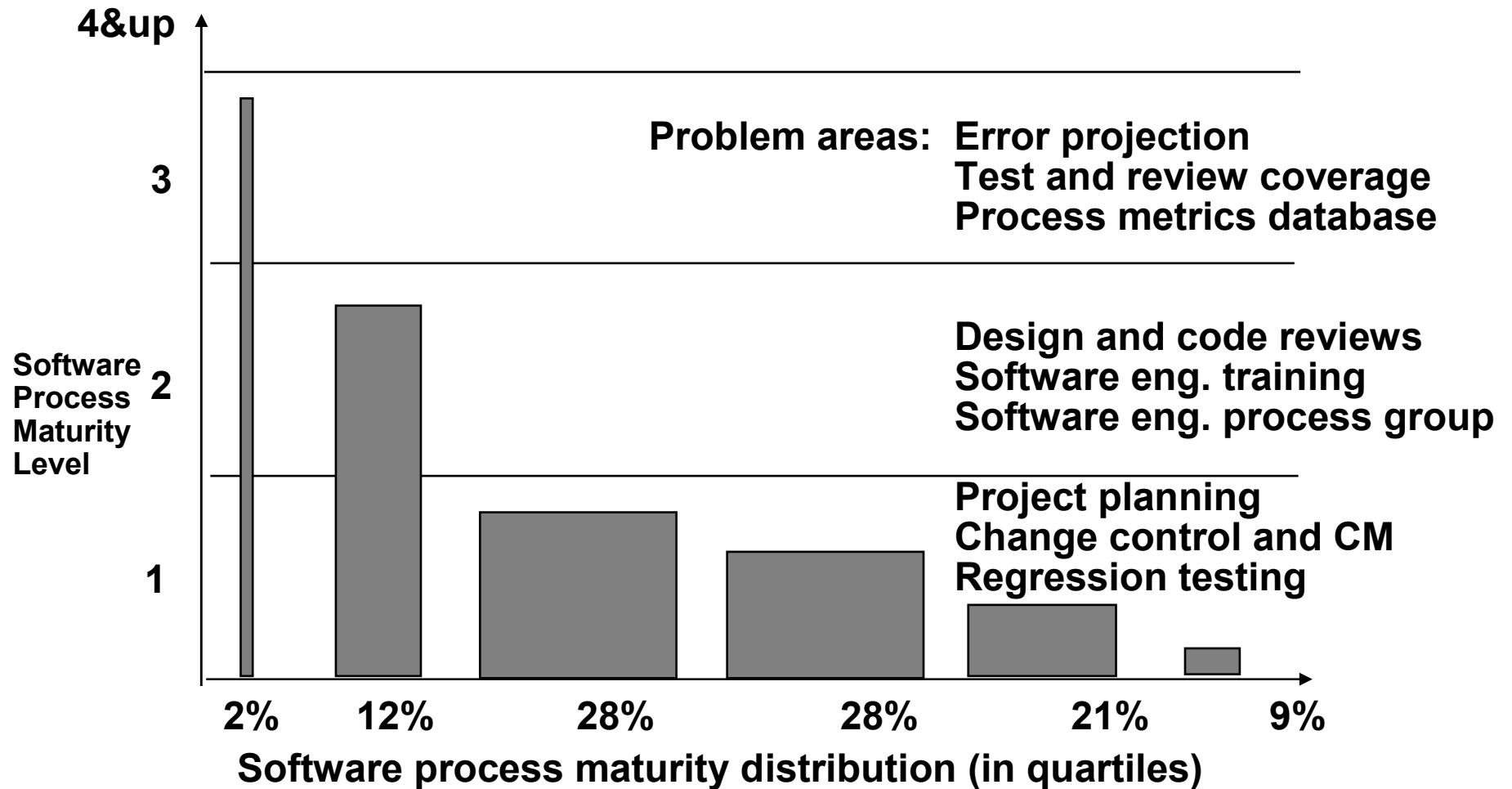2.3.9 Is software productivity analyzed for major process steps?

© 2007, Spencer Rugaber

Case Study: Hughes Aircraft - 1

- 500 people in part of one division

- 1987: Level 2; 1990: Level 3

- $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 group, more involvement in requirements process, technology transition organization

- Major 1990 recommendations
  - More division-wide data analysis; opportunities for automation

Early Results

4&up

3

Software Process Maturity Level **2**

1

Problem areas: **Error projection**
Test and review coverage
Process metrics database

Design and code reviews
Software eng. training
Software eng. process group

Project planning
Change control and CM
Regression testing

2% **12%** **28%** **28%** **21%** **9%**

Software process maturity distribution (in quartiles)

CMM Variations

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

CMMI Process Areas

- Causal Analysis and Resolution (CAR)
- Configuration Management (CM)
- Decision Analysis and Resolution (DAR)
- Integrated Project Management +IPPD (IPM+IPPD)
- Measurement and Analysis (MA)
- Organizational Innovation and Deployment (OID)
- Organizational Process Definition +IPPD (OPD+IPPD)
- Organizational Process Focus (OPF)
- Organizational Process Performance (OPP)
- Organizational Training (OT)
- Product Integration (PI)

- Project Monitoring and Control (PMC)
- Project Planning (PP)
- Process and Product Quality Assurance (PPQA)
- Quantitative Project Management (QPM)
- Requirements Development (RD)
- Requirements Management (REQM)
- Risk Management (RSKM)
- Supplier Agreement Management (SAM)
- Technical Solution (TS)
- Validation (VAL)
- Verification (VER)

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

CMM Benefits

- Level 2 leads to superior product quality

- 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

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