Personal Software Process (PSP)

- Application of CMM principles to small groups
- Developed by Watts Humphrey of the Software Engineering Institute (SEI) in the early 1990s
  - Extensive supporting materials: books, courses, forms, exercises
- Validated by data from numerous projects
  - 58% reduction in defects/KLOC (development)
  - 72% reduction in defects/KLOC (testing)
  - 21% improvement in productivity
- Complemented by Team Software Process (TSP)
- Strict waterfall plus process monitoring and improvement

Overview

- Disciplined personal framework for developing software
  - 50-5000 LOC projects
- Series of nine development exercises
- Metrics, forms, and scripts
- Produce low-defect products on schedule and within planned costs
- Manage quality, analyze results, improve process

Assumptions/Principles

- Every engineer is different. To be most effective, engineers must plan their work, and they must base their plans on their own personal data
- To consistently improve their performance, engineers must use well-defined and measured processes
- To produce quality products, engineers must feel personally responsible for the quality
- It costs less to find and fix defects earlier in a process than later
- The right way is always the fastest and cheapest way to do a job

Overall Approach

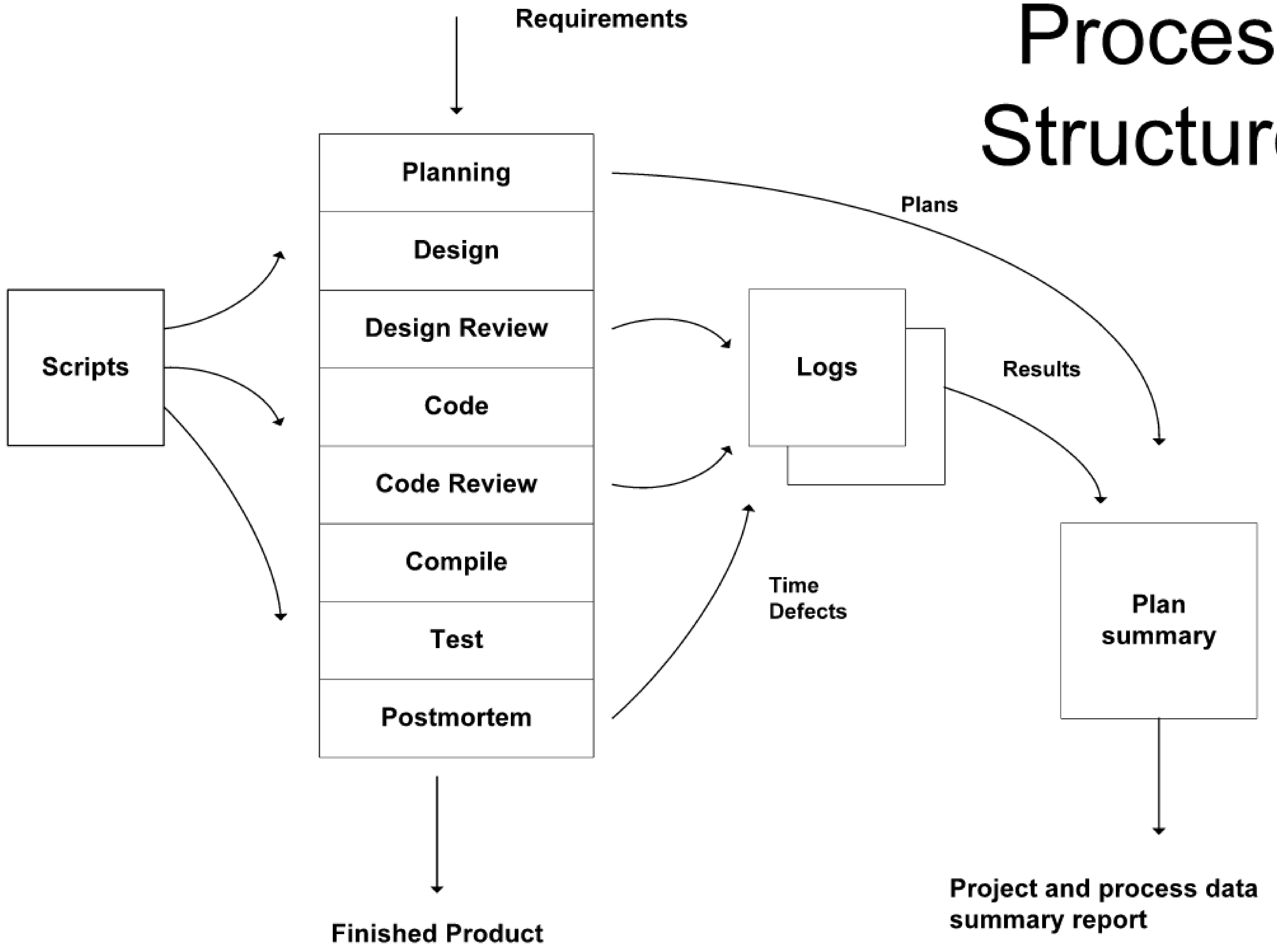
- Experienced programmers inject one defect per 7-10 lines of code
- People tend to make the same mistakes repeatedly
- To improve your organization's performance
  - Record data on defects; review data; make process changes to eliminate causes
  - Spend more up front time (design and detection activities)

PSP and CMM

- Complementary
  - CMM is top-down - management oriented
  - PSP is bottom-up - engineer oriented

- Level 2
  - Software configuration management
  - Software quality assurance
  - Software subcontract management
  - **Software project tracking and oversight**
  - **Software project planning**
  - Requirements management
- Level 3
  - **Peer reviews**
  - Intergroup coordination
  - **Software product engineering**
  - **Integrated software management**
  - Training program
  - **Organization process definition**
  - **Organization process focus**
- Level 4
  - **Software quality management**
  - **Quantitative process management**
- Level 5
  - **Process change management**
  - **Technology change management**
  - **Defect prevention**

Process Structure



PSP Phases

Phase	Emphasis	Features
0	Personal Management	Current process plus basic measures: development time, defects injected and removed; process: planning, development, analysis
0.1		Coding standards, process improvement proposal form, size measurements
1	Personal Planning	PROBE; Size estimation, time estimates, test report
1.1		Task planning, schedule planning
2	Personal Quality	Defect management: code reviews, design reviews
2.1		Design specification and analysis; defect prevention; process analysis; process benchmarks
3	Scaling Up	Cyclic development

PSP0

- Personal measurement
- Forms and scripts
- Time, defects injected and removed
- Phases: planning, development, postmortem
- PSP0.1: add in coding standards, size measurement, and process improvement proposal

PSP 1 Process Plan Summary

PSP0 Process Script

Phase Number	Purpose	To guide you in developing module-level programs
	Entry Criteria	• Problem description • PSP1 Project Plan Summary form • ***Size Estimating Template*** • ***Historical estimate and actual size data*** • Time and Defect Recording Logs • Defect Type Standard • Stop watch (optional)
1	Planning	• Produce or obtain a requirements statement. • ***Use the PROBE method to*** estimate the total new and changed LOC required. • ***Complete the Size Estimate Template.*** • Estimate the required development time. • Enter the plan data in the Project Plan Summary form. • Complete the Time Recording Log.
2	Development	• Design the program. • Implement the design. • Compile the program and fix and log all defects found. • Test the program and fix and log all defects found. • Complete the Time Recording Log.
3	Postmortem	Complete the Project Plan Summary form with actual time, defect, and size data.
	Exit Criteria	• A thoroughly tested program • Completed Project Plan Summary form with estimated and actual data • ***Completed Size Estimating Template*** • ***Completed Test Report Template*** • Completed PIP forms • Completed Defect and Time Recording Logs

PSP1 Process Script (SEI)

PSP1

- Personal planning
- PROBE estimation; confidence intervals
- PSP1.1: schedule and task planning

PSP2

- Personal quality
- Defect management: data, review checklists
- PSP2.1: design specification, defect prevention, process analysis, process benchmarks

PSP3

- Scaling up
- Cyclic development
- Design verification; process definition principles
- Subsumed by TSP

Overall PSP Strategy

- Gather data
- Estimate and plan
- Manage defects
- Manage yield
- Control cost of quality

Gathering Data

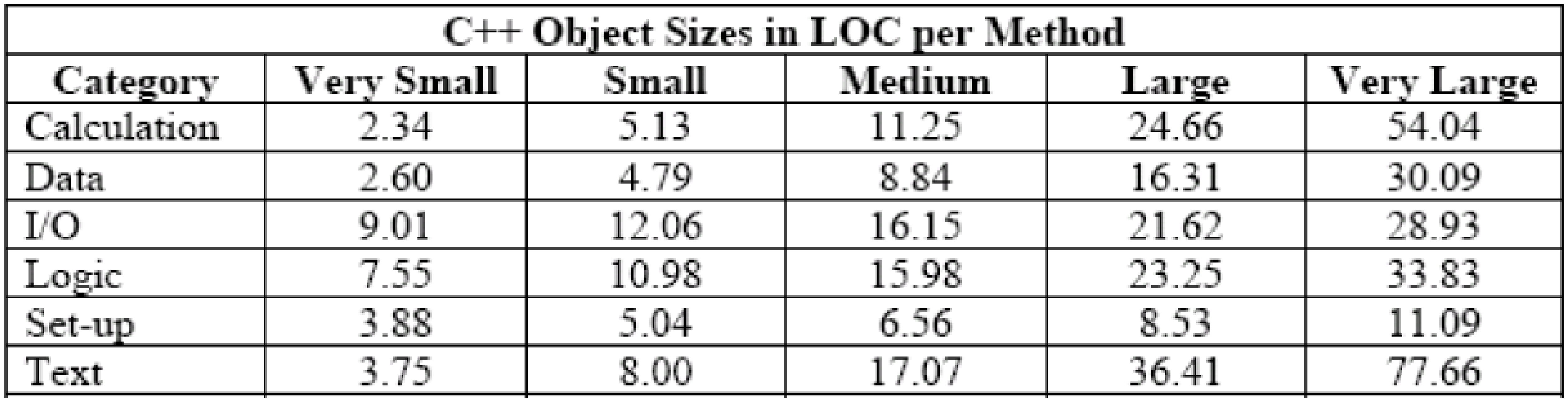
- Measurements taken
  - Time in each process activity (and for interrupts)
  - Defects introduced and removed for each activity
  - Developed product size (LOC)
    - Base, added, modified, deleted, new and changed, reused, new reuse, total

- Metrics computed
  - Size and time estimating error
  - Cost-performance index
  - Defect
    - Injected and removed per hour
    - Density
  - Process yield
  - Appraisal and failure cost of quality
  - Appraisal to failure ratio

Estimating and Planning

- PROBE – PROxy Based Estimation method
- PSP proxies: functions and object
  - Others include function points, screens, reports, sections of text
- Linear regression on at least 3 prior projects
- Goal is to improve estimates over time
  - PSP students improved their size estimates from 31% (within 20%) to 42% between programs one and ten
  - Improved time estimates from 33% (within 20%) to 49%

Example PROBE Data (C++)



C++ Object Sizes in LOC per Method					
Category	**Very Small**	**Small**	**Medium**	**Large**	**Very Large**
Calculation	2.34	5.13	11.25	24.66	54.04
Data	2.60	4.79	8.84	16.31	30.09
I/O	9.01	12.06	16.15	21.62	28.93
Logic	7.55	10.98	15.98	23.25	33.83
Set-up	3.88	5.04	6.56	8.53	11.09
Text	3.75	8.00	17.07	36.41	77.66

Size Categories (SEI)

- **Base** When an existing product is enhanced, base LOC is the size of the original product version before any modifications are made.
- **Added** Code written for a new program or added to an existing base program.
- **Modified** LOC in an existing (Base) program that are changed.
- **Deleted** LOC in an existing (Base) program that are deleted.
- **New and Changed** When engineers develop software, it takes them much more time to add or modify a LOC than it does to delete or reuse one. Thus, in the PSP, engineers use only the **Added** or **Modified** code to make size and resource estimates. This code is called the **New and Changed** LOC.
- **Reused** Code taken from a reuse library and used, without modification, in a new program. Reuse does not count the unmodified base code retained from a prior program version and it does not count any code that is reused with modifications.
- **New Reuse** LOC that an engineer develops and contributes to the reuse library.
- **Total** Total size of a program, regardless of its source (= **Base** - **Deleted** + **Added** + **Reused**).

Managing Defects

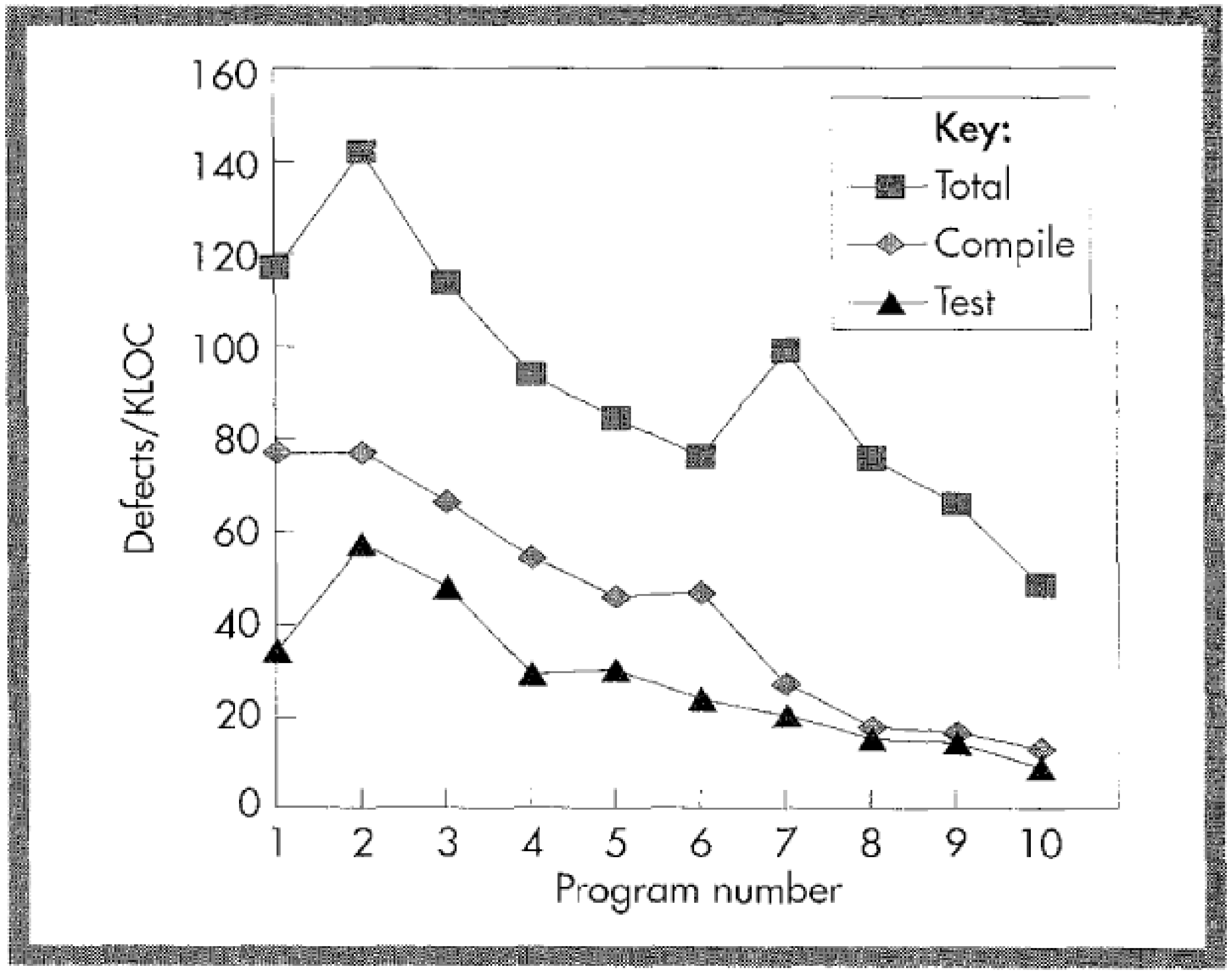
- Record, for each defect
  - Activity (phase) during which defect was injected and removed
    - Planning, design, design review, code, code review, compile, test
  - Defect type (next slide)
  - Fix time
  - Description
- Students reduced defect rates from 116/KLOC to 49 /KLOC between programs one and ten
  - Standard deviation also reduced

Defect Types

Type Number	Type Name	Description
10	Documentation	comments, messages
20	Syntax	spelling, punctuation, types, instruction formats
30	Build, package	change management, library, version control
40	Assignment	declaration, duplicate name, scope, limits
50	Interface	procedure calls and references, I/O, user format
60	Checking	error messages, inadequate checks
70	Data	structure, content
80	Function	logic, pointers, loops, recursion, computations, function defects
90	System	configuration, timing, memory
100	Environment	design, compile, test, or other support-system problems

Defects per KLOC Trend

(Humphrey - Fig. 4)



<u>Observations</u>

- Standard deviation also reduced
- Student programmers
- Hawthorn effect?
- Compilation defects fall faster

Question

- Would you rather have your testing group uncover a lot of failures or a few?

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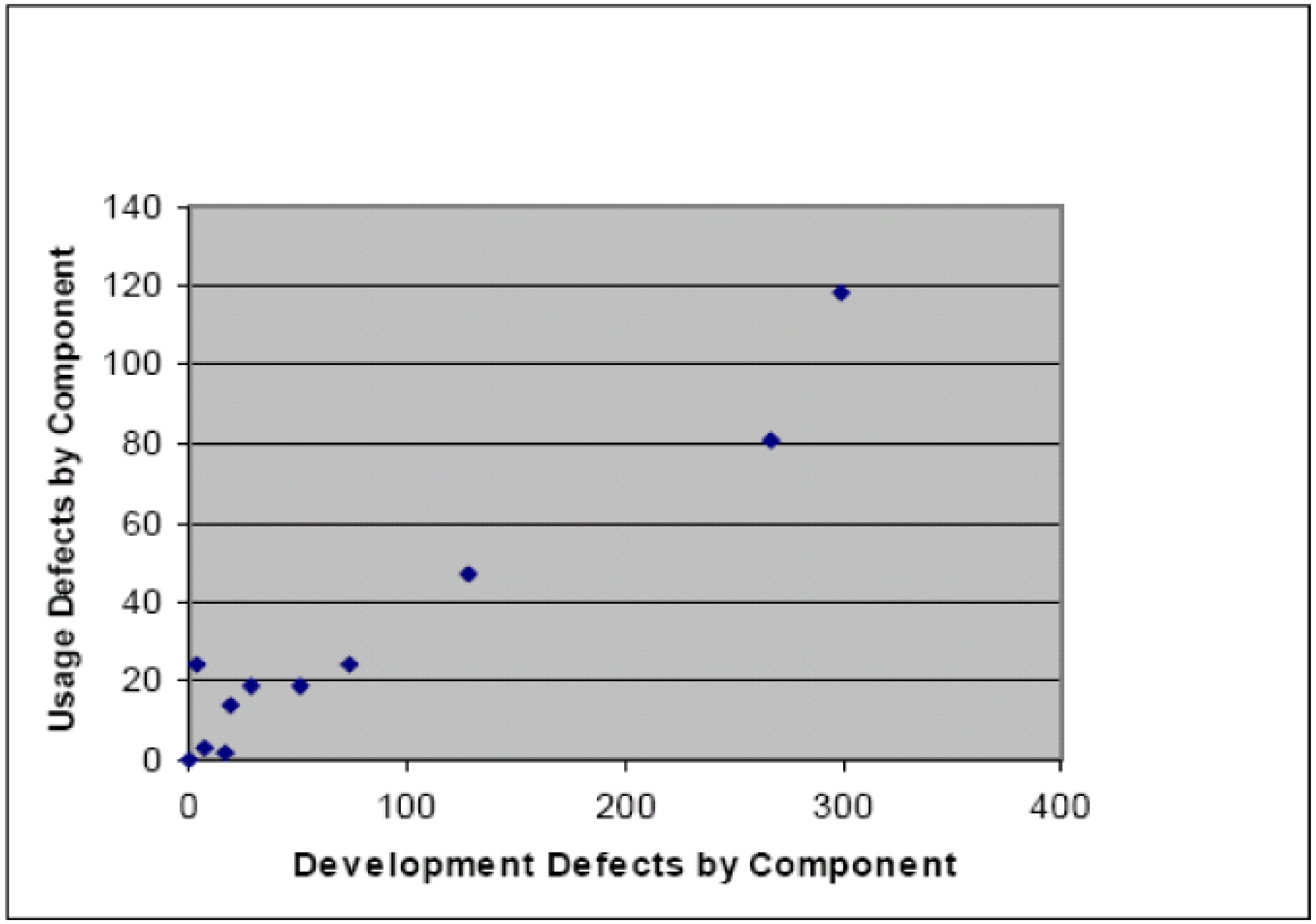


IBM

Managing Yield

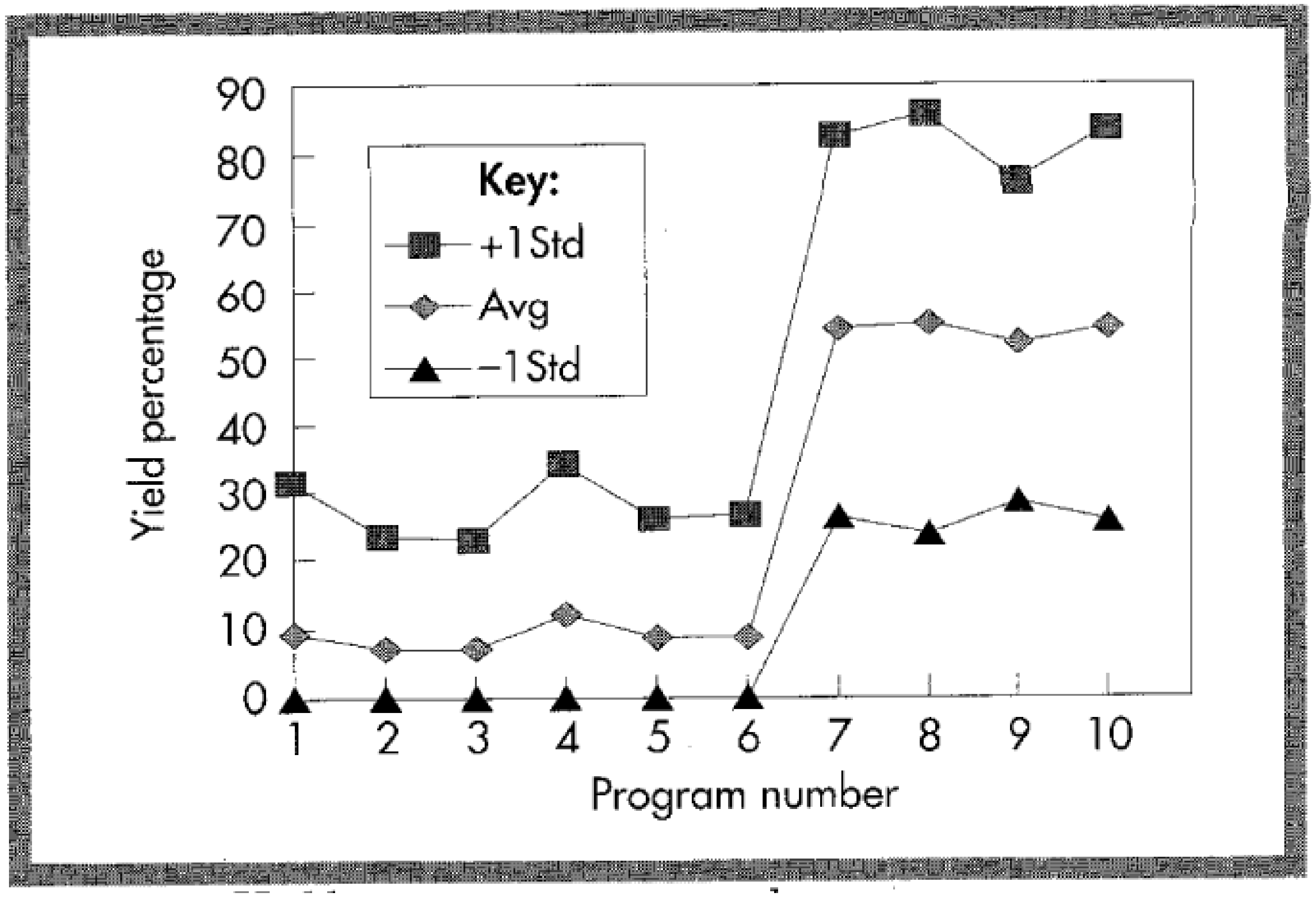
- Yield is PSP's principle quality measure
- If it is costly to find a defect during testing, then you need to find it earlier (during review)
  - (Or not insert it in the first place)
- Hold review before compilation
  - (But aren't compilers cheaper than programmers?)
  - (And desk check every new compilation)

Yield

- Yield = % defects found and fixed before compilation
  - Engineers review code before first compile
  - 9% of "syntax" error get by compiler
  - Defects found at compile time correlate with defects found during test (r = .71)
  - Strong correlation between defects found during test and customer failures (r = .91)
- Introduction of design and code reviews strongly improves yield

Yield versus Program Number

(Humphrey - Fig. 7)



Observations

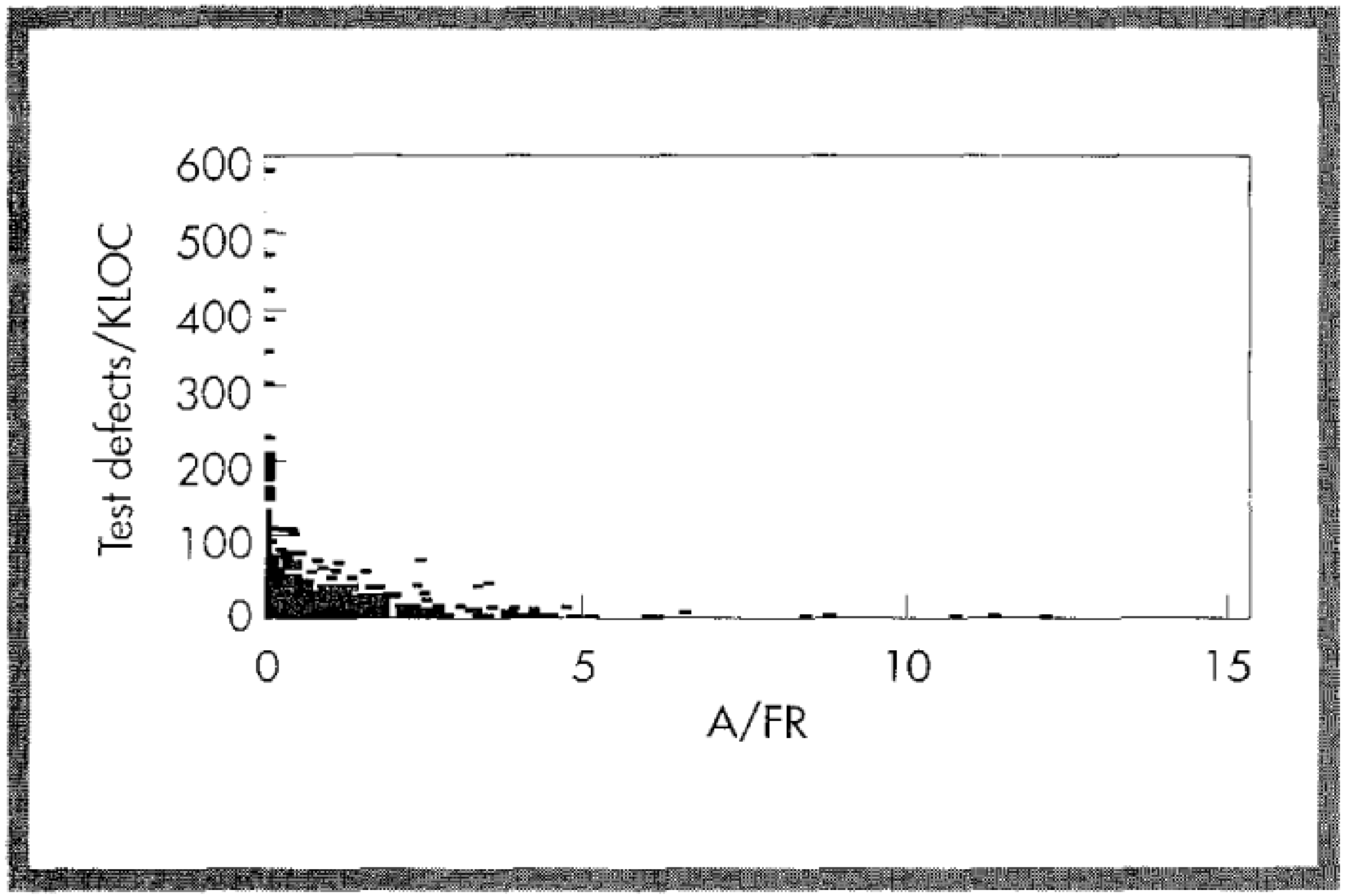
- Program 7 introduced reviews

Cost of Quality

- Appraisal cost
  - Time spent in design and code reviews
- Failure cost
  - Time spent in compile and test
- Prevention costs
  - Prototyping, formal specification
  - Not part of PSP
- Appraisal to failure ratio
  - Raise until quality is sufficient then gradually lower
  - Initial target at least two

Total Defects per KLOC versus A/F Ratio

(Humphrey - Fig. 9)



<u>Observations</u>

- Little improvement after 3:1
- Enables control of the productivity / quality tradeoff

How Much Time should you Spend in Reviews?

How Much Time should you Spend in Reviews?

- Spend as much time reviewing as is required to detect and remove all defects injected during the activity being reviewed
- Depends on the rates of fault injection and removal per time unit
- This means that you had better measure these rates
- PSP measurements on students indicate that they should spend 59% as much time reviewing as injecting for design activities and 65% for code

Another Answer

- PSP rule of thumb is to find twice as many problems during code review as you do during testing
- So if for module A, you found 15 during review and 45 during testing, you need to increase your review time by a factor of six!
  - 15 * 6 = 90 = 2 * 45

Design

- PSP does not prescribe a design method
  - Instead, it emphasized design *completion*
  - So it recommends making sure of the following
- Example schema
  - External static
    - Function interfaces: signatures, inheritance
  - External dynamic
    - Operational scenarios, call/return
  - Internal static
    - Attributes, constraints
  - Internal dynamic
    - State machines, response time, interrupts

PSP Results

- Estimation improvement
  - Reduced variance leads to better scheduling and staffing
- Reduced compile and test defects
  - Correlated with reduced customer-detected failures
- Mild productivity improvement

PSP Benefits

- Increases personal commitment by investing each engineer with process responsibility
- Assists engineers in making accurate plans
- Provides steps engineers can take to improve personal and project quality
- Sets benchmarks to measure personal process improvements
- Demonstrates the impact of process changes on an engineer's performance