

University of Southern California
Center for Software Engineering

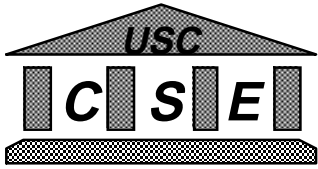
“Modeling Software Defect Introduction”

Sunita Devnani-Chulani

(sdevnani@sunset.usc.edu)

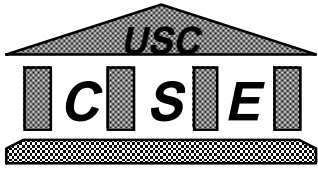
**University of Southern California
Center for Software Engineering**

*California Software Symposium
November 7, 1997*



Presentation Outline

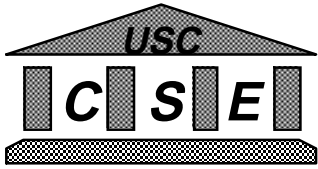
- ➔ **Motivation and Background Model**
- **Model Parameters and Modeling Methodology**
- **Initial Results and Ongoing Research**



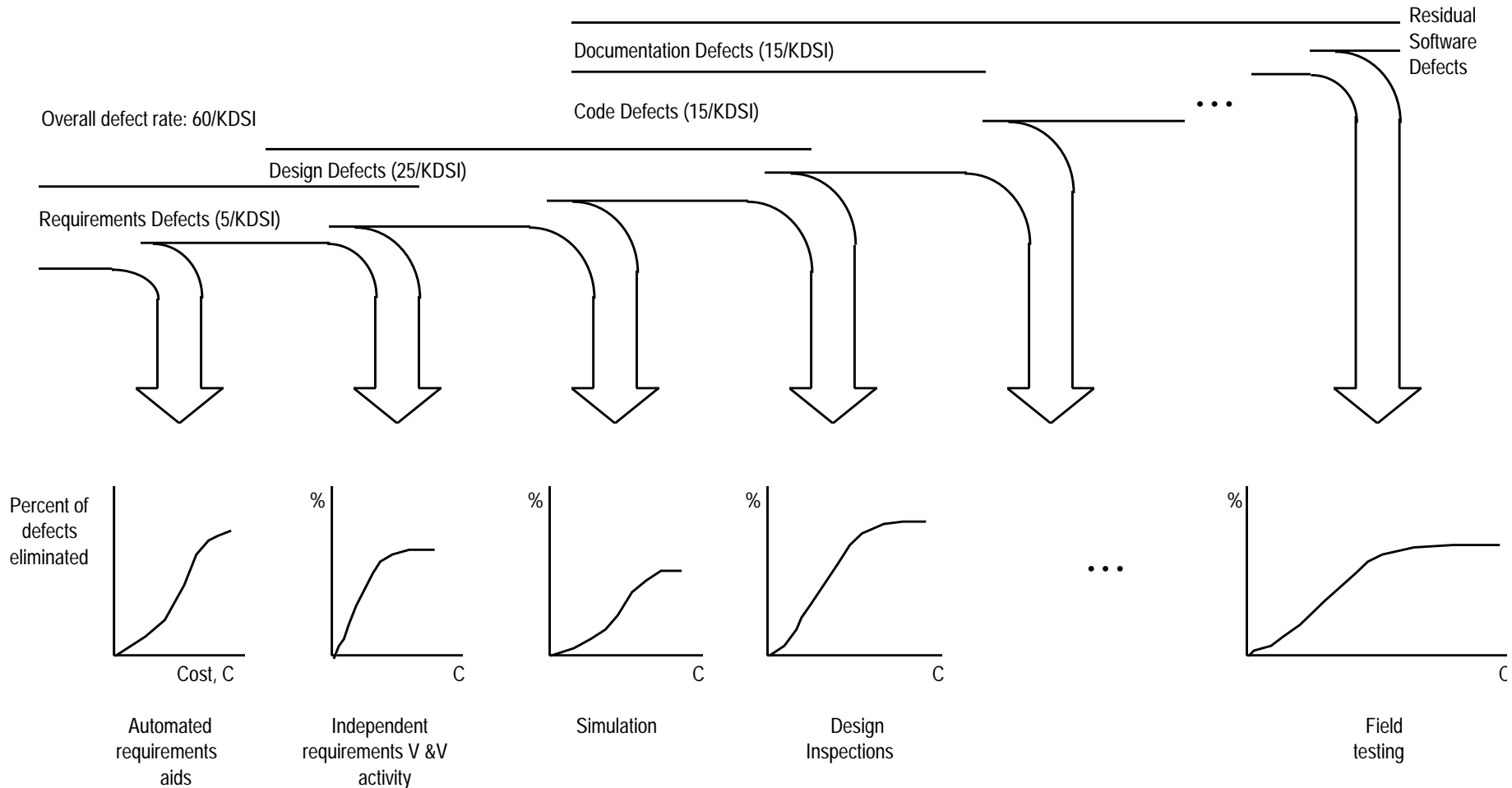
Motivation

- **Insight on Determining Ship Time**
- **Assessment of Quality Investment Payoffs**
- **Understanding of Quality Strategy Interactions**

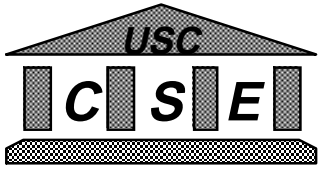
“Quality” = number of non-trivial delivered defects/KSLOC



The Software Defect Introduction and Removal Model

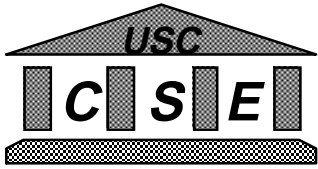


From Software Engineering Economics by Barry Boehm
Based on studies done by Thayer et al, Jones and Boehm
in the 1970's



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Model Parameters and Modeling Methodology

Step 1 : Analyze literature for factors affecting Defect Introduction Rate (DIR)

Step 2 : Perform Behavioral Analyses of factor effects

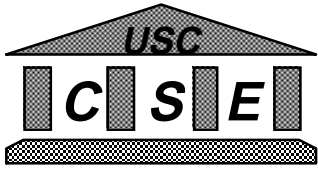
Step 3 : Identify Relative Significance of DIR-drivers on DIR

Step 4 : Do Delphi, determine expert-based DIR-driver values and a-priori variances

Step 5 : Gather Data

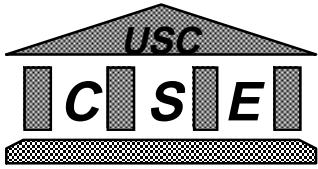
Step 6 : Determine A-Posteriori Set of Model Parameters using Bayesian Regression

Step 7 : Refine Model



Initial Set of DIR Drivers (Step 1)

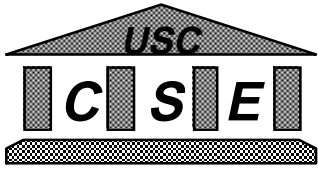
- **22 from COCOMO II**
 - **Project, Personnel, Product, Platform**
 - Later dropped Development Flexibility, FLEX
- **Disciplined Methods (Personal Software Process, Cleanroom Development, etc.)**
 - **Nominal** Defect prevention driven by RELY (Required Software Reliability) rating
 - **High** Moderate/Extra emphasis given to defect prevention
 - **Very High** Strong emphasis given to defect prevention equivalent to CMM defect prevention KPA.



Behavioral Analyses and Delphi Process (Steps 2-4)

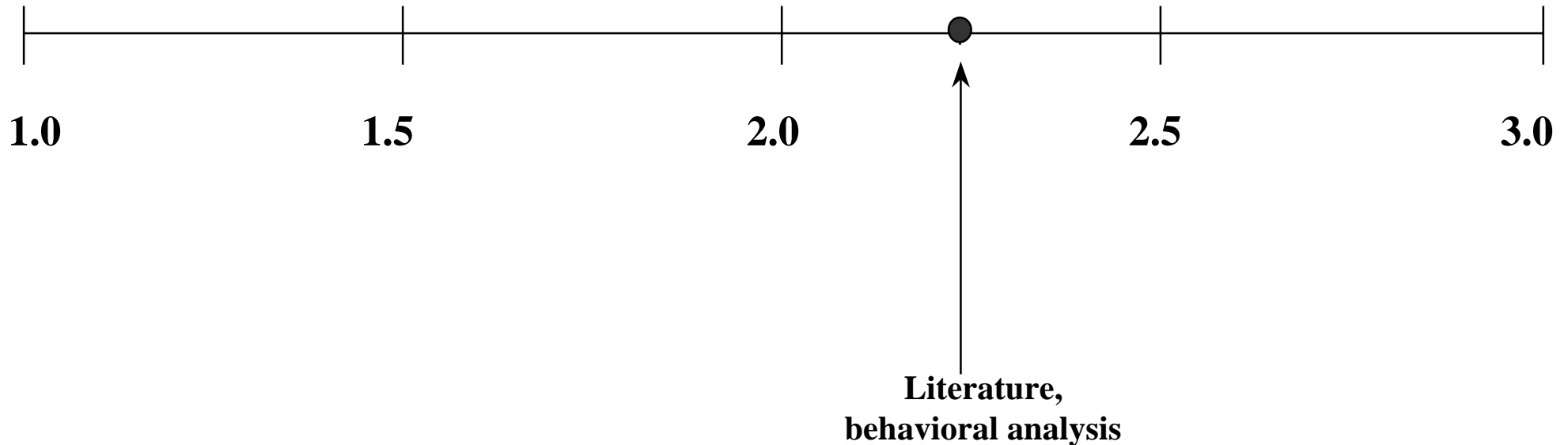
Required Software Reliability (RELY)

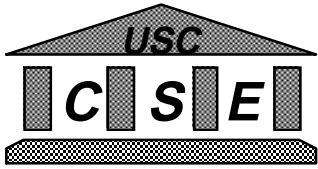
RELY level	Requirements	Design	Code	Documentation
VH	Fewer Requirements Completeness, consistency defects due to detailed verification, QA, CM, standards, SSR, documentation, IV&V interface, test plans, procedures 0.70	Fewer Design defects due to detailed verification, QA, CM, standards, PDR, documentation, IV&V interface, design inspections, test plans, procedures 0.69	Fewer Coding defects due to detailed verification, QA, CM, standards, documentation, IV&V interface, code inspections, test plans, procedures 0.69	Fewer Documentation defects due to requirements, design shortfalls 0.82
Nominal	Nominal level of defect introduction 1.0			
VL	More Requirements Completeness, consistency defects due to minimal verification, QA, CM, standards, PDR, documentation, IV&V interface, test plans, procedures 1.43	More Design defects due to minimal verification, QA, CM, standards, PDR, documentation, IV&V interface, design inspections, test plans, procedures 1.45	More Coding defects due to minimal verification, QA, CM, standards, PDR, documentation, IV&V interface, code inspections, test plans, procedures 1.45	More Documentation defects due to requirements, design shortfalls 1.22
Initial Quality Range	2.24	2.24	2.24	1.77
Range - Round 1	1.2-2.61	1.2-2.61	1.2-2.61	1.2-1.75
Median - Round 1	2	2	2	1.5
Range - Round 2	1.8-2.24	1.9-2.3	2-2.24	1.5-2
Final Quality Range (Median - Round 2)	2.05	2.1	2.1	1.5



Analysis Summary

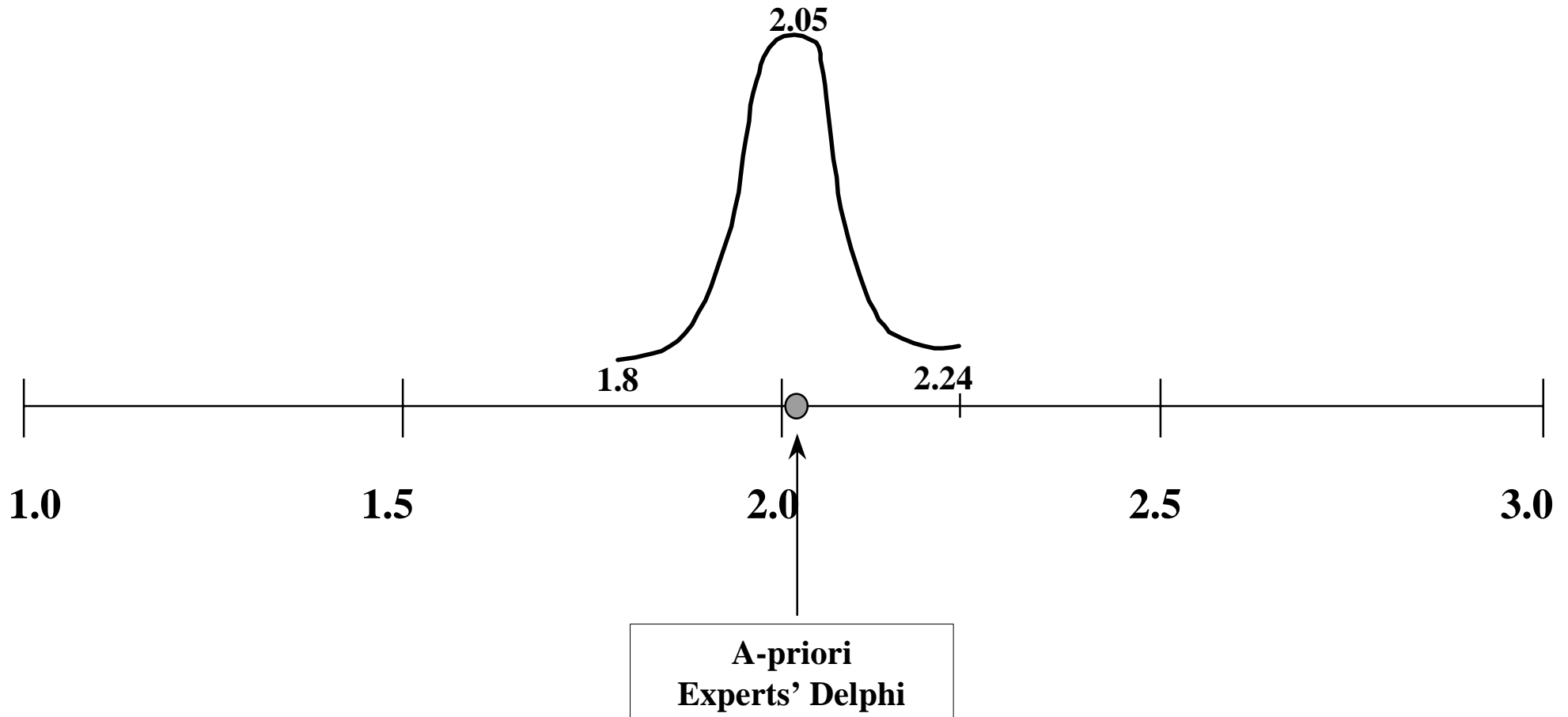
Quality Range of Required Software Reliability (RELY)

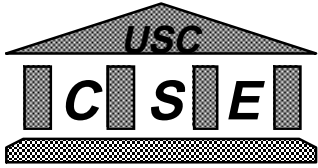




Analysis Summary

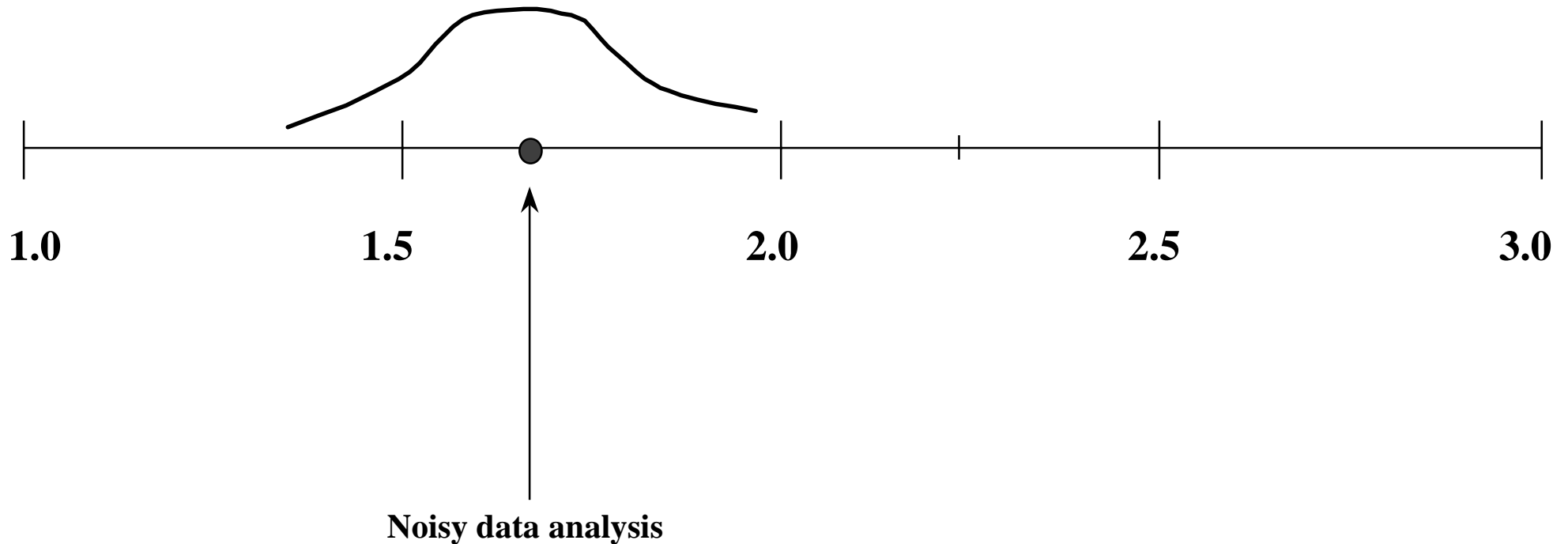
Quality Range of Required Software Reliability (RELY)

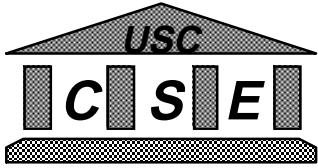




Analysis Summary

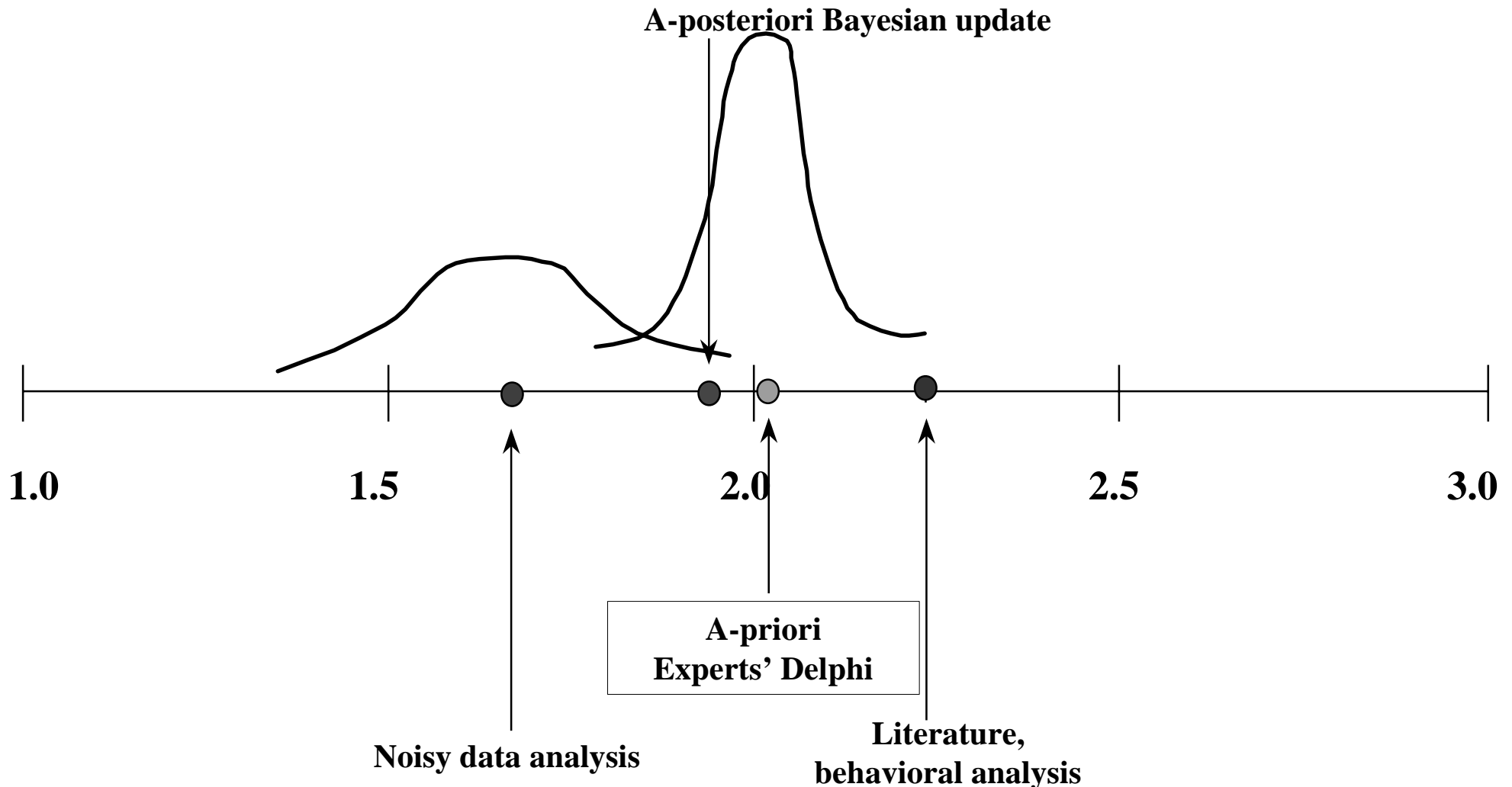
Quality Range of Required Software Reliability (RELY)

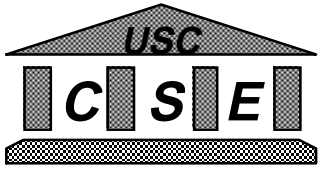




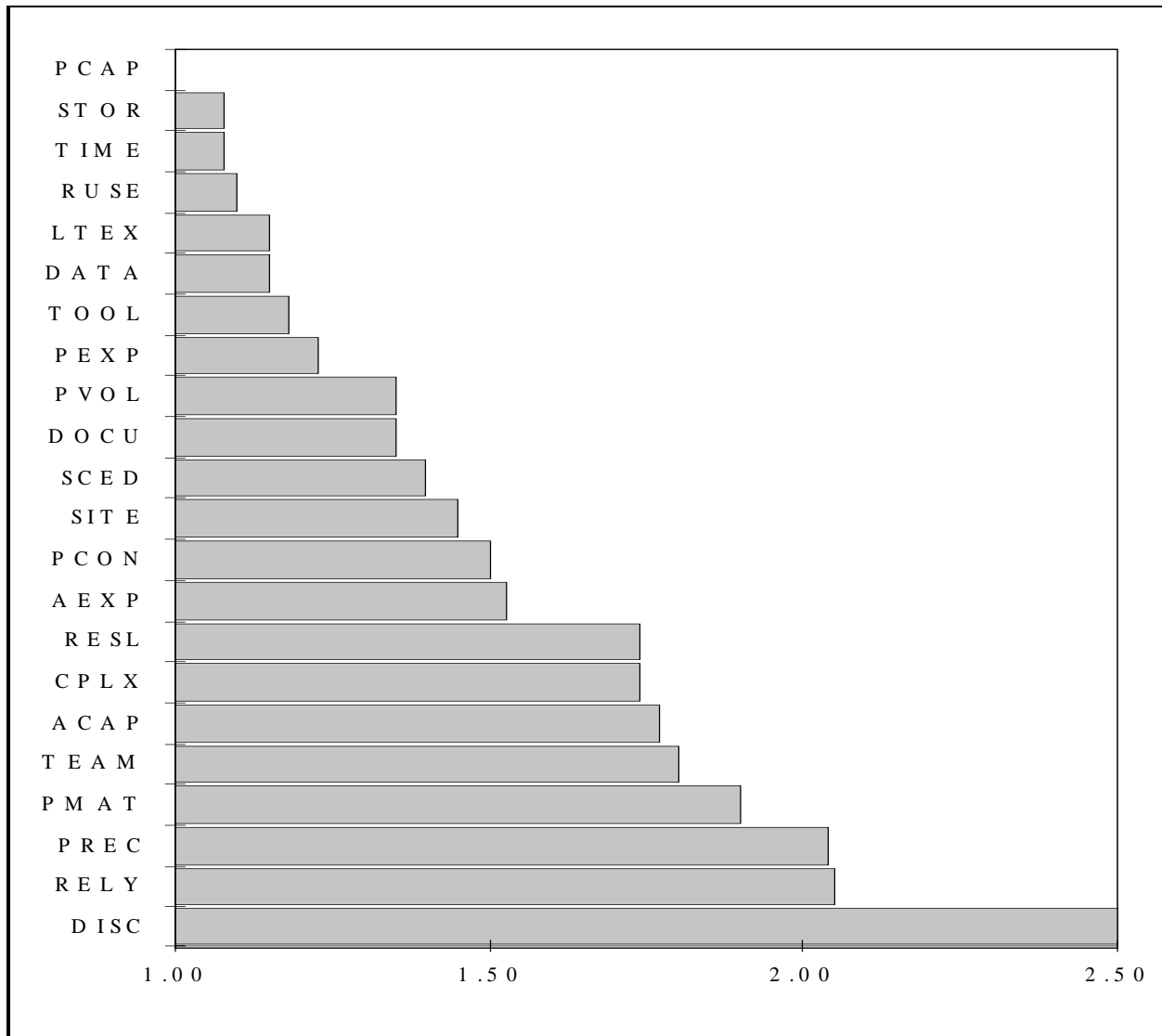
Analysis Summary

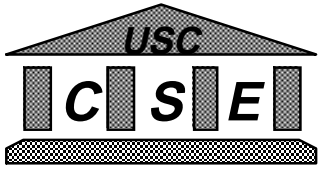
Quality Range of Required Software Reliability (RELY)





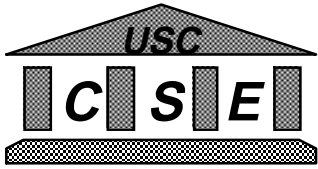
A-Priori Experts' Reqts. Quality Range





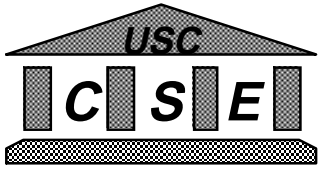
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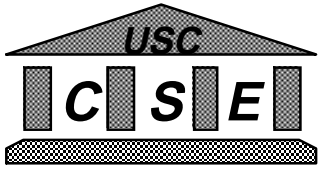
Defect Data Reporting Scheme

Activity →	Introduced + Unresolved / Resolved in Activity / Cost To Resolve by Activity							
	Reqts	Design	Code & Unit Test	SW Integ. and Test	SW Acceptance Test	System Implementation and Test	Post-Operational	Other
Requirements	50/30 /2	20+20/ 20/5	10+20/ 15/1.0	2+15/10 /1.5	1+7/6/4	...		
Design		55/25/ 1.0	15+30/ 25/2.5		
Code				
Documentation				...				



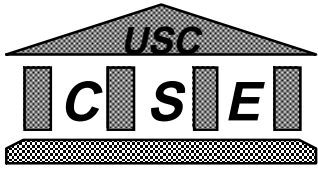
Results of initial-project data analysis

Type of Artifact	1970's Baseline DIRs	Quality Adjustment Factor	Predicted DIR	Actual DIR	Calibrated Constant (A)	1990's Baseline DIRs
Requirements	5	0.5	2.5	4.5	1.8	9
Design	25	0.44	11	8.4	0.77	19
Code	15	0.5	7.5	16.6	2.21	33
Documentation	15	0.57	8.55	3.9	0.45	7

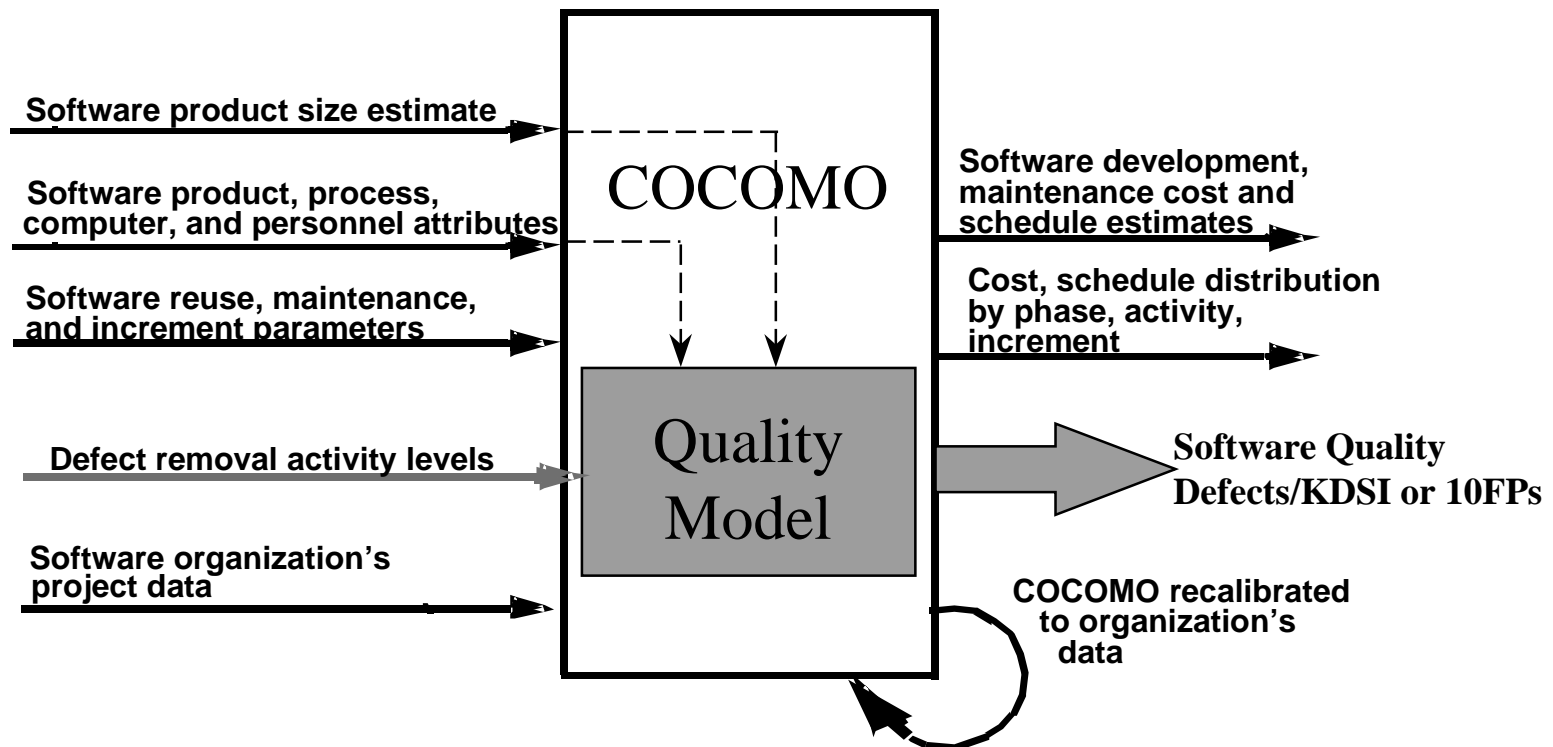


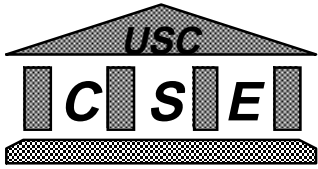
Ongoing Research

- **Develop Defect Removal Model**
- **Gather more data**
- **Statistically determine a-posteriori model**
- **Integrate to existing COCOMO II Post-Architecture Model**



Integrated Cost/Quality Model





Delphi Process

- **Round 1**

1. **Provided Participants with Round 1 Delphi Questionnaire with a proposed set of values for the Quality Ranges. This set was proposed based on experience.**
2. **Received nine completed Round 1 Delphi Questionnaires.**
3. **Ensured validity of responses by correspondence with the participants.**
4. **Did simple analysis based on ranges and medians of the responses.**

- **Round 2**

1. **Provided participants with Round 2 Delphi Questionnaire -- based on analysis of Round 1.**
2. **Repeated steps 2, 3, 4 (above)**
3. **Converged to Final Delphi Results which resulted in the definition of the initial model**