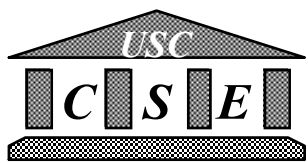




Reasoning about the Value of Dependability: iDAVE Model

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iDAVE Model Objectives

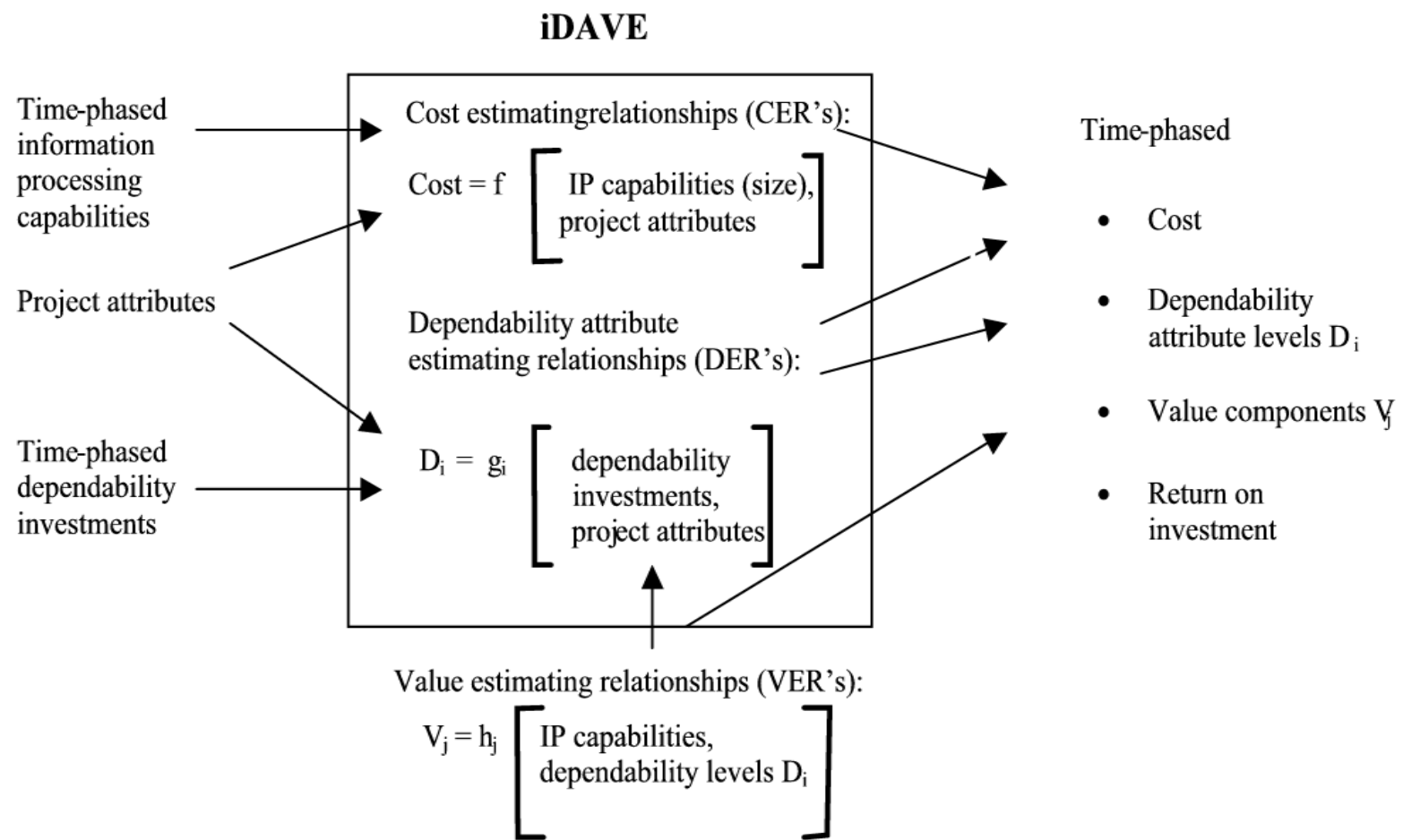
- iDAVE: Information Dependability Attribute Value Estimation
- Problem: how to make decisions about a software-intensive system's dependability level
 - Involve strong economic decisions
- Use iDAVE model to estimate and track software dependability ROI
 - Achieve the desired values for software dependability attributes
 - Help analyze and select the most effective software dependability strategies



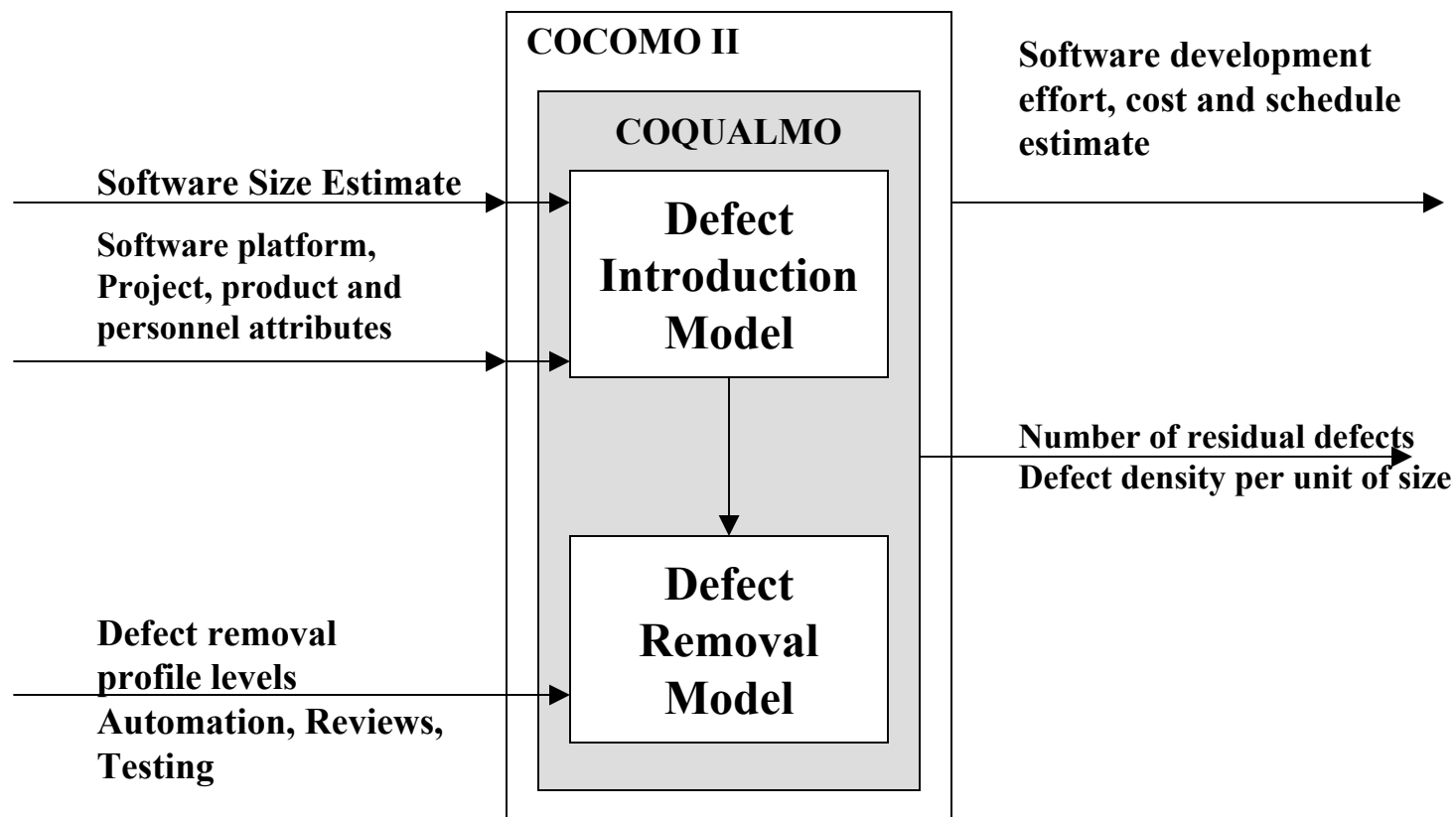
iDAVE Model Overview

- Cost Estimating relationships (CER's) from the Constructive Cost Model COCOMO II
- Dependability estimating relationships (DER's) from the Constructive Quality Model COQUALMO
- Value estimating relationships (VER's) supplied by the system's stakeholders

iDAVE Model Framework



COQUALMO Overview





COQUALMO Defect Removal Rating Scales

COCOMO II p.263

	Very Low	Low	Nominal	High	Very High	Extra High
Automated Analysis	Simple compiler syntax checking	Basic compiler capabilities	Compiler extension Basic req. and design consistency	Intermediate-level module Simple req./design	More elaborate req./design Basic dist-processing	Formalized specification, verification. Advanced dist-processing
Peer Reviews	No peer review	Ad-hoc informal walk-through	Well-defined preparation, review, minimal follow-up	Formal review roles and Well-trained people and basic checklist	Root cause analysis, formal follow Using historical data	Extensive review checklist Statistical control
Execution Testing and Tools	No testing	Ad-hoc test and debug	Basic test Test criteria based on checklist	Well-defined test seq. and basic test coverage tool system	More advance test tools, preparation. Dist-monitoring	Highly advanced tools, model-based test, extensive stress test

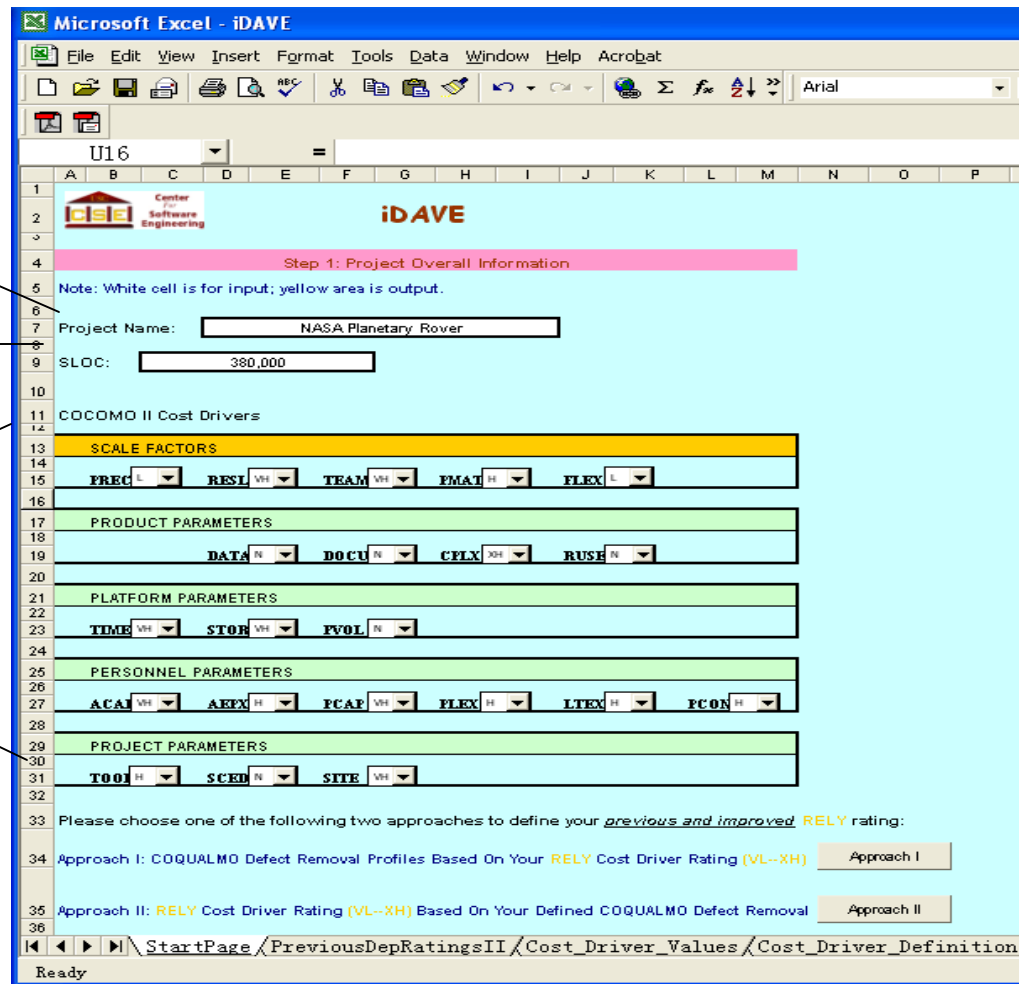
iDAVE Tool

— Step 1: Overall Project Information

Project Name

SLOC

**COCOMO II
Cost Drivers
(except RELY)**



The screenshot shows the iDAVE tool interface in Microsoft Excel. The window title is "Microsoft Excel - iDAVE". The menu bar includes File, Edit, View, Insert, Format, Tools, Data, Window, Help, and Acrobat. The toolbar contains various icons for file operations and editing. The spreadsheet area shows the following content:

- Row 1: U16
- Row 2: USC logo and "Center for Software Engineering" text.
- Row 3: "iDAVE" title.
- Row 4: "Step 1: Project Overall Information" (highlighted in pink).
- Row 5: "Note: White cell is for input; yellow area is output."
- Row 7: "Project Name: NASA Planetary Rover" (input field).
- Row 9: "SLOC: 380,000" (input field).
- Row 11: "COCOMO II Cost Drivers" section.
- Row 13: "SCALE FACTORS" section (highlighted in yellow).
- Row 14-16: "SCALE FACTORS" dropdowns: PREC (L), RESE (VH), TEAM (VH), FMAI (H), FLEX (L).
- Row 17: "PRODUCT PARAMETERS" section (highlighted in light green).
- Row 18-19: "PRODUCT PARAMETERS" dropdowns: DATA (N), DOCU (N), CPLX (XH), RUSH (N).
- Row 21: "PLATFORM PARAMETERS" section (highlighted in light green).
- Row 22-23: "PLATFORM PARAMETERS" dropdowns: TIME (VH), STOR (VH), PVOL (N).
- Row 25: "PERSONNEL PARAMETERS" section (highlighted in light green).
- Row 26-27: "PERSONNEL PARAMETERS" dropdowns: ACAI (VH), APEX (H), PCAL (VH), FLEX (H), LIEX (H), PCON (H).
- Row 29: "PROJECT PARAMETERS" section (highlighted in light green).
- Row 30-31: "PROJECT PARAMETERS" dropdowns: TOOL (H), SCED (N), SITE (VH).
- Row 33: "Please choose one of the following two approaches to define your *previous and improved* RELY rating:"
- Row 34: "Approach I: COQUALMO Defect Removal Profiles Based On Your RELY Cost Driver Rating (VL--XH) [Approach I button]"
- Row 35: "Approach II: RELY Cost Driver Rating (VL--XH) Based On Your Defined COQUALMO Defect Removal [Approach II button]"
- Row 36: Navigation buttons and status bar: "StartPage / PreviousDepRatingsII / Cost_Driver_Values / Cost_Driver_Definition"

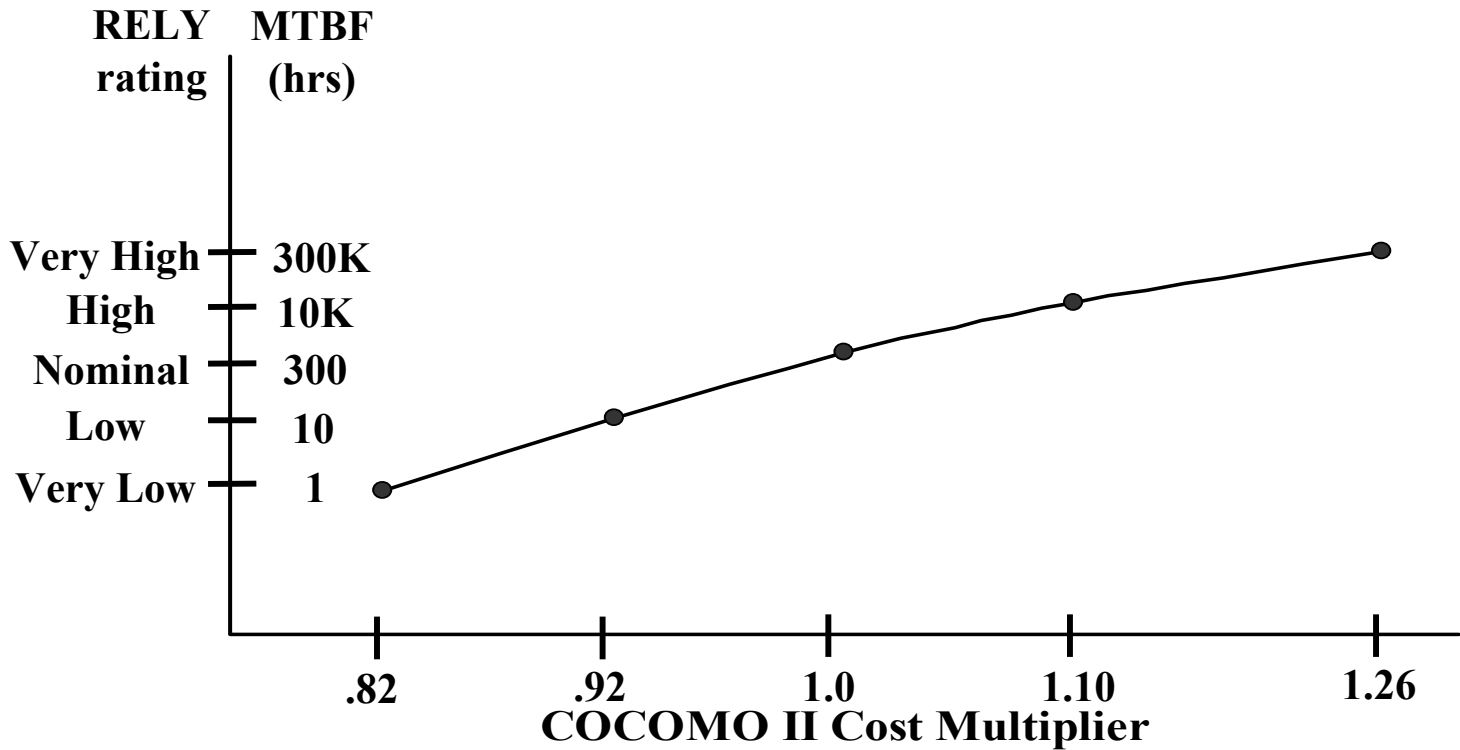


iDAVE Tool

— Define System Dependability Level

- System dependability level represented by RELY cost driver rating
- *Two approaches* to define the system dependability level
 - RELY rating determines defect removal profiles
 - Weighted average of defect removal factors determines RELY rating
- Starting from the baseline dependability investments

COCOMO II Cost/Reliability Tradeoff - Calibrated to 161 projects



If RELY = Extra High, MTBF = 1Mhrs

iDAVE Tool

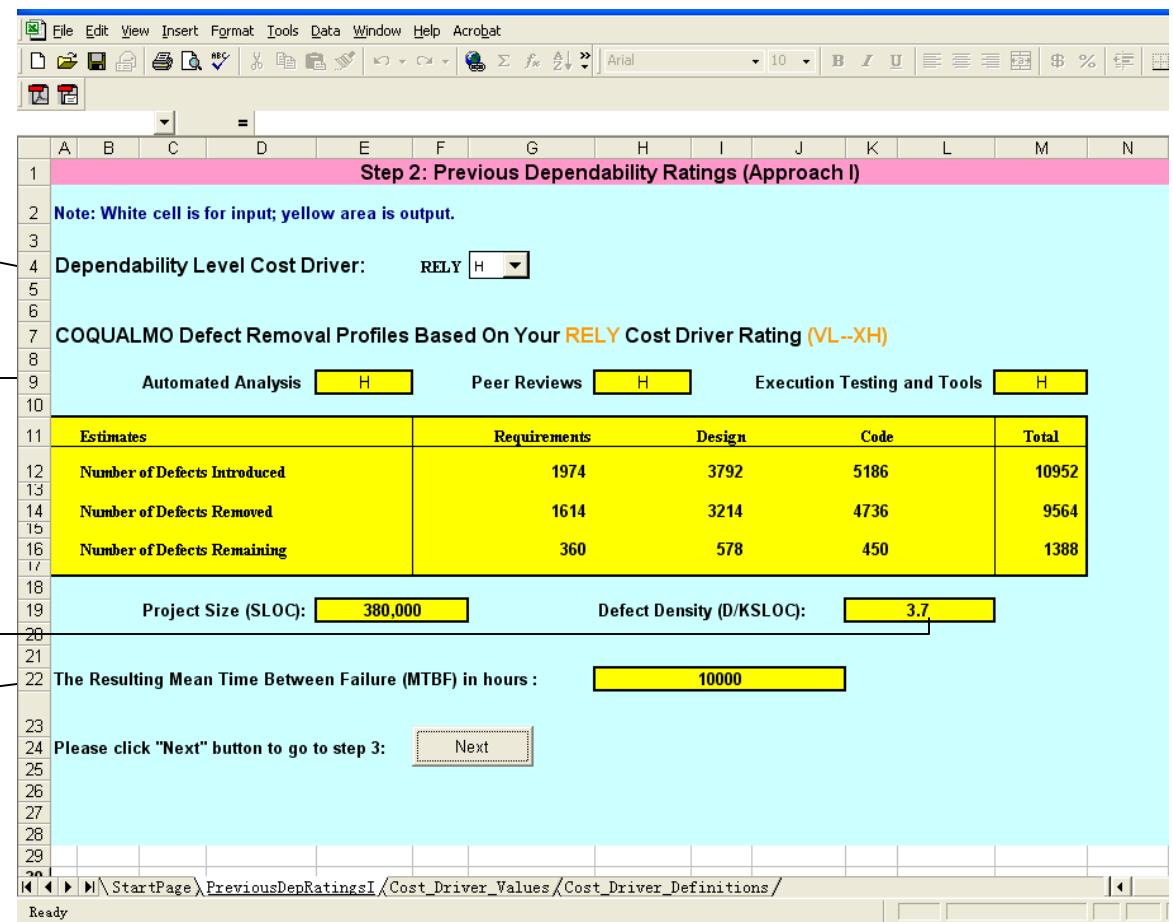
— Step 2: Previous Dependability Ratings (approach I)

Dependability cost driver: RELY

Three COQUALMO defect removal factors

Defect density

MTBF



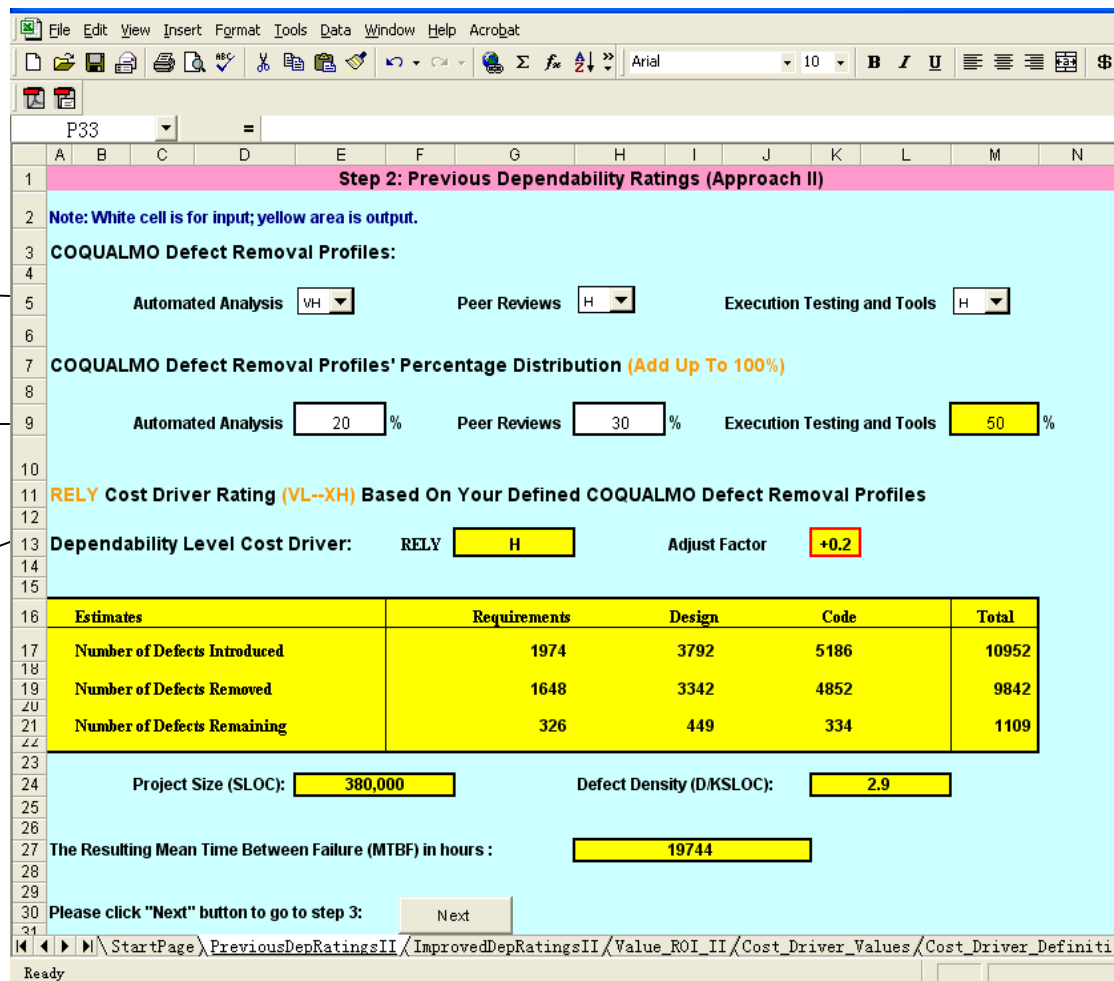
iDAVE Tool

— Step 2: Previous Dependability Ratings (approach II)

Three COQUALMO defect removal factors ratings

Weights of three defect removal factors

Dependability cost driver: RELY



Step 2: Previous Dependability Ratings (Approach II)

Note: White cell is for input; yellow area is output.

COQUALMO Defect Removal Profiles:

Automated Analysis: Peer Reviews: Execution Testing and Tools:

COQUALMO Defect Removal Profiles' Percentage Distribution (Add Up To 100%)

Automated Analysis: % Peer Reviews: % Execution Testing and Tools: %

RELY Cost Driver Rating (VL--XH) Based On Your Defined COQUALMO Defect Removal Profiles

Dependability Level Cost Driver: RELY Adjust Factor:

Estimates	Requirements	Design	Code	Total
Number of Defects Introduced	1974	3792	5186	10952
Number of Defects Removed	1648	3342	4852	9842
Number of Defects Remaining	326	449	334	1109

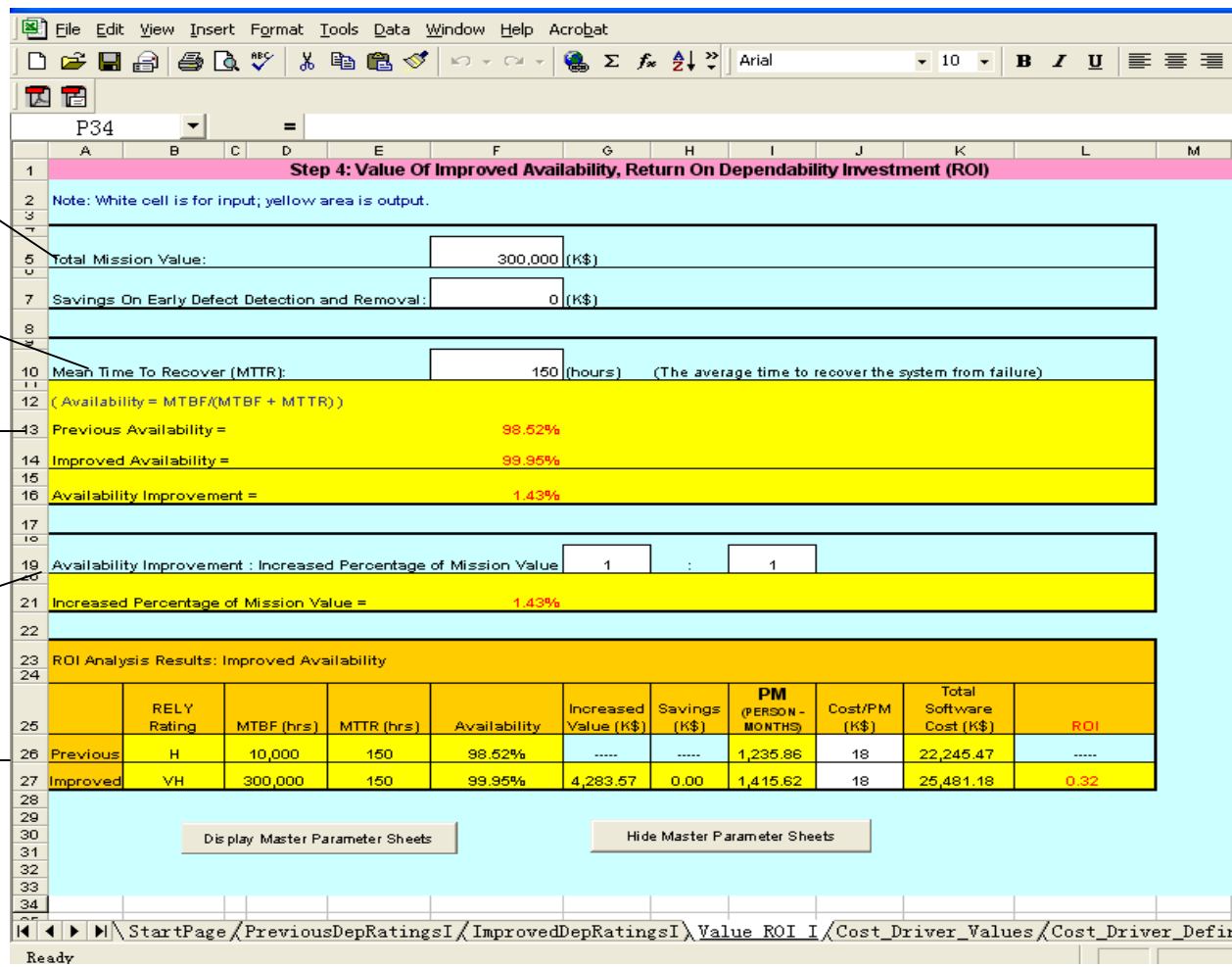
Project Size (SLOC): Defect Density (D/KSLOC):

The Resulting Mean Time Between Failure (MTBF) in hours:

Please click "Next" button to go to step 3:

iDAVE Tool

— Step 4: Display ROI Analysis Results



Step 4: Value Of Improved Availability, Return On Dependability Investment (ROI)

Note: White cell is for input; yellow area is output.

Total Mission Value: 300,000 (K\$)

Savings On Early Defect Detection and Removal: 0 (K\$)

Mean Time To Recover (MTTR): 150 (hours) (The average time to recover the system from failure)

(Availability = MTBF/(MTBF + MTTR))

Previous Availability = 98.52%

Improved Availability = 99.95%

Availability Improvement = 1.43%

Availability Improvement : Increased Percentage of Mission Value 1 : 1

Increased Percentage of Mission Value = 1.43%

ROI Analysis Results: Improved Availability

	RELY Rating	MTBF (hrs)	MTR (hrs)	Availability	Increased Value (K\$)	Savings (K\$)	PM (PERSON - MONTHS)	Cost/PM (K\$)	Total Software Cost (K\$)	ROI
Previous	H	10,000	150	98.52%	-----	-----	1,235.86	18	22,245.47	-----
Improved	VH	300,000	150	99.95%	4,283.57	0.00	1,415.62	18	25,481.18	0.32

Display Master Parameter Sheets Hide Master Parameter Sheets

Total Mission Value

MTTR

Availability = $\frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$

Δ Availability: Δ Value

Cost, Value, ROI analysis results

iDAVE Analysis

– Planetary Rover

- Top priority dependability attribute: survivability (JPL)
 - Without survivability, your first failure is your last
 - With survivable elements, always a chance to recover
 - With communication, can create fixes from Earth
- Availability: a proxy for survivability
 - Increase MTBF (mean time between failures)
 - Decrease MTTR (mean time to repair)
 - $\text{Availability} = \text{MTBF} / (\text{MTBF} + \text{MTTR})$



Representative Rover Availability ROI Parameters

- Total Mission value = Cost = \$300M
- Software cost (RELY = Nominal) = \$20M
- MTTR = 150 hours
 - About a week to diagnose, reprogram, recover
- Value of X% availability increase = $\$300\text{M}(X/100)$
- Baseline dependability investment level: High

Cost to Achieve Extra High Reliability

- Analysis tools and analysis -- \$2M
- Formal peer reviews -- 1M
- Advanced test tools, execution -- 3M
- Total -- \$6M

- Corresponds to 30% added cost for Independent V&V

ROI Analysis Results: Increasing MTBF

RELY Rating	MTBF (hrs)	MTTR (hrs)	Avail.	Loss (\$M)	Increased Value (\$M)	Cost (\$M)	Δ Cost (\$M)	ROI
High	10,000	150	0.9852	4.44	0	22	0	----
↓								
Very High	300,000	150	0.9995	0.15	4.29	25.2	3.2	0.32
↓								
Extra High	1M	150	0.99985	0.045	0.105	31.2	6.0	-0.98



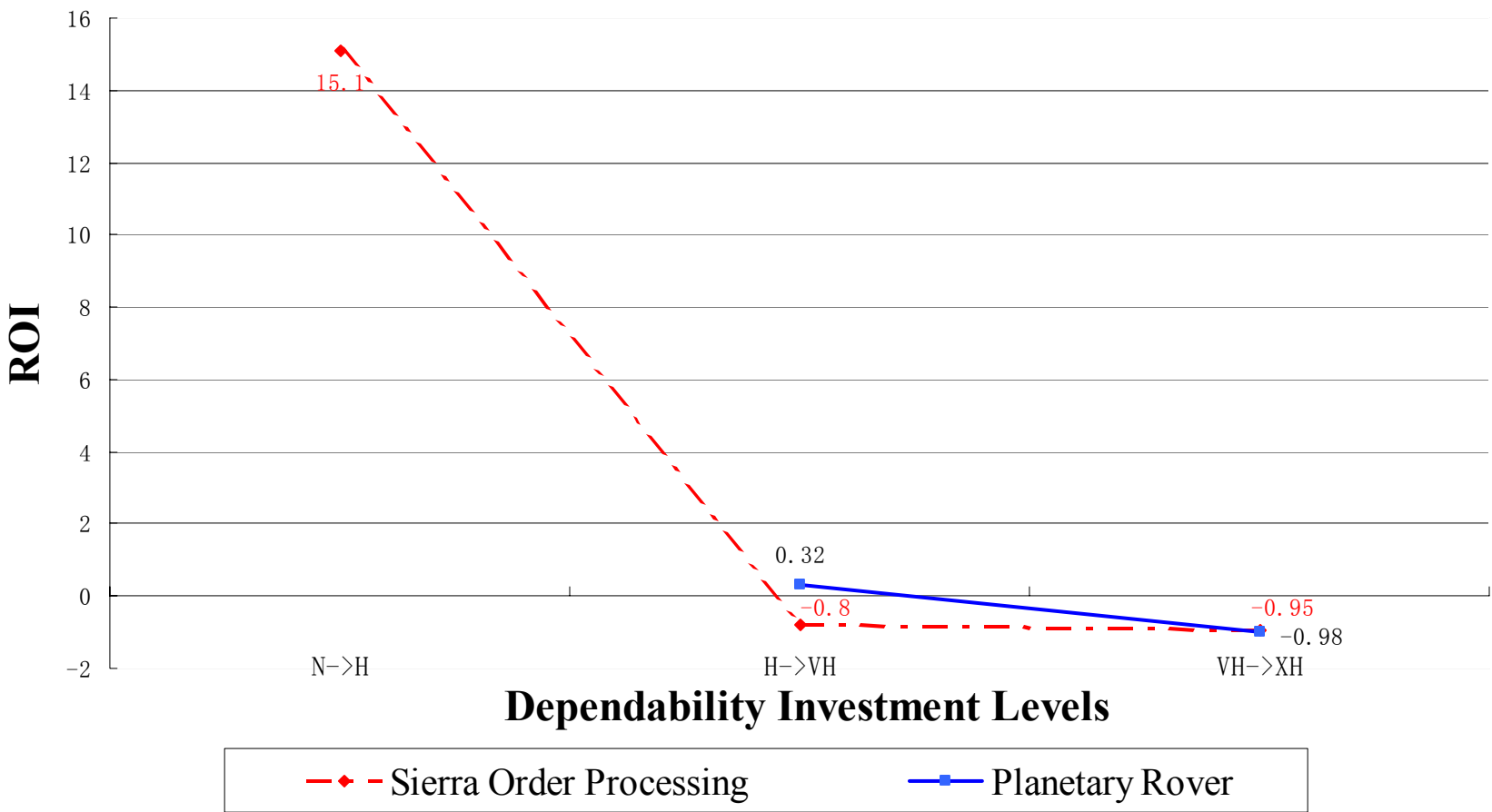
iDAVE Analysis

– Sierra Mountainbikes Order Processing

- Baseline Business Case Analysis
 - Estimated total sales: \$531M
 - Software cost (RELY = Nominal): \$3.45M
 - Mean time to repair (MTTR): 3 hrs
 - Assume 1% downtime, 1% lost sales and profits
 - Baseline dependability investment level: Nominal

ROI Analysis Results Comparison

**iDAVE ROI Analysis Results On Increasing Dependability Investment Levels
 (starting from baseline investments)**



User Feedback and Future Work

- Planetary Rover (JPL)
 - Worth pursuing and calibrating to project experience
 - Joint research proposal submitted
 - Value loss underestimated: serious failure impact reputation, cause delays in future mission preparations
- Supply Chain Software Developers
 - Stopping at High RELY level appropriate
 - Value loss function actually nonlinear
- Need to extend model to additional dependability attributes.
 - Safety, Security, Accuracy, and Performance Assurance