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Examining the Test Process: Predicting the Return on Investment of a Process Change

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Agenda

1. Motivation
2. What are Process Simulation Models
3. Benefits of Process Simulation
4. Examining the Testing Process
5. Goals, Questions, Performance Measures and Data
6. Model Results
7. Conclusion

Motivation

Competition within the U.S. and abroad is putting pressure on software firms to improve performance in terms of:

- Reducing costs
- Reducing cycle time
- Reducing defects

In order to compete, organizations need to incorporate new methods and tools into their development operations quickly

Introducing - Process Simulation

One area that can help companies improve their processes is ***Process Simulation***.

Process Simulation supports organizations at ***all*** levels of the CMMI

- Designing and defining processes
- Quantitative process management
- Continuous process improvement

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What is Process Simulation?

- Simulation is a computerized model (not a maturity model) designed to display significant features of the dynamic system it represents.
- Process simulation models focus on the dynamics of software and ***systems*** development, maintenance and acquisition activities.
- Process Simulation models represent the process
  - as currently implemented (as-is), or
  - as planned for future implementation (to-be)

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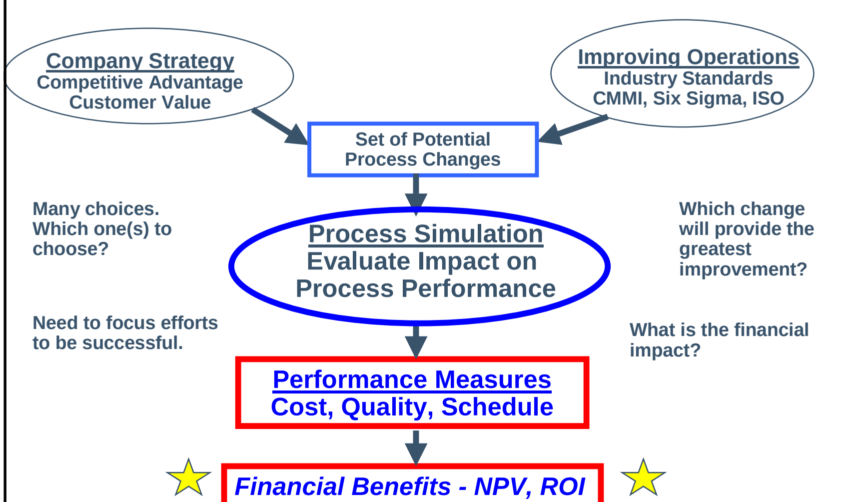

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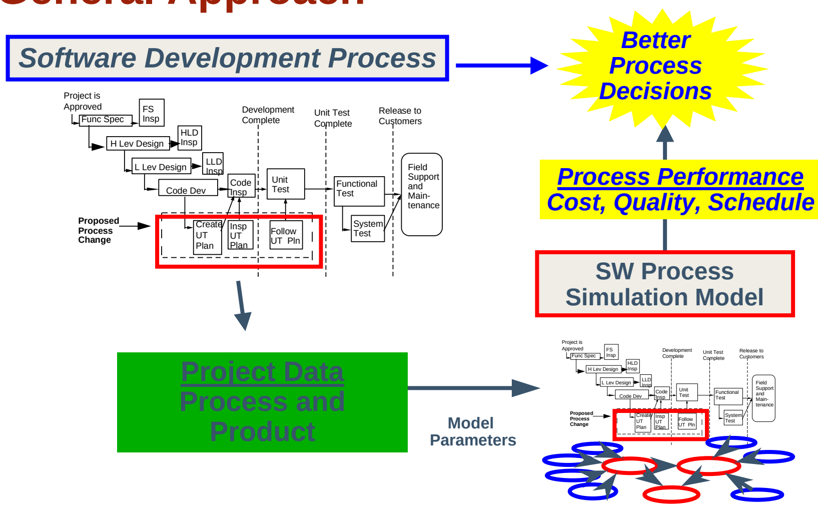
General Approach



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Process Tradeoff Analysis Method (PTAM)

- **Based on extensive research** into Software Process Modeling conducted in academia, SEI and industry.
- **Graphical user interface** and models software processes
- **Integrates SEI methods** to define processes and to support CMMI PAs
- **Integrates metrics** related to cost, quality, and schedule into understandable project performance picture.
- **Predicts project-level impacts** of process improvements in terms of cost, quality and cycle time
- **Support business case analysis** of process decisions - ROI, NPV and quantitatively assessing risk.

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Process Tradeoff Analysis Method (PTAM)

- **Reduces risk** associated with process changes by predicting the probability of improvement
- **Saves time, effort and expertise** over other methods

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What are the Benefits of Process Simulation?

		Project										
	Option	Total Effort (PM) Dev Eff + Dev Rwk	Rework Effort Devel Defects (PM)	Project Duration *(Calendar Months)*	Projected Cost or Revenue delta due to Duration Change	Total Injected Defects	Corrected Defects	Escaped Defects	Rework Effort for Field Defects *(PM)*	Implementation Costs *($)*	NPV	ROI
0	Base Case	200	90	18	$0.00	1150	990	160	40	$0.00	n.a.	n.a.
1	Implement QFD	190	75	17.5	$0.00	1150	1020	130	30	$100,000	$165,145	15%
2	Implement VOC	185	75	17	$ 100,000	1150	1050	100	20	$120,000	$185,231	29%
3	Add QuARS Tool	175	65	16	$ 300,000	1150	1090	60	10	$ 80,000	$289,674	88%
4	Eliminate	230	130	22	$(400,000)	1150	900	250	80	$0.00	-$378,043	-129%
5	Additional Process											

Benefits of Process Simulation

- Decision Support and Tradeoff Analysis
- Sensitivity Analysis – "What if"
- Supports Industry Certification and process improvement programs including CMMI, Six Sigma, and others
- Benchmarking
- Design and Define Processes
- Bring Lessons Learned Repositories Alive
- Can save cost, effort, and expertise
- Can be used to address project manager questions

Software Project Manager Concerns

- What development phases are essential?
- Which phases could be skipped or minimized to shorten cycle time and reduce costs without sacrificing quality?
- Are inspections worthwhile?
- What is the value of applying automated tools to support development activities?
- How do we predict the benefit associated with implementing a process change?
- How do we prioritize process changes?
- How to achieve higher levels of the CMMI?
- What is the level of Risk associated with a change?

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NASA IV&V Questions

- What is the optimal IV&V strategy for a given NASA project or NASA project type?
- What combination(s) of IV&V techniques enable us to meet or exceed the quality assurance goals for the system? Which alternative is best?
- Given a budget of “X” dollars, what IV&V activities should be conducted?
- What if the complexity or defect profiles for a particular project were different than expected?
- How is the duration of the IV&V effort impacted by the overall staffing level for the project? How will this affect the total project duration?
- What would be the impact if selected V&V techniques are handled as IV&V services?

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Potential Questions

- What would be the costs and benefits associated with implementing an IV&V technique on a selected software project?
- How would the IV&V technique contribute to the development process and quality assurance?
- How would IV&V activity “X” work in conjunction with other V&V or IV&V techniques?
- At what point in the process does this technique provide the greatest benefit (e.g. before or after testing)?
- What would be the impact if a IV&V technique “X” is applied at different portions of the process or applied multiple times?

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Supports CMMI Based Process Improvement

CMMI Levels 4 and 5

- Process simulation helps to fulfill PAs (OID, CAR, OPP and QPM - Sub Goals and Generic Goals)

CMMI Levels 2 and 3

- Process simulation can be used to evaluate alternative process choices (RD, TS, PI, V&V, RM, SAM, PPQA, and CM)
- Process simulation helps to fulfill PAs (OPF, OPD, OT, IPM, Risk, DAR, PP, PMA, MA, PPQA – Multiple Sub Goals and Generic Goals)

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Examining the Test Process: Organizational Setting

- Leading software development firm
- Peak staffing of 60 developers on project
- Assessed at strong Level 2 of CMM/CMMI
- Experienced development staff
- 5th release of commercial project
- Data available in electronic and paper form: quantitative and qualitative; professional estimates used to fill in gaps
- Active SEPG

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CMMI Level 3 PAs: Validation and Verification

- **Problem: Releasing defective products, had high schedule variance.**
- Why? Unit Test was main defect removal stage. They did it unreliably.
- Built a model of Large-Scale commercial development process
- Based on actual project data
- Predicted project performance in terms of effort, task duration and delivered defects.
- Part of a full business case analysis - determined financial performance of the process change

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Process Overview - 1

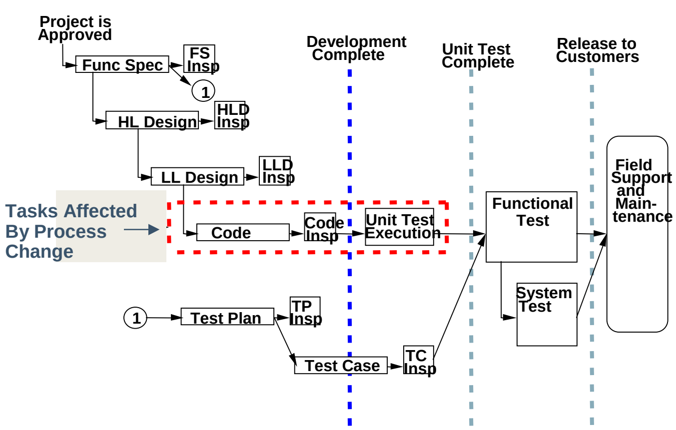

Diagram of the Field Study Life Cycle AS-IS Process

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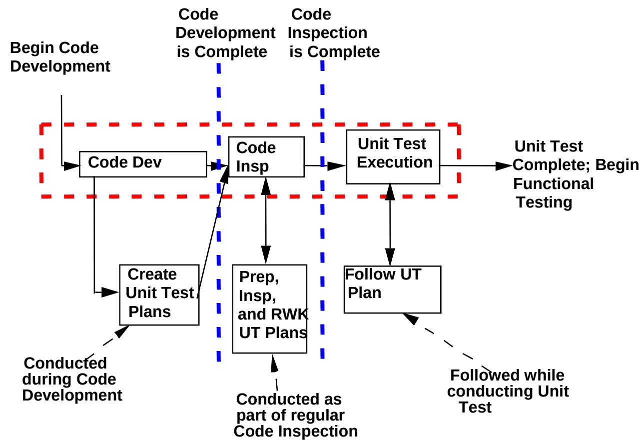
Process Overview - 2



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Questions Investigated

- Will the process change improve project performance?
- What is the cost the firm is currently paying by conducting Unit Tests incorrectly?
- Is partial implementation of the proposed process change possible?
- How would potential learning curve effects affect the performance of the process change?
- Would alternative process changes offer a greater improvement?
- Can the project benefit from reusing process artifacts?

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Performance Measures

Cost

- Person-Months of Development, Inspection, Testing and Rework effort
- Equivalent Manpower (Staffing levels)
- Implementation costs

Quality

- Number of delivered defects by type

Schedule

- Months of Effort

Input Data

- CMM/CMMI Level 2+ organization
- Process documents and assessments
- Project Size
- Productivity
- Earned Value by phase
- Total number of defects injected
- Defect injection, detection and correction rates
- Effort and schedule data
- Defect detection and rework costs

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Graphical Model

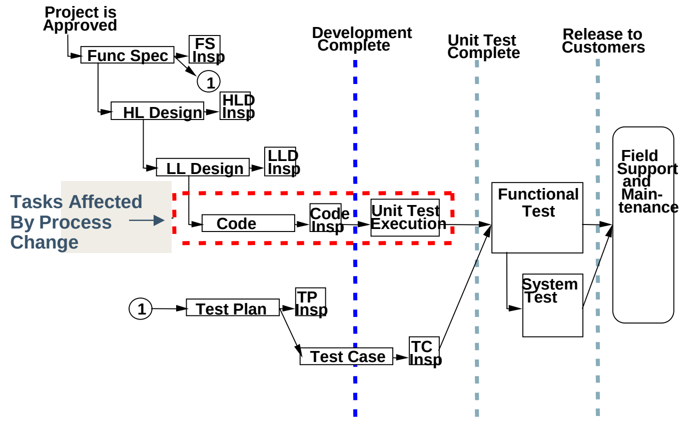

Diagram of the Field Study Life Cycle AS-IS Process

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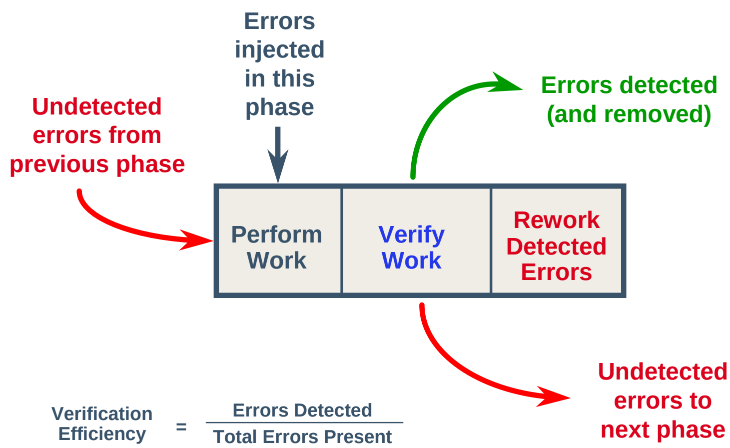
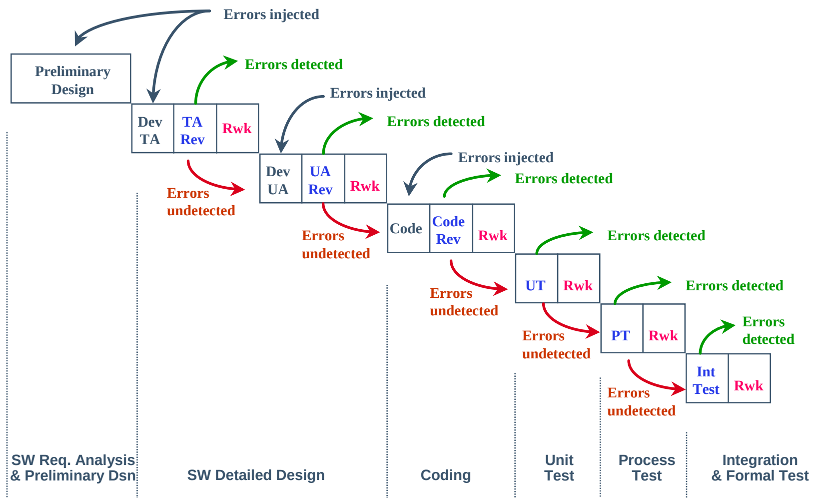
Simplified Error Model



More Detailed Error Model



Unit Test Planning Process Change

Estimate Localized Impacts

- Effort and schedule to develop test plans
- Early detection and removal of defects while creating test plans
- Inspection effort for inspecting and reworking test plans
- Improved efficiency during Unit Test due to following the plans

Key Parameters for the Process Change

Model Parameters	AS-IS Observed	TO-BE Estimated	TO-BE (Observed) Pilot Study Value
Create Unit Test Plan Effort (Hours per KLOC)	0.0	Min=47.6 Mode= 72.2 Max = 144.3	Min=83.3 Mode= 110.1 Max = 200.0
Percentage of Current Errors Removed before Code Inspections while creating the Unit Test Plans	0.0%	Min = 9.0% Mode=15.7% Max = 22.5%	Min = 0.0% Mode=6.4% Max = 28.6%
Percent Unit Test Effort Decrease due to following the plan	0.0%	Min = 5% Mode=10% Max = 15%	Min = 15% Mode=30% Max = 40%
Percent Increase in Unit Test Error Detection Capability	0.0%	Min = 10% Mode=15% Max = 20%	Min = 8% Mode=10% Max = 15%
Effort to Prepare for the Inspection of the Unit Test Plan	0.0	added 10% to the time of the Code Inspection	Min=11.4 Mode= 17.5 Max = 25.0
Effort to Inspect the Unit Test Plan (hours per meeting)	0.0	Min=0.25 Mode= 0.25 Max = 0.25	Min=0 Mode= 0.25 Max = 0.40
Effort to Rework the Unit Test Plan (hours per plan error)	0.0	0.0	Min=0.0 Mode= 2.0 Max = 3.0

Unit Test Planning Process Change

Model Predicts Project Level Impacts

- Cost, quality, and schedule impacts by phase for all phases of development
- Overall cost, quality, and schedule impacts for the project
- Implementation costs
- Post deployment quality

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Baseline Results

- The process change offered significant reductions in remaining defects, staff effort to correct field detected defects, and project duration. The expected ROI was 56% for a typical 30 KLOC release.
- Pilot implementations indicated that the process change provided a 37% ROI even under worst case conditions.

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Model Results

PERFORMANCE MEASURE	AS-IS	TO-BE	MEAN DIFF	PCT CHG	CHG STD	P-VAL	PROB IMPR
REMAINING ERRORS	10.21	8.51	1.70	16.65%	0.93	0.000	97%
LIFE CYCLE EFFORT (PM)	52.42	52.49	-0.07	-0.12%	1.02	0.446	49%
TOTAL EFFORT(PM)	62.00	60.47	1.53	2.47%	1.43	0.000	85%
LIFE CYCLE DURATION (Mo)	18.05	16.44	1.61	8.92%	1.75	0.000	79%

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Sensitivity Analysis Results

- Compressing Unit Test causes significant increases in schedule (+18%) and effort costs (+8%) during the later testing phases and reduces overall product quality(+48% increase in defects).
- Partial implementation of the process change is possible for complex portions of the code. Estimated ROI is 72%.
- Potential learning curve effects significantly enhance the performance of the process change. Expected ROI of 72% assuming only moderate improvements.

Mean Cost, Quality, and Schedule Impacts for Changes in Unit Test Error Detection Capability

COST (Hours of Staff Effort)	MODE = 0.200	MODE = 0.351*	TO-BE MODE= 0.403
Total Effort	66.62	62.00	60.47
Life Cycle Eff	52.43	52.42	52.49
UT Effort	7.06	9.19	8.45
FVT Effort	8.22	6.55	6.01
SVT Effort	3.89	3.40	3.23
QUALITY (Number of Remaining Errors)			
Remaining Err	15.13	10.2133	8.51333
Corr E-UT	57.28	101.727	85.4867
Corr E-FVT	82.29	57.18	48.1333
Corr E-SVT	29.81	20.8267	17.5133
SCHEDULE (Hours of Task Duration)			
Life Cycle Dur	21.21	18.05	16.44
UT Duration	1.80	2.34	2.15
FVT Duration	16.71	12.73	10.47
SVT Duration	10.50	7.71	6.54

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Sensitivity Analysis Results

- Improving inspections would be a more effective process improvement than the Creating Unit Test Plans process change.
- Reusing the Unit Test Plans on the next development cycle provided an overall ROI of 73% (compared to 56% expected improvement without reuse)

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Impact on the Company

- Supports strategic process improvement goals of for higher CMMI levels
- Provides a framework and direction for metrics program (made improvements)
- Supports business case analysis of process changes
- Provides quantitative risk assessment prior to the introduction of process changes
- Obtains Management buy-in for process change and collection of further metrics

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Rapidly Deployable Software Process Simulation Models

- Goal: To create a flexible decision support tool that can be easily used to support better project management, planning and tracking by quantitatively assessing the economic benefit of proposed process alternatives.

- **Motivation: Companies need to get useful results from simulation models quickly.**

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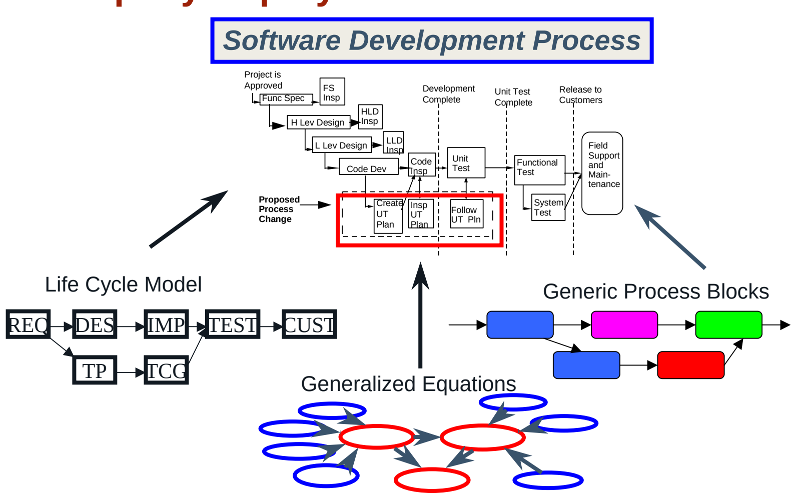
Rapidly Deployable Process Models



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Conclusions

Process simulation modeling has been used successfully to quantitatively address a variety of issues from strategic management to process understanding.

Key benefits include:

- Decision Support and Tradeoff Analysis
- Sensitivity Analysis – "What if"
- Supports Industry Certification and process improvement programs including CMMI, Six Sigma, and others
- Supports CMMI at all levels 2 through 5
- Design and Define Processes
- Benchmarking
- Can address project manager concerns
- Supports project management and control

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Conclusions

This study provided turnkey analysis and recommendations for making a Go/No go decision on the process change

- Expected benefit
- Partial Implementation
- Learning curve impacts
- Impact of bad behavior
- Alternative process changes
- Re-estimate based upon pilot study results

Not a silver bullet

Focus on RAPID DEPLOYMENT

- ***Reducing costs and making models easier to use – No simulation expert needed***

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The End

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6th International Workshop on Software Process Simulation and Modeling (ProSim 2005)

- May 14 and 15, 2005
- Held in conjunction with ICSE 2005 in St. Louis, Missouri, USA
- Sponsors: Portland State University, International Software Process Association, and Fraunhofer Institute
- E-mail: davidr@sba.pdx.edu
- Web: http://www.prosim.pdx.edu/

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