Evaluating the Impact of New Tools and Technologies Using Simulation

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Agenda

- Motivation
- Learned Defect Detectors Highlights
- Process Simulation Highlights
- Model Overview
- Three Scenarios and Results
- Conclusions

Motivation

- Good new technologies are wasted
  - unless there is a compelling business case to use them
- Without such a case:
  - Managers not convinced
  - No reallocation of scarce resources
- Good technology: data mining defect detectors
  - increased PDs (probability of detection)
  - Lower PFs (probability of false alarm)
  - Lower inspection effort (more time for other, more specialized methods
- This talk:
  - The business case
  - Developed via process simulation

Data mining defect detectors

- Data miners learn detect detectors from static code measures (McCabe and Halstead)at the module level.
  - Not perfect: widely deprecated (Shepherd, Fenton, and others)
  - Adequate as partial indicators (but watch that false alarm rate)

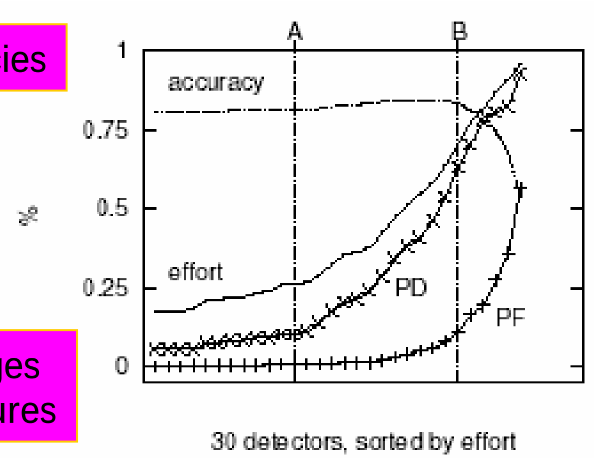
has defect

No	Yes	
A	B	detector silent
C	D	detector triggered

accuracy= (a+d)/(a+b+c+d)
pd = detection (or recall)
= d/(b+d)
pf = false alarms = c/(a+c)
prec = d/(c+d)
Effort = (C.loc + D.loc)/ (ABCD.loc)

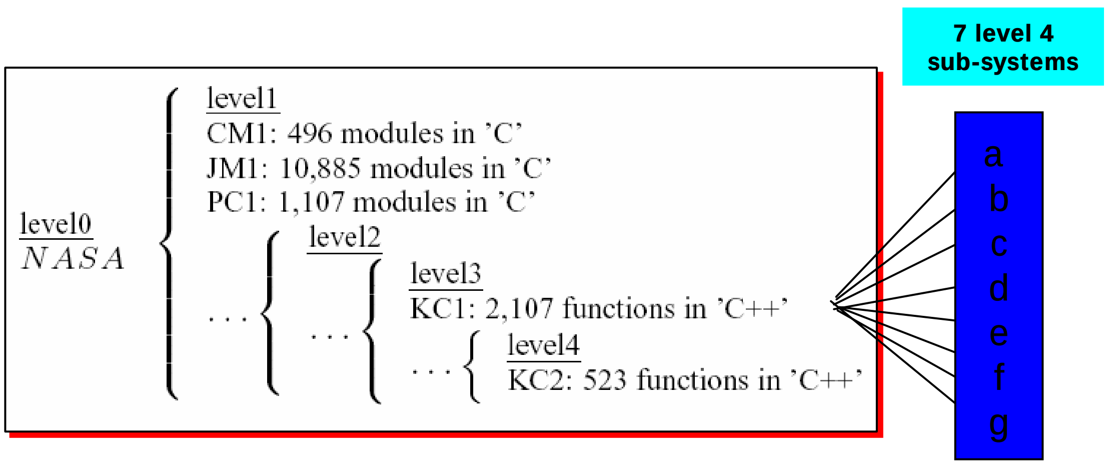
Stable accuracies

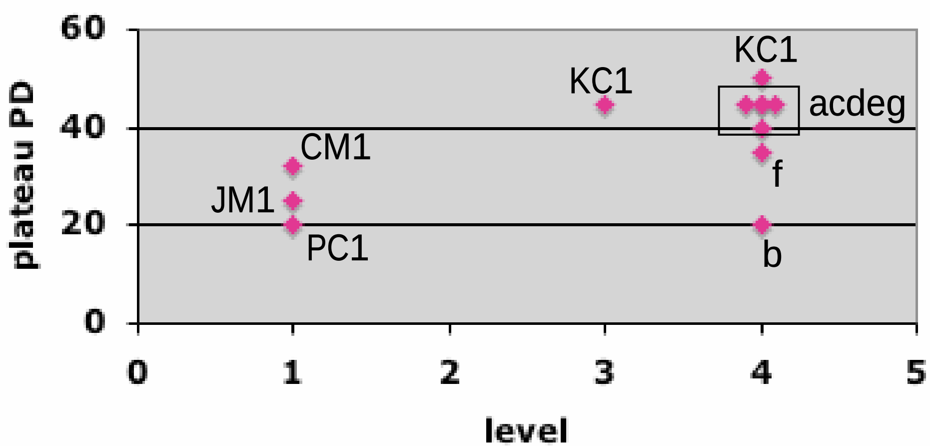
Massive changes in other measures

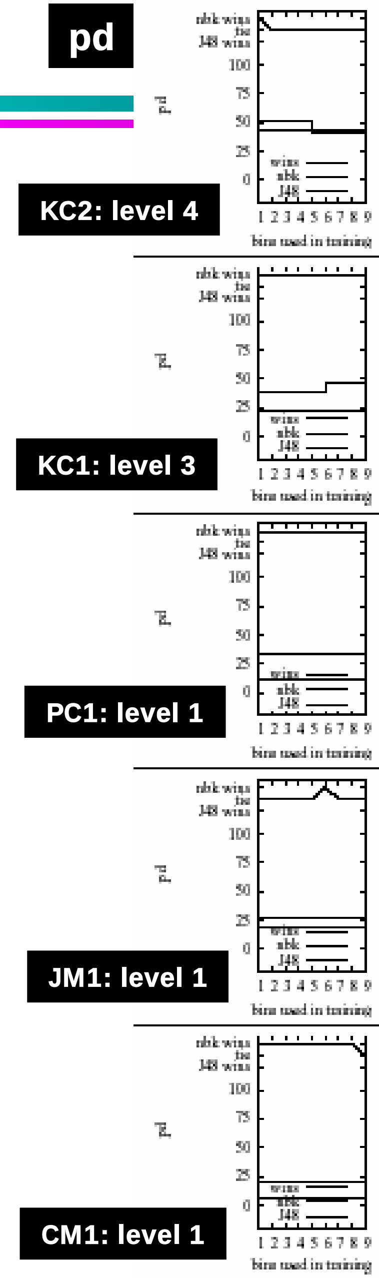


Results

- NBK will suffice (in 85% cases NBK same or better than J48)
- Early plateaus (50-200 examples are enough)
- Not shown: low PFs
- Stratification improves PD?







- Suggestive, not conclusive evidence for "stratification improves PD"

But, so what?

Is any of the above useful?

Introducing - Process Simulation

- One area that can help companies improve their processes is ***Process Simulation***.
- Process Simulation supports organizations to address
  - Strategic management
  - Process Planning
  - Control and operational management
  - Technology adoption
  - Understanding
  - Training and learning
  - Quantitative process management and other CMMI-Based Process Improvement

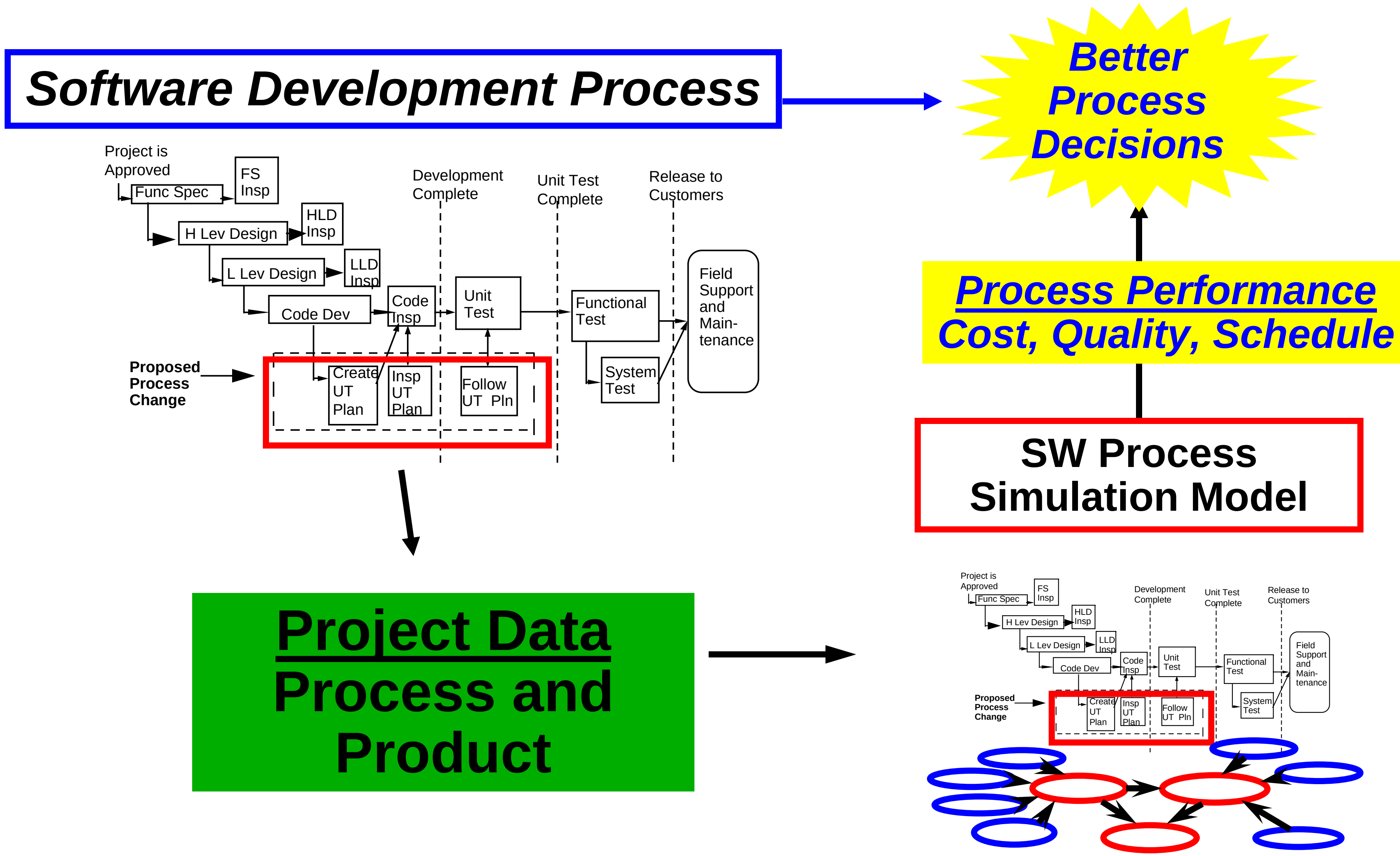
Features of Process Simulation and PTAM

- **Based on extensive research**.
- **Graphical user interface** and models software processes
- **Utilizes SEI methods** to define SW Processes
- **Integrates metrics** related to cost, quality, and schedule into understandable 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.
- **Designed for Rapid Deployment**

Importance/Benefits – Enduring Needs

- NASA Project Level
  - Software Quality Assurance Strategy Evaluation for NASA Projects
  - Independent Bottoms-Up NASA Project Cost Estimation (Going where COCOMO cannot – KSC project)
  - NASA Contractor Bid Evaluation (NASA IV&V integrated part of Planning and Scoping/Cost Estimation strategy)
  - Software Assurance Replanning
  - Cost/Benefit Evaluation of new technologies and tools

How it works


Software Development Process
Better Process Decisions
Project is Approved
Func Spec
FS Insp
H Lev Design
HLD Insp
L Lev Design
LLD Insp
Code Dev
Code Insp
Development Complete
Unit Test
Unit Test Complete
Functional Test
System Test
Release to Customers
Field Support and Main-tenance
Proposed Process Change
Create UT Plan
Insp UT Plan
Follow UT Pln
Process Performance
Cost, Quality, Schedule
SW Process Simulation Model
Project Data Process and Product

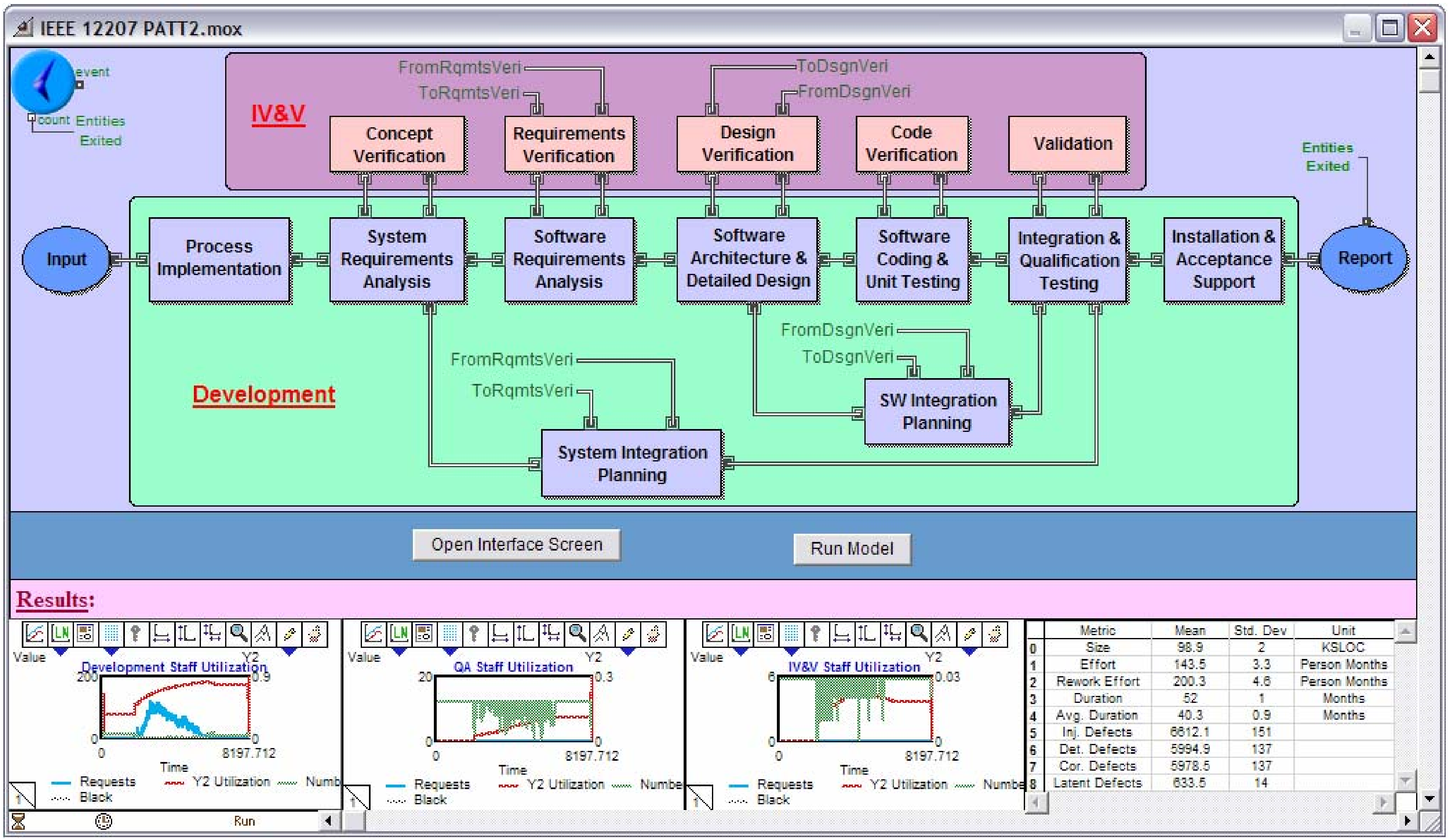
Goal

- In this presentation, we assess the impact of a new technology (i.e. Learned Defect Detectors) on a “typical” large-scale NASA project in terms of overall cost, quality and schedule performance
- Goal: To determine when the new technology might be ***useful*** and when they might be ***useless*** by providing a business case to support the adoption of these tools.

Business Case Questions

- What is the impact of applying new tools and technologies?
- What is the economic benefit or value of the tool or technology? What is the ***Return on Investment***?
- Under what conditions does the tool or technology perform best? Under what conditions does it perform poorly?
- What performance standards does the tool need to achieve in order to have a positive performance impact on the project/organization?
- Are there alternative ways to apply the tool or technology that enable it to provide a more positive impact?

NASA Model – Includes IV&V Layer with IEEE 12207 Software Development Lifecycle

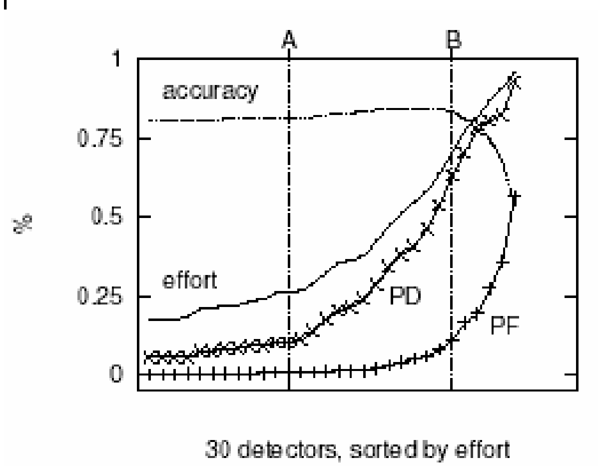


IV&V Layer – Select Criticality Levels for IV&V Techniques using pull-down menus

Notebook - IEEE 12207 PATT2.mox

		Concept Verification		Requirements Verification		Design Verification		Code Verification		Validation	
ID	IV&V Technique	Consequence	Error Potential	Consequence	Error Potential	Consequence	Error Potential	Consequence	Error Potential	Consequence	Error Potential
1.1	Management and Planning of Independent Verification and Validation	None	None	None	None	None	None	None	None	None	None
1.2	Issue and Risk Tracking	None	None	None	None	None	None	None	None	None	None
1.3	Final Report Generation	None	None	None	None	None	None	None	None	None	None
1.4	IV&V Tool Support	None	None	None	None	None	None	None	None	None	None
1.5	Management and Technical Review Support	None	None	None	None	None	None	None	None	None	None
1.6	Criticality Analysis	None	None	None	None	None	None	None	None	None	None
1.7	Identify Process Improvement Opportunities in the Conduct of IV&V	None	None	None	None	None	None	None	None	None	None
2.1	Reuse Analysis	None	None								
2.2	Software Architecture Assessment	None	None								
2.3	System Requirements Review	None	None								
3.1	Traceability Analysis – Requirements			None	None						
3.2	Software Requirements Evaluation			None	None						
3.3	Interface Analysis – Requirements			None	None						
3.4	System Test Plan Analysis			None	None						
4.1	Traceability Analysis – Design					None	None				

Assumptions

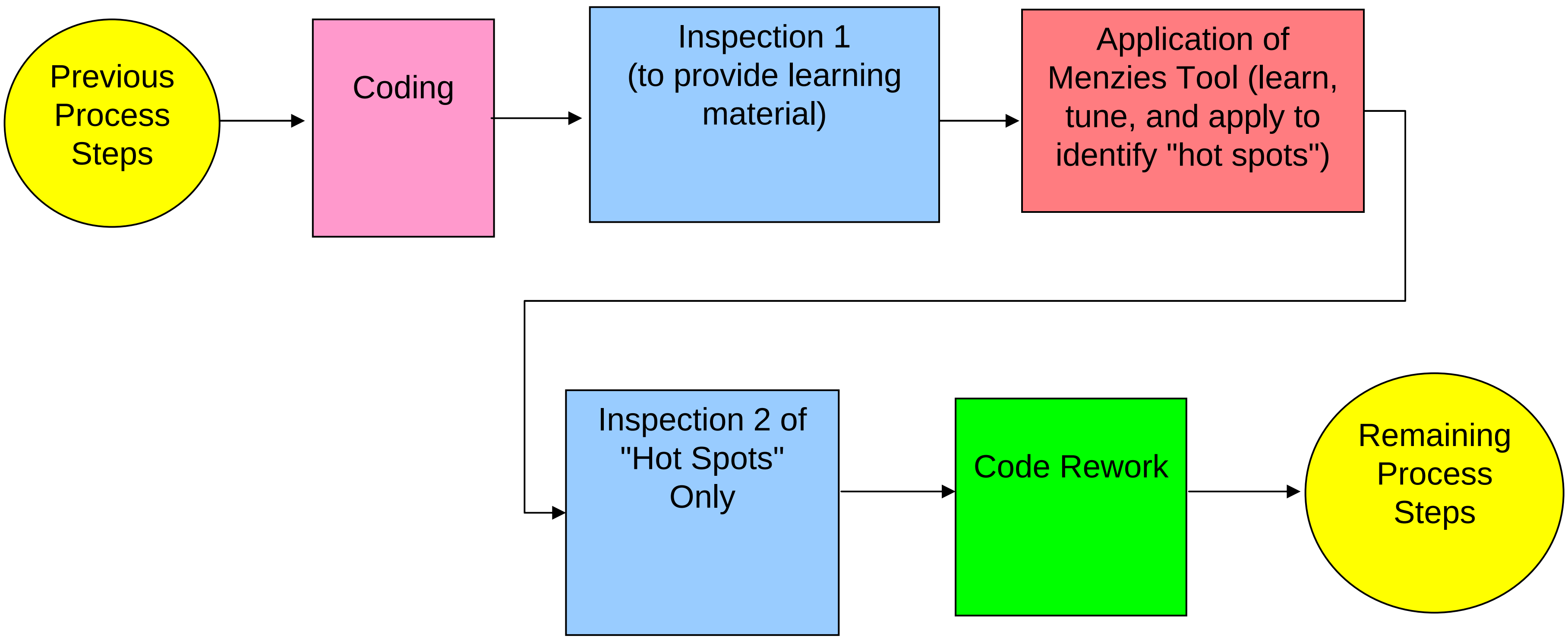


- Project Size is 100 KSLOC.
- Software process follows the IEEE 12207+IV&V model. True for many DoD and NASA projects.
- %LOC Inspected=PD+5% to 10%; and %LOC is proportional to Effort
- PF = 10%-30%.
- PD=40 to 70%.
- The PD rate assumes, in turn, that defect detectors are learned from data divided below the sub-system level.
- Standard manual inspections find 40% to 60% of the total defects.
- Perspective Based inspections find 80% to 90% of latent defects
- Defects uniformly distributed throughout code

Scenario I - Applying LDD to V&V

- Learned defect detectors are applied during project V&V.
  - Inspections are conducted on 11.5% of code to learn defect detectors
  - LDDs then applied to remaining code to identify high-risk portions of the system
  - Explored the impact of using higher PD combined with higher PF
  - Explored the impact of using regular inspections(weak training set) vs Perspective Based inspections (strong training set) for LDDs.

Changes to the Process



Scenario I - Results Summary

- Model recommendations for specific scenarios
- General Rule:

  Insp Effect* %Code_Inspected*95%<= E_LDD* TS_IE

Where:

Insp Effect – Probability of detection of V&V inspections

%Code_Inspected - % of code inspected during V&V

E_LDD – Probability of Detection for LDDs

TS_IE – Probability detection of Training Set inspections

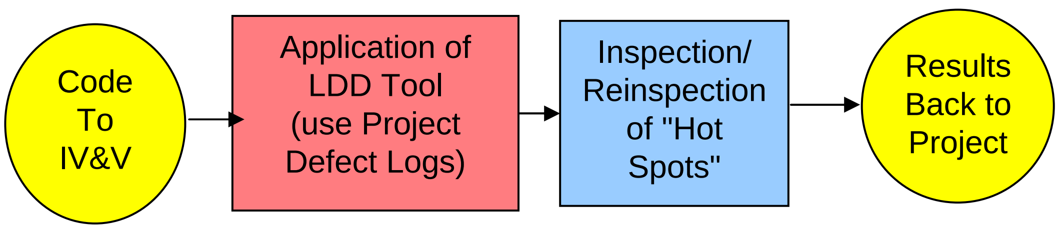
Scenario I - Results Summary

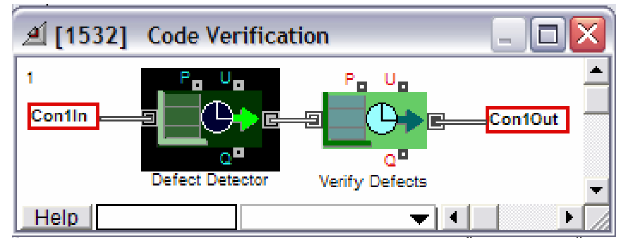
- LDDs are ***Useful*** (Significant benefits) in a V&V setting when:
  - 53% or less of the code is inspected during V&V (manned vs unmanned missions) using regular inspections and LDD PD =50%
  - Using high PD mode and Perspective based inspections
  - Project inspections are poor
- Applying LDDs to V&V are ***Useless*** when:
  - Project inspections are good or high quality
  - More than 53% of the code is inspected by V&V (typical for manned missions)

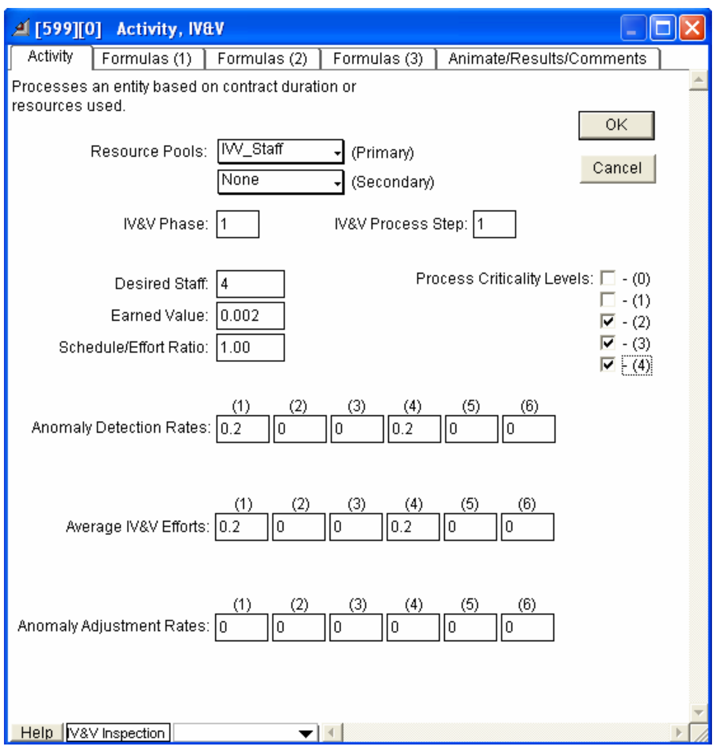
Scenario II - Applying LDD to IV&V

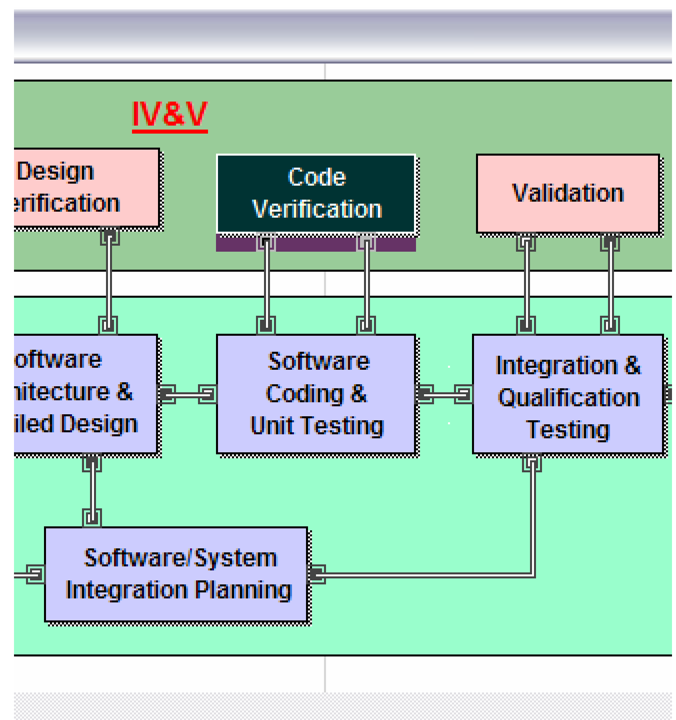
- Learned Defect Detectors (LDD) applied to IV&V (Shedding light on blind spots)
  - Project generated training sets (regular inspections)
  - Investigated the Impact of applying LDD to different project types (varied amount of code that is reinspected (100%-25%))
  - Varied the effectiveness of reinspection (2%-10%)

Changes to the Process – IV&V









Scenario II - Results

- Clear recommendations for specific scenarios
- Results (Excellent Application):
  - Low Risk = 1.2 PM with no defects detected
  - Improves quality if any defects are found (detection capability > 0)
  - Receive added assurance even if detection capability is 0
  - For Manned Missions, (100% reinspection), break-even on total project effort if IV&V reinspection effectiveness = 2%
  - Significantly improves cost, quality and schedule if reinspection effectiveness is >= 5%

Scenario II - Results

- Significant up side potential when LDDs are used to identify high risk portions of the code that were not previously inspected during project level V&V (unmanned missions).
- At 50% code inspected by V&V, 4%-7.5% reduction in delivered defects
- At 25% code inspected during V&V, reductions in delivered defects range from 15%-24%. Effort savings range from 18 PMs to 29 PMs.

Conclusions

- Learned Defect Detectors ***are useful*** when they ***increase*** the overall detection capability of the Coding phase.
- General Rule:
- Insp Effect* %Code_Inspected*95%<= E_LDD* TS_IE
- This occurs when:
  - Less than 53% of code is inspected during V&V or V&V has week inspections
  - Used as IV&V technique identifying blind spots and augmenting regular high-quality V&V
  - V&V has weak inspections

Conclusions

- Learned Defect Detectors ***are useless*** when they ***decrease*** the overall detection capability of the Coding phase.
- This occurs when:
  - Used to frivolously cut costs by replacing high quality code inspections.

Conclusions – Broader Impacts

- Identify the conditions under which application of a new technology **would be** beneficial and when applying this technology **would not be** beneficial.
- We can define ***performance benchmarks*** that a new tool or technology needs to achieve.

Conclusions – Broader Impacts

- We can ***diagnose problems*** associated with implementing a new tool or technology and ***identify new ways*** to apply the technology to the benefit of the organization (and the vendors)
- Finally, we can do all this ***before*** the technology is purchased or applied and therefore can save scarce resources available for process improvement.

The End

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