Predicting Software Quality Early in the Software Development Lifecycle and Producing Secure Software

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Main Points - 1

Defective software is insecure

Managing the software work is difficult because of the way it is currently done

To manage software, you need to manage quality

To manage software quality, developers need to manage quality of the software components built by them

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Main Points - 2

Procedural processes do not change engineering behavior

Need operational processes at the team and individual levels

Performance metrics that really matter come from the developers themselves and provide early warning

Why Are We Here? - 1

The adverse impact of software vulnerabilities caused by defective software is far-reaching

The defects that escape testing are exploited by hackers to launch cyber attacks

The current method of dealing with the increasing number of cyber attacks is reactive

Why Are We Here? - 2

We need a rapid transformation of the U.S. software industry from the current “Deliver now, fix later” culture to one capable of delivering substantially defect free code within predictable cost and schedule

This is a national high-priority need

If we continue with current methods, the U.S. taxpayer will pay billions of dollars for fixing defects in delivered products

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Why are We Here? - 3

U.S. Government Legacy Systems Modernization				
Estimated cost to taxpayer due to poor quality of delivered software				
	Instructor Estimate	**Your Estimate**		
Estimated size of modernization software in Functioin Points	20,000,000		A	
Estimated defect potential per Funtion Point at current capabil	5		B	
Defect potential	100,000,000	0	C=A*B	
% Cumulative defect removal efficiency	85		D	
% Defects in delivered product	15		E=100-D	
No. of defects in delivered product	15,000,000	0	F=E/100*C	
Cost to fix a defect	4,000		G	
Total cost to taxpayer	$60,000,000,000	$0	H=G*F	

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Managing the Software Work
State of the Practice - 1

In spite of increased adoption of PMP, Six Sigma, Lean, Agile, CMMI, ITIL etc, industry performance outcomes for cost, schedule and quality continue to be mixed

Changing managers, procurement regulations, acquisition procedures, and contracting provisions including oversight reporting have not resolved the cost, schedule, and quality problems of most software projects

Even with all of the emphasis on writing software with security in mind, most software applications remain riddled with security holes

Managing the Software Work
State of the Practice - 2

Current software quality methods rely on testing, and are expensive, unpredictable and ineffective

Heroic efforts rescue troubled projects; heroes are in short supply

High-performance teams are the exceptions and not the norm

Common Misconceptions About The Software Work - 1

We must start with firm requirements

If it passes test, it must be OK

Software quality can’t be measured

The problems are technical

We need better people

Software management is different

Source: *Managing the Software Process*, Watts Humphrey

Common Misconceptions About The Software Work – 2

Maturity level 3 is all that is needed

Higher maturity levels add to cost

Higher maturity levels are needed only for safety critical or business mission critical systems

If it is “agile” or “lean”, it is good

What we need are lean processes

Maturity levels guarantee results

Maturity level 5 is the end

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Contracts and Management Systems - 1

Too often, our contracts and management systems are based on the common misconceptions

Time and Materials and Cost Plus Fee contracts end up rewarding poor cost, schedule and quality performance

CMMI levels 2 or 3 specified as pass/fail criteria

Emphasis on product technical reviews which are important, but do not motivate change and are not helpful to improve the process or track status

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Contracts and Management Systems - 2

Not trusting teams to estimate the job, prepare aggressive and realistic plans, and negotiate responsible commitments

Lack of precision and timeliness in reporting contract performance and job status

Multi-contractor teams lack sense of purpose, goals and mission and do not act as a real team

Current Methods
“Deliver Now, Fix Later”

- Command and control management system not suitable for managing knowledge work
- Workers and managers have different objectives and different views of project success
- Lack of trust between management and teams
- Teams unable to negotiate schedule and cost commitment
- Arbitrary, unrealistic schedules creating culture of “Deliver now, fix later”
- Lack of precise project status measures

The Top 15 U.S. Software Cost Drivers in Rank Order Circa 2009

1. **The cost of finding and fixing bugs**
2. The cost of cancelled projects
3. The cost of producing paper documents and English words
4. The cost of recovery from security flaws and attacks
5. The cost of requirements changes during development
6. The cost of programming or coding
7. The cost of customer support
8. The cost of meetings and communication
9. The cost of project management
10. The cost of application renovation
11. **The cost of innovation and new kinds of features**
12. The cost of litigation for cancelled projects
13. The cost of training and learning software applications
14. The cost of avoiding security flaws
15. **The cost of acquiring reusable components**

Source: *Capers Jones, STN 13-1 April 2010: Software Quality, Reliability, and Error Prediction*

Schedule Compression and Quality

Schedule/Quality Trade-off				
	Default	10% Compression	20% Compression	10% Extension
Duration Mths	25.9	23.3	20.7	28.5
Defect Count	1,033	1,316	1,715	849
% Change		27.4%	66.0%	-17.8%

Source: *Donald M. Beckett and Douglas T. Putnam, STN 13-1 April 2010: Software Quality, Reliability, and Error Prediction*

Adding Staff and Quality

Staff/Quality Trade-off			
	Peak Staff 16	Peak Staff 32	% Change
Duration Mths	26	22.6	-13.1%
Defect Count	1,043	1,411	35.3%
Effort Months	225	392.0	74.2%

Source: Donald M. Beckett and Douglas T. Putnam, STN 13-1 April 2010: Software Quality, Reliability, and Error Prediction

Defect Injection Rate and Removal Percent - Sample

Phase	Injection Rate – Defects Per Hour	Percent Defects Removed - Yield
Requirements	0.5	
High Level Design	0.5	
Detailed Design	1.5	
Code	2.0	
Unit Test		50%
Integration Test		55%
System Test		35%

Your organization/projects have such data?

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Defects Per Function Point

Defect Origins	Defect Potentials	Removal Efficiency	Delivered Defects
Requirements	1.00	77%	0.23
Design	1.25	85%	0.19
Coding	1.75	95%	0.09
Document	0.60	80%	0.12
Bad Fixes	0.40	70%	0.12
Total	*5.00*	*85%*	*0.75*

Source: *Capers Jones, STN 13-1 April 2010: Software Quality, and Software Economics*

Managing Software Quality - 1

To meet schedule and cost commitments consistently, you must manage software quality

Quality without numbers is just talk

The common ways to manage software quality are with testing and reuse

Testing is now relied upon and is not sufficient

For reuse, the parts must be initially of high quality or the quality problems will be worse

Managing Software Quality - 2

Software-intensive products typically have many defects

The three defect removal strategies

- Test, test, test
- Inspect and test
- Review, inspect and test

Time to find and fix test defects can vary from a few hours to few weeks

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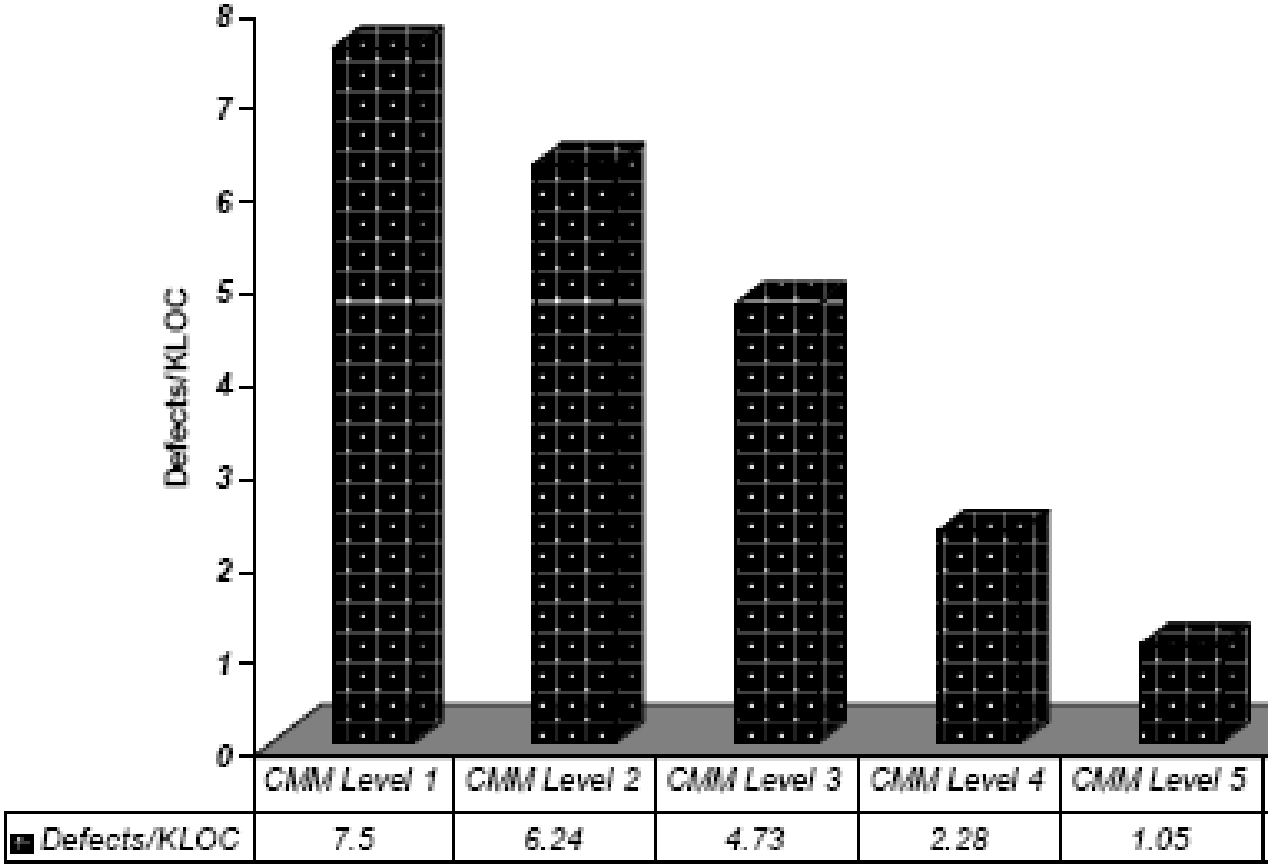
Managing Software Quality - 3

Quality work is more predictable

If you do not manage quality, your schedule problems will end up as quality disasters

Software professionals must be trained to make plans and negotiate commitments

CMMI Improves Quality - 1



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CMMI Improves Quality - 2

	For Projects of 5000 Function Points in Size		
CMM Level	Defect Potential per Function Point	Defect Removal Efficiency	Delivered Defects per Function Point
SEI CMM 1	5.50	73.00%	1.49
SEI CMM 2	4.00	90.00%	0.40
SEI CMM 3	3.00	95.00%	0.15
SEI CMM 4	2.50	97.00%	0.08
SEI CMM 5	2.25	98.00%	0.05

Source: *Capers Jones, STN 13-1 April 2010: Software Quality, and Software Economics*

Issues with Procedural Processes

Procedural processes rely on artifacts to make sure process is being followed

Artifacts are produced by organizational bureaucracy and not the developers

Artifacts may have no relationship to the actual work being done

Easier to pass appraisals than to change engineering behavior

Need for an Operational Process

The need is not for lots of process data and artifacts but for engineers who develop and use artifacts and data

What would happen if software professionals used sound engineering practices?

- Made and followed detailed plans
- Gathered and used historical data
- Measured and managed quality
- Analyzed and improved their processes

The need is for an operational process at the team and individual levels

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Managing the Software Work - 1

Software and systems development is knowledge work

The first rule for knowledge work is that managers can’t manage it - the workers must manage themselves

Managing the Software work - 2

The second rule is that developers and their teams

- Must know how to manage themselves
- Negotiate their commitments with management
- Manage with data
- Own their own work

The third rule is that management must trust the development teams to plan and manage their own work

Source: Acquiring Quality Software, Watts Humphrey

Software Components - 1

To manage software product quality, we need to manage quality of the components

Components are what developers build

Error-prone components account for a disproportionate number of defects found in integration, system and user acceptance tests

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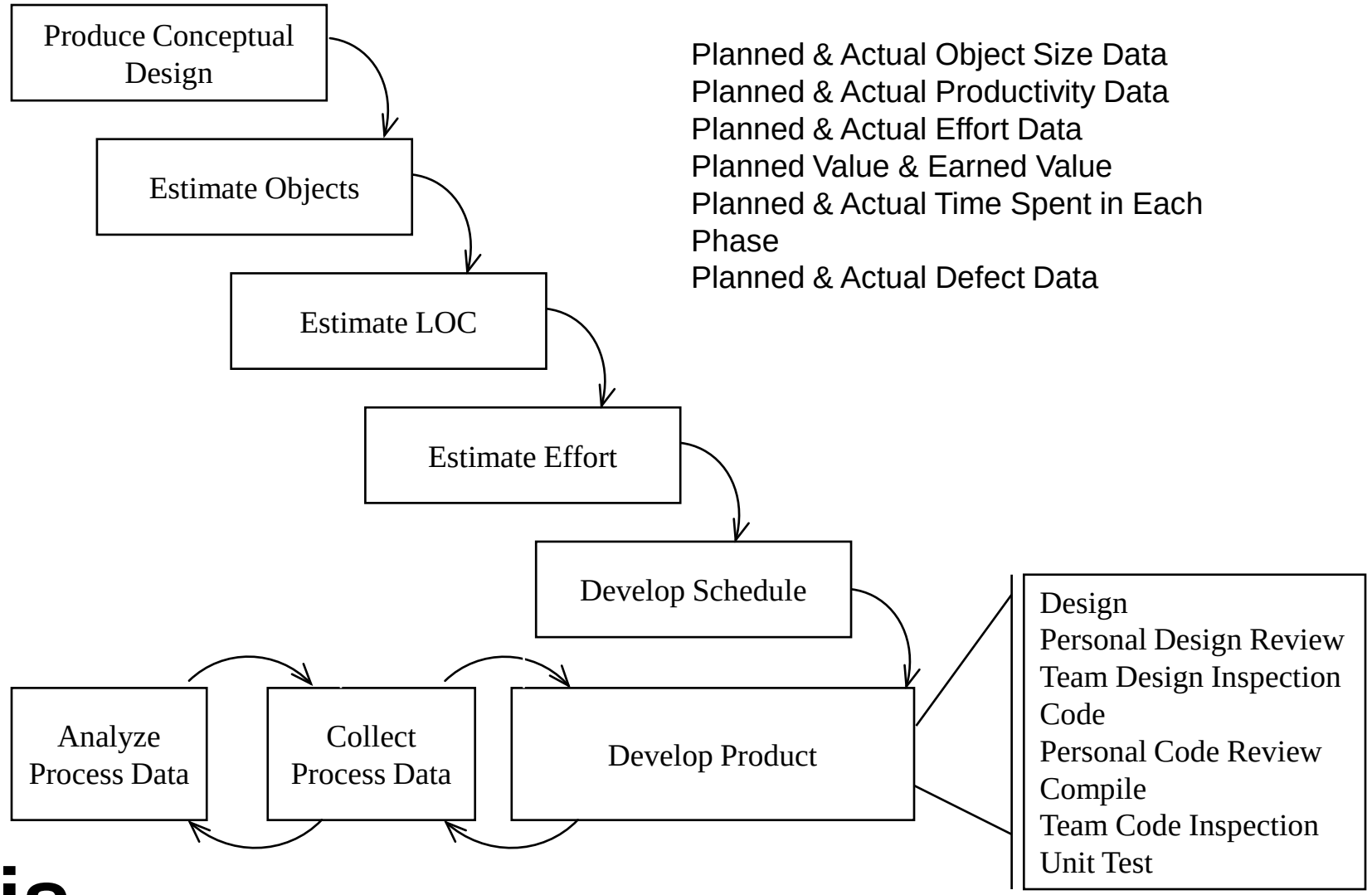
Software Components - 2

20% of the modules in a system typically account for 80% of the defects

It is extremely useful to know which components are likely to be error-prone in later testing so that we can take corrective actions pro-actively

Component Development Process



Planned & Actual Object Size Data
Planned & Actual Productivity Data
Planned & Actual Effort Data
Planned Value & Earned Value
Planned & Actual Time Spent in Each Phase
Planned & Actual Defect Data

Performance Metrics That Matter Benchmarking

	Industry Average	AIS Average
Schedule deviation	>50%	<10%
No. of defects in delivered product 100,000 LOC	>100	<15
% of design and code inspected	<100	100
Time to accept 100,000 LOC product	10 Months	5 Weeks
% of defects removed prior to system test	<60%	>85%
% of development time fixing system test defects	>33%	<10%
Cost of quality	>50%	<35%
Warranty on products	?	Lifetime

Performance Metrics That Matter
Team Goals for Phase Yields

Phase Yields (% defect removed)	Goal
Requirements Inspections	70%
Design reviews and inspections	70%
Code reviews and inspections	70%
Compiling	50%
Unit test at 5 or less defects/KLOC	90%
Integration and system test at <1.0 defects/KLOC	80%
Before compile	>75%
Before unit test	>85%
Before integration test	>97.5%
Before system test	>99%

Performance Metrics That Matter
Early Defect Removal

Developers measure and manage the quality of their individual components and remove defects early through personal reviews and team inspections

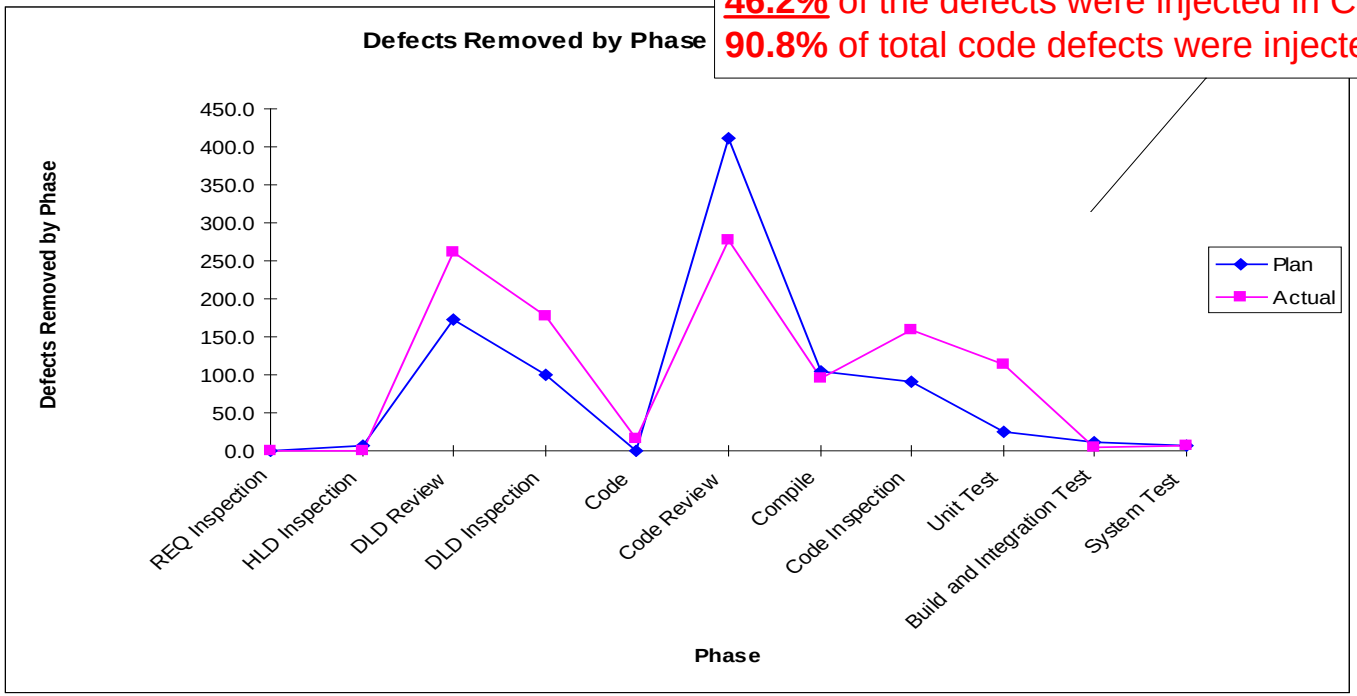
Include OWASP Top Ten and CWE/SANS Top 25 Most Dangerous Programming Errors in review and inspection checklists

Developers strive to get the highest quality product into test

Performance Metrics That Matter
Defects Removed by Phase

The project Injected and Removed a total of
1112 code defects throughout the project lifecycle

44.6% of the defects were injected in Detailed Design
46.2% of the defects were injected in Code
90.8% of total code defects were injected Design & Code



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Performance Metrics That Matter
Process Quality Index

PQI is a leading indicator of overall product quality

PQI gives ability to predict whether components that have been unit tested will have down-stream defects in integration, system, and user acceptance testing

Teams can take corrective action and reduce test and rework time

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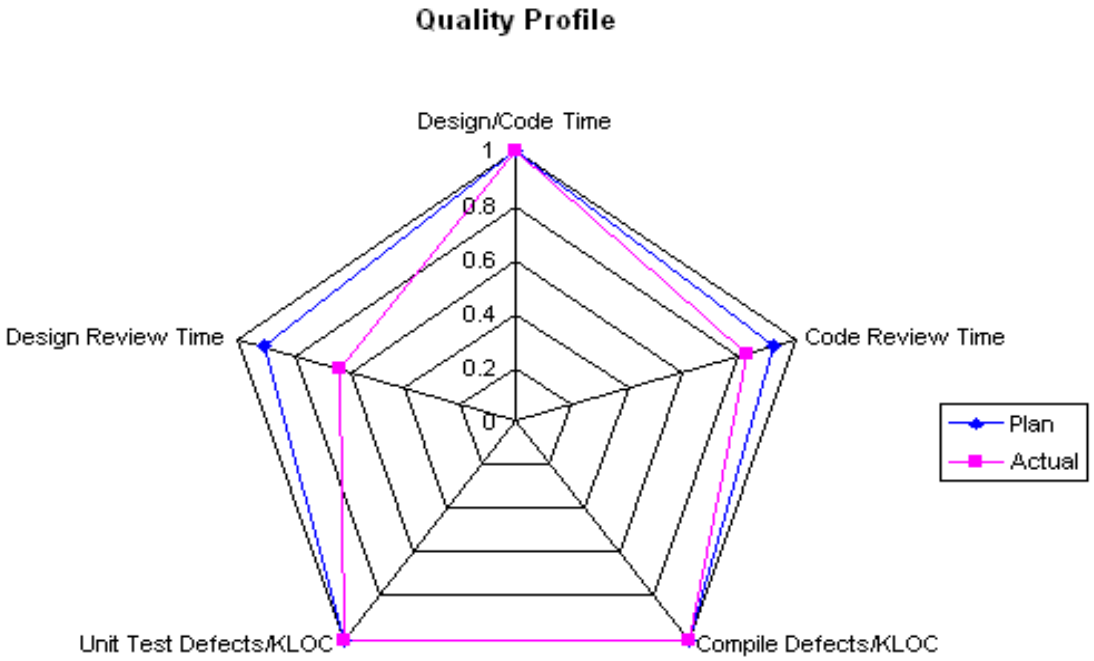
Performance Metrics That Matter
Quality Profile



The above chart shows our 5 measures to achieve our quality goals:

1) Design time to Code time comparison
2) Design Review Time as a % of design time (should be 50% or greater)
3) Code Review Time as a % of code time (should be 50% or greater)
4) Compile Defects per KLOC (Compile should find less than 10 defects per KLOC)
5) Unit Test Defects per KLOC (UT should find less than 5 defects per KLOC)

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Performance Metrics That Matter
Percent Defect Free Components

When knowledge workers have been trained and know how to manage themselves, they are capable of giving early warning to management when problems arise

A key metric is the percent of components in the product that are defect free

Management can motivate the technical teams to strive for 100% defect free components when both parties view project success the same way

Microsoft Fixed Schedule Project - 1

Teams negotiated features and resources to fit the schedule

Team members were empowered to stop a project from going into Code, SIT, UAT or Production

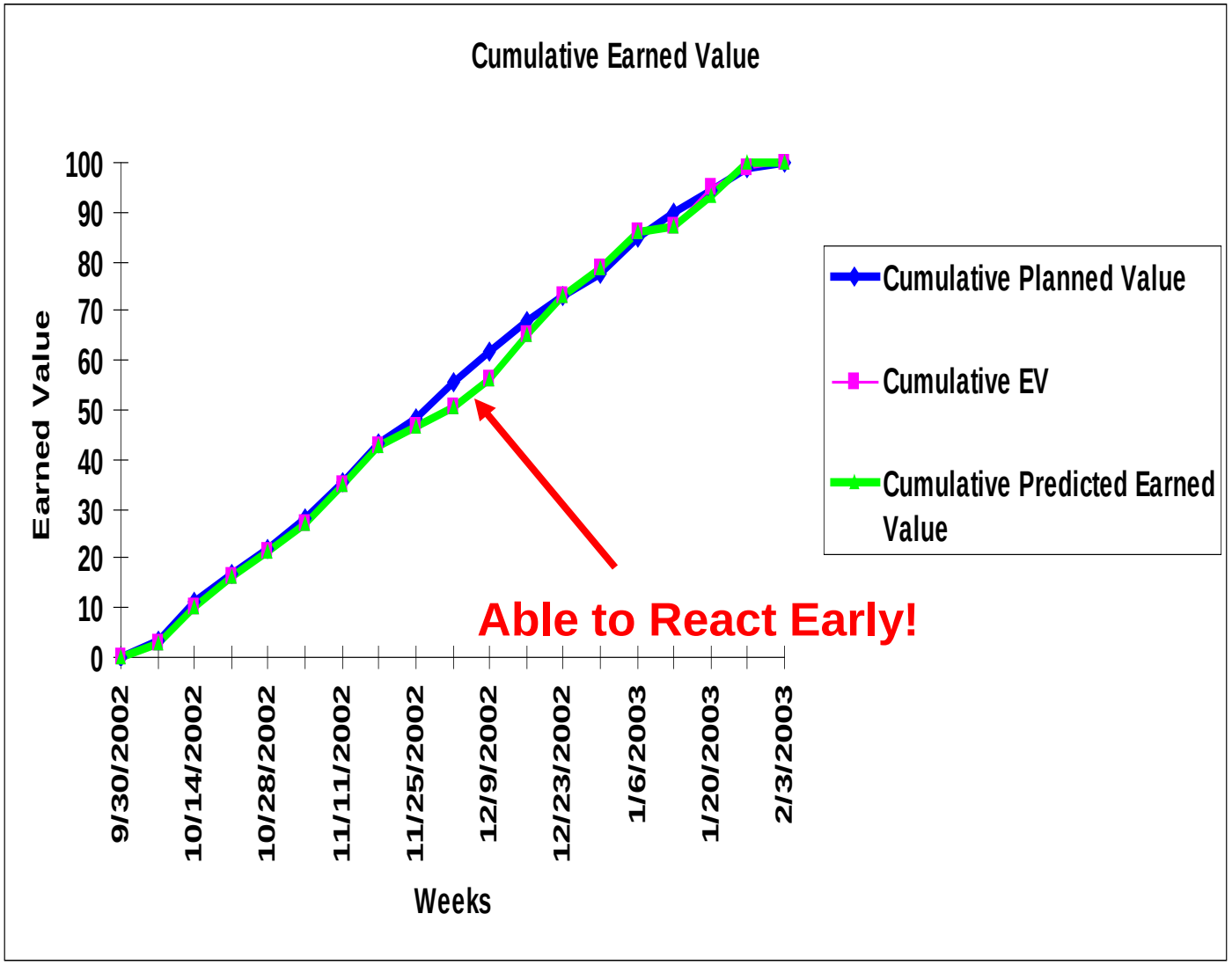
Predicted software quality early using metrics

Achieved work life balance

Developers released early from projects

Low budget for post production defects

Microsoft Fixed Schedule Project - 2



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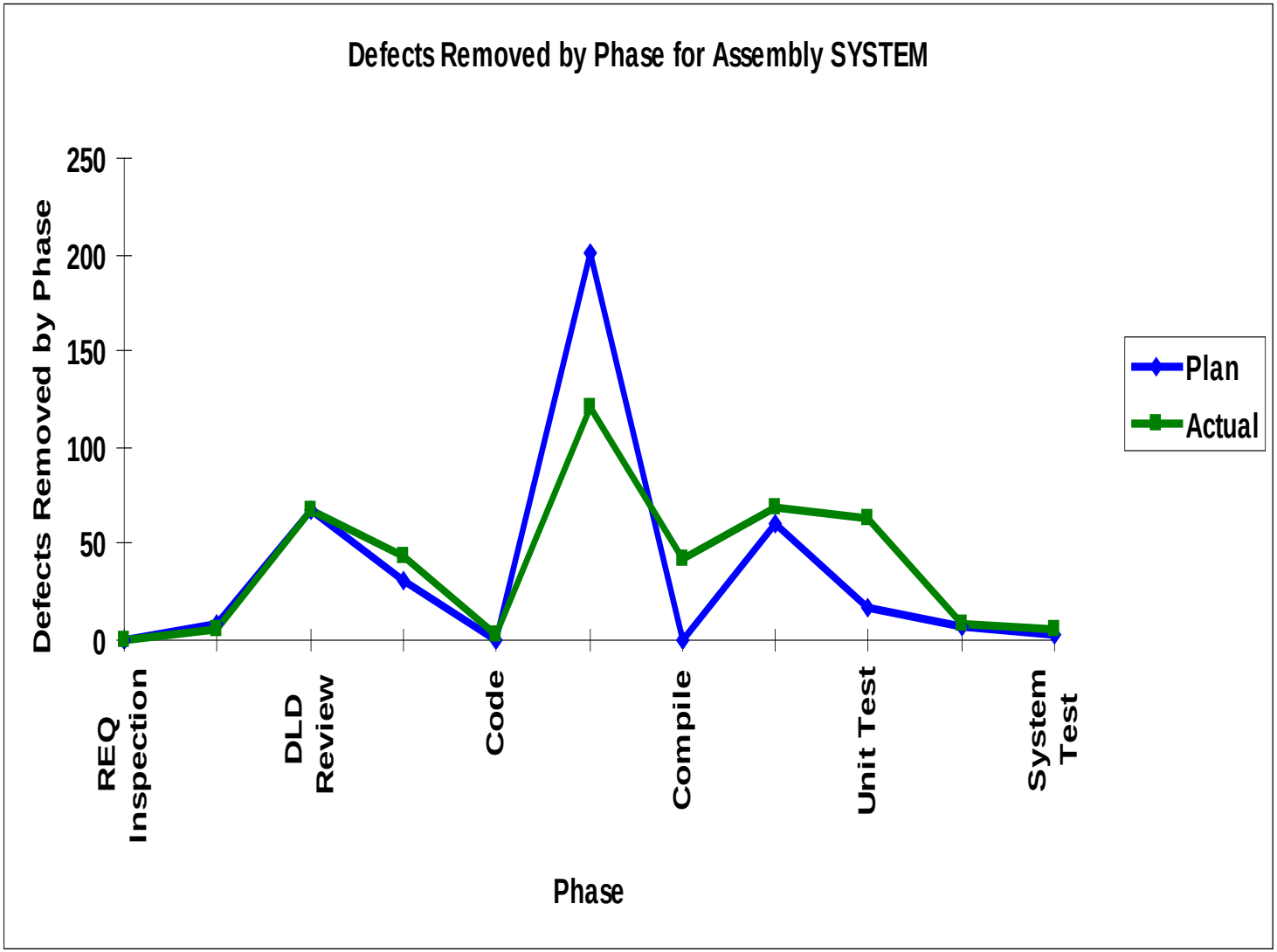
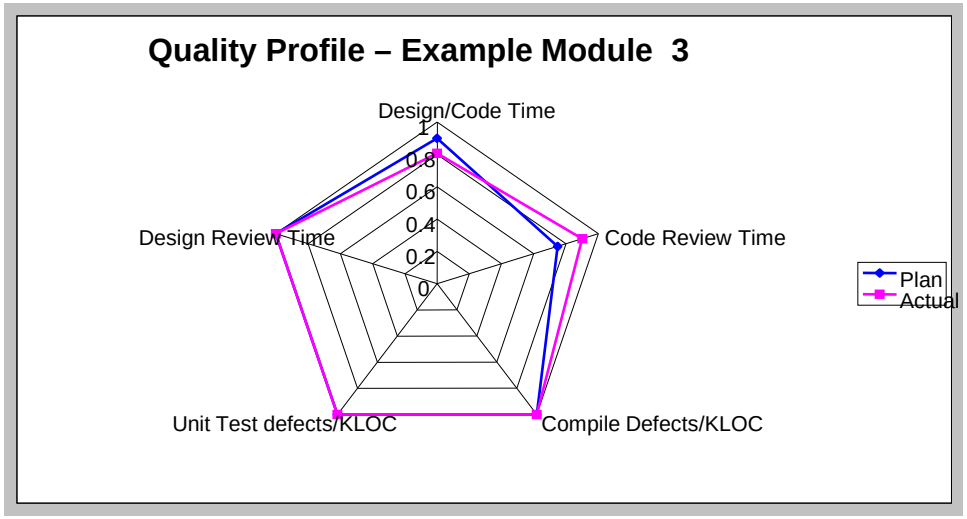
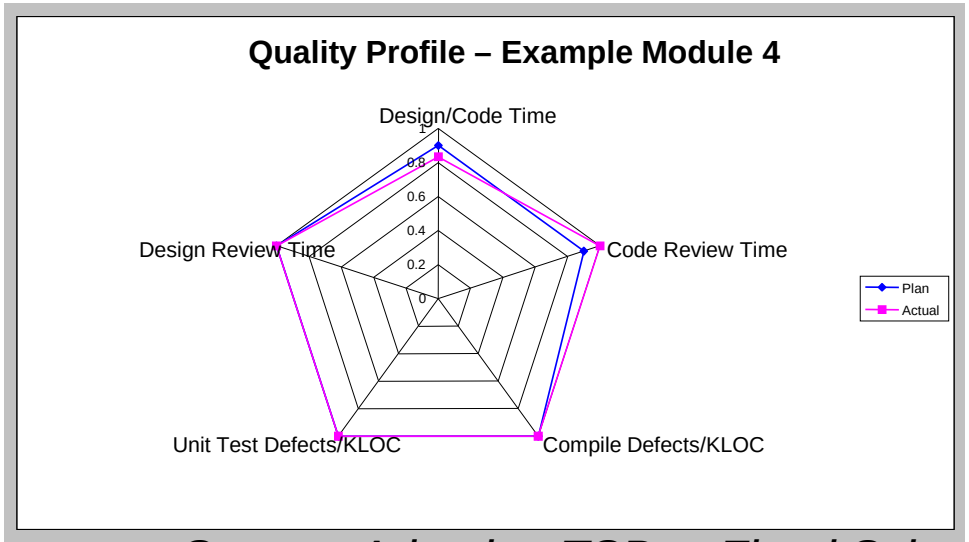
Microsoft Fixed Schedule Project - 3



Microsoft Fixed Schedule Project - 4





Planned correctly
- Executed correctly
- Planned & Actual PQI > 0.7
- Zero system test defects

Source: Adopting TSP to Fixed Schedule Projects, Microsoft Presentation, TSP Users Group Meeting 2005, Chennai, India

Intuit

Reduced project risk by finding 86% of defects before System Testing even started

Engineers doubled available time for developing features by reducing rework and testing time to <10%

Improved quality and time-to-market, while eliminating work that adds no value at Intuit

“Engineers love it… Once they adopt it they can’t imagine going back”

Source: Jim Sartain, Director, Intuit

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Adobe

Teams spent four times less rework than typical Adobe software projects

Teams removed 90% of total bugs prior to systems test

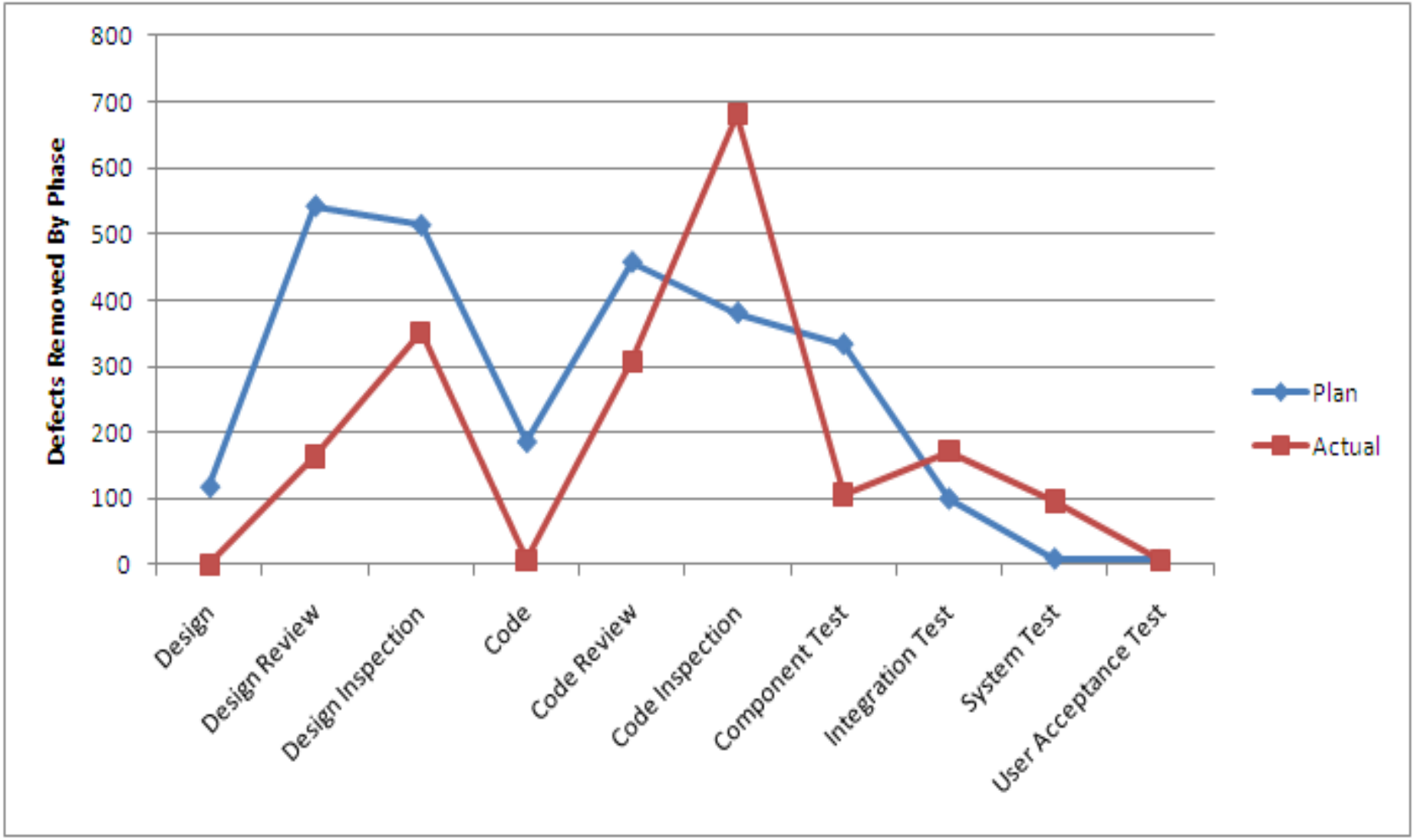
Teams plan, track, measure, and improve

Measurement has encouraged other improvements

- Improved design practices
- Defect analysis to determine common causes and implement improvement methods
- Better estimation methods

Source: The Evolution of Quality at Adobe, SEPG North America, March 20

AIS Federal IT Project Results - 1



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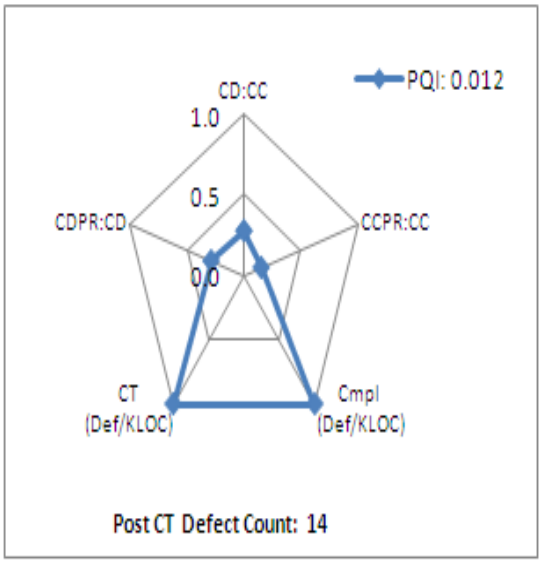
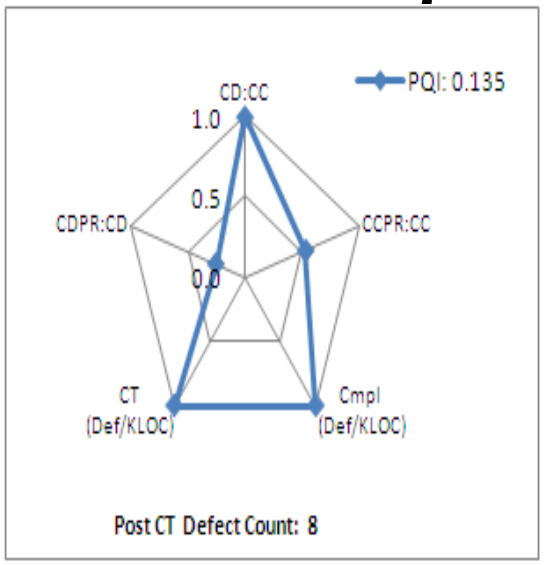
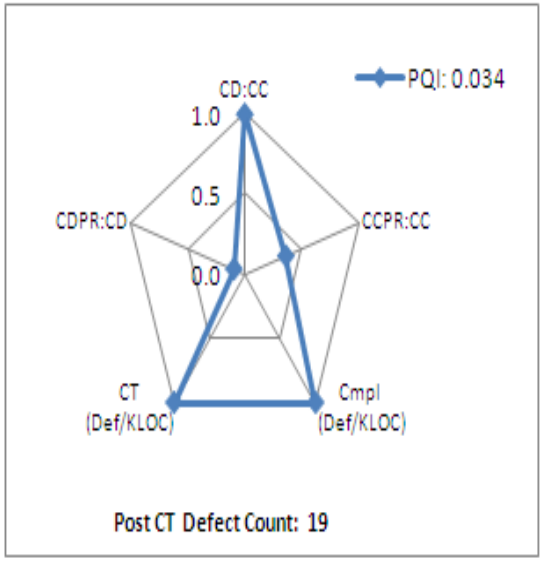
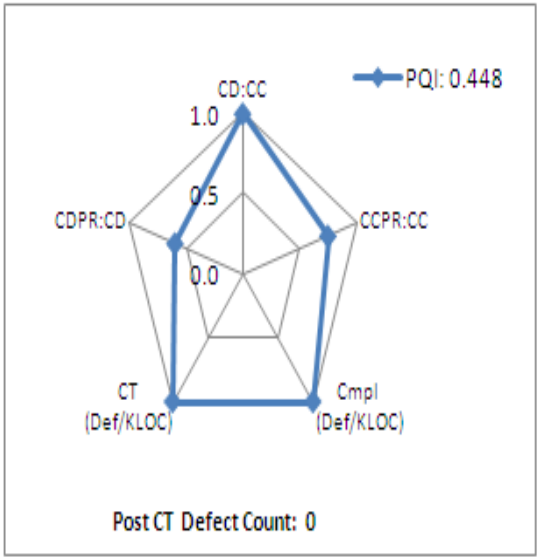
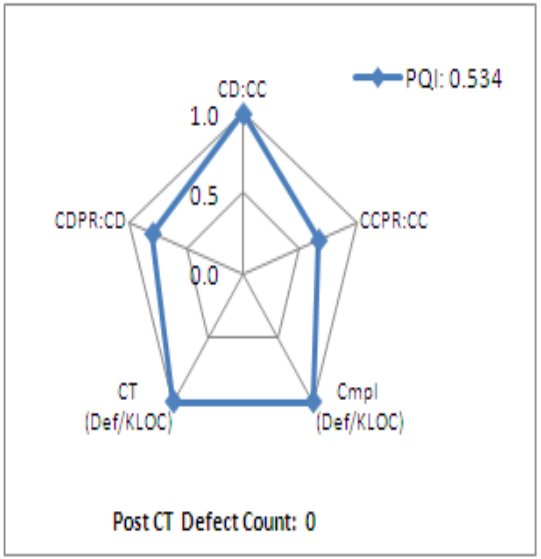
AIS Federal IT Project Results - 2

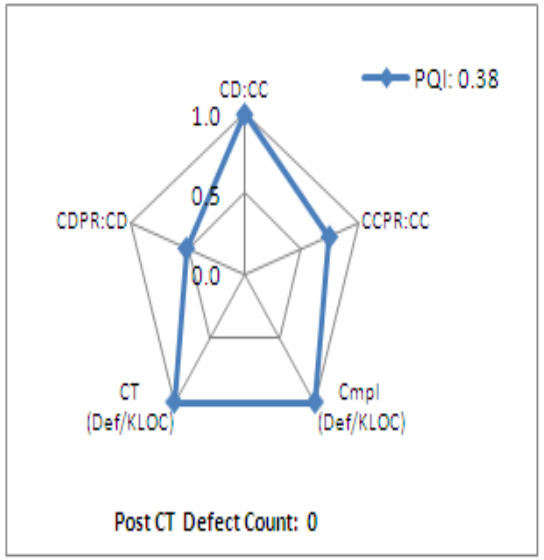












What does

“FUN ON THE JOB”

Mean to you?

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