Optimizing Inspections Through the Application of Statistical Quality Management Techniques

ICSPI

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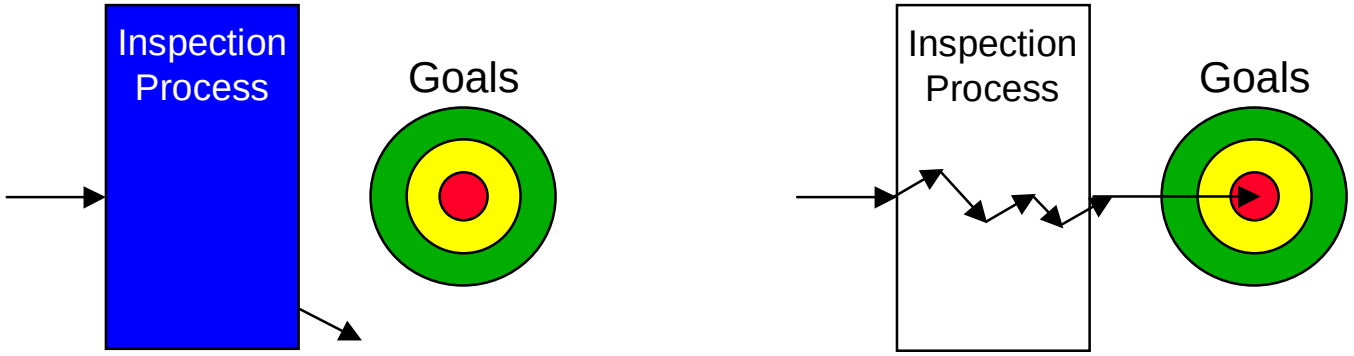
Inspections Goals

- **Business Goals**
  - **Improve productivity by 7% within 1 year**
  - **Improve delivered product quality**
  - **Attain CMM Level 3**
- **Implied Goals**
  - **Quick, visible success to maintain funding**
  - **Recover process improvement costs in less than 1 year**
  - **Since ~30% of development cost is spent in test, reduce time spent in test by 25%, reducing overall cost by 7%**
- **Strategy**
  - **Use inspections to remove defects early in the product life cycle at a lower cost resulting in fewer defects in test and fewer defects delivered to the customer**

Goals must be EXPLICITLY LINKED to business results to maintain management support and funding

Goals and Measurement

- **An inspection process that is not *actively managed* will probably be less effective in achieving its goals. It might even be counterproductive**
- **"You can't manage what you can't measure"**
- **Goals should be stated measurably**
- **Measures should be defined**



Measurements of the inspection process are key to managing the process and achieving the goals

Measurements

- Only three basic measurements
  - Effort: the effort required to prepare for, hold, and fix the defects found in, the inspection
  - Size: the size of the work product inspected, often measured in lines of code (LOC)
  - Defects: the number and type of defects, effort required to fix, point of injection and point of removal, description
- Simple and economical to collect in-process with an automated tool
- All other metrics are derived from these three measurements

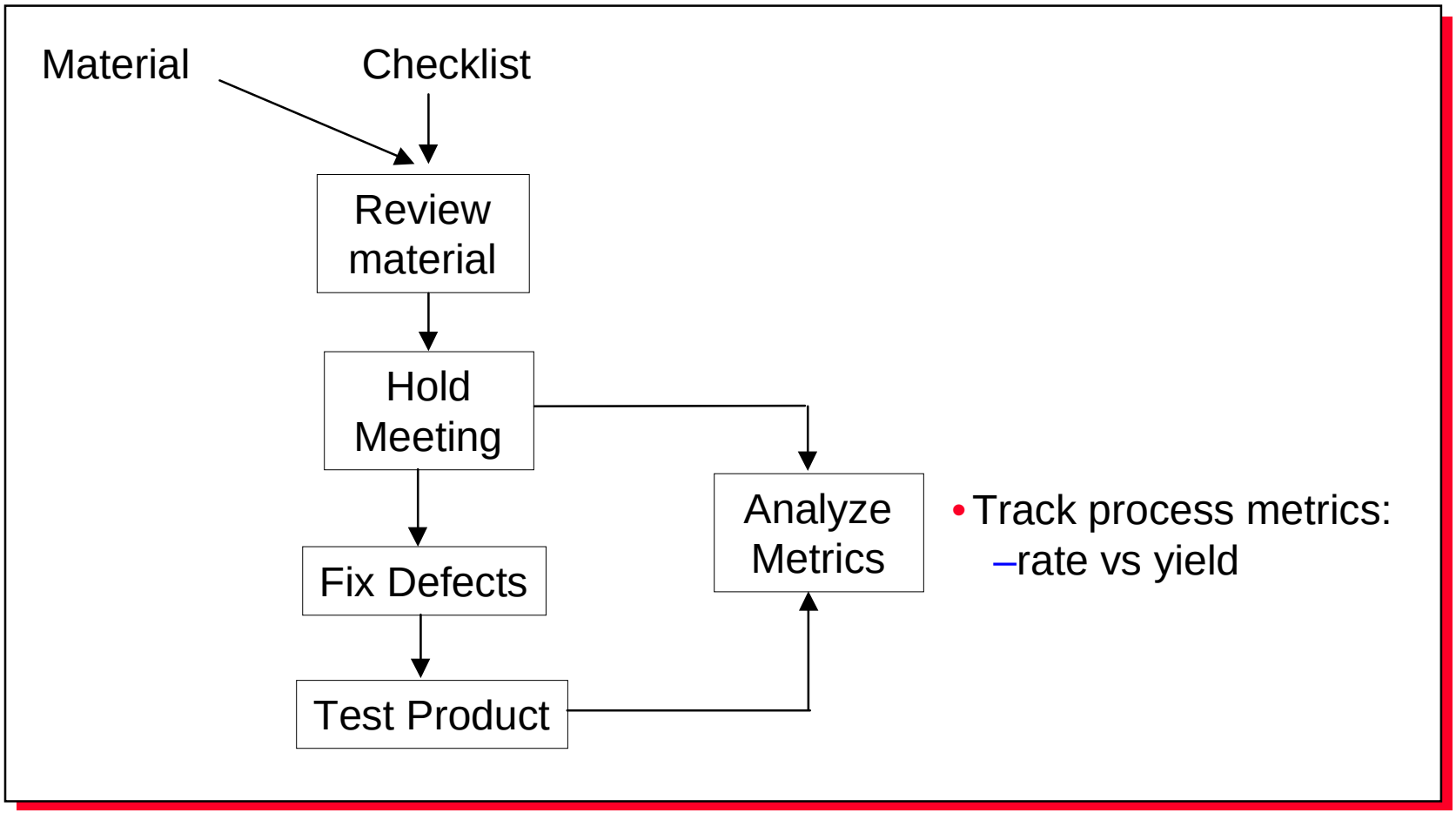
Derived Metrics

- Review Rate - LOC/hr
- Defect Density - Defects/KLOC
- Defect Removal Rate - Defects/hr
- Yield - Defects Removed/Defects Present
- Defect Removal Leverage - Inspection Removal Rate/Test Removal Rate
- Appraisal Cost of Quality – cost of all inspection activities expressed as a % of project cost
- Failure Cost of Quality – cost of all re-work related activities required to complete compilation and test expressed as a % of project cost

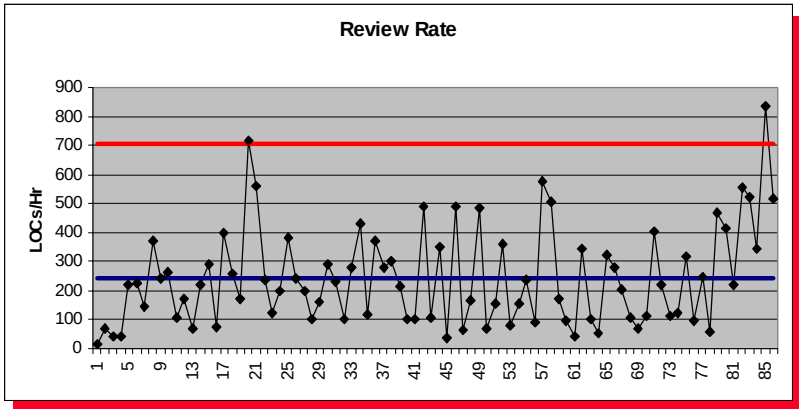
Types of Reviews

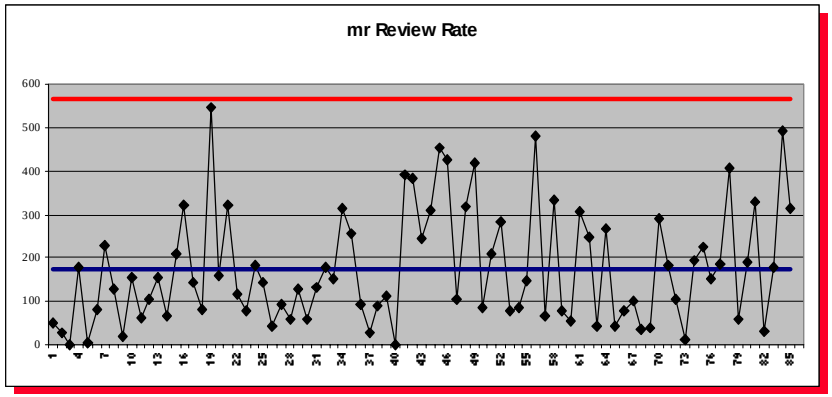
- Personal reviews
  - Single person bench check
  - Checklist based
  - Performed by author immediately after producing the product
- Team Inspections
  - Checklist based
  - Product review prior to inspection meeting
  - Inspection focus is on issue/defect identification
  - Example: Fagin inspections

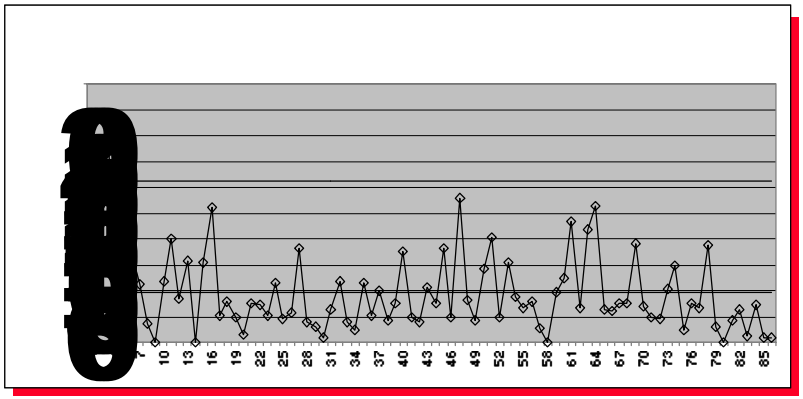
Open Loop Inspection Process - Tracking

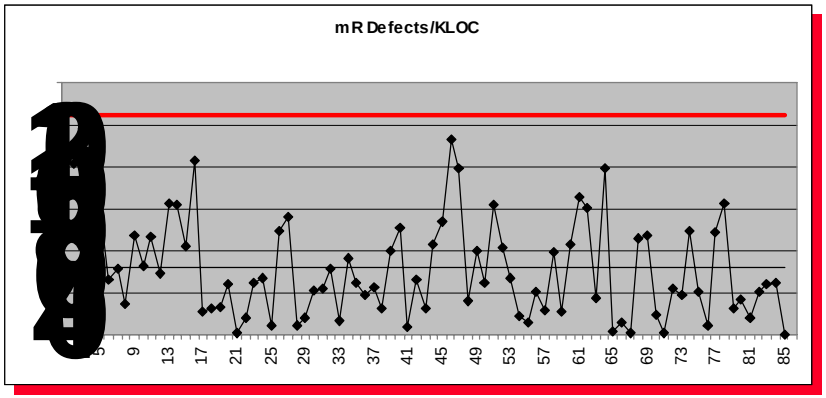


Open Loop Process Run Charts









- Average review rate 244 LOCs/Hr
- Average defect density 39 Defects/KLOC
- Average removal rate 6/Hr

A Control System Viewpoint

- **The outputs of a process, y, are usually a function, f, of a set of control variables, x, and include a process noise component ε:**

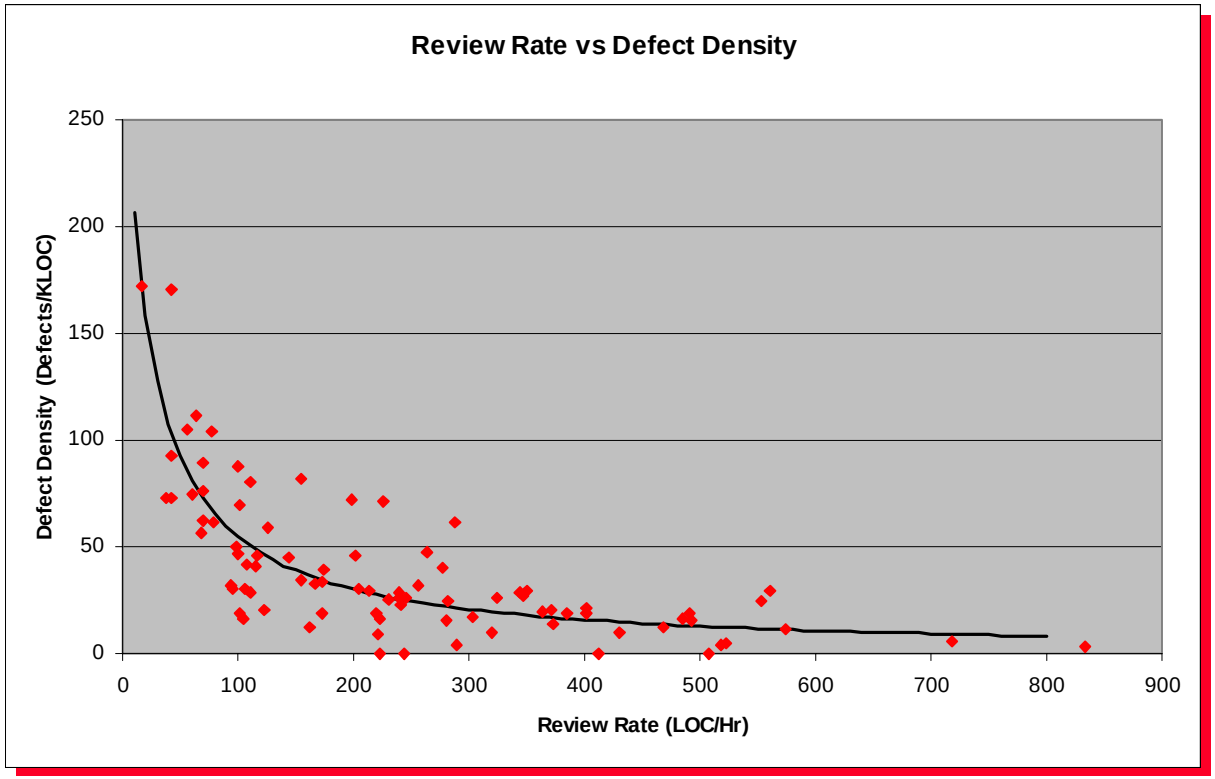
$$y = f(x) + \varepsilon$$

  - **The y's are not directly controllable, but they can be controlled by the directly controllable x's.**
  - **Statistical measurements are necessary to avoid re-acting to the noise ε**

- **Ideally we would like software inspection process that acts like a responsive, "closed loop" control system driving the x's to planned values and through their relationship to the y's, achieving overall product goals**

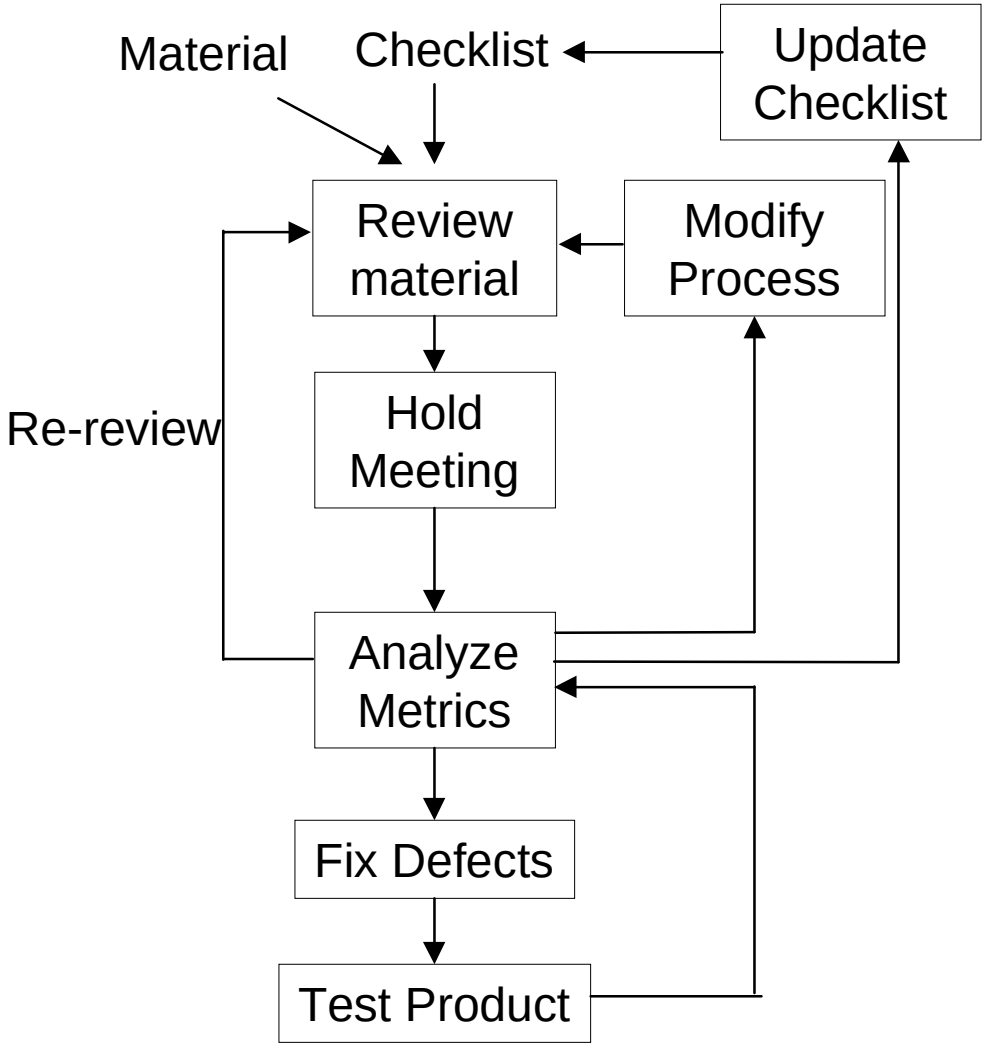
Our experience has shown that review rate is the x that drives the inspection yield

Correlation Analysis



- To evaluate review rate for suitability as a control variable use correlation analysis
- $r^2 = 0.67$ – moderately good fit by hyperbola
- Chart suggests targeting review rate in the 100 – 200 LOCs hour range

Closed Loop Inspection Process



Update Checklist

- **Remove questions that are not catching defects.**
- **Add questions to catch defects that are leaking out to test.**

Modify Process

- **Modify review rate**
- **Vary size of material reviewed**
- **Include test cases**

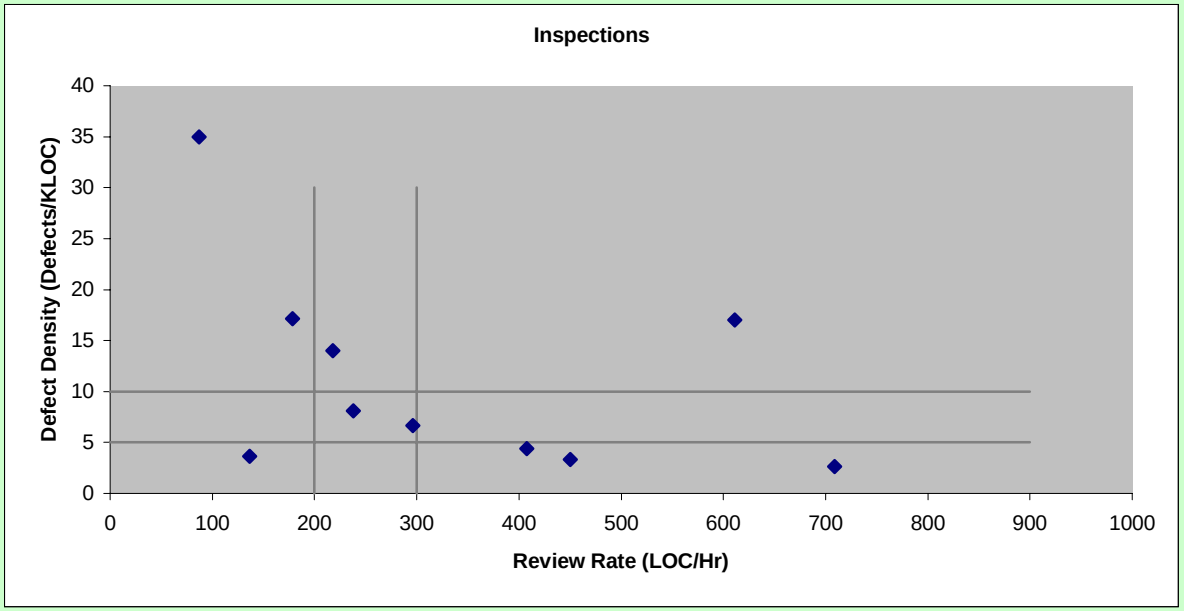
Analyze Metrics

- **Process metrics:**
  - **Rate vs Yield**
- **Product metrics:**
  - **Compare yields to quality plan**
  - **Re-review of products that fall outside quality thresholds**
  - **Buggiest products list**

Inspection Performance Assessment

Slow Review Rate & Many Defects
Is the product really buggy?
Was the review really effective?
Was the review cost efficient?

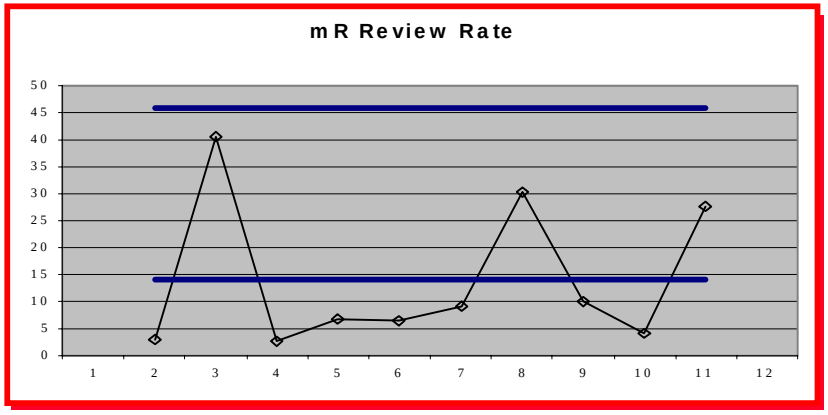
Fast Review Rate & Many Defects => Buggy Product
The product is buggy.
Return to author for rework
Ask someone else to rewrite

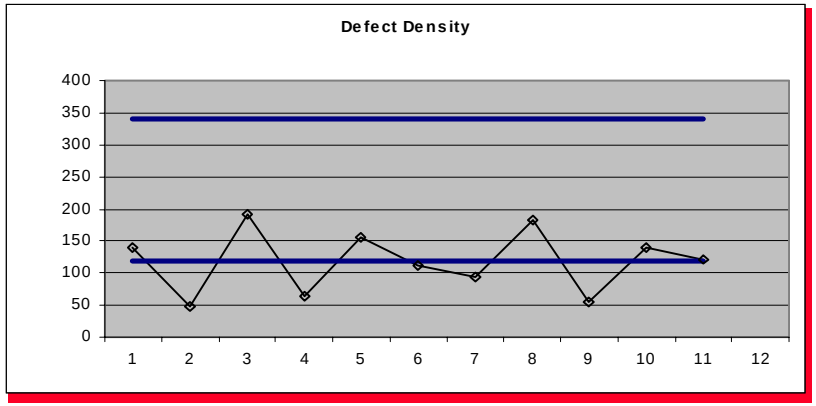


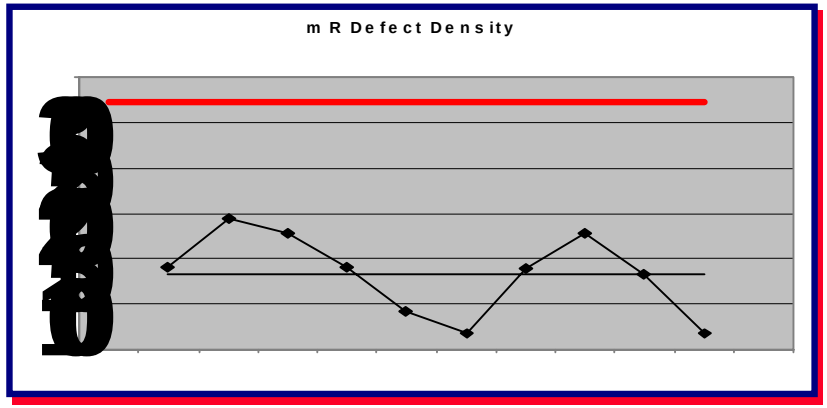
Slow Review Rate & Few Defects
Is the product really good?
Was the review really ineffective?
Was the review cost efficient?

Fast Review Rate & Few Defects => Poor Review
~~Is the product really good?~~
Re-review at a slower rate
Make sure reviewers are using the checklist

Closed Loop Run Charts







- Targeting rate yielded major decrease in variation
- Closed loop process achieved significant improvements
  - Average Review Rate 138 LOCs/hr
  - Average Defect Density 118 Defects/KLOC
  - Average Defect Removal Rate 15/hr

Optimization Strategy

- Personal reviews performed prior to team inspections
  - Remove all the errors the author can detect at the lowest possible inspection cost
  - Checklist derived from author's own list of compilation and test defects flags high risk areas where author has a history of making mistakes
- Frequent short team inspections
  - Checklists focus on interface and requirements related issues that can't easily be found in the personal review
  - Small teams that include the internal "customers" for the product
  - Focus on a few hundred lines of code at a time
- Periodic Defect Prevention meetings provided the development team with an opportunity to review their data and define approaches to detect defects earlier or prevent or prevent them entirely
- Defect prone products "pulled" from integration and test and re-inspected

Goal: Minimize review cost while maximizing yield

Optimization Strategy Advantages

- Doesn't waste team's time with defects the author can easily find
- By inspecting a few hundred lines at a time, preparation time required is on the order of an hour
- Reviewers can stay focused and inspection can be held on the same day that product is available
- Eliminates lags, removes the temptation for the author to move forward into test before the review takes place
- Entire cycle can take as little as 2 – 3 hours from product availability to end of inspection
- Developers use their own data for defect prevention
  - Eliminates handoffs

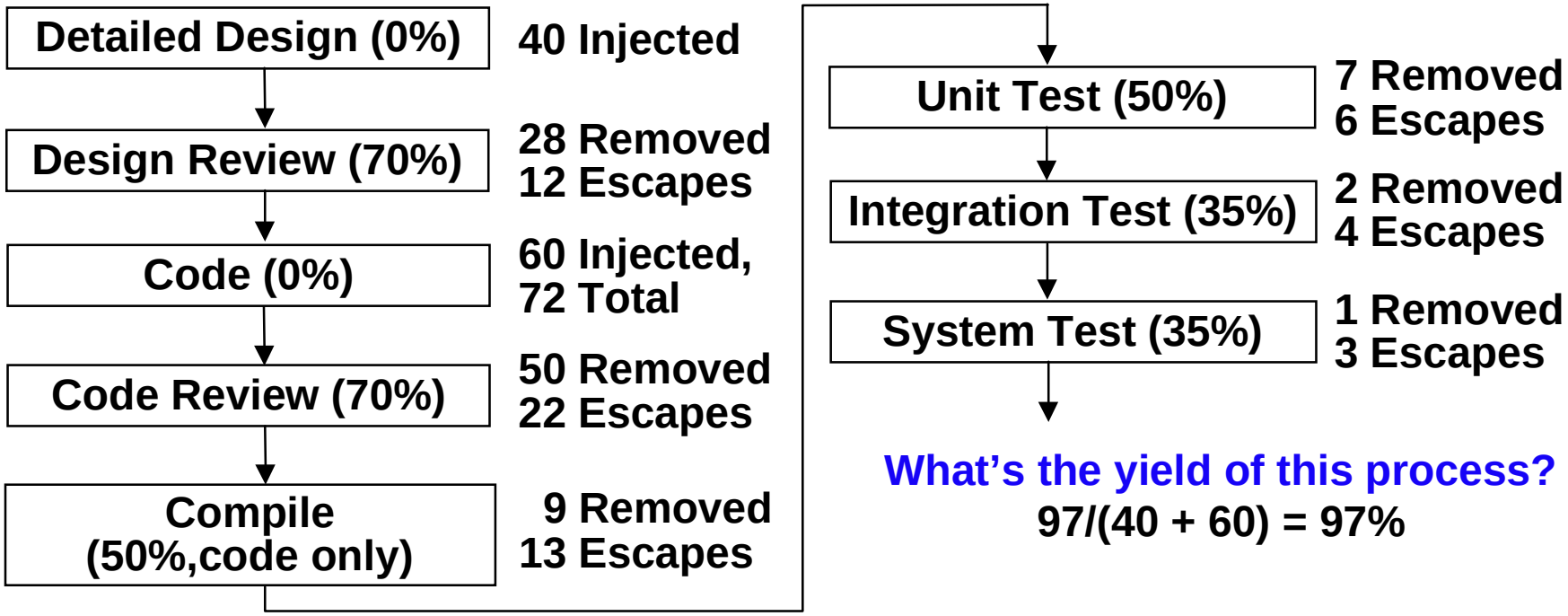
Defect Prevention

- Defect Prevention can be implemented by an organization that is performing inspections and collecting defect data.
- A Defect Prevention team sets and manages to their own goal.
- They use their own defect data, captured during inspections.
- Defects are analyzed using pareto charts to identify most expensive, most frequent, etc.
- Actions are taken to prevent a targeted defect type from occurring in the future.
  - Modify checklists, change coding and design standards
- The team members convince themselves of the value of the activity by calculating their own ROI.
- Lessons Learned are shared with other Defect Prevention teams on a periodic basis.

Data must be regularly used by the people collecting it, otherwise they will stop collecting it!

Yields and Quality Planning and Management

- Inspection process can be characterized by its yield
- Historical yields permit planning the number of defects that will be removed
- Manage to the plan by taking corrective action when actual values diverge from plan



Calculating Return on Investment - 1

- Costs can be directly measured
  - training, tools, performing the inspections
- The dominant costs are the inspection prep and the meeting time
- Savings require estimating the difference in cost between finding a defect in review and finding it later in the process

	Defects leaked from prev phase	New Defects Injected	Phase Yield	Defects Contained	Defects Leaked	Defect Removal Cost	Total Removal Cost (hrs)
Design	0.0	40	0%	0.0	40.0	n/a	0.00
Design Bench Check	40.0	0	0%	0.0	40.0	10 mins	0.00
Design Inspection	40.0	0	0%	0.0	40.0	30 mins	0.00
Code	40.0	60	0%	0.0	100.0	n/a	0.00
Code Bench Check	100.0	0	0%	0.0	100.0	5 mins	0.00
Compile	100.0	0	50%	50.0	50.0	1 min	0.83
Code Inspection	50.0	0	0%	0.0	50.0	15 mins	0.00
Unit Test	50.0	0	50%	25.0	25.0	15 mins	6.25
Integration Test	25.0	0	35%	8.8	16.3	18 hrs	157
System Test	16.3	0	35%	5.7	10.6	18 hrs	102
CUSTOMER	10.6						267

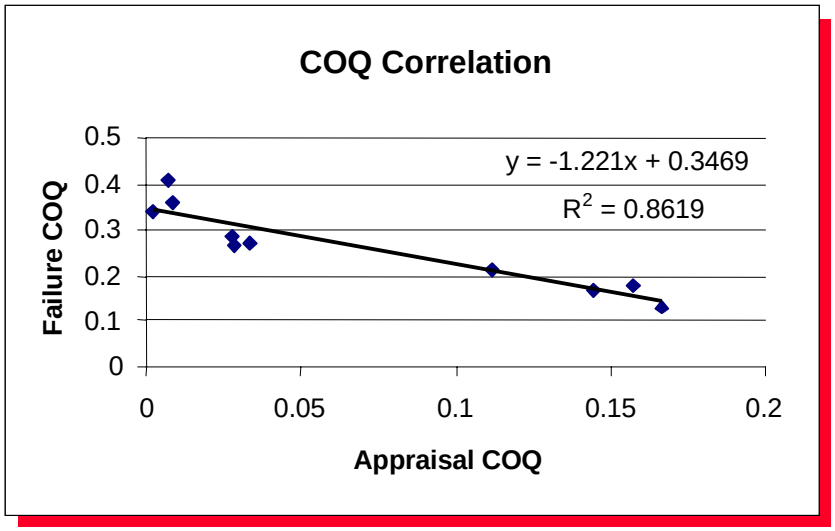
- Without inspections, the cost of defect removal is 267 hrs per KLOC

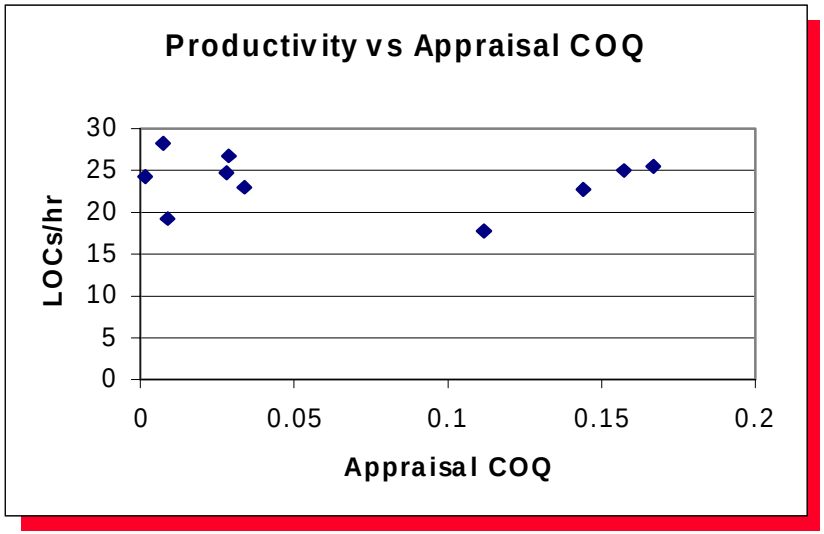
Calculating Return on Investment - 2

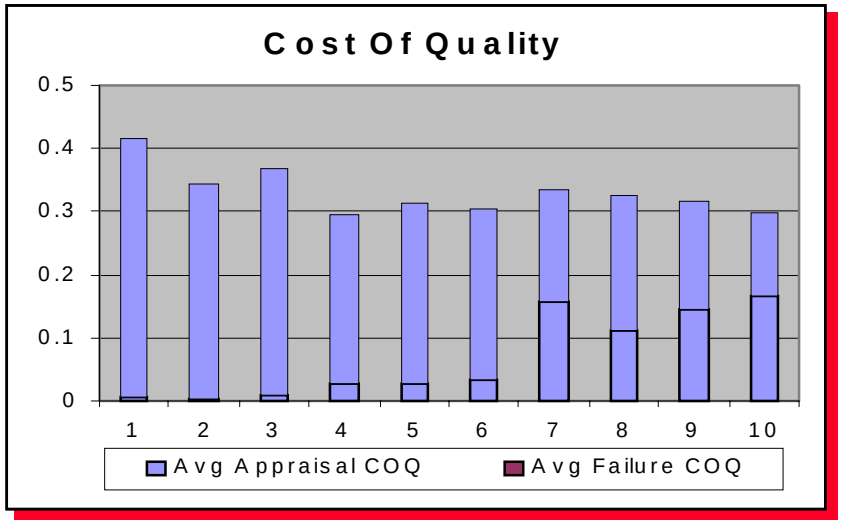
	Defects leaked from prev phase	New Defects Injected	Phase Yield	Defects Contained	Defects Leaked	Defect Removal Cost	Total Removal Cost (hrs)
Design	0.0	40	0%	0.0	40.0	n/a	0.00
Design Bench Check	40.0	0	50%	20.0	20.0	10 mins	3.33
Design Inspection	20.0	0	50%	10.0	10.0	30 mins	5.00
Code	10.0	60	0%	0.0	70.0	n/a	0.00
Code Bench Check	70.0	0	70%	49.0	21.0	5 mins	4.08
Compile	21.0	0	50%	10.5	10.5	1 min	0.18
Code Inspection	10.5	0	60%	6.3	4.2	15 mins	1.58
Unit Test	4.2	0	50%	2.1	2.1	15 mins	0.53
Integration Test	2.1	0	35%	0.7	1.4	18 hrs	13.23
System Test	1.4	0	35%	0.5	0.9	18 hrs	8.60
CUSTOMER	0.9						37

- With inspections, the cost of defect removal drops to 37 hours, a savings of 230 = 267 – 37 hours
- The cost of holding the inspections is about 40 hours (at 200 LOC/hr), so the net savings is 190 hours

Quality is Free

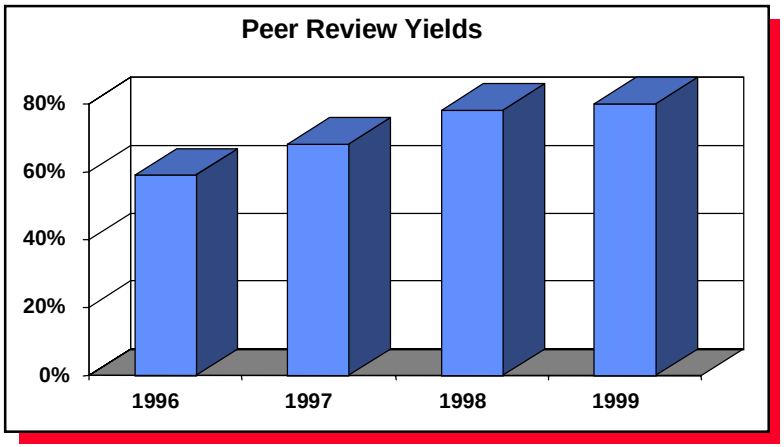


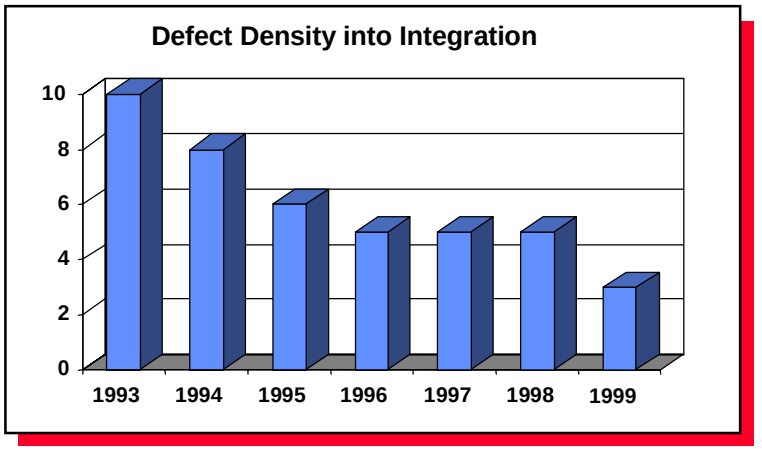




Results

- Over a period of 5 years, we gradually implemented the strategies described
- As Peer Review yields increased from 60% to 80% and we introduced personal reviews, defects into integration were reduced from 10/KLOC to 3/KLOC
- At the same time, cost of performing peer reviews decreased by 40% as we reduced the size of the inspection teams





The organization realized a net improvement of 190 hrs / KLOC!

Glossary of Terms

CMM®	**Capability Maturity Model**
COQ	**Cost Of Quality**
EV	**Earned Value**
KLOC	**Thousand Lines Of Code**
LOC	**Lines Of Code**
ROI	**Return On Analysis**
SEI	**Software Engineering Institute**
SPC	**Statistical Process Control**
SPI	**Software Process Improvement**

CMM® is registered in the U.S. Patent and Trademark Office.

References

- A more detailed introduction on using Six Sigma techniques to measure and control process variation was provided earlier at this conference in: *Six Sigma and Software Process Improvement*
- An explanation of how to use Six Sigma techniques in conjunction with Personal Software Process and Team Software Process is being presented later at this conference on *Wed, Nov 20 at 3:45* in: *Integrating PSP, TSP and Six Sigma*
- For additional information see our web site or to answer any questions contact:

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