Defect Escape Analysis: Test Process Improvement

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Definition of Escape

An escape is a defect that wasn't discovered by test teams. Instead, the defect was found by customers. When problems are exposed by customers, they are quite costly. The further back in the software development process that defects are uncovered, the less expensive they are. Much less money is spent overall when a problem is caught by the test team instead of by the customer. Furthermore, it is even less expensive when the development team catches a problem instead of the test team. Because of this, it is beneficial to analyze the escapes in order to determine why they escaped, prevent future escapes, and drive the defect discovery as far back into the software development process as possible. This will reduce costs and improve the quality of your software product.

Purpose

The purpose of Escape Analysis is to ensure that continual improvement is made on your software product and on your testing and development processes. This will be done through analyzing defects that have escaped development and test and making preventative plans to avoid future similar escapes. Continual improvement of the test processes will increase effectiveness of test environments and methods, decrease number of customer-found defects and therefore cost, and improve product quality, reputation, and sales. The more teams within the overall software development effort for your product that are involved in Escape Analysis, the more effective the Escape Analysis process will be. It will be most effective if development, as well as test, is closely involved.

This process focuses on high severity, prevalent, and costly problems. More specifically, the objectives of escape analysis are to:

-Separate escapes into useful categories for further, more in-depth analysis
-Run statistics on the categorized data
-Identify and implement overall process changes needed based on the statistics
-Identify and implement low-level (department-level) changes needed based on in-depth analysis of specific escapes
-Use metrics to demonstrate effectiveness of process changes

How To

The following steps should be followed to implement an Escape Analysis process. After becoming familiar with the steps, it should be decided how often the procedures will be performed. For the best results, you should follow a regular and consistent schedule. Once a month might be an appropriate timetable.

Planning

This process is designed to be most effective for a cross-functional team. If that is not possible, you can adapt the process to work within the boundaries of a test team.

This process is difficult to implement effectively if it is not given regular attention. For optimal results, there should be a specific number of people and a specific amount of time planned for Escape Analysis work. The effectiveness of the process is completely dependent on the manner in which it is implemented. Half-hearted attempts to apply the process will not bring about much improvement of your processes.

Before assigning escapes to categories, it might be helpful to choose only a subset of escapes for analysis. For instance, if your escapes had severity levels of one through four, four being the least severe, maybe it would be best only to analyze the severity one and two escapes. This will prevent you from doing needless work on defects that really don't matter too much to the customer. You also might want to wait to analyze only customer problems that have already been closed out and fixed. If they are analyzed before that, you might be missing some crucial information. It will also be helpful to eliminate defects that were cancelled, caused by user error, or duplicates. You only want to analyze valid defects that are truly an indication of a development or test process in need of improvement.

Categorize Escapes

The first step in Escape Analysis involves separating the escapes into useful and meaningful categories. Of course, a prerequisite is to obtain a list of escapes that includes as much detailed information as possible. It then must be decided what categories will be helpful in the analysis. Here are some examples:

- Process Step (where the escape should have been caught)
  - Development (Marketing Literature Review, Concept Review, Design Review, Code Review, Unit Test, Packaging, Information Development)
  - Test (Function Test Group, System Test Group, Translation Test Group, Device Driver Test Group, Installation Test Group, Performance Test Group, Error-Inject Test Group)
- Product Component (in which component of the code the defect occurred)
  - Component A, B, C, etc.
- Defect Impact (the impact experienced by the customer)
  - Crash, hang, data integrity, command failure, install failure, device/hardware, performance, documentation, usability, etc.
- Level Introduced
  - What version of the code the problem was introduced
- Platform
- Severity
- Release Discovered

The Process Step is the step in the product development process where a particular type of escape should have been caught. The purpose of creating a category like this would be to facilitate further low-level analysis within that process step. The Product Component is the component of code that the problem escaped from. The Defect Impact is the type of problem the escape caused for the customer. The Level Introduced is the version of code in which the defect was introduced. It should be the point at which the code was first 'broken.' The Platform is the platform or operating system on which the escape occurred. The Severity is the measurement of the degree of seriousness of the defect - for instance, critical, severe, wrong, or a nit. If this is not already a part of your defect logging process, then your Escape Analysis process should definitely assign a severity to each defect. The Release Discovered is the version of the software in which the escape was initially reported.

If you have been able to get development's buy-in for this process, it would be ideal to have representatives from development, test, support, and all other process steps that can be involved to meet regularly to categorize the most recent escapes. Support employees can be extremely helpful in providing more detail during discussion of the defects.

Your team may have need for other categories and may not need some of the suggested ones. It would be best to brainstorm with your team to determine which categories would be most useful.

Statistics are run on the output data from this categorizing for further high-level analysis. Each defect assigned to each process step is considered for low-level process changes in that process step.

Analysis - Tracking Tool

It would be very difficult to do Escape Analysis without some type of tracking tool. You should look for a tool that can keep totals for different categories. A good example of a tool is a Lotus Notes database. It is convenient to be able to slice the data in many different ways. Lotus Notes databases allow you to create different views on the same data, which will allow you to run many different statistics.

Analysis - Statistics

Statistics are used for analysis to make high-level process changes. It should be decided how often statistics will be performed. Once a quarter might be a good schedule for this. To perform statistics, you should compare the totals of each section within each category to the other sections in the same category. More statistics can be run on the sections with relatively high totals.

Analysis - High-level Process Changes

The escape analysis team should meet as often as the statistics are run, perhaps once a quarter, to specifically discuss the results. Based on the statistics, trends can be recognized and the team can begin to brainstorm ideas for high-level improvements within the overall development process. The group should then make formal recommendations for improvement in those areas and make plans for implementation of those recommendations. In subsequent meetings, the team should discuss the progress of the changes. Action items should be assigned and tracked in an escape analysis database or other tool of choice. An example of a high-level process change would be to add another test team, such as an error-inject test team if many of the defects seemed to occur in an environment where something had become corrupted. Another example of a high-level process change would be to improve the hardware acquisition process if there are many defects where the customer is using hardware that the test team doesn't have. These high-level changes would be vast in impact and would need management support and approval.

Analysis - Low-level Process Changes

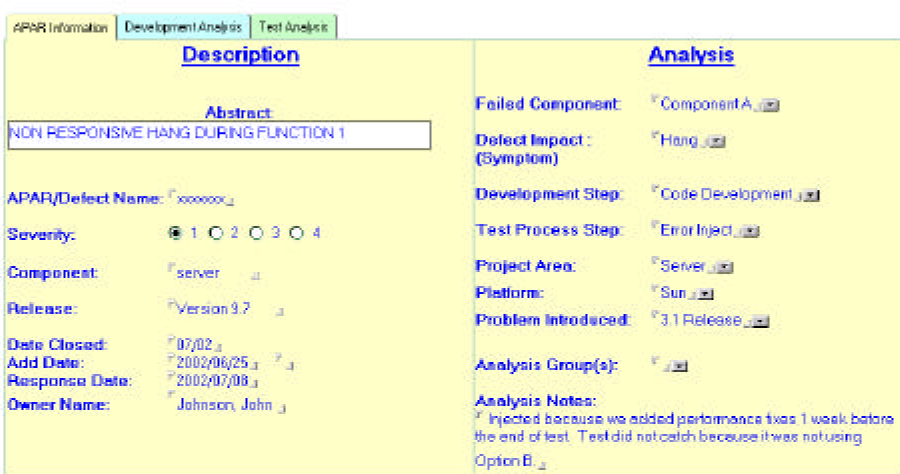
If working in a cross-functional team, a representative should be selected for each Process Step (i.e. Development, Test, Documentation, etc.) The escapes that have been categorized to each Process Step should be assigned to each representative for that area. For instance, an escape categorized to the Unit Test process step should be assigned to the Development representative for further low-level analysis. Each process area representative should take the list of escapes that were categorized to their area (listed in the Escape Analysis database) and come up with low-level improvements for their area. For instance, the Test representative could take the list of escapes that were categorized to Test, divide them up, and assign them to team members within Test to analyze. Those team members would then analyze the escapes and come up with an action plan to prevent that type of problem from "escaping" Test again. These action plans should then be completed, approved, and then implemented. This progress would be tracked in the database. Each action plan should be mapped to a single escape, and the Test representative should drive the completion, approval, and implementation of those action plans. It is important to note that these action plans are not created to fix a defect. Only escapes that have already been fixed should be analyzed. The action plans are simply to identify an improvement in the testing process (or development process, etc.). Based on the detailed information on the particular escape being analyzed, the action plan should identify how to avoid that *class* of problems from occurring in the future, not how to avoid that particular problem in the future (since it should already be fixed). An example would be to add a test case not previously considered. Another example would be to add a certain type of hardware to the test environment in an effort to more closely match what is common in a customer's environment. Creativity in the action plan development should be encouraged.

Metrics

The last step in the process of Escape Analysis is to periodically measure the improvements that have been made on your processes. This will be explained in detail later in this paper.

Examples

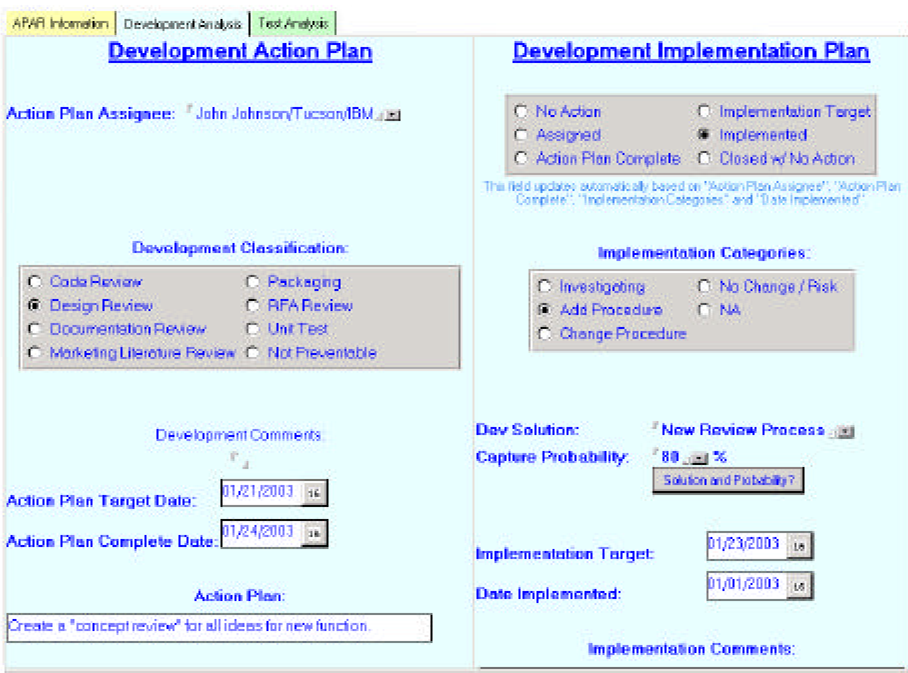
Figure 1



* APAR is a term to describe a field reported defect.

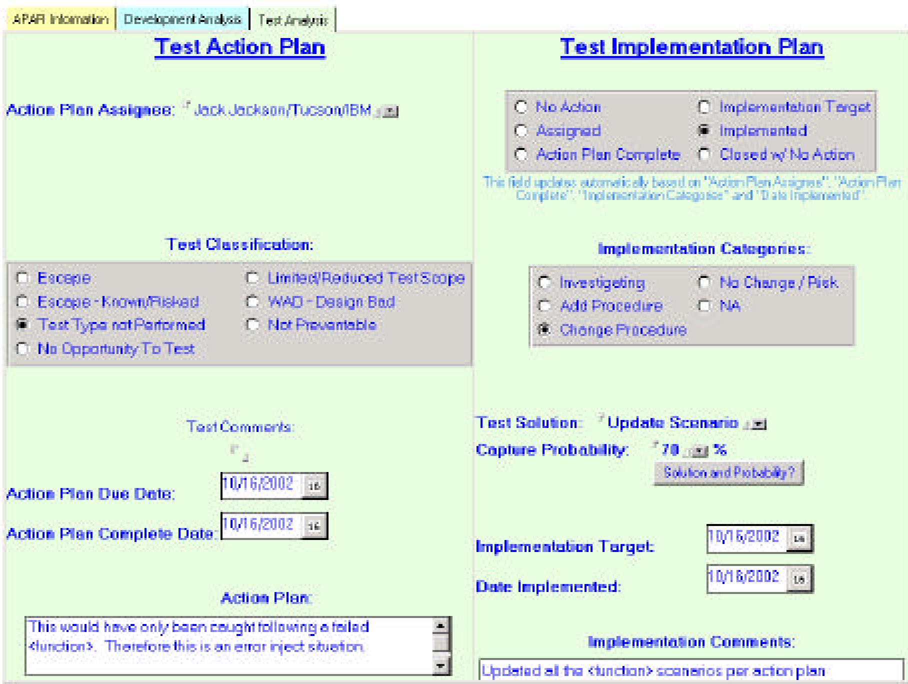
In Figure 1, a Lotus Notes database tool for a hypothetical product is demonstrated. There are three tabs to track data and analysis for a single escape. The first tab is for the detailed data about that escape. This data can come from the tool that tracks your defect information. It is best to automate the transport of this data into your Escape Analysis tool. Also, not shown in this screen shot is a large field that contains the details describing the history and summary of the defect.

Figure 2



In Figure 2, the Development Analysis tab is shown. Within development, there are different categories to which the escape can be classified. This particular example of an escape is classified as something that escaped the Design Review process. The example shows a procedure being added to create a "concept review" for all new functions for the product. The Capture Probability is designed to assess the effectiveness of the proposed change. It is a percentage that answers the question "what is the likelihood this defect would have been caught if the solution specified existed at the time the escape went through the development process?" This will be discussed later in the measurements section. This form also contains fields for the input of target completion dates of both the action plan development and the implementation of the action plan. In Lotus Notes, these fields can be set up to send reminder notes to the action plan assignee based on the target dates.

Figure 3



The Test Analysis tab example is displayed in Figure 3. The Test Classification field could be used to demonstrate whether or not the customer-reported defect was really an escape. In other words, it is important to identify whether there really is a hole in the test process or whether the defect was not worth the effort to find. It is important to keep in mind during Escape Analysis that some defects are just too expensive or obscure to catch. Some customers discover problems on environments that are uncommon or obsolete. It is then up to the Escape Analysis team to determine whether or not a change in the test process is needed. Perhaps the environment is uncommon, but the customer is an important customer and will always have that environment. It might be important to alter your test environment to accommodate that type of testing anyway, even if the setup is odd. In the example above, the defect was classified under the category “test type not performed” because it was an error inject situation. After running statistics on hundreds of escapes, if it is found that a large percentage are for a “test type not performed,” it may be that the test type needs to be added to the overall development process. The Capture Probability field is explained in the section above.

Measurements

Included here are several different suggestions for measurements. First, there are ideas for measurements that can guide the Escape Analysis team to develop appropriate action plans for needed improvements. Next, there are methods for measuring the effectiveness of your Escape Analysis process It might be helpful to use one of them, all of them, or to build upon the ideas to create your own measurements.

Measurements to Drive Action

Compare the totals within each category from the previously categorized data and create charts to reflect the comparisons. Below are some examples of this.

Figure 4 shows the percentage of total escapes that comes from each component of code (components A-Z). The chart makes it clear that over 50% of the escapes came from four components (B, C, D, and E). This measurement can help the team discover that actions need to be taken to improve the development of these four components.

Figure 4

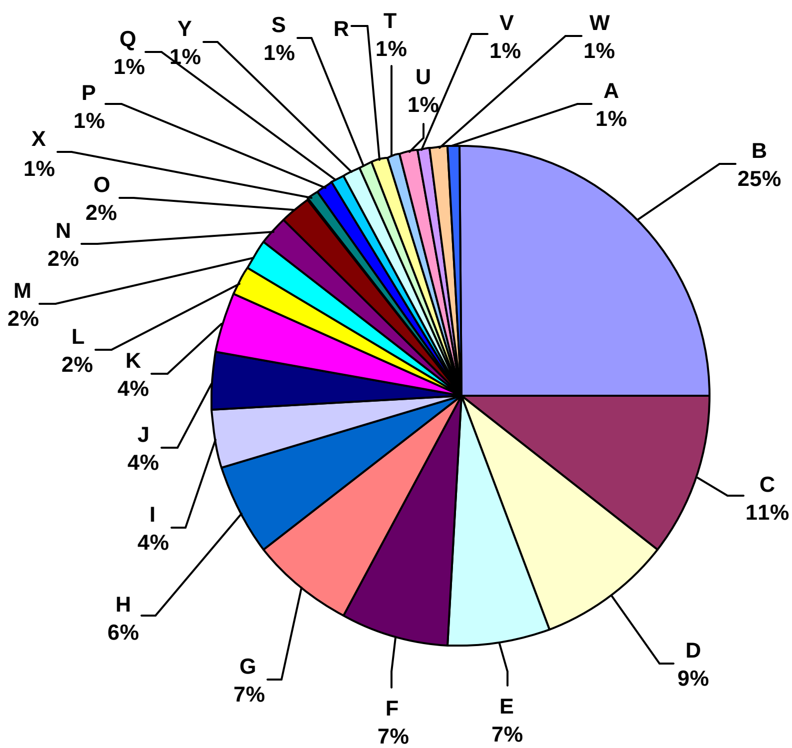


Figure 5

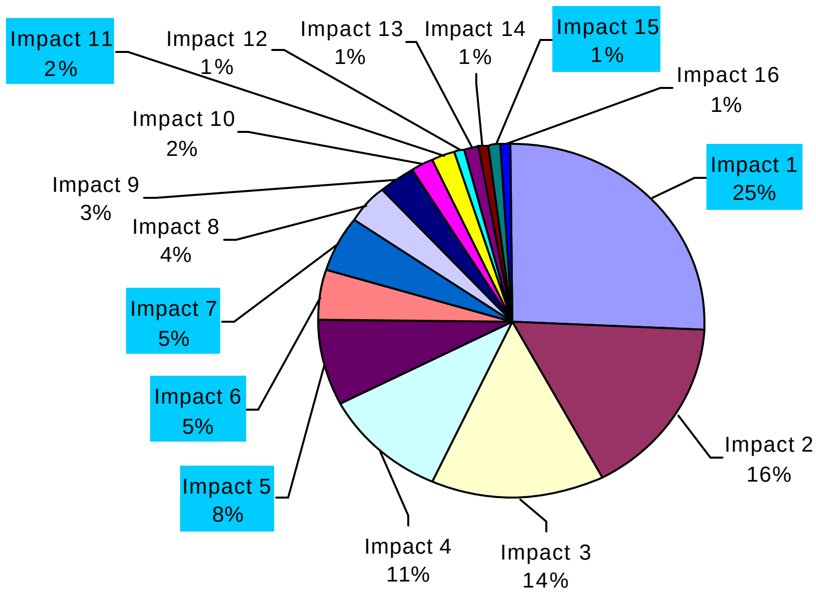


Figure 5 shows the analysis of different types of impacts to customers, such as hangs, crashes or device related problems. For instance, if "Impact 1" were device related problems, then the necessary action would probably be to improve the hardware that your software is tested on. Also, if the impacts in the blue squares were highly severe impact types, it would be helpful to see that less than half the escapes are highly severe impact types.

There are many other charts that could be created, based on the example database tool. The two illustrated above are just highlights of what could be done.

Measuring Escape Analysis Effectiveness

Accurate data and consistent reporting are necessary to measure improvement effectively.

TFVUD is the Total Field Valid Unique Defects. In other words, TFVUD is all of the defects found by customers that were not cancelled, duplicates, user errors, or suggestions. You probably only want to use defects that have been closed out or fixed for this measurement. Post Development Defects (PDD) is the defects found in the test cycle and after development is complete, but not including those found after release to the field. KLOC stands for thousands of lines of code.

A. TFVUD

KLOC changed & new

This value should go down over time, as one release is compared to another release at the same time checkpoint. For instance, the value measured one quarter after release 2.0 should be lower than the value measured one quarter after release 1.0. The purpose of this measurement is to reduce the number of valid problems found by customers relative to the size of the code.

B. PDD

PDD + TFVUD

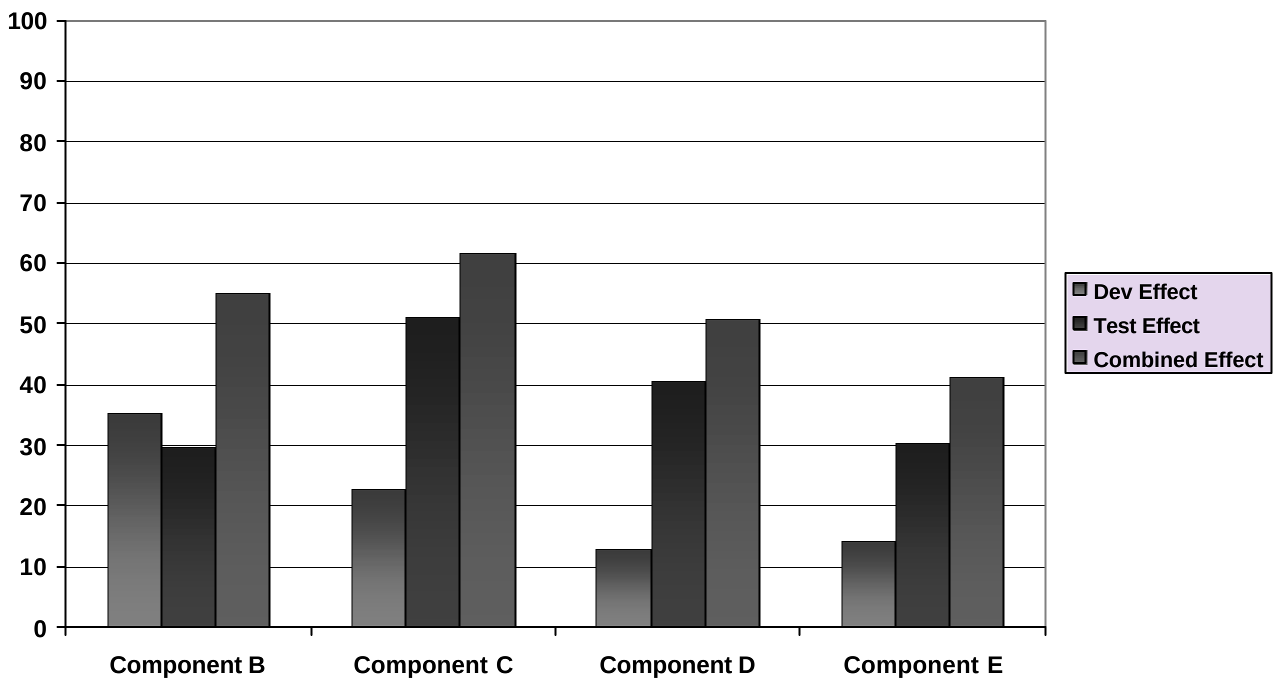
$$\frac{PDD}{PDD + TFVUD}$$

This value should go up over time, as one release is compared to another release at the same time checkpoint. For instance, the value measured one quarter after release 2.0 should be higher than the value measured one quarter after release 1.0. The purpose of this measurement is to drive the discovery of defects back earlier into the process, and to incur the least amount of cost.

C. Capture Probability

For this measurement, use a field in the database tool called "Capture Probability" (as explained in detail in the Examples section). This would be an estimate of how effective the process change would be in preventing that type of problem from escaping again. While only an estimate, this can be a good foundation for projecting effectiveness. The Capture Probabilities can be totaled and averaged to determine an overall projected effectiveness for a given product component, impact, etc. As a result, it is possible to project an estimate of reduced field problems.

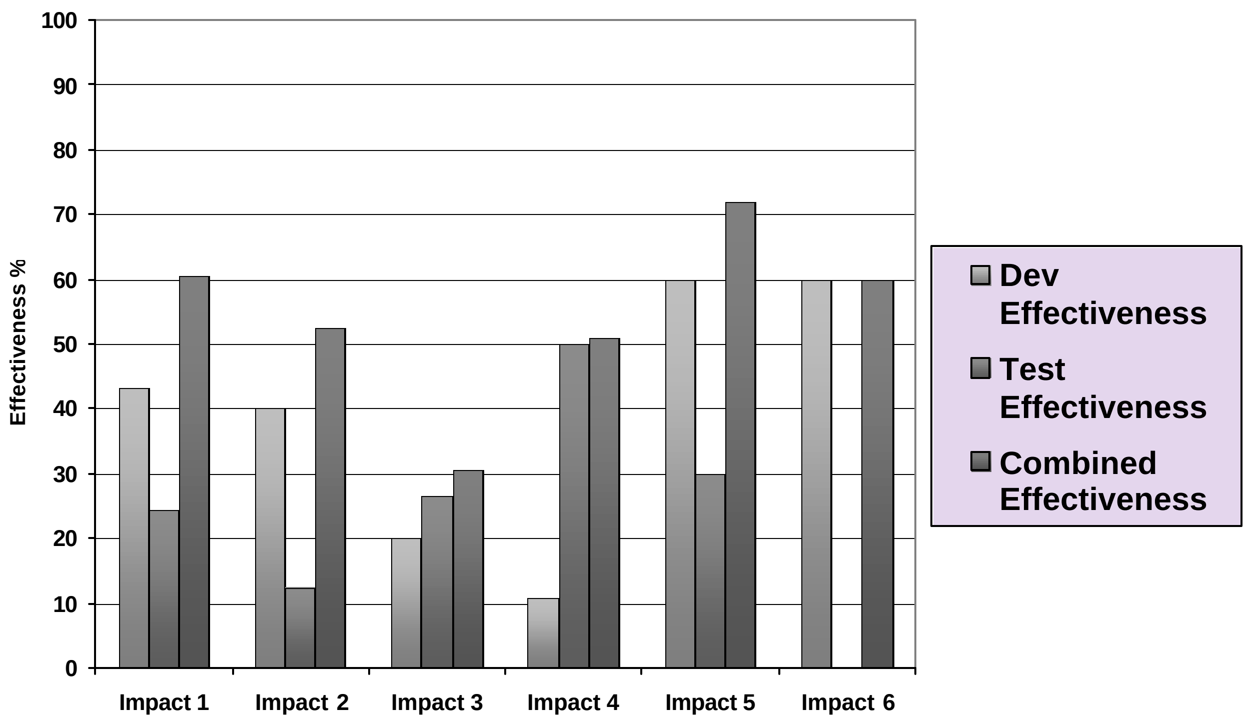
Figure 6



Example: For Component B, Development's Capture Probability or Estimated Effectiveness (as illustrated in Figure 6) was 35%. Test's Estimated Effectiveness for Component B was 30%. So if Development has 100 defects in their code, they would have caught 35 of them with that estimated effectiveness. This leaves 65 defects for test to work with. If test caught 30% of those 65, or 19.5 defects, then the total amount of defects caught would be 35 + 19.5, which is about

55 APARs or 55% of the original 100. This 55% is what we call the Combined Effectiveness. The equation for Combined Effectiveness as demonstrated above is (.35) + (1-.35)(.30) or D + (1-D)(T) where D is Development's Estimated Effectiveness and T is Test's Estimated Effectiveness. This example was based on the code components, though this measurement can be run on other categories, as demonstrated in Figure 7.

Figure 7



The last step is to project the amount by which the valid customer defects can be reduced. This is done by totaling and averaging the Combined Effectiveness values. First, select a group of escapes that will be the focus group for Projected Effectiveness. In this example, the focus group will consist of 76 escapes. If the Combined Effectiveness values for those 76 defects were totaled and averaged for the example above, the result would be 52.5% effectiveness for those 76 defects. This translates to 40 escapes that would be prevented. Now, suppose there were 250 escapes for a given time period such as a year. Assuming the 52.5% is an accurate projection, it is then true that 40 out of those 250 escapes, or 16% would be prevented. This is the final projection for the reduction in escapes for the next software release. And this is only the minimum, because we are assuming that the types of implementations made for the focus group escapes might not help other types of future problems. If we did not make that assumption, then the projected reduction in escapes would be a straight 52.5% which is probably not realistic.

Results

The key purpose in Escape Analysis is to improve product quality and customer satisfaction, and to lower costs spent on resolving customer-found defects. This is done by driving the defect discovery as far back into the software development process as possible. A software test team that implements this Escape Analysis process will benefit over other software development companies in many ways. Their test processes will become more sophisticated and their test environments will more closely match the customers' actual environments. The data collected from the analysis will provide accurate justification for spending on improvements such as additional hardware. The implementation of this process will demonstrate continual improvement during ISO audits. In addition, the process will foster inter-team communication, cooperation, and productivity to create the highest quality software product. It also adds value in being able to project the amount of customer-found defects in the future. Finally, this process is self-evaluating in that it is able to measure its own effectiveness and justify the resources spent on it.