We cover all **boundaries** of your software™

Traditional Software Testing is Costly

Software is an inherent part of many products, and its ever-growing complexity is increasing the cost of product development. Although testing is often estimated to be the biggest cost in any product development, it routinely fails to identify significant software defects before product release. The National Institute of Standards and Technology estimates the national cost of these defects at over $59 billion. Software testing and verification in many organizations is a manual process, relying on testers' experience and judgment to find problems hidden throughout the system. The complexity of today's software virtually guarantees defects will go undetected by these manual analyses and testing techniques. Although the worldwide market for software testing tools is projected to grow to more than $2.6 billion by 2004, most testing tools merely automate existing manual procedures.

A Comprehensive Approach

RAVE™ is a proven method and integrated toolset for requirement-based defect prevention and automated testing. It includes the T-VEC Tabular Modeler for requirements capture, management, and automated analysis to identify problems before they impact the software. The Tabular Modeler is integrated with T-VEC's model-based functional test generation system that automates the most expensive and error-prone testing activities. The result: on-time, under-budget, zero-defect software deliveries.

T-VEC Significant Benefits

T-VEC customers have reported savings between 40% and 60% of their development budgets while reducing test schedule by up to 90%. T-VEC tools and methods help product development teams incorporate requirement modeling, model analysis, and automated testing to eliminate labor-intensive, manual processes that cannot find bugs in complex systems.

RAVE™ Solutions:

- Identify requirement defects early to reduce expensive rework
- Systematically generate comprehensive tests from requirements
- Verify full test coverage, with at least one test per requirement
- Generate test drivers for any platform
- Provide full requirement-to-test traceability
- Generate measurement and status reports for tracking project status
- Promote early interface definition to stabilize system architecture

The Benefits:

- Considerable competitive advantages from reduced schedule and costs
- Increased quality and reliability
- Reduced risk to budgets and schedules
- Measurable project status, defects, and test coverage
- Testable requirements
- Reduced evolution and maintenance costs

The technology underlying T-VEC tools provides capabilities beyond other automated software testing tools. T-VEC developed and improved these tools for more than a decade to meet the needs of complex, mission-critical aircraft software systems. Although the roots of the technology were developed to meet the needs of ultra high assurance systems, T-VEC tools improve software quality in any industry's products including medical devices, communication systems, information systems and others.

About half of all test failures are related to requirement defects - this results in unnecessary and costly rework.

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Better Requirements

Quality software depends on consistent, precise requirements. RAVE™ includes the T-VEC Tabular Modeler (TTM) to record and manage requirements throughout the development process, giving teams a source for reference and ability to modify requirements in response to program changes. Users record requirements using TTM's graphical interface, building a model of what each product-component should do. This provides a disciplined approach to requirements definition and management.

Fewer Defects Reduce Cost and Rework

Poor requirements typically account for about half of all defects. These defects result in costly rework and schedule overruns. RAVE™ helps develop defect-free requirements through the TTM requirement-modeling tool, which combined with our method provides a way to refine, capture, and manage requirements. The RAVE™ tools identify errors in the requirements, such as inconsistencies and contradictions. Iterative requirement modeling with automated analysis produces a set of precise, consistent, and testable requirements. Removing requirement defects early in the process prevents them from flowing to design and coding activities where they can cost up to 100 times more to correct.

Better Tests Find Hidden Bugs

Comprehensive testing of even simple programs requires essentially infinite test combinations, exceeding the capabilities of any human or computer. To make the task manageable, T-VEC's Test Vector Generation System produces test vectors that guarantee a measurable and predictable level of coverage. Each test vector contains a set of inputs and expected outputs, along with a link to the requirement associated with the test. T-VEC uses algorithms based on domain testing to generate the optimal number of test vectors to systematically test each requirement. Empirical studies demonstrate these algorithms, which assume program flaws are located near program boundaries, are most effective for selecting tests that reveal both decision and computation defects.

Test case design is the most labor-intensive, and time-consuming testing activity contributing 60% of all test effort.

Test Driver Generation Reduces Manual Effort

Software development organizations currently spend significant effort manually creating and debugging test drivers (scripts). T-VEC's test driver generator provides a mechanism to easily map test vectors to a target implementation and test environment. A generic template is defined for each test environment and shared by all test engineers. If the test environment changes, the generic test driver template is updated. The test drivers are regenerated and re-executed to ensure the updated system operates correctly. Similarly when requirements change, the requirements models are updated and the tests and test drivers are regenerated. This simplifies program evolution, maintenance, and regression testing.
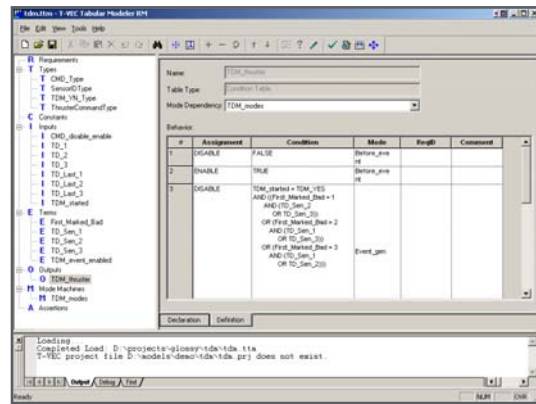
T-VEC Tabular Modeler (TTM) captures and manages precisely defined requirements that are then used to automatically generate tests.
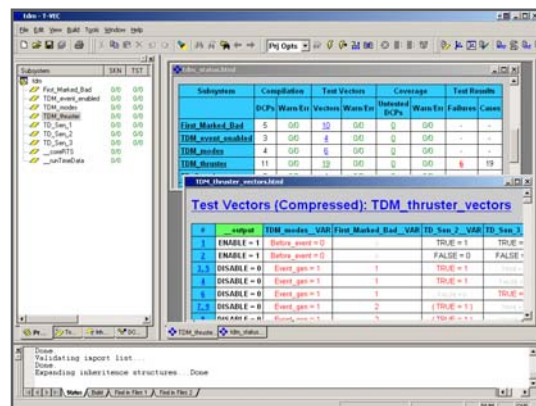
T-VEC Graphical Environment provides an interface to generate and view test vectors, test drivers, reports and status.

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Comprehensive Reports Improve Decision Making

T-VEC provides managers and developers with reports on project status and performance. Some report types include:

- Project Status
  - ⌄ Total number of test failures
  - ⌄ Total number of requirements
  - ⌄ Matrix of status on each requirement
- Requirement Status
  - ⌄ Number of requirements
  - ⌄ Number of test vectors
  - ⌄ Number of requirement defects
  - ⌄ Number of test failures and test cases
- Test vectors
- Requirement test coverage
- Requirement defects
- Test generation warnings
- Test results

Testing Throughout Development

A continuous approach to verification and validation reduces the frenzy of testing and rework that typically occurs near release deadlines. Test engineers are involved early in the process to refine and model the requirements. These activities identify errors before they impact the system. As the system is developed, test engineers create and refine the mappings for transforming test vectors into test drivers. When the system becomes available for testing, the engineers are well-prepared to complete the process quickly. T-VEC provides services to help organizations tailor their processes to this approach.

T-VEC tools and methods help product development teams incorporate requirement modeling, model analysis, and automated testing to eliminate labor-intensive, manual processes that cannot find bugs in complex systems. T-VEC customers have reported savings of between 40% and 60% of their development budgets while reducing test schedules by up to 90%.

T-VEC reports are generated in standard HTML format, allowing managers and developers to review project information with standard web browsers. The Project Status report allows managers to see the total number of requirements, requirement defects, test vectors, and test failures. Users can quickly navigate to areas of program risk highlighted in red.

T-VEC Solutions in Action

NASA started the Mars Polar Lander (MPL) project on February 7, 1994. On December 3, 1999, after the MPL had traveled 11 months and over 35 million miles, all contact with the craft was lost just 12 minutes from its scheduled landing on Mars. The MPL cost $165 million to develop and deploy. Could the crash have been prevented? Maybe. In fewer than 24

hours, the T-VEC RAVE™ tools identified an error in the software controlling the MPL's landing procedures. This software monitored the touchdown legs of the craft and controlled the engine. It is believed this software falsely indicated the MPL had landed, while it was still 40 meters above Mar's surface. Consequently, the engine was shut down prematurely, and the craft crashed. This defect could have been identified and fixed with the RAVE™ tools, if the requirements for the landing features of the MPL had been modeled and tested early in the process.

Features	Benefits
Requirement modeling	Produces testable requirements Captures undocumented requirements Builds repository of domain knowledge
Requirement management	Measurable level of requirement compliance Indicates impact of requirement changes
Detection of requirement defects	Defects corrected early Reduces rework Shorter, more predictable development schedule
Automatic test vector generation	Reduces test design effort (up to 90%) Produces complete and systematic test coverage without redundancies Traceability from test cases to requirements Supports requirement validation Eases impact of requirement changes
Automatic test driver generation	Reduces manual effort of developing and debugging test drivers Simplifies regression testing Applicable to any language, test environment, and platform
Modular requirements	Reusablity of common requirement models Supports concurrent development and verification Drives early stabilization of component interfaces
Advanced test generation support	Scales to complex systems Applicable to all domains Supports system, software integration, and unit testing Supports all common data types, including user-defined types
Measures and status reports	Allows management to track progress Identifies risk areas associated with requirement defects and test failures
Proven on systems meeting Federal Aviation Administration RTCA DO-178B specification	Meets the rigorous criteria for certification of mission critical and high assurance systems

1. Capture, Model and Manage Requirements
from textual or undocumented requirements and create links to associated documents.

2. Analyze Requirements for Defects
to locate model errors, such as logical inconsistencies or contradictions,which cannot be found effectively through manual inspections.

3. Generate Test Vectors
to automate test case design, which determines inputs and expected outputs for each required function. Automation virtually eliminates this manual and error prone activity.

4. Generate Test Drivers
to produce bug-free drivers at a fraction of the cost and time for any language and test environment.

(1-4) Generate Project Measurement and Status Reports
to track requirement modeling, requirement defects, test coverage, test failures, and overall test completion status.

Minimum System Requirements
‣ IBM PC or 100% compatible
‣ Microsoft Windows NT 4.0 SP3, 2000, XP

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