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SOFTWARE VERIFICATION AND VALIDATION METHODS AND TOOLS

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REWIS PROJECT

REVVIS – Reunião de Especialistas em Verificação e Validação de Software
Working Group - Benchmarking de métodos e ferramentas de V&V de software

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SUMMARY

LIST OF TABLES

1. Introduction

According to the Institute of Electrical and Electronics Engineers (IEEE),

> **verification** is (A) the process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase. (B) The process of providing objective evidence that the software and its associated products conform to requirements (e.g., for correctness, completeness, consistency, accuracy) for all life cycle activities during each life cycle process (acquisition, supply, development, operation, and maintenance); satisfy standards, practices, and conventions during life cycle processes; and successfully complete each life cycle activity and satisfy all the criteria for initiating succeeding life cycle activities (e.g., building the software correctly).

> **validation** is (A) the process of evaluating a system or component during or at the end of the development process to determine whether it satisfies specified requirements. (B) The process of providing evidence that the software and its associated products satisfy system requirements allocated to software at the end of each life cycle activity, solve the right problem (e.g., correctly model physical laws, implement business rules, use the proper system assumptions), and satisfy intended use and user needs. (IEEE-1012, 2005).

Software verification and validation (V&V) aid in determining that the software requirements are implemented correctly and completely and are traceable to system requirements, throughout the software lifecycle. It helps to ensure that the software requirements and the systems requirements are correct, complete, accurate and testable (IEEE-1012, 2005).

Software V&V includes assessment, evaluation, review, inspection, analysis and testing of software products and processes. Software V&V is performed in parallel with software development, not at the conclusion of the development effort, so different techniques, methods and tools are applied to each development phase.

1.1 Document Scope

This document presents a survey of methods and tools, currently used for software verification and validation. The methods and tools are organized according to the following phases of the software development lifecycle: *requirements*, *design*, *code* (or implementation) and *test*. Qualification, operation and maintenance phases are not covered here.

Concepts and tools descriptions were obtained from Wikipedia – The Free Encyclopaedia, available in: http://en.wikipedia.com; access in: February 2008. Particularly on Formal Methods, more information may be found in Centre for Applied Formal Methods (CAFM), available in: http://www.cafm.lsbu.ac.uk/ access in: 20 December 2007; and **Formal Methods** available in: http://vl.fmnet.info/, ftp://ftp.cordis.europa.eu/pub/ist/docs/summary05.pdf, access in: 20 December 2007, (Formal Methods). Taxonomy for Software Engineering is referred in (IEEE,1987).

This report is produced in the scope of the project named "REUNIÃO DE ESPECIALISTAS EM VERIFICAÇÃO E VALIDAÇÃO DE SOFTWARE" – REVVIS (Acción 507AC0326 – 2007- 2010 - CYTED) http://revvis.dei.uc.pt.

1.2 Document Structure

This document is organized as follows:

Section 1, this section, briefly introduces the document.

Section 2, Requirements Analysis, presents some of the methods and tools applicable to requirements analysis.

Section 3, Design Analysis, presents a survey of methods and tools that are suitable for the software *design* phase.

Section 4, Code Analysis, presents a survey of methods and tools suitable for the *code* analysis phases.

Section 5, Testing Activities, presents a survey of methods and tools suitable for the *testing* phases.

Section 6, presents a list of applicable references for this document.

1.3 Definitions and acronyms

B	The B method (Formal Methods)
CCS	Calculus of Communicating Systems (Formal Methods)
CSP	Communicating Sequential Processes (Formal Methods)
CSW	Critical Software, S.A.
FDIR	Failure Detection Isolation and Recovery
FMECA	Failure Mode Effects and Criticality Analysis
FSM	Finite State Machines
FTA	Fault Tree Analysis
HOOD	Hierarchical Object Oriented Design
HRT-HOOD	Hard Real-Time HOOD
HSIA	Hardware Software Interaction Analysis
HW	Hardware
ISVV	Independent Software Verification and Validation
LOTOS	Language Of Temporal Ordering Specifications (Formal Methods)
PN	Petri Nets (Formal Methods)
RAISE	Rigorous Approach for Industrial Software Engineering (Formal Methods)

SDL	Specification Description Language (Formal Methods)	
SFMECA	Software Failure Mode Effects and Criticality Analysis	
SFTA	Software Fault Tree Analysis	
SN	Study Note	
SW	Software	
UML	Unified Modelling Language	
VDM	Vienna Development Model (Formal Methods)	
WCET	Worst Case Execution Time	
Z	The Z method or, the Z Notation (Formal Methods)	

2. Requirements Analysis

2.1 Requirements Analysis Methods

This section presents a survey of methods and techniques that are suitable for the Requirements phase. The survey is presented in Table 1. Each method/technique is accompanied by a brief description.

Table 1 - Methods & Techniques for Requirements Analysis

Method / Technique	Brief description	References
Checklist	Checklists from various sources namely the ones provided with some standards.	N/A
Functional analysis	The analysis of system specifications (or business specifications) into the hierarchical structure of functions, activities and transactions for the system. Functional Analysis is described in the ESA ECSS standard ECSS-E-10-05A.	(ECSS, 1999)

Table 1 - Conclusion

Traceability analysis	The traceability analysis method consists of tracing (finding the correspondence of) specific items of one lifecycle phase to items of another lifecycle phase. Typically items are traced across adjacent lifecycle phases and the traceability can be done from inputs to the outputs (forward traceability) or from outputs to the inputs (backwards traceability). The main purpose of traceability analysis is to check the consistency and completeness of the items being reviewed.	http://www.traceability center.org
Modelling	Modeling consists on the elaboration of a model of the system using a modeling tool and/or language (e.g. UML, SDL, AADL, etc.). The primary target of this method is to help on the understanding of the system. Modeling can be used to cover a broad range of activities or tasks such as, data flow analysis, control flow analysis, state machine diagrams, etc. The method may be applied to all or specific parts of the system under verification.	http://en.wikipedia.org/wiki/Domain-specific_modelling http://en.wikipedia.org/wiki/General-purpose_modeling http://en.wikipedia.org/wiki/Modeling_languages
Requirements Verification	A process for assuring that the set of requirements is complete, correct, verifiable and traceable.	N/A

The list of methods and techniques shown in this section does not meant to be exhaustive nor complete. More information about this subject may be found in (Boehn, 1981). Safety and critical software is treated by Headquarters Air Force Inspection and Safety Center (AFISC, 1985).

2.2 Requirements Analysis Tools

This section presents a survey of tools that are suitable for the Design phase. The survey is presented in Table 2. Each tool is accompanied by a brief description.

Table 2 - Tools for Requirements Analysis

Tool	Brief description	References
DOORS - Telelogic	Telelogic DOORS®, the market- and technology-leading family of solutions for requirements definition and requirements management, improves quality by optimizing communication and collaboration, and by promoting compliance and verification through the following capabilities: • Intuitive interfaces that encourage all stakeholders, including business users, to actively participate in the requirements process • Scalability for any project, regardless of size or number of users • A flexible, up-to-date, easy-to-use requirements traceability matrix • The most comprehensive support for recording, structuring, managing, and analyzing requirements and their traceability • Unparalleled integration with Telelogic's other solutions and third-party tools to increase requirements visibility and to drive their traceability throughout the development lifecycle	http://www.telelogic.com/products/doors/index.cfm
Entreprise Architect	Enterprise Architect is a UML analysis and design tool. It supports generation and reverse engineering of Java, C#, C++, VB.Net, Delphi, Visual Basic and PHP source code.	Sparx Systems http://www.sparxsystems.com.au/ea.htm

Table 2 - Continuation

Statemate - Telelogic	Telelogic Statemate® is a graphical design, simulation and prototyping tool for the rapid development of complex embedded systems. It enables engineers to graphically capture their system requirements, specifications, and designs using a combination of the Unified Modeling Language and traditional functional design notations. The graphical models captured in Statemate are simulated on the host computer allowing errors in the requirements and specifications to be discovered early in the process when they are inexpensive to fix. Statemate automatically generates documentation, prototype code, and test vectors, and enables corporate re-use of key systems components. Built on an open API that enables seamless integration with leading requirements traceability and configuration management tools. Statemate has emerged as the standard for complex embedded system.	http://www.telelogic.com/products/statemate/index.cfm
Rhapsody	Rhapsody is one of the industry's leading Model-Driven Development environment based on UML 2.1 and OMG SysML™ 1.0 to address the needs of systems engineers. Rhapsody is a Model-Driven Development (MDD) environment for systems and software development of real-time and embedded applications. With its powerful requirements management and industry standard notations to capture the design supported out of the box make it a first class solution for the systems engineering community. Model-Driven Development (MDD) technology enables users to achieve unparalleled gains in productivity over traditional document driven approaches by enabling users to specify the system design and architecture graphically, simulate and automatically validate the system as ii is being you built, and ultimately produce a quality systems specification that users can be sure is correct, non-ambiguous and completely satisfies original requirements.	http://modeling.telelogic.com/products/rhapsody/index.cfm

Table 2 - Conclusion

| MagicDraw | MagicDraw is a visual UML modelling and CASE tool with teamwork support. Designed for Business Analysts, Software Analysts, Programmers, QA Engineers, and Documentation Writers, this dynamic and versatile development tool facilitates analysis and design of Object Oriented (OO) systems and databases. It provides one of the industry's best code engineering mechanism (with full round-trip support for J2EE, C#, C++, CORBA IDL programming languages, .NET, XML Schema, WSDL), as well as database schema modelling, DDL generation and reverse engineering facilities. | http://www.magicdraw.com/ |

The list of tools shown in this section does not meant to be exhaustive nor complete.

3. Design Analysis

3.1 Design Analysis Methods

This section presents a survey of methods and techniques that are suitable for the Design phase. The survey is presented in Table 3 - Methods & Techniques for Design Analysis. Each method/technique is accompanied by a brief description.

Table 3 - Methods & Techniques for Design Analysis

Method / Technique	Brief description	References
Checklist	Checklists from various sources namely the ones provided with some standards (e.g. HSIA).	N/A
Concurrent Behaviour Analysis: LOTOS, CCS, CSP, SDL, FSM, Petri, Nets.	Mathematical models that can be used to design and analyse the behaviour of concurrent systems (Formal Methods) (CAFM).	(ESA, 2000) (Leveson and Stolzy, 1987)

Continue

Table 3 - Continuation

HSIA – Hardware Software Interaction Analysis	The HSIA method is defined in ESA standard ECSS-Q-80-03. It consists of the systematic analysis of the HW/SW interfaces, with particular focus on the hardware faulty conditions and the handling of those faulty conditions by the SW.	(ESA, 2000) (ECSS, 2006) (Esteves et al., 2004)
Inspection	An activity such as measuring, examining, testing or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformity is achieved for each characteristic [ISO 8402:1994].	(ESA, 2000)
Modelling	Modeling consists on the elaboration of a model of the system using a modeling tool and/or language (e.g. UML, SDL, etc.). The primary target of this method is to help on the understanding of the system. Modeling can be used to cover a broad range of activities or tasks such as, data flow analysis, control flow analysis, state machine diagrams, etc. The method may be applied to all or specific parts of the system under verification.	http://en.wikipedia.org/wiki/Domain-specific_modelling http://en.wikipedia.org/wiki/General-purpose_modeling http://en.wikipedia.org/wiki/Modeling_languages
SCCFA/SCMFA – Software Common Cause/Mode Failure Analysis	SCCFA/SCMFA aims at identifying potential failure in redundant components, which would undermine the benefits of redundancy because of the appearance of the same failures in the redundant parts at the same time.	ESA, 2000)

Schedulability Analysis	Schedulability Analysis aims at determining whether a specific software system is schedulable or not. In other words, to check whether the software system accomplishes the deadlines it was designed for (does each function executes within the required time limit). Schedulability verification is performed by executing the scheduling algorithm (e.g. Rate Monotonic Scheduling) with the given tasks WCETs[1].	(ESA, 2000) (Audsley et al.,1991)
Sequential Behaviour Analysis: B, Z, RAISE, VDM	Algebraic models that can be used to analyze the sequential behaviour of a software program (CAFM).	(ESA, 2000) (Formal Methods, 2005)
SFMECA – Software Failure Modes, Effects and Criticality Analysis	The software failure modes effects analysis SFMEA is an iterative method, intended to analyse the effects and criticality of failure modes of the software within a system. Software Failure Modes Effects and Criticality Analysis (SFMECA) extends SFMEA by assigning a criticality level to each component failure. SFMECA uses intuitive reasoning and consists of five steps: (1) failure modes identification – and then for each failure mode – (2) analysis of local effects, (3) analysis of possible propagation at upper level, (4) assessment of the criticality related to the impact of the failure and (5) issuing of recommendations to reduce the probability of occurrence.	(ESA, 2000) (ECSS,2006)

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[1] At the design phase tasks WCETs are estimated values. Those values need then to be confirmed during and after coding.

Table 3 - Conclusion

SFTA – Software Fault Tree Analysis	Top-down fault/failure analysis that uses Boolean Logic to describe the combinations of individual software faults that can lead to a hazardous event. The SFTA application consists of three basis steps: (1) identification of top level feared events, (2) recursive identification of intermediate events down to the identification of basic events and (3) documentation of the analysis showing the dependencies between the top-level, intermediate and basic events.	(ESA, 2000) (ECSS, 2006)
Simulation (Design execution)	Simulation consists in exercising parts or the overall system in order check is behavioural characteristics and to inquire its feasibility, accuracy, etc. This method implies the elaboration of a model of the system and the environment it interacts with.	N/A
Traceability Analysis	The traceability analysis method consists of tracing (finding the correspondence of) specific items of one lifecycle phase to items of another lifecycle phase. Typically items are traced across adjacent lifecycle phases and the traceability can be done from inputs to the outputs (forward traceability) or from outputs to the inputs (backwards traceability). The main purpose of traceability analysis is to check the consistency and completeness of the items being reviewed.	http://www.traceabilitycenter.org
Walkthrough	A minimalist inspection of a work product (requirements, designs or code). Instead of a full inspection (or full reading) one walks through the items under review only stopping whenever some of the reviewers has some comment or consideration to made.	(ESA, 2000)

The list of methods and techniques shown in this section does not meant to be exhaustive nor complete. Other methods and techniques may be identified for Design Analysis, but those in Table 3 - Methods & Techniques for Design Analysis are in principle the most commonly known and used. More information related to design of hard-real time systems may be found in (British Aerospace and University of York, 1991).

Both Inspection and Walkthrough are built on the review technique. Modelling and Simulation methods are very general, and can also serve as the basis to implement other methods and techniques, such as Sequential Behaviour Analysis, Concurrent Behaviour Analysis, Sizing & Timing Analysis, or Stochastic Analysis.

3.2 Design Analysis Tools

This section presents a survey of tools that are suitable for the Design phase. The survey is presented in Table 4 - Tools for Design Analysis. Each tool is accompanied by a brief description, the vendor/institution responsible for the tool, and a major web link where comprehensive information can be found.

Table 4 - Tools for Design Analysis

Tools	Brief description	Vendor/Institution
BlockSim FTI	ReliaSoft's BlockSim provides a comprehensive platform for system reliability, maintainability, availability, optimization, throughput, life cycle cost and related analyses using the exact system reliability function and/or discrete event simulation. BlockSim provides sophisticated and flexible capabilities to model systems using a reliability block diagram (RBD) or fault tree analysis (FTA) approach.	ReliaSoft http://blocksim.reliasoft.com/
B-Toolkit	The B-Toolkit comprises a suite of fully integrated software tools designed to support a rigorous or formal development of software systems using the B-Method.	B-Core Ltd http://www.b-core.com/ONLINEDOC/BToolkit.html
CAFTA for Windows	A PC-based fault tree workstation with support for all phases of systems analysis. Includes full screen editor, multilevel reliability database, plotting, cut set generator, cut set results editor. Extensive syntax and logic checking, logical editing, supports macros, calculates unavailability from failure rate and exposure times, user definable fields, truncates on cut set probability or size.	Data Systems & Solutions EPRI - Electric Power Research Institute http://www.enre.umd.edu/tools/ftap.htm http://www.maracor.com/products.htm
CP HOOD	Toolset for HOOD (Burns and Wellings, 1993), the de facto standard in the European Defence industries for the design and development of real-time software and the generation of ADA code.	TNI Europe http://www.tni-world.com/cp_hood.asp

Table 4 - Continuation

Enterprise Architect	Enterprise Architect is a UML analysis and design tool. It supports generation and reverse engineering of Java, C#, C++, VB.Net, Delphi, Visual Basic and PHP source code.	Sparx Systems http://www.sparxsystems.com.au/ea.htm
MATLAB	MATLAB is a high-level technical computing language and interactive environment for analyzing data and developing algorithms and applications.	MathWorks http://www.mathworks.com
Object Domain R3	Object Domain R3 is a tool for UML modelling and collaborative development of enterprise systems.	Object Domain Systems Inc. http://www.objectdomain.com/products/od/overview.do
RAM-Tools FMEA/FMECA	RAM-Tools FMEA/FMECA is a FMECA supporting tool. RAM-Tools FMEA/FMECA is compliant with the MIL-STD-1629A and SAE standards.	RAM-Tools http://www.ram-tools.com/FMEA_FMECA.htm
RAM-Tools FTA	RAM-Tools FTA is a tool that facilitates Fault Tree Analysis application (can be used for both hardware and software (SFTA)). RAM-Tools FTA integrates and shares data with other RAM-Tools modules namely, RAM-Tools FMECA.	RAM-Tools http://www.ram-tools.com/FTA.htm
Rapid RMA	Rapid RMA is a real-time systems modelling tool that supports several scheduling algorithms (e.g. Rate Monotonic Analysis, Deadline Monotonic Analysis, etc.). Rapid RMA integrates into some well known modelling tools such as Rational Rose Technical Developer and I-Logix Rhapsody.	Tri-Pacific Software Inc. http://www.tripac.com/html/prod-toc.html
Rational Rose Technical Developer	Rational Rose Technical Developer is a UML 2.0 design tool. It provides generation of C, C++ and Java source code, runtime model execution and visualisation, real-time systems modelling, etc. Rational Rose Technical Developer was formerly known as Rational Rose Real-Time.	IBM http://www-306.ibm.com/software/awdtools/developer/technical/

Continue

Table 4 - Continuation

Relex Fault Tree/Event Tree	Relex Fault Tree/Event Tree is a tool to support the application of the FTA and ETA methods. The tool provides a user friendly interface for FTA/ETA diagram building. Relex Fault Tree/Event Tree integrates with Relex FMEA/FMECA.	Relex Software http://www.relexsoftware.com/products/ftaeta.asp
Relex FMEA/FMECA	Relex FMEA is a tool designed to support FMEA and FMECA. The tools supports a wide range of FMEA/FMECA method variations e.g. MIL-STD-1629A, IEC 60812, etc.	Relex Software http://www.relexsoftware.com/products/fmeafmeca.asp
SCAN	SCAN is a tool for schedulability analysis. The tool performs a real feasibility analysis and focuses on the predictability of an application's timing behaviour. SCAN underlying methodology is the well-established Rate Monotonic Analysis.	Advanced Informatics Ltd. http://www.advanced.gr/scan.html
Select Yourdon	Select Yourdon provides integrated modelling support for the full range of modelling techniques in the Yourdon Method.	Select Business Solutions, Inc. http://www.selectbs.com/products/products/select_yourdon.htm
Simulink	Simulink is a platform for multi-domain simulation and model-based design of dynamic systems. It provides an interactive graphical environment and a customizable set of block libraries that allow to accurately design, simulate, implement, and test control, signal processing, communications, and other time-varying systems. Simulink integrates into MATLAB.	MathWorks http://www.mathworks.com
Spreadsheet	A spreadsheet application such as Microsoft Excel, Lotus 123 or OpenOffice.org.	Microsoft OpenOffice.org
STOOD	Component Based Software Modelling Tool for Critical Systems based on HOOD (Burns and Wellings, 1993).	TNI Europe http://www.tni-world.com/stood.asp

Table 4 - Conclusion

Telelogic TAU/Architect	TAU/Architect is a model-based engineering tool for the development of software systems. TAU/Architect uses the industry standard visual modelling language UML 2.0.	Telelogic http://www.telelogic.com/products/tau/architect/index.cfm
Telelogic TAU SDL Suite	The Telelogic TAU SDL Suite is a model driven tool for real-time systems based on the Specification and Description Language (SDL). TAU SDL allows integration and translation between UML and SDL as well as automatic code generation (C and C++).	Telelogic http://www.telelogic.com/products/tau/sdl/index.cfm
Xfmea	ReliaSoft Xfmea is a tool that facilitates analysis, data management and reporting for failure mode and effects analysis (FMEA) and failure modes, effects and criticality analysis (FMECA). The tool supports all major FMEA/FMECA standards (AIAG FMEA-3, J1739, ARP5580, MIL-STD-1629A, etc.) and provides extensive customization capabilities for analysis and reporting.	ReliaSoft http://www.reliasoft.com/xfmea/xfmea.htm
VIATRA2	The VIATRA (VIsual Automated model TRAnsformations) framework is the core of a transformation-based verification and validation environment for improving the quality of systems designed using the Unified Modeling Language by automatically checking consistency, completeness, and dependability requirements.	http://dev.eclipse.org/viewcvs/indextech.cgi/gmt-home/subprojects/VIATRA2/download/index.html

The list of tools shown in this section is not meant to be exhaustive nor complete. Other tools may be identified for Design Analysis, but those in Table 4 - Tools for Design Analysis are in principle the most commonly known and used.

4. Code Analysis

4.1 Code Analysis Methods

This section presents a survey of methods and techniques that are suitable for code analysis. The survey is presented in table 5 – methods & techniques for code static analysis. Each method/technique is accompanied by a brief description. Each method/technique is accompanied by a brief description.

Table 5 - Methods & Techniques for Code static analysis

Method / Technique	Brief description	References
Bug Pattern Identification	Bug Pattern Identification consists on the identification of known programming language and library bug patterns.	N/A
Coding Standard Conformance	Coding Standard Conformance is method that aims at checking whether the implemented source code follows a specific coding convention or set of coding rules (this includes checking coding style, naming conventions, etc.).	N/A
Concurrent Behaviour Analysis: LOTOS, CCS, CSP, SDL, FSM, Petri, Nets.	Mathematical models that can be used to design and analyse the behaviour of concurrent systems (Formal Methods and CAFM).	(ESA, 2000) (Leveson and Stolzy, 1987)
HSIA – Hardware Software Interaction Analysis	The HSIA method is defined in ESA standard ECSS-Q-80-03. It consists of the systematic analysis of the HW/SW interfaces, with particular focus on the hardware faulty conditions and the handling of those faulty conditions by the SW.	(ESA, 2000) (ECSS, 2006) (Esteves et al.,2004)
Inspection	An activity such as measuring, examining, testing or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformity is achieved for each characteristic (ISO 8402:1994).	(ESA, 2000)
Data and control flow analysis	Modeling can be used to cover a broad range of activities or tasks such as, data flow analysis and control flow analysis. The method may be applied to all or specific parts of the system under verification.	N/A
Numeric Analysis	Numeric Analysis consists on the analysis of the algorithm and the code aimed at assessing the propagation of errors in numerical computation. This method is called Numeric Analysis because it is based on numerical theory.	(ESA, 2000)

Table 5 - Continuation

SCCFA/SCMFA – Software Common Cause/Mode Failure Analysis	SCCFA/SCMFA aims at identifying potential failure in redundant components which would undermine the benefits of redundancy because of the appearance of the same failures in the redundant parts at the same time.	(ESA, 2000)
Schedulability Analysis	Schedulability Analysis aims at determining whether a specific software system is schedulable or not. In other words, to check whether the software system accomplishes the deadlines it was designed for (does each function executes within the required time limit). Schedulability verification is performed by executing the scheduling algorithm (e.g. Rate Monotonic Scheduling) with the given tasks WCETs[2].	(ESA, 2000) (Audsley et al.,1991)
Sequential Behaviour Analysis: B, Z, RAISE, VDM.	Algebraic models that can be used to analyze the sequential behaviour of a software program (Formal Methods and CAFM).	(ESA, 2000)
SFMECA – Software Failure Modes, Effects and Criticality Analysis	The software failure modes effects analysis SFMEA is an iterative method, intended to analyse the effects and criticality of failure modes of the software within a system. Software Failure Modes Effects and Criticality Analysis (SFMECA) extend SFMEA by assigning a criticality level to each component failure. SFMECA uses intuitive reasoning and consists of five steps: (1) failure modes identification – and then for each failure mode – (2) analysis of local effects, (3) analysis of possible propagation at upper level, (4) assessment of the criticality related to the impact of the failure and (5) issuing of recommendations to reduce the probability of occurrence.	(ESA, 2000) (ECSS, 2006)

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[2] At the design phase tasks WCETs are estimated values. Those values need then to be confirmed during and after coding.

Table 5 - Continuation

SFTA – Software Fault Tree Analysis	Top-down fault/failure analysis that uses Boolean Logic to describe the combinations of individual software faults that can lead to a hazardous event. The SFTA application consists of three basis steps: (1) identification of top level feared events, (2) recursive identification of intermediate events down to the identification of basic events and (3) documentation of the analysis showing the dependencies between the top-level, intermediate and basic events.	(ESA, 2000) (ECSS, 2006)
Software Metrics Analysis	Extraction of metrics about the source code of a software application to measure several kinds of characteristics (e.g., cyclomatic complexity, lines of code, recursions, number of paths, etc.).	N/A
Traceability Analysis	The traceability analysis method consists of tracing (finding the correspondence of) specific items of one lifecycle phase to items of another lifecycle phase. Typically items are traced across adjacent lifecycle phases and the traceability can be done from inputs to the outputs (forward traceability) or from outputs to the inputs (backwards traceability). The main purpose of traceability analysis is to check the consistency and completeness of the items being reviewed.	http://www.traceabilitycenter.org
Walkthrough	A minimalist inspection of a work product (requirements, designs or code). Instead of a full inspection (or full reading) one walks through the items under review only stopping whenever some of the reviewers has some comment or consideration to made.	(ESA, 2000)
Worst Case Execution Time calculation	Worst Case Execution Time calculation or WCET is a method that aims at calculating the worst case execution time for a task, i.e. the maximum amount of time a specific task requires to complete its computation. Different techniques for WCET calculation exist, namely testing, simulation and static code analysis.	http://en.wikipedia.org/wiki/Worst-case_execution_time

Table 5 - Conclusion

| Sneak Analysis | A Sneak is a design condition (possibly in conjunction with a single-point failure) which gives rise to an unintended event or which inhibits an intended event. | http://www.saunalahti.fi/ility/SneakAnalysis.html |
| | An event can be: (1) a change in the state of the plant; (2) a transfer of material, energy, information, etc.; (3) a program operation | |

The list of methods and techniques shown in this section is not meant to be exhaustive nor complete. Other methods and techniques may be identified for Code Analysis, but those in Table 5 – methods & techniques for code static analysis are in principle the most commonly known and used.

Both Inspection and Walkthrough are built on the review technique. Modelling is very general, and can also serve as the basis to implement other methods and techniques, such as Sequential Behaviour Analysis, Concurrent Behaviour Analysis, or Sizing & Timing Analysis.

4.2 Code Analysis Tools

This section presents a survey of tools that are suitable for the Code static analysis.

The survey is presented in Table 6. Each tool is accompanied by a brief description, the vendor/institution responsible for the tool, and a major web link where comprehensive information can be bound.

Table 6 - Tools for Code Analysis

Tools	Brief description	Vendor / URL
Absint AIT	AIT is a WCET calculation tool that supports binaries generated from a restricted subset of ANSI-C. AIT supports source code annotations and provides an intuitive graphical user interface.	Absint http://www.absint.com/ait
AdaSTAT	AdaSTAT is a static analysis tool for Ada that extract software metrics and automatically finds coding violations.	DCS IP, LLC http://www.adastat.com
ASSENT	ASSENT is a static analysis tool that allows data and control flow analysis as well as programming standards verification (based on a set of programming rules).	TATA Consultancy Services http://www.tcs.com/0_products/assent/index.htm

Table 6 - Continuation

BlockSim FTI	BlockSim provides a comprehensive platform for system reliability, maintainability, availability, optimization, throughput, life cycle cost and related analyses using the exact system reliability function and/or discrete event simulation. BlockSim provides sophisticated and flexible capabilities to model systems using a reliability block diagram (RBD) or fault tree analysis (FTA) approach.	ReliaSoft http://blocksim.reliasoft.com/
Bound-T	Bound-T is a language independent Worst Case Execution Time calculation tool. Bound-T computes the WCET of a software task based upon the binary image of the executable. The supported targets are the Intel 8051, ERC32/SPARC V7 and the ADSP21020.	Tidorum Ltd http://www.tidorum.fi/bound-t/
B-Toolkit	The B-Toolkit comprises a suite of fully integrated software tools designed to support a rigorous or formal development of software systems using the B-Method. The tools are accessed through a custom build X Windows Motif Interface, providing full on-line help facilities.	B-Core Ltd http://www.b-core.com/ONLINEDOC/BToolkit.html
C++Test	C++Test is an automated C/C++ unit testing and coding standard analysis product. It automatically generates and executes unit tests for instant verification, and allows users to customize and extend these tests as needed. In addition, it checks whether code follows an extensive range of coding standard rules.	Parasoft http://www.parasoft.com/jsp/products/home.jsp?product=CppTest&itemId=46
CMT++	CMT++ (Complexity Measures Tool for C/C++) calculates the basic McCabe, Halstead and lines-of-code metrics for C and C++ code. Clear and compact report. Configurable alarm limits. Can measure non-preprocessed source code. Can produce Excel data file for customer specific analysis or for producing graphical representations. Processes 1000s of lines of code in a second and can manage huge code volumes. Does not require a C/C++ compiler, but if Visual C++ is available, CMT++ can be used via its GUI.	Testwell Oy http://www.testwell.fi/cmtdesc.html

Table 6 -Continuation

ClearMaker	ClearMaker is an analyser for COBOL programs that executes an outstandingly thorough analysis in a relatively short time. ClearMaker's analysis is based on a deep examination of impacts, called ripple effect analysis or slicing.	http://www.testingfaqs.org/t-static.html#ClearMaker
CodeSurfer	CodeSurfer is an analysis and inspection tool that lets software developers and maintainers easily understand detailed dependence relations in source code. CodeSurfer provides access to a program's deep structure semantic properties and relationships discovered by global program analyses that conventional tools do not see.	GrammaTech, Inc. http://www.grammatech.com/
Coverity Prevent / Coverity Extend	Coverity Prevent™ is a static analysis tool for making software more reliable and secure.	Verifysoft GmbH http://www.verifysoft.com/
Doxygen	Doxygen is a documentation system for C++, C, Java, Objective-C, IDL (CORBA and Microsoft flavours) and to some extent PHP, C# and D. It may also be used in order to extract call graphs from the source code.	Doxygen Org. http://www.doxygen.org
Hindsight/SQA	It generates metrics from the existing source code. User metrics can also be accepted for analysis. Metrics can be analyzed and printed out in a variety of report formats	IntegriSoft, Inc. http://www.integrisoft.com/
Imagix 4D	Imagix 4D is a reverse engineering tool that provides data collection and visualisation, UML diagrams, flow charts and control flow analysis, software metrics and source code checks as well as automated documentation generation.	Imagix Corporation http://www.imagix.com/products/products.html

Table 6 -Continuation

| LDRA | LDRA Testbed is a cost effective analysis tool for use in the improvement of software development and testing processes. Ideal for unit, integration and system testing. LDRA Testbed can be utilised throughout the software life-cycle. Coverage is measured at the following levels: *Statement, Branch/Decision, LCSAJ (Test Path), Procedure/Function Call, Branch Condition, Branch Condition Combination, Modified Condition/Decision, Dynamic Data Flow, Interface Coverage.* The analysis capabilities include programming standards verification, structured programming verification, complexity metric production, full variable cross reference, unreachable code reporting, static data flow analysis, code reformatting, information flow analysis, loop analysis, analysis of recursive procedures and procedure interface analysis. Dynamic Analysis analyses the code and provides an understanding of the code structure and measures code coverage of statements, branches, test paths (lcsaj coverage), sub conditions, & procedure calls. Several coverage levels are available including MC/DC level A of the DO-178B standard. The tool suite is available for C, C++, Ada83, Ada95 & Assemblers (Intel, Freescale and Texas Instruments). | LDRA Ltd.

http://www.tridentinfosol.com/asp/verify.html
http://www.ldra.co.uk/distributors.asp
http://www.ldra.co.uk/testbed.asp |

Table 6 -Continuation

MALPAS	Each of the five analysers in the MALPAS tool-set examines a different aspect of the software, revealing general problems (for example bad structure or inconsistent data usage) and pin-pointing specific errors such as incorrectly implemented algorithms or inconsistencies with the specification. Because MALPAS analyses source-code without actually executing it	Advantage Technical Consulting http://www.advantage-business.co.uk/products/article/0/44
MATLAB	MATLAB is a high-level technical computing language and interactive environment for analyzing data and developing algorithms and applications.	MathWorks http://www.mathworks.com
McCabeQA	McCabeQA is a quality assurance suite that, among other features, computes software metrics and provides control flow graphs.	McCabe & Associates http://www.mccabe.com/iq_qa.htm
METRIC	METRIC works as a stand-alone product or as part of the TestWorks/Advisor tool suite to quantitatively determine source code quality. It automatically computes various software measurements, including the Halstead Software Science metrics, which measure data complexity in routines; the *Cyclomatic Complexity* metrics, which measure logic complexity in routines; and size metrics, such as number of lines, comments and executable statements	Software Research, Inc. http://www.soft.com/TestWorks/
Object Domain R3	Object Domain R3 is a tool for UML modelling and collaborative development of enterprise systems.	Object Domain Systems Inc. http://www.objectdomain.com/products/od/overview.do
PC-Lint, FlexeLint	It checks C/C++ source code for bugs, glitches, inconsistencies, non-portable constructs, etc.	GimpelSoftware http://www.gimpel.com/
Polyspace Verifier	Solution for the automatic detection of run-time errors at compile time.	Polyspace Technologies http://www.polyspace.com/

Continue

Table 6 -Continuation

QA C, C++, Fortran	The focus is on automated enforcement of Coding Standards as an integrated step in the software development process for C, C++, Java and Fortran. The enforcement of coding standards is a key step for CMM Level 3 attainment. The tools also generate code metrics (e.g. Cyclomatic Complexity, Estimated Path Count, etc.) which can be used for CMM Level 4 process measurements, and form a basis for optimization in Level 5. The tools detect stylistic issues, dataflow problems, ISO C/C++ conformance, platform and compiler portability issues, metric threshold violations and enforce best practice issues in language implementation. In addition, the tools are available integrated with other IDE's such as Visual Developer Studio (Microsoft), Eclipse (Open Source, IBM) and Tornado (Windriver). They also produce a range of interactive source comprehension views such as call trees and control flow diagrams.	Programming Research Ltd. http://www.programmingresearch.com/
RAM-Tools FMEA/FMECA	RAM-Tools FMEA/FMECA is a FMECA supporting tool. RAM-Tools FMEA/FMECA is compliant with the MIL-STD-1629A and SAE standards.	RAM-Tools http://www.ram-tools.com/FMEA_FMECA.htm
RAM-Tools FTA	RAM-Tools FTA is a tool that facilitates Fault Tree Analysis application (can be used for both hardware and software (SFTA)). RAM-Tools FTA integrates and shares data with other RAM-Tools modules namely, RAM-Tools FMECA.	RAM-Tools http://www.ram-tools.com/FTA.htm
Rapid RMA	Rapid RMA is a real-time systems modelling tool that supports several scheduling algorithms (e.g. Rate Monotonic Analysis, Deadline Monotonic Analysis, etc.). Rapid RMA integrates into some well known modelling tools such as Rational Rose Technical Developer and I-Logix Rhapsody.	Tri-Pacific Software Inc. http://www.tripac.com/html/prod-toc.html
Rational Rose Technical Developer	Rational Rose Technical Developer is a UML 2.0 design tool. It provides generation of C, C++ and Java source code, runtime model execution and visualisation, real-time systems modelling, etc. Rational Rose Technical Developer was formerly known as Rational Rose Real-Time.	IBM http://www-306.ibm.com/software/awdtools/developer/technical/

Continue

Table 6 -Continuation

Relex Fault Tree/Event Tree	Relex Fault Tree/Event Tree is a tool to support the application of the FTA and ETA methods. The tool provides a user friendly interface for FTA/ETA diagram building. Relex Fault Tree/Event Tree integrates with Relex FMEA/FMECA.	Relex Software http://www.relexsoftware.com/products/ftaeta.asp
Relex FMEA/FMECA	Relex FMEA is a tool designed to support FMEA and FMECA. The tools supports a wide range of FMEA/FMECA method variations e.g. MIL-STD-1629A, IEC 60812, etc.	Relex Software http://www.relexsoftware.com/products/fmeafmeca.asp
SCAN	SCAN is a tool for schedulability analysis. The tool performs a real feasibility analysis and focuses on the predictability of an application's timing behaviour. SCAN underlying methodology is the well-established Rate Monotonic Analysis.	Advanced Informatics Ltd. http://www.advanced.gr/scan.html
STATIC	STATIC is the static analyzer system for the fully integrated TestWorks/Advisor suite of static source code analyzers and measurement tools. It provides more comprehensive syntax and semantic analysis for C programs than most compilers, including locating non-portable constructs and dead code. STATIC also searches the entire program for inconsistencies across the modules that comprise an application.	Software Research, Inc. http://www.soft.com/TestWorks/
Splint	Splint is a tool for statically checking C programs for security vulnerabilities and coding mistakes.	Splint Org. http://www.splint.org/
Spreadsheet	A spreadsheet application such as Microsoft Excel, Lotus 123 or OpenOffice.org.	Microsoft OpenOffice.org
TAU Architect	TAU/Architect is a model-based engineering tool for the development of software systems. TAU/Architect uses the industry standard visual modelling language UML 2.0.	Telelogic http://www.telelogic.com/products/tau/architect/index.cfm
TAU Logiscope	Quality and Productivity for the development, test and maintenance of software applications. It consists of: Logiscope TestChecker, Logiscope RuleChecker, Logiscope ImpactChecker and Logiscope Audit.	Telelogic http://www.telelogic.com/products/tau/logiscope/index.cfm

Table 6 -Continuation

Telelogic TAU SDL Suite	The Telelogic TAU SDL Suite is a model driven tool for real-time systems based on the Specification and Description Language (SDL). TAU SDL allows integration and translation between UML and SDL as well as automatic code generation (C and C++).	Telelogic http://www.telelogic.com/products/tau/sdl/index.cfm
Testwell CTC++ Code Coverage-Analyser and Code Complexity Measure Toll for C/C++	CTC++ is an instrumentation-based tool supporting testing and tuning of programmes written in C and C++. This test coverage analyser supports coverage for function, decision, statement, condition, multi-condition (MCC) and modified condition / decision coverage (MC/DC). CMT++ supports metrics like McCabe Cyclomatic Number, Halsteads Software Science Metrics and Line-of-Code-Metrics. CMT++ gives an estimation of the number of test cases needed to test all paths of a function.	Verifysoft GmbH http://www.verifysoft.com/
Understand	Understand is a reverse engineering tool that provides some software metrics and allows easy and intuitive navigation throughout the source code. This tool is specially targeted to understanding and analysing third party or legacy code.	Scientific Toolworks, Inc. http://www.scitools.com
Universal Report	Universal report is a generic code analysis and documentation tool. It computes some software metrics and generates documentation that allows easy navigation throughout the source code. Universal report supports a broad range of programming languages and development environments.	Omegacomputer http://www.omegacomputer.com/home.htm

Table 6 -Conclusion

Visustin	Visustin is an automated diagramming tool for software developers and document writers. Save documentation efforts with automatic code visualization. Visustin reverse engineers your source code into flow charts or UML Activity Diagrams. Visustin reads the if and else statements, loops and jumps and builds a diagram — fully automated. No manual drawing is required. Visustin flowcharts Ada, ASP, assembler, BASIC, C/C++, C#, Clipper, COBOL, ColdFusion, Fortran, Java, JSP, JavaScript, LotusScript, Pascal/Delphi, Perl, PHP, PL/SQL, PowerScript, PureBasic, Python, QuickBASIC, REALbasic, T-SQL, VB, VBA, VB.NET, Visual FoxPro or XSLT.	http://www.aivosto.com/visustin.html
Xfmea	ReliaSoft Xfmea is a tool that facilitates analysis, data management and reporting for failure mode and effects analysis (FMEA) and failure modes, effects and criticality analysis (FMECA). The tool supports all major FMEA/FMECA standards (AIAG FMEA-3, J1739, ARP5580, MIL-STD-1629A, etc.) and provides extensive customization capabilities for analysis and reporting.	ReliaSoft http://www.reliasoft.com/xfmea/xfmea.htm

The list of tools shown in this section is not meant to be exhaustive nor complete. Other tools may be identified for Code Analysis, but these are in principle the most commonly known and used.

Other tools may be found at http://www.testingfaqs.org/t-static.html#hindsight and at http://en.wikipedia.org/wiki/List_of_tools_for_static_code_analysis.

5. Testing Activities

5.1 Test Methods

The International American Society for Testing and Materials (ASTM), an international standard organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services, defines a **test method** as a definitive procedure that produces a test result.

The software tests may be classified as black-box, white-box and regression tests.

Black-box (or functional) testing - the black box testing treats the software as a black-box without any understanding of internal behaviour. It aims to test the functionality according to the requirements. Thus, the tester inputs data and only sees the output from the test object. This level of testing usually requires thorough test cases to be provided to the tester who then can simply verify that for a given input, the output value (or behaviour), is the same as the expected value specified in the test case. Black box testing methods include: equivalence partitioning, boundary value analysis, all-pairs testing, fuzz testing, model-based testing, traceability matrix, etc

White-box testing - It is a test case design method that uses the control structures of the programme to derive test cases. (Pressman, 2005) The following types of white box testing exist:

- code coverage - creating tests to satisfy some criteria of code coverage. For example, the test designer can create tests to cause all statements in the program to be executed at least once.
- mutation testing methods.
- fault injection methods.
- static testing - White box testing includes all static testing.

Regression Testing – used to determine that changes have not caused unintended side effects:

Do the unmodified parts of the system still work as before?
Do the new or modified parts work as required?

A survey of software testing methods and techniques to specify and design test cases is presented in Table 7. Each method/technique is accompanied by a brief description.

Table 7 – Methods for test phase

Method / Technique	Brief description	References
Alpha testing	Alpha testing is performed at the developer's sites, with the developer checking over the customers shoulder as they use the system to determine errors.	N/A
Beta testing	Beta testing is conducted at more than one customer locations with the developer not being present. The customer reports any problems they have to allow the developer to modify the system.	N/A
Boundary Value Analysis	Determine test cases covering off-by-one errors. An **off-by-one error (OBOE)** is a logical error involving the discrete equivalent of a boundary condition. The boundaries of software component input ranges are areas of frequent problems.	N/A
Cause-Effect Graphing Techniques	Cause-effect graphing is a test case design approach that offers a concise depiction of logical conditions and associated actions. The approach has four stages: (1) cause (input conditions) and effects (actions) are listed for a module and an identifier is allocated to each; (2) a cause-effect graph is created; (3) the graph is altered into a decision table; (4) decision table rules are modified to test cases.	N/A
Code coverage	**Code coverage** is a measure used in software testing. It describes the degree to which the source code of a program has been tested. It is a form of testing that inspects the code directly and is therefore a form of white box testing. Different parts of the software may be analyzed by covered: (1) *Statement* – Has each line of the source code been executed?; (2) *Branch*; (3) *Condition* – Has each evaluation point (such as a true/false decision) been executed? ; (4) *Data flow;* (5) *Linear Code Sequence and Jump*; (6) *Path* – Has every possible route through a given part of the code been executed?; (7) *Entry/exit* – Has every possible call and return of the function been executed?	http://en.wikipedia.org/wiki/Code_coverage
Configuration /installation testing	Type of tests that focuses on what customers will need to do to install and set up the new software successfully.	N/A
Conformance testing	Testing to determine whether a system meets some specified standard(s).	N/A

Table 7 -Continuation

Equivalence Partitioning	Equivalence partitioning is a black box testing approach that splits the input domain of a program into classes of data from which test cases can be produced.	N/A
Error guessing	error guessing is a test design technique where the experience of the tester is used to anticipate what defects might be present in the component or system under test as a result of errors made, and to design tests specifically to expose them	N/A
Fault Injection Technique	To test fault tolerance and fault recovery mechanisms. Fault injection tests can be software based or hardware related, can include testing existing API's and interfaces or mutation testing.	N/A
Interface Testing	Interface Testing is one of the most important tests carried out during any Quality Assurance process. Interface testing aims to ensure that customers don't face any problem in using the software once the software is delivered to them.	N/A
Interoperability Testing	Testing to ensure compatibility with existing equipment or with other systems. Interoperability testing is a superset of compatibility testing and integration testing. Interoperability testing requires that other systems and/or equipment are available for the testing phase. Should this equipment not be available then simulators (stubs and drivers) of the missing equipment can be used to represent these other entities in the interoperability tests.	N/A
Load/volume testing	In the testing literature, the term "load testing" is usually defined as the process of exercising the system under test by feeding it the largest tasks it can operate with. Load testing is sometimes called volume testing, or longevity/endurance testing.	N/A
Loop Testing	Loop testing is the testing of a resource or resources multiple times under program control. Testing application loops is necessary to ensure that the full path coverage is achieved, and that no errors are left on the program flow by forgetting to test specific path within loops.	N/A

Continue

Table 7 –Continuation

Model-based test cases	Also considered in conformance test area. It consists of generating tests starting from a model. Generally is a State-based diagram (Finite state machine, Statecharts, etc.)	N/A
Monte-Carlo Testing	There is no single Monte Carlo method; instead, the term describes a large and widely-used class of approaches. However, these approaches tend to follow a particular pattern: • Define a domain of possible inputs. • Generate inputs randomly from the domain, and perform a deterministic computation on them. • Aggregate the results of the individual computations into the final result.	http://en.wikipedia.org/wiki/Monte_Carlo_method
Mutation analysis	Mutation analysis is a powerful technique for assessing and improving the quality of test data used to unit test software	(Wong, 2001)
Random Testing	A black-box testing approach in which software is tested by choosing an arbitrary subset of all possible input values. Random testing helps to avoid the problem of only testing what you know will work.	N/A
Robustness Testing	Robustness is defined as the degree to which a system operates correctly in the presence of exceptional inputs or stressful environmental conditions. The goal of robustness testing is to develop test cases and test environments where a system's robustness can be assessed.	(IEEE,1990)
Runtime Analysis	Pseudo-execution of the system code. Performed automatically by some tools, such as Polyspace Verifier. A set of runtime verifications are performed over the source code according to a set of predefined rules and standards.	N/A
Statistical Testing	Statistical tests provide a mechanism for making quantitative decisions about a process or processes. The intent is to determine whether there is enough evidence to "reject" a conjecture or hypothesis about the process. The conjecture is called the null hypothesis. Not rejecting may be a good result if we want to continue to act as if we "believe" the null hypothesis is true. Or it may be a disappointing result, possibly indicating we may not yet have enough data to "prove" something by rejecting the null hypothesis.	N/A

Table 7 -Conclusion

Stress Testing	Testing aimed at investigating the behaviour of software or hardware equipment in out of ordinary operating conditions.	N/A
Thread Testing	Thread testing is used during the early stages of the integration testing. Thread testing is an approach where the strings of units that accomplish a specific function in the application are tested. Thread testing and incremental testing are usually used in conjunction and complement each other. For example, "Units can undergo incremental testing until enough units are integrated and a single business function performing specific task can be tested, threading through the integrated components."	N/A
Traceability to requirements	Traceability means recording and analysing the antecedent and successor of development work products. In testing, traceability to requirements means to check if each requirement can be traced to a test case.	N/A

5.2 Test Tools

This section presents a survey of tools that are suitable for the Test phase. These tools can be categorized based upon their tool objectives and features (Lewis, 2005).

These categories are:

- Function/Regression Tools: These tools help you test software through a native graphical user interface. Some also help with other interface types. Another example is Web test tools that test through a browser, for example, capture/replay tools.

- Test Design/Data Tools: These tools help create test cases and generate test data.

- Load/Performance Tools: These tools are often also GUI test drivers.

- Test Process/Management Tools: These tools help organize and execute suites of test cases at the command line, API, or protocol level. Some tools have graphical user interfaces, but they don't have any special support for testing a product that has a native GUI. Web test tools that work at the protocol level are included here.

- Unit Testing Tools: These tools, frameworks, and libraries support unit testing, which is usually performed by the developer, usually using interfaces below the public interfaces of the software under test.

- Test Implementation Tools: These tools assist with testing at runtime.

- Test Evaluation Tools: Tools that help you evaluate the quality of your tests. Examples include code coverage tools.

- Static Test Analyzers: Tools that analyze programs without running them. Metrics tools fall in this category.

- Defect Management Tools: Tools that track software product defects and manage product enhancement requests. Manages defect states from defect discovery to closure.

- Application Performance Monitoring/Tuning Tools: Tools that measure and maximize value across the IT service delivery life cycle to ensure applications meet quality, performance, and availability goals.

- Runtime Analysis Testing Tools: Tools that analyze programs while running them.

The survey is presented in Table 8. Each tool is accompanied by a brief description, the vendor/institution responsible for the tool, and a major web link where comprehensive information can be found.

Table 8 – Tools for test phase

Function /Regression Tools		
Testing Tool	**Description**	**Vendor/URL**
Abbott	The Abbot framework is a Java library that provides methods to reproduce user actions and examine the state of GUI components. Improving upon the very rudimentary functions provided by the java.awt.Robot class (A Better 'Bot). The framework may be invoked directly from Java code or accessed without programming through the use of scripts. It is suitable for use both by developers for unit tests and QA for functional testing.	Timothy Wall http://abbot.sourceforge.net/
Allpairs	Allpairs is a command-line executable based on a Perl script. Allpairs.pl is a Perl script that constructs a reasonably small set of test cases that included all pairings of each value of each set of parameters.	Satisfice, Inc. http://satisfice.com/

<div align="right">Continue</div>

Table 8 - Continuation

Allpairs.java	It is a java program that can design a set of test using the all-pairs method, which reduces potentially combination of variables into a manageable set that still makes for an effective test suite in most situations.	Cunningham & Cunningham, Inc http://fit.c2.com /wiki.cgi?AllPair s
Android	Automated GUI Client testing tool. Android is an open-source GUI testing tool that can observe and record your interactions with a graphical user interface, creating a script that can repeat the session to any desired level of accuracy.	Smith House http://www.smi th-house.org/ope n.html
Assertion Definition Language (ADL)	High level language that provides a formal grammar for the expression of programmatic assertions. It can be used to automatically tests based on API specifications and to produce natural language representations of these assertions for documentation. The language has C/C++, IDL and Java dialects each of which are designed to reflect the syntax of those languages to help developers to better describe native APIs.	The Open Group http://adl.openg roup.org/
Astra Quick Test	Astra Quick Test is an icon-based tool that allows novice and experts testers to validate dynamically changing web applications. It quickly creates interactive maintainable tests by mirroring end-user behaviour.	Mercury Interactive www.merc-int.com
AutoIt	It is a simple tool that simulates pulsations of keys, movements of mouse and command of window to automate any task based on windows. AutoIt presents syntax similar to BASIC and can be used as a language of writing of general purpose.	HiddenSoft www.hiddensof t.com
AutomX	Is an Active X control designed for the development of automated software testing. It can be embedded within a Delphi™ 5, 6 or 7 of the user's design and run on the windowsl 95/98/ME/NT4/2000/XP platforms. AutomX includes more than instructions. It has network distributed testing capability, on line help and two tools for helping of test cases.	Vantage View Software http://www.vant ageviewsoftwa re.com/

Continue

Table 8 - Continuation

AutoPilot	AutoPilot is a tool for automated GUI testing by scripts. • C/C++ like script interpreter compliable, strong typing • script wizard • automated script generation from spreadsheets, event tracking, auto code generator • event and action tracing • remote script execution / networking capabilities • verification capabilities • string and file andling, environment variables • time-tagged and event-triggered script execution, synchronization of scripts by (named) semaphores • test coverage, tracking and analysis • on-line training facility • image processing • random data generation (context-driven)	BSSE System and Software Engineering www.bsse.biz/
Autotester for OS/2	It is an automated testing tool designed specifically for the creation, execution and documentation of automated tests for OS/2-based applications.	AutoTester Inc. www.autotester.com
Autotester for Windows	It is an automated testing solution designed for the creation, execution and documentation of automated tests for windows 3.x. NT, and 95 applications.	AutoTester Inc. www.autotester.com
Capbak	It captures user's activities during the testing process including keystrokes, mouse movements, captured ASCII characters and captured bitmap images , and records them as a C-language interpreter plays back all recorded events and actions. CAPBAK/MSW's Multiple Synchronization modes ensure reliable playback, allowing tests to be run unsupervised as often as required.	Software Research, Inc. www.soft.com/Products/index.html

Table 8 - Continuation

Certify	Business-user-oriented automated testing system. Certify provides enterprises level test automation. It allows tests to span applications, platforms and test tools while shielding users from the complexities of script languages. Certify detects application changes and automatically maps them to affected tests, simplifying maintenance and protecting the investment in the test repository.	WorkSoft Inc. http://www.worksoft.com/
CitraTest	Automated GUI client testing tool. CitraTest is the client side Automated Testing Solution for all Citrix hosted applications. This tool is ideal for latency, functional, and regression testing.	Tevron, LLC http://www.tevron.com
DARTT	It is a tool for verification of software and for quality analysis of the inspected code. DARTT scans incrementally or randomly the full input range of subprograms parameters for exceptions or anomalies and generates test output. When it's used as quality analysis tool it identifies unhandled exceptions or significant changes of output. As test tool DARTT produces and documents the results over the full input parameter domain such results may be subject of further manual or automatic analysis.	BSSE System and Software Enginering http://www.bsse.biz/
Datagen2000	It is a test data generator designed exclusively for Oracle databases. A level of flexibility, scalability and ease of use. The ability of harness the power of PL/SQL (Procedural Language/Structured Query Language) to define your test sets. Comprehensive support for foreign key relationships.	Superfine Software www.superfinesoftware.com
DGL	The DGL language was designed to facilitate the construction of data generators that select items at random from a set of items described by a probabilistic context free grammar.	Peter Maurer http://cs.ecs.baylor.edu/~maurer/

Table 8 - Continuation

Eggplant for Mac OS X	Eggplant is the automated test tool for Mac OS X. Designed specifically for GUI testing, Eggplant combines image-capture-and-compare technology with a powerful scripting language that allows test teams to automate their repetitive tasks. Eggplant runs on a Mac OS X platform and is used to test a second computer running almost any operating system. Current customers use Eggplant to test Windows, Mac OS 9, Mac OS X, Solaris, HP-UX, AIX, and Linux.	Redstone Software Inc. www.redstonesoftware.com
e-Monitor	e-Monitor, a component of the e-Test Suite, provides continuous, comprehensive testing for Web applications after deployment. E-Monitor acts like a quality assurance engineer, testing and reporting failures in real time. Re-using Visual Scripts created with e-Tester, the test authoring tool, e-Monitor schedules comprehensive regression testing around the clock. On detecting a problem, e-Monitor provides a wide variety of corrective actions as well as extensive notification options to alert systems managers to the problem and its nature.	Empirix www.empirix.com
EMOS Framework	EMOS Framework is an advanced technique for development of automated regression tests with WinRunner. Through its holistic approach EMOS Framework is suitable for rapid creation of new WinRunner projects. Through its open API and 100% TSL implementation it is well suited for integration into existing WinRunner projects, too.	EMOS Computer Consulting GmbH http://groups.yahoo.com/group/EMOS_framework/
e-Tester	e-Tester, a component of the e-Test Suite, is the state-of-the-art for functional testing of web applications that use HTML, Java or Active-X technologies and is the easiest of all record/playback tools. It features our powerful and intuitive Visual Scripts used for building test scripts, a built in Site Spider to quickly map your Web Application, Data Banks allow quick, efficient creation of data-driven automated tests.	Empirix www.empirix.com

Table 8 - Continuation

eValid	It helps organizations maintain e-Business continuity, improve website quality and integrity, reduce down time, control costs and enhance performance to prevent customer loss.	Software Research Inc. http://www.soft.com/eValid/
Eventcorder suite	It records and plays back Windows events. Events can be edited and optimized. It uses "Clickviews" playback can continue safely even when the driven application changed GUI. It will find the right place to click at. The Clickviews can be cloned and clipped to make the search process even more robust.	CM Software http://www.volny.cz/eventcorder/eventcorder.htm
IBM Rational Robot	Regression and functional testing tool for e-commerce, ERP, and client/server applications	IBM Rational Software http://www.rational.com/products/robot/
Imbus GUI Test Case Library	This Library is a powerful and easy to use add-on for Mercury Interactive WinRunner. It extends WinRunners functionality and provides solutions for frequent test programming problems. The library functions help you to improve, simplify and speed up your test implementation process.	Imbus AG http://www.imbus.de/
Jacareto	It is a capture and replay tool for programs written in Java. You can capture actions on applications and replay them later on (like macros). Jacareto can be used for many purposes: GUI test, creation of animated demonstration, creation of macros, qualitative and quantitative analyses of user behavior.	Ludwigsburg University of Education http://www.phudwigsburg.de/mathematik/personal/spannagel/jacareto/
Jemmy	It is a JavaTM library that is used to create automated tests for Java GUI applications. It contains methods to reproduce all user actions which can be performed on swing and AWT components (i.e. button pushing, text typing, tree node expanding).	SUN Microsystems http://jemmy.netbeans.org/

Table 8 - Continuation

Jenny	Jenny generates test cases that cover all pairs (or triples) of features. For example, all feature pairs for 20 dimensions of 10 features each is covered by 210 test cases. You can specify restrictions (combinations of features not to cover), for example feature combinations that are supposed to raise errors. Similar to ALLPAIRS or AETG. Public Domain.	Bob Jenkins http://burtleburtle.net/bob/math/jenny.html
jfcUnit	jfcUnit enables developers to write test cases for Java Swing based applications. It provides support for: • Obtaining handles on Windows/Dialogs opened by the Java code. • Locating components within a component hierarchy that occur within the containers found above. • Raising events on the found components, e.g. clicking a button, typing text in a TextComponent. • Handling testing of components in a thread safe manner.	jfcUnit project http://jfcunit.sourceforge.net/
Marathon	Marathon is a GUI-test tool that allows you to play and record scripts against a java swing. It's written in java, and uses python as its scripting language – the emphasis being on an extremely simple, readable syntax that customers/testers/analysts feel comfortable with. It is full fledged python, so it is also extremely powerful and customizable for developer-types.	ThoughtWorks, Inc. http://marathonman.sourceforge.net/

Table 8 - Continuation

Move for Legacy	It is specially designed to extract and move legacy data to support a variety of data processing tasks: • Integrate DB2 and legacy data to create a accurate, consistent and realistic test data. • Take advantage of COBOL or PL/I copybook information for transforming legacy records. • Define relationships to extract all required legacy data for easy migration to a target legacy system or relational database. • Move data from multiple databases and legacy data files without complex SQL or custom programs. • Mask sensitive data or transform legacy data for specific scenarios.	Princenton Softech Inc. http://princeton softech.com/pr odutcs/compar efordb2.asp
Orchid	Orchid is a test case design tool that helps you to design effective test cases that are adequate and yet minimal. Features • Helps you to convert your functional requirements to logic and data • Generates test values with well-known techniques of boundary value, equivalence class and special value conditions. • Saves the generated test cases in a test repository and helps you in reusing the test cases. • Extracts class methods and their signatures from Java APIs. Shows the argument list and the values it can accept. • Complete & Comprehensive documentation on the test cases generated. Documents the generated test cases in html format. • Helps you to test the Java APIs with test drivers compatible with Junit.	Stag software private limited http://www.stag software.com/

Continue

Table 8 - Continuation

Panorama C/C++	Coverage, Metrics, Test Case Minimization, Error Check/simulation/Detection. Panorama C/C++ is a comprehensive software testing environment consists of OOAnalyzer, OO-Browser, OO-Diagrammer, OO-SQA and OO-Test (the key tools for test evaluation)	International Software Automation, Inc. www.software automation.co m
Panorama-2	It is an enhanced product of Panorama C/C++. It is a comprehensive environment for software design, coding, testing, QA, reengineering, debugging, defect tracing, and problem management, consists of eight integrated tools (OO-Playback, OO-MemoryChecker, OO-DefectTracer, OO-Test, OO-SQA, OO-Browser, OO-Diagrammer, and OO-analyzer), offers Object (Window) oriented and GUI-based capture/playback (without scripting and extra programming) with test coverage analysis and test case minimization so that only the minimized test cases will be played back.	International Software Automation, Inc.(ISA) http://www.soft wareautomatio n.com
Perl X11:GUITest	It is a Perl package intended to facilitate the testing of GUI applications by means of user emulation. It can be used to test and interact with GUI applications; which have been built in some fashion (GTK+, Qt, Motif, etc.) upon the X library.	Dennis K. Paulsen http://sourcefor ge.net/projects/ x11guitest
Phantom	The Phantom scripting language is a powerful Windows automation language that allows you to take control of windows and perform functions automatically. Simulate any combination of key strokes and mouse clicks, as well as many built in functions for edits, buttons, menus, lists, and more.	Phantom Automated Solutions http://www.pha ntomtest.com/
Pounder	Pounder is a utility for automating Java GUI tests. It allows developers to dynamically load GUI's, record scripts, and then use those scripts in a test harness. Requires Java 1.4. It is licensed under the GNU Library General Public License.	Matthew Pekar http://pounder. sourceforge.ne t/

Table 8 - Continuation

QARunTM	QARun™ is an enterprise-wide test script development and execution tool that is part of Compuware's Qacenter™ family of application testing products. QARun's automated capabilities improve the productivity of testers, enabling them to efficiently create test scripts, verify tests, and analyze test results.	Compuware Corporation www.compuware.com
QC/Replay	QC/Replay offers "widget-based" testing of GUI based applications. Testers can record sessions and play them back on a variety of platforms. "Widget-based" rather than bitmap based verification makes test scripts robust: they are unaffected by changes in window size, position, window manager, screen size and colour, as well as changes in the application during normal development.	CenterLine www.centerline.com
QES/DatEZ (date-easy)	Enables user to check future and past dates in system	Qestest www.qestest.com
QES/EZ for GUI	QES/EZ is an automated GUI software testing system without the need for scripting or programming. The test data is stored in a relational database, which makes the maintenance and management of the test data very efficient and easy.	Qestest www.qestest.com
qftestJUI	qftestJUI is a tool for the creation, execution and management of automated tests for Java/Swing applications with a graphical user interface (GUI).	Quality First Software GmbH http://www.qfs.de/
Quick Test Professional	It is an automated testing solution that allows you to generate libraries of functional tests and regression. It meets the needs of all types of users (with expertise or not), allowing his company to deliver high quality applications in quickly and efficiently, reducing costs and risks.	Mercury interactive www.merc-int.com
Rational Functional Tester for Java and Web	It provides testers with automated testing capabilities for functional testing, regression testing, GUI testing and data-driven testing. Provides automated testing, functional testing, and regression testing of Web-based. .Net, Java, 3270 (zSeries™) and 5250 (iSeries™), Siebel, and SAP ®applications.	IBM Rational http://www-306.ibm.com/software/

Continue

Table 8 - Continuation

Rational Robot	It allows user to create, modify, and run automated functional, regression, and smoke tests for e-applications built using a wide variety of independent development.	Rational www.rational.com
Rational TeamTest	It is a complete set of functional testing tools, delivering seamlessly integrated functional testing of enterprise-level client/server applications. Built on a scalable, integrated server-based test repository, Rational TeamTest combines leading-edge testing power and comprehensive management tools to set the standard for automated testing of client/server applications.	Rational www.rational.com
SAFS (Software Automation Framework Support)	SAFS provides for the implementation of compatible keyword-driven test automation frameworks. Initially, but not exclusively, for Rational Robot and Mercury Interactive WinRunner.	SAS Institute http://safsdev.sourceforge.net/
SilkTest	Automated functional and regression testing.	Borland Software Corporation http://www.segue.com/
Silktest International	It is an advanced, standards-based testing platform for today's global enterprise applications. With SilkTest, Segue® extends the capabilities of its leading SilkTest functional and regression testing solution by providing users with the ability to perform simultaneous testing of localized applications across multiple languages, platforms and Web browsers with a single test script.	Segue www.segue.com
Smalltalk Test Mentor	Test Mentor is an automated testing framework for smalltalk. It seamlessly integrates UI record/playback with domain object testing for deep regression testing of your applications. Test mentor automatically gathers executions and method coverage metrics, and provides analysis tools so you can rapidly measure the health of your project.	Silvermark www.silvermark.com

Table 8 - Continuation

SQA Team Test: ERP Extension for SAP	SQA Team Test ERP (Enterprise Resource Planning) Extension provides automated validation (functional testing) of SAP R/3 implementations. It is packaged as an SQA Robot extension, so you get the advantages of SQA Robot's object-level recording, which provides robust test scripts, even when the SAP application changes as a result of configuration changes.	Rational www.rational.com
SQA Test Foundation for PeopleSoft	SQA TestFoundation for PeopleSoft is an Automated Application Quality (AAQ) solution for PeopleSoft. SQA TestFoundation for PeopleSoft contains industry-proven methods for successful implementations, comprehensive requirements lists and their related validation steps, and the software solution for automated validation from Rational.	Rational www.rational.com
Tasker	Tasker is a GUI keyboard and mouse recorder with a clean and simple interface that was inspired by the VCR: buttons for Record, Stop, and Play. It is easy to get started with Tasker since it is not necessary to learn the scripting language. Once you record your actions for testing, you can play them back at the speed you desire and loop as many times as you like. There are many advanced features as well, such as dynamic auto-typing for unique data entry, loop interruption, playback logging, and the ability to compile native .EXE programs. Any actions that you record can be saved as an editable text file (.TXT), and there is a small scripting language available as well. These features allow you to have complete control over the playback actions.	Vista Software, Inc. http://www.vista-software.com/
TDGEN	It is a test data generator which works as a stand- alone product or as part of the fully integrated TestWorks/Advisor tool suite. TDGEN takes an existing test script and substitutes new random or sequential data values to create additional tests. With minimal work, TDGEN increases the size of a test suite to more fully exercise the application under test. With TDGEN hundreds of additional tests can be created in a short amount of time.	Software Research, Inc. www.soft.com/Products/index.html

Table 8 - Continuation

Test Now	Add-on package to Microsoft Test. It has been discontinued, but is still available as a free download.	ST Labs, Inc. www.stlabs.com
	The idea of the product is made up of four parts: (1) It supplies the user with common routines that must always be created when starting a new project with Visual Test. Basically, it's 10,000 lines of code the user doesn't have to write but would have had to otherwise. (2) It supplies the user with a common approach to creating their test cases. All too often people are given Visual Test and told to "automate the testing of the product." Keeping things flexible to make future changes and enhancements easier is difficult to do your first couple of times automating a product. This guides the user to help keep things flexible for future needs by allowing them to incorporate a "framework." (3) A full and heavily commented suite of tests is included. Basically, it's a "real world" test suite that they can tear apart and learn from when creating their own automated tests when using Microsoft Test. (4) A stand-alone utility for not only capturing X-Y coordinates when dealing with "fake" or virtual Windows controls, but to also keep it on an independent system so that moving from one resolution to another will keep coordinate changes to a bare minimum.	
	The product comes with the source code for most of the routines.	
TestAgent	TestAgent focuses on making User Acceptance Testing more efficient and it enables developers and QA to meet deadlines without compromising quality. Some of the key features include capturing and recording all data on the applications' pages, automatically detecting and capturing standard and custom content errors. TestAgent doesn't only report that the page failed but it also gives all the information necessary to troubleshoot the problem. Detailed reports on historical performance are available.	Strenuus http://www.strenuus.com/

Table 8 - Continuation

TestBase	TestBase eliminates the need to copy an entire database to test systems or write complicated and error-prone SQL scripts. TestBase extracts sub-sets or volume data reading all Referential Integrity (RI) information directly from the DB2 catalog tables. Alternatively, TestBase allows you to enter desired RI and masking rules and to then allow all testing personnel to utilise these rules when extracting their production data. Correctly applying RI and masking rules to all DB2 and legacy production data significantly improves test data as well as the overall quality of application testing. Furthermore, TestBase's Mandatory Masking permits your organisation to comply with data privacy mandates while providing data compliance to auditors. TestBase also improves testing efficiency by giving each user a distinct view of their data. This allows multiple developers to concurrently load, refresh, compare and test against the same tables without unnecessary overhead or risk of data corruption or contention while eliminating the need for multiple test environments.	Macro4 www.macro4.com
TestBench for iSeries	Total test automation for the IBM AS400 (iSeries). TestBench400 – fully integrated Database, Screen & Report test automation designed specifically for AS/400 systems: • Batch and Interactive program coverage • Advanced Test Planning, Data Creation and Management • Recording, Playback and Verification of Scripts – Native, GUI & web browser • Full Test Results Analysis and Audit-Ready Reporting.	Original Software www.origsoft.com
Tester	A complete user interface testing tool that will help you automate everything from thick client applications to Web front ends running in Microsoft Internet Explorer to Windows Forms-based Microsoft .NET applications.	MSDN Magazine http://msdn.microsoft.com/msdnmag/issues/02/03/Bugslayer/

Table 8 - Continuation

TestGUI	It offers unrivalled GUI test automation for the IBM iSeries (AS/400), SQL Server, MS Access and Oracle platforms. TestGUI offers: • Detailed testing of all Windows applications • Intelligent interrogation of individual screen elements • Complete understanding of Jwalk, Cool:Plex, Delphi and Visual Lansa, Visual Basic and C++ object classes • Also supports Microsoft.Net and VideoSoft Flexgrid controls • Fast-start function & regression testing • Full verification of underlying batch & interactive processes for the AS/400 • Dramatic increase in applications quality and performance	Original Software www.origsoft.com
TestQuest Pro Test Automation System	TestQuest provides non-intrusive test automation tools and services for information appliances, general computing, handheld devices and industrial control.	TestQuest, Inc. www.testquest.com
TestSmith	TestSmith is a powerful and versatile Functional/Regression Test Tool. It features an Intelligent, HTML/DOM-Aware and Object Mode Recording Engine, and a Data-Driven, Adaptable and Multi-Threaded Playback Engine. TestSmith provides a complete and stable solution for testing Web Sites, Web Applications and Desktop/Windows Applications at very low cost.	Quality Forge www.qualityforge.com
Trecorder	Trecorder is a class that allows to record and play back mouse and keyboard events	Cyamon Software http://www.cyamon.com/recorder.html

Table 8 - Continuation

Turbo Data	TurboData is a test data generator. Simply read in the table and column information directly from your database, press 2 pushbuttons, and TurboData will load your database with valid test data, all the foreign keys will be correctly resolved.	Canam Software Labs, Inc. http://www.turbodata.ca/
Unified TestPro (UTP)	Unified TestPro is a proven 3rd generation test automation solution, which uses a roles-based software test automation approach to Design, Build and Run automated test cases. Using Key Words UTP creates cost-effective and maintainable test suites allowing more automated testing with fewer technical resources. SDTs extensive customer base has successfully employed this solution for use in many technological areas – Legacy Client/Server, E-commerce, Embedded, APIs, Telecom, Java, Web, etc.	SDT (Software Development Technologies) http://www.sdtcorp.com/
Vermont High Test Plus	Vermont HighTest Plus is an integrated tool set for automated testing of Windows 95, NT, and 3.1 applications. Capabilities include object-level record/playback of all Windows and VB controls, a Point and Click Suite Manager, a natural-syntax scripting language, automatic logging of test results, and an integrated debugger.	Vermont Creative Software www.vtsoft.com
Visual Test	Rational Visual Test is an automated testing tool that makes it easier and cost-effective for organizations to deploy mission-critical applications for the Microsoft Windows 95 and Windows NT operating systems and for the Web. Rational Visual Test helps developers rapidly create tests for applications of virtually any size and created with any development tool. Visual Test is integrated with Microsoft Developer Studio, a desktop development environment, and has extensive integration with Microsoft Visual C++.	Rational Software Corporation www.rational.com

Table 8 - Continuation

WebKing	It is an automated web test tool, which provides exhaustive tests and analysis of the sites and applications web to assure that they expire with the reliability, safety and goals of developments necessary to support your business with efficiency.	Parasoft www.parasoft.com
WinRunner	WinRunner is an integrated, functional testing tool for your entire enterprise. It captures, verifies and replays user interactions automatically, so that you can identify defects and ensure that business processes, which span across multiple applications and databases, work flawlessly the first time and remain reliable.	Mercury Interactive www.merc-int.com
xrc-X Remote Control	Xrc is a record and playback user emulator used for a variety of testing and demonstration purposes. Xrc runs on any X workstation with the Xtrap or Record extensions to achieve true event-driven synchronization (perfect for measuring interactive response time performance).	Absol-Puter http://www.absol.com/
Xrunner	Designed for testing the GUI portion of Xwindows applications.Xrunner 4.0 's integrated testing tool components includes the RapidTest ScripWizard, which navigates all available UI paths to create a complex test script suite for unattended regression testing, and the Visual testing environment, which combines object-oriented recording, point-and-click test generation and test script logic into a single environment ,flexible verification and replay options, sophisticated reporting tools and portability across multiple platforms.	Mercury Interactive www.merc-int.com
Test Design /Data Tools		
Testing Tool	**Description**	**Vendor/URL**
File-AID/CS	It is a comprehensive test data management tool designed to help developers, testers, and DBAs works efficiently with data as they develop, test and implement distributed applications.	

Table 8 - Continuation

Smart TestTM	ASG-SmartTest is the interactive tester and debugger for ASG-Existing Systems Workbench TM (ESW®), an integrated life cycle solution for managing your company's existing systems. SmartTest populates the Application Knowledge Repository™ (AKR™) with Analytical Engine™ to provide source-level debugging for COBOL, Assembler, and PL/I application programs. With SmartTest, you can quickly set up, execute, and log an application test session.	ASG software solutions www.asg.com
Load / Performance Tools		
Testing Tool	**Description**	**Vendor/URL**
Application Expert	Application Expert 2.5 offers network and application managers integration with EcoPREDICTOR for predicting an application's impact on a network before deployment. Information from EcoPREDICTOR serves as the basis of providing analysis for capacity planning with real data captured from an existing network. Customers will be able to browse for Application Expert transaction libraries whether they reside on a platform containing EcoPREDICTOR or on a machine that is accessible from the EcoPREDICTOR platform. Application Expert enables application profiling and troubleshooting in pre-production environments. The tool enables network managers and application developers to work together to analyze an application's impact on the network before it is deployed.	Compuware www.compuware.com
Astra Load Test	Tests the scalability and performance of Web applications. Emulates the traffic of thousands of users to identify and isolate bottlenecks and optimize user experience.	Mercury Interactive www.merc-int.com

Table 8 - Continuation

ClientVantage	IT administrators and operations managers face an increasingly difficult challenge ensuring applications are available and perform at acceptable levels. Systems and applications are more complex, users more demanding. ClientVantage provides an alternative to hit-or-miss methods by getting to the right information automatically. It provides diagnostic data to narrow down the cause of application performance problems so IT teams know where to look, even before problems affect end users.	Compuware www.compuware.com
iStrobe	iStrobe provides analysis of Strobe application performance data via a web browser. iStrobe works in conjunction with Strobe enabling users throughout the IT organization to analyze measurement data interactively from their workstations' web browser. iStrobe consolidates Strobe reports to bring together the information you need to make performance issues easier to pinpoint. In addition, iStrobe's intuitive interface allows users to easily locate the source of performance problems, and the online performance hints and tips provide critical information necessary to solve these problems. With iStrobe you get real business benefits: • analysis of Strobe application performance data via a web browser • guided help throughout the application performance analysis process • recommendations for changing SQL statements and DB2 database definitions to improve application performance • performance analysis of applications that use Java, CICS, DB2, IMS, WebSphere MQ, z/OS, UNIX System Services, ADABAS, Advantage CA-IDMS and Advantage Gen System Services and written in COBOL, PL/I or C.	Compuware www.compuware.com
LoadRunner	Multi-user system and server testing tool. Automated client/server system testing tools which provide performance testing, load testing and system tuning for multi-user applications	Mercury Interactive www.merc-int.com

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Table 8 - Continuation

NetworkVantage	NetworkVantage is a passive monitoring solution that delivers enterprise-wide metrics on application performance and network resource consumption. It gathers traffic flow information for over 2000 applications and protocols, ranging from enterprise applications and environments such as MS/Exchange, SAP R/3, Oracle and Citrix, to peer-to-peer applications such as KaZaA and eDonkey, to protocols such as HTTP(S), SIP, FTP, L2TP and GPRS.	Compuware www.compuware.com
Rational Performance Tester	Performance Tester is a multi-user load testing and performance-testing tool for validating Web application scalability. Creates, executes and analyzes tests to validate the reliability of complex e-business applications.	Rational www.rational.com
ServerVantage	ServerVantage increases application availability and reduces response times by monitoring applications, servers and databases and identifying problems before they impact critical business processes. ServerVantage corrects problems without operator intervention.	Compuware Corporation www.compuware.com
SilkPerformer	SilkPerformer V is a load-testing tool that provides true visual verification under load capabilities for Web applications. This allows you to capture content errors that occur only when your application is subjected to a realistic load, enabling you to greatly increase the accuracy and reliability of your system. SilkPerformer V's extensive request/response logging mechanism allows for extremely efficient root cause analysis even in large-scale load tests.	Segue Software www.segue.com
SilkPerformer Lite	It is a highly accurate, cost-efficient, and easy-to-use load and stress-testing tool for predicting the performance, scalability, and reliability of Web applications with up to 100 simultaneous users prior to their launch.	Segue www.segue.com

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Table 8 - Continuation

Strobe / APM	Strobe is a performance measurement system from Compuware Corporation. It produces a collection of reports that tells where and how much time is spent in a batch processing program or online subsystem. Customers use this information to determine how to revise their program or subsystem to help improve its performance. APM stands for Application Performance Management and works in conjunction with Stobe MVS. APM allows application developers to use a workstation to develop, test and maintain OS/390 applications, using a graphical user interface.	Compuware Corporation www.compuware.com
Test Process / Management Tools		
Testing Tool	**Description**	**Vendor/URL**
ApTest Manager	It provides software test case management, improving consistency, organization, and control throughout the test lifecycle. Test are entered into ApTest Manager's Test Case repository on-line and becomes immediately available to your entire team to document test requirements, test specifications, and test plans; execute repeatable comprehensive test cycles; and review and compare the results of test runs. Reports can be generated at any time for any test run showing the results of testing, both separately and in comparison to other test runs on different product configurations or versions. Test Specifications can be produced as can management reports showing planed versus actual schedules, test runs executed by date, test area, and tester, etc.	Applied Testing and Technology, Inc. http://www.aptest.com/atm2/
AutoTester Client/Server for use with SAP R/3	Designed for SAP R/3 implementation teams, this product provides automated unit, functional, integration and regression testing, as well as a powerful scripting language for general task automation. AutoTester Client/Server is a comprehensive automated testing solution specifically designed to support R/3 project teams in the configuration and automated testing of SAP R/3.	AutoTester Inc. www.autotester.com

Table 8 - Continuation

E-SIM	E-SIM is native software simulator (NSS) for embedded software. It makes it possible to develop and test software before any target hardware is available. E-SIM provides high level I/O simulation library for creating interface models of missing hardware, RTOS kernel simulation library, visualization, monitoring and trace tools, Man-Machine-Interface simulation and record/replay facility.	Accelerated Technology http://www.acceleratedtechnology.com/
McCabe Enterprise Quality	Users are now able to import and export Integrated Quality (IQ) project data without having a direct network connection to the IQ data. This is useful when the project team is dispersed and requires reporting on IQ data across the enterprise.	McCabe Software www.mccabe.com
QA Director	*QA*Director® is a Windows-based test process management tool that is part of Compuware's comprehensive *QA*CenterTM family of application testing products. It provides application and system managers, developers and QA workgroups with a single point of control for orchestrating all phases of testing. *QA*Director integrates test management with automated testing to provide a framework for managing the entire testing process-from planning and design to test execution and analysis. *QA*Director also enables you to make the best use of existing test assets (test plans, cases, scripts), methodologies and application testing tools.	Compuware Corporation www.compuware.com/qacenter
QES / Architect	QES/Architect is a complete CAST (Computer-aided Software Testing) system without the need for scripting or programming. The test data is stored in a relational database, which makes the maintenance and management of the test data very efficient and easy.	QES Inc www.qestest.com

Table 8 - Continuation

Rational Test RealTime System Testing	It is a Cross-platform solution for component testing and runtime analysis. • Designed specifically for those who write code for embedded and other types of pervasive computing products. • Supports safety- and business-critical embedded applications. • Allows you to be more proactive in your debugging, discovering and correcting errors before they make their way into production code. • Automated source code review, which reports on adherence to guidelines for C source code. • Integrates with IBM® Rational® solutions for model-driven development, test management, and software configuration management. • Integrates with industry-leading third-party tools, such as Mathworks Simulink, Microsoft Visual Studio, and TI Code Composer Studio. • Eclipse plug-in allowing for seamless integration for Runtime Analysis with the Eclipse C/C++ Development Tools (CDT)	Rational www.rational.com
Reconcile	Reconcile is designed to do accounting reconciliations. To assist quick learning, the program looks very similar to a spreadsheet, and has many of the same menu commands. With complete data, reconciliation is normally finished and printed with a few mouse clicks. This program will handle different types of reconciliation, not just the simple case where two entries contra each other. There is a detailed audit trail. Small differences can be handled, and accounted for exactly. Data can be imported from databases (using the ODBC system). Various text file formats can also be used. Even more easily, a correctly formatted new file can be generated by copying and pasting data.	Reconcile Software www.reconcilesoftware.com

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Table 8 - Continuation

SDTF-SNA Development Test Facility	It provides PC-based environment for development, architectural conformance verification, load/stress and performance testing. Provides over 13,000 ready-to-run validated tests, and allows development of additional tests using test case development tools and an open API (Application Programming Interface).	Applied Computer Technology www.acomtech.com
SilkPilot	SilkPilot is a tool to test distributed application components. The maker of SilkPilot is Segue, a provider of testing tools for the enterprise. Their family of Silk products includes other testing tools for various areas of Web, Java and distributed development.	Segue www.segue.com
SilkPlan Pro	It is a premier automated test management product that spans the entire development lifecycle of a company's core enterprise applications – from the earliest planning stages through test design, scheduling and execution phases. The solution is designed to help QA testers and developers create predictable outcomes for their projects, manage costs, provide more effective risk management and accelerate their products' time-to-market.	Segue www.segue.com
Test Case Manager (TCM)	It is a tool designed for software test engineers to organize test cases for storage and execution logging. Test cases are written up in a standard format and saved into the system.	Pierce Business Systems http://jupiter.drw.net/matpie/PBSystems/products/Development.html
Test Station	It provides a powerful environment for developing, debugging, and running in-circuit board test programs.	Teradyne www.teradyne.com
TestDirector	Test planning and design, automated test creation, manual and automatic test execution, defect tracking and application quality analysis	Mercury Interactive Corp. https://h10078.www1.hp.com/cda/hpms/display/main/

Table 8 - Continuation

Test Manager	TestManager is a software development system written in 100% pure Java. It provides an IDE (Interactive Development Environment) for working with regression test suites, including the facility to create, categorize, execute, and archive a set of tests.	Julian Jones Ltd. www.julianjones.com
TestWorks	It is an integrated suite of testing tools accessible from a GUI or command line. Its comprises four product bundles that work independently or together: STW/Regression automates test execution for GUI and client/server applications; STW/Coverage measures how much of your code has been tested in branch, call-pair, and path coverage; STW/Advisor uses 17 metrics to analyze an application's data, logic, and size complexity; STW/Web supports development and maintenance of web applications. TestWorks for Windows includes STW/Regression for Windows and TCAT C/C++.	Software Research www.methodstools.com/tools/testing.html
Test Environment Toolkit (TET)	The Test Environment Toolkit (TET) offers the core facilities of TETware to UNIX and Linux users only. It is provided as an open source, unsupported, command-line product. It is widely used in many test applications including The Open Group's UNIX Certification program and the Free Standards Group's LSB Certification program. TET is a multi-platform uniform test framework, into which non-distributed and distributed test suites can be incorporated.	The Open Group http://tetworks.opengroup.org/Products/tet.htm
TMS	The Test Management System (TMS) suite consists of three products: TPS (Test Planning System), TCS (Test Control System) and PRS (Problem Reporting System). TPS creates sophisticated Test Plans. TCS is designed to manage test data for complex mainframe systems with multiple interfaces. PRS provides a solution to problem management. Each product can be purchased individually or all in the complete suite.	TESTMASTERS www.testmastersinc.com

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Table 8 - Continuation

T-Plan Professional	The T-Plan Professional Product is modular in design, clearly differentiating between the analysis, design and management of the test assets from planning to execution.	T-plan www.t-plan.com
Versa Test Classic	It provides the power for testing professionals who want to be in control. Confidence of operation means that applications, systems, devices, and networks are tested before they go into a live environment. The VersaTest Classic runtime engine is the VPRO process, which exchanges messages with any application that it is testing. Multiple communication protocols and middleware stacks are available including TCP/IP, Websphere MQ, XPNET, X.25, SNA and many other legacy protocols.	Ascert www.ascert.com

Unit Testing Tools

Testing Tool	Description	Vendor/URL
AQTest	Automated support for functional, unit, and regression testing. Aqtest automates and manages functional tests, unit tests and regression tests, for applications written with VC++, VB, Delphi, C++Builder, Java or VS.NET. It also supports white-box testing, down to private properties or methods. External tests can be recorded or written in three scripting languages (VBScript, Jscript, DelphiScript).	Automated QA Corp. http://www.automatedqa.com/
Aunit	Aunit is a set of Ada packages based on the xUnit family of unit test frameworks. It's intended as a developer's tool to facilitate confident writing and evolution of Ada software. It is purposely lightweight, as one of its main goals is to make it easy to develop and run unit tests, rather than to generate artefacts for process management. The framework supports easy composition of sets of unit tests to provide flexibility in determining what tests to run for a given purpose.	ACT Europe http://libre.act-europe.fr/aunit/

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Table 8 - Continuation

Check	Check features a simple interface for defining unit tests, putting little in the way of the developer. Tests are run in a separate address space, so Check can catch both assertion failures and code errors that cause segmentation faults or other signals. The output from unit tests can be used within source code editors and IDEs. Check was inspired by similar frameworks that currently exist for most programming languages; the most famous example being Junit for Java.	SourceForge http://check.sourceforge.net/
cUnit	Unit testing framework for C. It is based on the initial architecture of CppUnit and supports various test runner interfaces like console, curses and XML based.	
HarnessIt	It is a unit testing software for the Microsoft.NET languages. Designed from the ground up for the .NET Framework, HarnessIt takes full advantage of language innovations provided by .NET to create a simpler, more flexible unit testing framework.	United Binary, LLC. http://www.unittesting.com/
HtmlUnit	HtmlUnit is a java unit-testing framework for testing web based applications. It is similar in concept to httpunit but is very different in implementation. Which one is better for you depends on how you like to write your tests. HttpUnit models the http protocol so you deal with request and response objects. HtmlUnit on the other hand, models the returned document so that you deal with pages and form and tables.	Gargoyle Software http://htmlunit.sourceforge.net/
Nunit	Nunit is a unit-testing framework for all .Net languages. Initially ported from Junit, the current production release, version 2.4, is the fifth major release of this xUnit based unit testing tool for Microsoft .NET. It is written entirely in C# and has been completely redesigned to take advantage of many .NET language features, for example custom attributes and other reflection related capabilities. Nunit brings xUnit to all .NET languages.	Nunit www.nunit.org

Table 8 - Continuation

QtUnit	QtUnit is a unit-testing framework for C++, originally based on CppUnit 1.5 written by Michael Feathers. All code has been refactored and ported to exclusively use Qt 3.x as it base library. This makes it highly portable to all the platforms supported by Qt, without compromising on the advanced features that are currently expected from modern software.	UWYN http://www.uwyn.com/projects/qtunit/
SmartTestTM	This product suite offers a unique approach to load testing that combines the power of Real User Traffic with extensive protocol coverage across Layers 2-7 to effectively test device/application weaknesses and proactively tune Access Network devices for massive production deployments. With it, engineers can test product performance and scalability under real-world scenarios by emulating the patterns and trends of end-user. The product is software solution that leverages open systems technology, is scalable across hardware platforms, and is architected to easily integrate new protocols and authentication standards as they are developed.	interNetwork, Inc. http://www.inw.com/
TagUnit	TagUnit provides a way to perform assertions on the content that custom tags generate and the side effects that they have on the environment such as the introduction of scoped (request/page/session/application) attributes, cookies and so on. In addition to this, assertions can be made on the constraints specified within the tag library descriptor file that give us a way to verify the contract that a tag provides.	
Test Mentor – Java Edition	A functional test and test modeling tool for Java developers & QA Engineers to use as they develop their Java classes, clusters, subsystems, frameworks, and other components, either deployed on the client or the server during unit and integration testing.	SilverMark Inc www.javatesting.com
XMLUnit	XMLUnit enables Junit-style assertions to be made about the content and structure of XML. It is an open source project that grew out of a need to test a system that generated and received custom XML messages.	Sourceforge http://xmlunit.sourceforge.net/

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Table 8 - Continuation

XSLTunit	It provides a unit testing framework for XSLT transformations similar to the "*unit" environments available for other languages (i.e. Junit for Java). Although not a general purpose programming language, XSLT is Turing complete and allows to develop powerful (and complex) transformations that deserve unit testing.	XSLTunit http://xsltunit.org/
X-Unity	X-Unity is a unit-testing environment designed for Microsoft .NET framework. Its primary purpose is to automate and facilitate day-by-day unit testing activities, making them a natural part of your development process. The creation of X-Unity was inspired by ideas of Extreme Programming and Refactoring, and its code was written from scratch with heavy usage of these techniques.	Validio Ukraine http://x-unity.miik.com.ua/
Test Implementation Tools		
Testing Tool	**Description**	**Vendor/URL**
Access for DB2	Modify, insert or delete data in test database. To fully test your applications, it is necessary for your test database to contain specific test cases. Some of those test cases may include data errors or combinations of data values that are rarely found in your production database.	Princeton Softech, Inc. http://www.princetonsoftech.com/
Compare for servers	Compare for Servers analyzes complete sets of referentially intact data and identifies the differences automatically. You specify the sources for the data you want to compare, run or schedule the compare request, and review the results in seconds. Compare for Servers enables you to easily verify the accuracy of your test results and improve the quality of your applications. You save hours of coding verification programs or manually inspecting tables. Compare for Servers supports the major distributed databases, including Oracle, DB2/UDB, Sybase, SQL Server and Informix.	Princeton Softech Inc. http://princetonsoftech.com/

Table 8 - Continuation

DateWise FileCompare	Automated token-by-token text and binary file comparison utility. Patented file comparison utility designed for both binary and text files with expected differences without requiring detailed file specification. Current versions support combinations of ASCII, EBCDIC, *big endian*, and *little endian* files.	Date Wise Ltd. www.datewise.com/mt
MemCheck for windows	The MemCheck code is designed to provide Windows NT/2K/XP driver developers with a tool to help in the detection of the following memory handling issues: Buffer overrun, Buffer corruption, Buffer use after buffer release, Double buffer releases.	IBM http://www1.ibm.com/support/docview.wss?uid=swg24003878
Rational Purify	Rational Purify® for UNIX has long been the standard in error detection for Sun, HP, and SGI UNIX platforms. With patented Object Code Insertion technology (OCI), Purify provides the most complete error and memory leak detection available. It checks all application code, including source code, third party libraries, and shared and system libraries. With Purify, you can eliminate problems in all parts of your applications, helping you deliver fast, reliable code.	Rational Software Corp www.rational.com
SilkRealizer	Functional and performance testing tool. SilkRealizer is a scenario tool that enables no technical, as well as technical users to develop and deploy true system level testing by combining functional and performance tests to simulate real world events to assure that applications will meet the requirements, before "going live".	Segue Software www.segue.com
ZeroFault	Memory analysis tool. ZeroFault is the next generation in active memory analysis tools. Using patent pending technology, it detects and reports run-time memory problems before they become expensive. ZeroFault works on any AIX executable without recompilation, or re-linking.	The Kernel Group www.tkg.com

Table 8 - Continuation

Defect Management Tools		
Testing Tool	**Description**	**Vendor/URL**
Advanced Defect Tracking	Advanced Defect Tracking is designed for software companies to simplify their feature development, bug tracking, and helpdesk support. The software allows you to track features, defects, bugs by product, version, customer etc. Once defects, incidents or features are entered, real-time reports can be generated by employee, or by product and version to quickly determine what has or has not been resolved/fixed. Advanced Defect Tracking's greatest benefit is allowing you to ensure that all the features, bugs etc, for a product, are resolved by the time the product is released.	Borderwave Software http://www.borderwave.com/
Bug tracker Software	Bug Tracker Software is a web-based bug tracking and defect data sharing system. Features include database support for MSSQL, ORACLE, Sybase, Access, Postgres, DB2, etc. Offers E-mail and instant messaging support, cross platform support and web browser operation. Free product demo package available through website.	Bug Tracker Software http://www.bug -tracker- software.com/
BugAware	It is web based available ASP Hosted or locally installed. Submit bugs, which include custom fields, file attachments, time tracking, change history and a user discussion thread.	Jackal Software Pty Ltd http://www.bug aware.com/
Buggit	It manages bugs and features throughout the software development process. Testers, developers, and managers can all benefit greatly from the use of Buggit. They can enter and edit bugs/features, perform quick lookups of existing issues, print from a wide variety of powerful reports and graphs (see screen shot links at PBSystems webpage), administer new bug project databases, and much more. Buggit provides an unlimited number of central, multi-user databases, each capable of handling multiple concurrent users across the development team.	Pierce Business Systems http://www.win site.com/bin/Inf o?5000000257 51

Table 8 - Continuation

Bugzilla	It is server software designed to help you manage software development • Optimized database structure for increased performance and scalability • Excellent security to protect confidentiality • Advanced query tool that can remember your searches • Integrated email capabilities • Editable user profiles and comprehensive email preferences • Comprehensive permissions system • Proven under fire as Mozilla's bug tracking system	http://www.bugzilla.org/
ClearDDTS	Designed to track and manage product defects and enhancement requests uncovered during product development and quality assurance testing.	IBM Rational Software http://www-306.ibm.com/software/awdtools/clearddts/
ClearQuest	It provides defect tracking, process automation, reporting and lifecycle traceability for better visibility and control of the software development lifecycle.	IBM Rational http://www-306.ibm.com/software/awdtools/clearquest/
Defect Agent	It is powerful, get-to-the point defect tracking software for software development teams. Track bugs and enhancement suggestions easily. General features include bug tracking, workflow management, project prioritization, detailed audit history for each item, data table definition, and the ability to maximize communication between all technical staff members. Development, quality assurance, documentation and technical support teams all use Defect Agent to facilitate defect reporting, verification, repair, test and final release.	Inborne Technology Corporation http://www.defectagent.com/

Table 8 - Continuation

Elementool	Elementool is the leading provider of web based project management tools for help desk, bug and defect tracking and time tracking tools. Customers from all over the world use the web based project management tools on a daily basis as part of their project development and testing process.	Elementool Inc. http://elementool.com/
McCabe TRUEtrack	McCabe CM – TRUEtrack enables organizations to track the tasks and changes in their software development processes, helping to eliminate duplicate problems and to increase visibility and accountability throughout the change process.	McCabe Software, Inc. http://www.mccabe.com/
Merant Tracker	Merant Tracker delivers automated tracking of bug reports, defects and other project issues and changes, as well as Merant Version Manager™, which enables simplified and error-free parallel development.	Merant Enterprise www.merant.com
Ozibug	Ozibug is a platform-independent, Web-based bug tracking system. It is written entirely in Java, and utilizes *servlet* technology. This allows Ozibug to be installed and run on any platform for which a Java Virtual Machine (JVM) and *servlet* container are available. It is ready to work straight out of the box on any platform. However, for those who require more flexibility, it provides features such as role based access, audit trails, email notifications, full internationalization, and a customizable appearance.	Tortuga Technologies http://www.tortuga.com.au/
Problem Tracker	It is a powerful, easy-to-use Web-based collaboration tool to help companies track business issues and automatically manage them through to resolution.	Net Results Corporation www.problemtracker.com
ProjectTrack Bug	It is a database for programmers costumed designed to hold multiple projects so you can track your changes, registrations, and bug lists as you develop your software products. Each of the projects in the database has four sub-databases attached to it. One for bug, customer and development note, and an eMail log.	Wabbit Wanch Design http://www.wabbitwanch.com/

Table 8 - Continuation

PVCS Tracker	It automates the capture and communication of issues and change requests across development and other project teams. Integration within PVCS Professional enables developers to link associated development files with Tracker-managed issues and changes, while enabling managers to visualize and report on team progress and prioritize workflow tasks.	Merant Enterprise www.merant.com
QuickBugs	QuickBugs is used to manage product development by focusing effort on the tasks required to efficiently bring the project to completion. Developers, testers and managers use it to record and track the progress of defects (bugs), problems and new features. Each bug report progresses according to a defined workflow that can be fully customized by the organization.	Excel Software www.excelsoftware.com
Remedy Quality Management	It provides a structured mechanism to bring your back-end operational or engineering organizations closer to your customers. This best-of-breed application enables you to prioritize customer issues, assign and route them to appropriate resources, dynamically update priorities based on ongoing customer inquiries, and automatically update the customer on progress and outcomes. As a result, you can raise customer satisfaction by ensuring that their requests pertaining to product defects are more efficiently resolved and that future product iterations reflect their input.	Bmc software www.bmc.com
SilkRadar	With SilkCentral Issue Manager (formerly SilkRadar), you can reduce the cost and speed the resolution of defects and other issues throughout the entire application lifecycle. SilkCentral Issue Manager features a flexible, action-driven workflow that adapts easily to your current business processes and optimizes defect tracking by automatically advancing each issue to its next stage.	Segue www.segue.com

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Table 8 - Continuation

TestDirector	It is a scalable test management tool for planning, executing, and communicating quality control during the entire development process.	Mercury Interactive www.merc-int.com
TrackRecord	It provides an automated tracking system that keeps vital defect information flowing between testing and development teams. Through integration with DevPartner Studio products, TrackRecord easily fits into your organization's automated testing process. It frees up development and test teams to focus on resolving problems and improving application quality.	Compuware www.compuware.com
ZeroDefect	It is a management tool that everyone can use. ZeroDefect comes complete with the following powerful features: • Multi User shared Data Base. • Runs with most ODBC and ANSI SQL compliant data bases. • Simple Point and click interface. • Completely customizable. • Integrated help. • Several levels of security. • Easy for novices, advanced features for power users. • Custom Drop Down Lists. • Integrates with your existing Email system. • Complete set of reports.	ProStyle Software Inc. http://www.prostyle.com/issue.html
Application Performance Monitoring / Tuning Tools		
Testing Tool	**Description**	**Vendor/URL**
IBM Rational Test RealTime	Is is a cross-platform solution for component testing and runtime analysis. Designed specifically for those who write code for embedded and other types of pervasive computing products. Allows you to be more proactive in your debugging, discovering and correcting errors before they make their way into production code.	Rational www.rational.com

Table 8 - Continuation

ProTune	ProTune Validation Service is a hosted, Web-based capacity validation and problem identification service that conducts full-scale testing of your Web site or Web-based application to ensure optimal performance. The ProTune Validation Service team runs validation tests that determine the number of users your site can support before encountering performance problems. During the testing process, you can observe the results online in real time and communicate with ProTune Validation Service experts via conference calls. The test results enable you to identify and fix bottlenecks, to ensure that your Web site or Web-based application will perform at its peak and that each user has a positive experience.	Mercury Interactive www.merc-int.com
Silk Vision	SilkVision from Segue Software is a Web-based enterprise-monitoring product that allows customers to manage the performance of their Web-based applications. With support capabilities for Web, middleware, database, and proprietary server monitoring, SilkVision is the entrepiece of Segue's Reliability Management System. Designed to maintain the health of e-business systems and improve problem identification, SilkVision integrates the latest systems for high-volume Web site application reliability.	Segue www.segue.com
Runtime Analysis Testing Tools		
Testing Tool	**Description**	**Vendor/URL**
AdaTest95/ Cantata++	Cantata++ is a major new version of the Cantata tool suite which has been designed around the requirements of the C/C++ languages to produce a tool which allows developers to efficiently perform unit and integration testing. The product offers high productivity and a unique set of testing, coverage analysis and static analysis features.	http://www.iplbath.com/products/tools/pt400.uk.php

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Table 8 - Continuation

CodeTEST	Consists of six software modules to test embedded software, including Trace, Memory Analysis, Performance Analysis, Statement Coverage, Decision Coverage (DC) and Modified Condition Decision Coverage (MCDC)	Metrowerks http://www.amc.com/http://www.metrowerks.com/MW/Develop/AMC/CodeTEST/default.htm
eValid	eValid helps organizations maintain e-Business continuity, improve website quality and integrity, reduce down time, control costs, and enhance performance to prevent customer loss.	eValid http://www.soft.com/eValid/
IBM Rational Test RealTime	Rational Test Real Time Coverage has the flexibility to address all the coverage needs of developers and QA according to the verification phase of the development or maintenance process, the coverage level and rate to be achieved, and the specific testing requirements	IBM Rational Software http://www.rational.com/

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Table 8 - Continuation

| LDRA | LDRA Testbed is a cost effective analysis tool for use in the improvement of software development and testing processes. Ideal for unit, integration and system testing. It can be used throughout the software life-cycle. Coverage is measured at the following levels:
• Statement
• Branch/Decision
• LCSAJ (Test Path)
• Procedure/Function Call
• Branch Condition
• Branch Condition Combination
• Modified Condition/Decision
• Dynamic Data Flow
• Interface Coverage
The analysis capabilities include programming standards verification, structured programming verification, complexity metric production, full variable cross reference, unreachable code reporting, static data flow analysis, code reformatting, information flow analysis, loop analysis, analysis of recursive procedures and procedure interface analysis. Dynamic Analysis analyses the code and provides an understanding of the code structure and measures code coverage of statements, branches, test paths (lcsaj coverage), sub conditions, & procedure calls. Several coverage levels are available including MC/DC level A of the DO-178B standard. The tool suite is available for C, C++, Ada83, Ada95 & Assemblers (Intel, Freescale and Texas Instruments). | LDRA Ltd

http://www.tridentinfosol.com/asp/verify.html
http://www.ldra.co.uk/distributors.asp
http://www.ldra.co.uk/testbed.asp |
| MemCheck for Windows | The MemCheck code is designed to provide Windows NT/2K/XP driver developers with a tool to help in the detection of the following memory handling issues: Buffer overrun, Buffer corruption, Buffer use after buffer release, Double buffer releases. | IBM
http://www-1.ibm.com/support/docview.wss?uid=swg24003878 |

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Table 8 - Continuation

PolySpace Verifier	PolySpace™ products verify C, C++, and Ada code for embedded applications by detecting run-time errors before code is compiled and executed. This advanced verification technology uses formal methods not only to detect errors, but to prove mathematically that certain classes of run-time errors do not exist. You can use these tools on hand-written code, or code generated automatically from Model-Based Design tools. For automatically generated code, PolySpace Link products trace results back to models to help you correct design errors.	http://www.mathworks.com/products/polyspace
Rational Purify	It is a powerful run-time error checking and memory leak detection tool. It combines comprehensive run-time error checking with an easy-to-use graphical interface. Purify helps users identify execution errors and memory leaks everywhere they occur within an application including source code, system or third party DLL's, COM components and Active X controls. Developers can eliminate run-time problems in all parts of their applications and deliver more reliable applications faster.	IBM Rational www.rational.com
Rational Purify Plus	It is a runtime analysis solution designed to help developers write faster, more reliable code. Runtime analysis includes four basic functions: memory corruption detection, memory leak detection, application performance profiling, and code coverage analysis.	IBM® Rational® www.rational.com
TestWorks/Coverage	It is an integrated suite of coverage analyzers, works individually or as part of the TestWorks multi-platform suite of testing tools. TestWorks/Coverage tools indicate where testing is incomplete by providing measurements to determine how well test cases exercise programs during unit, system and integration test levels. With TestWorks/Coverage, available testing efforts can be focused on untested code, rather than generating redundant or deficient tests. It helps determine when enough testing has been performed so that the product can ship.	TestWorks http://www.soft.com/TestWorks/index.html

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Table 8 - Conclusion

T-SCOPE	T-SCOPE, is a test data observation tool, works directly with TCAT and S-TCAT, part of the fully integrated TestWorks/Coverage testing suite. TSCOPE dynamically depicts logical branches and function-calls as they are exercised during the testing process.	Software Research, Inc. www.soft.com/ Products/index .html

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