

Supplement to SW Development & Quality Assurance

Mgmt of Information Assurance – IS 342 Supplement to CSH5 Chapter 39

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Supplement to CSH5 Chapter 39

- Notorious Software QA Failures
- Psychology and Economics of QA
- Inspections / Walkthroughs / Reviews
- Types of Testing
- Types of Errors
- Designing Good Tests
- Automated Testing

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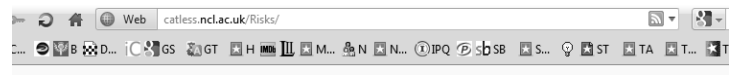
Why Bother with Extensive Lists of SW Glitches?

- Most people don't realize full extent of lousy software
- Alert students to prevalence of errors
- Some errors have spectacular consequences
- Forces realization of how embarrassing and costly such errors can be
- Motivate students to
 - Test their designs and implementations
 - Reject bad software – not inherent in product
- Subscribe to RISKS FORUM DIGEST
 - (see next slide)

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RISKS FORUM DIGEST (1)



THE RISKS DIGEST

Forum On Risks To The Public In Computers And Related Systems

ACM Committee on Computers and Public Policy, Peter G. Neumann, moderator

Search RISKS using

The RISKS Forum is a moderated digest. Its USENET equivalent is comp.risks. ([Google/Deja news archive](#))

- [Vol 26 Issue 31 \(Friday 21 January 2011\)](#) <= Latest Issue
- [Vol 26 Issue 30 \(Friday 14 January 2011\)](#)
- [Vol 26 Issue 29 \(Thursday 13 January 2011\)](#)
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Selectors for locating a particular issue from a volume

Volume number: Issue Number:

Volume Index

The dates and counts do not include the index issues for each volume.

Volume Number	Date Range	Number of Issues
Volume 1	1 Aug 1985 - 31 Jan 1986	45 issues
Volume 2	1 Feb 1986 - 30 May 1986	56 issues
Volume 3	4 Jun 1986 - 30 Oct 1986	91 issues
Volume 4	2 Nov 1986 - 6 Jun 1987	96 issues
Volume 5	7 Jun 1987 - 31 Dec 1987	84 issues
Volume 6	2 Jan 1988 - 31 May 1988	94 issues
Volume 7	1 Jun 1988 - 22 Dec 1988	98 issues
Volume 8	4 Jan 1989 - 29 Jun 1989	87 issues
Volume 9	6 Jul 1989 - 30 May 1990	97 issues
Volume 10	1 Jun 1990 - 31 Jan 1991	85 issues
Volume 11	4 Feb 1991 - 28 Jun 1991	95 issues
Volume 12	1 Jul 1991 - 24 Dec 1991	71 issues
Volume 13	6 Jan 1992 - 2 Nov 1992	89 issues

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RISKS FORUM DIGEST (3)

Volume 14	4 Nov 1992 - 27 Aug 1993	89 issues
Volume 15	2 Sep 1993 - 29 Apr 1994	81 issues
Volume 16	2 May 1994 - 22 Mar 1995	96 issues
Volume 17	27 Mar 1995 - 1 Apr 1996	96 issues
Volume 18	5 Apr 1996 - 31 Mar 1997	96 issues
Volume 19	1 Apr 1997 - 23 Sep 1998	97 issues
Volume 20	1 Oct 1998 - 31 Jul 2000	98 issues
Volume 21	15 Aug 2000 - 29 Mar 2002	98 issues
Volume 22	1 Apr 2002 - 27 Oct 2003	98 issues
Volume 23	7 Nov 2003 - 2 Aug 2005	96 issues
Volume 24	10 Aug 2005 - 30 Dec 2007	93 issues
Volume 25	7 Jan 2008 - 1 Apr 2010	98 issues
Volume 26	8 Apr 2010 - 21 Jan 2011	31 issues

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Notorious QA Failures of 1996



- Mar – New York Times sends out 11,000 default letters instead of 89
- May – new traffic-light program in Washington DC jams traffic for hours by switching to weekend pattern
- Jun – Netcom ISP drops service 13 hours; share price falls 15% overnight
- Jun – Jeopardy TV show on cable interrupted by porn
- Jun – 3-year-old gets IRS refund for \$219,495
- Jul – MS publishes unverified Spanish thesaurus, includes insulting slurs; PR disaster

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1996 (cont'd)



- Jul – GM engine firmware bugs can cause fires
- Oct – ENT Federal Credit ATMS count only first withdrawal, cause \$1.2M loss (recovered)
 - ❑ Bank staff ignored customer warnings for months
- Nov – Amtrak reservation system goes down, has no paper backup
- Nov – CIBC Bank credit card system fails, stops ½ all VISA transactions in Canada
- Dec – Dentist receives 16,000 copies of identical tax form

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1997



- Jan – Finnish DMV sends 11,000 threatening letters to wrong owners
- Jan – Flintstones viewers in Springfield, MO suddenly received Playboy Channel
- Jan – SkyTel pager operator sends PIN to 100,000 beepers; entering PIN caused repetition of broadcast
- Jan – 5,000 new BT pay phones allow free LD calls (discovered after 5 months)

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1997 (cont'd)



- Mar – Intuit admitted its MacInTax software has serious bug; promised to pay any IRS penalties
- Mar – 2 groups secret policemen in Basque country shot at each other because their computers could not correctly identify each others' car registration plates
- Mar – Bank of America refused to believe that honest users had deposited \$3,700 instead of what records showed: \$37,000.
- Mar – Vagrant applies to Sandoz for \$2 refund of price of Ex-Lax; receives check for his ZIP code (\$98,002), promptly disappears (discovered 7 months later)

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1997 (cont'd)



- Apr – MS spell-check consistently suggests that “zzzz” should be “sex”
- May – floating point arithmetic on Pentium II and Pentium Pro chips is bad
- Jun – Smith Barney adds \$19,000,000 to each of 525,000 accounts for a few minutes (total ~\$10 TRILLION accounting error)
- Jun – First Natl Bank Chicago adds almost \$900 MILLION to each of 900 customer accounts (total ~\$764 BILLION error)

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1997 (cont'd)



- Jul – Netscape upgrades its Website to be compatible with Netscape Navigator 4.0, promptly turns to mush for Navigator 4.0 ONLY
- Sep – AT&T tech loads bad Routing and Translation Tables, crashes entire 800-number system for 90 minutes
- Nov – Pentium/MMX chips halts on single instruction available through buffer overflow

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1998



- Jan – CVS Pharmacy records use FirstnameLastname as key
- Jan – MS-Excel 97 includes flight simulator as Easter Egg, crashes systems
- Apr – Los Angeles County underpays employee pension fund for 20 years of errors due to program design – total liability \$1.2B
- Apr – 50,000 GTE customers in S. CA with unlisted numbers see their info published and sold
- Apr – Los Alamos Natl Lab reports SW error almost smashes 2 masses of U-235 together; similar error could exceed critical mass

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1998 (cont'd)



- Jun – AZ lottery never generated #9 in winning combinations
- Jun – Matsushita Panasonic Interactive Media kids' spelling game emits foul language
- Jul – Eudora e-mail v3.0 & 4.0 sends old messages instead of new ones
- Oct – Anderson Consulting installs new SW for UK Social Security, destroys entire database; denial of service for 1 month, causing losses, fraud
- Nov – BBC TV replaced by Eros Channel for a few hours

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1999



- Jan – Excel truncates data on export/import
- Jan – Malmö accounting SW loses transactions, puts city AP in default
- Feb – Photocopier accuses professor of creating 4,294,967,026 copies in two weeks (~3551 copies/second continuously 24 hours), secretary removes photocopy privileges

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1999 (cont'd)



- Mar – Windows 9x incapable of running continuously for more than 49.7 days (so what?)
- Apr – Nissan software includes 24,000 customer e-mail addresses on each e-mail message
- Oct – Toshiba pays \$2.1B to settle lawsuit over bad software in laptops (trashed diskettes)

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2000



- Jan – BulkRegister registers domain names, sells them again 2 days later
- Jan – OUTLOOK interprets words "begin" as instruction to convert rest of text to attachment
- Feb – IRS glitch rejects 40,000 valid e-returns
- Apr – Microsoft's Explorapedia v 1.0 shows the Earth rotating the wrong way. [There was no truth to the rumor that Bill Gates had suggested that the planet's rotation be reversed to match his software's description.]

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2001



- Apr – 51 year-old lady imprisoned by computerized outhouse in Newcastle-on-Tyne; rescued by ripping roof off toilet stall
- Dec – market trader enters order to sell 16 shares Dentsu stock at ¥610,000 (U\$4,924.53); types order to sell 610,000 shares at ¥16, causes 50% collapse in share price

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2002



- Jan – Georgetown, TX bills man \$21,000 for water tax
- Apr – Florida's Brevard County announces errors in transfer payments to towns, demands 10% back
- May – Seattle City Light overcharges customers by 1000%
- May – COMPAQ Web programming error charges \$0.01 for Presario laptops

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Psychology & Economics of Program Testing



- Definitions & Orientation
- The SDLC
- Economics
- Testing Principles

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Definitions & Orientation

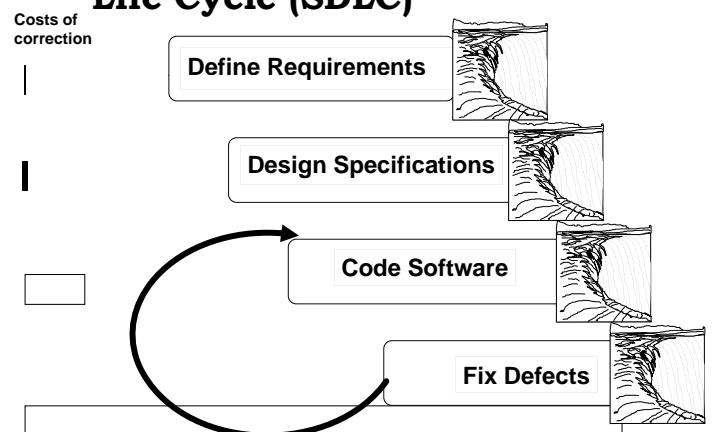


- Trying to *find* errors
- NOT trying to show there are *no* errors
- *Successful* test finds errors
- Problems of language and psychology

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The System Development Life Cycle (SDLC)



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Economics of Testing



- Costs of errors
 - ❑ Roughly 10x increase at every level of development*
 - ❑ Analysis, design, coding, implementation
- Costs of finding errors
 - ❑ Must balance cost of error vs cost of finding error
 - ❑ Possible test cases usually infinite
 - ❑ Impossible to locate all errors
 - ❑ Unnecessary to locate all errors: just significant ones

***"The Economic Impacts of Inadequate Infrastructure for Software Testing"
< <http://www.nist.gov/director/prog-ofc/report02-3.pdf> >
prepared in May 2002 for the National Institute of Standards and Technology (NIST).
See pp 5.3-5.4 for details.

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Economics of Testing



- Black-Box Testing
 - ❑ Derive test data from specifications only
 - ❑ Use exhaustive input testing
 - ❑ But include all possible wrong inputs too
 - ❑ Time and money constraints make it impossible to test everything
- White-Box Testing
 - ❑ try to execute all possible execution paths
 - ❑ but astronomically high # paths
 - ❑ and have to multiply by # of inputs

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Some Principles of Testing



- Define expected values
- Use independent testers
- Pay attention to every result
- Include invalid and unusual inputs
- Look for forbidden results
- Record test cases for re-use
- Errors bespeak more errors
- 80/20 rule (Pareto Principle)

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Inspections / Walkthroughs / Reviews



- Human testing can be highly effective
 - ❑ Apply after analysis/design
 - ❑ Before coding
 - ❑ Catch errors early = cheaper & better correction
- Inspections – team approach
 - ❑ Finds 30%-70% errors
 - ❑ Programmer explains every line of code (~150 lines 3GL/hour)
- Walkthroughs – play computer (think about every instruction)
- Desk checking simply doesn't work

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Types of Testing



- Module / Unit
- Integration Testing
- Function Testing
- System Testing*
- Acceptance Testing
- Installation Testing

*see below for more on system testing

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Testing Modules Alone



How can we execute a subroutine by itself?

- A *driver* program
 - ❑ Calls a module and
 - ❑ Passes parameters to it
- A *stub* program
 - ❑ Represents an as-yet missing module
 - ❑ Not simply a place-holder
 - ❑ Must receive data from calling module
 - ❑ Must return valid values to calling module

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System Testing



- Facility Testing
- Stress Testing
- Volume Testing
- Usability Testing
- Security Testing
- Performance Testing
- Storage Testing
- Configuration Testing
- Compatibility / Conversion Testing
- Installability Testing
- Reliability Testing
- Recovery Testing
- Serviceability Testing
- Documentation Testing
- Procedure Testing

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Types of Errors



- User I/F
- Error handling
- Boundary-related errors
- Calculation errors
- Initial and later states
- Control-flow errors
- Errors in handling or interpreting data
- Race conditions
- Load conditions
- Hardware
- Source, version and I/D control
- Errors in the testing process

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Designing Good Tests

- Design Philosophy
- Boundary analysis
- Testing state transitions
- Testing race conditions and other time dependencies
- Function-equivalence testing
- Regression testing

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Test-Case Design Philosophy

- Complete testing is impossible
- Therefore define subset of test cases likely to detect most (or at least many) errors
- Intuitive approach is “random-input testing”
 - Sit at terminal
 - Invent test data at random
 - See what happens
 - Worst possible approach

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Boundary-Value Analysis

- Cases at boundaries have high value for testing
- Select cases just below, at and just above limits of each equivalency class
- Some testers include mid-range value as well just for additional power of test

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Testing State Transitions

- Every change in output is a state transition
- Test every option in every menu
- If possible, test every pathway to every option in every menu
- Interactions among paths
 - Draw menu maps
 - Identify multiple ways of reaching every state
 - Keep careful records of what you test (can get confusing)

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Testing Race Conditions and Other Time Dependencies

- Check different speeds of input
- Try to disrupt state transitions (e.g, press keys while program switches menus)
- Challenge program just before and just after time-out periods
- Apply heavy load to cause failures (not just poor performance)

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Function-Equivalence Testing

- Use a program that produces known-good output
- Feed same inputs to both the standard program and the program under test
- Compare the outputs
- Automated testing techniques can help
 - For numerical and alphanumeric output
 - For real-time process-control applications

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Regression Testing

- Did the bug get fixed?
 - ❑ Some programmers patch symptom
 - ❑ Few test effectively
- Check that you can produce bug at will in bad version of code
- Use same tests on revised code
 - ❑ Stop if bug reappears
 - ❑ Push the testing if bug seems to have been fixed

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Automated Testing

- Current Testing Methods are Inadequate
- Consequences of Manual Testing Methods
- Automated Testing
- Limitations of Capture/Playback
- Structured Automated Testing
- Benefits of Structured Automated Testing
- Case Study:
COGNOS / Ottawa

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Current Testing Methods are Inadequate

- Manual input
- Unstructured
- Slow
- Depend on testers' awareness and attention
- Leave no audit trail
- Poor or no statistics
- Manual demonstration of errors

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Consequences of Manual Testing Methods

- Quality is not emphasized during SDLC
- Time pressures always squeeze testing
- Testing never catches all the bugs

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Automated Testing

- Capture/Playback
 - ❑ record macros showing mouse movements and alphanumeric input
 - ❑ typically no editing language
- Structured Automated Testing
 - ❑ tool creates structured, editable script
 - ❑ can use databases as source of input
 - ❑ intelligent handling of errors

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Limitations of Capture/Playback

- Merely automate manual procedures
- Difficult to maintain as application changes
- Cannot build regression database
- Must wait until application is ready
- No mechanism for detecting errors
- No mechanism for reporting results

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Structured Automated Testing



- Define test plan
- Document logic
- Generate test procedures
- Apply test procedures
- Evaluate results

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Benefits of Structured Automated Testing



- Consistent, reproducible testing
- Increased test coverage
- Easier maintenance
- Fully documented testing
- Higher-quality software

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Case Study: COGNOS / Ottawa



Using manual testing:

- 6 people
- 3 test phases per product release
- 3,000 manual tests per phase
- 12.5% test coverage
- 15 days for testing
- \$81,000 per release @ 12.5% coverage
- (\$648,000 per release @ 100%)

Using automated testing:

- 6 people
- 3 test phases
- 24,000 tests/phase
- 100% test coverage
- 5 days elapsed time
- \$81,000 per release @ ~100% coverage

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Automated Testing at COGNOS



- 5 days elapsed time
- 6 people
- 3 test phases
- 24,000 tests/phase
- \$27,000/phase using AutoTester

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DISCUSSION



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