

Supplement to SW Development & Quality Assurance

Mgmt of Information Assurance – IS 342 Supplement to CSH6 Chapter 39

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Supplement to CSH6 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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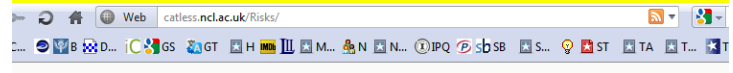
Why Bother with Extensive Lists of SW Glitches?

- 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 [swish-e](#)

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 \(Thursday 13 January 2011\)](#)
- [News about the RISKS web pages](#)
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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

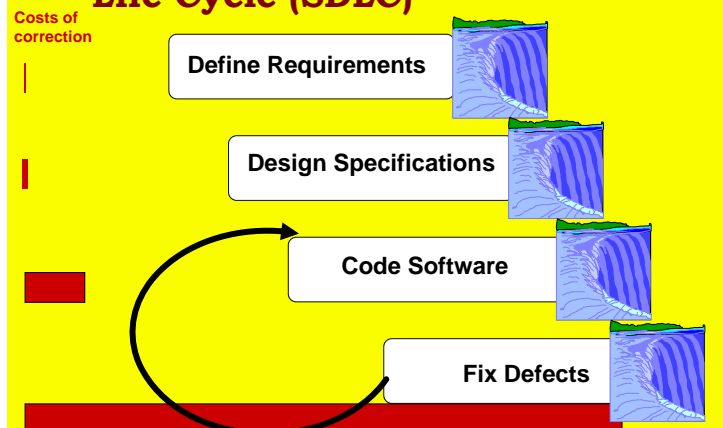


- Trying to *find* errors
- NOT trying to show there are *no* errors
- *Successful* test finds errors
- Problems of language and psychology

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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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Now go and study



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