Implementing Automated Software Testing

How to Save Time and Lower Costs While Raising Quality

Elfriede Dustin
Thom Garrett
Bernie Gauf

Addison-Wesley
Upper Saddle River, NJ • Boston • Indianapolis • San Francisco
New York • Toronto • Montreal • London • Munich • Paris • Madrid
Capetown • Sydney • Tokyo • Singapore • Mexico City
Contents

Foreword by Admiral Edmund P. Giambastiani, Jr.  xv
Foreword by Dr. William Nylin, Jr.  xvii
Preface  xix
Acknowledgments  xxiii
About the Authors  xxv

I. What Is Automated Software Testing and Why Should We Automate?  1

1. What Is Effective Automated Software Testing (AST)?  3
   1.1 Automated Software Testing Definition  4
   1.2 Automated Software Testing Recipes  5
   1.3 Advances in AST Technologies  8
   1.4 Automating Various Software Testing Types  11
   1.5 Providing AST-Based Production Support  16
      Support Troubleshooting the Production Issue, As Needed  16
      Support Identifying the Specific Program Components Affected by
      the Correction  16
      Verify the Accuracy and Quality of the Program Correction  17
      Support the Production STR Triage  17
   1.6 Automating Standards Assessments  18
   Summary  20
   Notes  21

2. Why Automate?  23
   2.1 The Challenges of Testing Software Today  24
   2.2 Reducing the Time and Cost of Software Testing  26
      Automated Test Planning and Development—Initial Test Effort Increase  28
Contents

Test Data Generation—Test Effort/Schedule Decrease 28
Test Execution—Test Effort/Schedule Decrease 32
Test Results Analysis—Test Effort/Schedule Decrease 33
Error Status/Correction Monitoring—Test Effort/Schedule Decrease 35
Report Creation—Test Effort/Schedule Decrease 37
Other Mitigating Factors to Consider 37

2.3 Impacting Software Quality 38

2.4 Improvements to Your Software Test Program 42
   Improved Build Verification Testing (Smoke Test) 43
   Improved Regression Testing 43
   Multiplatform and Configuration Compatibility Testing 44
   Improved Execution of Mundane Tests 44
   Improved Focus on Advanced Test Issues 44
   Testing What Manual Testing Can’t Accomplish 45
   Ability to Reproduce Software Defects 45
   Enhancement of System Expertise 45
   After-Hours “Lights-Out” Testing 45
   Improved Requirements Definition 46
   Improved Performance Testing 46
   Improved Stress and Endurance Testing 47
   Quality Measurements and Test Optimization 47
   Improved System Development Lifecycle 48
   Improved Documentation and Traceability 48
   Distributed Workload and Concurrency Testing 49
   Summary 49
   Notes 50

3. The Business Case 51

3.1 Definition of the Business Case 51

3.2 Identifying the Business Needs 53
   Need for Speeding Up the Testing Effort and Increasing Efficiency 53
   Need for Decreasing the Testing Cost 54
   Need for Applying Test Team Member Skills Most Effectively 55

3.3 Justifying Automation in Terms of Cost and Benefits 55
   Estimating ROI 55
   Overall Test Automation Savings 57
   Test Environment Setup Time Savings 57
   Test Development Time Savings 59
   Test Execution Time Savings 61
   Test Evaluation/Diagnostics Time Savings 62
   Other ROI Considerations 63
   More ROI Metrics 65

3.4 Risks 65

3.5 Other Considerations 67
## Contents

Summary 68  
Notes 68  

4. Why Automated Software Testing Fails and Pitfalls to Avoid 69  
4.1 R&D Does Not Generally Focus on Automated or Manual Testing Efforts 71  
4.2 AST Myths and Realities 74  
    Automatic Test Plan Generation 74  
    Test Tool Fits All 75  
    Immediate Test Effort Reduction 76  
    Immediate Reduction in Schedule 77  
    Tool Ease of Use 77  
    Universal Application of AST 77  
    100% Test Coverage 79  
    Equating Capture/Playback to AST 80  
    AST is a Manual Tester Activity 81  
    Losing Sight of the Testing Goal: Finding Defects 82  
    Focusing on System Test Automation and Not Automating Unit Tests 82  
4.3 Lack of Software Development Considerations for AST 83  
    Build Testability into the Application 84  
    Adhere to Open Architecture Standards 86  
    Adhere to Standard Documentation Format 87  
    Document Test Cases in a Standard Way 88  
    Adhere to Coding Standards 89  
    Use of OMG’s IDL 89  
    GUI Testing Recommendations 89  
    GUI Object Naming Standards 91  
    Library Concept of Code Reuse 91  
4.4 The Forest for the Trees—Not Knowing Which Tool to Pick 91  
    How to Evaluate and Choose a Tool 92  
4.5 Lack of Automation Standards across Tool Vendors 94  
    Sample Automated Test Tool Standards 95  
4.6 Lack of Business Case 97  
    Summary 97  
    Notes 97  

II. How to Automate: Top Six Keys for Automation Payoff 99  

5. Key 1: Know Your Requirements 101  
5.1 Understand the AST Support Requirements 102  
    AUT or SUT Requirements 103  
    AST Framework (ASTF) and Tool Requirements 105
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST Data Requirements</td>
<td>105</td>
</tr>
<tr>
<td>Test Environment Requirements</td>
<td>108</td>
</tr>
<tr>
<td>AST Process Requirements</td>
<td>112</td>
</tr>
<tr>
<td>5.2 Additional Information in Support of AST Requirements</td>
<td>114</td>
</tr>
<tr>
<td>Manual Testing Procedure</td>
<td>114</td>
</tr>
<tr>
<td>Design Documents</td>
<td>115</td>
</tr>
<tr>
<td>Prototypes</td>
<td>115</td>
</tr>
<tr>
<td>5.3 When Information Is Not Available</td>
<td>116</td>
</tr>
<tr>
<td>Conducting Interviews</td>
<td>118</td>
</tr>
<tr>
<td>Further Increasing Your Knowledge Base</td>
<td>120</td>
</tr>
<tr>
<td>Developing Requirements Based on a Legacy Application or Legacy System</td>
<td>121</td>
</tr>
<tr>
<td>5.4 Start Implementing Your Requirements Traceability Matrix (RTM)</td>
<td>124</td>
</tr>
<tr>
<td>Information in an RTM</td>
<td>125</td>
</tr>
<tr>
<td>Example RTM</td>
<td>125</td>
</tr>
<tr>
<td>Summary</td>
<td>128</td>
</tr>
<tr>
<td>Notes</td>
<td>128</td>
</tr>
<tr>
<td>6. Key 2: Develop the Automated Test Strategy</td>
<td>129</td>
</tr>
<tr>
<td>6.1 The AST Strategy Document</td>
<td>131</td>
</tr>
<tr>
<td>6.2 Scope and Automated Test Objectives</td>
<td>132</td>
</tr>
<tr>
<td>Deciding Which Tests to Automate</td>
<td>133</td>
</tr>
<tr>
<td>Prioritize—Base Automation Requirements on a Prioritized Feature</td>
<td>137</td>
</tr>
<tr>
<td>Defining the Test Objectives: An Example</td>
<td>138</td>
</tr>
<tr>
<td>6.3 Identify the Approach</td>
<td>139</td>
</tr>
<tr>
<td>Designing and Developing the Test Cases</td>
<td>139</td>
</tr>
<tr>
<td>6.4 Automated Software Test Framework (ASTF)</td>
<td>146</td>
</tr>
<tr>
<td>6.5 AST Environment/Configuration</td>
<td>150</td>
</tr>
<tr>
<td>Test Configurations</td>
<td>151</td>
</tr>
<tr>
<td>Other Test Environment Automated Testing Requirements</td>
<td>153</td>
</tr>
<tr>
<td>Automating the Test Environment Management—Automated CM</td>
<td>153</td>
</tr>
<tr>
<td>6.6 Automating the RTM</td>
<td>159</td>
</tr>
<tr>
<td>Require Standard Test Case Templates That Are Usable for Your Automation Framework</td>
<td>160</td>
</tr>
<tr>
<td>Hyperlink the Test Cases</td>
<td>160</td>
</tr>
<tr>
<td>Update the Test Case Steps to Include Pass/Fail Results</td>
<td>161</td>
</tr>
<tr>
<td>Update the RTM to Include Pass/Fail Results</td>
<td>161</td>
</tr>
<tr>
<td>6.7 Automated Defect Tracking</td>
<td>164</td>
</tr>
<tr>
<td>Summary</td>
<td>164</td>
</tr>
<tr>
<td>Notes</td>
<td>165</td>
</tr>
</tbody>
</table>
## Contents

### 7. Key 3: Test the Automated Software Test Framework (ASTF) 167

#### 7.1 Verify That the ASTF Meets Specified Requirements and That Features Behave As Expected 169

- Verify That Effective ASTF Development Processes Have Been Applied 169

#### 7.2 Peer-Review All ASTF-Related Artifacts, Including Design, Development, and Test Cases 170

- Peer Review As Part of the Software Development Lifecycle 170
- Evaluate All ASTF Components 173
- Review Test Cases 173
- Review Test Logic 175
- Review Test Data 176
- Review Automated Test Code 178

#### 7.3 Verify Requirements and Coverage 182

- Traceability 182
- Coverage 183

#### 7.4 Hold a Customer Review 183

- Summary 184
- Notes 184

### 8. Key 4: Continuously Track Progress—and Adjust Accordingly 187

#### 8.1 AST Program Tracking and Defect Prevention 188

- Conduct Technical Interchanges and Walk-throughs 189
- Conduct Internal Inspections 189
- Examine Constraints and Associated Risks 189
- Implement Risk Mitigation Strategies 190
- Safeguard the Integrity of the AST Process and Environments 190
- Define, Communicate, and Track Schedules and Costs 191
- Track Actions, Issues, and Defects 192

#### 8.2 AST Metrics 192

- Percent Automatable or Automation Index 196
- Automation Progress 198
- Test Progress 199
- Percent of Automated Test Coverage 199
- Defect Density 201
- Defect Trend Analysis 202
- Defect Removal Efficiency 203
- Automated Software Testing ROI 204
- Other Software Testing Metrics 204

#### 8.3 Root Cause Analysis 205

- Summary 206
- Notes 207
9. Key 5: Implement AST Processes
   9.1 AST Phases and Milestones
   9.2 AST Phase 1: Requirements Gathering—Analyze Automated Testing Needs
   9.3 AST Phase 2: Test Case Design and Development
   9.4 AST Phase 3: Automated Software Testing Framework (ASTF) and Test Script Development
   9.5 AST Phase 4: Automated Test Execution and Results Reporting
   9.6 AST Phase 5: Program Review and Assessment
   9.7 Virtual Quality Gates
   9.8 Process Measurement
      Summary
      Notes

10. Key 6: Put the Right People on the Project—Know the Skill Sets Required
      Soft Skills
      10.1 Program Management
         AST Phase 1: Requirements Gathering—Analyze Automated Testing Needs
         AST Phase 2: Test Case Design and Development
         AST Phase 3: Automated Software Testing Framework (ASTF) and Test Script Development
         AST Phase 4: Automated Test Execution and Results Reporting
         AST Phase 5: Program Review and Assessment
      10.2 Systems Engineering
         AST Phase 1: Requirements Gathering—Analyze Automated Testing Needs
         AST Phase 2: Test Case Design and Development
         AST Phase 3: Automated Software Testing Framework (ASTF) and Test Script Development
         AST Phase 4: Automated Test Execution and Results Reporting
         AST Phase 5: Program Review and Assessment
      10.3 Software Development
         AST Phase 1: Requirements Gathering—Analyze Automated Testing Needs
         AST Phase 2: Test Case Design and Development
         AST Phase 3: Automated Software Testing Framework (ASTF) and Test Script Development
         AST Phase 4: Automated Test Execution and Results Reporting
         AST Phase 5: Program Review and Assessment
      10.4 Configuration Management
         AST Phase 1: Requirements Gathering—Analyze Automated Testing Needs
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST Phase 2: Test Case Design and Development</td>
<td>243</td>
</tr>
<tr>
<td>AST Phase 3: Automated Software Testing Framework (ASTF) and Test</td>
<td>243</td>
</tr>
<tr>
<td>Script Development</td>
<td></td>
</tr>
<tr>
<td>AST Phase 4: Automated Test Execution and Results Reporting</td>
<td>243</td>
</tr>
<tr>
<td>AST Phase 5: Program Review and Assessment</td>
<td>243</td>
</tr>
<tr>
<td>10.5 Quality Assurance</td>
<td>244</td>
</tr>
<tr>
<td>AST Phase 1: Requirements Gathering—Analyze Automated Testing Needs</td>
<td>244</td>
</tr>
<tr>
<td>AST Phase 2: Test Case Design and Development</td>
<td>244</td>
</tr>
<tr>
<td>AST Phase 3: Automated Software Testing Framework (ASTF) and Test</td>
<td>245</td>
</tr>
<tr>
<td>Script Development</td>
<td></td>
</tr>
<tr>
<td>AST Phase 4: Automated Test Execution and Results Reporting</td>
<td>245</td>
</tr>
<tr>
<td>AST Phase 5: Program Review and Assessment</td>
<td>245</td>
</tr>
<tr>
<td>10.6 Subject Matter Experts (SMEs)</td>
<td>246</td>
</tr>
<tr>
<td>Training</td>
<td>246</td>
</tr>
<tr>
<td>Summary</td>
<td>247</td>
</tr>
<tr>
<td>Notes</td>
<td>248</td>
</tr>
</tbody>
</table>

### Appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Process Checklist</td>
<td>251</td>
</tr>
<tr>
<td>A.1 AST Phase 1: Requirements Gathering—Analyze Automated Testing Needs</td>
<td>252</td>
</tr>
<tr>
<td>Checklist</td>
<td>252</td>
</tr>
<tr>
<td>Products</td>
<td>252</td>
</tr>
<tr>
<td>A.2 AST Phase 2: Test Case Design and Development</td>
<td>253</td>
</tr>
<tr>
<td>Checklist</td>
<td>253</td>
</tr>
<tr>
<td>Products</td>
<td>254</td>
</tr>
<tr>
<td>A.3 AST Phase 3: Automated Software Testing Framework (ASTF) and Test Script Development</td>
<td>254</td>
</tr>
<tr>
<td>Checklist</td>
<td>254</td>
</tr>
<tr>
<td>Products</td>
<td>255</td>
</tr>
<tr>
<td>A.4 AST Phase 4: Automated Test Execution and Results Reporting</td>
<td>255</td>
</tr>
<tr>
<td>Checklist</td>
<td>255</td>
</tr>
<tr>
<td>Products</td>
<td>256</td>
</tr>
<tr>
<td>A.5 AST Phase 5: Program Review and Assessment</td>
<td>256</td>
</tr>
<tr>
<td>Checklist</td>
<td>256</td>
</tr>
<tr>
<td>Products</td>
<td>256</td>
</tr>
<tr>
<td>B. AST Applied to Various Testing Types</td>
<td>257</td>
</tr>
<tr>
<td>B.1 Security Testing</td>
<td>257</td>
</tr>
<tr>
<td>B.2 Soak Testing</td>
<td>261</td>
</tr>
<tr>
<td>B.3 Concurrency Testing</td>
<td>263</td>
</tr>
</tbody>
</table>
## Contents

**B.4 Performance Testing**  
265

**B.5 Code Coverage Testing**  
269

**B.6 Unit Testing**  
271

Notes  
274

**C. The Right Tool for the Job**  
275

**C.1 Requirements Management (RM)**  
276

*Automating Requirements Management*  
278

**C.2 Unit Testing Frameworks—Example Evaluation**  
281

*How to Evaluate and Choose a Framework*  
281

**C.3 Configuration Management—Example Evaluation**  
284

*Benefits of Software Configuration Management (SCM)*  
285

*The SCM Tools Evaluated*  
286

**C.4 Defect Tracking—Example Evaluation**  
292

*How to Evaluate and Choose a Defect Tracking Tool*  
292

*Bugzilla versus Trac*  
296

*Conclusion: Security Is Job 1*  
298

**C.5 Security Testing**  
299

*Static Analysis versus Dynamic Analysis*  
300

*Source Analysis versus Binary Analysis*  
301

*Application Footprinting*  
302

*Fuzz Testing or Penetration Testing*  
302

*Threat Modeling—Prioritizing Security Testing with Threat Modeling*  
303

*Automated Regression Testing*  
303

*Wireless Security Assessment Tools*  
303

**C.6 Automated Software Testing Framework (ASTF)—Example Evaluation**  
306

*Test Case Development*  
307

*High-Level Languages*  
307

*Platform Support*  
307

*Open-Source*  
307

*Cost*  
308

*Multiple Process Management*  
309

*Capturing Test Case Results*  
309

*Support of Distributed Environment*  
309

*Future Execution Time*  
310

*Scalable*  
310

*Footprint on SUT*  
310

*E-mail*  
311

*Conclusion for ASTF*  
311

*Automated Test Tool Example: Testplant's Eggplant*  
312
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.7 Other STL Support Tools</td>
<td>316</td>
</tr>
<tr>
<td><em>Self-testable or Autonomic Computing</em></td>
<td>318</td>
</tr>
<tr>
<td>Notes</td>
<td>319</td>
</tr>
<tr>
<td><strong>D. Case Study: An Automated Software Testing Framework (ASTF) Example</strong></td>
<td>321</td>
</tr>
<tr>
<td>D.1 Key Design Features</td>
<td>323</td>
</tr>
<tr>
<td>D.2 Test Manager</td>
<td>325</td>
</tr>
<tr>
<td>D.3 More on Automated Test Case and Test Code Generation</td>
<td>326</td>
</tr>
<tr>
<td>D.4 Results Reporting</td>
<td>328</td>
</tr>
<tr>
<td>D.5 Automated Defect Reporting</td>
<td>328</td>
</tr>
<tr>
<td>Notes</td>
<td>329</td>
</tr>
<tr>
<td>Contributing Authors</td>
<td>331</td>
</tr>
<tr>
<td>Index</td>
<td>333</td>
</tr>
</tbody>
</table>