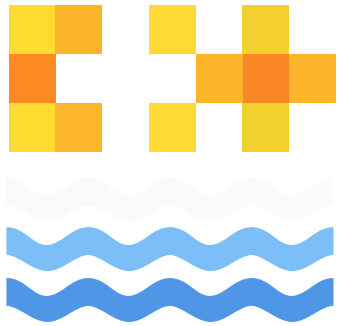


Quickly Testing Legacy Code

Clare Macrae

5 February 2019

@ClareMacraeUK

Contents

Contents

Llewellyn Falco
@LlewellynFalco

As part of expanding my c++ I was thinking of improving #ApprovalTests and making it work with GoogleTest. Anyone interested in pairing on that?

12:52 PM - 26 Nov 2017

Llewellyn Falco
@LlewellynFalco

As part of expanding my c++ I was thinking of improving #ApprovalTests and making it work with GoogleTest. Anyone interested in pairing on that?

12:52 PM - 26 Nov 2017

Clare Macrae
@ClareMacraeUK

Replying to @LlewellynFalco

Would be interested in hearing more.

2:46 PM - 26 Nov 2017

A year of remote pairing later…

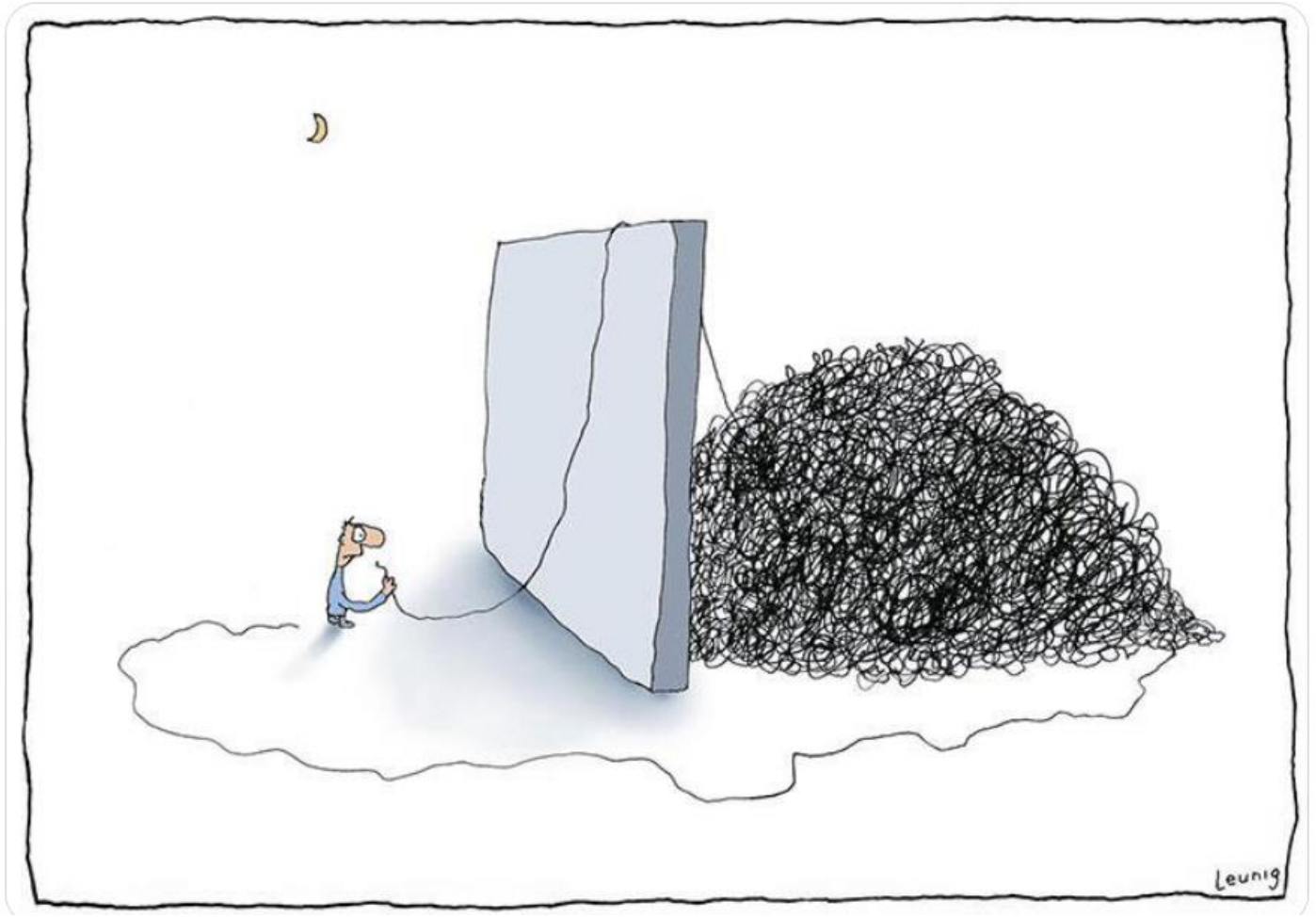
Goal:
Share techniques for easier testing in challenging scenarios

Contents

Quickly Testing **Legacy Code**

kenbot
@KenScambler

Legacy. Looks easy; should be done in half an hour I reckon.

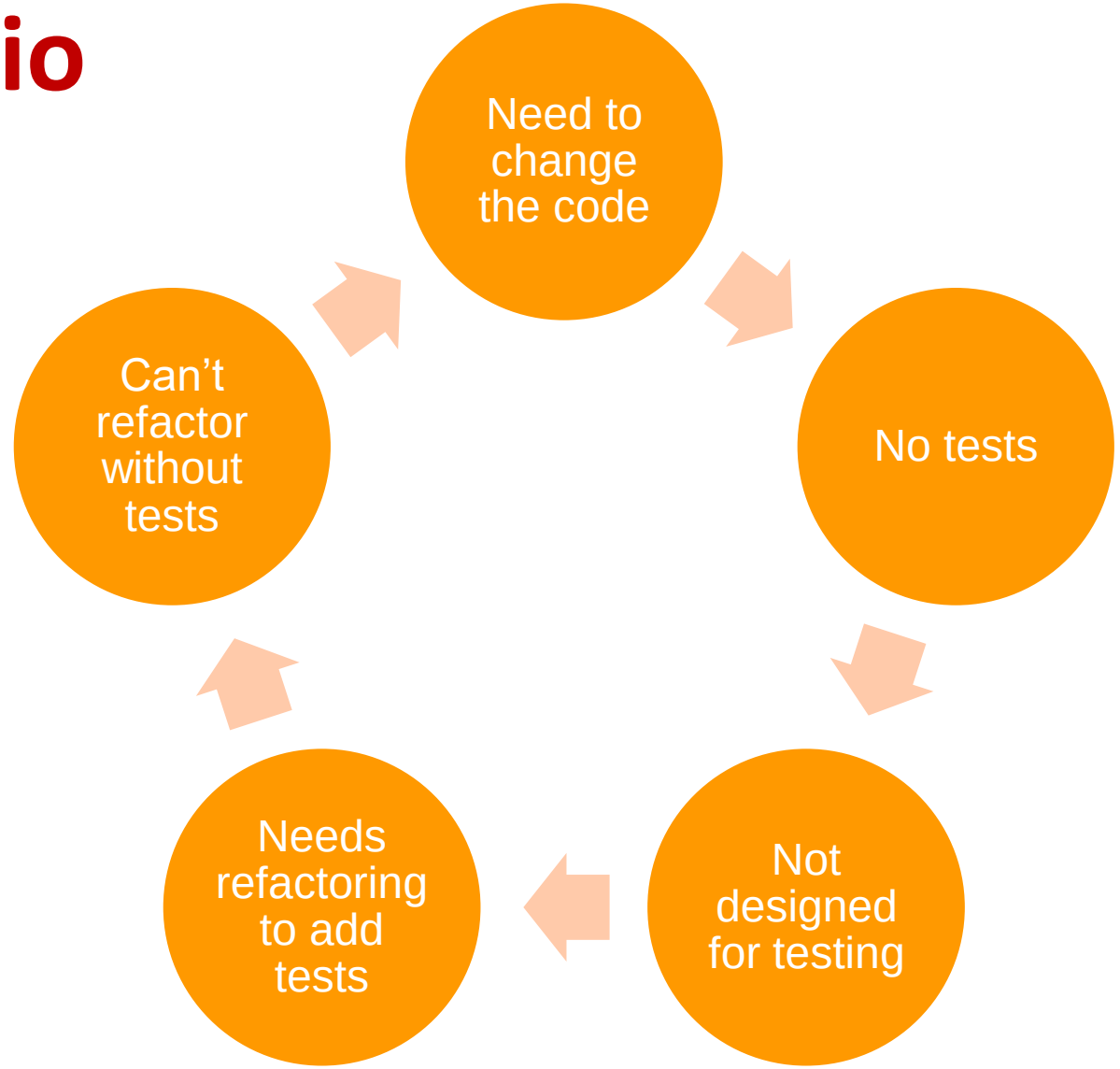


What does Legacy Code really mean?

- **Michael Feathers**
  - "code **without unit tests**"
- **J.B. Rainsberger**
  - "**profitable code** that we feel afraid to change."
- **Kate Gregory**
  - "any code that you **want to change, but are afraid to**"

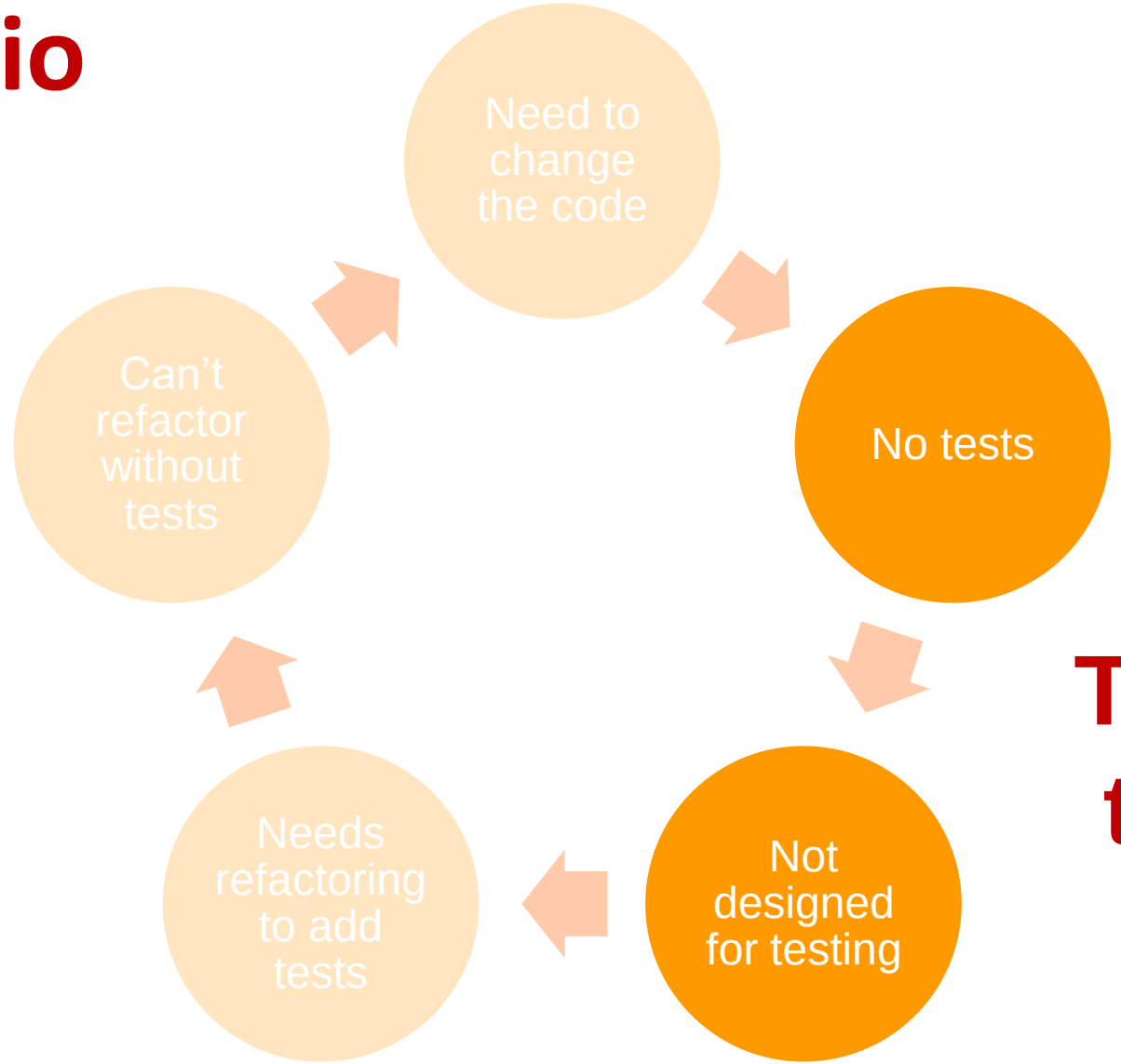
Typical Scenario

- I've inherited some legacy code
- It's valuable
- I need to add feature
- Or fix bug
- How can I ever break out of this loop?



Typical Scenario

- I've inherited some legacy code
- It's valuable
- I need to add feature
- Or fix bug
- How can I ever break out of this loop?



Topics of this talk

Assumptions

- Value of testing
- No worries about types of tests
  - (unit, integration, regression)

Any existing tests?

What, no tests?

- If absolutely no tests…
- Stop now!
- Set one up!
- Existing framework

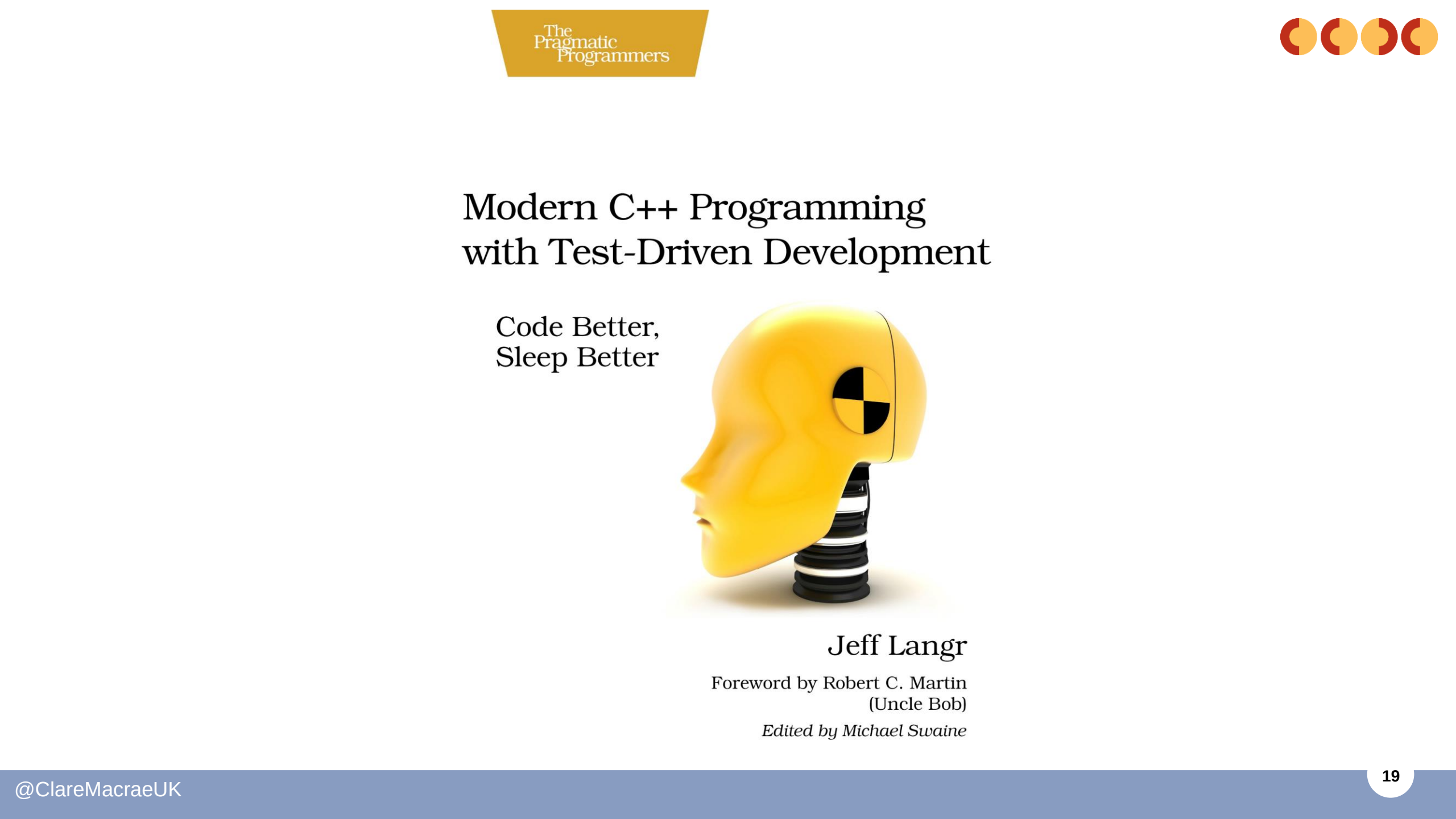
Popular Test Frameworks

Google Test

- Google's C++ test framework
- https://github.com/google/googletest

Catch

- Phil Nash’s test framework
- https://github.com/catchorg/Catch2


The Pragmatic Programmers
Modern C++ Programming with Test-Driven Development
Code Better, Sleep Better
Jeff Langr
Foreword by Robert C. Martin (Uncle Bob)
Edited by Michael Swaine

How good are your existing tests?

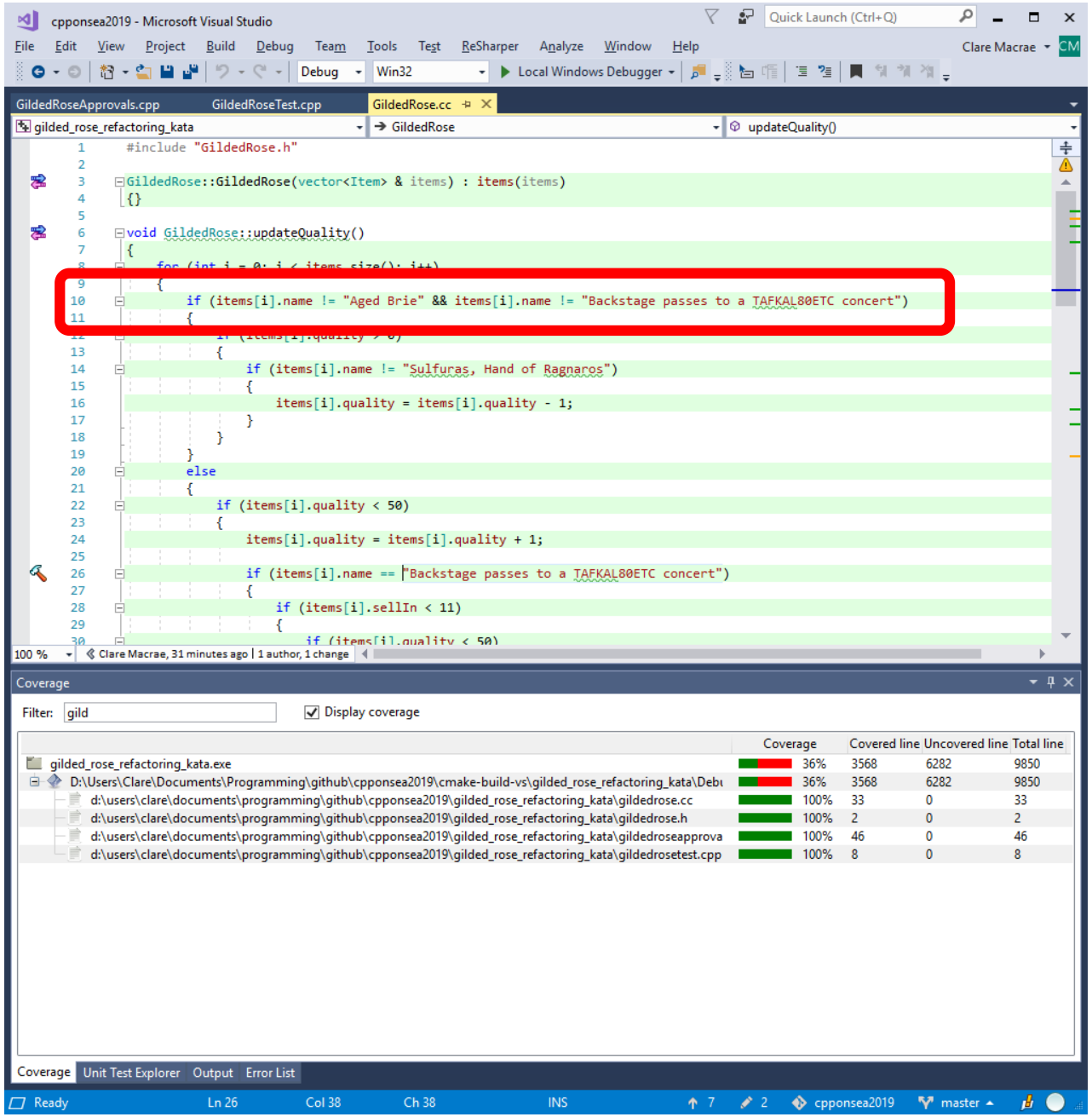
First evaluate your tests

- If you do have tests….
- **Test the tests**!
- In area you are changing
- Reliable?

Code Coverage

- Caution!
- Unexecuted code

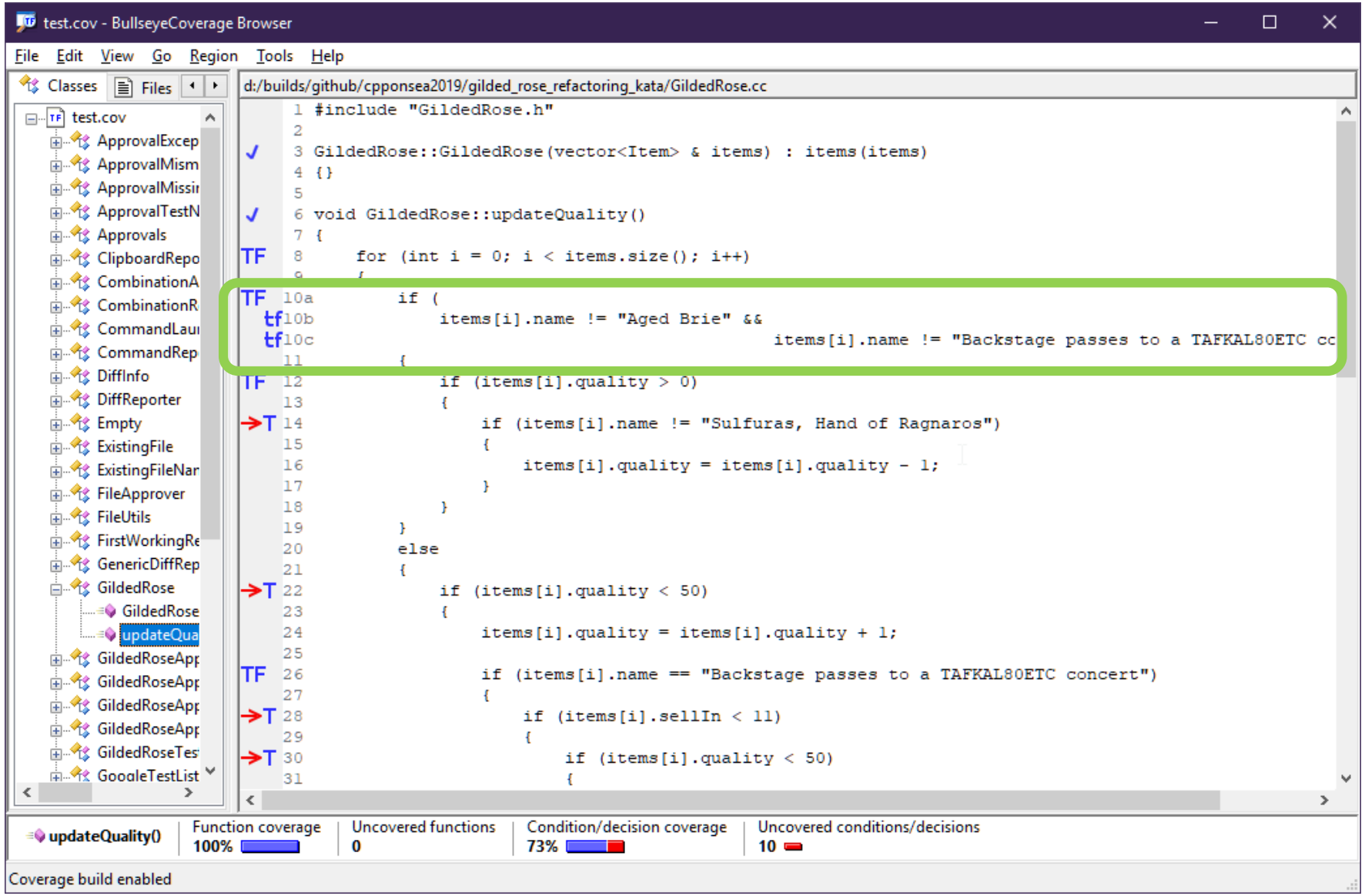
- **Techniques**
- Debugger
- Code coverage tool
  - What to measure?



100% Test Coverage

Or is it?

OpenCppCoverage does not show branch/condition coverage.



BullseyeCoverage:

Unrolls If conditions (line 10)

73% of conditions covered

Mutation testing: Sabotage the code!

- Test the tests
- Small changes
- Re-run tests
- Fail: ☺
- Pass: ☹

Mutation testing approaches

- By hand,
  - e.g. + to -
- By tool
  - e.g. Mutate++ - https://github.com/nlohmann/mutate_cpp

If tests need improving…
And unit tests not viable…

Contents

Quickly **Testing** Legacy Code

Key Phrase :
“Locking Down Current Behaviour”

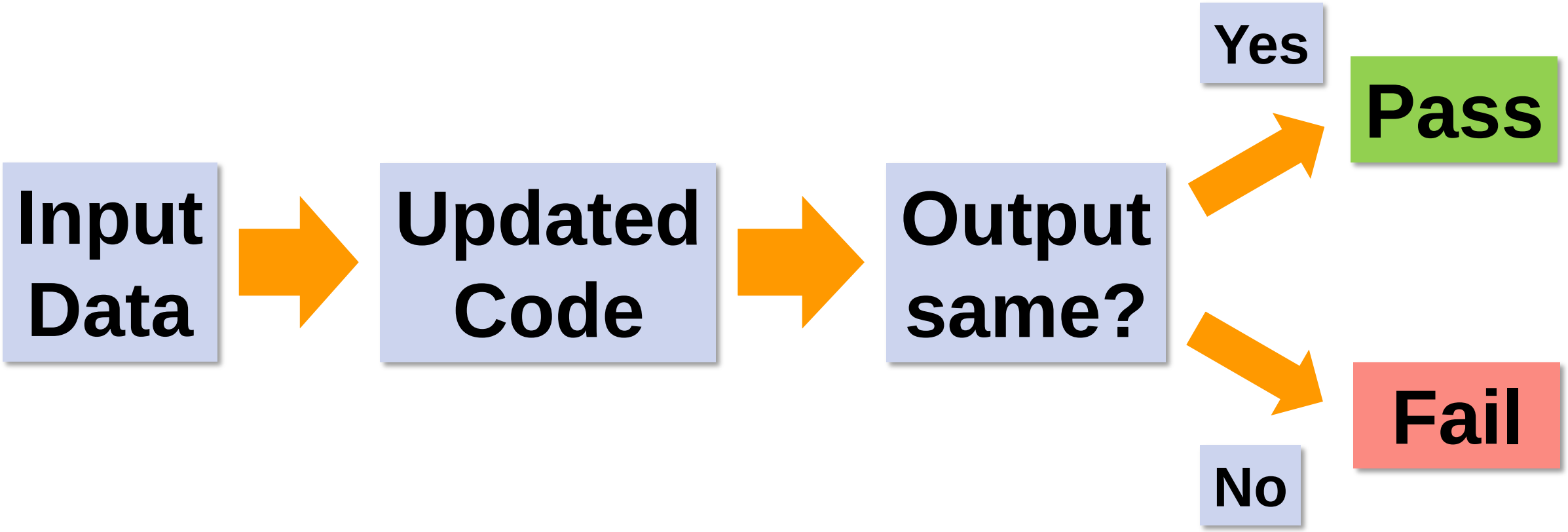
Writing Unit Tests for Legacy Code

- Time-consuming
- What's intended behaviour?
- Is there another way?

Alternative: Golden Master Testing

Golden Master Test Setup

Golden Master Tests In Use



Thoughts on Golden Master Tests

- Good to start testing legacy systems
- Poor Person's Integration Tests)
- Depends on ease of
  - Capturing output
  - Getting stable output
  - Reviewing any differences
  - Avoiding overwriting Master by mistake!
- Doesn't matter that it's not a Unit Test

Contents

- Introduction
- Legacy Code
- Golden Master
- **Approval Tests** 
- Example
- Resources
- Summary

Quickly Testing Legacy Code

One approach: “ApprovalTests”

- Llewellyn Falco’s convenient, powerful, flexible Golden Master implementation
- Supports many language

GO	.Net.ASP	Perl
Java	NodeJS	Python
Lua	Objective-C	Swift
.NET	PHP	TCL

And now C++!

ApprovalTests.cpp

- New C++ library for applying Llewellyn Falco's "Approval Tests" approach
- For testing cross-platform C++ code (Windows, Linux, Mac)
- For legacy and green-field systems
- It's on github

ApprovalTests.cpp

- Header-only
- Open source - Apache 2.0 licence

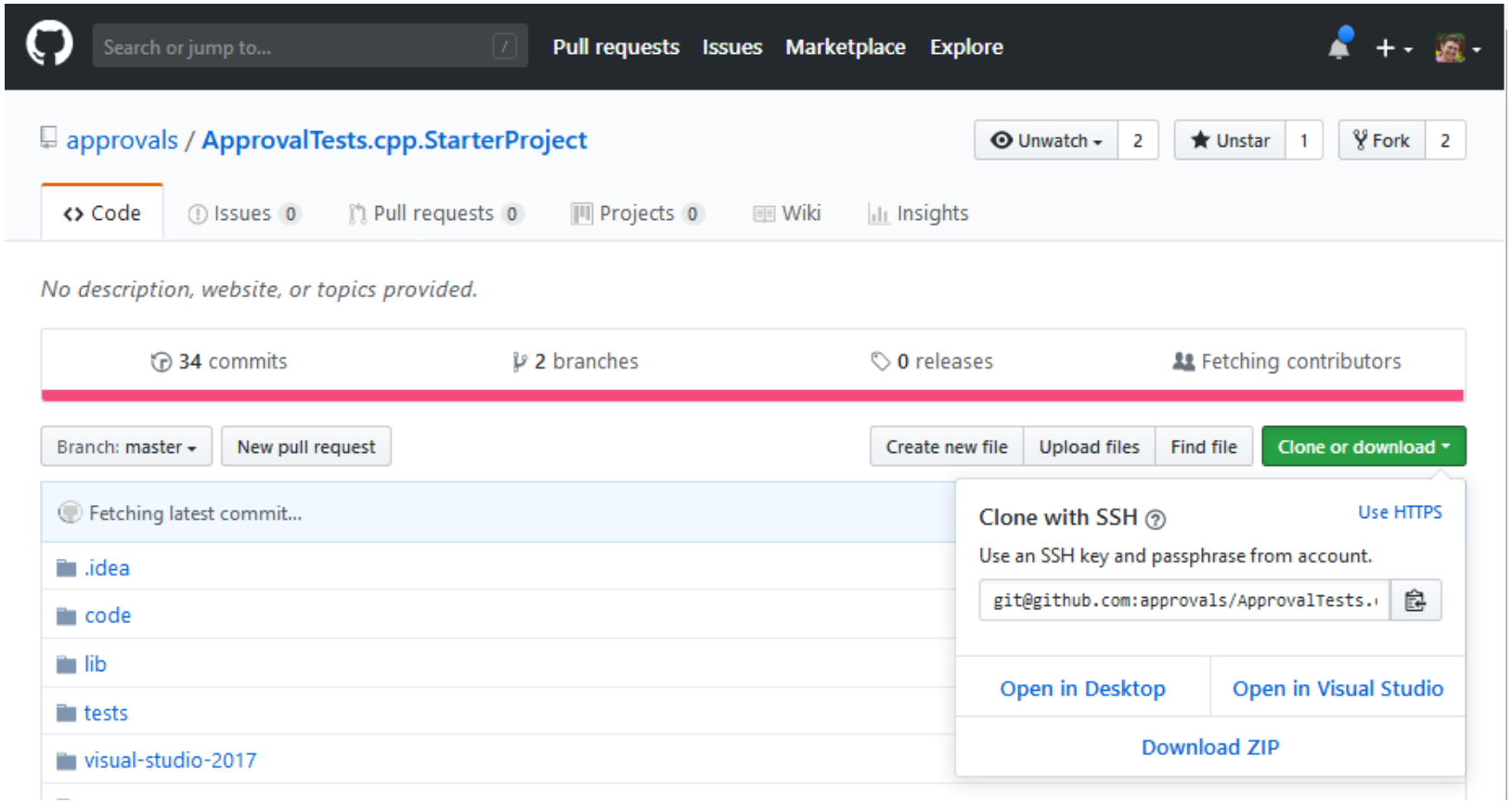
ApprovalTests.cpp

- Works with a range of testing frameworks
- Currently supports Catch1, Catch2, Google Test and Okra

Getting Started with Approvals

StarterProject with Catch2

- https://github.com/approvals/ApprovalTests.cpp.StarterProject
- Download ZIP



How to use it: Catch2 Boilerplate

- Your main.cpp

```
#define APPROVALS_CATCH
#include "ApprovalTests.hpp"
```

Pure Catch2 Test

- A test file

```
#include "Catch.hpp"

// Catch-only test
TEST_CASE( "Sums are calculated" )
{
    REQUIRE( 1 + 1 == 2 );
    REQUIRE( 1 + 2 == 3 );
}
```

Approvals Catch2 Test

- A test file (Test02.cpp)

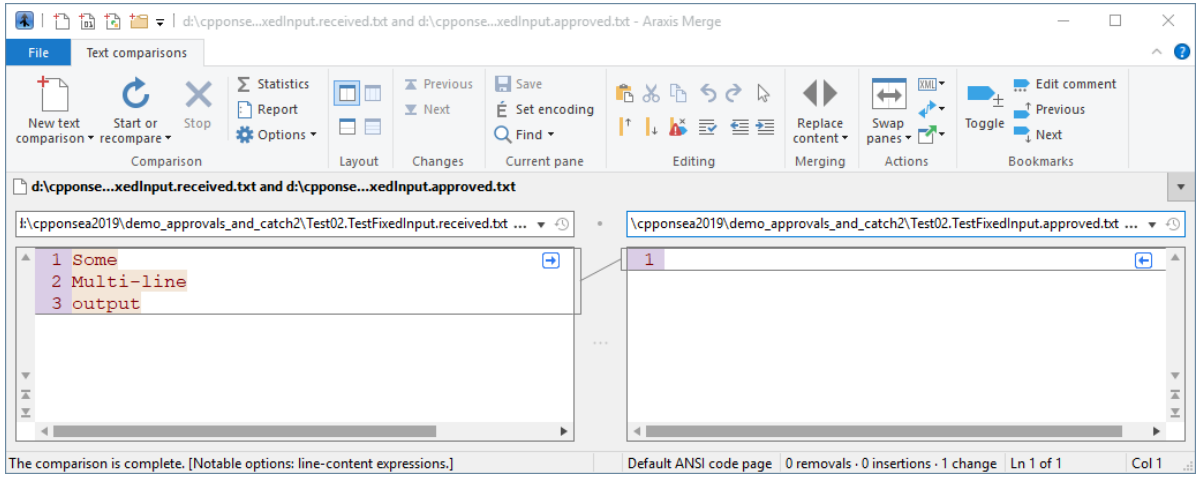
```
#include "ApprovalTests.hpp"
#include "Catch.hpp"

// Approvals test - test static value, for demo purposes
TEST_CASE("TestFixedInput")
{
    Approvals::verify("Some\nMulti-line\noutput");
}
```

First run

- 1. TestFixedInput failed

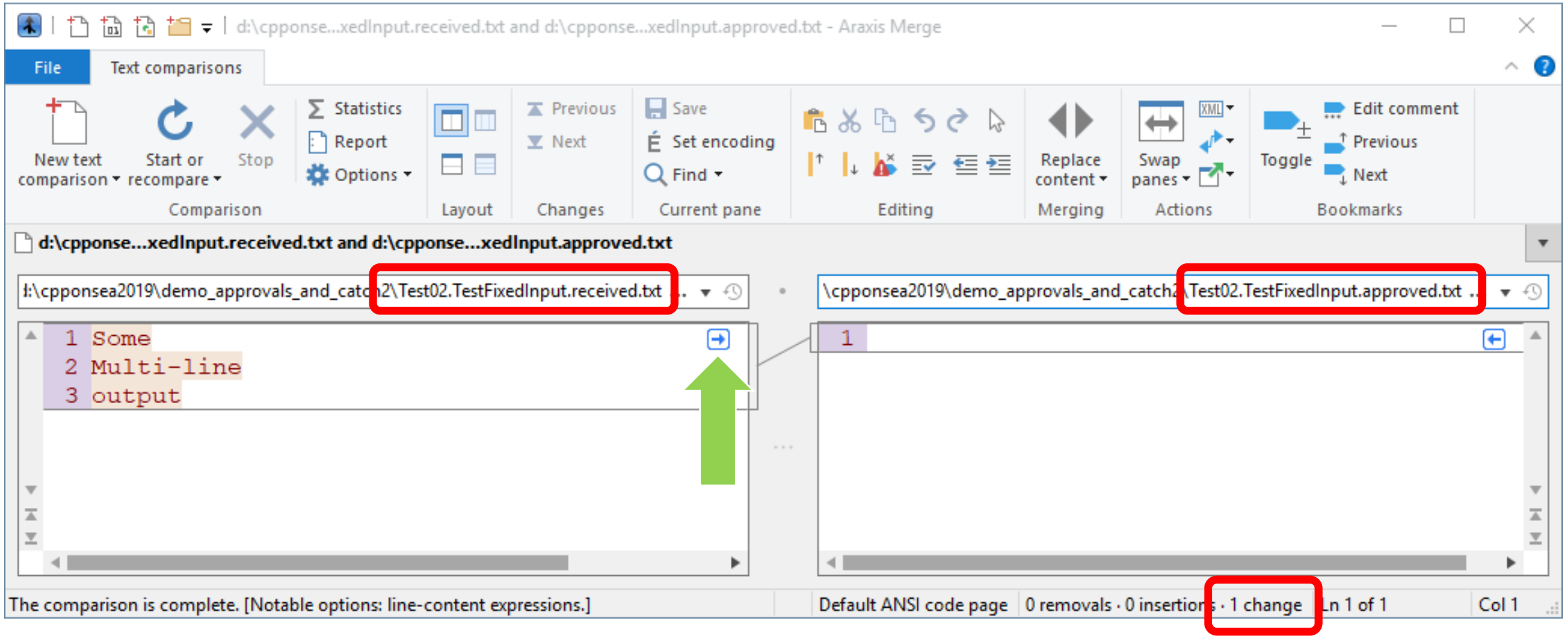
```
d:\cpponsea2019\demo_approvals_and_catch2\test02.cpp(5): exception: Failed Approval:
Approval File Not Found
File: "d:\cpponsea2019\demo_approvals_and_catch2\Test02.TestFixedInput.approved.txt"
```

- 2. Differencing tool pops up (Araxis Merge, in this case)



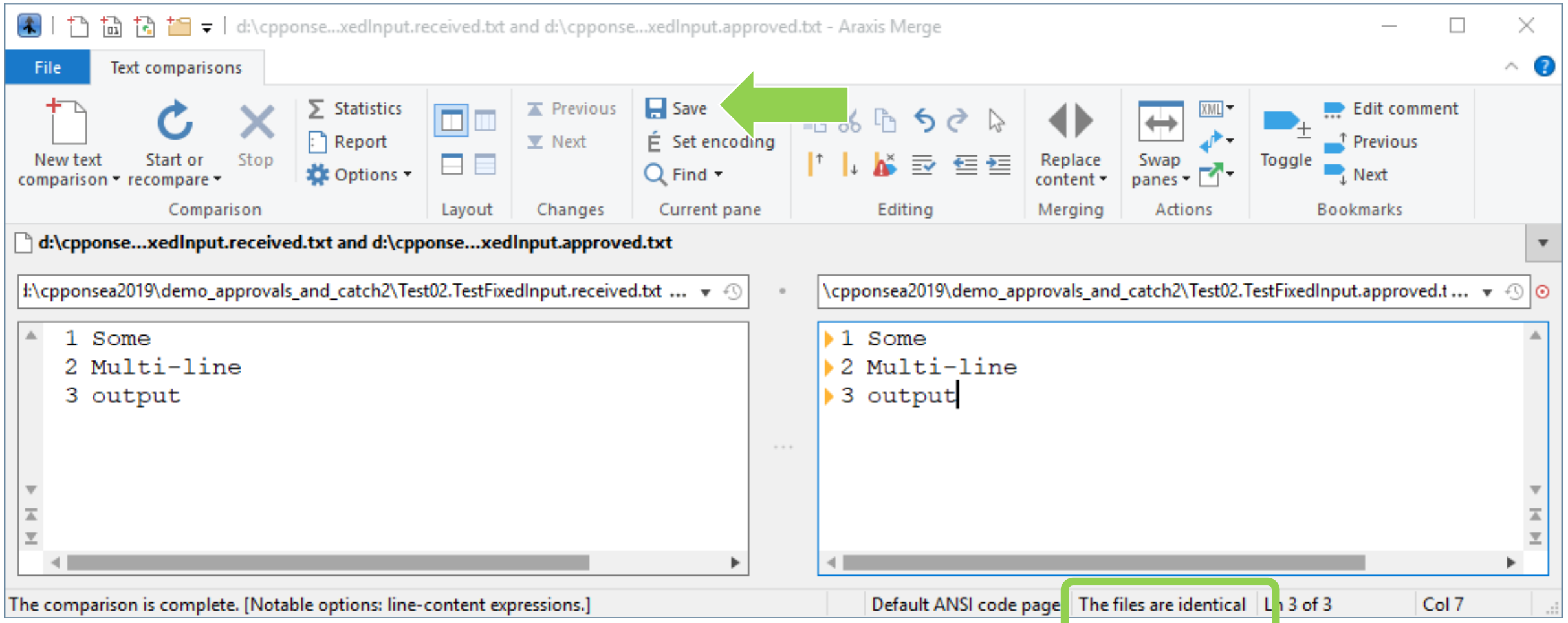
Actual/Received

Expected/Approved



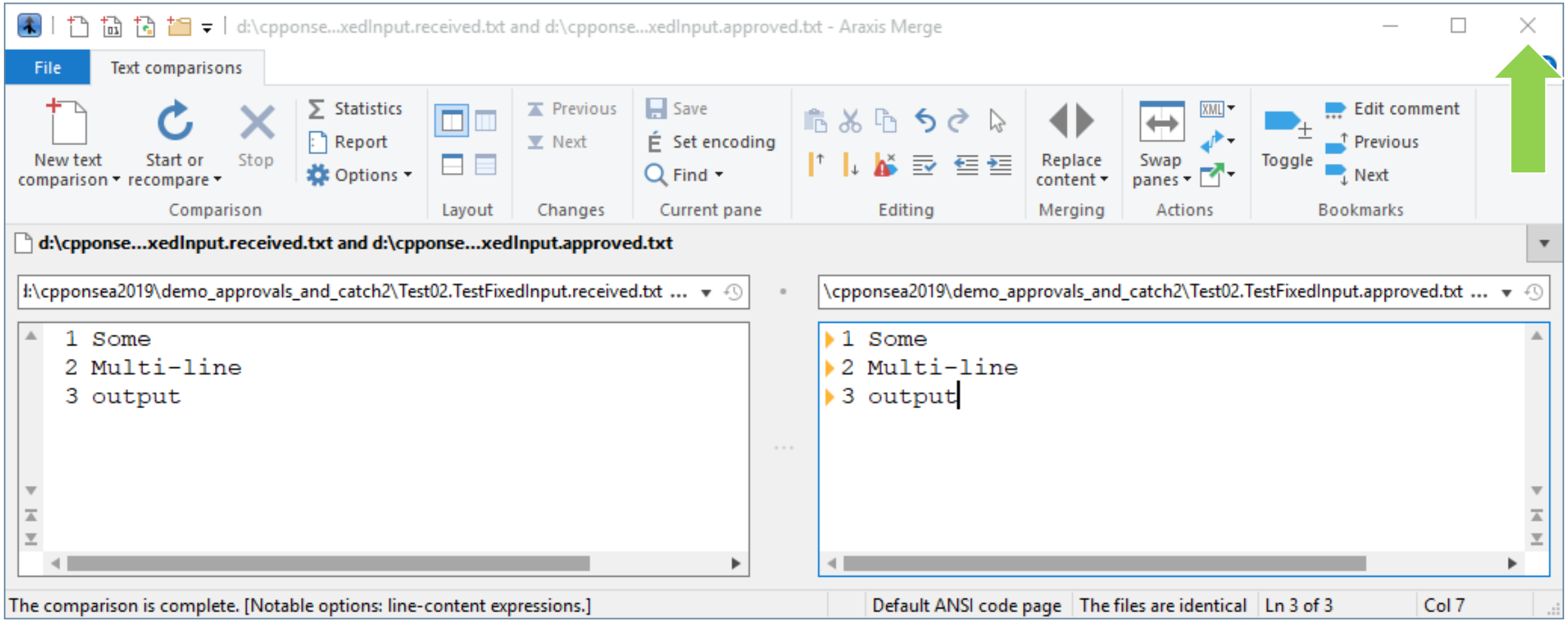
Actual/Received

Expected/Approved



Actual/Received

Expected/Approved



Second run

- I approved the output

```
TestFixedInput passed
```

- Then we commit the test, and the approved file(s) to version control
- The diffing tool only shows up if:
  - there is not (yet) an Approved file or
  - the Received differs from the Approved

What's going on here?

- It's a very convenient form of Golden Master testing
- Objects being tested are stringified – that's a requirement
- Captures snapshot of current behaviour
- Useful for locking down behaviour of existing code
  - Not intended to replace Unit Tests

Example test directory

Test02.cpp	02/02/2019 17:42	CPP File	4 KB
Test02.TestFixedInput.approved.txt	02/02/2019 17:42	Text Document	1 KB
Test03CustomReporters.cpp	02/02/2019 17:42	CPP File	1 KB
Test03CustomReporters.UseCustomReporter.approved.txt	02/02/2019 17:42	Text Document	1 KB
Test03CustomReporters.UseQuietReporter.approved.txt	02/02/2019 17:42	Text Document	1 KB
Test03CustomReporters.UseSpecificReporter.approved.txt	02/02/2019 17:42	Text Document	1 KB
Test04ConsoleReporter.cpp	02/02/2019 17:42	CPP File	1 KB
Test04ConsoleReporter.UseConsoleReporter.approved.txt	02/02/2019 17:42	Text Document	1 KB
Test05VerifyAll.cpp	02/02/2019 17:42	CPP File	3 KB
Test05VerifyAll.verifyAllWithHeaderAndVector.approved.txt	02/02/2019 17:42	Text Document	1 KB
Test05VerifyAll.verifyAllWithHeaderBeginEndAndLambda.approved.txt	02/02/2019 17:42	Text Document	1 KB
Test05VerifyAll.verifyAllWithHeaderContainerAndLambda.approved.t	02/02/2019 17:42	Text Document	1 KB
Test05VerifyAll.verifyAllWithVector.approved.txt	02/02/2019 17:42	Text Document	1 KB

How to use it: GoogleTest Boilerplate

- Your main.cpp

```
#define APPROVALS_GOOGLETEST
#include "ApprovalTests.hpp"
```

Pure Google Test

- A test file

```
#include <gtest/gtest.h>

// Google-only test
TEST( Test01, SumsAreCalculated )
{
    EXPECT_EQ( 1 + 1, 2 );
    EXPECT_EQ( 1 + 2, 3 );
}
```

Approvals Google Test

- A test file

```
#include "ApprovalTests.hpp"
#include <gtest/gtest.h>

// googletest - test static value, for demo purposes
TEST( Test02, TestFixedInput )
{
    Approvals::verify("Some\nMulti-line\noutput");
}
```

Reference: Add to existing GoogleTest

- Your main.cpp

```
#define APPROVALS_GOOGLETEST_EXISTING_MAIN
#include "ApprovalTests.hpp"

int main(int argc, char** argv)
{
    ::testing::InitGoogleTest(&argc, argv);
    initializeApprovalTestsForGoogleTests();
    return RUN_ALL_TESTS();
}
```

Reference: Supporting a new test framework

- Any test framework that supplies the following:
  - Current test's name
  - Current test's source file (with correct case of filename)
  - Report unexpected exceptions as a test failure
- That's all that's needed

A note on Tools

- I'll be using a variety of tools in the talk
- I'll mention them as I go
- Slides of references at the end

How does this help with legacy code?

Applying this to legacy code

```
TEST_CASE("New test of legacy feature")
{
    // Standard pattern:
    // Wrap your legacy feature to test in a function call
    // that returns some state that can be written to a text file
    // for verification:
    const LegacyThing result = doLegacyOperation();
    Approvals::verify(result);
}
```

Implementation

```
class LegacyThing;

std::ostream &operator<<(std::ostream &os, const LegacyThing &result) {
    // write interesting info from result here:
    os << result…;
    return os;
}
LegacyThing doLegacyOperation() {
    // your implementation here..
    return LegacyThing();
}
```

Feature: Consistency over machines

- Naming of output files
- Approved files version controlled

Feature: Consistency over OSs

- Line-endings

Feature: Quick to write tests

```
TEST_CASE("verifyAllWithHeaderBeginEndAndLambda")
{
  std::list<int> numbers{ 0, 1, 2, 3};
  // Multiple convenience overloads of Approvals::verifyAll()
  Approvals::verifyAll(
    "Test Squares", numbers.begin(), numbers.end(),
    [](int v, std::ostream& s) { s << v << " => " << v*v << '\n' ; });
}
```

Feature: Quick to get good coverage

```
TEST_CASE("verifyAllCombinationsWithLambda")
{
    std::vector<std::string> strings{"hello", "world"};
    std::vector<int> numbers{1, 2, 3};
    CombinationApprovals::verifyAllCombinations<
        std::vector<std::string>,       // The type of element in our first input container
        std::vector<int>,               // The type of element in our second input container
        std::string>(                   // The return type from testing one combination of inputs
            // Lambda that acts on one combination of inputs, and returns the result to be approved:
            [](std::string s, int i) { return s + " " + std::to_string(i); },
            strings,                    // The first input container
            numbers);                   // The second input container
}
```

All values in single output file:

```
(hello, 1) => hello 1
(hello, 2) => hello 2
(hello, 3) => hello 3
(world, 1) => world 1
(world, 2) => world 2
(world, 3) => world 3
```

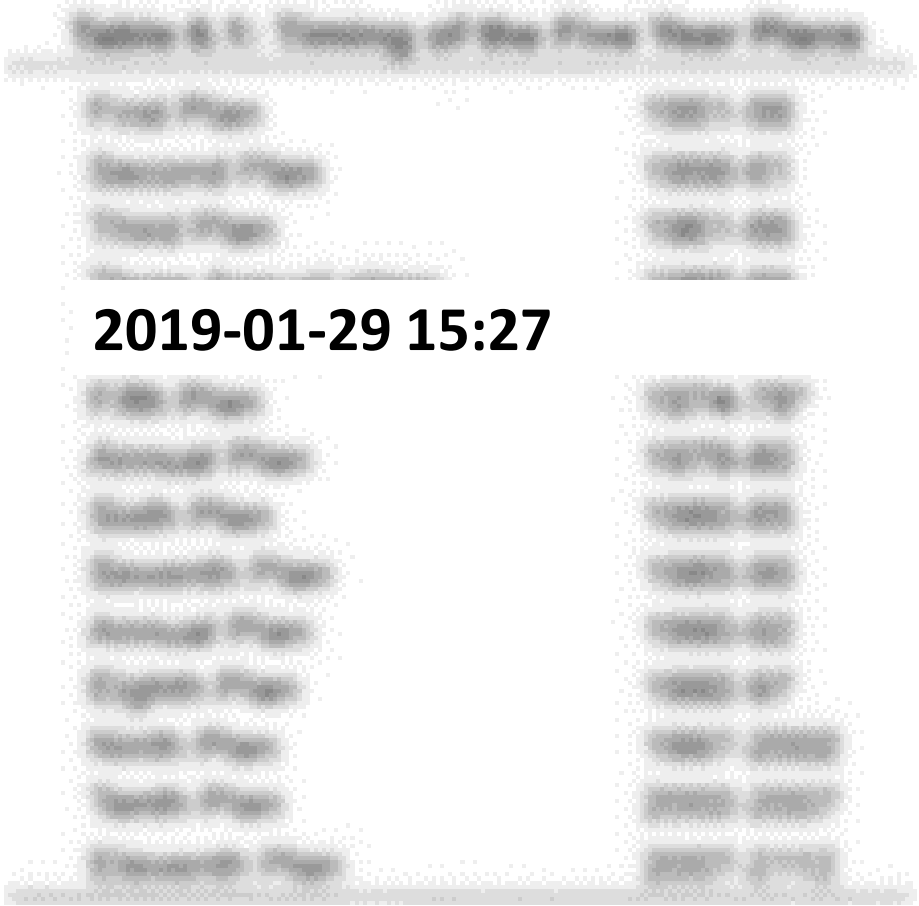
Challenge: Golden Master is a log file

- Dates and times?
- Object addresses?

Options for unstable output

- Introduce date-time abstraction?
- Customised comparison function?
- Or: strip dates from the log file

Tip: Rewrite output file



2019-01-29 15:27

[date-time-stamp]

Customisability: ApprovalWriter interface

```
class ApprovalWriter
{
public:
    virtual std::string getFileExtensionWithDot() = 0;
    virtual void write(std::string path) = 0;
    virtual void cleanUpReceived(std::string receivedPath) = 0;
};
```

Feature: Run on build servers

```
TEST_CASE("UseQuietReporter")
{
    // QuietReporter does nothing if a failure occurs.
    // Failing tests will still fail, but nothing is launched.
    Approvals::verify(
        "Some\nMulti-line\noutput",
        QuietReporter());
}
```

Customisability: Reporters

- Very simple but powerful abstraction
- Gives complete user control over how to inspect and act on a failure
- If you adopt Approvals, do review the supplied reporters for ideas

Tip: currentReporter()

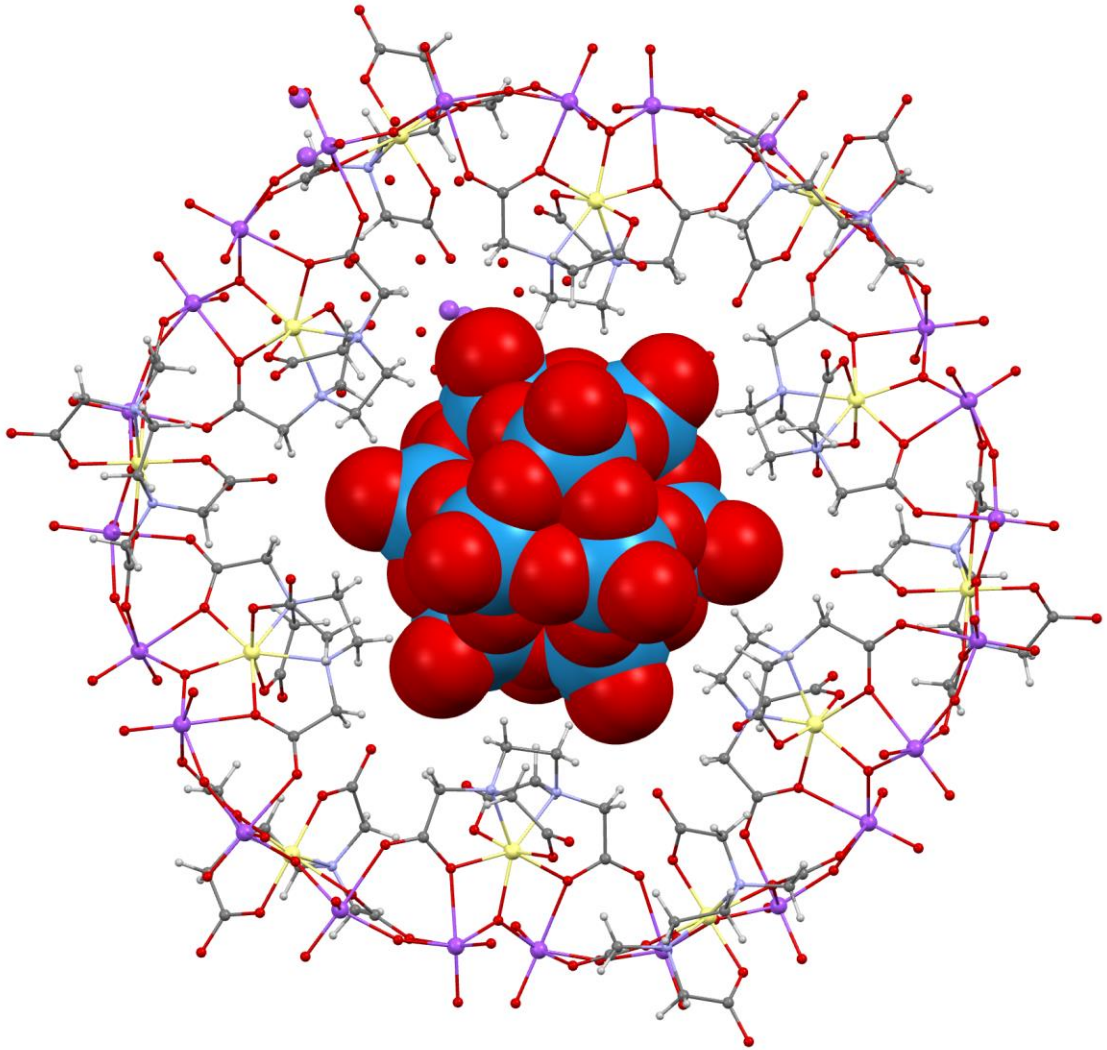
- Easy to switch reporter behaviour

Feature: Convention over Configuration

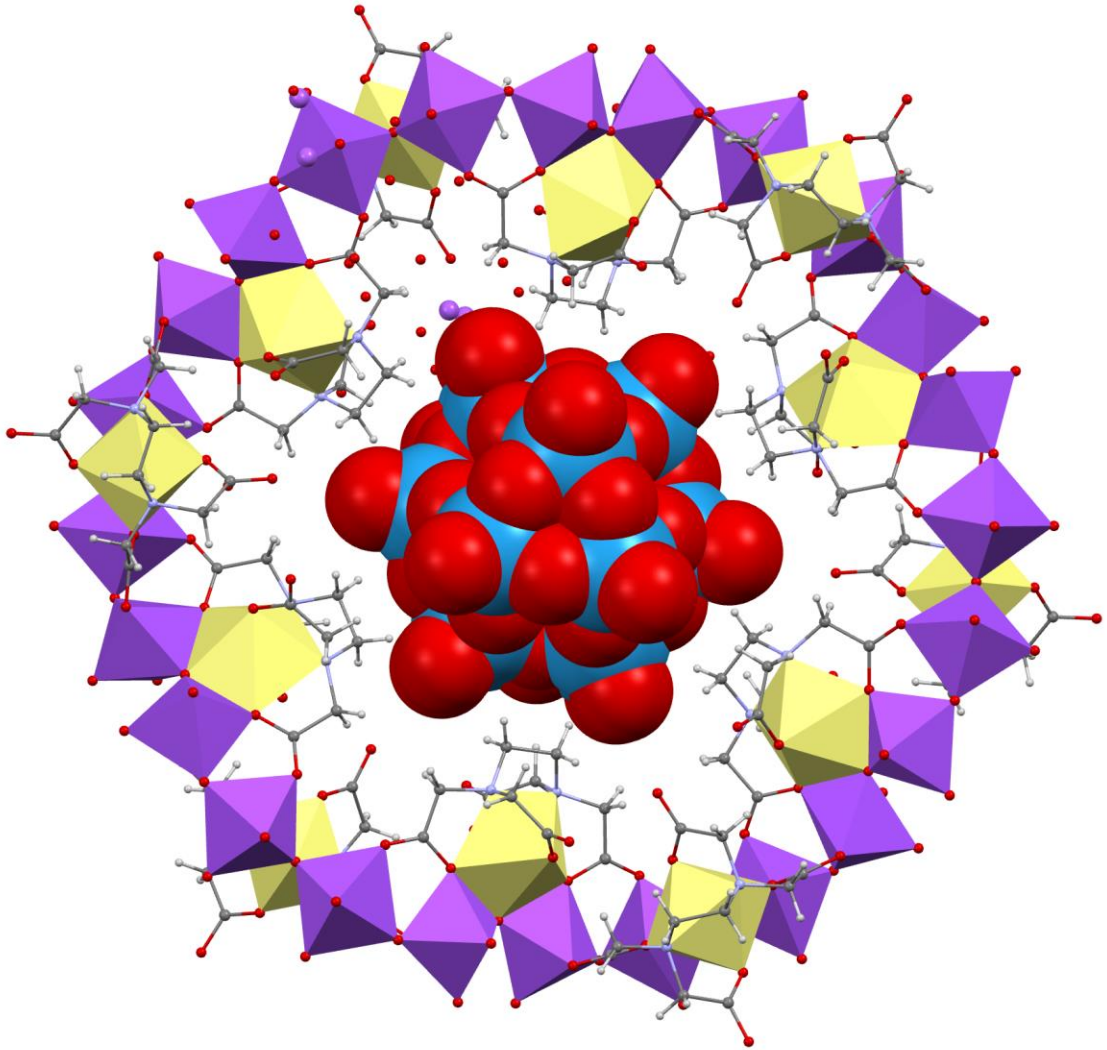
- Fewer decisions for developers
- Users only specify unusual behaviours

Contents

What I can do:

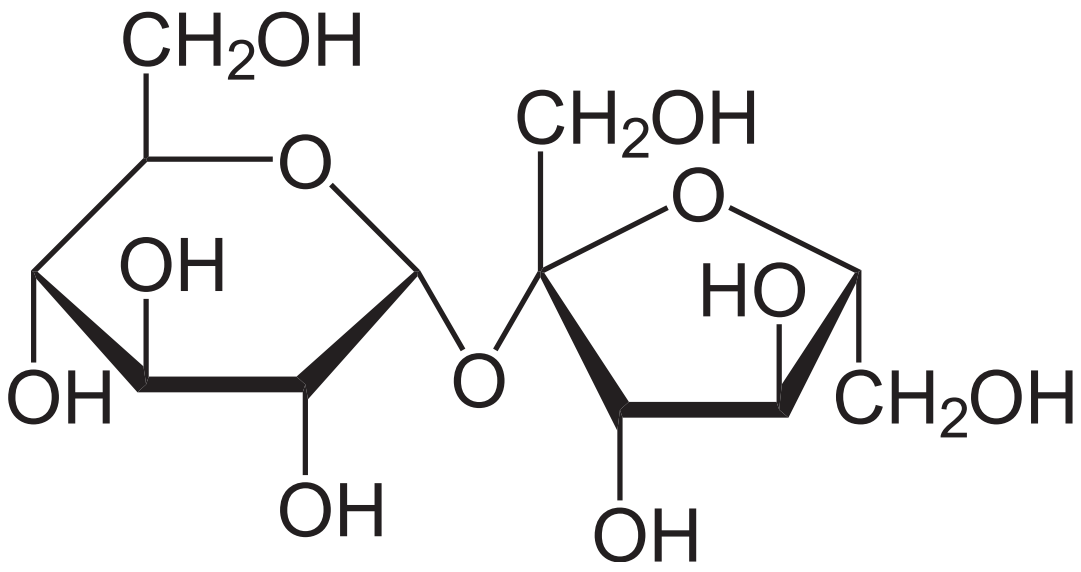


What I need to do:

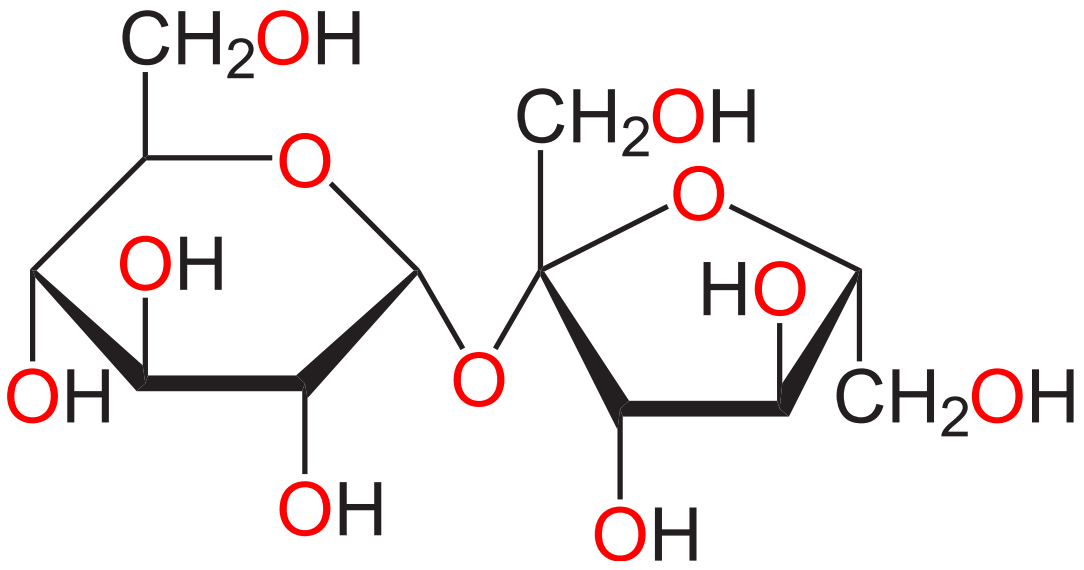


Sugar - sucrose

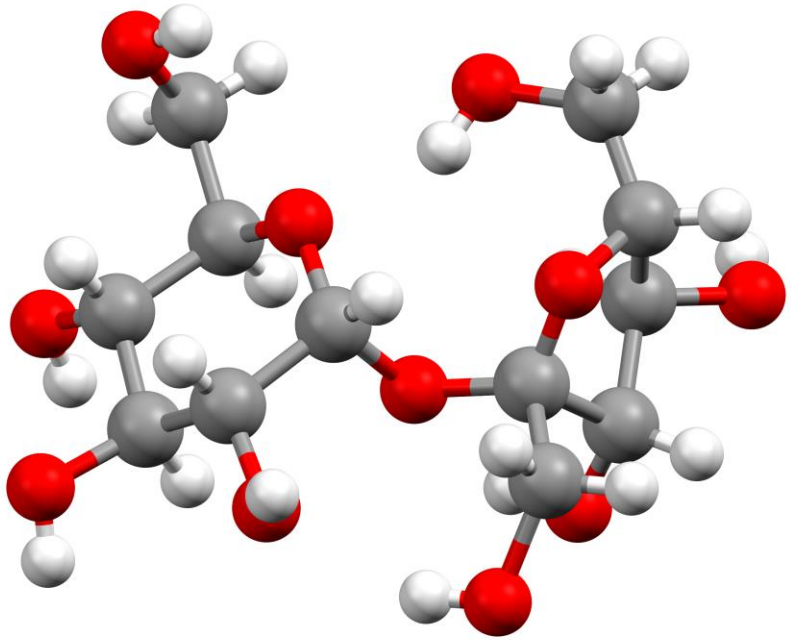
Sugar - sucrose



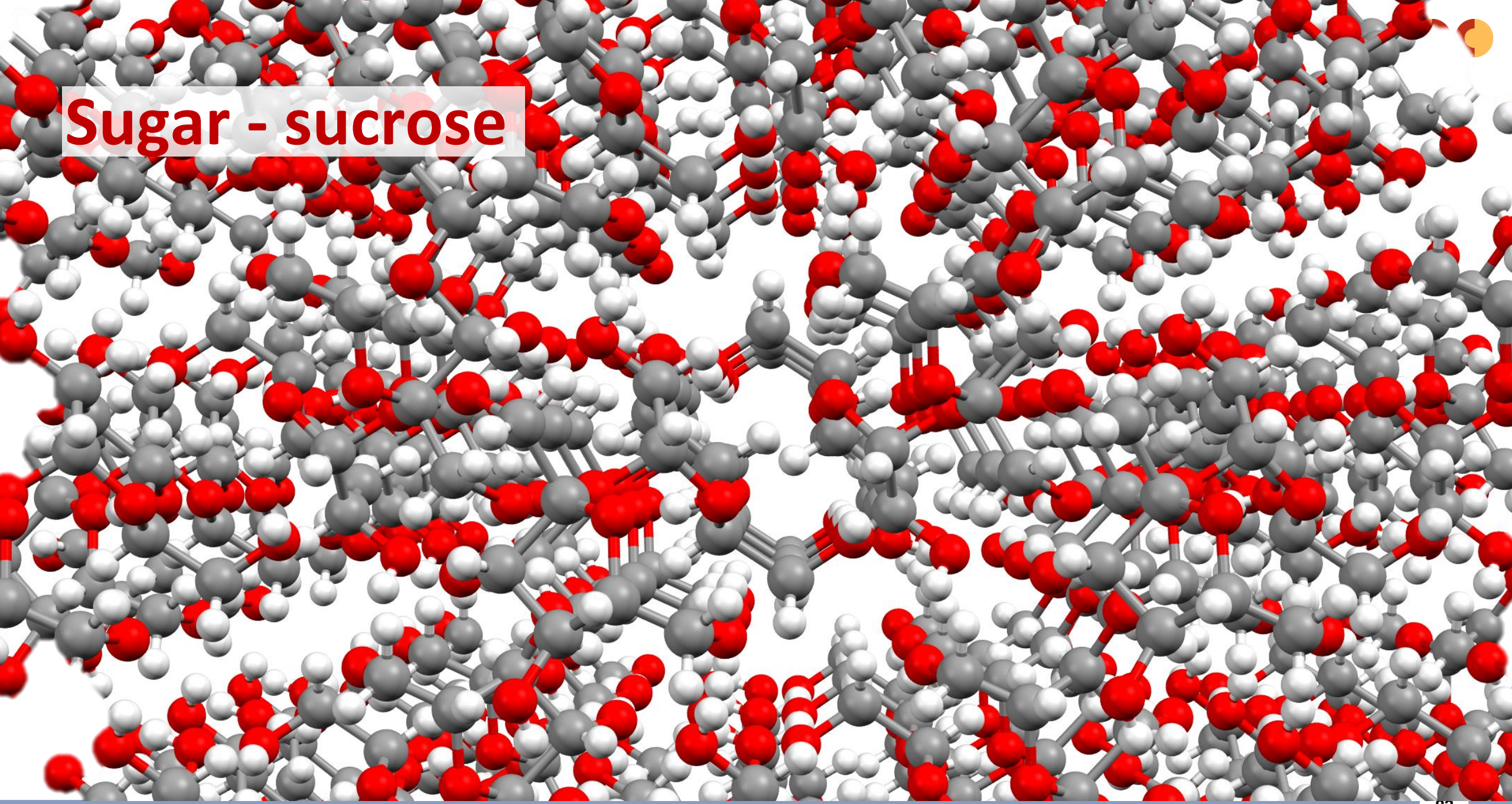
Sugar - sucrose



Sugar - sucrose



Sugar - sucrose



The Cambridge Structural Database (CSD)

The world's comprehensive and up-to-date database of crystal structures with over 950,000 curated entries

Approving Images

What I'm aiming for

```
TEST(PolyhedralGraphicsStyleApprovals, CUVXAT)
{
    // CUVXAT identifies a crystal structure in the database
    const QImage crystal_picture = loadEntry("CUVXAT");
    verifyQImage(crystal_picture, *currentReporter());
}
```

Foundation of Approval tests

```
void FileApprover::verify(
    ApprovalNamer& namer,
    ApprovalWriter& writer,
    const Reporter& reporter);
```

Idiomatic verification of Qt image objects

```
void verifyQImage(
    QImage image, const Reporter& reporter = DiffReporter())
{
    ApprovalTestNamer namer;
    QImageWriter writer(image);
    FileApprover::verify(namer, writer, reporter);
}
```

Customisability: ApprovalWriter interface

```
class ApprovalWriter
{
public:
    virtual std::string getFileExtensionWithDot() = 0;
    virtual void write(std::string path) = 0;
    virtual void cleanUpReceived(std::string receivedPath) = 0;
};
```

QImageWriter declaration

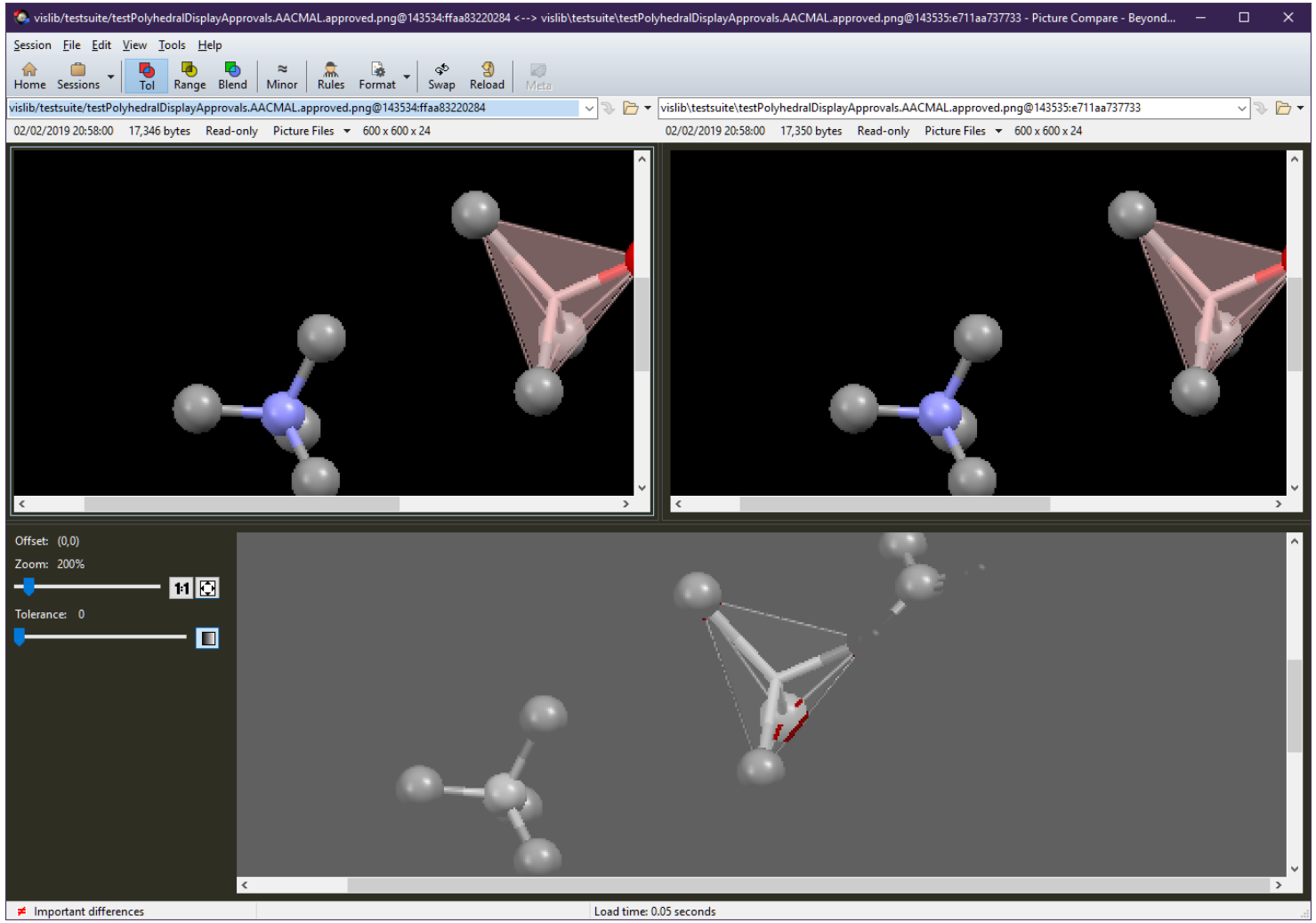
```
class QImageWriter : public ApprovalWriter
{
public:
    explicit QImageWriter(QImage image, std::string fileExtensionWithDot = ".png");
    std::string getFileExtensionWithDot() override;
    void write(std::string path) override;
    void cleanUpReceived(std::string receivedPath) override;

private:
    QImage image_;
    std::string ext;
};
```

QImageWriter::write()

```
void QImageWriter::write(std::string path)
{
    // Have to convert std::string to QString
    image_.save( QString::fromStdString(path) );
}
```

Useful feedback

BeyondCompare 4

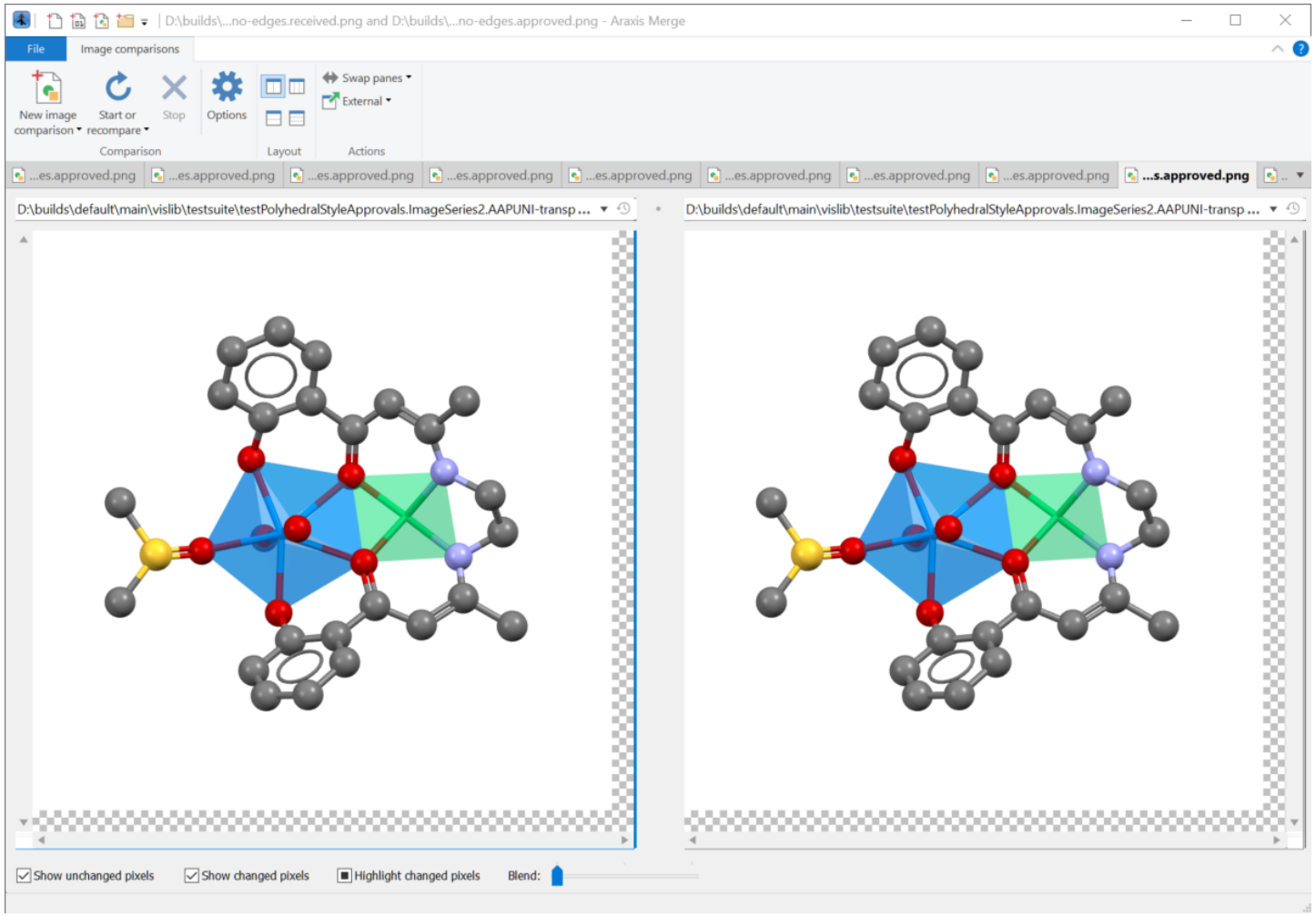


Back In work…

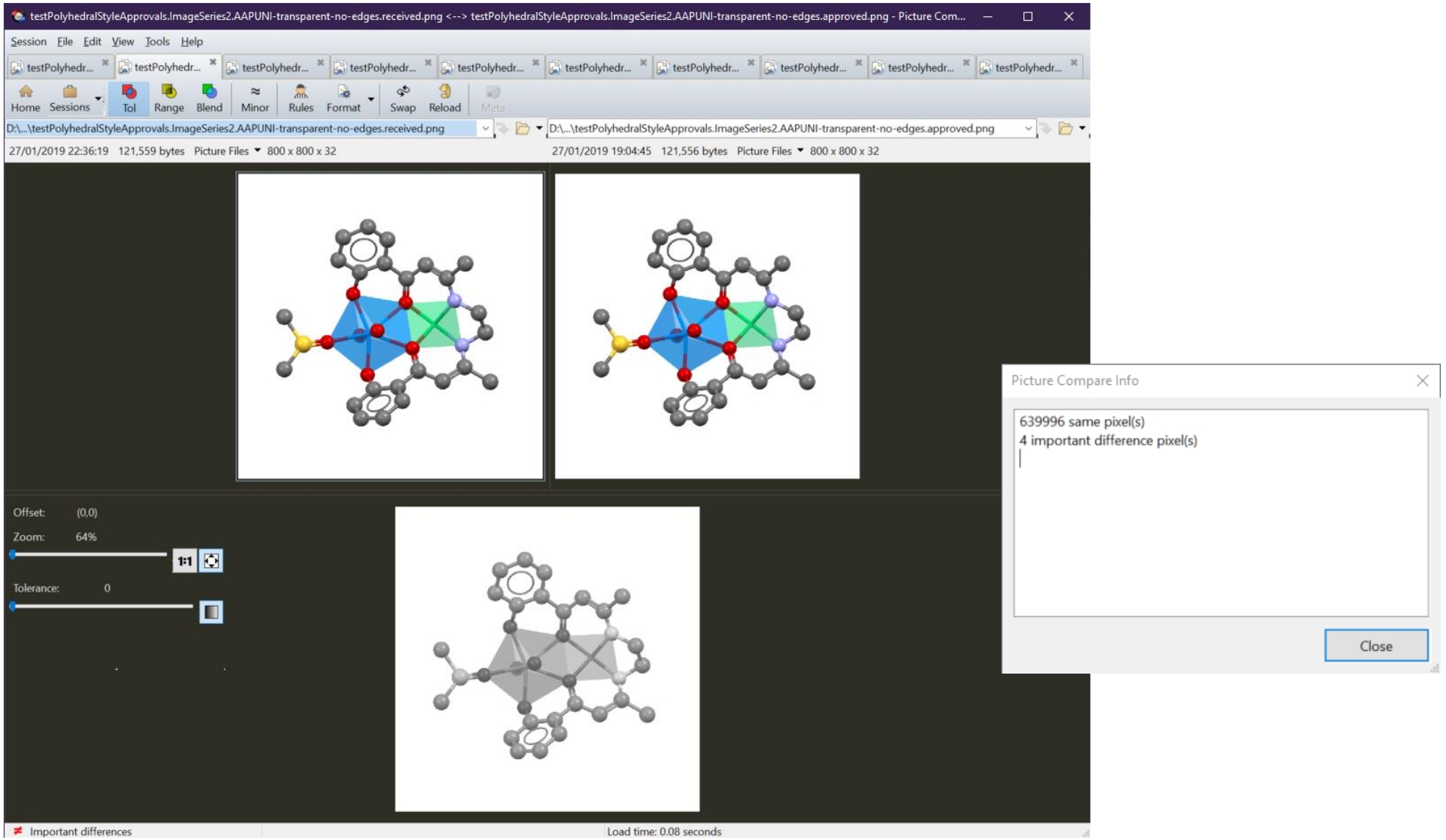
- Previously, working from home via Remote Desktop
- The tests started failing when I ran them in work

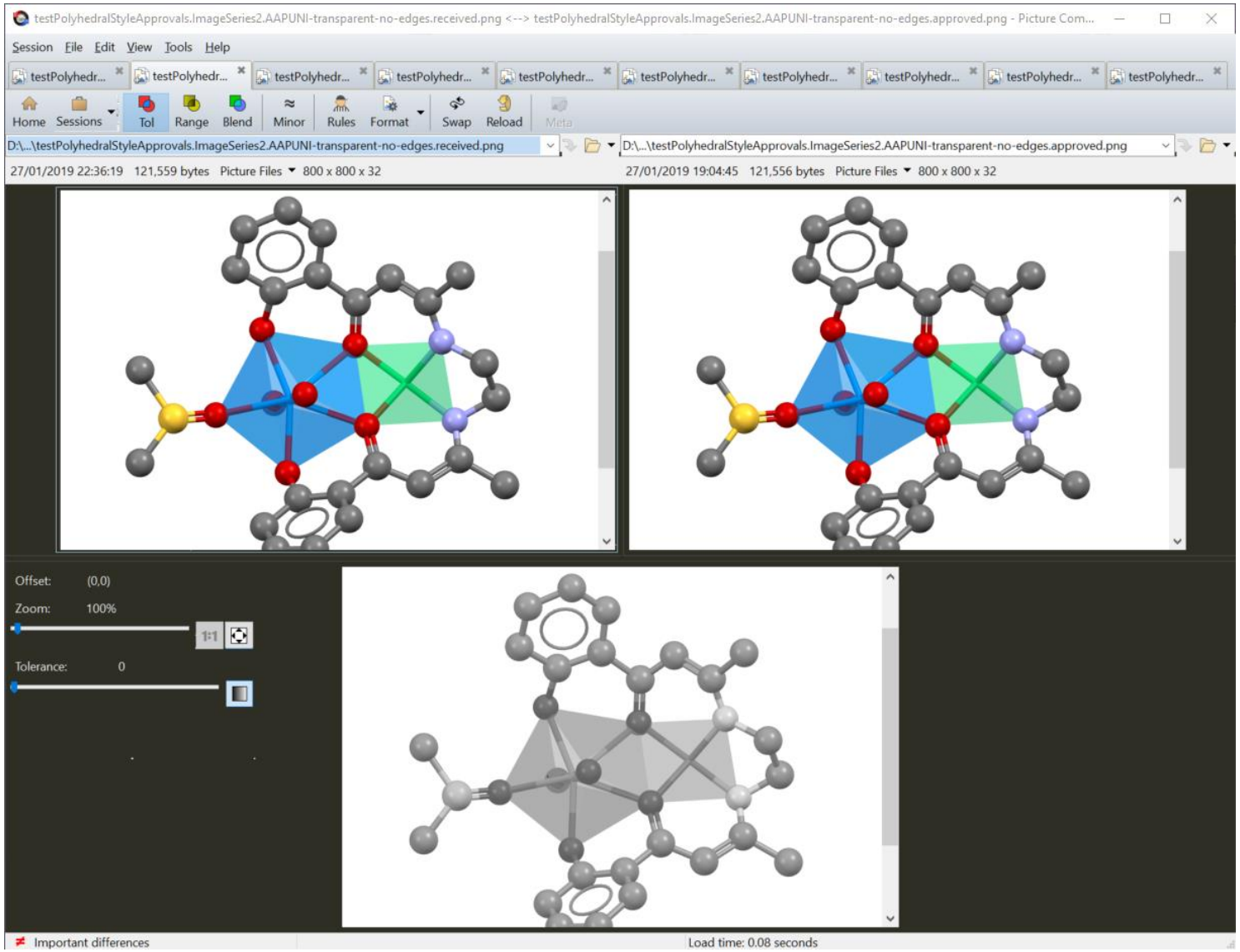
What? Re-running now gives random failures

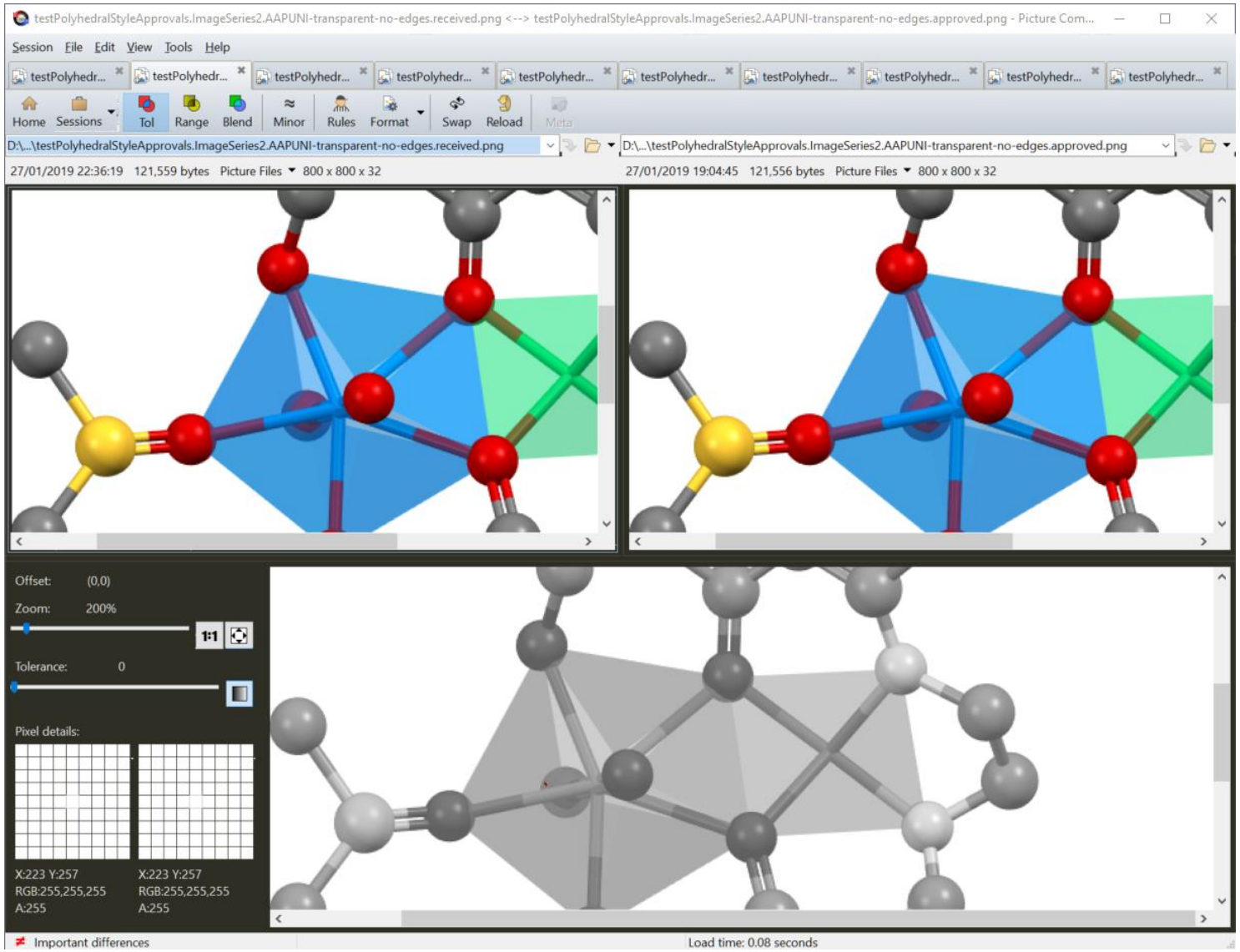
Araxis Merge

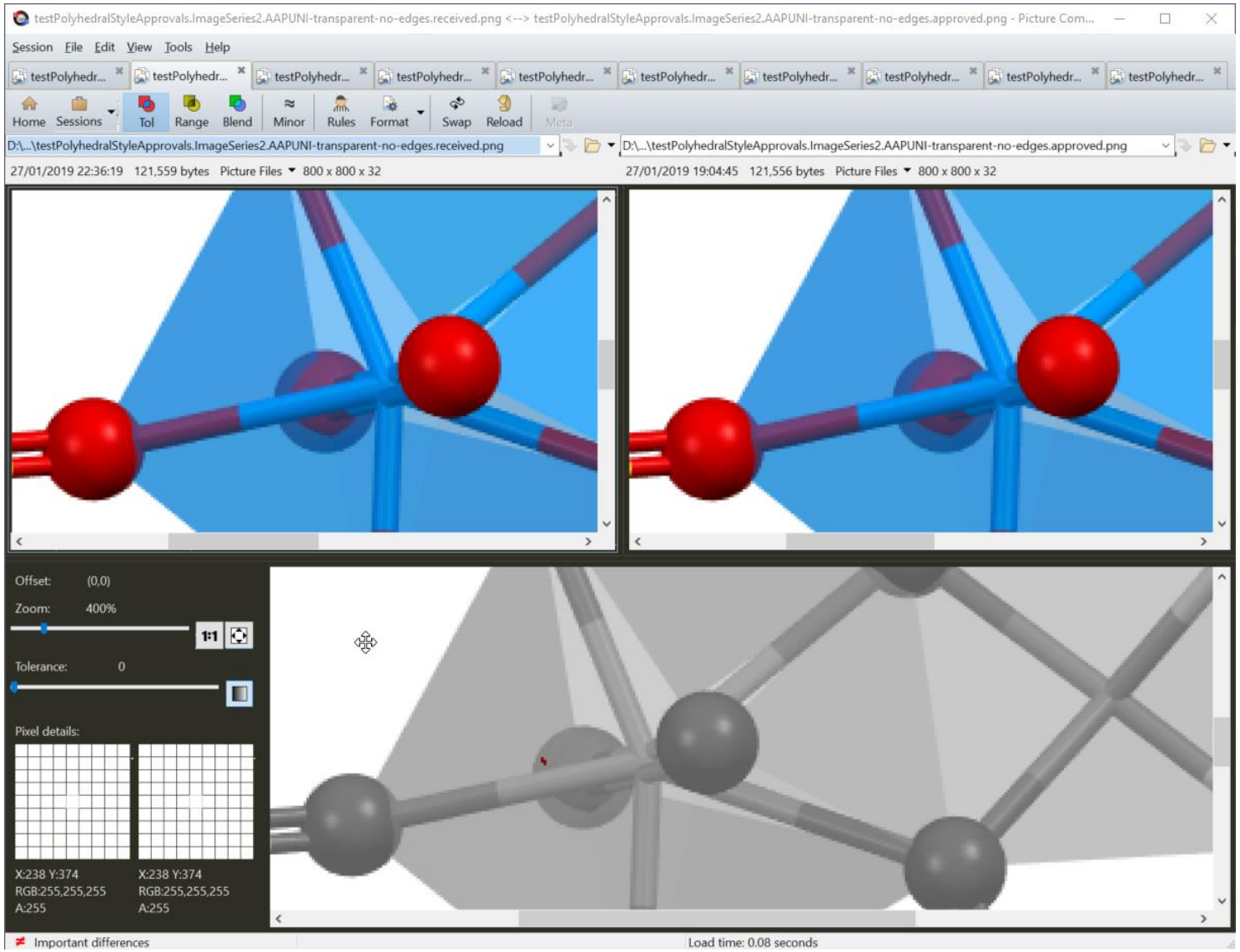


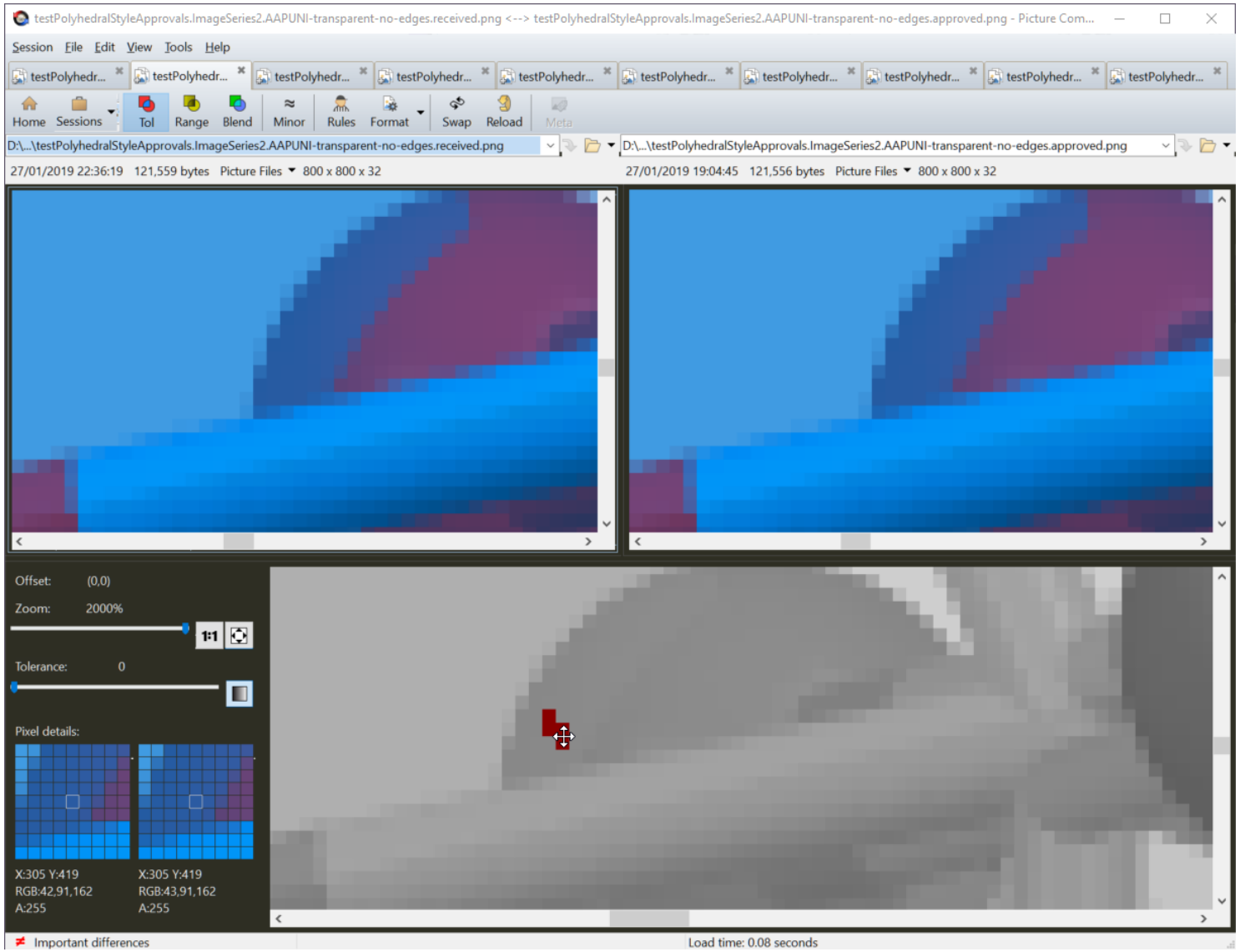
BeyondCompare 4

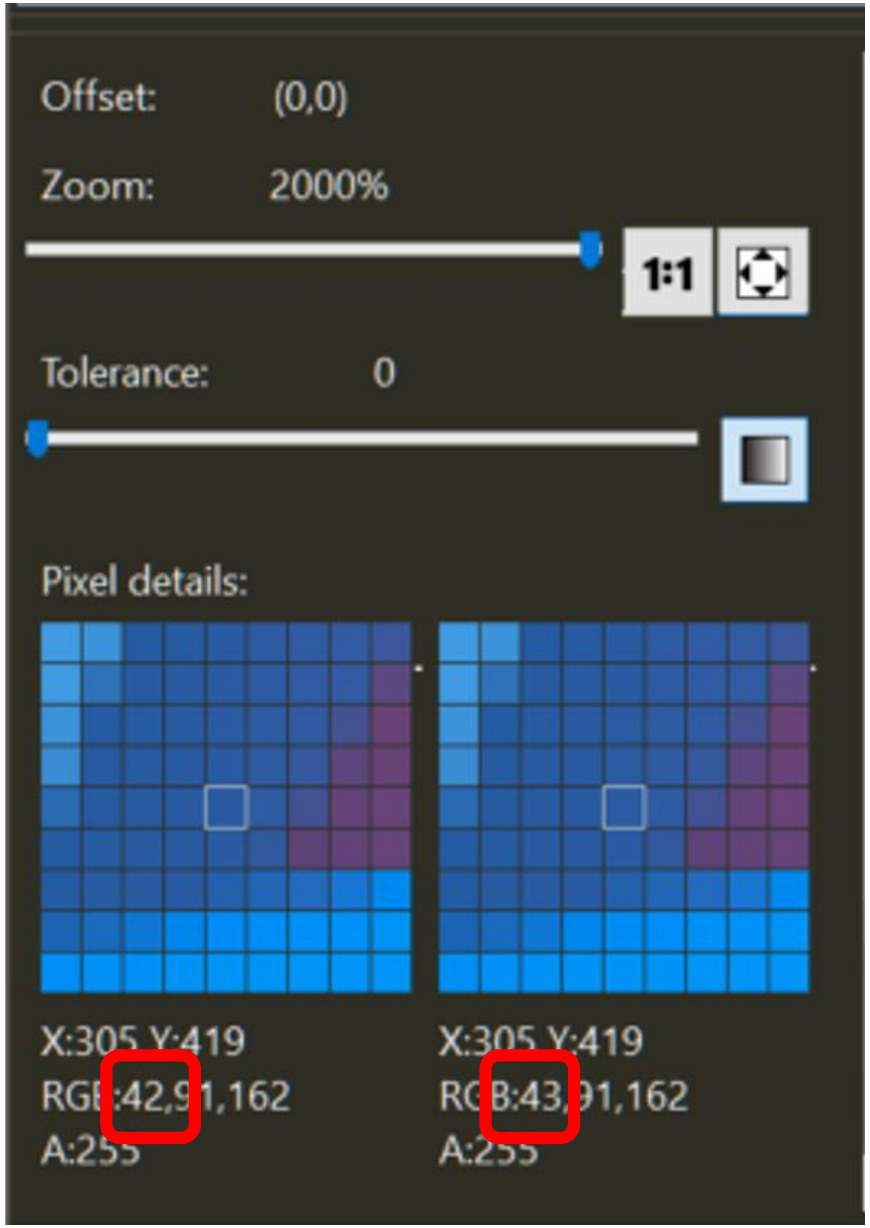



testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.received.png <--> testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.approved.png - Picture Com...
Session File Edit View Tools Help
Home Sessions Tol Range Blend Minor Rules Format Swap Reload Meta
D:\...\testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.received.png
D:\...\testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.approved.png
27/01/2019 22:36:19 121,559 bytes Picture Files 800 x 800 x 32
27/01/2019 19:04:45 121,556 bytes Picture Files 800 x 800 x 32
Offset: (0,0)
Zoom: 100%
1:1
Tolerance: 0
Important differences
Load time: 0.08 seconds


testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.received.png <--> testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.approved.png - Picture Com...
Session File Edit View Tools Help
Home Sessions Tol Range Blend Minor Rules Format Swap Reload Meta
D:\...\testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.received.png
D:\...\testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.approved.png
27/01/2019 22:36:19 121,559 bytes Picture Files 800 x 800 x 32
27/01/2019 19:04:45 121,556 bytes Picture Files 800 x 800 x 32
Offset: (0,0)
Zoom: 200%
1:1
Tolerance: 0
Pixel details:
X:223 Y:257
RGB:255,255,255
A:255
X:223 Y:257
RGB:255,255,255
A:255
Important differences
Load time: 0.08 seconds


testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.received.png <--> testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.approved.png - Picture Com...
Session File Edit View Tools Help
Home Sessions Tol Range Blend Minor Rules Format Swap Reload Meta
D:\...\testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.received.png
D:\...\testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.approved.png
27/01/2019 22:36:19 121,559 bytes Picture Files 800 x 800 x 32
27/01/2019 19:04:45 121,556 bytes Picture Files 800 x 800 x 32
Offset: (0,0)
Zoom: 400%
1:1
Tolerance: 0
Pixel details:
X:238 Y:374
RGB:255,255,255
A:255
X:238 Y:374
RGB:255,255,255
A:255
Important differences
Load time: 0.08 seconds


testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.received.png <--> testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.approved.png - Picture Com...
Session File Edit View Tools Help
Home Sessions Tol Range Blend Minor Rules Format Swap Reload Meta
D:\...\testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.received.png
D:\...\testPolyhedralStyleApprovals.ImageSeries2.AAPUNI-transparent-no-edges.approved.png
27/01/2019 22:36:19 121,559 bytes Picture Files 800 x 800 x 32
27/01/2019 19:04:45 121,556 bytes Picture Files 800 x 800 x 32
Offset: (0,0)
Zoom: 2000%
1:1
Tolerance: 0
Pixel details:
X:305 Y:419
RGB:42,91,162
A:255
X:305 Y:419
RGB:43,91,162
A:255
Important differences
Load time: 0.08 seconds


Offset: (0,0)
Zoom: 2000%
1:1
Tolerance: 0
Pixel details:
X:305 Y:419
RGB:42,91,162
A:255
X:305 Y:419
RGB:43,91,162
A:255

Customisability: ApprovalComparator

```
class ApprovalComparator
{
public:
    virtual ~ApprovalComparator() = default;

    virtual bool contentsAreEquivalent(std::string receivedPath,
                                       std::string approvedPath) const = 0;
};
```

Create custom QImage comparison class

```
// Allow differences in up to 1/255 of RGB values at each pixel, as saved in 32-bit images
// sometimes have a few slightly different pixels, which are not visible to the human eye.
class QImageApprovalComparator : public ApprovalComparator
{
public:
    bool contentsAreEquivalent(std::string receivedPath, std::string approvedPath) const override
    {
        const QImage receivedImage(QString::fromStdString(receivedPath));
        const QImage approvedImage(QString::fromStdString(approvedPath));

        return compareQImageIgnoringTinyDiffs(receivedImage, approvedImage);
    }
};
```

Register the custom comparison class

```
// Somewhere in main…
FileApprover::registerComparator(
    ".png",
    std::make_shared<QImageApprovalComparator>());
```

Does the difference matter?

- Legacy code is often brittle
- Testing makes changes visible
- Then decide if change matters
- Fast feedback cycle for efficient development

Looking back

- User perspective
- Learned about own code
- Enabled unit tests for graphics problems
- Approvals useful even for temporary tests

ApprovalTests Customisation Points

- `Reporter`
- `ApprovalWriter`
- `ApprovalComparator`
- `ApprovalNamer`

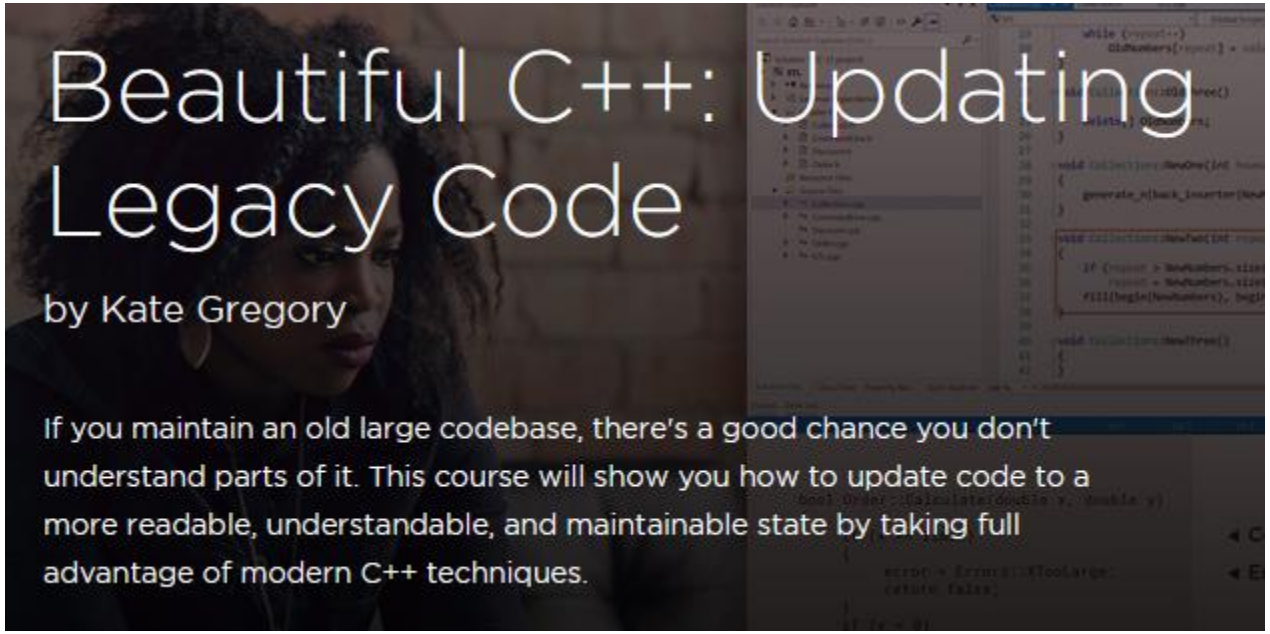
Contents

References: Tools Used

- Diffing
  - Araxis Merge: https://www.araxis.com/merge/
  - Beyond Compare: https://www.scootersoftware.com/
- Code Coverage
  - OpenCppCoverage and Visual Studio Plugin: https://github.com/OpenCppCoverage
  - BullseyeCoverage: https://www.bullseye.com/

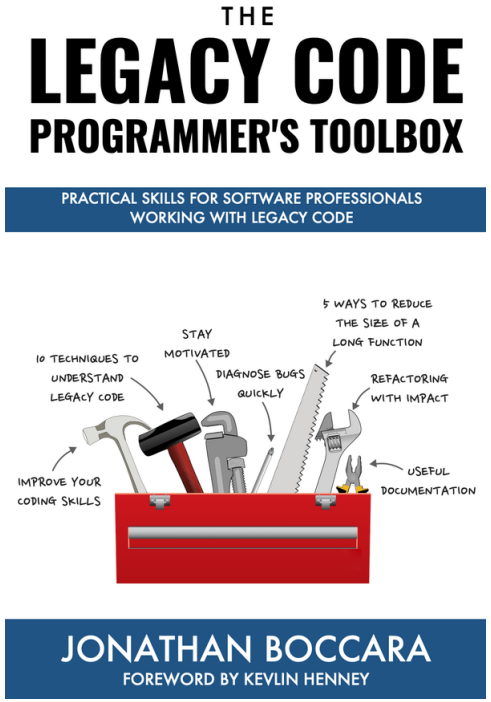
Beautiful C++: Updating Legacy Code

- https://app.pluralsight.com/library/courses/cpp-updating-legacy-code/table-of-contents



The Legacy Code Programmer’s Toolbox

- https://leanpub.com/legacycode
- The Legacy Code Programmer's Toolbox: Practical skills for software professionals working with legacy code, by Jonathan Boccara

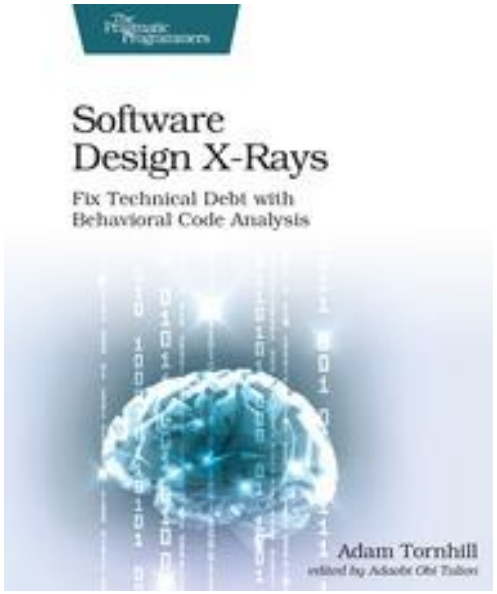


Videos


Practical
Refactoring
with
@WoodyZuill &
@Llewellyn Falco
SPUN
LABORATORIES
INCORPORATED
2 Minutes
to
Better Code
By Llewellyn Falco & Woody Zuill
Practical Refactoring - How to clean code in many small steps
58,016 views
486
23
SHARE
SAVE

Adam Tornhill's Books

- Mining actionable information from historical code bases (by Adam Tornhill)
  - Your Code as a Crime Scene
  - Software Design X-Rays: Fix Technical Debt with Behavioural Code Analysis



Contents

Adopting legacy code

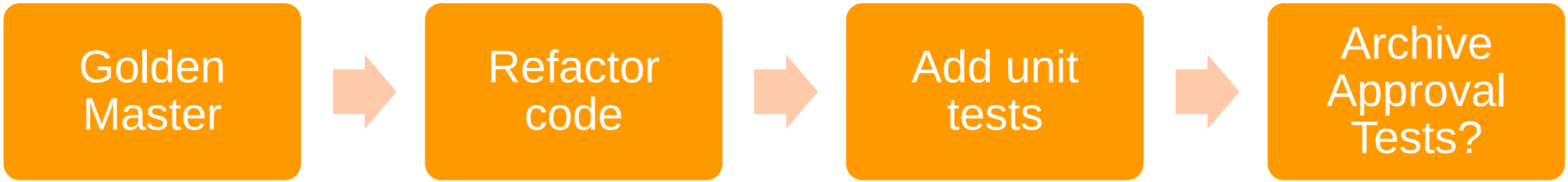
- You can do it!
- Evaluate current tests
- Quickly improve coverage with Golden Master
- ApprovalTests.cpp makes that really easy
- Even for non-text types

ApprovalTests

- Powerful Golden Master tool
- verify(), verifyAll(), verifyAllCombinations()
- Adjust output files, after writing, to simplify comparison

ApprovalTests.cpp

- Not (always) a replacement for Unit Tests!



Thank You: Any Questions?

- Example Code: https://github.com/claremacrae/cpponsea2019

- Slides: https://www.slideshare.net/ClareMacrae
  - (later this week)

- ApprovalTests.cpp
  - https://github.com/approvals/ApprovalTests.cpp
  - https://github.com/approvals/ApprovalTests.cpp.StarterProject