MICHIGAN STATE
UNIVERSITY

Project Plan Presentation

Test Driven Development For Embedded Software

The Capstone Experience

Team Magna TDD4ES

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From Students…
…to Professionals

Project Sponsor Overview

- Magna is one of the largest automotive suppliers, producing systems, modules, and other components for companies like GM, Ford and BMW.
- Founded in 1957 with headquarters in Ontario, Canada.
- Manages more than 340 manufacturing sites and 105 product development, sales, and engineering facilities across 27 countries.

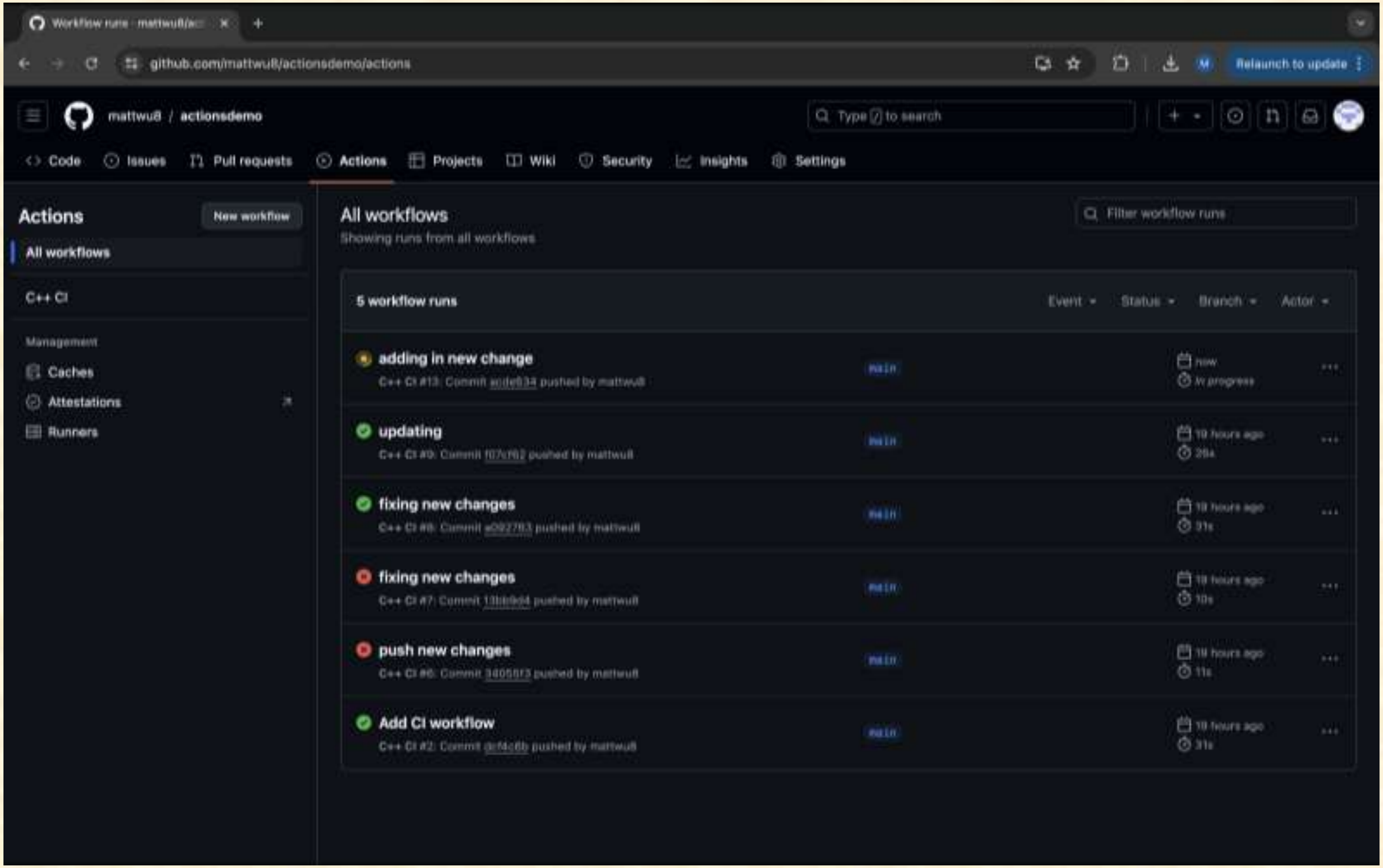
Project Functional Specifications

- Magna engineers are currently working with a relatively large, untested codebase.
- Implement TDD process into the development of embedded software by setting up the necessary infrastructure.
- Add test cases to existing codebase as proof of concept, using a testing framework.
- Automate the testing pipeline using GitHub Actions to run test jobs.

Project Design Specifications

- For each component or function, test cases will be written to ensure maximum coverage.
- Test cases will not only cover primary functionality, but edge cases and possible memory leaks.
- GitHub Actions will be used as the front end to manage and view specific test runs.
- Additional tools like Gcov and scripts used to generate test reports.

Screen Mockup: Actions Overview



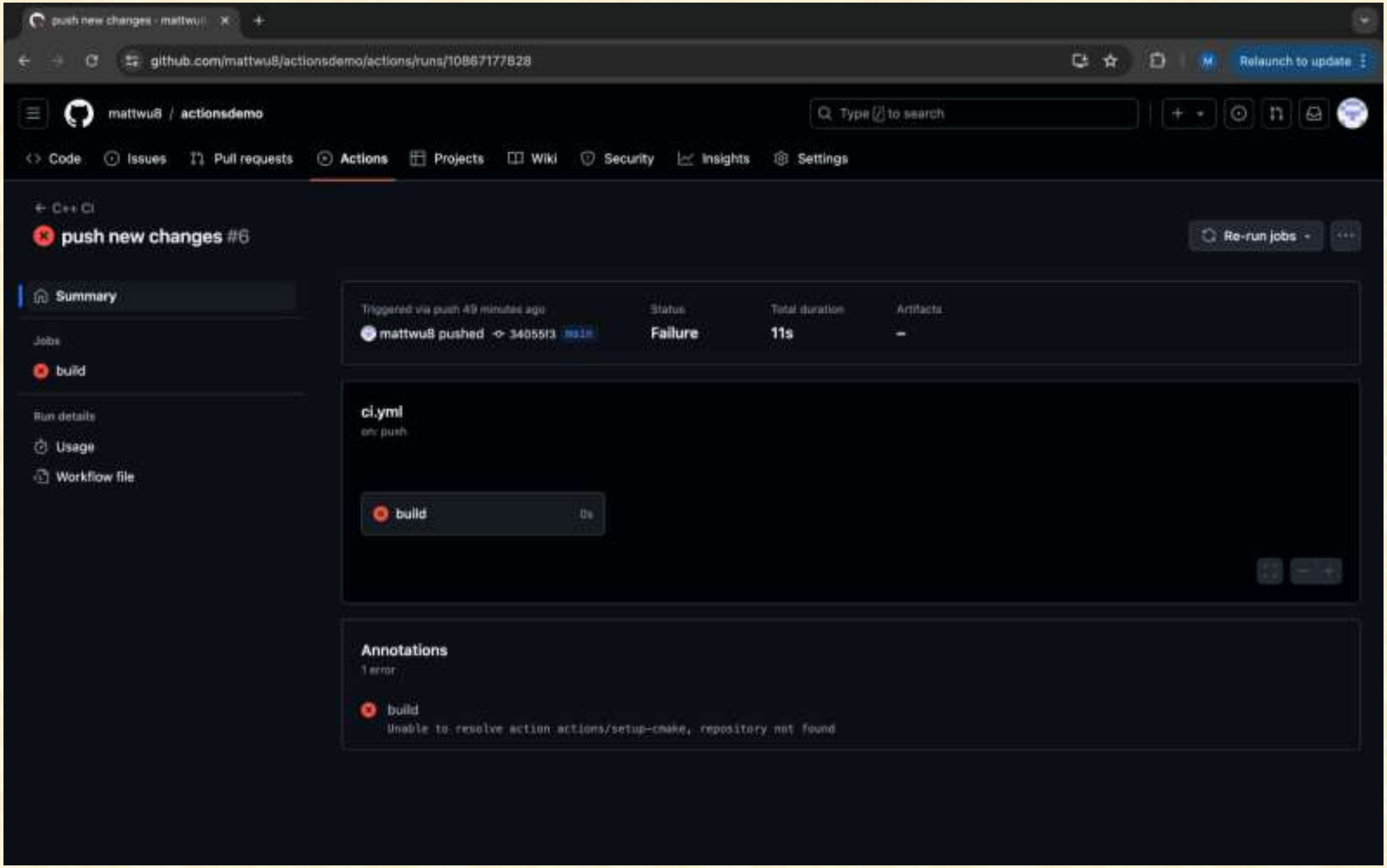
All workflows

Showing runs from all workflows

5 workflow runs

adding in new change C++ CI #13: Commit acde834 pushed by mattwu8	main	now In progress	···
updating C++ CI #9: Commit f07c762 pushed by mattwu8	main	19 hours ago 28s	···
fixing new changes C++ CI #8: Commit a092763 pushed by mattwu8	main	19 hours ago 31s	···
fixing new changes C++ CI #7: Commit 13bb9d4 pushed by mattwu8	main	19 hours ago 10s	···
push new changes C++ CI #6: Commit 3405513 pushed by mattwu8	main	19 hours ago 11s	···
Add CI workflow C++ CI #2: Commit dcf4c6b pushed by mattwu8	main	19 hours ago 31s	···

Screen Mockup: Detailed Job View



push new changes #6

Triggered via push 49 minutes ago: mattwu8 pushed 3405513 main

Status: Failure

Total duration: 11s

Artifacts: –

ci.yml
on: push

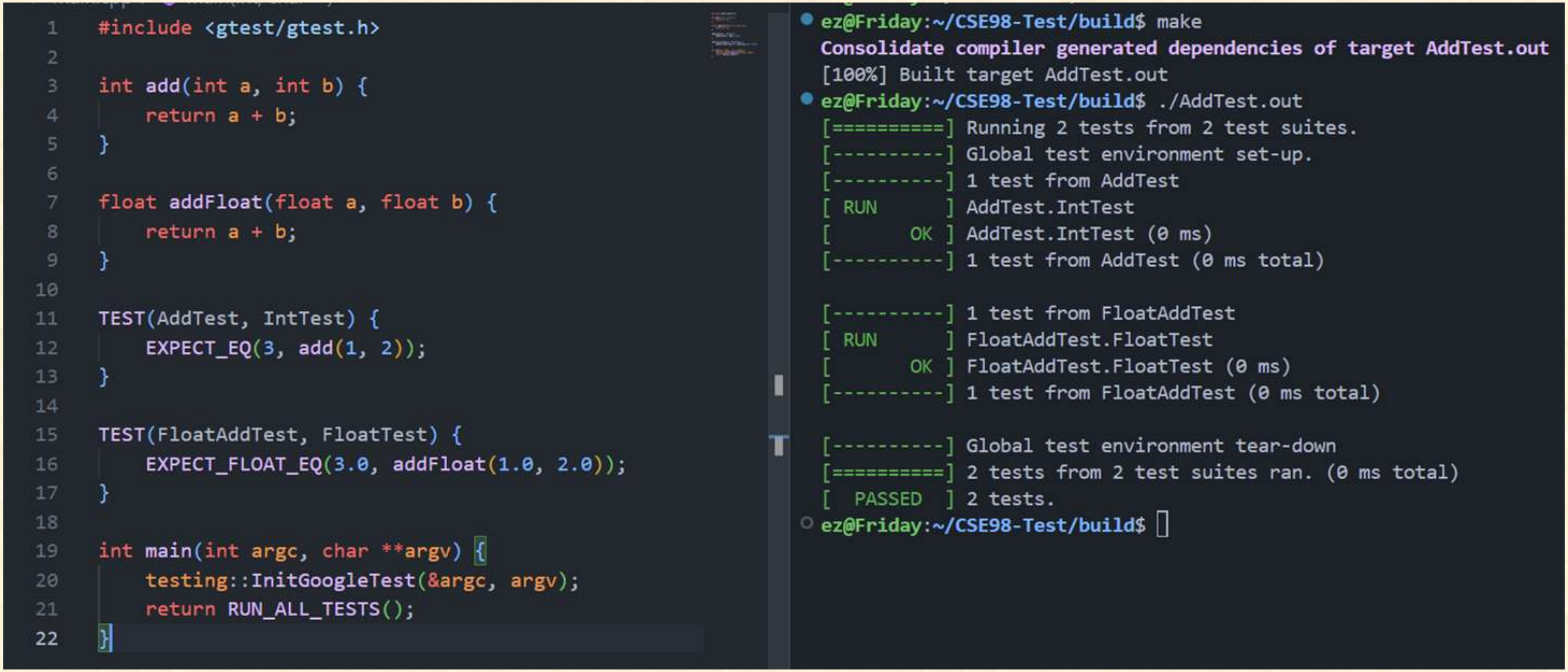
build 0s

Annotations
1 error

build

```
Unable to resolve action actions/setup-cmake, repository not found
```

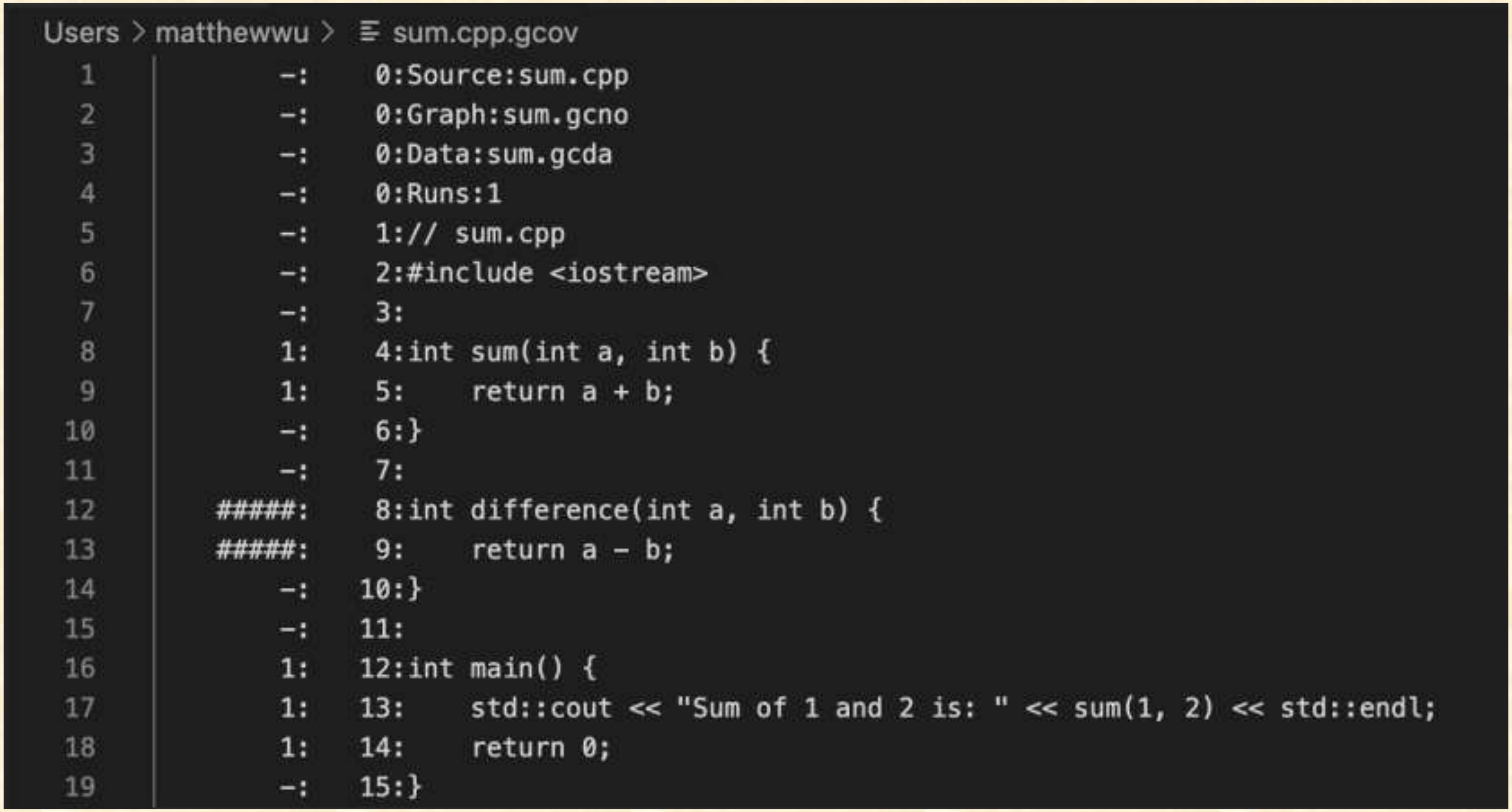
Screen Mockup: Test Output



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

int add(int a, int b) {
    return a + b;
}

float addFloat(float a, float b) {
    return a + b;
}

TEST(AddTest, IntTest) {
    EXPECT_EQ(3, add(1, 2));
}

TEST(FloatAddTest, FloatTest) {
    EXPECT_FLOAT_EQ(3.0, addFloat(1.0, 2.0));
}

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

```
ez@Friday:~/CSE98-Test/build$ make
Consolidate compiler generated dependencies of target AddTest.out
[100%] Built target AddTest.out
ez@Friday:~/CSE98-Test/build$ ./AddTest.out
[==========] Running 2 tests from 2 test suites.
[----------] Global test environment set-up.
[----------] 1 test from AddTest
[ RUN      ] AddTest.IntTest
[       OK ] AddTest.IntTest (0 ms)
[----------] 1 test from AddTest (0 ms total)

[----------] 1 test from FloatAddTest
[ RUN      ] FloatAddTest.FloatTest
[       OK ] FloatAddTest.FloatTest (0 ms)
[----------] 1 test from FloatAddTest (0 ms total)

[----------] Global test environment tear-down
[==========] 2 tests from 2 test suites ran. (0 ms total)
[  PASSED  ] 2 tests.
ez@Friday:~/CSE98-Test/build$ 
```

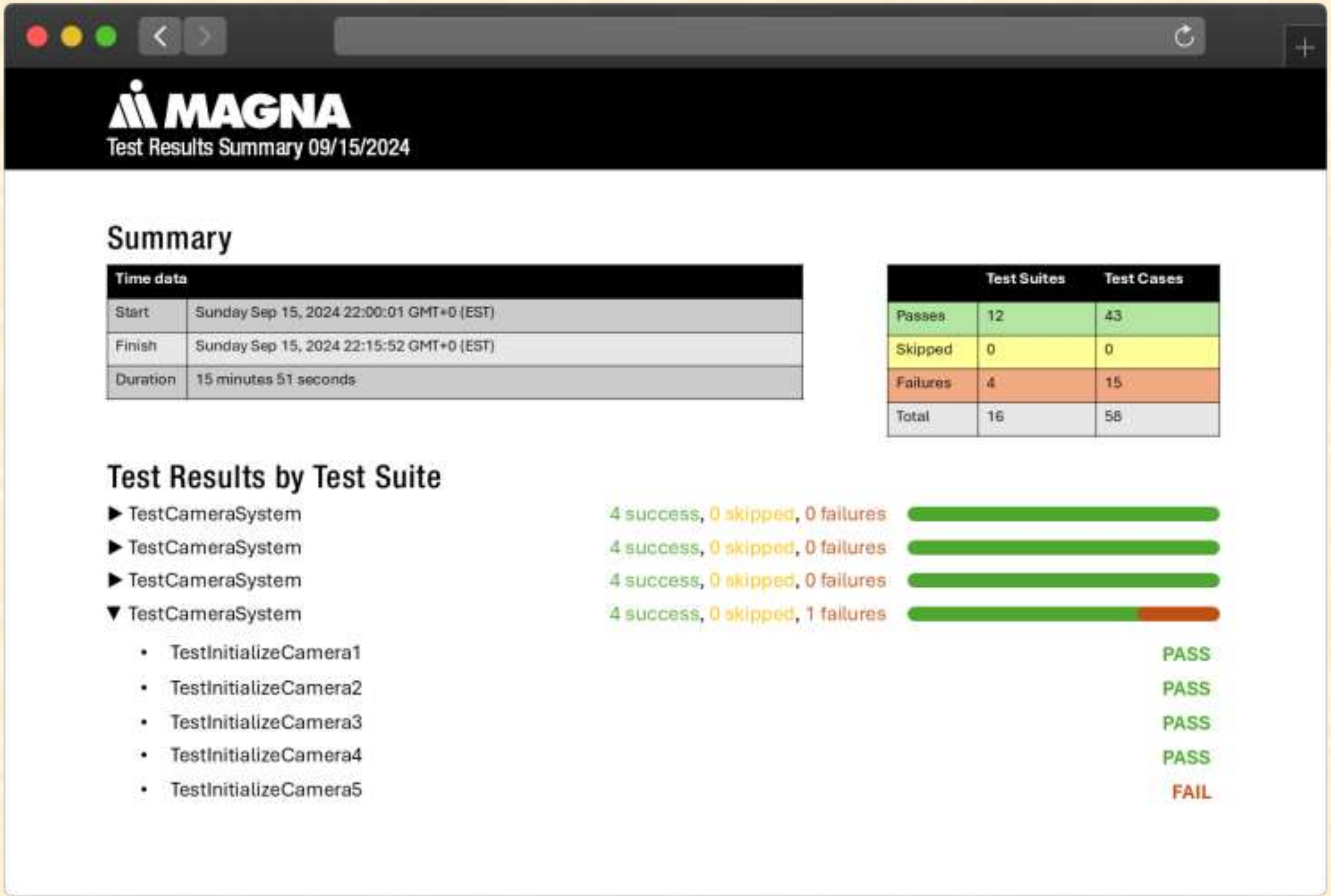
Screen Mockup: Gcov Coverage Report



Users > matthewwu > sum.cpp.gcov

```
        -:    0:Source:sum.cpp
        -:    0:Graph:sum.gcno
        -:    0:Data:sum.gcda
        -:    0:Runs:1
        -:    1:// sum.cpp
        -:    2:#include <iostream>
        -:    3:
        1:    4:int sum(int a, int b) {
        1:    5:    return a + b;
        -:    6:}
        -:    7:
    #####:    8:int difference(int a, int b) {
    #####:    9:    return a - b;
        -:   10:}
        -:   11:
        1:   12:int main() {
        1:   13:    std::cout << "Sum of 1 and 2 is: " << sum(1, 2) << std::endl;
        1:   14:    return 0;
        -:   15:}
```

Screen Mockup: Test Summary Report



MAGNA

Test Results Summary 09/15/2024

Summary

Time data	
Start	Sunday Sep 15, 2024 22:00:01 GMT+0 (EST)
Finish	Sunday Sep 15, 2024 22:15:52 GMT+0 (EST)
Duration	15 minutes 51 seconds

	Test Suites	Test Cases
Passes	12	43
Skipped	0	0
Failures	4	15
Total	16	58

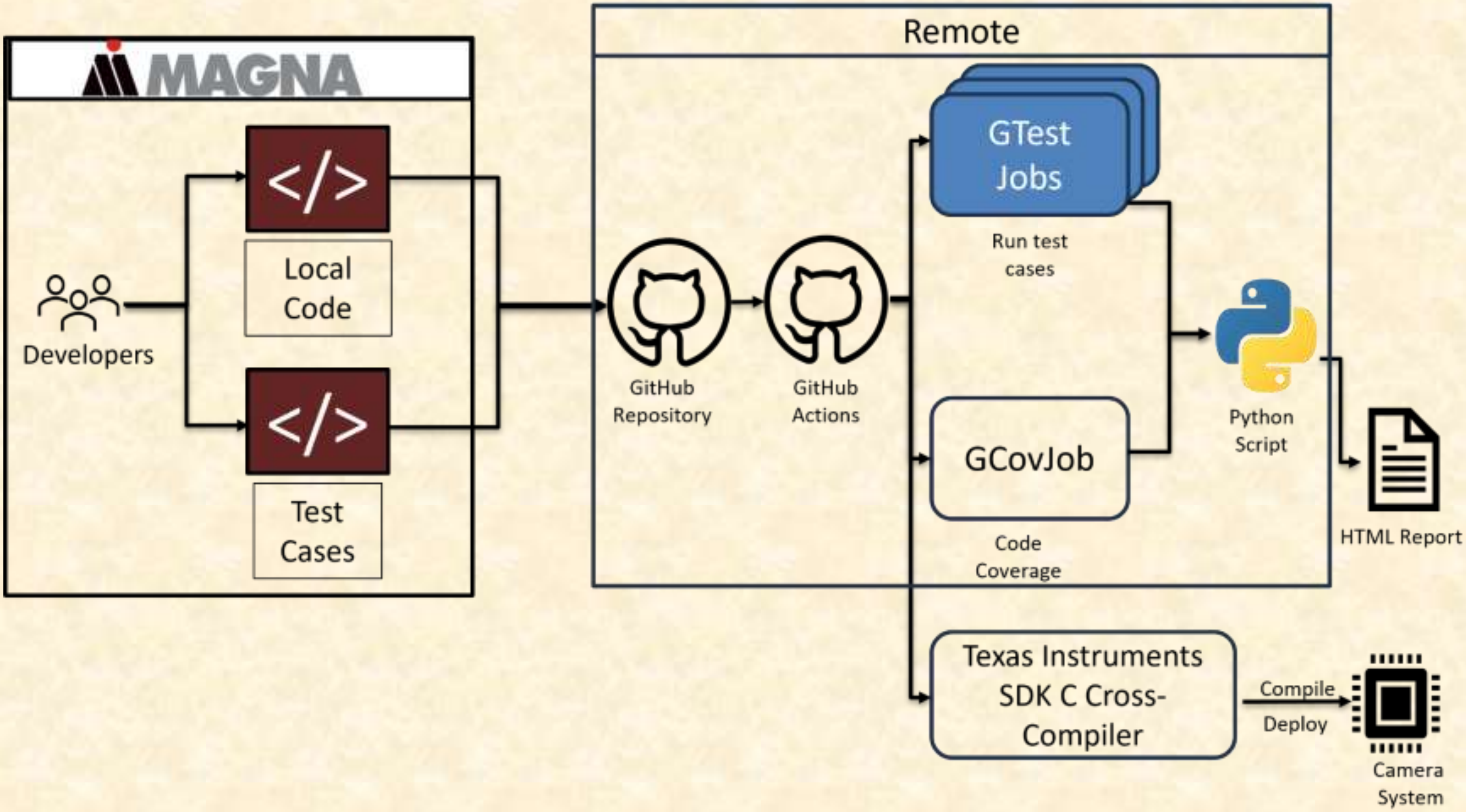
Test Results by Test Suite

- ▶ TestCameraSystem — 4 success, 0 skipped, 0 failures
- ▶ TestCameraSystem — 4 success, 0 skipped, 0 failures
- ▶ TestCameraSystem — 4 success, 0 skipped, 0 failures
- ▼ TestCameraSystem — 4 success, 0 skipped, 1 failures
  - TestInitializeCamera1 PASS
  - TestInitializeCamera2 PASS
  - TestInitializeCamera3 PASS
  - TestInitializeCamera4 PASS
  - TestInitializeCamera5 FAIL

Project Technical Specifications

- GitHub Actions to trigger a test run on code push, to make sure new changes do not conflict with existing systems.
- Google Test Framework as our testing framework, to write test cases.
- Gcov will be used to generate test coverage reports.
- Python will be used to generate test result summary.

Project System Architecture



Project System Components

- Software Platform
  - Linux
  - GitHub Actions
- Development Technologies
  - C/C++
  - Google Test
  - Texas Instruments TDA4VM SDK
  - Gcov
  - Python

Project Risks

- Running Code on Embedded Systems
  - Code must be tested on embedded systems that we don’t have.
  - Design architecture-agnostic tests and/or send code to client to run.
- Testing Frameworks for Embedded System
  - Unsure what testing frameworks are compatible with hardware.
  - Tests will be designed to run on any architecture, can collect mock data from client, Google Test is selected for its robustness and familiarity.
- GitHub Actions Integration
  - Users should be able to interact with tests through GitHub. GitHub Actions may not provide an Emulator for our architecture.
  - Architecture concerns are mitigated, test jobs will be run on Linux-based jobs.
- Optimization Requirements
  - Tests are ineffective if take a long time to complete.
  - Split test groups into different Actions jobs to be run in parallel.

Questions?

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