CS1632:
Test Plans and TM

Wonsun Ahn

Test Plans

What is a Test Plan?

- Test Plan: A document laying out a plan for testing a software system

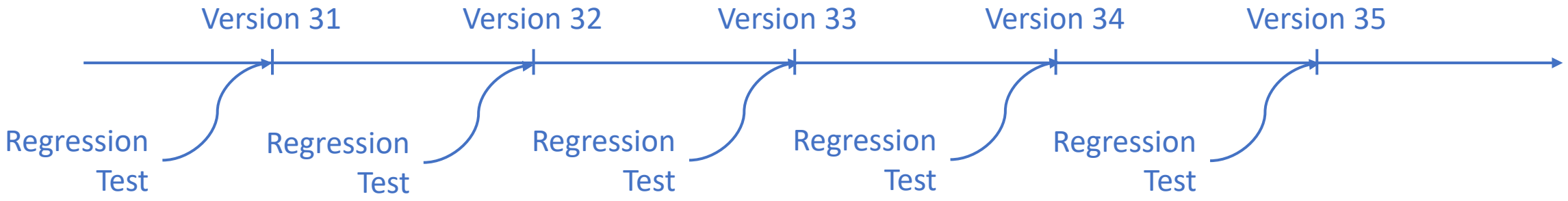
- Why do we need a **plan**?
  - Goal of testing is to minimize risk of defects given a time/cost budget
  - Careful planning can maximize test coverage with a limited number of tests

- Why do we need to **document** the plan?
  - Allows project managers to estimate test coverage and manage risk
  - Allows quality engineers to reliably repeat the same tests over and over again
  - **Repeatability** of tests is particularly important for *regression tests*

Regression Tests prevent SW from regressing

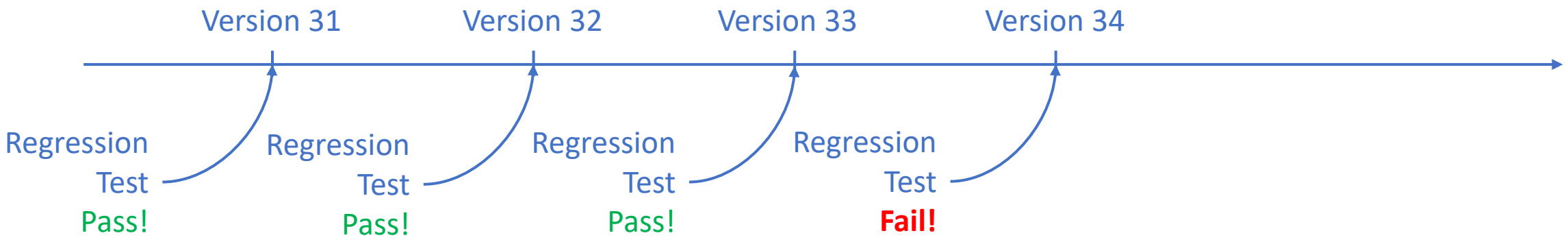
- *Regression*: A failure of a previously working feature
  - Can be caused by (seemingly) unrelated enhancements or defect fixes
  - Why? Because code fixes often have non-local effects
  - Regression test must test modified feature but also all other features

- For timely regression detection, regression test is run on each code update



Repeatable tests can pinpoint defective version

- Suppose a regression test fails on a code update:



- We can pinpoint where the defect crept in, at Version 34.
- Why? Because we are confident that we are repeating the same tests!
- Now, if we ran different tests each time, would we know?

How formal should the plan be documented?

- As formal or informal as necessary!

- Think about what you are testing
  - How critical is the software that you are testing?
  - How many times is the test plan going to be used?

What are you testing?

- Throw-away script?
- Development tool?
- Internal website?
- Enterprise software?
- Commercial software?
- Operating system?
- Avionics software?

Testing is context-dependent

- How you test
- How much you test
- What tools you use
- What documentation you provide

- ...All vary based on software context.

Test Cases

Test Plans and Test Cases

- A test plan consists of a list of related test cases that are run together

- *Test case*: a test scenario with precise steps on how to perform it
  - Describes what is to be tested and what steps to perform
  - Describes expected behavior after the steps are performed

Test Case main body consists of …

- *Preconditions*: State of system before execution steps. E.g.,
  - Packages X and Y are installed on the system
  - Configuration file X contains entry Y
  - Database has table X set up populated with Y entry
- *Execution Steps*: Steps to perform test
- *Postconditions*: **Expected** state after execution steps
  - Derived from **requirements** based on preconditions + execution steps

Test Case header identifies and describes it

- *Identifier*: A way to identify the test case
  - Could be numerical, e.g. TC-452
  - Or a descriptive label, e.g. INVALID-PASSWORD-THREE-TIMES-TEST

- *Test Case*: A short description of what is being tested

In full, a test case contains the following items

- Identifier
- Test Case
- Preconditions
- Execution Steps
- Postconditions

See IEEE 829, "Standard for Software Test Documentation", at resources/IEEE829.pdf

Example Test Case

- Identifier: SORT-ASCENDING-FOUR-INTEGERS-TEST
- Test Case: When SORT_ASCENDING flag is set, calling sort([9,3,4,2]) returns a new sorted array [2,3,4,9].
- Preconditions: SORT_ASCENDING global variable is set to true.
- Execution Steps:
  1. Set test_array = [9,3,4,2].
  2. Call sort(test_array).
- Postconditions: Return value of sort(test_array) is array [2,3,4,9].

Test Run – Actual execution

- *Test run*: Actual execution of a test case
  - Subsets of test cases may be chosen to run from the entire test suite
  - All depends on the type of code modification and the testing context

- The purpose of a test run is to obtain *observed behavior*
  - Passes or fails after comparing *observed behavior* with *postcondition*

Status after Test Run

- Possible Statuses
  - PASSED: Completed with expected result
  - FAILED: Completed but unexpected result
  - PAUSED: Test paused in middle of execution
  - RUNNING: Test in the middle of execution
  - BLOCKED: Did not complete because precondition not fulfilled
  - ERROR: Problem with running test itself

- During test run, tester manually (or automatically) executes each test case and sets the status for each
- A FAILED status signals a defect that needs to be reported.

Creating Good Test Cases

A good test case is two things

- A good test case verifies **requirements faithfully**
  - No false negatives: all defective behaviors results in Postcondition failures
  - No false positives: all correct behaviors results in Postcondition passes

- A good test case is **repeatable**
  - Test results are consistent regardless of who / when / where the tests are run
  - Preconditions + Execution Steps are enough to guarantee consistent results

Pitfall 1:
Using Observed Behavior for Postcondition

- Never use screenshots (or copy-and-paste) of output even if correct
  - Screenshots contain spurious info that result in **false positive defects**

- Suppose requirement is: “The sum of the 2 arguments is displayed.”
- Execution Step is: “Pass in values of 1 and 2 as arguments.”
- Postcondition is: Result is: 3 is displayed.
- Observed behavior is: Value is: 3
- The test case would fail, but is this a defect? No!

- Postconditions should be derived from **requirements**
  - Correct postcondition: “The result value of 3 is displayed.”

Pitfall 2: Using Requirement for Postcondition

- Do not paste requirements verbatim as postconditions
  - Forces tester to derive expected behavior based on own interpretation
  - Results in **unrepeatable** tests as well as both false negative and positive defects

- Suppose requirement is:
  "Fibonacci sequence following number given as argument is returned."
- Execution Step is: "Run program passing 5 as argument."
- Postcondition is: (a copy of the above requirement)
- Would the tester be able to tell what the expected return value should be?

- Postconditions should describe expected behavior explicitly
  - Correct postcondition: "The value of 8 is returned."

Pitfall 3: Imprecise Preconditions / Execution Steps

- Incomplete preconditions (OS / DB / Filesystem / Memory state)
  - E.g. OS environment variable that impacts test case is not specified
  - E.g. A configuration file that impacts test case is not specified
- Imprecise execution steps
  - E.g. “Open new browser” → Multiple ways: Ctrl+N, Menu, Double click
- Results in **unrepeatable** tests

Listing Preconditions as Preconditions (Potentially less precise)

- Identifier: ADD-ONE-WIDGET-TO-CART-TEST
- Test Case: When shopping cart is empty, when I add one widget to the cart, the number of widgets in the cart becomes one.
- Preconditions:
  - Microsoft Windows (version 10) is running on the machine.
  - Chrome browser (version 100) is running on the machine.
  - The URL https://my.ecommerce.site is open on Chrome browser.
  - Shopping cart is empty.
- Execution Steps:
  1. Select first widget from the list of widgets by clicking on the checkbox.
  2. Click “Add to Cart“ button.
- Postconditions: Shopping cart displays one widget.

Initializing Preconditions in Execution Steps (Potentially more precise)

- Identifier: ADD-ONE-WIDGET-TO-CART-TEST
- Test Case: When shopping cart is empty, when I add one widget to the cart, the number of widgets in the cart becomes one.
- Preconditions:
  - The machine has a newly formatted hard drive.
- Execution Steps:
  1. Install and launch Windows 10 on the machine.
  2. Install and launch Chrome browser (version 100).
  3. Enter URL https://my.ecommerce.site on Chrome browser search box.
  4. Click on the search button on Chrome browser.
  5. Select first widget from the list of widgets by clicking on the checkbox.
  6. Click “Add to Cart“ button.
- Postconditions: Shopping cart displays one widget.

Where is the Sweet Spot?

- Documenting preconditions as preconditions
  - If conditions already satisfied, no need to perform – saves time
    (e.g., if Windows is already installed, no need to install again)
  - Does not enforce same steps to reach condition – less repeatable
    (e.g., Windows may have been installed with different options)

- Documenting preconditions as initial execution steps
  - Enforces same steps resulting in a more uniform condition – more repeatable
    (e.g., installing Windows from scratch results in a more uniform environment)
  - Sometimes performed even when redundant – wastes time

- Docker Containers is both repeatable and saves time! (will learn later)

Pitfall 4 - A Test Case that is not Independent

- Test case shouldn’t depend on the execution of a previous test case
  - E.g. Should not depend on database entries inserted by previous test case

- Results in **unrepeatable** tests
  - If the previous test case fails, this test case will be impacted
  - Test cases may be run selectively, and previous case may not be selected to run
  - Test cases may execute out of order, causing previous case to execute later (Often, test cases are executed in parallel to save testing time)

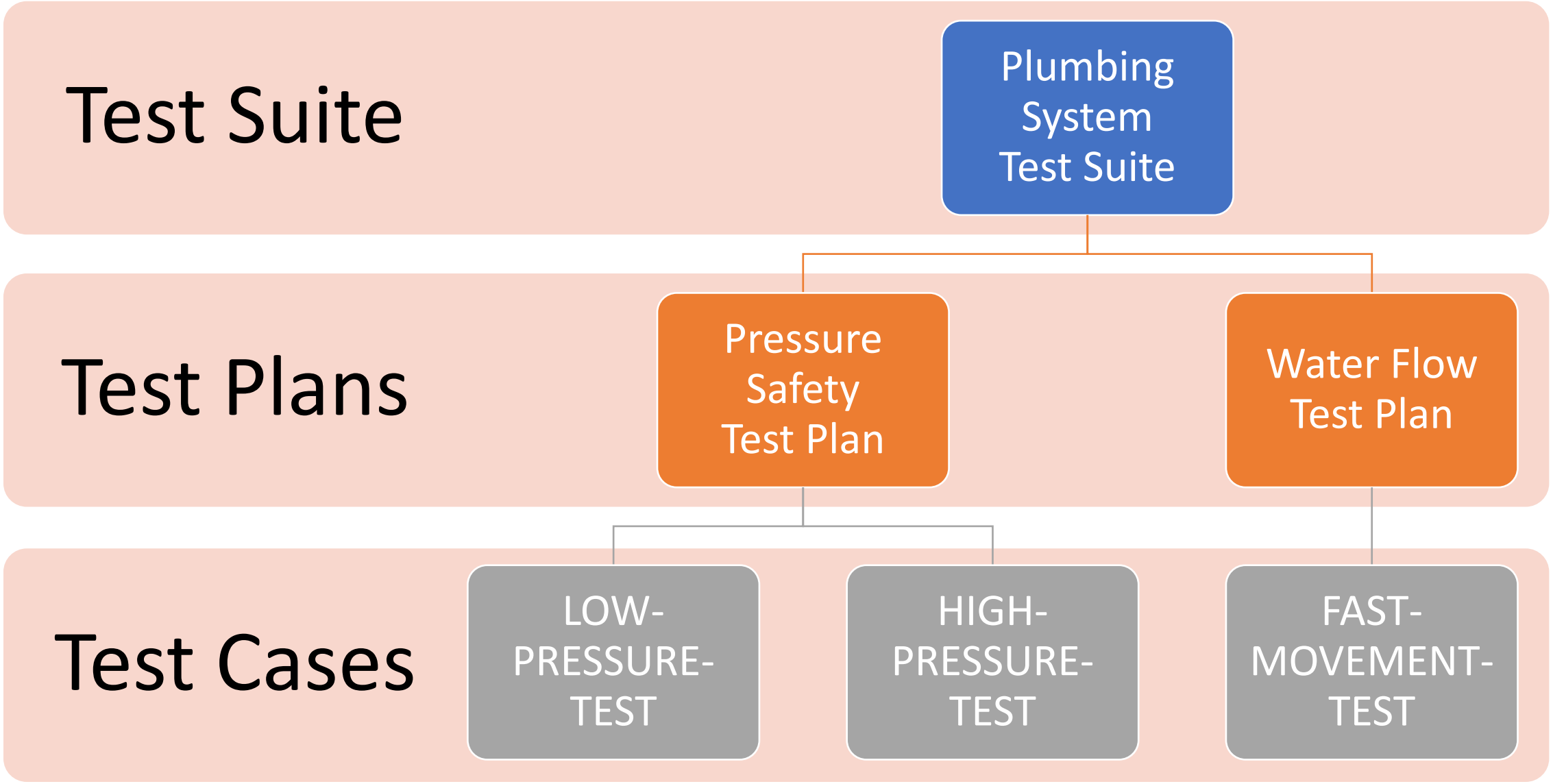
Pitfall 5 - A Test Case testing Multiple Scenarios

- Test case shouldn’t merge multiple scenarios into one
  - On fail, cannot tell easily which scenario resulted in test failure
  - Failure of a previous scenario may prevent accurate testing of a later scenario

- Example of a merged test case:
  - Execution Steps:
    1. Call sqrt(4)
    2. Call sqrt(9)
    3. Call sqrt(16)
  - Postconditions:
    - Results of first, second, and third calls are 2, 3, 4, respectively.

Testing Hierarchy

A group of test plans make up a *test suite*…



Creating a test suite from requirements

- Take top-down approach to create hierarchy of test plans and cases.

1. Subdivide system into features or subsystems
2. For each feature, create a test plan with varied inputs + preconditions
3. For each input + precondition, create a test case

- Test base / edge / corner cases for each feature to maximize coverage.

Traceability Matrix

Traceability: Ability to trace requirements to test cases (and vice versa)

- Forward Traceability
  - Ability to trace **requirement → test cases**
  - Given a requirement, allows listing of all test cases that test it
  - Ensures there are no requirements with insufficient test coverage
- Backward Traceability
  - Ability to trace **test case → requirements**
  - Given a test case, allows listing of all requirements that are tested
  - Ensures there are no test cases that are not testing any requirements
    → “Orphaned” test cases need to be removed, along with the implementation
- Ensures requirements, and only requirements, are implemented

Traceability Matrix ensures traceability

- **Traceability Matrix**:
  Table describing relationship between requirements and test cases

- Why is it a “matrix”?
  - One test case may test multiple requirements
  - One requirement may be tested by multiple test cases
  - It’s a many-to-many relationship, hence the matrix

Good Forward Traceability Matrix Example

REQ1: TEST_CASE_1, TEST_CASE_2
REQ2: TEST_CASE_1, TEST_CASE_3
REQ3: TEST_CASE_1
REQ4: TEST_CASE_2
REQ5: TEST_CASE_4

- Mapping requirements → test cases
- All requirements have at least one test case testing that requirement
- All requirements have **some** test coverage

Bad Forward Traceability Matrix Example

REQ1: TEST_CASE_1, TEST_CASE_2

REQ2:

REQ3: TEST_CASE_1

REQ4: TEST_CASE_2

REQ5: TEST_CASE_4

- *No test case is testing requirement 2!*
- *Add test cases for requirement 2!*

Good Backward Traceability Matrix Example

TEST_CASE_1: REQ1, REQ2, REQ3

TEST_CASE_2: REQ1, REQ4

TEST_CASE_3: REQ2

TEST_CASE_4: REQ5

- Mapping test cases → requirements
- All test cases have at least one requirement it is testing

Bad Backward Traceability Matrix Example

TEST_CASE_1: REQ1, REQ2, REQ3

TEST_CASE_2: REQ1, REQ4

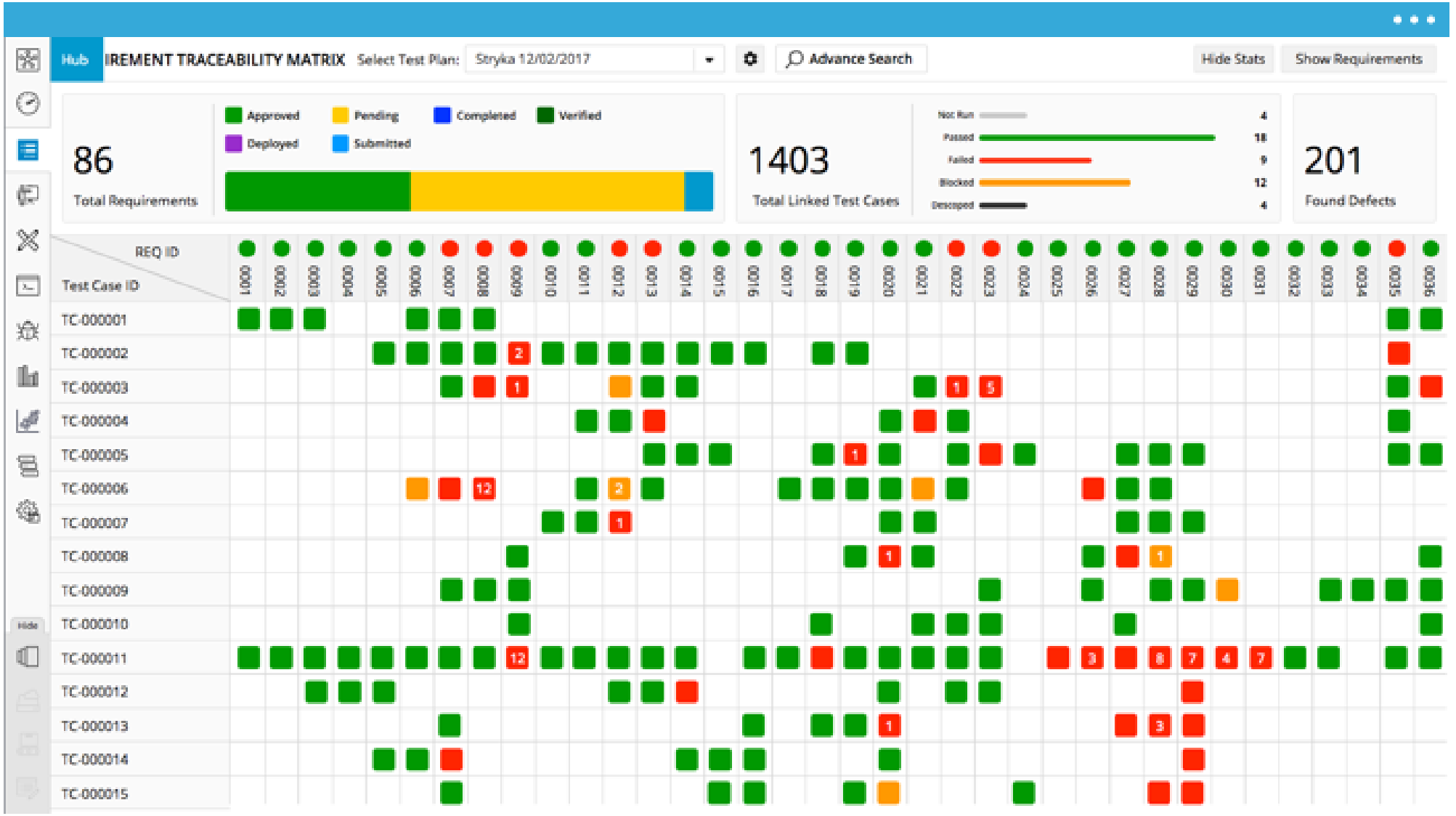
TEST_CASE_3: REQ2

TEST_CASE_4: REQ5

TEST_CASE_5:

- *Test case 5 not checking any requirement*
- *Remove test case 5 along with the implementation code!*

A Bi-Directional Traceability Matrix



Reference:
reportportal.io

Now Please Read Textbook Chapters 6 and 8

- If you are interested in further reading:

  IEEE Standard for Software Test Documentation (IEEE 829-2008)

- Can be found in resources/IEEE829.pdf in course repository