Project Title: System Verification and Validation Plan for MTOBridge

Team 15, Alpha Software Solutions
Badawy, Adham
Yazdinia, Pedram
Jandric, David
Vakili, Farzad
Vezina, Victor
Chiu, Darren

November 2, 2022

1 Revision History

Date	Version	Notes
October 30	Darren	Non-Functional System Tests
November 1	Pedram	Functional System Tests
November 1	Victor	Unit Tests Intro
November 1	Victor	Non-Functional System Tests

Contents

List of Tables

[Remove this section if it isn't needed —SS]

List of Figures

[Remove this section if it isn't needed —SS]

2 Symbols, Abbreviations and Acronyms

symbol	description
T	Test

[symbols, abbreviations or acronyms – you can simply reference the SRS (**?**) tables, if appropriate —SS]

This document ... [provide an introductory blurb and roadmap of the Verification and Validation plan —SS]

3 General Information

3.1 Summary

[Say what software is being tested. Give its name and a brief overview of its general functions. —SS]

3.2 Objectives

[State what is intended to be accomplished. The objective will be around the qualities that are most important for your project. You might have something like: "build confidence in the software correctness," "demonstrate adequate usability." etc. You won't list all of the qualities, just those that are most important. —SS]

3.3 Relevant Documentation

[Reference relevant documentation. This will definitely include your SRS and your other project documents (MG, MIS, etc). You can include these even before they are written, since by the time the project is done, they will be written. —SS]

?

4 Plan

[Introduce this section. You can provide a roadmap of the sections to come. —SS]

4.1 Verification and Validation Team

[You, your classmates and the course instructor. Maybe your supervisor. You shoud do more than list names. You should say what each person's role is for the project. A table is a good way to summarize this information. —SS]

4.2 SRS Verification Plan

[List any approaches you intend to use for SRS verification. This may just be ad hoc feedback from reviewers, like your classmates, or you may have something more rigorous/systematic in mind.. —SS]

[Remember you have an SRS checklist —SS]

4.3 Design Verification Plan

[Plans for design verification —SS]

[The review will include reviews by your classmates —SS]

[Remember you have MG and MIS checklists —SS]

4.4 Implementation Verification Plan

[You should at least point to the tests listed in this document and the unit testing plan. —SS]

[In this section you would also give any details of any plans for static verification of the implementation. Potential techniques include code walkthroughs, code inspection, static analyzers, etc. —SS]

4.5 Automated Testing and Verification Tools

[What tools are you using for automated testing. Likely a unit testing framework and maybe a profiling tool, like ValGrind. Other possible tools include a static analyzer, make, continuous integration tools, test coverage tools, etc. Explain your plans for summarizing code coverage metrics. Linters are another important class of tools. For the programming language you select, you should look at the available linters. There may also be tools that verify that coding standards have been respected, like flake9 for Python. —SS]

[The details of this section will likely evolve as you get closer to the implementation. —SS]

4.6 Software Validation Plan

[If there is any external data that can be used for validation, you should point to it here. If there are no plans for validation, you should state that here. —SS]

5 System Test Description

5.1 Tests for Functional Requirements

Below are system tests for the functional requirements in the SRS for MTO-Bridge. Each functional requirement has at least one system test. The identifiers follow a pattern of functional requirement number, system test number. For example, FR1.ST2 refers to the second system test for functional requirement 1.

MATLAB Communication

1. FR1.ST1

   Control: Automatic

   Initial State: None

   Input: None

   Output: MATLAB engine started

   Test Case Derivation: The first step in the communication is to get the MATLAB engine to start.

   How test will be performed: The test will instantiate our MATLAB engine wrapper.

2. FR1.ST2

   Control: Automatic

   Initial State: None

   Input: Truck, Bridge, and Analysis configurations

   Output: Any result from standard out or standard error

   Test Case Derivation: We just need to confirm that the engine is processing our input in some way, whether it gives an error or not.

   How test will be performed: Start the MATLAB engine through our wrapper, create some default truck, bridge, and analysis configurations, and try to run the analysis.

Truck Configuration

1. FR2.ST1

   Control: Automatic

   Initial State: GUI exists

   Input: Axle load, axle spacing, number of trucks, headway

   Output: GUI fields are filled

   Test Case Derivation: If the data of the input fields can be entered, then the user should also be able to fill in the fields.

   How test will be performed: Input fields will filled, and checked if they have the correct value.

2. FR2.ST2

   Control: Automatic

   Initial State: GUI exists

   Input: Invalid axle load, axle spacing, number of trucks, headway

   Output: GUI fields are filled, highlighted as incorrect

   Test Case Derivation: The user should be able to enter data, but be informed if the entered information is invalid.

   How test will be performed: Input fields will filled with incorrect information, and the fields should be highlighted as incorrect.

3. FR3.ST1

   Control: Automatic

   Initial State: GUI exists

   Input: Valid truck configuration

   Output: A valid visualization of the truck platoon shown

   Test Case Derivation: If a valid truck configuration is given, the user should be able to visualize the truck platoon.

How test will be performed: Given a valid truck configuration, a visualization will be generated. The visualization will be saved as a picture and compared to the expected visualization.

4. FR3.ST2

   Control: Automatic

   Initial State: GUI exists

   Input: Invalid truck configuration

   Output: A message informing the user of an incorrect truck configuration

   Test Case Derivation: If an invalid truck configuration is given, the user should be informed that the visualization cannot be created without a valid truck configuration.

   How test will be performed: Given an invalid configuration, the program will not show a visualization, but a message informing the user that a visualization cannot be created/shown until the configuration is valid.

5. FR4.ST1

   Control: Automatic

   Initial State: GUI exists

   Input: A truck configuration

   Output: A file with the correctly saved configuration

   Test Case Derivation: See FR.4.

   How test will be performed: Given a truck configuration, a file will be created. Its contents will be compared with the expected contents.

6. FR5.ST1

   Control: Automatic

   Initial State: GUI exists, a truck configuration file exists

   Input: None

Output: Truck configuration input fields will be filled correctly

Test Case Derivation: See FR.5.

How test will be performed: Given a truck configuration, a file will be created. Its contents will be compared with the expected contents.

Bridge Configuration

1. FR6.ST1

   Control: Automatic

   Initial State: GUI exists

   Input: Number of spans, bridge length

   Output: GUI fields are filled

   Test Case Derivation: If the data of the input fields can be entered, then the user should also be able to fill in the fields.

   How test will be performed: Input fields will filled, and checked if they have the correct value.

2. FR6.ST2

   Control: Automatic

   Initial State: GUI exists

   Input: Invalid number of spans, bridge length

   Output: GUI fields are filled, highlighted as incorrect

   Test Case Derivation: The user should be able to enter data, but be informed if the entered information is invalid.

   How test will be performed: Input fields will filled with incorrect information, and the fields should be highlighted as incorrect.

3. FR7.ST1

   Control: Automatic

   Initial State: GUI exists

Input: Valid bridge configuration

Output: A valid visualization of the bridge shown

Test Case Derivation: If a valid bridge configuration is given, the user should be able to visualize the bridge.

How test will be performed: Given a valid bridge configuration, a visualization will be generated. The visualization will be saved as a picture and compared to the expected visualization.

4. FR7.ST2

   Control: Automatic

   Initial State: GUI exists

   Input: Invalid bridge configuration

   Output: A message informing the user of an incorrect bridge configuration

   Test Case Derivation: If an invalid bridge configuration is given, the user should be informed that the visualization cannot be created without a valid bridge configuration.

   How test will be performed: Given an invalid configuration, the program will not show a visualization, but a message informing the user that a visualization cannot be created/shown until the configuration is valid.

5. FR8.ST1

   Control: Automatic

   Initial State: GUI exists

   Input: A bridge configuration

   Output: A file with the correctly saved configuration

   Test Case Derivation: See FR.4.

   How test will be performed: Given a bridge configuration, a file will be created. Its contents will be compared with the expected contents.

6. FR9.ST1

   Control: Automatic

   Initial State: GUI exists, a bridge configuration file exists

   Input: None

   Output: bridge configuration input fields will be filled correctly

   Test Case Derivation: See FR.5.

   How test will be performed: Given a bridge configuration, a file will be created. Its contents will be compared with the expected contents.

5.1.1 File Manager

1. UTFR-2.1

   Control: Automatic

   Initial State: None

   Input: File location path

   Output: New MTOBridge instance initialized with the given data instead of the default

   Test Case Derivation: Config file contains data that were previously inputted by a user, so to the load the data we have to restart the process

   How test will be performed: The test involves instantiating an MTOBridge process with the saved data and then running our logic checks to validate the saved input.

2. UTFR-2.2

   Control: Automatic

   Initial State: None

   Input: File location path

   Output: Boolean variable indicating True or False

Test Case Derivation: Require a method to check for the integrity of the saved configurations as the data can be faulty or incomplete

How test will be performed: The test is performed by validating the completeness and metadata of the file to make sure the file hasn't been corrupted hence preventing an instance construct call with faulty data.

5.1.2 Solver Setup

1. UTFR-3.1

   Control: Automatic

   Initial State: None

   Input: text input to indicate the desired solver

   Output: Calculation results based on the selected solver

   Test Case Derivation: The current logic allows for calculation of the demand at different areas called concerened sections. These can show the forces for both a single section as well as the entire bridge.

   How test will be performed: The test involves running a series of predetermined calculation using both solvers and then comparing with the auotmaic output selecting one solver at a time.

5.1.3 Bridge Config

1. UTFR-4.1

   Control: Automatic

   Initial State: None

   Input: text input to indicate the desired section

   Output: Calculation results based on the selected section

   Test Case Derivation: The current logic allows for calculation of the demand at different areas called concerened sections. These can show the forces for both a single section as well as the entire bridge.

How test will be performed: Once the section is selected, the test is performed by executing different types of platoon and bridge characteristic to derive actual results. These results are validated and compared to the exepected results calculated through the engine only.

2. UTFR-4.2

   Control: Automatic

   Initial State: None

   Input: text input to indicate the discretization length

   Output: Calculation results based on the defined length

   Test Case Derivation: In order to use the second solver, the system requires information on the number of equally spaced parts of the bridge.

   How test will be performed: Using an array of discretization lengths, we can take advantage of the engine's efficiency to calculate the maximum demand force in different context and compare with our own expected results.

5.1.4 Calculation Parameters

1. UTFR-5.1

   Control: Automatic

   Initial State: None

   Input: text input to indicate the desired force type

   Output: Calculation results based on the selected parameters

   Test Case Derivation: The current implmentation of the engine allows for calculation across shear, torsion and flexural resistance

   How test will be performed: The test entails creating a series of bridge types with different truck platoons that can be tested for all force types such as shear, torsion and flexural. Each data test is manually fed into the engine to output an expected output.

2. UTFR-5.2

Control: Automatic

Initial State: None

Input: text input to indicate the desired moment

Output: Calculation results based on the selected parameters

Test Case Derivation: The current implmentation of the engine allows for calculation using postivie and negative moment

How test will be performed: The test will be performed by using our pool of pre-determined bridge and truck platoon configs to test for both positive and negative moment given a certain force type.

5.1.5 Result Visualizer

1. UTFR-6.1

   Control: Automatic

   Initial State: None

   Input: calculations based on the concerened section

   Output: Animation and visualiation highlighting the resulting properties on the specified bridge and load

   Test Case Derivation: As one of the main purposes of the program, the visualization will be interactable to show various views

   How test will be performed: Relying on the pre-determined and validated data, we will graph the visulizations of each through the system as well as manually through the data produced by the engine. We can then compare the the expected and actual result across all available views.

2. UTFR-6.2

   Control: Automatic

   Initial State: None

   Input: calculations based on the discretization length

   Output: Animation and visualiation highlighting the resulting properties on the specified bridge and load

Test Case Derivation: As one of the main purposes of the program, the visualization will be interactable to show various views

How test will be performed: Relying on the pre-determined and validated data, we will graph the visulizations of each through the system as well as manually through the data produced by the engine. We can then compare the the expected and actual result across all available views.

5.1.6 Exectution Flow Logging

1. UTFR-7.1

Control: Automatic

Initial State: None

Input: text input to indicate logging flags

Output: text output, "logs"

Test Case Derivation: With the engine built in another framework, its important to log every state change throughout the calculations as triggered by the system

How test will be performed: While running multiple calculations, the system is asked to comprehensively log the flow in the engine. The system will be interrupted at times to test the robustness as well. The resulting logs should be clearly highlighting the steps taken including any errors or warnings.

5.2 Tests for Nonfunctional Requirements

[The nonfunctional requirements for accuracy will likely just reference the appropriate functional tests from above. The test cases should mention reporting the relative error for these tests. —SS]

[Tests related to usability could include conducting a usability test and survey. —SS]

5.2.1 Look and Feel Requirements

Graphics Informative Value Test

1. NFR1.ST1

   Initial State: Bridge UI mockups containing graphic elements will be prepared

   Type: Manual, Static

   How test will be performed: Civil engineers will be presented with mockups and expected to identify what the graphic elements represent with at least 90% accuracy. Refer to Figure 1 for example UI mockup.

5.2.2 Usability and Humanity Requirements

Intuitiveness Test

1. NFR2.ST1

   Initial State: Application is opened with no past data

   Type: Manual, Dynamic

   Input/Condition: User inputs

   Output/Results: Bridge analysis within 5 minutes of introduction

   How test will be performed: Civil engineer will be asked to provide inputs

Display Resolution Test

1. NFR3.ST1

   Initial State: Application is opened

   Type: Manual, Dynamic

   Input/Condition: Application is running on a computer with 1280x720 display

   Output/Results: All buttons and animation window remain visible and accessible

2. NFR3.ST2

   Repeat test NFR.ST3 for 1366x768 display

3. NFR3.ST3

   Repeat test NFR.ST3 for 1920x1080 display

4. NFR3.ST4

   Repeat test NFR.ST3 for 2560x1440 display

5. NFR3.ST5

   Repeat test NFR.ST3 for 3840x2160 display

Text Resizing Test

1. NFR4.ST1

   Initial State: Application is opened with no past data

   Type: Manual, Dynamic

   Input/Condition: Font size setting is changed to display as 8pt

   Output/Results: All buttons and animation window remain visible and accessible

2. NFR4.ST2

   Repeat test NFR.ST8 with font size 16pt

3. NFR4.ST3

   Repeat test NFR.ST8 with font size 24pt

4. NFR4.ST4

   Repeat test NFR.ST8 with font size 32pt

Ease of Installation Test

1. NFR5.ST1

   Initial State: Application is not installed

   Type: Manual

   Input/Condition: Application is downloaded and installed

   Output/Results: Application is ready to use within 30 minutes

   How test will be performed: By civil engineer

Consistent UI Test

1. NFR6.ST1

   Initial State: Visually similar UI elements are grouped into categories by developers

   Type: Manual, Static

   Input/Condition: Civil engineer asked to associate UI elements with their respective categories

   Output/Results: Civil engineer sorts at least 90% of UI elements into their predefined categories

5.2.3 Performance Requirements

UI Speed Test

1. NFR10.ST1

   Initial State: Application is opened with no past data

   Type: Manual, Dynamic

   Input/Condition: Application used to generate a small bridge analysis whose total execution time is at most X seconds

   Output/Results: Total execution time will not exceed underlying MATLAB script's execution time by 10%

2. NFR10.ST2

   Initial State: Application is opened with no past data

   Type: Manual, Dynamic

   Input/Condition: Application used to generate a large bridge analysis whose total execution time is at least Y seconds

   Output/Results: Total execution time will not exceed underlying MATLAB script's execution time by 10%

5.2.4 Operational and Environmental Requirements

User Computer Test

1. NFR12.ST1

   Initial State: Application is opened on expected users' computer

   Type: Manual, Dynamic

   Input/Condition: Application used to generate a small bridge analysis

   Output/Results: Time needed on user computer will not exceed time needed on developer computers by 10%(?)

   How test will be performed: The bridge analysis configuration will be one whose total execution time is at most X seconds on developer computers

2. NFR12.ST2

   Initial State: Application is opened on expected users' computer

   Type: Manual, Dynamic

   Input/Condition: Application used to generate a large bridge analysis

   Output/Results: Time needed on user computer will not exceed time needed on developer computers by 10%(?)

   How test will be performed: The bridge analysis configuration will be one whose total execution time is at least Y seconds on developer computers

5.2.5 Maintainability and Support Requirements

Ease of Maintenance Test

1. NFR13.ST1

   Type: Automatic, Static

   Input/Condition: Measure code file length in lines

   Output/Results: At least 75% of files will contain 750 lines of code or less

   How test will be performed: Clang-tidy linter

2. NFR13.ST2

   Type: Automatic, Static

   Input/Condition: Measure method length in lines

   Output/Results: At least 75% of methods will contain 75 lines of code or less

   How test will be performed: Clang-tidy linter

3. NFR13.ST3

   Type: Automatic, Static

   Input/Condition: Measure length of code lines

   Output/Results: At least 75% of lines will contain **120** characters or less

   How test will be performed: Clang-tidy linter

4. NFR13.ST4

   Type: Automatic, Static

   Input/Condition: Measure nesting depth of methods

   Output/Results: At least 75% of methods will have a maximum nesting depth of 5 or less

   How test will be performed: Clang-tidy linter

5.3 Traceability Between Test Cases and Requirements

Table 1: System Test Traceability

Requirement	System Tests
NFR1	NFR1.ST1
NFR2	NFR2.ST1
NFR3	NFR3.ST1, NFR3.ST2, NFR3.ST3, NFR3.ST4, NFR3.ST5
NFR4	NFR4.ST1, NFR4.ST2, NFR4.ST3, NFR4.ST4
NFR5	NFR5.ST1
NFR6	NFR6.ST1
NFR7	
NFR8	
NFR9	
NFR10	NFR10.ST1, NFR10.ST2
NFR11	
NFR12	NFR12.ST1, NFR12.ST2
NFR13	NFR13.ST1, NFR13.ST2, NFR13.ST3, NFR13.ST4
NFR14	
NFR15	

6 Unit Test Description

As outlined in our Development Plan, we will be using Qt Test and Google Test to conduct our unit testing. These testing frameworks will allow us to create and run unit tests quickly and easily.

6.1 Unit Testing Scope

[What modules are outside of the scope. If there are modules that are developed by someone else, then you would say here if you aren't planning on verifying them. There may also be modules that are part of your software,

but have a lower priority for verification than others. If this is the case, explain your rationale for the ranking of module importance. —SS]

6.2 Tests for Functional Requirements

[Most of the verification will be through automated unit testing. If appropriate specific modules can be verified by a non-testing based technique. That can also be documented in this section. —SS]

6.2.1 Module 1

[Include a blurb here to explain why the subsections below cover the module. References to the MIS would be good. You will want tests from a black box perspective and from a white box perspective. Explain to the reader how the tests were selected. —SS]

1. test-id1

   Type: [Functional, Dynamic, Manual, Automatic, Static etc. Most will be automatic —SS]

   Initial State:

   Input:

   Output: [The expected result for the given inputs —SS]

   Test Case Derivation: [Justify the expected value given in the Output field —SS]

   How test will be performed:

2. test-id2

   Type: [Functional, Dynamic, Manual, Automatic, Static etc. Most will be automatic —SS]

   Initial State:

   Input:

   Output: [The expected result for the given inputs —SS]

Test Case Derivation: [Justify the expected value given in the Output field —SS]

How test will be performed:

3. ...

6.2.2 Module 2

...

6.3 Tests for Nonfunctional Requirements

[If there is a module that needs to be independently assessed for performance, those test cases can go here. In some projects, planning for nonfunctional tests of units will not be that relevant. —SS]

[These tests may involve collecting performance data from previously mentioned functional tests. —SS]

6.3.1 Module ?

1. test-id1

   Type: [Functional, Dynamic, Manual, Automatic, Static etc. Most will be automatic —SS]

   Initial State:

   Input/Condition:

   Output/Result:

   How test will be performed:

2. test-id2

   Type: Functional, Dynamic, Manual, Static etc.

   Initial State:

   Input:

   Output:

How test will be performed:

6.3.2 Module ?

...

6.4 Traceability Between Test Cases and Modules

[Provide evidence that all of the modules have been considered. —SS]

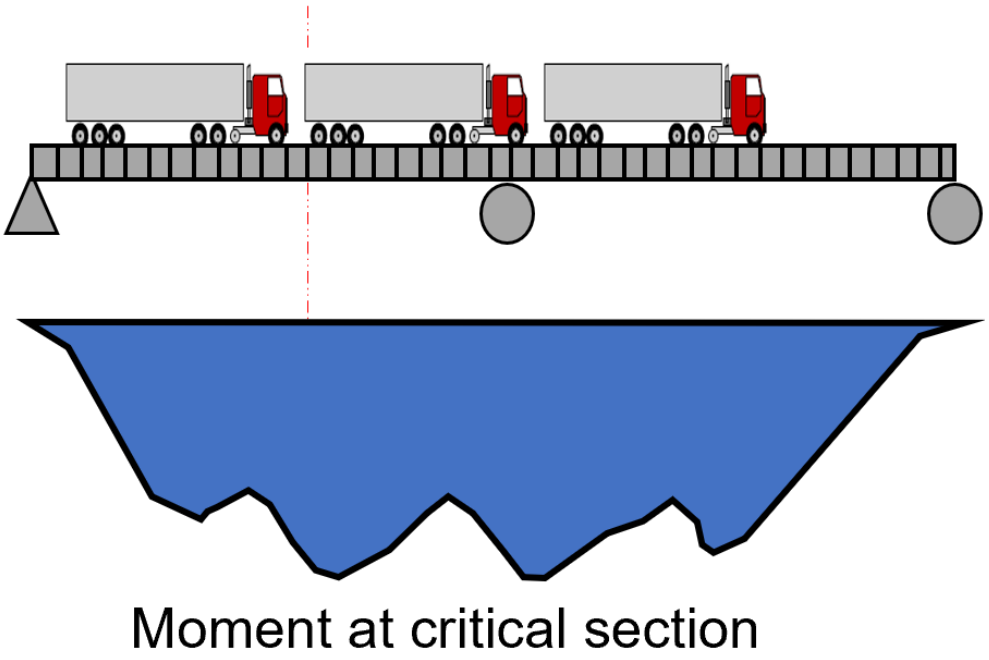

Figure 1: UI mockup

7 Appendix

This is where you can place additional information.

7.1 Symbolic Parameters

The definition of the test cases will call for SYMBOLIC_CONSTANTS. Their values are defined in this section for easy maintenance.

7.2 Usability Survey Questions?

[This is a section that would be appropriate for some projects. —SS]

Appendix — Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Lifelong Learning. Please answer the following questions:

1. What knowledge and skills will the team collectively need to acquire to successfully complete the verification and validation of your project? Examples of possible knowledge and skills include dynamic testing knowledge, static testing knowledge, specific tool usage etc. You should look to identify at least one item for each team member.

2. For each of the knowledge areas and skills identified in the previous question, what are at least two approaches to acquiring the knowledge or mastering the skill? Of the identified approaches, which will each team member pursue, and why did they make this choice?

Darren
Most Important Learning(s): We intend to use tools for validation including setting up CI/CD on the repo and clang-tidy for code analysis. Although I've used these or similar tools in the past, I haven't personally prepared them before.
Plan to learn what is needed: Some approaches for learning this is to research into the respective tools and reviewing past projects that used them, or to participate in their implementation and collaborate with team members on this. These aren't mutually exclusive, but I intend to mainly focus on learning through participating in the implementation and working with team members, since I feel that will be more effective in bringing results to the project.

your name here
Most Important Learning(s): text 1.
Plan to learn what is needed: text 2.