

Project Title: System Verification and Validation Plan for Chess Connect

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1 Revision History

Table 1: Revision History

Date	Developer(s)	Change
2022-10-31	Jonathan Cels	NFR Testing
2022-10-31	Arshdeep Aujla	Added section 3
2022-11-02	Jonathan Cels	Traceability matrix
2022-11-02	Joshua Chapman	Section 4.1,4.2,4.3,4.4
2022-11-02	Joshua Chapman	Section 4.1, 4.2, 4.3, 4.5
2022-11-02	Alexander Van Kralingen	Completed Section 4.4, 4.6, 4.7

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[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
(Author, 2019) tables, if appropriate —SS]
[Remove this section if it isn't needed —SS]

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

3 General Information

3.1 Summary

The project name is Chess Connect. It is comprised of software and hardware components. The hardware will consist of a reactive chess set connected to a microcontroller. The microcontroller will relay information on the chess board in the form of LEDs of the possible moves the user can make. The software component of this project will consist of a web application that will reflect all of the chess piece's location on the physical board.

3.2 Objectives

The following objectives are the qualities that are the most important for the project.

- The hardware should reflect relevant information on the LEDs on the chess board
- The software component should reflect the physical chess board in near-real time
- The movement of the chess pieces should be recorded by the hardware

3.3 Relevant Documentation

The following documents are relevant to this project.

- SRS
- Hazard Analysis
- Requirements Document
- Design Document
- VnV Report

- MIS
- MG

4 Plan

This section discusses the general plans for hardware and software testing. The responsibilities of members are assigned and requirements verifications are discussed. Design and implementation verification include high-level plans to execute hardware and software systems. Automated testing techniques and tools are outlined. A detailed software validation plan discusses the external tools required for completeness.

4.1 Verification and Validation Team

Alexander Van Kralingen	Web application connection tests GitHub integration testing Microcontroller code testing
Arshdeep Aujla	Sensor accuracy testing Microcontroller hardware & code testing Touchscreen UI latency tests
Jonathan Cels	Microcontroller code testing Chess API integration testing Communication protocol testing
Joshua Chapman	Power distribution design and integration testing Microcontroller hardware & code testing Communication protocol testing
Rupinder Nagra	Chess API integration testing Web application connection tests Web application functionality testing

4.2 SRS Verification Plan

SRS verification is performed by the teammates throughout the design and testing process. They will reference requirements and consider the results

throughout design. Teammates will periodically verify this completeness throughout the design process. The verification and validation report will reference an associated requirement for each test. This allows for tracking of individual requirement fulfillment throughout the process.

4.3 Design Verification Plan

Hardware Design Verification begins with LTSpice and Multisim design software packages. The designed circuits are simulated in the software and tested accordingly. Testing includes simulating inputs and verifying that expected outputs are returned. Edge cases are simulated to verify safety and failure conditions of the circuits.

Software Design Verification utilizes the compiler to verify code correctness. Arduino integrated development environments contain the tools to compile and check for errors. Code walkthroughs are performed by collaborators that did not write the program. This includes detailed inspection and a report describing the function of the code based on their perspective. This tests the readability and functionality of the code.

4.4 Verification and Validation Plan Verification Plan

The Verification and Validation Plan verification will include reviewing the [Verification and Validation Plan checklist](#) and adjusting this document accordingly. The verification will also include considering feedback from issues created by another team, as well as from the TA assigned to this project. Comments and improvements will be implemented after completing revision 0 of this document.

4.5 Implementation Verification Plan

Hardware Implementation Verification begins with individual components. First the power supply is tested with a voltmeter for accuracy and precision. Then, the microcontroller is powered on and each individual I/O is tested for correctness. Inputs will be powered via the power supply and readings are verified for correctness using custom testing software installed on the controller. Outputs are verified using the voltmeter to measure correctness relative to the controller value. Finally, sensors and circuits are tested

using the IO of the microcontroller. This allows for accurate and detailed inspection of the components and verifies their correctness.

Software Implementation Verification requires the hardware to be tested and assembled before beginning. The software is downloaded to the controller and the inputs and outputs are configured one-by-one. Functionality of code is tested with unit tests from section 5.1 with the appropriate hardware. Once each section is unit tested, the sub-systems can begin to combine to test completeness of full systems and their functionality.

4.6 Automated Testing and Verification Tools

Automated testing will be carried out for the software involved with this project. Unit tests will be created to test the functionality of each function created for the program. A minimum of one "successful" test will be written to describe the intended program execution, and one or more "unsuccessful" tests will be written to test the robustness of the program. This will ensure complete code coverage for the software. There are 3 main classes of tests that will be run involving the different aspects Chess Connect:

- **Linting:** Performed on Python and Javascript code. This will be integrated into VS Code to assist in local development; this will be run as a Github Workflow as a non-blocking check before building the software.
 - [ESLint](#) to be used for Javascript
 - [Flake8](#) to be used for Python
- **Unit Tests:** Detailed in Section ??, unit tests will be performed for Python, Javascript and C code.
 - [React Testing Library](#) will be used for Javascript unit tests.
 - [PyTest](#) will be used for Python unit tests.
 - [AceUnit](#) will be used for C unit tests.
- **Dynamic Analysis Tool:** in addition to creating unit tests for the C code, memory leaks and access errors will be caught using [ValGrind](#).

Debuggers: Dynamic analysis will also be performed on the code through debuggers to verify the system and unit tests, as well as normal operation. These tools will be used extensively to bring all unit tests to a successful state, and to determine the root cause of any inconsistent behaviour from the hardware.

- The browser's (Chrome, Firefox, etc.) built in debugger will be used for stepping through the Javascript code on the web application.
- `pdb` will be used for Python debugging.
- [Arduino Zero Built-in Debugger Interface](#) will be used for debugging embedded C code.

4.7 Software Validation Plan

Software will be validated by reviewing the requirements in the [Software Requirement Specifications](#) document and ensuring the software matches the expected performance and behaviour. The chess engine software integration will be validated by comparing it alongside an established online chess engine running the same Stockfish build as is selected for Chess Connect, and comparing the recommended moves. One website that may be used is [365Chess.com](#).

Feedback from members of the team that are assigned to another area of the system will be called to verify the software is performing adequately. For example, a member working on the web app may come to test the hardware to ensure the sequences and behaviour is intuitive and user friendly. Feedback and comments from the professor and TA assigned to this project will also be considered when making adjustments to the software.

Unit tests will be created that capture both normal-use and failure modes to validate the software as well. Unit tests will be integrated in a Github workflow to ensure that changes are never made to the software that conflict with other areas of the code. Failing unit tests will be used as direction to change parts of the software back to a valid state of operation.

5 System Test Description

5.1 Tests for Functional Requirements

[Subsets of the tests may be in related, so this section is divided into different areas. If there are no identifiable subsets for the tests, this level of document structure can be removed. —SS]

[Include a blurb here to explain why the subsections below cover the requirements. References to the SRS would be good here. —SS]

5.1.1 Area of Testing¹

[It would be nice to have a blurb here to explain why the subsections below cover the requirements. References to the SRS would be good here. If a section covers tests for input constraints, you should reference the data constraints table in the SRS. —SS]

Title for Test

1. test-id1

Control: Manual versus Automatic

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

Control: Manual versus Automatic

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:

5.1.2 Area of Testing2

...

5.2 Tests for Nonfunctional Requirements

5.2.1 Look and Feel

Style

1. NFT1

Type: Structural, Static, Manual

Initial State: Users have not seen the product before, and the product is in its initial game state.

Input/Condition: Users are asked to identify the product.

Output/Result: The majority of users are able to successfully identify the product as a chess set without any outside assistance within 10 seconds.

How test will be performed: A test group of people who do not play chess regularly are asked to identify the product immediately after it is revealed to them. The time it takes for them to identify the product will be recorded. The subjects must identify the product as a chess set within 10 seconds or less, averaged over the number of people in the test group.

5.2.2 Usability and Humanity

Learnability

1. NFT2

Type: Structural, Static, Manual

Initial State: Product is in normal mode, a game has started, and the users have not interacted with the product before.

Input/Condition: Users are asked to use the product and move one specified piece from one square to another specified square on the board.

Output/Result: The majority of users understand which piece they moved and to where, and are able to identify that the web application has reflected their move in the virtual model within 30 seconds of studying the visual representation of the board state.

How test will be performed: A test group of people who do not play chess regularly are asked to move pieces on the chessboard. They are then asked to identify the move they just made as reflected in the web application model. The subjects must identify that the piece they moved on the board has also been moved on the web application's virtual model within 30 seconds or less, averaged over the number of people in the test group.

2. NFT3

Type: Functional, Dynamic, Manual, Static etc.

Initial State: The product shall be representing the state of the game that is in progress. The pieces shall be in a legal position according to the rules of chess. The pieces shall not all be in their starting positions, and there is at least one of each type of piece (pawn, knight, bishop, rook, queen, king) on the board.

Input: Users are asked to identify the names of different pieces and squares based on their visual appearance in both the physical product and the web application.

Output: The majority of users are able to identify the names of pieces and squares based on their likeliness to historically used symbols and shapes.

How test will be performed: A test group of people who have played chess in the past or play chess regularly are asked to identify each of the pieces and squares from an in-progress game of chess using the system. The justification for this is to avoid piece identification based on their starting positions. The majority of the group should be able to visually identify every piece and square within 2 minutes of seeing the position for the first time.

5.2.3 Performance

Speed and Latency

1. NFT4

Type: Structural, Static, Manual

Initial State: The product is in normal mode, and a game has started.

Input/Condition: Users are asked to pick up a piece and suspend it midair without placing it down.

Output/Result: The board shall visually indicate where the held piece is able to move according to the rules of chess within a specific time frame.

How test will be performed: A test group of people who have played chess in the past or play chess regularly are asked to pick up a specific piece and hold it. The system will give visual indicators of where the held piece is able to move according to the rules of chess. The time between when they pick up the piece and when the visual response occurs is measured and recorded. This process is repeated 5 times per user. The individual and average times are recorded. The response times are then averaged over the entire test group. The average response time of the entire test group must be less than 0.5 seconds.

2. NFT5

Type: Structural, Static, Manual

Initial State: The results of the previous test, NFT4, have been measured and recorded.

Input/Condition: The results of NFT4.

Output/Result: The maximum recorded time of any individual response is within a specific time frame.

How test will be performed: The times measured in the previous test, NFT4, will be inspected. The maximum recorded individual time must be less than 1 second.

3. NFT6

Type: Structural, Static, Manual

Initial State: The product is in normal mode, and a game has started.

Input/Condition: Users are asked to pick up a piece and legally move it to a square according to the rules of chess.

Output/Result: The web application shall reflect their move in the virtual model within a specific time frame.

How test will be performed: A test group of people who have played chess in the past or play chess regularly are asked to pick up a specific piece and legally move it to another square according to the rules of chess. The web application will reflect their move in the virtual model. The time between when they place down the piece and when the web application response occurs is measured and recorded. This process is repeated 5 times per user. The individual and average times are recorded. The response times are then averaged over the entire test group. The average response time of the entire test group must be less than 2 seconds.

4. NFT7

Type: Structural, Static, Manual

Initial State: The results of the previous test, NFT6, have been measured and recorded.

Input/Condition: The results of NFT6.

Output/Result: The maximum recorded time of any individual response is within a specific time frame.

How test will be performed: The times measured in the previous test, NFT6, will be inspected. The maximum recorded individual time must be less than 5 seconds.

Health and Safety

1. NFT8

Type: Structural, Static, Manual

Initial State: The product is in normal mode, and a game has started.

Input/Condition: 10 wires are chosen as a sample.

Output/Result: The maximum power on any single wire shall be within the required limit.

How test will be performed: A sample of 10 wires are chosen arbitrarily from across the entire system. The voltage and amperage of each wire in the sample are measured and recorded. The power shall then be calculated and recorded. The maximum power of any wire in the sample must not exceed the safe limits determined in the Canadian Electrical Code [CSA \(2021\)](#).

Precision and Accuracy

1. NFT9

Type: Structural, Static, Manual

Initial State: The product is in the initial game state.

Input/Condition: Users are instructed to play a full game of chess using the Chess Connect system.

Output/Result: The web application will properly reflect the moves made on the physical product the majority of the time.

How test will be performed: A test group of people who have played chess in the past or play chess regularly are asked to play a full game of chess. Their moves and the web application response will be recorded and compared against each other. The number of discrepancies between the physical moves and moves made on the web application will be recorded. The number of discrepancies averaged over the entire test group must be less than or equal to 1.

Capacity

1. NFT10

Type: Structural, Static, Manual

Initial State: The product is in the initial game state and is in engine mode.

Input/Condition: Moves are made until the game state is in one of a set of predetermined computationally complicated chess positions.

Output/Result: The level of memory used by the web application shall be no more than 1 Gigabyte (GB) at any measured point.

How test will be performed: Moves will be made until the game state is in one of a set of predetermined computationally complicated chess positions. The engine will then be using the maximum amount of memory to compute the best possible moves for the position. The amount of memory used will be measured and recorded using windows task manager. The amount of memory must never exceed 1 GB at any measured point.

5.2.4 Security

Integrity

1. NFT11

Type: Structural, Static, Manual

Initial State: The product is in normal mode and a chess game is in progress on the system.

Input/Condition: The Bluetooth connection is severed between the web application and the product.

Output/Result: The web application indicates that the Bluetooth connection has been lost.

How test will be performed: A game of chess is being played when the Bluetooth option is switched off on the server, severing the connection. The web application must display an alert that the Bluetooth connection has been lost.

1. NFT12

Type: Structural, Static, Manual

Initial State: The product is in normal mode and a chess game is in progress on the system.

Input/Condition: The power connection to the system is severed.

Output/Result: The system stores the game state in local memory until power is restored.

How test will be performed: A game of chess is being played when the power is switched off. The power is then restored after 5 or more seconds. A single move is made and the state of the game is tested against

the web application. The state of the game should be unchanged from before power was lost.

5.3 Traceability Between Test Cases and Requirements

Test	Requirement
NFT1	LF3
NFT2	UH5
NFT3	UH6
NFT4	PR1
NFT5	PR2
NFT6	PR3
NFT7	PR4
NFT8	PR6
NFT9	PR7
NFT10	PR10
NFT11	SR4
NFT12	SR3

References

Author Author. System requirements specification. <https://github.com/...>, 2019.

CSA. *Canadian Electrical Code*. CSA Group, 2021.

6 Appendix

This is where you can place additional information.

6.1 Symbolic Parameters

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

6.2 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:

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?