# Test Plan for the Library of Linear Algebraic Equation Solver

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# 1 Revision History

| Date | Version | Notes |
|---|---|---|
| October 25, 2017 | 1.0 | Initial draft |

# 2 Symbols, Abbreviations and Acronyms

| symbol | description |
|---|---|
| T | Test |
| O | Output |
| CA | Commonality Analysis |
| IM | Instance Module |
| $\epsilon$ | Difference |

# Contents



# List of Tables

# 3 General Information

The following section gives an overview of the Verification and Validation ( V & V ) plan for the Library of Linear Algebraic Equation Solver. This section also explains the purpose, scope and overview of the document.

## 3.1 Purpose

The purpose of this document is to plan the Verification and Validation process for the Library of Linear Algebraic Equation Solver. The main purpose of this document is to check whether the Library of Linear Algebraic Equation Solver meets the specifications and fulfill its intended purpose. This document will be used as the reference and guidance for testing the Library of Linear Algebraic Equation Solver.

## 3.2 Scope

The scope of testing is limited to Library of Linear Algebraic Equation Solver. The library includes two linear algebraic solving functions. The scope is limited to these two solving functions.

## 3.3 Overview of Document

The following sections provides in depth information about the V & V of Library of Linear Algebraic Equation Solver. The following sections also provides information about automated testing approach, testing tools. Test cases for system testing and unit testing are provided.

# 4 Plan

## 4.1 Software Description

Software which is tested is Library of Linear Algebraic Equation Solver. The library contains two linear algebraic equation solving algorithms. Given the initial values of algebraic equation A and B, the program calculates the final value x by using numerical methods.

## 4.2 Test Team

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## 4.3 Automated Testing Approach

Automated unit testing will be done for the Library of Linear Algebraic Equation Solver. Unit Testing Framework and R's Test Class will be used in a combination for automated testing. Syntax checking will be done automatically by the compiler.

## 4.4 Verification Tools

The verification tools which will be used are as follows :

1. Comparison is done between the RStusio's own functional programs with the Library of Linear Algebraic Equation Solver by the Unit Testing Framework designed in RStudio. The following algorithm is used for comparison.

$$\epsilon_{relative} = \frac{Result_{RStudio} - Result_{Library of Linear Algebraic Equation Solver}}{Result_{RStudio}}$$

2. The framework for automated system testing is provided by using RStudio's Test Class .

3. For program debugging and for checking syntax errors the program's IDE ( RStudio ) will be used as a Static Analyzer tool .

4. covr is used for code coverage.

## 4.5 Non-Testing Based Verification

Not Applicable

# 5 System Test Description

System Test is done to verify whether the goals mentioned in Commonality Analysis are achieved. Input and Output analysis is used to test the system as a whole by black box testing approach.

## 5.1 Tests for Functional Requirements

### 5.1.1 Calculation Tests

**Gaussian Elimination Method**

1. **T-1: Simple Linear system involving two equations and two variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: A = $\begin{bmatrix} 2 & 3 \\ 4 & 9 \end{bmatrix}$, B = $\begin{bmatrix} 6 \\ 15 \end{bmatrix}$

   Output: = x = $\begin{bmatrix} 3/2 \\ 1 \end{bmatrix}$, Success = true

   How test will be performed: Automated system test

2. **T-2: Linear system involving three equations and three variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: A = $\begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}$, B = $\begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

   Output: x = $\begin{bmatrix} -15 \\ 8 \\ 2 \end{bmatrix}$, Success = true

   How test will be performed: Automated system test

3. **T-3: Linear system involving six equations and six variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: A = $\begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}$, B = $\begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

Output: x = $\begin{bmatrix} -15 \\ 8 \\ 2 \end{bmatrix}$, Success = true

How test will be performed: Automated system test

4. **T-4: Linear system of equations which are singular**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: A = $\begin{bmatrix} 0 & 2 & -1 \\ 3 & -2 & 1 \\ 3 & 2 & -1 \end{bmatrix}$, B = $\begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

   Output: x = no solution, Success = true

   How test will be performed: Automated system test

**Gauss-Jordan Method**

1. **T-5: Simple Linear system involving two equations and two variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: A = $\begin{bmatrix} 2 & 3 \\ 4 & 9 \end{bmatrix}$, B = $\begin{bmatrix} 6 \\ 15 \end{bmatrix}$

   Output: = x = $\begin{bmatrix} 3/2 \\ 1 \end{bmatrix}$, Success = true

   How test will be performed: Automated system test

2. **T-6: Linear system involving three equations and three variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

Input: A = $\begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}$, B = $\begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

Output: x = $\begin{bmatrix} -15 \\ 8 \\ 2 \end{bmatrix}$, Success = true

How test will be performed: Automated system test

3. **T-7: Linear system involving six equations and six variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: A = $\begin{bmatrix} 1 & 1 & -2 & 1 & 3 & -1 \\ 2 & -1 & 1 & 2 & 2 & -3 \\ 1 & 3 & -3 & -1 & 2 & 1 \\ 5 & 2 & -1 & -1 & 2 & 1 \\ -3 & -1 & 2 & 3 & 1 & 3 \\ 4 & 3 & 1 & -6 & -3 & -2 \end{bmatrix}$, B = $\begin{bmatrix} 4 \\ 20 \\ -15 \\ -3 \\ 16 \\ -27 \end{bmatrix}$

   Output: x = $\begin{bmatrix} 1 \\ -2 \\ 3 \\ 4 \\ 2 \\ -1 \end{bmatrix}$, Success = true

   How test will be performed: Automated system test

4. **T-8: Linear system of equations which are singular**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: A = $\begin{bmatrix} 0 & 2 & -1 \\ 3 & -2 & 1 \\ 3 & 2 & -1 \end{bmatrix}$, B = $\begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

Output: x = no solution, Success = true

How test will be performed: Automated system test

## 5.2 Tests for Nonfunctional Requirements

### 5.2.1 Performance Requirements

**Test for calculating speed**

1. **T-9: Calculation speed of Library of Linear Algebraic Equation Solver.**

   Type: Non-Functional, Manual, Performance

   Initial State: Not Applicable

   Input/Condition: $\mathrm{A} = \begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}$, $\mathrm{B} = \begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

   Output/Result: Time

   How test will be performed: Manually Comparing the time of Library of Linear Algebraic Equation Solver.

### 5.2.2 Result Analysis

**Accuracy**

1. **T-10: Calculating the accuracy of Library of Linear Algebraic Equation Solver.**

   Type: Non-Functional, Manual, Accuracy

   Initial State: Not Applicable

   Input/Condition: $\mathrm{A} = \begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}$, $\mathrm{B} = \begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

   Output/Result: $\epsilon_{Relative}$ will be calculated by comparing the result obtained by Library of Linear Algebraic Equation Solver and the RStudio's own functional programs by the following algorithm

$$\epsilon_{relative} = \frac{Result_{RStudio} - Result_{Library of Linear Algebraic Equation Solver}}{Result_{RStudio}}$$

How test will be performed: Manually Comparing the result of Library of Linear Algebraic Equation Solver.

## 5.3 Traceability Between Test Cases and Requirements

The following table shows the traceability mapping for test case and the requirements described in Commonality Analysis.

Table 1: Requirements Traceability Matrix

| **Test Number** | **CA Requirements** |
|---|---|
| T1 | IM1 |
| T2 | IM1 |
| T3 | IM1 |
| T4 | IM1 |
| T5 | IM2 |
| T6 | IM2 |
| T7 | IM2 |
| T8 | IM2 |

# 6 Unit Testing plan

## 6.1 Determinant Check Test

1. **T-11: Simple**

   Type: Functional, Unit.

   Initial State: Not applicable

   Input: A = $\begin{bmatrix} 1 & 3 \\ 2 & 6 \end{bmatrix}$

Output: Determinant is 0, there is no solution

How test will be performed: Automated Unit Test

2. **T-12: Linear system involving three equations and three variables**

   Type: Functional, Unit.

   Initial State: Not applicable

   Input: $A = \begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}$

   Output: Determinant is not 0,there is a unique solution

   How test will be performed: Automated Unit Test

# 7 Appendix

## 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.

| symbol | unit | description |
|---|---|---|
| $\epsilon$ | none | The measure of the difference between results obtained with Library of Linear Algebraic Equation Solver and RStudio. |

## 7.2 Usability Survey Questions?

Not Applicable