ABSTRACT
This document provides the LIME Toolbox verification report, i.e. testing of the developed software, for the LIME-2 project.

Javier Gatón
Ramiro González
Carlos Toledano
Pieter De Vis
Jacob Fahy
Stefan Adriaensen

UVa , NPL, VITO
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LIME TOOLBOX
VERIFICATION REPORT

LUNAR IRRADIANCE MODEL OF ESA

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Signatures and version history

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Written by	Javier Gatón	UVa	25 January 2023
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Contents

1. Introduction

1.1 Purpose and Scope

This document provides the LIME Toolbox (TBX) verification report, therefore all the testing performed to the software of the toolbox itself. The scope is to ensure the correct functioning of the LIME TBX and the LIME model.

Testing can demonstrate that software has errors, but it cannot demonstrate that it is error free. This verification and validation report outlines how software has been tested. Verification is aimed at making sure the system supplied meets the stated requirements, validation is about making sure that the software addresses what the customer really wants.

1.2 Applicable and reference documents

1.2.1 Applicable Documents

The following applicable documents are those specification, standards, criteria, etc. used to define the requirements of this task.

Number	Reference

[AD0] ESA-EOPG-EOPGMQ-SOW-24. Improving the Lunar Irradiance Model of ESA.

1.3 Glossary

1.3.1 Abbreviations

Abbreviation	Stands For	Notes
ASD	Analytical Spectral Devices	Instrument manufacturer
Cimel	(Not an abbreviation)	Instrument manufacturer, also used as shorthand for instrument itself
EO	Earth Observation	
ESA	European Space Agency	Project customer
FOV	Field of View	
GIRO	GSICS Implementation of the ROLO Model	
GSICS	Global Space Based Inter-calibration System	
GUI	Graphical User Interface	
KO	Kick-off meeting	
LIME	Lunar Irradiance Model of ESA	
NPL	National Physical Laboratory	Project partner
ROLO	RObotic Lunar Observatory	
SoW	Statement of Work	
TBX	Toolbox	
TOA	Top of Atmosphere	
UVa	University of Valladolid	Project partner
VITO	Vlaamse Instelling voor Technologisch Onderzoek; Flemish Institute for Technological Research	Project partner

2. LIME Toolbox verification strategy

The LIME TBX implementation plan is described in deliverable D7, and the verification strategy is described in deliverable D8.

The strategy to ensure that the code is of high quality is to perform unit tests and end-to-end tests. This document describes the tests performed that verify the LIME TBX and how they have been implemented and executed throughout the project.

The overall testing strategy is as follows:

- Most testing effort has gone into the most complex parts.
- After that, the next priority area was the most used part.
- The level of testing factored in the level of risk.
- Users were involved in the testing.
- Testing took place at all stages.
- Tests are quantitative, documented, repeatable and have clear acceptance criteria.

3. Tests

3.1 Unit tests

Most non-trivial functions have automatic unit tests that are based on white-box testing techniques, like code coverage, Statement Coverage and Decision Coverage, and black-box techniques like Equivalence Class Testing to homogenize the code.

These tests have been designed and performed throughout the development. Python's module "unittest" has been used for their development, and the module "coverage" has been used to check the code coverage.

The target was to achieve a total code coverage of around 90 or 95%, and individual module code coverage of over 85%. The achieved total code coverage is 91%, and there are 5 modules which code coverage is slightly less than 85% (all of them reach 84%).

Next, a breakdown of the 216 different unit tests performed for almost all the different toolbox modules will be shown. Notably, the toolbox's "gui" module doesn't contain unit tests as the user interface is tested through the end-to-end tests. The "local_storage" module is not present in the following analysis, because although there are unit tests that test its functions, the code coverage varies between the operative system that is being used, as its function is to store data and files in the computer, so the executed functions are different between different systems.

3.1.1 cli

Unit tests performed: 49

Code coverage: 87%

This module is in charge of interpreting and parsing the command line interface. Its tests not only check that its functions are well defined and that they work fine, but a lot of them are also end-to-end tests that check full command line use cases.

3.1.2 coefficients.access_data

Unit tests performed: 3

Code coverage: 100%

This module contains the functionality that allows access to local coefficient data and similar data.

3.1.3 coefficients.update

Unit tests performed: 5

Code coverage: 100%

This module is responsible for checking for coefficients updates, and for downloading those updated coefficients.

3.1.4 datatypes.datatypes

Unit tests performed: 22

Code coverage: 98%

This module contains different data structures and classes used for the exchange of data between different modules of the TBX.

3.1.5 datatypes.logger

Unit tests performed: 5

Code coverage: 96%

This module contains the functionality that allows logging the output log messages that should be stored in the computer just in case anything goes wrong, so some context and information is stored and can be understood afterwards.

3.1.6 datatypes.templates

Unit tests performed: 5

Code coverage: 100%

This module contains constant templates for the creation of datasets with NPL's obsarray module.

3.1.7 eocfi_adapter

Unit tests performed: 10

Code coverage: 94%

This module contains abstractions, interfaces and functions that implement the connection to ESA's EOCFI library to perform satellite calculations.

3.1.8 filedata.coefficients

Unit tests performed: 1

Code coverage: 84%

Module that allows reading the coefficient files from netcdf files.

3.1.9 filedata.csv

Unit tests performed: 9

Code coverage: 90%

This module contains the functionality that transfers LIME data into CSV files and vice versa.

3.1.10 filedata.lglod_factory

Unit tests performed: 3

Code coverage: 91%

This module creates LGLOD datatypes that then can be stored as a LGLOD format file.

3.1.11 filedata.moon

Unit tests performed: 4

Code coverage: 94%

This module contains the functionality that allows readoin moon observations file from GLOD format files.

3.1.12 filedata.srf

Unit tests performed: 1

Code coverage: 86%

This module contains the functionality that allows reading Spectral Response Function files from GLOD format files.

3.1.13 interpolation.interp_data

Unit tests performed: 10

Code coverage: 84%

Module in charge of retrieving interpolation data (spectra, etc) from local storage.

3.1.14 interpolation.spectral_interpolation

Unit tests performed: 5

Code coverage: 88%

Module in charge of performing spectral interpolation.

3.1.15 lime_algorithms.dolp

Unit tests performed: 8

Code coverage: 84%

This module calculates the extra-terrestrial lunar disk degree of polarization.

3.1.16 lime_algorithms.lime.eli

Unit tests performed: 5

Code coverage: 100%

This module calculates the extra-terrestrial lunar irradiance.

3.1.17 lime_algorithms.lime.elref

Unit tests performed: 5

Code coverage: 100%

This module calculates the extra-terrestrial lunar reflectance.

3.1.18 lime_algorithms.lime.esi

Unit tests performed: 4

Code coverage: 96%

This module calculates the extra-terrestrial solar irradiance.

3.1.19 lime_algorithms.lime.lime

Unit tests performed: 4

Code coverage: 99%

This module calculates the extra-terrestrial lunar disk irradiance.

3.1.20 simulation.comparison

Unit tests performed: 12

Code coverage: 95%

This module abstracts and encapsulates use-cases related to simulations from ESA satellites and performs the actions and calculations that are related to each of them.

3.1.21 simulation.lime_simulation

Unit tests performed: 19

Code coverage: 84%

Module containing the class that contains the state of the simulation, and that calls the other modules that perform the calculations.

3.1.22 simulation.moon_data_factory

Unit tests performed: 8

Code coverage: 100%

Module containing the factory class for MoonData.

3.1.23 simulation.spectral_integration

Unit tests performed: 4

Code coverage: 82%

This module performs spectral integrations over spectral response functions and more data.

3.1.24 spice_adapter

Unit tests performed: 8

Code coverage: 88%

This module acts as an interface/adapter with NASA's SPICE software.

3.2 End-to-end tests

End-to-end tests have been performed for each use-case stated by the customer. They have been partially automated. Their aim is to detect defects caused by bringing the various parts of the system together.

Two kinds of end-to-end tests are performed. Testing the software product as a whole, which has been done manually using the GUI, and testing big parts of the code involving several critical functions, like testing exported functions from important modules without having to instantiate the GUI. The latter are included in the unit tests, especially in the CLI module unit tests.

The manual end-to-end tests have been performed by the LIME team and the individual results for each test are available in Annex I. All end-to-end tests were executed by more than one of the testers and all of them passed. The testers were able to check the user guide for help. Every test execution has a related table like the following one:

Unique test reference/run	A unique number to identify each test followed by "/" and a number incremented each time this test is run.	**Version of requirements**	A reference to the Functional Requirements document and its version
Observation If the test failed, then document what was seen. If it passed, then this slot may be used for additional comments if required. Supplement by screen grabs etc if necessary.			
System info	Information of the environment and OS where the test was executed.		
Pass/fail	Was the test passed?		
Tester	Who performed the test?		
Date	Date of test.		

The end-to-end tests performed are the following:

3.2.1 Install the LIME TBX

Unique test reference/run	1/<run_reference>	**Version of requirements**	2.0
Requirement RNF404, RNF405, RNF406			
Test purpose The actor user will be able to install the LIME TBX in their computer			
Pre-requisites Not having the TBX installed			
Test instructions			

1. The actor user will inform the system that they wish to install the LIME TBX. 2. The system will ask user for input and data in different steps 3. The user will give the appropiate data 4. The system will inform the user that the TBX is installed 5. The user will inform the system that they wish to open the TBX 6. The system will open the TBX
Acceptance criteria The TBX will be available in the system and will open correctly

3.2.2 Simulate lunar observations irradiance from Earth, storing and loading.

Unique test reference/run	2/<run_reference>	**Version of requirements**	2.0
Requirement RF101, RNF101, RF301, RF303, RNF301, RNF303			
Test purpose The actor user will be able to simulate the irradiance of a lunar observation for any observer position on Earth. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.			
Pre-requisites Opening the LIME TBX			
Test instructions 1. The actor user will inform the system that they wish to simulate lunar observations from Earth. 2. The system will ask the user to input the needed data for the location. 3. The actor user inputs valid data. 4. The system informs the user that they can proceed with the calculation. 5. The actor user asks the system to simulate the lunar observation irradiance. 6. The system will show the user the result of the simulation. 7. The user will ask the system to export the output to an image. 8. The system will create an image with the generated graph. 9. The user will ask the system to export the output to a CSV file. 10. The system will create a CSV file with the output data. 11. The user will ask the system to show the integrated irradiance (signal). 12. The system will show a table with the signal data. 13. The user will ask the system to export that data into a CSV file. 14. The system will create a CSV file with the signal data. 15. The user will choose to export all the output to a LGLOD format file. 16. The system will export the output to a LGLOD format file. 17. The user will ask the TBX to be closed			

18. The system will close the TBX
19. The user will open the TBX again
20. The system will open the TBX
21. The user will ask the system to load the previously generated LGLOD format file.
22. The system will load the file and will show the user the same data as before (both result and signal tabs).

Acceptance criteria

There will be 4 new files (an image, two CSV files and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.3 Simulate lunar observations reflectance from Earth, storing and loading.

Unique test reference/run	3/<run_reference>	**Version of requirements**	2.0

Requirement

RF101, RNF101, RF301, RF303, RNF301, RNF303

Test purpose

The actor user will be able to simulate the reflectance of a lunar observation for any observer position on Earth. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will inform the system that they wish to simulate lunar observations from Earth.
2. The system will ask the user to input the needed data for the location.
3. The actor user inputs valid data.
4. The system informs the user that they can proceed with the calculation.
5. The actor user asks the system to simulate the lunar observation reflectance.
6. The system will show the user the result of the simulation.
7. The user will ask the system to export the output to an image.
8. The system will create an image with the generated graph.
9. The user will ask the system to export the output to a CSV file.
10. The system will create a CSV file with the output data.
11. The user will choose to export the output to a LGLOD format file.
12. The system will export the output to a LGLOD format file.
13. The user will ask the TBX to be closed
14. The system will close the TBX
15. The user will open the TBX again
16. The system will open the TBX
17. The user will ask the system to load the previously generated LGLOD format file.

18. The system will load the file and will show the user the same data as before.

Acceptance criteria

There will be 3 new files (an image, a CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.4 Simulate lunar observations polarization from Earth, storing and loading.

Unique test reference/run	4/<run_reference>	**Version of requirements**	2.0

Requirement

RF101, RNF101, RF302, RF304, RNF302, RNF303

Test purpose

The actor user will be able to simulate the polarization of a lunar observation for any observer position on Earth. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will inform the system that they wish to simulate lunar observations from Earth.
2. The system will ask the user to input the needed data for the location.
3. The actor user inputs valid data.
4. The system informs the user that they can proceed with the calculation.
5. The actor user asks the system to simulate the lunar observation polarization.
6. The system will show the user the result of the simulation.
7. The user will ask the system to export the output to an image.
8. The system will create an image with the generated graph.
9. The user will ask the system to export the output to a CSV file.
10. The system will create a CSV file with the output data.
11. The user will choose to export the output to a LGLOD format file.
12. The system will export the output to a LGLOD format file.
13. The user will ask the TBX to be closed
14. The system will close the TBX
15. The user will open the TBX again
16. The system will open the TBX
17. The user will ask the system to load the previously generated LGLOD format file.
18. The system will load the file and will show the user the same data as before.

Acceptance criteria

There will be 3 new files (an image, a CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.5 Simulate lunar observations irradiance from custom point, storing and loading.

Unique test reference/run	5/<run_reference>	**Version of requirements**	2.0

Requirement

RF102, RNF101, RF301, RF303, RNF301, RNF303

Test purpose

The actor user will be able to simulate the irradiance of a lunar observation for any custom observer point. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will inform the system that they wish to simulate lunar observations from a custom point.
2. The system will ask the user to input the needed data for the point.
3. The actor user inputs valid data.
4. The system informs the user that they can proceed with the calculation.
5. The actor user asks the system to simulate the lunar observation irradiance.
6. The system will show the user the result of the simulation.
7. The user will ask the system to export the output to an image.
8. The system will create an image with the generated graph.
9. The user will ask the system to export the output to a CSV file.
10. The system will create a CSV file with the output data.
11. The user will ask the system to show the integrated irradiance (signal).
12. The system will show a table with the signal data.
13. The user will ask the system to export that data into a CSV file.
14. The system will create a CSV file with the signal data.
15. The user will choose to export all the output to a LGLOD format file.
16. The system will export the output to a LGLOD format file.
17. The user will ask the TBX to be closed
18. The system will close the TBX
19. The user will open the TBX again
20. The system will open the TBX
21. The user will ask the system to load the previously generated LGLOD format file.
22. The system will load the file and will show the user the same data as before (both result and signal tabs).

Acceptance criteria

There will be 3 new files (an image, two CSV files and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.6 Simulate lunar observations reflectance from custom point, storing and loading.

Unique test reference/run	6/<run_reference>	**Version of requirements**	2.0

Requirement

RF102, RNF101, RF301, RF303, RNF301, RNF303

Test purpose

The actor user will be able to simulate the reflectance of a lunar observation for any custom observer point. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will inform the system that they wish to simulate lunar observations from a custom observer point.
2. The system will ask the user to input the needed data for the point.
3. The actor user inputs valid data.
4. The system informs the user that they can proceed with the calculation.
5. The actor user asks the system to simulate the lunar observation reflectance.
6. The system will show the user the result of the simulation.
7. The user will ask the system to export the output to an image.
8. The system will create an image with the generated graph.
9. The user will ask the system to export the output to a CSV file.
10. The system will create a CSV file with the output data.
11. The user will choose to export the output to a LGLOD format file.
12. The system will export the output to a LGLOD format file.
13. The user will ask the TBX to be closed
14. The system will close the TBX
15. The user will open the TBX again
16. The system will open the TBX
17. The user will ask the system to load the previously generated LGLOD format file.
18. The system will load the file and will show the user the same data as before.

Acceptance criteria

There will be 3 new files (an image, a CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.7 Simulate lunar observations polarization from custom point, storing and loading.

Unique test reference/run	7/<run_reference>	**Version of requirements**	2.0

Requirement

RF102, RNF101, RF302, RF304, RNF302, RNF303

Test purpose

The actor user will be able to simulate the polarization of a lunar observation for any custom observer point. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will inform the system that they wish to simulate lunar observations from a custom observer point.
2. The system will ask the user to input the needed data for the point.
3. The actor user inputs valid data.
4. The system informs the user that they can proceed with the calculation.
5. The actor user asks the system to simulate the lunar observation polarization.
6. The system will show the user the result of the simulation.
7. The user will ask the system to export the output to an image.
8. The system will create an image with the generated graph.
9. The user will ask the system to export the output to a CSV file.
10. The system will create a CSV file with the output data.
11. The user will choose to export the output to a LGLOD format file.
12. The system will export the output to a LGLOD format file.
13. The user will ask the TBX to be closed.
14. The system will close the TBX.
15. The user will open the TBX again.
16. The system will open the TBX.
17. The user will ask the system to load the previously generated LGLOD format file.
18. The system will load the file and will show the user the same data as before.

Acceptance criteria

There will be 3 new files (an image, a CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.8 Simulate lunar observations irradiance from satellite point, storing and loading.

Unique test reference/run	8/<run_reference>	**Version of requirements**	2.0

Requirement

RF105, RNF101, RNF104, RF301, RF303, RNF301, RNF303
Test purpose The actor user will be able to simulate the irradiance of a lunar observation for any satellite point. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.
Pre-requisites Opening the LIME TBX
Test instructions 1. The actor user will inform the system that they wish to simulate lunar observations from a satellite point. 2. The system will ask the user to input the needed data for the point. 3. The actor user inputs valid data. (Any satellite) 4. The system informs the user that they can proceed with the calculation. 5. The actor user asks the system to simulate the lunar observation irradiance. 6. The system will show the user the result of the simulation. 7. The user will ask the system to export the output to an image. 8. The system will create an image with the generated graph. 9. The user will ask the system to export the output to a CSV file. 10. The system will create a CSV file with the output data. 11. The user will ask the system to show the integrated irradiance (signal). 12. The system will show a table with the signal data. 13. The user will ask the system to export that data into a CSV file. 14. The system will create a CSV file with the signal data. 15. The user will choose to export all the output to a LGLOD format file. 16. The system will export the output to a LGLOD format file. 17. The user will ask the TBX to be closed 18. The system will close the TBX 19. The user will open the TBX again 20. The system will open the TBX 21. The user will ask the system to load the previously generated LGLOD format file. 22. The system will load the file and will show the user the same data as before (both result and signal tabs).
Acceptance criteria There will be 3 new files (an image, two CSV files and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.9 Simulate lunar observations reflectance from satellite point, storing and loading.

Unique test reference/run	9/<run_reference>	**Version of requirements**	2.0
Requirement			

RF105, RNF101, RNF104, RF301, RF303, RNF301, RNF303
Test purpose The actor user will be able to simulate the reflectance of a lunar observation for any satellite point. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.
Pre-requisites Opening the LIME TBX
Test instructions 1. The actor user will inform the system that they wish to simulate lunar observations from a satellite point. 2. The system will ask the user to input the needed data for the point. 3. The actor user inputs valid data. (Any satellite) 4. The system informs the user that they can proceed with the calculation. 5. The actor user asks the system to simulate the lunar observation reflectance. 6. The system will show the user the result of the simulation. 7. The user will ask the system to export the output to an image. 8. The system will create an image with the generated graph. 9. The user will ask the system to export the output to a CSV file. 10. The system will create a CSV file with the output data. 11. The user will choose to export the output to a LGLOD format file. 12. The system will export the output to a LGLOD format file. 13. The user will ask the TBX to be closed 14. The system will close the TBX 15. The user will open the TBX again 16. The system will open the TBX 17. The user will ask the system to load the previously generated LGLOD format file. 18. The system will load the file and will show the user the same data as before.
Acceptance criteria There will be 3 new files (an image, a CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.10 Simulate lunar observations polarization from satellite point, storing and loading.

Unique test reference/run	10/<run_reference>	**Version of requirements**	2.0
Requirement RF105, RNF101, RNF104, RF302, RF304, RNF302, RNF303			
Test purpose			

The actor user will be able to simulate the polarization of a lunar observation for any satellite point. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.
Pre-requisites Opening the LIME TBX
Test instructions 1. The actor user will inform the system that they wish to simulate lunar observations from a satellite point. 2. The system will ask the user to input the needed data for the point. 3. The actor user inputs valid data. (Any satellite) 4. The system informs the user that they can proceed with the calculation. 5. The actor user asks the system to simulate the lunar observation polarization. 6. The system will show the user the result of the simulation. 7. The user will ask the system to export the output to an image. 8. The system will create an image with the generated graph. 9. The user will ask the system to export the output to a CSV file. 10. The system will create a CSV file with the output data. 11. The user will choose to export the output to a LGLOD format file. 12. The system will export the output to a LGLOD format file. 13. The user will ask the TBX to be closed 14. The system will close the TBX 15. The user will open the TBX again 16. The system will open the TBX 17. The user will ask the system to load the previously generated LGLOD format file. 18. The system will load the file and will show the user the same data as before.
Acceptance criteria There will be 3 new files (an image, a CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data).

3.2.11 Simulate lunar observations with user-defined SRF, storing and loading.

Unique test reference/run	11/<run_reference>	**Version of requirements**	2.0
Requirement RF101, RF103, RF106, RNF101, RNF105, RF301, RF303, RF305, RNF301, RNF303			
Test purpose The actor user will be able to simulate a lunar observation with a user-defined spectral response function. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.			
Pre-requisites			

Opening the LIME TBX
Test instructions 1. The actor user will inform the system that they wish to load a custom SRF file in netCDF format 2. The system will load the SRF and show a graph to the user. 3. The user will ask the system to export the SRF as a CSV file. 4. The system will create a CSV file of the SRF. 5. The user will ask the system to simulate the irradiance with that SRF 6. The system will show the user the simulated irradiance. 7. The user will ask the user to see the integrated irradiance / signal for the SRF 8. The system will show the user the integrated irradiances for each channel of the SRF 9. The user will choose to export the output to a CSV file 10. The system will export the integrated irradiances to a CSV file 11. The user will ask the system to export the data to a LGLOD file. 12. The system will export the output to a LGLOD format file. 13. The user will ask the TBX to be closed 14. The system will close the TBX 15. The user will open the TBX again 16. The system will open the TBX 17. The user will ask the system to load the previously generated LGLOD format file. 18. The system will ask the user to select the SRF file that was used for that simulation 19. The user will select the SRF file used 20. The system will load both files and will show the user the same data as before.
Acceptance criteria There will be 3 new files (two CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data, and SRF graph).

3.2.12 Simulate lunar observations from Earth for multiple times.

Unique test reference/run	12/<run_reference>	**Version of requirements**	2.0
Requirement RF101, RF104, RNF101, RNF102, RF301, RF303, RNF301, RNF303			
Test purpose The actor user will be able to simulate a lunar observation from Earth for multiple dates and times, using a user-defined time-series file in CSV format. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.			
Pre-requisites Opening the LIME TBX			
Test instructions			

1. The actor user will inform the system that they wish to simulate lunar observations from Earth.
2. The system will ask the user to input the needed data for the location.
3. The user will ask the system to load a time-series file
4. The system will modify the input interface
5. The user will ask the system to load the file
6. The system will load the user-selected file
7. The user will ask the system to see the loaded datetimes
8. The system will show a window with the loaded datetimes
9. The user will ask the system to close the datetimes window
10. The system will close the datetimes window
11. The actor user inputs valid data.
12. The system informs the user that they can proceed with the calculation.
13. The system will close the datetimes window
14. The actor user asks the system to simulate the lunar observation irradiance.
15. The system will show the user the result of the simulation.
16. The user will ask the system to export the output to an image.
17. The system will create an image with the generated graph.
18. The user will ask the system to export the output to a CSV file.
19. The system will create a CSV file with the output data.
20. The user will ask the system to show the integrated irradiance (signal).
21. The system will show a table with the signal data.
22. The user will ask the system to export that data into a CSV file.
23. The system will create a CSV file with the signal data.
24. The user will ask the system to show the reflectance.
25. The system will show the simulated reflectance.
26. The user will ask the system to export the reflectance as a CSV file.
27. The system will export it into a CSV file.
28. The user will ask the system to simulate the polarization.
29. The system will show the polarization data.
30. The user will ask the system to export the polarization as a CSV file.
31. The system will export it into a CSV file.
32. The user will choose to export all the output to a LGLOD format file.
33. The system will export the output to a LGLOD format file.
34. The user will ask the TBX to be closed
35. The system will close the TBX
36. The user will open the TBX again
37. The system will open the TBX
38. The user will ask the system to load the previously generated LGLOD format file.
39. The system will load the file and will show the user the same data as before (both result and signal tabs).

Acceptance criteria

There will be 6 new files (an image, four CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data, and the datetimes when asked to see the datetimes).

3.2.13 Simulate lunar observations from a satellite point for multiple times.

Unique test reference/run	13/<run_reference>	**Version of requirements**	2.0
Requirement RF104, RF105, RNF101, RNF102, RNF104, RF301, RF303, RNF301, RNF303			
Test purpose The actor user will be able to simulate a lunar observation from a satellite point for multiple dates and times, using a user-defined time-series file in CSV format. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.			
Pre-requisites Opening the LIME TBX			
Test instructions 1. The actor user will inform the system that they wish to simulate lunar observations from a Satellite. 2. The system will ask the user to input the needed data for the location. 3. The user will ask the system to load a time-series file 4. The system will modify the input interface 5. The user will ask the system to load the file 6. The system will load the user-selected file 7. The user will ask the system to see the loaded datetimes 8. The system will show a window with the loaded datetimes 9. The user will ask the system to close the datetimes window 10. The system will close the datetimes window 11. The actor user inputs valid data. (Any satellite) 12. The system informs the user that they can proceed with the calculation. 13. The actor user asks the system to simulate the lunar observation irradiance. 14. The system will show the user the result of the simulation. 15. The user will ask the system to export the output to an image. 16. The system will create an image with the generated graph. 17. The user will ask the system to export the output to a CSV file. 18. The system will create a CSV file with the output data. 19. The user will ask the system to show the integrated irradiance (signal). 20. The system will show a table with the signal data. 21. The user will ask the system to export that data into a CSV file. 22. The system will create a CSV file with the signal data. 23. The user will ask the system to show the reflectance. 24. The system will show the simulated reflectance.			

25. The user will ask the system to export the reflectance as a CSV file.
26. The system will export it into a CSV file.
27. The user will ask the system to simulate the polarization.
28. The system will show the polarization data.
29. The user will ask the system to export the polarization as a CSV file.
30. The system will export it into a CSV file.
31. The user will choose to export all the output to a LGLOD format file.
32. The system will export the output to a LGLOD format file.
33. The user will ask the TBX to be closed
34. The system will close the TBX
35. The user will open the TBX again
36. The system will open the TBX
37. The user will ask the system to load the previously generated LGLOD format file.
38. The system will load the file and will show the user the same data as before (both result and signal tabs).

Acceptance criteria

There will be 6 new files (an image, four CSV and a netCDF file) and the system will show the same data in the final step as it did when generating it (even the same input data, and the datetimes when asked to see the datetimes).

3.2.14 Perform comparisons, store them and reload them.

Unique test reference/run	14/<run_reference>	**Version of requirements**	2.0

Requirement

RF201, RF202, RNF201, RNF202, RNF203, RNF204, RNF402

Test purpose

The actor user will be able to perform comparisons of lunar observations in GLOD format from a remote sensing instrument to the LIME output. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will inform the system that they wish to perform comparisons from a remote sensing instrument.
2. The system will ask the user to input the needed data for the comparisons.
3. The user will ask the system to load some observations in GLOD data.
4. The system will load the observations.
5. The user will ask the system to load the SRF file of the SRF related to those observations.
6. The system will load the SRF and will let the user know that they can proceed with the comparisons.

7. The user will ask the system to perform the comparisons.
8. The system will perform the comparisons, letting the user know how many observations have been processed and compared during the comparison. When finished, it will show the comparison of the first channel ordered by datetime.
9. The user will ask the system to export the channel comparison as a graph.
10. The system will export it as a graph
11. The user will ask the system to export the channel comparison as a CSV.
12. The system will export the output as a CSV
13. The user will ask the system to show another channel (if possible)
14. The system will show another channel
15. The user will ask the system to compare by moon-phase-angel instead of by datetime.
16. The system will show the comparison based on moon-phase-angle.
17. The user will ask to export the channel comparison it as a CSV.
18. The system will export the channel comparison it as a CSV.
19. The user will ask to export the whole comparison as a LGLOD file
20. The system will store the comparison in a LGLOD file.
21. The user will ask the TBX to be closed
22. The system will close the TBX
23. The user will open the TBX again
24. The system will open the TBX
25. The user will ask the system to load the previously generated LGLOD format file.
26. The system will ask the user for the SRF file related to that comparison.
27. The user will select the correct SRF file.
28. The system will load the files and will show the user the same data as before (for all channels).

Acceptance criteria

There will be 4 new files (an image, two CSV files and a netCDF file) and the system will show the same data in the final step as it did when generating it.

3.2.15 Perform comparisons using Apollo spectrum, store them and reload them.

Unique test reference/run	15/<run_reference>	**Version of requirements**	2.0

Requirement

RF201, RF202, RNF201, RNF202, RNF203, RNF204

Test purpose

The actor user will be able to perform comparisons of lunar observations in GLOD format from a remote sensing instrument to the LIME output using the Apollo 16 spectrum as the interpolation spectrum. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will ask the system to modify the settings
2. The system will show the settings to the user
3. The user will let the system know that they want to use the Apollo 16 spectrum
4. The system will close the settings window.
5. The actor user will inform the system that they wish to perform comparisons from a remote sensing instrument.
6. The system will ask the user to input the needed data for the comparisons.
7. The user will ask the system to load some observations in GLOD data.
8. The system will load the observations.
9. The user will ask the system to load the SRF file of the SRF related to those observations.
10. The system will load the SRF and will let the user know that they can proceed with the comparisons.
11. The user will ask the system to perform the comparisons.
12. The system will perform the comparisons, letting the user know how many observations have been processed and compared during the comparison. When finished, it will show the comparison of the first channel ordered by datetime.
13. The user will ask the system to export the channel comparison as a graph.
14. The system will export it as a graph
15. The user will ask the system to export the channel comparison as a CSV.
16. The system will export the output as a CSV
17. The user will ask the system to show another channel (if possible)
18. The system will show another channel
19. The user will ask the system to compare by moon-phase-angel instead of by datetime.
20. The system will show the comparison based on moon-phase-angle.
21. The user will ask to export the channel comparison it as a CSV.
22. The system will export the channel comparison it as a CSV.
23. The user will ask to export the whole comparison as a LGLOD file
24. The system will store the comparison in a LGLOD file.
25. The user will ask the TBX to be closed
26. The system will close the TBX
27. The user will open the TBX again
28. The system will open the TBX
29. The user will ask the system to load the previously generated LGLOD format file.
30. The system will ask the user for the SRF file related to that comparison.
31. The user will select the correct SRF file.
32. The system will load the files and will show the user the same data as before (for all channels).

Acceptance criteria

There will be 4 new files (an image, two CSV files and a netCDF file) and the system will show the same data in the final step as it did when generating it.

3.2.16 Perform simulations using Apollo spectrum, store them and reload them.

Unique test reference/run	16/<run_reference>	**Version of requirements**	2.0

Requirement

RF101, RNF101, RF301, RF303, RNF301, RNF303

Test purpose

The actor user will be able to perform simulations of lunar observations using the Apollo 16 spectrum as the interpolation spectrum. Then it will be able to export it with different formats and will be able to reload it from a netCDF file.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will ask the system to modify the settings
2. The system will show the settings to the user
3. The user will let the system know that they want to use the Apollo 16 spectrum
4. The system will close the settings window.
5. The actor user will inform the system that they wish to simulate lunar observations from Earth.
6. The system will ask the user to input the needed data for the location.
7. The actor user inputs valid data.
8. The system informs the user that they can proceed with the calculation.
9. The system will close the datetimes window
10. The actor user asks the system to simulate the lunar observation irradiance.
11. The system will show the user the result of the simulation.
12. The user will ask the system to export the output to an image.
13. The system will create an image with the generated graph.
14. The user will ask the system to export the output to a CSV file.
15. The system will create a CSV file with the output data.
16. The user will ask the system to show the integrated irradiance (signal).
17. The system will show a table with the signal data.
18. The user will ask the system to export that data into a CSV file.
19. The system will create a CSV file with the signal data.
20. The user will ask the system to show the reflectance.
21. The system will show the simulated reflectance.
22. The user will ask the system to export the reflectance as a CSV file.
23. The system will export it into a CSV file.
24. The user will choose to export all the output to a LGLOD format file.
25. The system will export the output to a LGLOD format file.
26. The user will ask the TBX to be closed
27. The system will close the TBX
28. The user will open the TBX again

29. The system will open the TBX
30. The user will ask the system to load the previously generated LGLOD format file.
31. The system will load the file and will show the user the same data as before (both result and signal tabs).

Acceptance criteria

There will be 6 new files (an image, four CSV files and a netCDF file) and the system will show the same data in the final step as it did when generating it.

3.2.17 Download updated coefficients.

Unique test reference/run	17/<run_reference>	**Version of requirements**	2.0

Requirement

RF401, RF402, RNF401

Test purpose

The actor user will be able to download an updated version of the LIME coefficients.

Pre-requisites

Opening the LIME TBX

Test instructions

1. The actor user will ask the system to download updated coefficients.
2. The system will connect to the server and download the updated coefficients (if any) and report the results to the user.
3. The user will accept the results
4. The system will close the window
5. The user will ask the system to let them choose the coefficients
6. The system will show a window to the user, asking to select the coefficients version.
7. The user will select a coefficients version.
8. The system will close the settings window.
9. The user will ask the system to calculate the simulated irradiance
10. The system will show the output, with the newly selected coefficients version in the outputed graph subtitle.

Acceptance criteria

The output graph will have the newly selected coefficients version as the coefficient's version.

3.3 Acceptance Tests

Acceptance testing checks that the system meets customer requirements, which for this project are described in Annex II. These tests are performed by the customer. These usually are similar to the end-to-end tests, as they both contain all or most of the use-cases required by the customer, which are described in Annex III.

Down below, the proposed acceptance tests are described. They are based on the use cases, and they are a subset of the end-to-end test cases.

Simulate lunar observations from Earth

The actor user will be able to simulate lunar observations for any observer position on Earth.

1. The actor user will inform the system that they wish to simulate lunar observations from Earth.
2. The system will ask the user to input the needed data for the location.
3. The actor user inputs valid data.
4. [Optional]: Use case “Simulate the lunar observations for a user-defined spectral response”.
5. The system informs the user that they can proceed with the calculation.
6. The actor user asks the system to simulate the lunar observations.
7. The system will show the user the result of the simulation.
8. The system will let the user export the output to a GLOD format file.
9. The user will choose to export the output to a GLOD format file.
10. The system will export the output to a GLOD format file.

Simulate lunar observation for custom selenographic latitude and longitude

The actor user will be able to simulate lunar observations for a custom observer and solar selenographic latitude and longitudes.

1. The actor user will inform the system that they wish to simulate lunar observations for custom selenographic latitude and longitude.
2. The system will ask the user to input the needed data for the simulation.
3. The actor user inputs valid data.
4. [Optional]: Use case “Simulate the lunar observations for a user-defined spectral response”.
5. The system informs the user that they can proceed with the calculation.
6. The actor user asks the system to simulate the lunar observations.
7. The system will show the user the result of the simulation.
8. The system will let the user export the output to a GLOD format file.
9. The user will choose to export the output to a GLOD format file.
10. The system will export the output to a GLOD format file.

Simulate lunar observations from a satellite position

The actor user will be able to simulate lunar observations from a satellite position, for at least the satellites defined in RNF104 (Annex II).

1. The actor user will inform the system that they wish to simulate lunar observations from a satellite position.
2. The system will ask the user to select the ESA satellite.
3. The user will select an ESA satellite.
4. The system will ask the user to input the needed data for the simulation.
5. The actor user inputs valid data.
6. [Optional]: Use case “Simulate the lunar observations for a user-defined spectral response”.
7. The system informs the user that they can proceed with the calculation.
8. The actor user asks the system to simulate the lunar observations.
9. The system will show the user the result of the simulation.

10. The system will let the user export the output to a GLOD format file.
11. The user will choose to export the output to a GLOD format file.
12. The system will export the output to a GLOD format file.

Simulate the lunar observations for a user-defined spectral response

The actor user will be able to simulate the lunar observations for a specific user defined instrument spectral response SRF.

1. The actor user will inform the system that they want to use a user defined spectral response SRF instead of a default satellite spectral band SRF.
2. The system will ask the user to choose the input file from which the spectral response SRF will be read from.
3. The actor user will select the SRF file.
4. The system will inform the user that the SRF has been loaded successfully.

Compare lunar observations from a remote sensing instrument

The actor user will be able to perform comparisons of lunar observations from a remote sensing instrument to the LIME output.

1. The actor user will inform the system that they wish to perform comparisons of lunar observations from a remote sensing instrument to the LIME output.
2. The system will ask the user to select the GLOD format file that stores the remote sensing instrument observations.
3. The user will select the correct file.
4. The system will show the user plots providing the data described in requirements RNF202 and RNF203.
5. [Optional]: Use case “Export plot”.

Export plot

The actor user will be able to export plots.

1. The actor user will inform the system that they wish to export a plot.
2. The system will ask the user to select the type of file it will be exported to (pdf or jpg).
3. The actor user will select a format.
4. The system will export the file following that format.

Manually check for updates

The actor user will be able to manually check for updates.

1. The actor user will inform the system that they wish to manually check for updates.
2. The system will inform the user that it’s looking for updates.
3. The system will tell the user that there are no updates, or that there are and they have been downloaded.

Annex I: End-to-end test executions

Linux test runs

Unique test reference/run	1/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	2/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	3/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	4/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	5/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	6/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	7/1	**Version of requirements**	2.0
Observation			

None	
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux
Pass/fail	Pass
Tester	Javier Gatón Herguedas
Date	2024/01/25

Unique test reference/run	8/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	9/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	10/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		

Tester	Javier Gatón Herguedas
Date	2024/01/25

Unique test reference/run	11/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	12/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	13/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	14/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	15/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	16/1	**Version of requirements**	2.0
Observation None			
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	17/1	**Version of requirements**	2.0
Observation			

None	
System info	5.15.0-91-generic #101~20.04.1-Ubuntu SMP Thu Nov 16 14:22:28 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux
Pass/fail	Pass
Tester	Javier Gatón Herguedas
Date	2024/01/25

Windows test runs

Unique test reference/run	1/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	2/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	3/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		

Date	2024/01/25

Unique test reference/run	4/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	5/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	6/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	7/1	**Version of requirements**	2.0
Observation None			

System info	Windows 10
Pass/fail	Pass
Tester	Javier Gatón Herguedas
Date	2024/01/25

Unique test reference/run	8/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	9/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	10/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	11/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	12/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	13/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	14/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		

Pass/fail	Pass
Tester	Javier Gatón Herguedas
Date	2024/01/25

Unique test reference/run	15/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	16/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	17/1	**Version of requirements**	2.0
Observation None			
System info	Windows 10		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Mac test runs

Unique test reference/run	1/1	**Version of requirements**	2.0
Observation If opened from safari download window the installation cannot be done. It says: “pkg cannot be opened because it is from an unidentified developer”. When opened from the Finder it allowes you to install it.			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	2/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	3/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	4/1	**Version of requirements**	2.0
Observation			

None	
System info	macOS 10.15 Catalina
Pass/fail	Pass
Tester	Javier Gatón Herguedas
Date	2024/01/25

Unique test reference/run	5/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	6/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	7/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	8/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	9/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	10/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	11/1	**Version of requirements**	2.0
Observation None			

System info	macOS 10.15 Catalina
Pass/fail	Pass
Tester	Javier Gatón Herguedas
Date	2024/01/25

Unique test reference/run	14/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Unique test reference/run	17/1	**Version of requirements**	2.0
Observation None			
System info	macOS 10.15 Catalina		
Pass/fail	Pass		
Tester	Javier Gatón Herguedas		
Date	2024/01/25		

Annex II: Requirements elicitation

Requirements have been divided into four groups.

- **General user functionalities**: Requirements related to most main functionalities.
- **Comparisons**: Requirements related to the comparison functionality.
- **LIME Output**: Requirements related to the output and its format.
- **System requirements**: Other requirements like performing automatic updates, the programming language, etc.

General user functionalities

Functional Requirements

RF101: Allow users to simulate lunar observations for any observer's position around the Earth and at any time.

RF102: Allow users to simulate lunar observation for any observer/solar selenographic latitude and longitude (thus bypassing the need for their computation from the position/time of the observer).

RF103: Allow users to simulate the lunar observations for any user defined instrument spectral response SRF.

RF104: Allow users to simulate lunar observation for a single observation or for a time series of observations.

RF105: The user must be able to simulate lunar observations for an ESA satellite.

RF106: Allow users to either choose between default satellite spectral band SRF or select a user defined SRF (**RF103**).

Non-Functional Requirements

RNF101: The simulation input of a single lunar observation (**RF104**) must be introduced via the GUI.

RNF102: The simulation input for a time series of lunar observations (**RF104**) must be done via an input file.

RNF103: In order to simulate lunar observations from a satellite position (**RF105**) the user must provide an orbital scenario file in EOCFI compatible format.

RNF104: The ESA satellites available for selection must include ENVISAT, Proba-V, S2, S3, FLEX.

RNF105: The user defined SRF (**RF103**) must be defined via a user generated SRF file.

RNF 106: The user should be able to perform the simulation via command line using parameters or input files.

Comparisons

Functional Requirements

RF201: Allow performing comparisons of lunar observations from a remote sensing instrument to the LIME model output.

RF202: Allow exporting plots.

Non-Functional Requirements

RNF201: The remote sensing instrument observations (**RF201**) must be pre-stored in a GLOD format file.

RNF202: The comparison plots shall provide: relative differences between measured and modeled lunar irradiance/reflectance vs. time and vs. lunar phase angle.

RNF203: The comparison plots shall display statistical indicators (mean relative difference, standard deviation of the mean relative difference, temporal trend if applicable, number of comparison samples, etc.)

RNF204: The exported plots must be in .jpg or .pdf format.

RNF205: The user should be able to perform the simulations via command line using parameters or input files.

LIME output

Functional Requirements

RF301: The LIME TBX shall output simulated lunar disk irradiance or reflectance.

RF302: The LIME TBX shall output the simulated lunar disk degree of polarization.

RF303: The LIME TBX shall output simulated lunar irradiance or reflectance associated uncertainty.

RF304: The LIME TBX shall output the simulated lunar degree of polarization's associated uncertainty.

RF305: Allow the visualization of the user defined spectral response used for the spectral integration of the LIME output into a sensor spectral band.

Non-Functional Requirements

RNF301: The simulated lunar disk irradiance or reflectance (**RF301**) must be in the spectral range of 400 nm to 2500 nm.

RNF302: The simulated lunar disk degree of polarization (**RF302**) must be in the spectral range of 400 nm to 2500 nm.

RNF303: The LIME simulated output shall be available to be exported to GLOD format files.

RNF304: The LIME version number shall be visible on all outputs (plots/files) of the TBX.

System requirements

Functional Requirements

RF401: The LIME TBX must be able to perform automatic updates of the LIME coefficients.

RF402: The user shall be able to select past LIME coefficients with whom perform the calculations.

Non-Functional Requirements

RNF401: The LIME coefficients of the automatic updates (**RF401**) must be stored on a dedicated repository.

RNF402: The LIME TBX shall read the database of lunar observations formatted in GLOD format

RNF403: The LIME TBX shall use the EOCFI as orbit propagator and to derive satellite orbital positions.

RNF404: Be to the largest extent platform/operating system independent.

RNF405: Run at least under Windows / mac OS / Linux operating systems.

RNF406: Be to the largest extent a self-installing SW package.

RNF407: The LIME TBX shall be to the largest extent developed in Python.

RNF408: The LIME TBX code shall be available on a password protected web repository allowing versioning of the software (e.g., GitHub).

Annex III: Use cases

The use cases are:

Simulate lunar observations from Earth: The actor user will be able to simulate lunar observations for an observer position on Earth.

Simulate lunar observation for custom selenographic latitude and longitude: The actor user will be able to simulate lunar observations for a custom observer and solar selenographic latitude and longitudes.

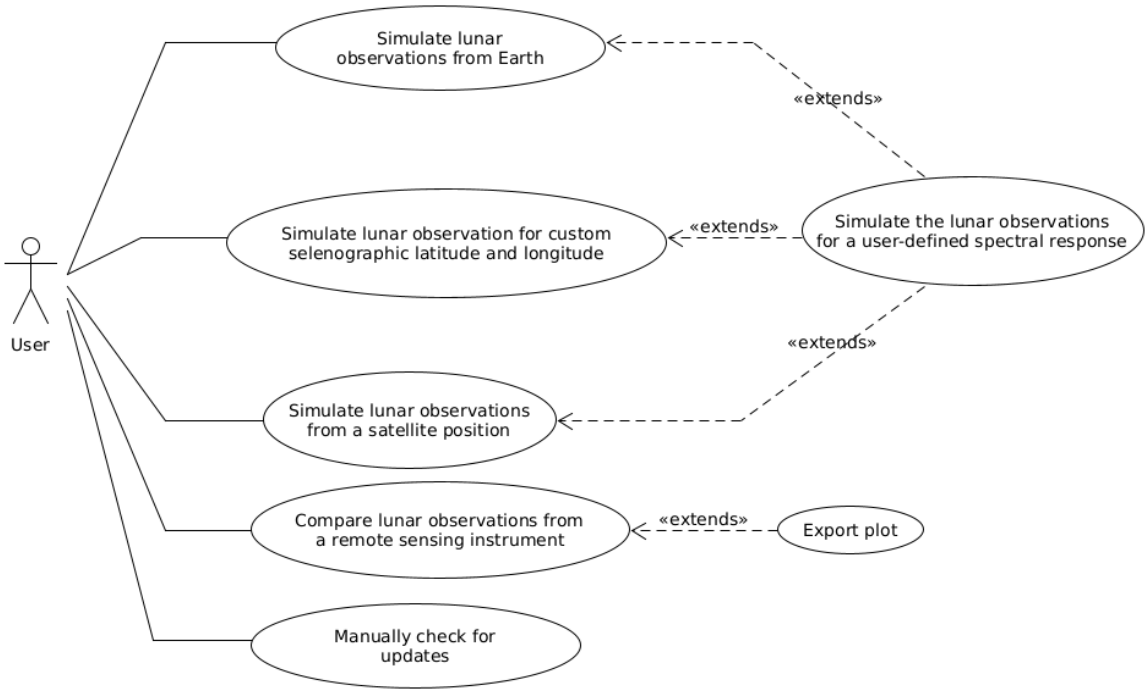
Simulate the lunar observations for a user-defined spectral response: The actor user will be able to simulate the lunar observations for a specific user defined instrument spectral response SRF.

Simulate lunar observations from a satellite position: The actor user will be able to simulate lunar observations from a satellite position, for at least the satellites defined in RNF104.

Compare lunar observations from a remote sensing instrument: The actor user will be able to perform comparisons of lunar observations from a remote sensing instrument to the LIME output.

Export plot: The actor user will be able to export plots.

Manually check for updates: The actor user will be able to manually check for updates.


Simulate lunar observations from Earth
«extends»
Simulate lunar observation for custom selenographic latitude and longitude
«extends»
Simulate the lunar observations for a user-defined spectral response
«extends»
User
Simulate lunar observations from a satellite position
Compare lunar observations from a remote sensing instrument
«extends»
Export plot
Manually check for updates