

## 4.4 CONSTRAINTS

BLTS will have as objective the reusability on different ESA projects to delta-qualify the mathematical library in the scope of different projects. The development of BLTS itself shall be compliant to a tailoring of the ECSS-E-ST-40C and ECSS-Q-ST-80C, criticality category D. The user can specify at configuration time (by using configuration file) which elements of the mathematical library and for which target the test will be executed.

As we already mentioned, TSE shall be executed on different targets (as minimum RASTA platform with LEON 2 processor) and BLTS host application shall be executed on x86\_64 PC. From functionality point of view, the GNU Project Debugger (*gdb*) will be the software interface between BLTS and the remote target platforms. *gdb* will be used to execute TSE on the target platform (see also REQ-BLTS-0240 and §8.1, 8.2). The cross-development environment needs packages/programs in order to create a binary code that can execute on specific target architecture. The communication interface between the host and the target platform is either a serial link or an Ethernet network connection.

BLTS must be designed in such way that can be executed in batch or manual mode.

## 5 REQUIREMENTS

### 5.1 GENERAL

The following paragraphs present the requirements for the *Basic Library Test Suite* application" (BLTS).

The requirements defined in this document have the following structure:

- Unique identifier in the format : **REQ-BLTS-nnnn**; BLTS stands for Basic Library Test Suite, nnnn is an unique 4-digits number, initially in increments of ten;
- Description - Text with the requirements definition;
- An optional Note with remarks which are not part of the requirement;
- Rationale – for defining the source or up-trace of the requirement;
- Verification method – to define the verification method of the requirement :
  - A – for analysis
  - I – for inspection
  - R – for Review of Design
  - T – for test (this is the preferred method)

The remarks that add explications to requirements are being marked with “*Remark*” or are present inside parenthesis. The derived requirements justifications are being marked with “*Justification*”.

### 5.2 FUNCTIONAL REQUIREMENTS

General:

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0010	BLTS shall be implemented in ISO C99 / C++11.	R	SOW 2.2.1
REQ-BLTS-0020	BLTS shall be reusable and shall not make use of commercial third party software.	R	GTD-TR-01-BLTS-0012

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0070	BLTS shall work on both host platforms: on Windows and Linux. <i>Remark:</i> The TSE execution on a target platform will be controlled from a host PC running Windows or Linux.	T	GTD-TR-01-BLTS-0005
REQ-BLTS-0150	BLTS shall support tests for all functions and macros of BL in single (32bit) and double (64bit) floating point precision.	T	GTD-TR-01-BLTS-0006
REQ-BLTS-0210	BLTS shall be designed to work as a stand-alone application.	R	SOW 2.2.2

#### Test run:

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0030	BLTS shall be expandable, allowing the integration of new mathematical functions by configuration means and dedicated code source files.	R	SOW 2.2.2
REQ-BLTS-0032	BLTS shall allow user to select one or more functions for running a test.	T	SOW 2.2.2
REQ-BLTS-0033	BLTS shall allow the user to select one of the predefined test types before a test run.	T	SOW 2.2.2
REQ-BLTS-0034	BLTS shall allow the user to select one of the configured targets before a test run.	T	SOW 2.2.2
REQ-BLTS-0036	BLTS shall support the automatically build of the target-native binaries on the host machine for the functions selected for test, based on a user adapted build script for specific target. <i>Remark:</i> The upload of the binaries to the target may be done either automatically by BLTS or manually with external tools.	T	SOW 2.2.2
REQ-BLTS-0038	BLTS shall execute the test on host and target using GDB as a common interface.	T	GTD-TR-01-BLTS-0013
REQ-BLTS-0060	BLTS shall automatically export all results of the TSE execution on a target into documents in order to provide the qualification evidence of the BL (see also REQ-BLTS-0130, REQ-BLTS-0140).	T	SOW 2.2.2 GTD-TR-01-BLTS-0014
REQ-BLTS-0130	BLTS shall not loose results from previous runs. BLTS shall archive the obtained test report along with platform information as a performed run results. <i>Justification:</i> Archiving different runs allow user not only to later check the results but also to measure reproducibility of the library by comparing them.	T	derived
REQ-BLTS-0140	The archived results shall also contain configuration information previously set by the user in order to permit the reproducibility of the test. <i>Remark:</i> Will be archived, at least: test input files, produced and used binaries, intermediary and log files,	T	derived

	result documents. <i>Justification:</i> Archiving configuration information allows the user to rerun the test if necessary.		
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#### Test types:

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0040	BLTS shall allow the execution of functional unit tests. <i>Remark:</i> Unit tests are written in order to verify tested function requirements, domain limits, corner cases, etc. Justification of the chosen values will be part of the BL SValP/SUITP.	T	SOW 2.2.2
REQ-BLTS-0045	BLTS shall build a specific report to present functional unit tests results after unit tests run. It will contain at minimum: <ul style="list-style-type: none"> <li>- result status PASS/FAIL per test case</li> <li>- input, expected and obtained values per test case</li> <li>- summary PASS/FAIL per function</li> </ul>	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0014
REQ-BLTS-0080	BLTS shall allow tests that adjust the value of the functions parameters by sweeping the parameter values through a user defined range. <i>Remark:</i> 1. This test type will be used in conjunction with accuracy / performance tests. 2. The iteration of sweeping parameter can be of the following types: float, linear, logarithmic, binary.	T	derived
REQ-BLTS-0090	BLTS shall allow tests that check mathematical properties of tested functions. <i>Justification:</i> This will help the users understand and identify the mathematical properties that they should rely on. Details will be given in SValP/SVS	T	derived
REQ-BLTS-0095	Deleted.		
REQ-BLTS-0100	BLTS shall allow comparison of tests to help assessing numerical reproducibility of the results produced by the mathematical library, from one run to the next, either on the same or different machines for the same input data set. <i>Remark:</i> 1. Numerical reproducibility means getting bitwise identical results from different functions calls. See [RD 7]. 2. The comparison will be done by using outputs of previous runs as the reference for comparisons (instead of the reference library).	T	GTD-TR-01-BLTS-0001
REQ-BLTS-0105	BLTS shall generate a report to present numerical reproducibility results which contains: input values, output values obtained on current run and on reference run; ULP, relative and absolute error calculated between the runs.	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0014
REQ-BLTS-0110	Deleted		

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0120	BLTS shall provide structural coverage information for execution of the unit tests. A special coverage report will be generated containing at minimum: <ul style="list-style-type: none"> <li>- code coverage % per test</li> <li>- code coverage % global per function</li> <li>- coverage summary</li> </ul>	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0014
REQ-BLTS-0160	BLTS shall provide execution time measurements for each tested function. <i>Remark:</i> The execution time will be used to provide time performance calculations for BL (e.g. average time, max/min, etc.)	T	GTD-TR-01-BLTS-0002 GTD-TR-01-BLTS-0003
REQ-BLTS-0165	BLTS shall provide in report file the execution time measurements after performance / timing tests.	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0014
REQ-BLTS-0170	Deleted		
REQ-BLTS-0180	BLTS shall allow tests that check for accuracy (e.g. ULP error, absolute error and relative error). <i>Remark:</i> for accuracy tests parameter sweeping will be done on a selected range or special values (see REQ-BLTS-0080).	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0008
REQ-BLTS-0190	The BLTS shall evaluate the accuracy of the tested library against a bit accurate reference library. <i>Remark:</i> For agreed reference mathematical libraries see [RD 5].	T	GTD-TR-01-BLTS-0007
REQ-BLTS-0195	BLTS shall produce a report after accuracy tests. The reports will contain at minimum: <ul style="list-style-type: none"> <li>- Input data: Range of the parameters taken in consideration and step</li> <li>- Reference values obtained with reference mathematical library</li> <li>- Output value obtained with BL</li> <li>- Error information: ULP error, absolute error, relative error</li> </ul>	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0014

### 5.3 PERFORMANCE REQUIREMENTS

The main performance metrics of the software applications are the response time and computational resources used by applications.

In the case of BLTS application, the response time is the execution time (including TSE execution and report building). The computational resources are represented by the amount of memory, CPU and space on disk used by the application.

The execution time depends of:

- the function to be tested and complexity of the implemented algorithm;
- the number of test cases and type of test cases;
- the processor on the target platform;

Except for the BLTS core which is executed on the host machine and which has no specific memory constraints, the amount of memory used by TSE on the target platform depends on the number of test cases and of the input data.

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0910	BLTS application shall run on a standard x86_64 PC with Windows / Linux operating system, with a minimum of 4 GB RAM and at least an Intel i3 (or equivalent) processor.	T	SOW 2.2.2
REQ-BLTS-0915	Deleted		
REQ-BLTS-0920	TSE executable size shall not exceed 1024 kB.	T	SOW 2.2.2
REQ-BLTS-0925	During tests execution, BLTS shall inform the user about the progress of the test being executed. <i>Justification:</i> This information help the user to assess that test run is in progress or test run hung up.	T	derived
REQ-BLTS-0930	Deleted		
REQ-BLTS-0935	BLTS shall be able to handle large amount of data results in case of parameter sweeping tests, for example testing $10^6$ input values in a test case. <i>Remark:</i> The application will retrieve the results during the test if their size will increase over a certain limit. <i>Justification:</i> This might be required when running the sweeping tests.	T	derived

## 5.4 INTERFACE REQUIREMENTS

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0220	BLTS shall use the following type of input files: <ul style="list-style-type: none"> <li>- configuration files in XML format</li> <li>- test cases written in in XML format</li> </ul> <i>Remark:</i> A predefined format may be used for test cases in order to help generate documentation files.	T	SOW 2.2.2
REQ-BLTS-0222	The BLTS application configuration file will contain at least: <ul style="list-style-type: none"> <li>- Localization of toolchain used for TSE compilation on the host machine;</li> <li>- Localization of libraries to be included in TSE compilation for the target machine;</li> <li>- The target configuration</li> </ul> <i>Justification:</i> This information is required for building target binary and later for report generation.	T	derived
REQ-BLTS-0224	For each test execution, the BLTS shall use as input a test configuration file which contains at least this information: <ul style="list-style-type: none"> <li>- Name of the function(s) to be tested</li> <li>- Type of the test</li> <li>- Tested values and expected values for single value tests</li> <li>- Range of parameter values for the tests that need sweeping the function parameter values</li> <li>- Any other configuration parameter needed to run the tests.</li> </ul> <i>Justification:</i> This minimal information is required for qualification reports.	T	derived
REQ-BLTS-0230	The output of BLTS shall be: <ul style="list-style-type: none"> <li>- Details result files (ASCII / csv format) describing inputs, outputs, expected values, etc</li> <li>- High level report documents (HTML, XML format) describing global information</li> </ul>	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0014
REQ-BLTS-0234	Detail test report files in csv format contains: <ul style="list-style-type: none"> <li>- Input values</li> <li>- Expected values</li> <li>- Obtained values</li> <li>- Errors (ULP, absolute, relative)</li> <li>- Execution time</li> </ul>	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0014
REQ-BLTS-0235	High level test report documents in html/xml format contains: <ul style="list-style-type: none"> <li>- Target information</li> <li>- BL information</li> <li>- BLTS and toolchain information</li> <li>- Name of the function tested</li> <li>- Description of the test type selected</li> <li>- Summarisation section containing information interpreting the results of the suite of tests.</li> </ul>	T	GTD-TR-01-BLTS-0007 GTD-TR-01-BLTS-0014

Identifier	Description	Verif. Method	Rationale
	- Depending of type of the test, for each function may be provided several types of graphs, e.g. ULP, absolute and relative error vs argument value.		
REQ-BLTS-0240	<i>gdb</i> shall be the software interface between BLTS and the target platforms. It will be used to execute the TSE on the target. <i>Remark.</i> <i>gdb</i> will be used even the target is the host machine	T	GTD-TR-01-BLTS-0013

## 5.5 OPERATIONAL REQUIREMENTS

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0310	Deleted		
REQ-BLTS-0320	BLTS shall allow running the tests in batch mode.	T	GTD-TR-01-BLTS-0011
REQ-BLTS-0330	BLTS shall allow running the tests manually.	T	GTD-TR-01-BLTS-0011

## 5.6 RESOURCES REQUIREMENTS

### 5.6.1 Hardware resources

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0410	TSE shall run as a minimum in RTEMS versions 4.8 – 4.11, on the target SPARC V8 Hardware (HW), a LEON 2 (AT697E/F) processor with Meiko FPU.	T	SOW 2.2.3 GTD-TR-01-BLTS-0015
REQ-BLTS-0420	The host processors where TSE shall execute are x86-64 architecture.	T	GTD-TR-01-BLTS-0015
REQ-BLTS-0430	TSE shall run under RTEMS versions 4.8 – 4.11, on the target SPARC V8 Hardware (HW), with LEON 4 using GR-CPCI-LEON4-N2X platform.	T	GTD-TR-01-BLTS-0015

### 5.6.2 Software resources

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0510	BLTS shall not make use or depend on commercial third party software. If necessary, free and open source tools	R	GTD-TR-01-BLTS-0012



	may be used integrated in the testing framework. <i>Remark:</i> Commercial third party tools can be used to gather MC/DC and loop coverage data. This data will not be produced when running the TSE on target.		
REQ-BLTS-0520	On target boards, TSE shall be able to run under RTEMS Operating system, versions 4.8 – 4.11.	R	GTD-TR-01-BL-0003
REQ-BLTS-0525	TSE shall be able to run under Window and Linux Operating systems	R	SOW 2.2.2
REQ-BLTS-0530	Deleted		

## 5.7 DESIGN REQUIREMENTS AND IMPLEMENTATION CONSTRAINTS

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0610	BLTS development shall be compliant to the software standard ECSS-EST-40C [AD 2] criticality category D and the necessary documentation shall be produced.	R	GTD-TR-01-BLTS-0004
REQ-BLTS-0620	Deleted		

## 5.8 SECURITY AND PRIVACY REQUIREMENTS

NA

## 5.9 PORTABILITY REQUIREMENTS

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0710	TSE shall be portable on different platforms, at least between Intel, AMD, Sparc V8 based processors. See also REQ-BLTS-0410, REQ-BLTS-0420.	T	GTD-TR-01-BLTS-0015
REQ-BLTS-0720	Deleted		

## 5.10 SOFTWARE QUALITY REQUIREMENTS

According to SPAP [RD 2], the ECSS-Q-HB-80-04A [AD 4] quality model and associated metrication is used, with proposed target values for the metrics. Project defined target values are defined in this section.

The product-related main characteristics of the quality model are: Functionality, Reliability, Maintainability, Reusability and Usability.

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0810	Deleted		
REQ-BLTS-0820	Deleted		



REQ-BLTS-0830	BLTS shall be developed compliant to the (tailored) software standard ECSS-Q-ST-80C [AD 3] criticality category D and the necessary documentation shall be produced.	R	SOW 2.2.2
REQ-BLTS-0840	The BLTS statement coverage (source code) metric achieved by validation/integration/unit tests shall be at least 70%.	I	SOW 2.2.2
REQ-BLTS-0850	BLTS development shall respect software metrics target values defined in ECSS-Q-HB-80-04A quality model for category D, excepting following metrics defined not applicable for BLTS: <ul style="list-style-type: none"> <li>• Modular span of control</li> <li>• Modular coupling</li> <li>• Modular cohesion</li> <li>• Process reliability adequacy</li> <li>• Statement Coverage (Object Code)</li> <li>• Decision Coverage (Source Code)</li> <li>• Modified Condition &amp; Decision Coverage (Source Code)</li> <li>• Safety activities adequacy</li> <li>• Security checklist</li> <li>• User documentation clarity</li> <li>• Process assessment [ECSS-HB-Q-80-02]</li> </ul>	I	SOW 2.2.2

BLTS application will be built using C++ code for BLTS core application running on host and C code for TSE running on target. Following requirements define the coding style for both components. The coding style chosen for TSE also covers real-time development constraints

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-0900	The coding rules used for C++ development in BLTS shall follow the "Google C++ Style Guide" defined at: <a href="https://google.github.io/styleguide/cppguide.html">https://google.github.io/styleguide/cppguide.html</a> <i>Justification:</i> The BLTS will be developed in C++.	I	derived
REQ-BLTS-0905	The coding rules used for C development in BLTS shall follow the "The Power of Ten - Rules for Developing Safety Critical Cod" defined at: <a href="http://spinroot.com/gerard/pdf/P10.pdf">http://spinroot.com/gerard/pdf/P10.pdf</a>	I	SOW 2.2.2

## 5.11 SOFTWARE RELIABILITY REQUIREMENTS

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-1210	BLTS shall check the communication with the target (through GDB) by using checksums on transferred packets and it shall implement retry management.	T	derived

## 5.12 SOFTWARE MAINTAINABILITY REQUIREMENTS

See §5.10

## 5.13 SOFTWARE SAFETY REQUIREMENTS

NA.

## 5.14 SOFTWARE CONFIGURATION AND DELIVERY REQUIREMENTS

The configuration status will be verified by the product assurance process as defined in the SPAP [RD 2], based on the information provided in the Software Configuration File, the Configuration Status Accounting Report and the Configuration Item List.

Identifier	Description	Verif. Method	Rationale
REQ-BLTS-1010	Two logical repositories will be used for the configuration management activities: <ul style="list-style-type: none"> <li>the development repository: this repository will contain and handle the version control of the complete project data as it is been developed</li> <li>the master repository: this repository will contain and handle the baselines of the CIs as listed in the CIL.</li> </ul> <i>Remark:</i> Detailed process is given in SCMP [RD 3].	I	derived
REQ-BLTS-1020	The following data formats will be used for the CIs produced for distribution and archiving: <ul style="list-style-type: none"> <li>PDF for documents</li> <li>ZIP for source code files.</li> </ul> <i>Remark:</i> For content creation the formats will correspond to the tools being used. These files will be version controlled in these formats in the development repository and converted/packed to PDF or ZIP once they are released and put in the master repository.	R	SOW 2.2.2

## 5.15 DATA DEFINITION AND DATABASE REQUIREMENTS

Data definition requirements are already defined within the functional requirements in §5.2.

No database requirements are defined for BLTS.

## 5.16 HUMAN FACTORS RELATED REQUIREMENTS

NA

## 5.17 ADAPTATION AND INSTALLATION REQUIREMENTS

Identifier	Description	Verif. Method	Rationale
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REQ-BLTS-1110	The BLTS source files shall be accompanied by a makefile. <i>Justification:</i> A makefile eases the compilation of the application.	I	derived
REQ-BLTS-1120	The BLTS shall provide or generate a makefile for each binary it intends to cross-compile for target execution. <i>Justification:</i> A makefile eases the compilation of the TSE.	R	derived

## 6 VALIDATION REQUIREMENTS

Table 1 lists the verification method identified for each defined requirement.

Requirement	Verification Method
REQ-BLTS-0010	R
REQ-BLTS-0020	R
REQ-BLTS-0070	T
REQ-BLTS-0150	T
REQ-BLTS-0210	R
REQ-BLTS-0030	R
REQ-BLTS-0032	T
REQ-BLTS-0033	T
REQ-BLTS-0034	T
REQ-BLTS-0036	T
REQ-BLTS-0038	T
REQ-BLTS-0060	T
REQ-BLTS-0130	T
REQ-BLTS-0140	T
REQ-BLTS-0040	T
REQ-BLTS-0045	T
REQ-BLTS-0080	T
REQ-BLTS-0090	T
REQ-BLTS-0095	T
REQ-BLTS-0100	T
REQ-BLTS-0105	T
REQ-BLTS-0120	T
REQ-BLTS-0160	T
REQ-BLTS-0165	T
REQ-BLTS-0180	T
REQ-BLTS-0190	T
REQ-BLTS-0195	T
REQ-BLTS-0910	T
REQ-BLTS-0920	T
REQ-BLTS-0925	T