

Why Your Project Needs the LibmCS

Mathematical libraries are used in nearly any flight software, in particular in the AOCS/GNC and scientific algorithms.
The Mathematical Library for Critical Systems (**LibmCS**) provides an **open source, standard compliant** (IEEE-754, ISO C18, and POSIX) mathematical library (libm), **pre-qualified** to ECSS E-ST-40 and Q-ST-80 Category B, so that project specific **integration** and **delta-qualification efforts** for this building block are **minimized** and its long term maintenance guaranteed.

LibmCS Main Attributes

- ▶ Standard compliance (IEEE-754-2019, ISO C18, POSIX, MISRA C:2012)
- ▶ ECSS Category B qualification evidence including ISVV
- ▶ Designed to support many processor architectures: x86-64, SPARC V8 (all LEON), ARM, RISC-V...
- ▶ Fully compatible with qualified RTEMS 6 SMP and EDISOFT RTEMS 4.8
- ▶ Provides step by step Qualification Guideline and qualification template
- ▶ Minimized project specific delta-qualification effort (below 2 days of test execution)
- ▶ Freely available (Qualification Kit also free for ESA Missions)
- ▶ Much extended functionality and improved test-suite over the precursor MLFS library
- ▶ Improved accuracy compared to the Newlib libm
- ▶ Clearly characterized accuracy and execution time behavior

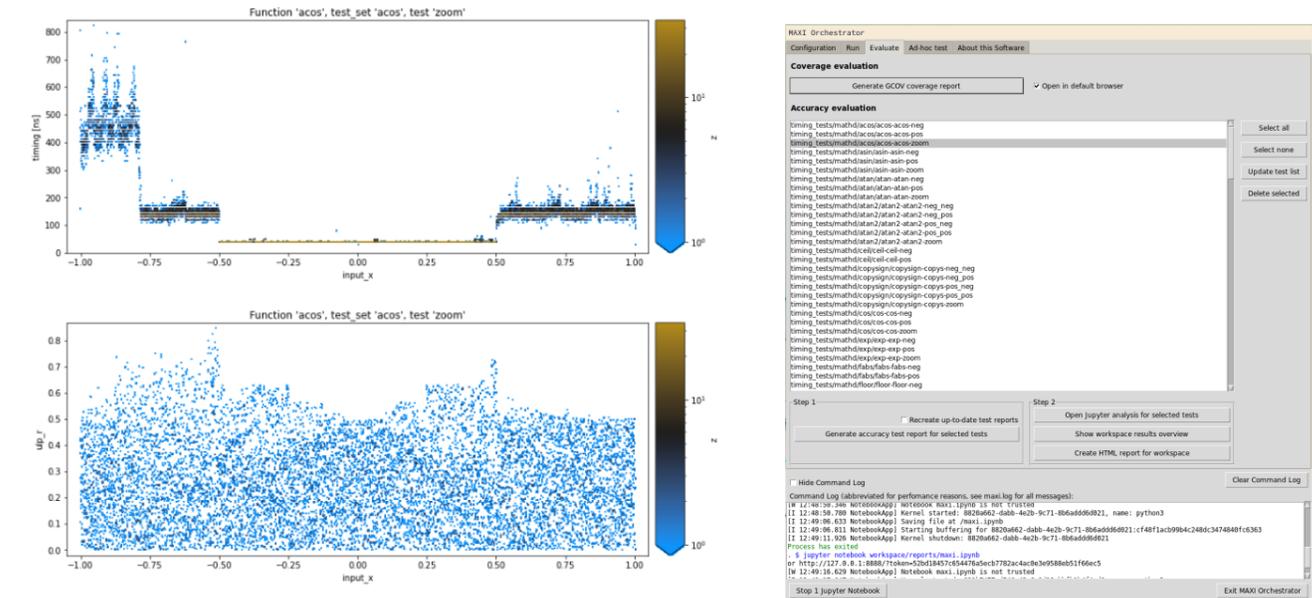
Provided math.h Procedures in 32 bit and 64 bit Precision

- ▶ Classification macros: fpclassify, isfinite, isinf, isnan, isnormal, signbit
 - ▶ Trigonometric functions: acos, asin, atan, atan2, cos, sin, tan
 - ▶ Hyperbolic functions: acosh, asinh, atanh, cosh, sinh, tanh
 - ▶ Exponential and logarithmic functions: exp, exp2, expm1, frexp, ilogb, ldexp, log, log10, log1p, log2, logb, modf, scalbn, scalbln
 - ▶ Power and absolute-value functions: cbrt, fabs, hypot, pow, sqrt
 - ▶ Error and gamma functions: erf, erfc, lgamma, tgamma
 - ▶ Nearest integer functions: ceil, floor, nearbyint, rint, lrint, llrint, round, lround, llround, trunc
 - ▶ Remainder functions: fmod, remainder, remquo
 - ▶ Manipulation functions: copysign, nan, nextafter, nexttoward
 - ▶ Maximum, minimum, and positive difference functions: fdim, fmax, fmin
 - ▶ Fused multiply-add: fma
 - ▶ Comparison macros: isgreater, isgreaterequal, isless, islessequal, islessgreater, isunordered
 - ▶ Bessel functions (only in 64 bits): j0, j1, jn, y0, y1, yn
- In addition all required standard complex functions of complex.h are provided for integration purposes.

The Test-Suite (MAXI)

The provided Test-Suite enables through its GUI:

- ▶ the assessment (numerical and timing behavior) of the mathematical procedures and
- ▶ their full automated qualification on target.



The Test Specification

- ▶ Over 4.000 Unit-Tests achieving full statement, decision, and even 100% MC/DC coverage
- ▶ Over 1.000 single value Validation-Tests
- ▶ Over 250.000.000 floating-point accuracy tests

Provided Data Package

The complete Qualification-Kit includes:

- ▶ Full ECSS engineering documentation in compliance with E-ST-40 and Q-ST-80
- ▶ Full qualification evidence on x86-64, LEON2 (AT697), and LEON4 (N2X) platforms
- ▶ Qualification Guideline and qualification template

Availability and Contact

- ▶ ESA ESSR:
<https://essr.esa.int/project/libmcs-mathematical-library-for-critical-systems>
- ▶ GitLab:
<https://gitlab.com/gtd-gmbh/libmcs>
- ▶ GTD GmbH: libmcs@gtd-gmbh.de