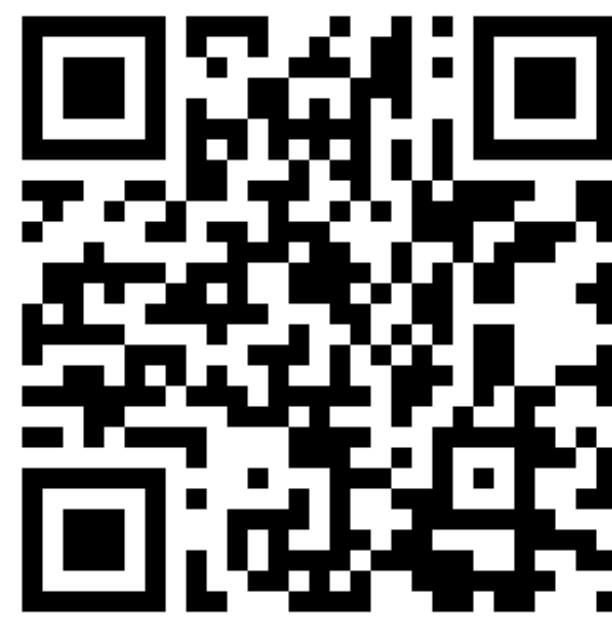




INTRODUCTION

SuperNOVAS is a high-precision, fast, and modern C/C++ positional astronomy and astrometry library based on the Naval Observatory Vector Astrometry Software (NOVAS) C edition^[1]. Its goals are:

- precision (latest standards and methods^[2,3,4])
- usability and expanded functionality
- performance
- portability
- code safety and best practices
- accessible documentation
- optional high-level object-oriented (OOP) API
- community involvement

IMPROVEMENTS

SuperNOVAS improves and modernizes the existing NOVAS C API:

- IAU 2000/2006 methodology for μ s precision
- GNU Make / CMake build support
- **enum** types instead of integer option parameters
- **const** and **restrict** pointer modifiers
- error returns, **errno**, and debug traces
- allow updating variable in situ
- HTML documentation with **Doxygen**
- thread-safe
- more accurate spectroscopic calculations
- regression testing with 100% code coverage

NEW FEATURES

New features make SuperNOVAS more powerful than NOVAS ever was.

- elegant, high-level **C++11** API
- **CALCEPH**^[5] / **CSPICE**^[6] integration
- efficient observing frame-based approach
- airborne and Solar-system based observers
- astronomical timescales and conversions
- Keplerian orbital elements
- ITRF realizations and Earth ellipsoids
- interferometric *uvw* projections
- more atmospheric refraction models
- *and more....*

BENCHMARKS

SuperNOVAS is 3 to 5 orders of magnitude faster than *astropy*^[7] for calculations on the true equator of date.

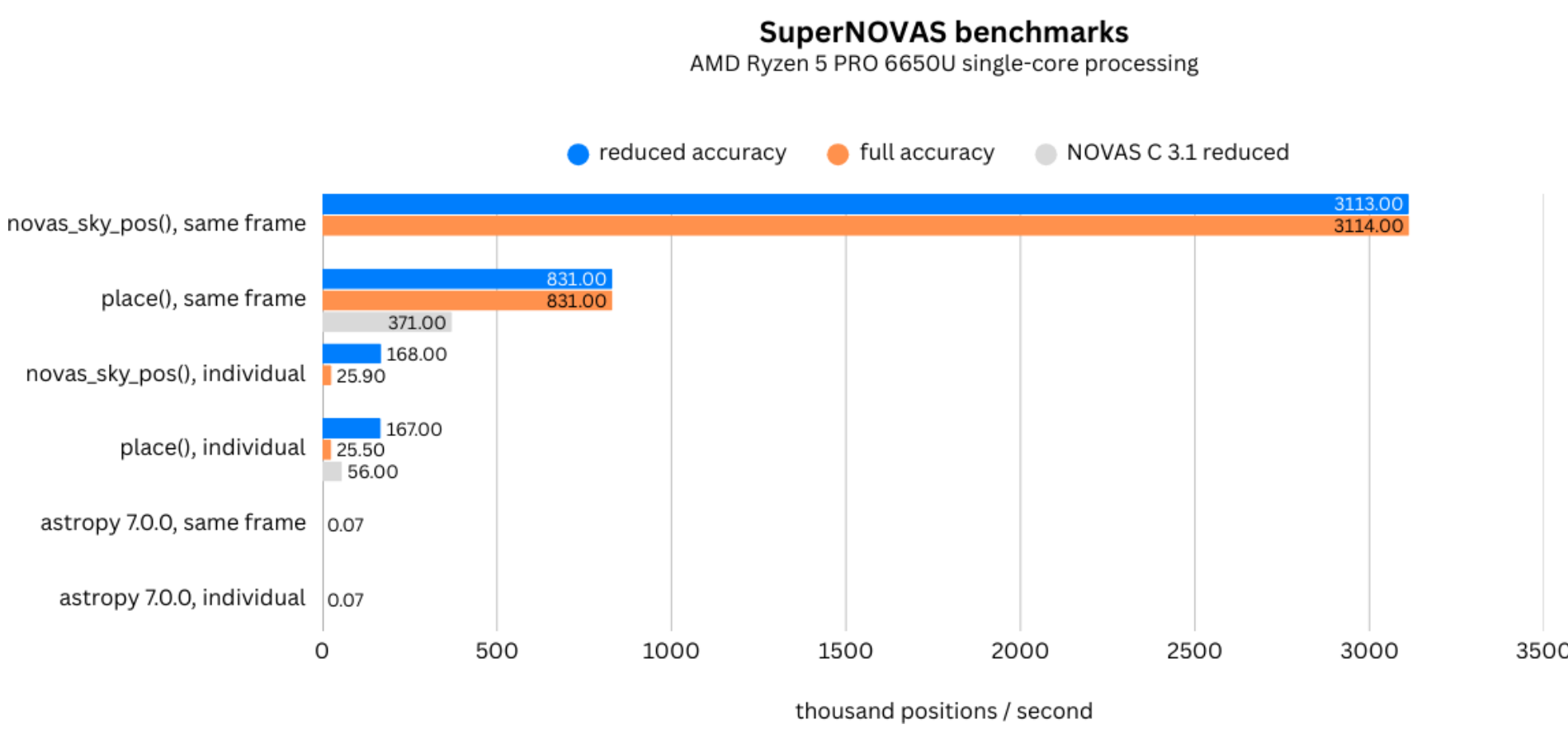


Fig. 3: Benchmarks against NOVAS and *astropy*

***SuperNOVAS* can calculate true-of-date positions for the entire Gaia dataset (1.7 billion stars) to 1 μ s in under 1 minute on a typical desktop PC.**

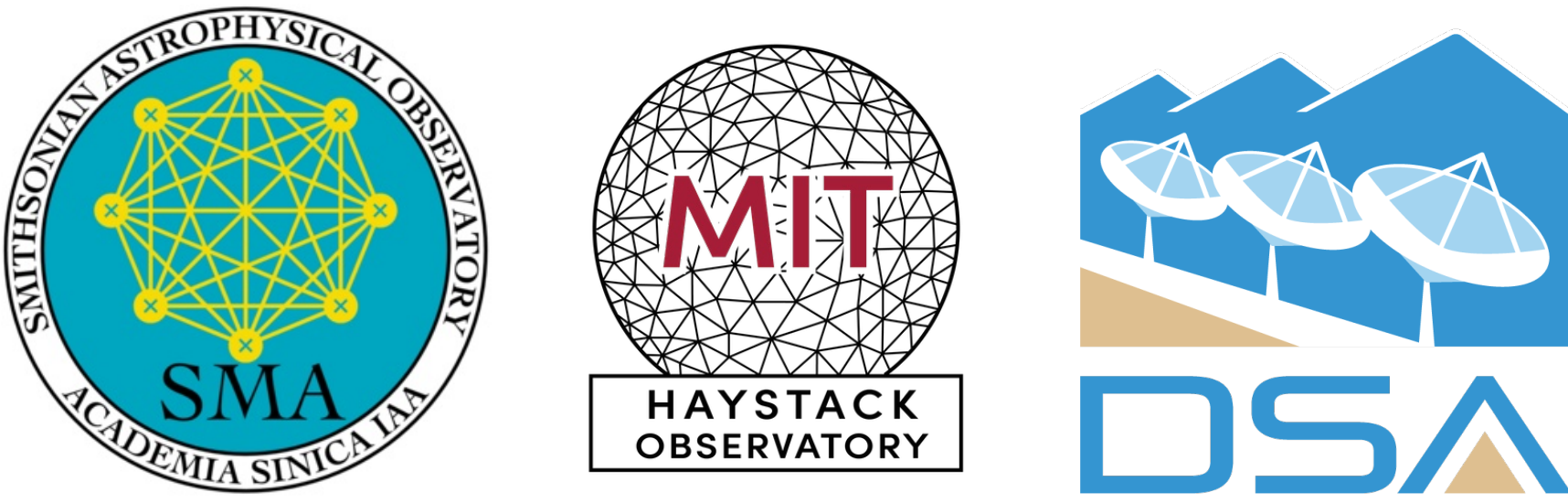
AVAILABILITY

SuperNOVAS is free and open-source software (FOSS) with no licensing restrictions ("Unlicense").

- Sigmyne/SuperNOVAS **GitHub** repository
- **Fedora** / **EPEL** / **Debian** Linux packages
- **vcpkg** repository
- **Homebrew** (attipaci/pub/supernovas)
- **NIX** package

CONCLUSIONS

SuperNOVAS brings the simplicity, elegance, and (much of) the safety of Python and *astropy* to precision astrometry in modern C/C++, while providing superior performance. It is actively maintained, well documented, and suitable for embedded systems also. **SuperNOVAS** already powers major observatories. Will yours be next?



REFERENCES

1. Bangert, J., et al., USNO (2011)
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3. IERS Conventions (2010)
4. Capitaine, N., et al., **A&A**, 432 (2), 355 (2005)
5. Gastineau, M., et al. *Ascl*:1505.001 (2015)
6. Acton, C. H., **P&SS**, 44 (1), 65 (1996)
7. Astropy Collaboration, **ApJ**, 935, 167 (2022)

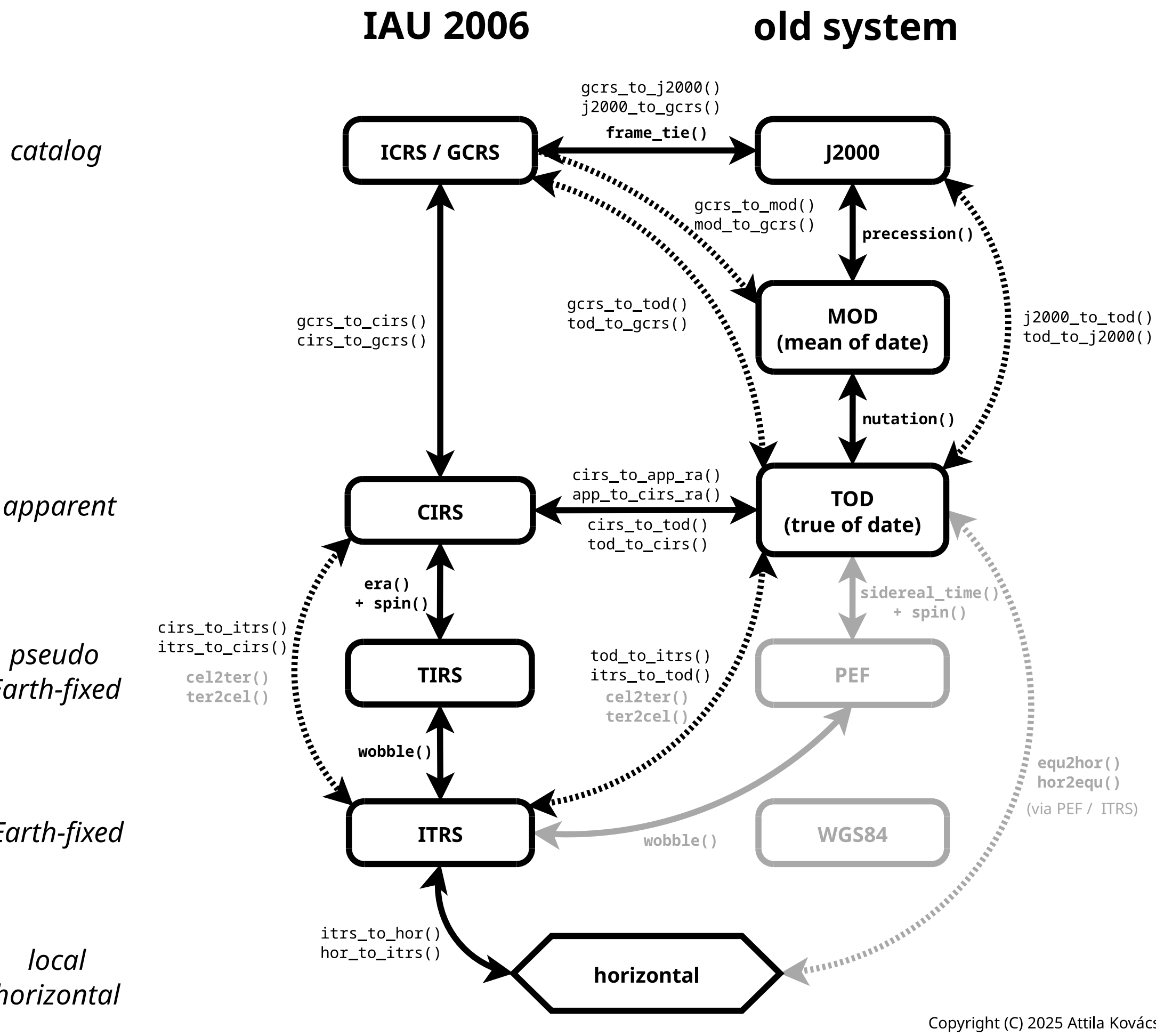


Fig. 1: SuperNOVAS coordinate systems and transforms



Fig. 2: Calculating the position of a star in the Celestial Intermediate Reference System (CIRS) of date.