Annex I
(informative)

Conformance testing for SRF operations

I.1 Introduction

This annex provides guidelines that may be useful for developing conformance requirements and conformance tests for implementation of the concepts specified in this International Standard including, but not limited to, the API specified in Clause 11.

I.2 Computational error

The meaning of "error" depends on the context and application domain. Potential sources of error in SRF operations include formulation error, numerical approximation error, round-off error, truncation error and other errors associated with implementing SRF operations. In Annex B, computational error is defined to be the sum of digitization error and approximation errors made to simplify the implementation or to improve the computational efficiency of the process. Errors of this nature should not be confused with errors arising from modelling the true shape of a spatial object (celestial or abstract) by an approximate shape. In this International Standard, an ORM used to approximate the shape of an object is assumed exact. How well an ORM approximates the shape of a celestial object is outside the scope of this International Standard.

The specification of an SRF operation defines the domain and range as well as providing a functional specification of how each value in the domain is converted into a value in the range. The functional specifications are the mathematical functions in one or more variables given in Clause 10. These functional specifications include a set of rules related to the appropriate ORM, bindings to the CS, and instances related to a particular celestial object.

I.3 SRF operations baseline

Each SRF operation specified in Clause 10 has a theoretically exact specification in terms of mathematical functions. These formulations are specified assuming the use of theoretically exact arithmetic (infinite precision) for developing values of an SRF operation. These exact specifications fall into one of four basic categories:

a) a finite sum of elementary mathematical functions,

b) a finite sum of quadratures,

c) an infinite iterative process, or

d) an infinite power series.

In practice, implementations that use one of these categories require the use of finite precision arithmetic along with termination in a finite number of steps or after a finite number of terms are computed. Some of the formulations may have removable singularities in the domain of a function, usually at extremes of the domain. When implementing such formulations, care should be taken in the neighbourhood of singularities to use the appropriate numerical approximations or to isolate the singular points with an open set.

I.4 Implementations

This International Standard may be implemented in many different ways. Potential implementations include:

a) manual computation without using computers,

b) fixed-purpose hardware, or

c) software executing on general-purpose digital computers ranging from embedded processors to large-scale computer systems.

Given the wide range of possible implementations and the differing requirements of application domains, conformance requirements in this International Standard may be restricted to a sub-set of the domains involved. (See Annex B for a discussion of computational error and Clause 14 for specifics on conformance.)

I.5 Fundamental measure of conformance

There are several conformance criteria that are discussed in Clause 14. One fundamental measure is the numerical difference between the individual data points of an exact or reference set of points and the corresponding data points generated by a particular implementation. The absolute difference between the points in the reference data set and the corresponding points obtained from a particular implementation is referred to as a computational error. The computational error may have units of length, be angular measures or be dimensionless depending on the particular SRF operation being evaluated.

When the reference data are generated, it assumes a computational digital accuracy at least as accurate as double precision, as specified in IEC 60559 (see [IEC 60559]). This means that the size of the mantissa of a floating-point number is 52 bits, which corresponds to about 15,5 decimal digits of precision (see [IEC 60559]). Particular implementations may not have to meet this requirement on precision but developers of the system should understand that use of lower precision arithmetic could increase the computational error when dealing with SRF operations.

I.6 Error metrics for SRF operations

An error metric is a function that allows data points developed using the exact formulations of Clause 10 to be compared to corresponding data points resulting from using an implementation, in order to determine the numerical difference between them. The value of the error metric is the computational error between the data points that are being compared. Computational errors as defined in this International Standard are absolute errors. These are positive numbers and may have units of measure associated with them. When the values being compared are in terms of the same units of measure, there are standard computational error measures based on the Euclidean metric.

In the case of geodetic to geocentric coordinate conversion, a given exact geodetic coordinate (λ, φ, h) corresponds to an exact geocentric coordinate (x, y, z) and both coordinates are assumed to be known. An implementation may use an approximate method for performing the conversion. This results in an approximate geocentric coordinate (x_a, y_a, z_a). The error in the conversion is then given directly in metres by

$$E = \sqrt{(dp)^2 + (ds)^2 + (h - h_a)^2}\ .$$

Sometimes the data that is being compared involves a mixture of measurement units, such as metres and radians, and the process for determining the computational error should be designed to handle such cases.

SRF operations will sometimes result in an approximate coordinate whose components are in terms of both units of distance and angles. In the case of geocentric to geodetic coordinate conversion, a given exact geocentric coordinate (x, y, z) corresponds to an exact geodetic coordinate (λ, φ, h), where both points are

