Review of Changes to be Implemented for IERS Conventions Chapter 1: General Definitions and Numerical Standards

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Abstract

The IERS Conventions (v1.3) Chapter 1 "General definitions and numerical standards" contains a table of IERS numerical standards (Table 1.1) and a table of Parameters of the Geodetic Reference System (GRS80) (Table 1.2). Many of the constants listed in the IERS numerical standards table are candidates to be updated based on IAG, IUGG, and IAU resolutions and based on widely accepted usage. However, before finalizing any updates based on widely accepted usage, the IERS Conventions chapter expert and editor-in-chief have compiled a list of IERS and other components who might be affected by any change in values. This list of proposed constant changes and known component usages is presented in this poster. In addition, some of the constants listed in Table 1.2 have differing values from that listed in Table 1.1, which may confuse users. **We ask users and various IERS and other services and components to review the information in this poster and contact the IERS Conventions with any concerns well before the publication date of the next IERS Conventions update.**

Background and Goals

- The IERS Conventions Center is proposing to consolidate updates for the next major revision.
- IERS Conventions 2010 v1.3 is the last official publication of the IERS Conventions.
- This poster will discuss updates to Chapter 1 that are proposed to be implemented by fall of 2026 and **elicit comments/concerns/questions before publication.**
- Several of the Values of the Numerical Standards in Chapter 1 of the IERS Conventions Table 1.1 need to be updated.
- It is proposed that Table 1.2, Parameters of the Geodetic Reference System GRS80, be moved to a Reference or Appendix.
- A paragraph is proposed to be added to identify the proposed replacement of the GRS80 system by a new system, based on the International Height Reference Frame (IHRF)
- A mention will be made regarding the new International Height Reference System (IHRF). Work published by Laura Sánchez et al. 2021 will be referenced.

Table 1.1 Numerical Standards, IERS 2010, v1.3

Constant	Value	Uncertainty	Ref.	Description
	Natural defining constants			
c	299792458 ms^{-1}	Defining	[1]	Speed of light
	Auxiliary defining constants			
k	$1.720209895 \times 10^{-2}$	Defining	[2]	Gaussian gravitational constant
L_G	$6.969290134 \times 10^{-10}$	Defining	[3]	1−d(TT)/d(TCG)
L_B	$1.550519768 \times 10^{-8}$	Defining	[4]	1−d(TDB)/d(TCB)
TDB_0	-6.55×10^{-5} s	Defining	[4]	TDB−TCB at JD 2443144.5 TAI
θ_0	0.7790572732640 rev	Defining	[3]	Earth Rotation Angle (ERA) at J2000.0
$d\theta/dt$	1.00273781191135448 rev/UT1day	Defining	[3]	Rate of advance of ERA
	Natural measurable constant			
G	6.67428×10^{-11} m^{3}kg^{-1}s^{-2}	6.7×10^{-15} m^{3}kg^{-1}s^{-2}	[1]	Constant of gravitation
	Body constants			
$GM_\odot{}^{\#}$	$1.32712442099 \times 10^{20}$ m^{3}s^{-2}	1×10^{10} m^{3}s^{-2}	[5]	Heliocentric gravitational constant
$J_{2\odot}$	2.0×10^{-7}	(adopted for DE421)	[5]	Dynamical form factor of the Sun
μ	0.0123000371	4×10^{-10}	[6]	Moon-Earth mass ratio
	Earth constants			
$GM_\oplus{}^\dagger$	$3.986004418 \times 10^{14}$ m^{3}s^{-2}	8×10^5 m^{3}s^{-2}	[7]	Geocentric gravitational constant
$a_E{}^{\dagger\ddagger}$	6378136.6 m	0.1 m	[8]	Equatorial radius of the Earth
$J_{2\oplus}{}^\ddagger$	1.0826359×10^{-3}	1×10^{-10}	[8]	Dynamical form factor of the Earth
$1/f^\ddagger$	298.25642	0.00001	[8]	Flattening factor of the Earth
$g_E{}^{\dagger\ddagger}$	9.7803278 ms^{-2}	1×10^{-6} ms^{-2}	[8]	Mean equatorial gravity
W_0	62636853.4 m^{2}s^{-2}	0.02 m^{2}s^{-2}	[10]	Potential of the geoid
$R_0{}^\dagger$	6363672.6 m	0.1 m	[8]	Geopotential scale factor ($GM_\oplus/W_0$)
H	3273795×10^{-9}	1×10^{-9}	[9]	Dynamical flattening
	Initial value at J2000.0			
ϵ_0	$84381.406''$	$0.001''$	[4]	Obliquity of the ecliptic at J2000.0
	Other constants			
$au^{\dagger\dagger}$	$1.49597870700 \times 10^{11}$ m	3 m	[6]	Astronomical unit
L_C	$1.48082686741 \times 10^{-8}$	2×10^{-17}	[3]	Average value of 1−d(TCG)/d(TCB)

Footnotes for the table can be found at http://iers-conventions.obspm.fr, IERS Conventions v1.3

Numerical Constant	Current Value Table 1.1	Proposed Change	IERS Conv 1996	IAU value[1]	Other organizations	Comments
k: Gaussian Gravitational constant.	1.720 209 895 x 10^−2 Defining	Remove value from Table 1.1	N/A	1.720 209 895 x 10^−2 Defining		Reason: See IAU Resolution B2 (2012) [1]
L$_G$: 1-d(TT)/d(TCG)	6.969 290 134 x 10^-10 Defining	Add a footnote: "The value of Lg will not change as the value of W0 (Potential of the Geoid) changes" [2]	6.969 290 23 x 10^-10 Uncertainty: 1 x 10^-7	6.969 290 134 x 10^-10 Defined		Value will not change as other related values change, such as W0. See IAG Resolution 1 (2015) [2]
G: Constant of Gravity	6.674 28 X 10^-11 m^2 kg^-1 s^-2 Uncertainty: 6.7 X 10^-15	6.674 30 x 10-11 m^2 kg-1 s-2 Uncertainty: 2.2 X 10^-15 [3]	6.672 59 x 10^-11 m^3 kg^-1 s^-2 Uncertainty: 8.54 x 10^-15	6.674 28 x 10^−11 m3 kg−1 s−2 Uncertainty: 6.7 X 10^-15		Recommendation from CODATA (2018) [3]
GMO: Heliocentric gravitational constant	1.327 124 420 99 x10^20 m^3 s^-2 Uncertainty: 1 x 10^10	1.32 712 440 042 x 10^20 m^3 s^-2 [4] Uncertainty: 1 x 10^10	N/A	1.327 124 400 41 x10^20 m3 s−2 (TDB-compatible) Uncertainty: 1x10^10		E. V. Pitjeva 2015, value appears to be TDB compatible
GM⊕: Geocentric gravitational constant	3.986 004 418x10^14 m^3 s^-2 Uncertainty: 8 x 10^5	Only indicate that the value is TCB-compatible.	3.986 004 418x10^14 m^3 s^-2 Uncertainty: 8 x 10^5 m^3 s^-2	3.986 004 418 x10^14 m^3 s^-2 [TCB - compatible]; [5] 3.986 004 415 x 10^14 m^3 s^−2 [TT- compatible]; 3.986 004 356 x 10^14 m^3 s^−2 [TDB - compatible]	Bernese: 3.98 600 441 5 x 10^14 m^3 s^-2 [TT-compatible] GipsyX: 3.98 600 441 5 x 10^14 m^3 s^-2 [TT-compatible] GRS80: 3.98 600 441 8x10^14 m^3 s^-2	Value adopted by Groton 2004 [6]
a$_E$: The Equatorial Radius of the Earth	637 813 6.6 m [7] Uncertainty: 0.1 m	No change proposed – Just note discussion in Urs Marti presentation[8]	637 813 6.49 m Uncertainty: 0.1 m	6.378 1366 x 10^6 m [TT-compatible] Uncertainty: 1 x 10^-1	GipsyX: 637 813 6.6 m [9] GRS80: 637 813 7 m Urs Marti IAG 2025: 637 813 6.8470 m	
W0: Potential of the Geoid	62 636 853.4 m3 s-2 Uncertainty: 0.02	No change proposed. Just note the difference with GRS80		6.263 685 60 x 10^7 m^2 s^−2 Uncertainty: 5 x 10^-1		
J2⊕: Dynamical form factor of the Earth	1.082 635 9 x 10^-3 Uncertainty: 1 x 10^-10	No change proposed. Just note the difference with GRS80	1.082 635 9 x 10^-3 Uncertainty: 1 x 10^-10	1.082 635 9 x 10^-3 Uncertainty: 1 x 10^-10	Bernese: 1.08 263 59 x 10^-3 Uncertainty: ? GipsyX: "we set the C20 coefficients from whichever gravity model we are using for a given application " [9] GRS80: 1.08 263 x 10^-3 Uncertainty: not provided in reference.	
au: Astronomical unit	1.495 978 707 00 x 10^11 m Uncertainty: 3 m	Proposed to remove uncertainty and state that it is an "exact value" [9]		1.495 978 707 00 x 10^11 m Uncertainty: 3 m		IAU Resolution B2 (2012)[1]

1 https://drive.google.com/file/d/1FBKjaswlP-rTs6z6V4WygXsbdHKVHYcP/view
2 https://geodesy.science/iag/about-iag/iag-resolutions/
3 Tiesinga, E., Mohr, P. Newell, D., et al, "CODATA Recommended Values of the Fundamental Physical Constants: 2018"
J. Phys. Chem. Ref. Data 50, 033105 (2021); doi: 10.1063/5.0064853l , page 033105-41.
4 Pitjeva, E. V., "Determination of the Value of the Heliocentric Gravitational Constant (GM⊙) from Modern Observations of Planets and Spacecraft", J. Phys. Chem. Ref. Data, Vol. 44, No. 3, 2015.
5 Uncertainties provided at https://iau-a3.gitlab.io/NSFA/IAU2009_consts.html are 8 x 10^5 for all time scales listed.
6 Groton, E., "Fundamental Parameters and Current (2004) Best Estimates of the Parameters"
DOI 10.1007/s00190-003-0373-y
7 Value provided in zero-tide system
8 *Marti, U.,* "Towards a consistent set of parameters for the definition of a new GRS", IAG Scientific Assembly, GGOS Days Sept 2025
9 Personal communication from Paul Ries of JPL

Further changes to Chapter 1 Text:

1. Paragraph to be added at the end of Section 1.2: With regard to the treatment of the permanent tide for the International Height Reference System (IHRS), it is recommended that coordinates of the International Height Reference Frame (IHRF) be described in the mean-tide system (see IAG Resolution 2015, No. 1; Drewes et al. 2016). Based on the theoretical foundations for the definition of the IHRS (Ihde et al. 2017), the strategy for the implementation of the IHRF is described in Sánchez et al. 2021.

2. Add this paragraph in Section 1.3, after the first paragraph where the GRS is mentioned in the last sentence: It shall be noted that the GGOS Working Group "Consolidation of a best estimate GRS based on the adopted W0 of the IHRF" (chaired by Urs Marti, Switzerland) associated with the GGOS Bureau of Products and Standards (Angermann et al. 2022) is tasked to define a consistent set of parameters and formulas for the definition of a new conventional GRS. This includes the geometry (size and shape of a reference ellipsoid), the gravity field (normal gravity field of this ellipsoid), physical heights, terrestrial time and Earth rotation. The new set of parameters is based on the four fundamental parameters: W0 (Potential at Reference Level), J2 (dynamic form factor, "flattening"), GM (geocentric gravitational constant) and ω (angular velocity of the Earth). A draft version of a preliminary set of defining parameters is available (Marti 2025; Panou and Marti 2024). The definitive choice of the numerical values of the defining parameters will be one of the next steps. Once agreement has been reached in the geodetic community, an IAG resolution will be prepared.

3. Removal of Table 1.2 and providing a reference to the GRS80 publication. Moritz, H, "Geodetic Reference System 1980", Bull. Geodesique 54, 395–405 (1980). https://doi.org/10.1007/BF02521480.