ISO/IEC JTC1/SC24 **N 3024**

Our ref.: DIH

Date: 2008-02-18

Secretariat of ISO/IEC JTC 1/SC 24

"Computer graphics, image processing and environmental data representation"

Title:	Results of ballot N 3006 ISO/IEC 18026 FPDAM
Source:	ITTF
Replaces:	--
Document Type:	Vote results
Projects:	ISO/IEC 18026:2006 SRM Amd 1
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Result of voting

Ballot Information:	
Ballot reference:	JTC 1 SC 24 N 3006 ballot
Ballot type:	CD/FCD
Ballot title:	Ballot ISO/IEC 18026 FPDAM
Opening date:	2007-10-04
Closing date:	2008-02-04
Note:	4-month FPDam ballot: **Approved**

Member responses:	
Votes cast (9)	Australia (SA) China (SAC) Czech Republic (CNI) France (AFNOR) Germany (DIN) Japan (JISC) Korea, Republic of (KATS) United Kingdom (BSI) USA (ANSI)
Comments submitted (0)	
Votes not cast (3)	Egypt (EOS) Kazakhstan (KAZMEMST) Portugal (IPQ)

Questions:	
Q.1	"Do you agree with approval of the CD/FCD Text?"
Q.2	"If you approuve the CD/FCD Text with comments, would you please indicate which type ? (General, Technical or Editorial)"
Q.3	"If you Disappove the Draft, would you please indicate if you accept to change your vote to Approval if the reasons and appropriate changes will be accepted?"

Answers to Q.1: "Do you agree with approval of the CD/FCD Text?"		
6 x	**Approval as presented**	**Australia (SA)** **China (SAC)** **Czech Republic (CNI)** **Japan (JISC)** **Korea, Republic of (KATS)**

		United Kingdom (BSI)
2 x	**Abstention**	**France (AFNOR)** **Germany (DIN)**
1 x	**Approval with comments**	**USA (ANSI)**
0 x	**Disapproval of the draft**	

Answers to Q.2: "If you approuve the CD/FCD Text with comments, would you please indicate which type ? (General, Technical or Editorial)"

9 x	**Ignore**	**Australia (SA)** **China (SAC)** **Czech Republic (CNI)** **France (AFNOR)** **Germany (DIN)** **Japan (JISC)** **Korea, Republic of (KATS)** **United Kingdom (BSI)** **USA (ANSI)**
0 x	**All**	
0 x	**Editorial**	
0 x	**General**	
0 x	**Technical**	

Answers to Q.3: "If you Disappove the Draft, would you please indicate if you accept to change your vote to Approval if the reasons and appropriate changes will be accepted?"

9 x	**Ignore**	**Australia (SA)** **China (SAC)** **Czech Republic (CNI)** **France (AFNOR)** **Germany (DIN)** **Japan (JISC)** **Korea, Republic of (KATS)** **United Kingdom (BSI)** **USA (ANSI)**
0 x	**No**	
0 x	**Yes**	

Comments from Voters

Member:	Comment:	Date:
USA (ANSI)	***Comment File***	2008-01-23

1	2	(3)	4	5	(6)	(7)
MB[1]	**Clause No./ Subclause No./ Annex** (e.g. 3.1)	**Paragraph/ Figure/Table/ Note** (e.g. Table 1)	**Type of com-ment**[2]	**Comment (justification for change) by the MB**	**Proposed change by the MB**	**Secretariat observations** on each comment submitted
US	Clause 10.7.2		Te	Clause 10.7.2 needs a technical correction, not included in the above Amendment. Some remarks seem necessary to shed the proper light on this. SRM policy has been to provide the mathematically exact formulations ("closed form solutions") for any coordinate conversion or spatial operation. This is commendable and ambitious and definitely needed. However, in the case of the geodesic distance formula in Clause 10.7.2, the literature is concentrated on approximate solutions for problems of majority need. This is different than the SRM agenda. Therefore, a succinct geodesic distance formula within SRM policy would be a contribution to the discipline, but has been hard to find.	Below are two potential revisions for the editors to consider Revision "A" for Clause 10.7.2 Introduction As an enhancement of the Spatial Reference Model (SRM), there could be a longer discussion of geodesics to include: 1.1. Definition (it *locally* minimizes arclength) 1.2. Differential relationships between longitude λ, latitude ϕ, azimuth α, and arclength s 1.3. Clairaut Equation and constant 1.4. Statement of the Direct Problem 1.5. Statement of the Indirect Problem 1.6. References to algorithms The following draft was originally conceived as a replacement for Clause 10.7.2 when Revision "B" was not available. The goals at the time were to define terms, state the founding principles, provide examples, and omit further technical details. Now the following text is proposed as an enhancement. Draft A geodesic is a curve which is everywhere locally a distance minimizer	

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NOTE Columns 1, 2, 4, 5 are compulsory.

1	2	(3)	4	5	(6)	(7)
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					[Wiki]. More precisely, a curve on the ellipsoid is called a *geodesic* if at every point P_0 on the curve there is a sufficiently small segment of the curve containing P_0 such that for any two points P_1 and P_2 on this segment, the shortest distance on the ellipsoid from P_1 to P_2 is the same as the arclength of the curve from P_1 to P_2. EXAMPLE 1: The Equator in its entirety is a geodesic. Also, any continuous piece of the Equator is a geodesic. For any smooth curve lying on the ellipsoid, the following four quantities pertain to any point P on the curve: $\lambda =$ the longitude of P $\phi =$ the latitude of P $s =$ the distance traveled along the curve from an initial point to P $\alpha =$ the azimuth of the tangent to the curve at P Let the tangent (half-line) be given in the same direction as the direction of travel along the curve, and let the (forward) azimuth α be measured clockwise from North as pictured:	

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					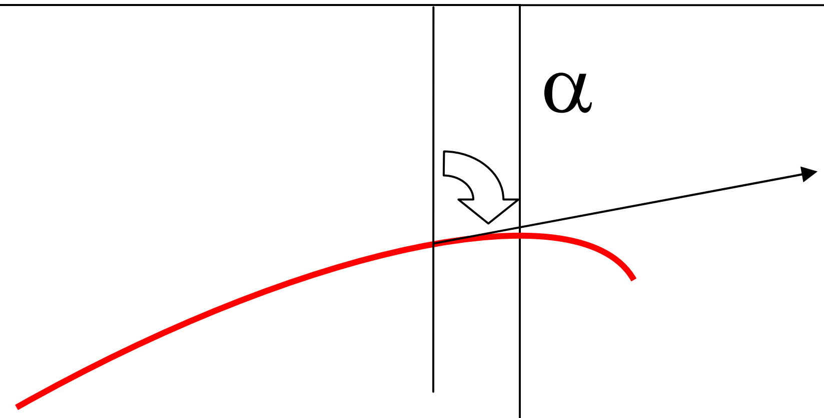 A geodesic curve obeys and is characterized by this system of differential equations: $ds \cos\alpha = R_M \, d\phi$ $ds \sin\alpha = R_N \cos\phi \, d\lambda$ $d\alpha = \sin\phi \, d\lambda$ Eq.s (1,2,3) Where, at any point on the ellipsoid, R_M is the radius of curvature of the North-South normal section, and R_N is the radius of curvature of the East-West normal section. The Clairaut equation, $(\sin\alpha) R_N (\cos\phi) = \text{constant}$, and all	

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					other properties of geodesics may be derived from Eq.s (1-3). Eq.s (1-3) may be rewritten to use any one of $d\lambda$, $d\phi$, ds, or $d\alpha$ as the integration step, and the other three differentials given as (non-constant) multiples of it. The *Direct Problem* of geodesics starts with an initial position $(\lambda,\phi)=(\lambda_1,\phi_1)$ and an initial azimuth $\alpha=\alpha_1$ and computes for any length of travel s, the terminating point $(\lambda,\phi)=(\lambda_2,\phi_2)$ and the azimuth $\alpha=\alpha_2$ at the terminus. The *Indirect Problem* of geodesics starts with two points, P_1 given by (λ_1,ϕ_1) and P_2 given by (λ_2,ϕ_2), and asks: Of all the geodesic curves that start at P_1 and finish at P_2, which one realizes (or which ones realize) the shortest distance on the ellipsoid surface between the two points? Identifying information and other relevant information for the selected geodesic(s) is to be computed, such as α_1, α_2, the Clairaut constant, and the distance traveled. EXAMPLE 2: For an ellipsoid with $\varepsilon>0$, from $(\lambda,\phi)=(0,0)$ to	

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					$(\lambda,\phi)=(180°,0)$ there are two geodesic curves which solve the Indirect Problem, namely $\alpha_1=0$ and $\alpha_1=180°$. There are other connecting geodesics which do not, such as $\alpha_1=90°$ (half the Equator) and $\alpha_1=-90°$ (the other half). The above example is a special case. More typical is the following: EXAMPLE 3: From P_1 given by $(\lambda,\phi)=(0,0)$ to P_2 given by $(\lambda,\phi)=(90°,45°)$ there is just one solution to the Indirect Problem. On the WGS84 ellipsoid this works out to $\alpha_1=$ 45 deg 05 min 45.644 sec with $s=$ 10010386.361 m. Using instead, $\alpha_1=$ 45 deg 05 min 27 sec, there is another geodesic starting at P_1 traversing 450 degrees of longitude and terminating at P_2. With $\alpha_1=$ 45 deg 04 min 49 sec, there is a third geodesic traversing 810 degrees of longitude and connecting P_1 to P_2. Et cetera. There is a vast literature about the geometry of geodesics and about the various algorithms for computing them	

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					and solving the Direct and Indirect Problems. The algorithms for the Indirect Problem are differently designed depending on the distance s involved. There are separate approximation formulas for the short distance case where $s \le 200\,\mathrm{km}$, for the medium distance case where $s \le 1000\,\mathrm{km}$ and for the long lines case where the two given points are antipodal (Example 2) or nearly antipodal. Comments The above is the text proposed for inclusion in the SRM. Some additional explanations follow: The definition of geodesic proposed here for the SRM has the backing of the mathematicians (e.g. [Wiki] and [STRUIK]). Arguably, the subject needs a term for the curves that obey Eq.s (1-3), and that is the definition recommended here. This is a matter for discussion. The alternative is to make the term synonymous with solution(s) to the Indirect Problem. This is awkward, as examples will show. The draft defines the term geodesic only for curves on an ellipsoid, but that can be extended in a natural way to curves on other surfaces, e.g. Digital Elevation Model surfaces. In the differential geometry of curves and	

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					surfaces, “geodesic” is often defined as follows: A smooth curve lying on a smooth surface is a geodesic if, at every point of the curve, the normal vector to the curve (taking away the surface) is identical to the normal vector to the surface (taking away the curve). In other words, a geodesic has no curvature “of its own”, but only what it inherits from lying on the surface. It is as straight as possible within the constraint to lie on the surface. This approach is equivalent to the definition proposed here for the SRM. The typical text in differential geometry starts with the above definition and treats questions about distance minimization in a later chapter. See for example [STRUIK]. Eq.s (1, 2) are the decomposition of an infinitesimal piece of curve into its North-South and East-West components respectively, and are true for any curve on the ellipsoid. Eq. (3), also called the Bessel equation, makes the curve a geodesic. It may be derived from the calculus of variations using the fact that geodesics are local distance minimizers, or it may be derived from the differential geometry concepts above. References [NGS] On-line calculator at http://www.ngs.noaa.gov/cgi-	

Template for comments and secretariat observations

Date: 01/22/08	Document: **ISO/IEC 18026** **FPDAM1 Spatial Reference Model**

1	2	(3)	4	5	(6)	(7)
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					bin/Inv_Fwd/inverse2.prl. [PEAR] Pearson, Frederick II. *Map Projections: Theory and Application*. Boca Raton (Florida): CRC Press, 1990. ISBN 084936888X [STRUIK] Struik, Dirk J., *Lectures on Classical Differential Geometry*, 2nd Ed. Dover Publications Inc., New York, NY, 1961. [JEKELI] Jekeli, Christopher, *Geometric Reference Systems in Geodesy*, The Ohio State University, Columbus, OH, 2005. [LAUF] Lauf, G. B. *Geodesy and Map Projections*. Collingswood, Victoria, Australia, 1983. [Wiki] Wikipedia article at http://en.wikipedia.org/wiki/Geodesic#Metric_geometry. Revision "B" for Clause 10.7.2 Introduction The formula for $d_G((\lambda_1,\phi_1),(\lambda_2,\phi_2))$ in Section 10.7.2 ("Geodesic distance") should be replaced by the following: Revised formula If $\lambda_1 = \lambda_2$, without loss of generality $\phi_1 \le \phi_2$, and $d_G = \int_{\phi 1}^{\phi 2} R_M \, d\phi$.	

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					If $\lambda_1 = -\lambda_2$, If $\phi_2 \geq -\phi_1$, $d_G = \int_{\phi 1}^{\pi/2} R_M \, d\phi + \int_{\pi/2}^{\phi 2} (-R_M) \, d\phi$ If $\phi_2 < -\phi_1$, $d_G = \int_{\phi 1}^{-\pi/2} (-R_M) \, d\phi + \int_{-\pi/2}^{\phi 2} R_M \, d\phi$ If neither of the above, without loss of generality $0 \leq \lambda_1 < \lambda_2 < \pi$, and the remaining cases are handled as follows: If $\phi_1 = \phi_2 = 0$ and $\lambda_2 - \lambda_1 \leq \pi \sqrt{1-\varepsilon^2}$, $d_G = a(\lambda_2 - \lambda_1)$. If $\phi_1 = \phi_2 = 0$ and $\lambda_2 - \lambda_1 > \pi \sqrt{1-\varepsilon^2}$, d_G is given by Equations (1, 2, 3) below with the added stipulation that either $\phi'(\lambda_1) > 0$ (producing the Northern hemisphere geodesic) or $\phi'(\lambda_1) < 0$ (producing the (symmetric) Southern hemisphere geodesic). Either stipulation leads to the same value for d_G. If $\phi_1 \neq \phi_2$, d_G is given by Equations (1, 2, 3) below. where	

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					$d_G = \int_{\lambda 1}^{\lambda 2} \sqrt{R_M{}^2 (\phi'(\lambda))^2 + R_N{}^2 \cos^2 ($ (Equation 1) where the function $\phi = \phi(\lambda)$ satisfies the autonomous 2nd order differential equation, $\phi''(\lambda) = -\frac{\cos(\phi)\sin(\phi)(1-\varepsilon^2 \sin^2(\phi))}{1-\varepsilon^2} - \frac{(2}{}$ (Equation 2) with boundary conditions $\phi(\lambda_1) = \phi_1$ and $\phi(\lambda_2) = \phi_2$. (Equation 3) where R_M, R_N, a, ε are defined in Table 5.6 of Section 5.9 Comments The above is the text proposed for inclusion in the SRM. Some additional remarks are these: The above is undergoing technical review at NGA and SEDRIS. It should not be considered final. To eliminate the complications of the longitude discontinuity at $\lambda = \pm\pi$, which disturbs the rotational symmetry of the problem, this memo has imposed the non-essential restriction $0 \le \lambda_1 < \lambda_2 < \pi$ stated above. This detail can be reworked to be consistent with the style and conventions of the SRM.	

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					If the typography is weak, note that ϕ' ("phi-prime") is the first derivative of ϕ as a function of λ. From Table 5.6 of Section 5.9, $a =$ the semi-major axis of the ellipsoid; $\varepsilon^2 =$ the eccentricity squared of the ellipsoid; $R_M =$ the radius of curvature of the meridian; and $R_N =$ the radius of curvature of the normal section in the East-West direction.	
US						

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