CHANGES TO DMA TR 8350.2-B,

SUPPLEMENT TO DEPARTMENT OF DEFENSE WORLD GEODETIC SYSTEM 1984 TECHNICAL REPORT, PART II - PARAMETERS, FORMULAS, AND GRAPHICS FOR THE PRACTICAL APPLICATION OF WGS 84, 1 December 1987.

The enclosed pages are changes as of 1 March 1989 which update both the first and second printings of the report.

Table 20.16

Local Geodetic System-to-WGS 84
Datum Transformation Multiple Regression Equations ($\Delta\phi$, $\Delta\lambda$, ΔH)
- ED 50 (Cyprus) to WGS 84 -

$$\Delta\phi'' = -3.84288 + 0.09188\,U + 0.03581\,V - 0.07481\,UV$$

$$\Delta\lambda'' = -1.10294 - 0.04240\,U + 0.12748\,V - 0.32783\,UV^2 + 0.51023\,UV^3 - 0.01600\,V^7 - 0.1718\,U^3V^9$$

$$\Delta H_m = 24.430 - 5.719\,U + 0.778\,V + 5.631\,U^2 - 23.892\,UV + 18.980\,U^2V - 0.988\,V^3 + 106.027\,U^3V - 42.824\,U^4V - 323.655\,U^9V^2 + 2.261\,U^4V^9$$

In the preceding equations:

$U = K(\phi - 35)$
$V = K(\lambda - 33)$
$K = 0.78539816$
ϕ = geodetic latitude, local geodetic system, in degrees and decimal part of a degree; positive north (0° to 90°), negative south (0° to -90°)
λ = geodetic longitude, local geodetic system, in degrees and decimal part of a degree; positive east from 0° to 360°

The preceding equations reproduced Doppler-derived WGS 84 geodetic coordinates at 16 comparison points to the following root-mean-square (RMS) differences:

ϕ: ±0.5 m; λ: ±0.3 m; H (geodetic height): ±0.2 m

Test Case:

Input data for ED 50 (Cyprus) test point:	ϕ =	34°43'23.316"N	$\Delta\phi$ =	-3.885"
	λ =	32°28'06.026"E	$\Delta\lambda$ =	-1.126"
			ΔH =	23.64 m

Table 20.29

Local Geodetic System-to-WGS 84
Datum Transformation Multiple Regression Equations ($\Delta\phi$, $\Delta\lambda$, ΔH)
- Minna Datum* to WGS 84 -

$$\Delta\phi'' = 0.49461 - 0.69094\,U + 0.39940\,V - 7.44709\,U^3 - 1.82129\,U^2V - 2.92752\,UV^2 + 5.70789\,U^3V - 2.10838\,U^2V^2 - 6.88780\,UV^3 + 14.35602\,U^5 + 5.10389\,UV^4 + 6.18524\,U^6 + 8.62320\,UV^5 + 48.52705\,U^7V^2 - 0.49769\,V^9 - 11.39331\,U^4V^8$$

$$\Delta\lambda'' = -2.62435 - 0.21876\,U + 0.43678\,V + 0.35068\,UV - 1.53864\,U^2V - 0.46268\,UV^3 + 2.20240\,U^4V - 0.11456\,V^5 + 1.59485\,U^3V^4$$

$$\Delta H_m = 20.013 + 2.098\,U - 11.691\,V + 47.983\,U^2V - 60.195\,U^4V - 21.214\,U^2V^3 + 8.642\,V^5 - 12.588\,U^5V - 27.760\,U^3V^8$$

<u>In the preceding equations</u>:

$U = K\,(\phi - 10)$
$V = K\,(\lambda - 8)$
$K = 0.15707963$
ϕ = geodetic latitude, local geodetic system, in degrees and decimal part of a degree; positive north (0° to 90°), negative south (0° to -90°)
λ = geodetic longitude, local geodetic system, in degrees and decimal part of a degree; positive east from 0° to 360°

The preceding equations reproduced Doppler-derived WGS 84 geodetic coordinates at 23 comparison points to the following root-mean-square (RMS) differences:

ϕ: ±1.2 m; λ: ±1.0 m; H (geodetic height): ±0.7 m

<u>Test Case</u>:

Input data for Minna	ϕ =	9°19'09.051"N	$\Delta\phi$ =	0.930"
Datum test point:	λ =	12°13'50.125"E	$\Delta\lambda$ =	-2.348"
			ΔH =	13.43m

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* Nigeria

Table 20.31

Local Geodetic System-to-WGS 84
Datum Transformation Multiple Regression Equations ($\Delta\phi$, $\Delta\lambda$, ΔH)
- NAD 27 (Alaska) to WGS 84 -

$$\begin{aligned}\Delta\phi'' = & - 2.08611 + 0.59833\ U + 0.52967\ V + 0.23473\ U^2 + 0.23563\ UV + 0.28672\ UV^2 + 0.27573\ V^3 \\ & + 0.19561\ U^4 - 0.15184\ U^3V - 0.21241\ U^2V^2 + 0.04891\ V^4 - 0.18860\ UV^4 - 0.17032\ V^5 - 0.05741\ UV^5 \\ & - 0.04292\ U^2V^5 + 0.02097\ V^7 - 0.01487\ U^2V^6 - 0.00384\ V^8 - 0.18402\ U^9 - 0.00188\ U^3V^7\end{aligned}$$

$$\begin{aligned}\Delta\lambda'' = & - 8.19369 - 1.56665\ U + 0.73861\ V - 3.10809\ U^2 - 0.35323\ UV - 0.06926\ V^2 - 0.68114\ UV^2 \\ & - 0.32398\ V^3 + 0.74679\ U^4 + 0.43200\ U^3V + 4.24388\ U^2V^2 + 0.14065\ UV^3 - 0.30990\ U^2V^3 \\ & + 0.11365\ V^5 - 1.48566\ U^4V^2 - 1.96501\ U^2V^4 + 2.04229\ U^6V - 0.48255\ U^5V^2 + 0.09847\ UV^6 \\ & + 0.49313\ U^2V^6 - 1.00218\ U^8V - 0.02809\ U^2V^8 + 0.00054\ U^5V^9\end{aligned}$$

$$\begin{aligned}\Delta H_m = & \ 8.352 - 13.742\ U - 8.268\ V + 0.900\ V^2 + 5.340\ U^3 + 2.960\ UV^2 - 2.016\ V^3 + 5.087\ U^3V + 1.437\ UV^3 \\ & + 0.951\ V^5 - 2.461\ U^3V^4 - 1.560\ U^8 - 1.980\ U^7V - 0.205\ U^5V^3 + 0.094\ UV^8 - 2.885\ U^8V^2 \\ & - 0.011\ UV^9\end{aligned}$$

In the preceding equations:

$U = K\ (\phi - 62)$
$V = K\ (\lambda - 208)$
$K = 0.10471975$
ϕ = geodetic latitude, local geodetic system, in degrees and decimal part of a degree; positive north (0° to 90°), negative south (0° to -90°)
λ = geodetic longitude, local geodetic system, in degrees and decimal part of a degree; positive east from 0° to 360°

The preceding equations reproduced Doppler-derived WGS 84 geodetic coordinates at 85, 86, and 86 comparison points to the following root-mean-square (RMS) differences, respectively:

ϕ: ±1.7 m; λ: ±1.7 m; H (geodetic height): ±1.2 m

Test Case:

Input data for NAD 27 (Alaska) test point:	ϕ = 64°31'09.064"N	$\Delta\phi$ = -2.648"
	λ = 194°37'28.092"E	$\Delta\lambda$ = -9.525"
		ΔH = 19.20 m

Table 20.32

Local Geodetic System-to-WGS 84
Datum Transformation Multiple Regression Equations ($\Delta\phi$, $\Delta\lambda$, ΔH)
- NAD 27 (Canada) to WGS 84 -

$$\begin{aligned}\Delta\phi'' = {} & 0.79395 + 2.29199\ U + 0.27589\ V - 1.76644\ U^2 + 0.47743\ UV + 0.08421\ V^2 - 6.03894\ U^3 \\ & - 3.55747\ U^2V - 1.81118\ UV^2 - 0.20307\ V^3 + 7.75815\ U^4 - 3.10170\ U^3V + 3.58363\ U^2V^2 \\ & - 1.31086\ UV^3 - 0.45916\ V^4 + 14.27239\ U^5 + 3.28815\ U^4V + 1.35742\ U^2V^3 + 1.75323\ UV^4 \\ & + 0.44999\ V^5 - 19.02041\ U^4V^2 - 1.01631\ U^2V^4 + 1.47331\ UV^5 + 0.15181\ V^6 + 0.41614\ U^2V^5 \\ & - 0.80920\ UV^6 - 0.18177\ V^7 + 5.19854\ U^4V^4 - 0.48837\ UV^7 - 0.01473\ V^8 - 2.26448\ U^9 \\ & - 0.46457\ U^2V^7 + 0.11259\ UV^8 + 0.02067\ V^9 + 47.64961\ U^8V^2 + 0.04828\ UV^9 + 36.38963\ U^9V^2 \\ & + 0.06991\ U^4V^7 + 0.08456\ U^3V^8 + 0.09113\ U^2V^9 + 5.93797\ U^7V^5 - 2.36261\ U^7V^6 + 0.095775\ U^5V^8\end{aligned}$$

$$\begin{aligned}\Delta\lambda'' = {} & - 1.36099 + 3.61796\ V - 3.97703\ U^2 + 3.09705\ UV - 1.15866\ V^2 - 13.28954\ U^3 - 3.15795\ U^2V \\ & + 0.68405\ UV^2 - 0.50303\ V^3 - 8.81200\ U^3V - 2.17587\ U^2V^2 - 1.49513\ UV^3 + 0.84700\ V^4 \\ & + 31.42448\ U^5 - 14.67474\ U^3V^2 + 0.65640\ UV^4 + 17.55842\ U^6 + 6.87058\ U^4V^2 - 0.21565\ V^6 \\ & + 62.18139\ U^5V^2 + 1.78687\ U^3V^4 + 2.74517\ U^2V^5 - 0.30085\ UV^6 + 0.04600\ V^7 + 63.52702\ U^6V^2 \\ & + 7.83682\ U^5V^3 + 9.59444\ U^3V^5 + 0.01480\ V^8 + 10.51228\ U^4V^5 - 1.42398\ U^2V^7 - 0.00834\ V^9 \\ & + 5.23485\ U^7V^3 - 3.18129\ U^3V^7 + 8.45704\ U^9V^2 - 2.29333\ U^4V^7 + 0.14465\ U^2V^9 + 0.29701\ U^3V^9 \\ & + 0.17655\ U^4V^9\end{aligned}$$

$$\begin{aligned}\Delta H_m = {} & - 26.806 + 9.266\ U - 5.857\ V + 14.794\ U^2 + 3.497\ UV + 9.600\ V^2 - 7.664\ UV^2 - 40.040\ U^2V^2 \\ & - 3.439\ V^4 + 14.592\ U^2V^3 - 23.902\ U^5V + 15.246\ U^4V^2 + 18.445\ U^2V^4 + 0.770\ V^6 - 130.424\ U^6V \\ & - 11.874\ U^2V^5 - 100.769\ U^7V - 3.165\ U^2V^6 - 0.182\ UV^7 - 0.066\ V^8 + 2.404\ U^2V^7 + 0.073\ UV^8 \\ & - 0.074\ U^2V^9\end{aligned}$$

Table 20.41

Local Geodetic System-to-WGS 84
Datum Transformation Multiple Regression Equations ($\Delta\phi$, $\Delta\lambda$, ΔH)
- Qatar National Datum* to WGS 84 -

$$\Delta\phi'' = 2.47363 + 0.08786\ U + 0.14283\ U^2 + 0.04380\ UV + 0.07142\ V^2 - 0.08879\ UV^2 - 0.11089\ U^5 - 0.06321\ U^3V^4 + 0.01669\ U^9$$

$$\Delta\lambda'' = -\ 2.80439 + 0.10489\ V + 0.02697\ V^2 - 1.10721\ U^2V^2 + 2.88786\ U^2V^3 - 0.06281\ U^5V - 2.59921\ U^3V^6$$

$$\Delta H_m = -28.376 + 2.381\ U - 1.126\ U^2 + 3.095\ V^2 - 4.112\ U^3V^3 - 13.156\ V^7 - 2.048\ U^8 + 1.618\ U^9 + 18.689\ UV^8$$

In the preceding equations:

$U = K\ (\phi - 25)$
$V = K\ (\lambda - 51)$
$K = 1.04719754$
ϕ = geodetic latitude, local geodetic system, in degrees and decimal part of a degree; positive north (0° to 90°), negative south (0° to -90°)
λ = geodetic longitude, local geodetic system, in degrees and decimal part of a degree; positive east from 0° to 360°

The preceding equations reproduced Doppler-derived WGS 84 geodetic coordinates at 15 comparison points to the following root-mean-square (RMS) differences:

ϕ: ±0.3 m; λ: ±0.2 m; H (geodetic height): ±0.2 m

Test Case:

Input data for Qatar National	ϕ =	24°34'55.061"N	$\Delta\phi$ =	2.465"
Datum test point:	λ =	50°59'06.940"E	$\Delta\lambda$ =	-2.806"
			ΔH =	-29.64 m

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* Qatar Island (Persian Gulf)

Table 23.21

Multiple Regression Equation for DMA-Developed
Local Geodetic System Geoid Heights
- Kandawala Datum* -

$$N_m = -0.979 + 1.853\,U - 3.443\,U^2 + 2.523\,U^3 - 5.423\,U^2V - 5.278\,V^3 + 3.965\,U^4V^3 - 0.899\,U^7V^2 + 5.225\,U^2V^9$$

<u>In the preceding equation:</u>

$U = K\,(\phi - 7)$
$V = K\,(\lambda - 80)$
$K = 0.52359877$
ϕ = geodetic latitude, local geodetic system, in degrees and decimal part of a degree; positive north (0° to 90°), negative south (0° to -90°)
λ = geodetic longitude, local geodetic system, in degrees and decimal part of a degree; positive east from 0° to 360°
N = DMA-developed Kandawala Datum geoid height (in meters) referenced to the Everest Ellipsoid

The preceding equation reproduced the geoid heights from which it was generated to a root-mean-square (RMS) difference of ± 0.4 meter; 17 sites involved in the comparison.

<u>Test Case:</u>

Input data for Kandawala Datum test point:	ϕ = 7°37'02.730"N λ = 81°40'49.750"E	N = -4.55 m (Everest Ellipsoid)

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* Sri Lanka; Everest Ellipsoid

[Revised: 1 March 1989]

Table 23.27

Multiple Regression Equation for DMA-Developed
Local Geodetic System Geoid Heights
- Nahrwan Datum* -

$$N_m = 7.464 - 3.286\,U - 3.024\,V - 3.944\,U^2 - 4.720\,V^2 - 2.019\,U^3 - 1.613\,V^3$$

In the preceding equation:

$U = K\,(\phi - 23)$
$V = K\,(\lambda - 57)$
$K = 0.41887902$
ϕ = geodetic latitude, local geodetic system, in degrees and decimal part of a degree; positive north (0° to 90°), negative south (0° to -90°)
λ = geodetic longitude, local geodetic system, in degrees and decimal part of a degree; positive east from 0° to 360°
N = DMA-developed Nahrwan Datum geoid height (in meters) referenced to the Clarke 1880 Ellipsoid

The preceding equation reproduced the geoid heights from which it was generated to a root-mean-square (RMS) difference of ±1.2 meters; 19 sites involved in the comparison.

Test Case:

Input data for Nahrwan Datum test point:	ϕ =	24°58'07.671"N	N = 1.11 m (Clarke 1880 Ellipsoid)
	λ =	55°00'07.720"E	

* Masirah Island (Oman) and United Arab Emirates only (Clarke 1880 Ellipsoid). Contact DMA (see PREFACE) if data in this form is needed for Saudi Arabia.