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 ($\Delta\phi$, $\Delta\lambda$, $\Delta H$)
- 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:

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

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

\[\phi: \pm0.5 \, m; \quad \lambda: \pm0.3 \, m; \quad H \, (\text{geodetic height}): \pm0.2 \, m\]

Test Case:

Input data for ED 50 (Cyprus) test point:
\[\phi = 34^\circ43'23.316"N\]
\[\lambda = 32^\circ28'06.026"E\]
\[\Delta \phi = -3.885"\]
\[\Delta \lambda = -1.126"\]
\[\Delta H = 23.64 \, m\]
Table 20.29

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

\[
\Delta\phi = 0.49461 - 0.69094 U + 0.39940 V - 7.44709 U^3 - 1.82129 U^2 V - 2.92752 U V^2 + 5.70789 U^3 V
+ 48.52705 U^7 V^2 - 0.49769 V^9 - 11.39331 U^4 V^8
\]

\[
\Delta\lambda = -2.62435 - 0.21876 U + 0.43678 V + 0.35068 U V - 1.53864 U^2 V - 0.46268 U V^3 + 2.20240 U^4 V
- 0.11456 V^5 + 1.59485 U^3 V^4
\]

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

In the preceding equations:

\[
U = K (\phi - 10)
V = K (\lambda - 8)
K = 0.15707963
\]

\(\phi\) = geodetic latitude, local geodetic system, in degrees and decimal part of a degree;
\(\phi\) = geodetic latitude, local geodetic system, in degrees and decimal part of a degree;
\(\lambda\) = positive north (0° to 90°), negative south (0° to -90°)
\(\lambda\) = geodetic longitude, local geodetic system, in degrees and decimal part of a degree;
\(\lambda\) = 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:

\(\phi\): ±1.2 m; \(\lambda\): ±1.0 m; \(H\) (geodetic height): ±0.7 m

Test Case:

Input data for Minna
\(\phi = 9°19'09.051"N\)
\(\Delta\phi = 0.930"\)

Datum test point:
\(\lambda = 12°13'50.125"E\)
\(\Delta\lambda = -2.348"\)
\(\Delta H = 13.43m\)

* Nigeria
Table 20.31

Local Geodetic System-to-WGS 84
Datum Transformation Multiple Regression Equations (Δφ, Δλ, ΔH)
- NAD 27 (Alaska) to WGS 84 -

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

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

\[
\Delta H_m = 8.352 - 13.742\ U - 8.268\ V + 0.900\ V^2 + 5.340\ U^3 + 2.960\ UV^2 - 2.016\ V^3 + 5.087\ U^3V + 1.437\ UV^3
+ 0.951\ V^5 - 2.461\ U^3V^4 - 1.560\ U^8 - 1.980\ U^7V - 0.205\ U^5V^3 + 0.094\ UV^8 - 2.885\ U^8V^2
- 0.011\ UV^9
\]

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:

\[
\phi: \pm 1.7\ m; \ \lambda: \pm 1.7\ m; \ \text{H (geodetic height): } \pm 1.2\ m
\]

Test Case:

Input data for NAD 27 (Alaska) test point:

\[
\phi = 64°31'09.064''N \quad \Delta \phi = -2.648'' \\
\lambda = 194°37'28.092''E \quad \Delta \lambda = -9.525'' \\
\Delta H = 19.20\ m
\]

[Revised: 1 March 1989]
Datum Transformation Multiple Regression Equations (Δx, Δy, Δz):

\[
\Delta \phi^v = 0.79395 + 2.29199 \ U + 0.27589 \ V - 1.7664 \ U^2 + 0.47743 \ U^2 + 0.08421 \ V^2 - 6.03894 \ U^3
\]
\[
+ 3.55747 \ U^2 V + 5.83633 \ U^2 V^2 + 1.18118 \ U^3 V + 0.28070 \ U^3 V^2 + 7.75515 \ U^4 + 3.10170 \ U^4 V + 3.35742 \ U^4 V^2 + 3.18323 \ U^5 V^2 + 1.19144 \ U^5 V^3 + 0.41161 \ U^5 V^4
\]
\[
+ 0.80250 \ U^6 V + 0.18177 \ U^7 + 0.11299 \ U^8 V + 0.002067 \ U^9 + 4.876961 \ U^8 V^2 + 0.48837 \ U^9 V + 0.04822 \ U^9 V^2 + 0.049503 \ U^9 V^3 + 0.3677 \ U^9 V^4 + 0.095751 U^9 V^5
\]
\[
\Delta \lambda^v = 1.36099 + 3.61796 \ V - 3.97703 \ U^2 + 3.09705 \ U^2 + 1.15866 \ V^2 - 1.328954 \ U^3 - 3.157952 \ U^3 V^2 + 1.15866 \ U^3 V^4
\]
\[
+ 0.68405 \ U^2 V + 0.50303 \ U^2 V^2 + 8.81200 \ U^2 V^3 + 2.17587 \ U^2 V^4 + 1.49513 \ U^3 V^5 + 0.84700 \ U^4 V^6
\]
\[
+ 3.14249 \ U^5 V^7 + 1.78687 \ U^5 V^8 + 0.5940 \ U^4 V^9 + 17.55842 \ U^4 V^10 + 0.1418 \ U^4 V^11 + 0.1418 \ U^5 V^12 + 0.812000 \ U^5 V^13 + 0.48837 \ U^6 V^14 + 0.04822 \ U^6 V^15
\]
\[
+ 0.095751 U^6 V^16 + 0.095751 U^7 V^17 + 0.095751 U^7 V^18 + 0.095751 U^8 V^19 + 0.095751 U^8 V^20
\]
\[
\Delta z = 26.806 + 9.266 \ U - 5.857 \ V + 14.794 \ U^2 + 3.497 \ U^2 + 9.600 \ U^4 + 7.664 \ U^4 \ V + 40.040 \ U^4 \ V^2 + 130.424 \ U^4 \ V^3 + 0.770 \ U^5 V + 15.246 \ U^5 V^2 + 18.445 \ U^5 V^3 + 0.246 \ U^5 V^4 + 0.095 \ U^5 V^5
\]
\[
+ 0.073 U^5 V^6 + 0.073 U^5 V^7 + 0.073 U^5 V^8 + 0.073 U^5 V^9 + 0.073 U^5 V^{10}
\]
Table 20.41
Local Geodetic System-to-WGS 84
Datum Transformation Multiple Regression Equations (Δφ, Δλ, ΔH)
- Qatar National Datum* to WGS 84 -

\[
\begin{align*}
\Delta \phi'' &= 2.47363 + 0.08786 U + 0.14283 U^2 + 0.04380 UV + 0.07142 V^2 - 0.08879 UV^2 - 0.11089 U^5 \\
&\quad - 0.06321 U^3 V^4 + 0.01669 U^9 \\
\Delta \lambda'' &= -2.80439 + 0.10489 V + 0.02697 V^2 - 1.10721 U^2 V^2 + 2.88786 U^2 V^3 - 0.06281 U^5 V - 2.59921 U^3 V^6 \\
\Delta H_m &= -28.376 + 2.381 U - 1.126 U^2 + 3.095 V^2 - 4.112 U^3 V^3 - 13.156 V^7 - 2.048 U^8 + 1.618 U^9 \\
&\quad + 18.689 U V^8
\end{align*}
\]

In the preceding equations:

\[
\begin{align*}
U &= K (\phi - 25) \\
V &= K (\lambda - 51) \\
K &= 1.04719754 \\
\phi &= \text{geodetic latitude, local geodetic system, in degrees and decimal part of a degree; positive north (0° to 90°), negative south (0° to -90°)} \\
\lambda &= \text{geodetic longitude, local geodetic system, in degrees and decimal part of a degree; positive east from 0° to 360°}
\end{align*}
\]

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

\[
\begin{align*}
\phi: &\pm 0.3 \text{ m} & \lambda: &\pm 0.2 \text{ m} & H (\text{geodetic height}): &\pm 0.2 \text{ m}
\end{align*}
\]

Test Case:

\[
\begin{align*}
\text{Input data for Qatar National} &,& \phi &= 24^\circ 34' 55.061''N & \Delta \phi &= 2.465'' \\
\text{Datum test point} &,& \lambda &= 50^\circ 59' 06.940''E & \Delta \lambda &= -2.806'' \\
& & & & \Delta H &= -29.64 \text{ m}
\end{align*}
\]

* Qatar Island (Persian Gulf)
Table 23.21

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

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

In the preceding equation:

\[ U = K (\phi - 7) \]
\[ V = K (\lambda - 80) \]

\[ K = 0.52359877 \]

\[ \phi = \text{geodetic latitude, local geodetic system, in degrees and decimal part of a degree; positive north (0° to 90°), negative south (0° to -90°)} \]

\[ \lambda = \text{geodetic longitude, local geodetic system, in degrees and decimal part of a degree; positive east from 0° to 360°} \]

\[ N = \text{DMA-developed Kandawala Datum geoid height (in meters) referenced to the Everest Ellipsoid} \]

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.

Test Case:

Input data for Kandawala Datum test point:

\[ \phi = 7°37'02.730"N \quad \lambda = 81°40'49.750"E \]

\[ N = -4.55 \text{ m (Everest Ellipsoid)} \]

* Sri Lanka; Everest Ellipsoid
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:
- \( U = K (\phi - 23) \)
- \( V = K (\lambda - 57) \)
- \( K = 0.41887902 \)
- \( \phi \) = geodetic latitude, local geodetic system, in degrees and decimal part of a degree;
  positive north (0° to 90°), negative south (0° to -90°)
- \( \lambda \) = 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 \( \pm 1.2 \) meters; 19 sites involved in the comparison.

Test Case:

Input data for Nahrwan

Datum test point:

\[ \phi = 24°58'07.671"N \]
\[ \lambda = 55°00'07.720"E \]

* 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.