NAD 83: WHAT IS IT AND WHY YOU SHOULD CARE

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Abstract

Space exploration has shown that a more refined ellipsoid model of the earth was needed. That new model, WGS 84, has, in turn, required a new datum for geographical coordinates, known as NAD 83. The FAA has been requiring NAD 83 coordinates since 1992, whereas the FCC still requires NAD 27 coordinates. The differences between NAD 27 and NAD 83 are explained, and conversion algorithms between the two datums are discussed.

NEW ELLIPSOID MODEL OF THE EARTH

Broadcast Engineers are routinely required to use geographical coordinates in their dealings with the Federal Communications Commission (FCC) and with the Federal Aviation Administration (FAA). For years there was only one datum for the United States, NAD 27. NAD 27 stands for "North American Datum 1927", which is based on a model of the earth called the Clarke Ellipsoid of 1866. As a result of space exploration beginning in the late 1960's, it became clear that a center-of-mass model of the earth would be more consistent with satellite-based global positioning systems ("GPS").

The improved ellipsoid model is know as the World Geodetic System of 1984, or WGS 84. Geographic coordinates based on this earth model are referred to as North American Datum 1983, or NAD 83.

While the Clarke Ellipsoid of 1866 was designed to fit the shape of the contiguous United States, Canada, and Alaska, WGS 84 is global in extent. The primary advantage of WGS 84 is that it facilitates the calculation of geometric relationships on a global as well as a continental scale. WGS 84 is a geocentric ellipsoid, indirectly employing the Earth's center of mass. In contrast, the Clarke Ellipsoid of 1866 is based on a coordinate pair centered on a station known as Meades Ranch in Kansas.

For comparison purposes, the Clark Ellipsoid of 1866 has an equatorial axis radius "a" of 6,378.206 kilometers, a polar radius "b" of 6,356.584 kilometers, and an ellipticity "f" of 1/294.98, where $f = 1 - (b/a)$. WGS 84 has an equatorial axis radius of 6,378.137 kilometers and an ellipticity of 1/298.26.

LATITUDE AND LONGITUDE DIFFERENCES

As shown by Figure 1, the maximum latitude difference for the contiguous U.S. between the two datums is approximately 1.3 seconds, occurring in southern Florida. As shown by Figure 2, the maximum longitude difference for the contiguous U.S. between the two datums is approximately 4.4 seconds. The minimum shifts between the two datums occur in the eastern third of the U.S., near the state of Indiana.

MAP-BASED NAD 83 COORDINATES

Double-Sided Topographic Maps

A novel approach for allowing map users to derive NAD 83 coordinates was attempted by the United States Geological Survey (USGS) in 1988: several experimental topographic maps were printed. These maps had printing on *both* sides of the sheet: on one side was a traditional topographic map, based on NAD 27, with integer-second map edges; on the other side was the corresponding area, based on NAD 83, and with *non*-integer-second map edges.

Figures 3A and 3B show examples of a standard topographic map and one of the experimental maps. In Figure 3A, the lower right-hand map corner represents an integer number of (NAD 27) seconds; in this case, 37° 52' 30" North, 122° 30' 00" West. However, for the NAD 83 version, the lower right-hand map corner represents a non-integer number of (NAD 83) seconds: 37° 52' 29.73" North, 122° 20' 03.90" West.

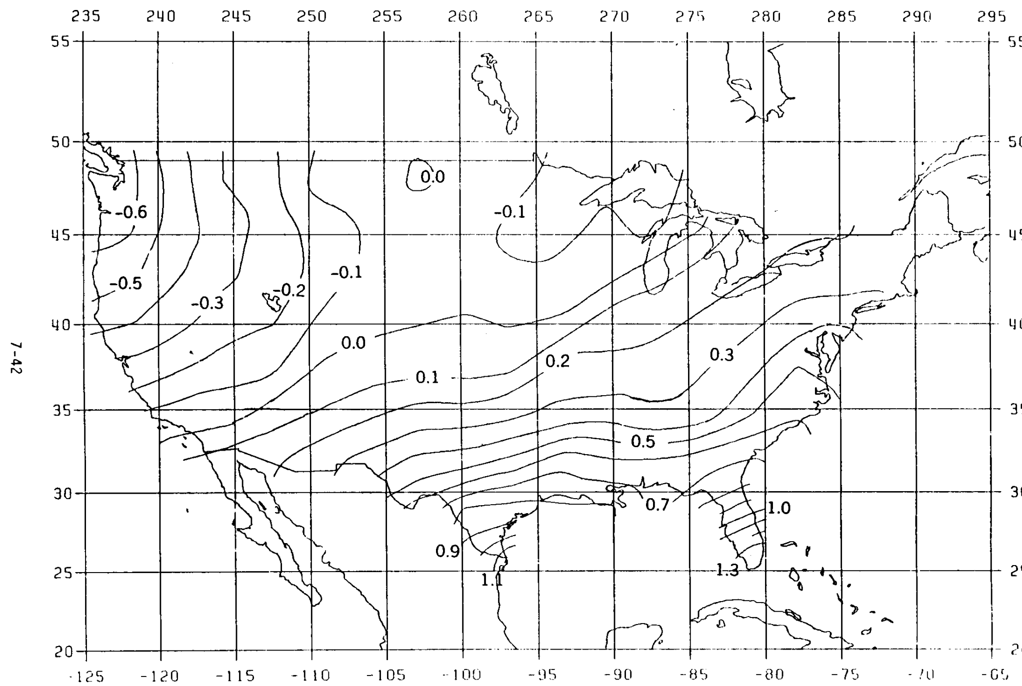

Figure 7.7. Contour Chart–Latitude Differences, WGS 84 Minus NAD 27 (CONUS; Contour Interval = 0.1 Arc Second)

Figure 1. Map showing shifts in latitude between NAD 27 and NAD 83 for the contiguous United States.

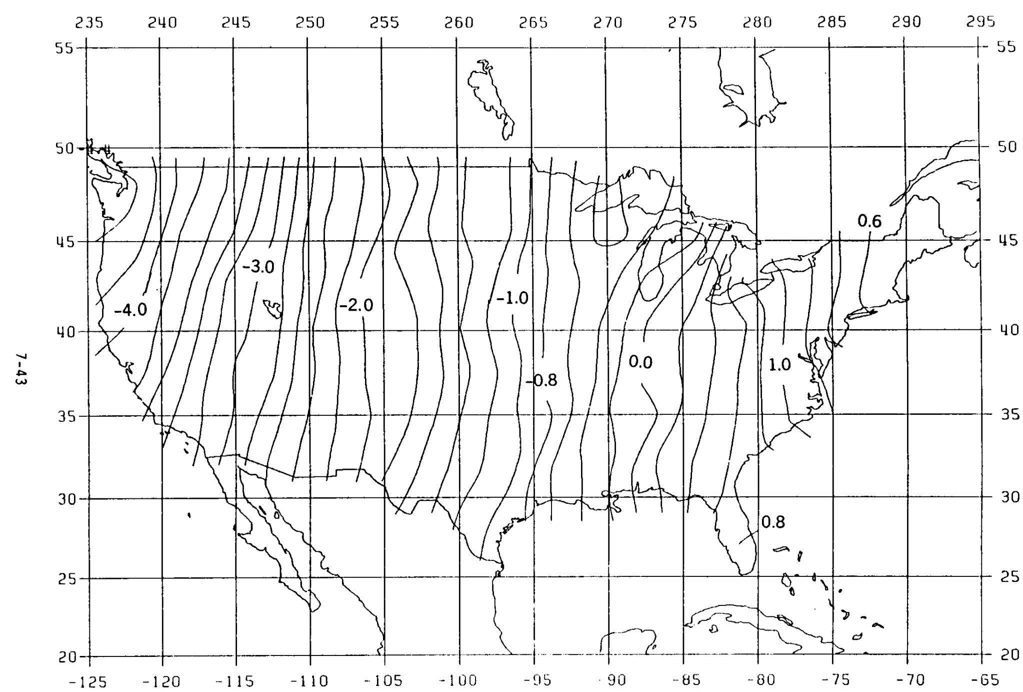

Figure 7.8. Contour Chart–Longitude Differences, WGS 84 Minus NAD 27 (CONUS; Contour Interval = 0.2 Arc Second)

Figure 2. Map showing shifts in longitude between NAD 27 and NAD 83 for the contiguous United States. Both maps are from Reference [1].

Thus, a user could graphically derive NAD 83 datum coordinates directly from the topographic map; a mathematical conversion was not required.

Of course, there are some drawbacks to this approach: the USGS would have to re-print approximately 55,000 topographic maps, and users who have difficulty determining the latitude and longitude of a given point by ratioing between bracketing integer tick marks would have an even more daunting task by having to ratio between bracketing *non*-integer tick marks.

It appears that this approach to deriving NAD 83 coordinates has "died," either due to budgetary limitations or, just perhaps, due to a senior government official applying the "common sense" test, and concluding that re-printing 55,000 *double-sided* topographic maps was not the way to go.

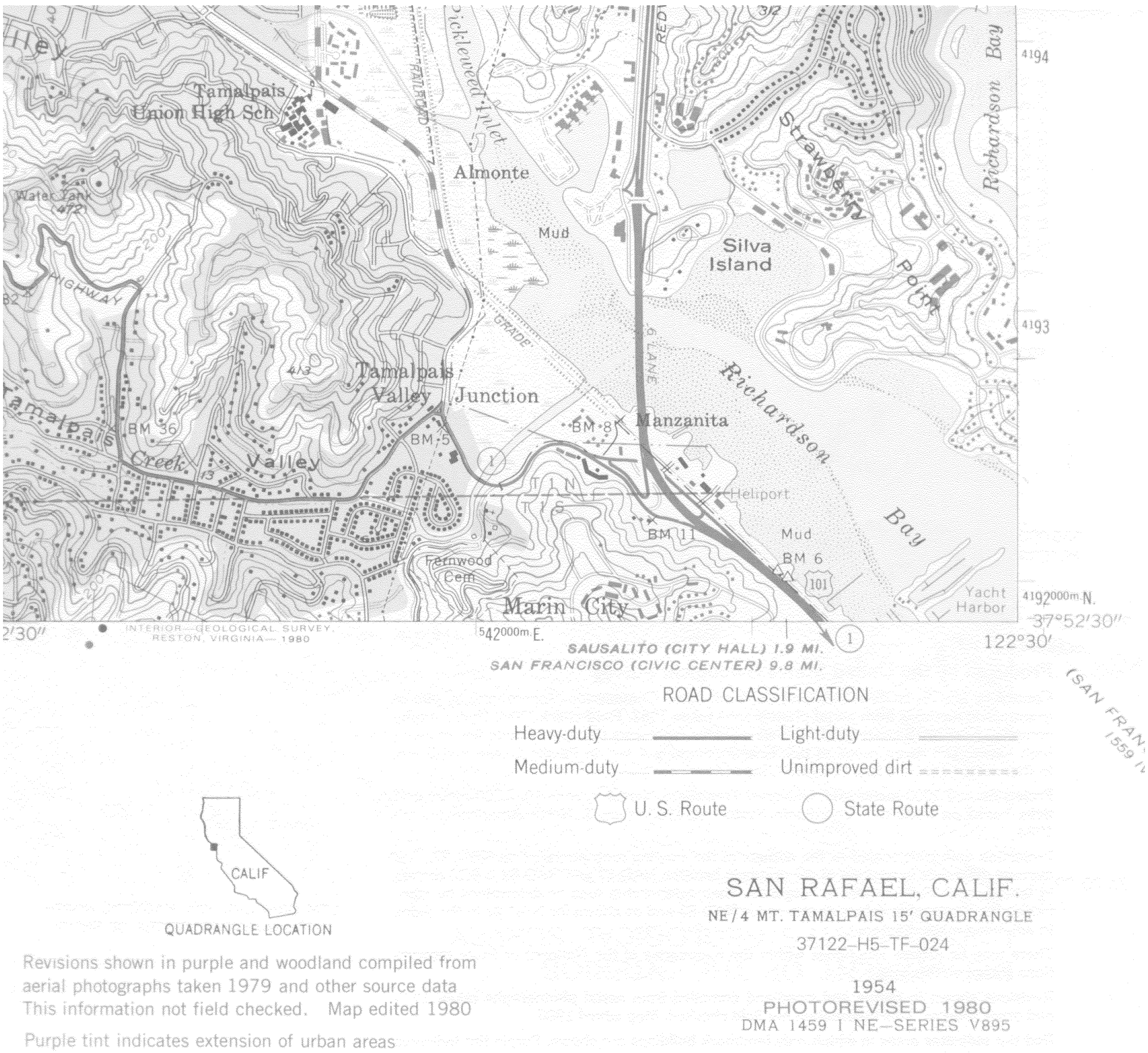

Figure 3A. Standard USGS 7.5-minute series topograhic map, with integer-second lower right-hand corner coordinates.

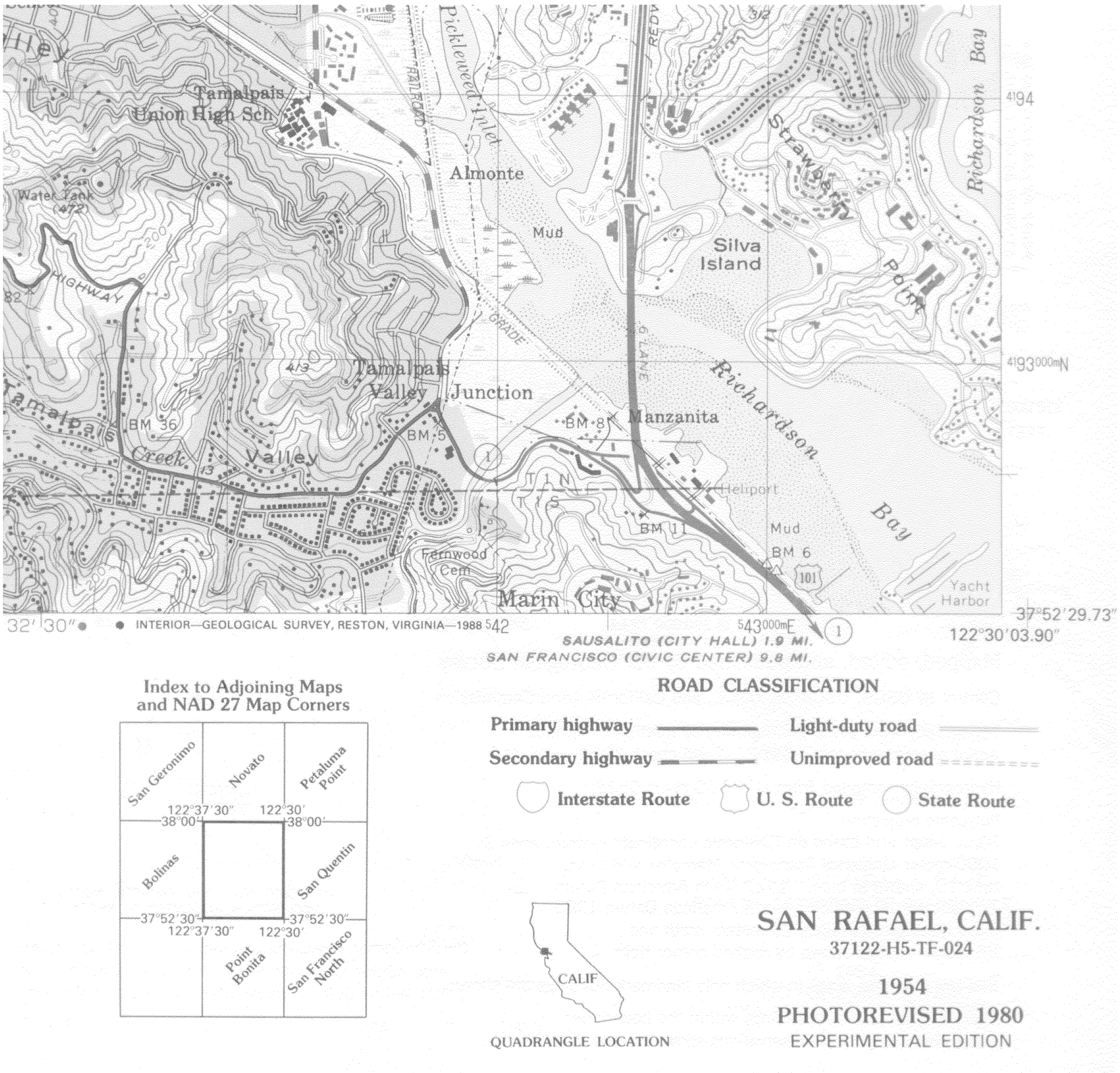

Figure 3B. Experimental USGS 7.5-minute series NAD 83 topograhic map, with *non*-interger-second lower right-hand corner coordinates. From Reference [3].

CONVERSION ALGORITHMS

Fortunately, there is a more practical approach: determine the NAD 83 coordinates mathematically. Given the widespread availability of programmable calculators and computers, conversion algorithms that would have been impractical twenty or even ten years ago now are much more attractive than a graphical (map-based) approach.

DMA Algorithm

The Defense Mapping Agency (DMA) has developed an algorithm that converts NAD 27 coordinates to NAD 83 coordinates. The advantage of this algorithm is that it uses relatively simple 13th-order polynomials for the transforms, and therefore is the sort of program that can fit in a programmable calculator. The disadvantages of the DMA algorithm are that it is "one-way", that is, it will only convert NAD 27 coordinates to NAD 83 coordinates, it does not apply in Alaska or Hawaii, and the conversion accuracy is "only" on the order of ±0.04 seconds for latitude and ±0.06 seconds for longitude. Figure 4A shows the polynomial equations used by the DMA algorithm. Figure 4B shows a printout of the DMA algorithm as implemented on the Hewlett Packard HP-41 series programmable calculator.

Table 7.6

Local Geodetic System-to-WGS 84
Datum Transformation Multiple Regression Equations ($\Delta\phi$, $\Delta\lambda$, ΔH)
- North American Datum 1927 (NAD 27)* to WGS 84 -

$$\Delta\phi'' = 0.16984 - 0.76173\,U + 0.09585\,V + 1.09919\,U^2 - 4.57801\,U^3 - 1.13239\,U^2V + 0.49831\,V^3 - 0.98399\,U^3V + 0.12415\,UV^3 + 0.11450\,V^4 + 27.05396\,U^5 + 2.03449\,U^4V + 0.73357\,U^2V^3 - 0.37548\,V^5 - 0.14197\,V^6 - 59.96555\,U^7 + 0.07439\,V^7 - 4.76082\,U^8 + 0.03385\,V^8 + 49.04320\,U^9 - 1.30575\,U^6V^3 - 0.07653\,U^3V^9 + 0.08646\,U^4V^9$$

$$\Delta\lambda'' = -0.88437 + 2.05061\,V + 0.26361\,U^2 - 0.76804\,UV + 0.13374\,V^2 - 1.31974\,U^3 - 0.52162\,U^2V - 1.05853\,UV^2 - 0.49211\,U^2V^2 + 2.17204\,UV^3 - 0.06004\,V^4 + 0.30139\,U^4V + 1.88585\,UV^4 - 0.81162\,UV^5 - 0.05183\,V^6 - 0.96723\,UV^6 - 0.12948\,U^3V^5 + 3.41827\,U^9 - 0.44507\,U^8V + 0.18882\,UV^8 - 0.01444\,V^9 + 0.04794\,UV^9 - 0.59013\,U^9V^3$$

7-30

$$\Delta H_m = -36.526 + 3.900\,U - 4.723\,V - 21.553\,U^2 + 7.294\,UV + 8.886\,V^2 - 8.440\,U^2V - 2.930\,UV^2 + 56.937\,U^4 - 58.756\,U^3V - 4.061\,V^4 + 4.447\,U^4V + 4.903\,U^2V^3 - 55.873\,U^6 + 212.005\,U^5V + 3.081\,V^6 - 254.511\,U^7V - 0.756\,V^8 + 30.654\,U^8V - 0.122\,UV^9$$

$$U = K\,(\phi - 37)$$

$$V = K\,(\lambda - 265)$$

$$K = 0.05235988$$

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

7-31

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 447, 425, and 428 comparison points to the following root-mean-square (RMS) differences, respectively:

ϕ: ±1.3 m; λ: ±1.3 m; H (geodetic height): ±1.2 m

Test Case:

Input data for NAD 27 test point:	ϕ = 34°47'08.833"N	$\Delta\phi$ = 0.356"
	λ = 273°25'07.825"E	$\Delta\lambda$ = 0.080"
		ΔH = -38.06 m

*Contiguous United States (CONUS)

Figure 4A. Polynomial equations used by DMA NAD 27 to NAD 83 conversion algorithm.

```
           XROM "NAD83"
LAT(27)?
      34.4708833    RUN
LONG(27)?
      86.3452175    RUN
LAT(27)=34.4709
LONG(27)=86.3452

DLTA LAT=0.356 SEC
DLTA LONG=-0.080 SEC
DLTA H=-38.1 M

LAT(83)=34.4709
LONG(83)=86.3452
```

Figure 4B. HP-41 printout of DMA program.

NADCON Algorithm

The National Geodetic Survey (NGS) has developed an algorithm known as the North American Datum Conversion program, or NADCON. This program is bi-directional, meaning that it will convert NAD 83 coordinates to NAD 27 coordinates, as well and NAD 27 coordinates to NAD 83 coordinates. It also applies in Alaska, Hawaii, and Puerto Rico. But, most importantly, it is the conversion algorithm recommended by statute. The Federal Register dated August 10, 1990, Volume 55, Number 155, Page 32681, stated:

"The intent of this notice is to standardize a horizontal datum transformation method when a mathematical transformation is desired. FGCC [Federal Geodetic Control Committee] selected the method incorporated in the software identified as NADCON. It is not the intent of the notice to declare when to use a datum transformation or by what method but only to declare that when a mathematical transformation is appropriate, NADCON is recommended."

Thus, while use of NADCON is not mandatory, use of conversion algorithms other than NADCON may result in a rounding error that will cause the results to be inconsistent with those obtained by the FAA or by the FCC, which do use NADCON.

NADCON uses a minimum-curvature approach to transforming between the two datums, and requires three reference files: a large file for the contiguous United States, and smaller files for Alaska and Hawaii. By having a separate set of polynomial coefficients for each 7.5-minute topographic map, NADCON achieves an improved conversion accuracy of approximately ±0.0003 seconds in latitude and ±0.0005 seconds in longitude. Because of the size of these data files, programmable calculators are unable to implement the program, but today's personal computers are certainly capable of loading the NADCON data files.

NADCON currently sells for $98.00 and is available from National Oceanic & Atmospheric Administration (NOAA), NGS, N/CG174, 1315 East-West Highway, Station 9202, Silver Spring, Maryland 20910-3282. Telephone numbers are 301/713-3242 (voice), 301/713-4172 (facsimile). Hours are Monday-Friday, 7:00 AM to 4:30 PM, Eastern Time. NGS accepts personal checks, Visa, Mastercard, and American Express.

The NADCON software (Version 2.1) and data files are provided on two 3.5-inch disks for IBM-compatible personal computers with a math coprocessor chip. The source code can be re-compiled for use with other computers. A hard drive with at least 1.5 Mbytes of RAM is recommended.

An example of a NADCON printout is given in Figure 5.

```
                    North American Datum Conversion
                           NAD 27 to NAD 83
                      NADCON Program Version 2.10

===============================================================================

                                                                 Page    2

                      Transformation #:     1       Region: Continental US

Station name:   test

                                  Latitude                 Longitude
NAD 27 datum values:           47 38  1.00000          122 21 20.00000
NAD 83 datum values:           47 38  0.35318          122 21 24.45931
NAD 83 - NAD 27 shift values:        -0.64682                  4.45931(secs.)
                                    -19.976                   93.091  (meters)
Magnitude of total shift:                           95.210(meters)

                            Statistics for Region
===============================================================================

                                   Latitude                  Longitude
 NAD 83 - NAD 27 shifts        MIN        MAX             MIN        MAX
 Range of shift (meters)     -19.976  -19.976           93.091    93.091
 Range of shift (seconds)     -0.647   -0.647            4.459     4.459

        Mean shift (meters)       -19.976                    93.091
        Variance of mean shift      0.000                     0.000
        Std. Dev. of mean shift     0.000                     0.000

        Mean shift (seconds)       -0.647                     4.459
        Variance of mean shift      0.000                     0.000
        Std. Dev. of mean shift     0.000                     0.000


The total number of conversions:        1

                          Region of Conversions



  NAD 27
  Longitude:         122 21 20.000              122 21 20.000
  Latitude:           47 38  1.000 ************  47 38  1.000
                            *                          *
                            *                          *
                            *                          *
                            *                          *
                            *                          *
                            *         NAD 27           *
                            *          data            *
                            *         points           *
                            *                          *
                            *                          *
                            *                          *
                            *                          *
                            *                          *
  Latitude:           47 38  1.000 ************  47 38  1.000
  Longitude:         122 21 20.000              122 21 20.000

                  AVAILABLE DATUM CONVERSIONS

                        NAD 27, NAD 83
                        NAD 83, HPGN

 Hit RETURN for NAD 27, NAD 83
 Press any other key (except 'Q') then RETURN for NAD 83,HPGN
 Press 'Q' then RETURN to quit
```

Figure 5. Sample NADCON printout.

BUG IN NADCON PROGRAM

Users of the NADCON program should be aware of a “bug” in the NADCON disks that existed between approximately February 1994 and June 1994. The problem has now been rectified, so only users who purchased the NADCON software between these dates need be concerned.

The problem was discovered by Hammett & Edison in April of this year. We had alerted another engineering firm operating in the Bay Area, C.S.I. Telecommunications, to the existence of the NADCON program. Mr. Michael S. Newman, Vice President of C.S.I., indicated he would immediately order the NADCON program. We requested that he provide us with a copy of the program when it was received, so we could compare it to our NADCON program, which had been purchased in 1992. We wanted to see if any changes had been made, in which case would order the updated version.

Our examination of the NADCON disks showed that the NADCON program itself was still Version 2.1, but we discovered that the data files were different. The differences all appeared to be due to data file corruption. The “ALASKA.LOS” and “HAWAII.LAS” data files both had single-bit errors, that is, one byte of the file had one bit different than the corresponding byte in our 1992 NADCON disks. The result in both cases was a numerical value that was clearly wrong; that is, something like a shift between the NAD 27 and NAD 83 datums of 10^{20} seconds!

The error in the “CONUS.LOS” data file was much more subtle. That file had a large contiguous section of data near the middle of the file that was also different but not obviously so, as was the case for the Alaska and Hawaii data files. What seems to have happened was that a chunk of the original data was lost and was replaced by a chunk from elsewhere is the same file, or maybe from one of the other binary files. Persons running the NADCON program using this corrupted data file would get reasonable looking, but wrong, answers. For example, the 1992 data file showed shifts between the datums of about *plus* 4 seconds, whereas the corrupted portion of the data file showed shifts of about *minus* 2 seconds. Anyone running the NADCON program for the portion of the U.S. covered by the corrupted data would get an answer with about a 6-second error in the converted coordinates.

NADCON Users Should Check to See if They Received Defective Disks or Ran NADCON for an Affected Area of the U.S.

Figure 6 shows that area of the U.S. where the corrupted data files applied. Fortunately, we have been in contact with staff at the NGS and found out that the problem was traced to new computer hardware used to duplicate the NADCON disks, and that the error was systematic; that is, all NADCON disks sent out had the same data file errors. We have also learned that only about 15 defective orders were sent out, and that corrected disks have now been provided to all of the parties who had received the defective disks.

However, the corrected disks sent to C.S.I. Telecommunications showed up with only a simple invoice referring to two enclosed replacement NADCON disks, with no explanation of the reason for the replacement. So, if you are one of the 15 or so customers who ordered the NADCON program from the NGS in early 1994, or mysteriously received replacement disks in June, you now know the reason. You can also use the map in Figure 6 to determine if you had used the NADCON program to convert coordinates in the portion of the U.S. where the defective data file existed, in which case you would be well advised to re-calculate the NAD 83 coordinates.

NEW FAA FORM 7460-1

An updated version of FAA Form 7460-1, *Notice of Proposed Construction or Alteration*, has been adopted by the FAA. This new form has blocks for both NAD 27 coordinates and NAD 83 coordinates. The NAD 83 coordinate blocks are in the portion of the form marked “For FAA Use Only”, meaning that the FAA will use the NADCON program to convert the reported NAD 27 coordinates to NAD 83 coordinates.

Unfortunately, FAA staff appears to not understand the difference between precision and accuracy. As shown in Figure 7, which was a filing recently submitted by Hammett & Edison to the FAA, the tower coordinates were reported only to the nearest second, but then logged by the FAA staff to the nearest *hundredth* of a second when converted to NAD 83 coordinates. This runs the risk that the proponent, or others, will then use NADCON to derive the NAD 27 coordinates to the nearest hundredth of a second, by taking the false precision NAD 83 coordinates and running NADCON “backwards.” Of course, such NAD 27 coordinates would be bogus, because they would have been derived from NAD 27 coordinates that had been rounded, or possibly truncated, to the nearest second.

So the author urges all users of the NADCON program to avoid confusing precision with accuracy, and to realize that just because coordinates in either datum might be reported to the nearest tenth or hundredth of a second, to take with a grain of salt whether the geographic location of a tower is really known to that order of precision.

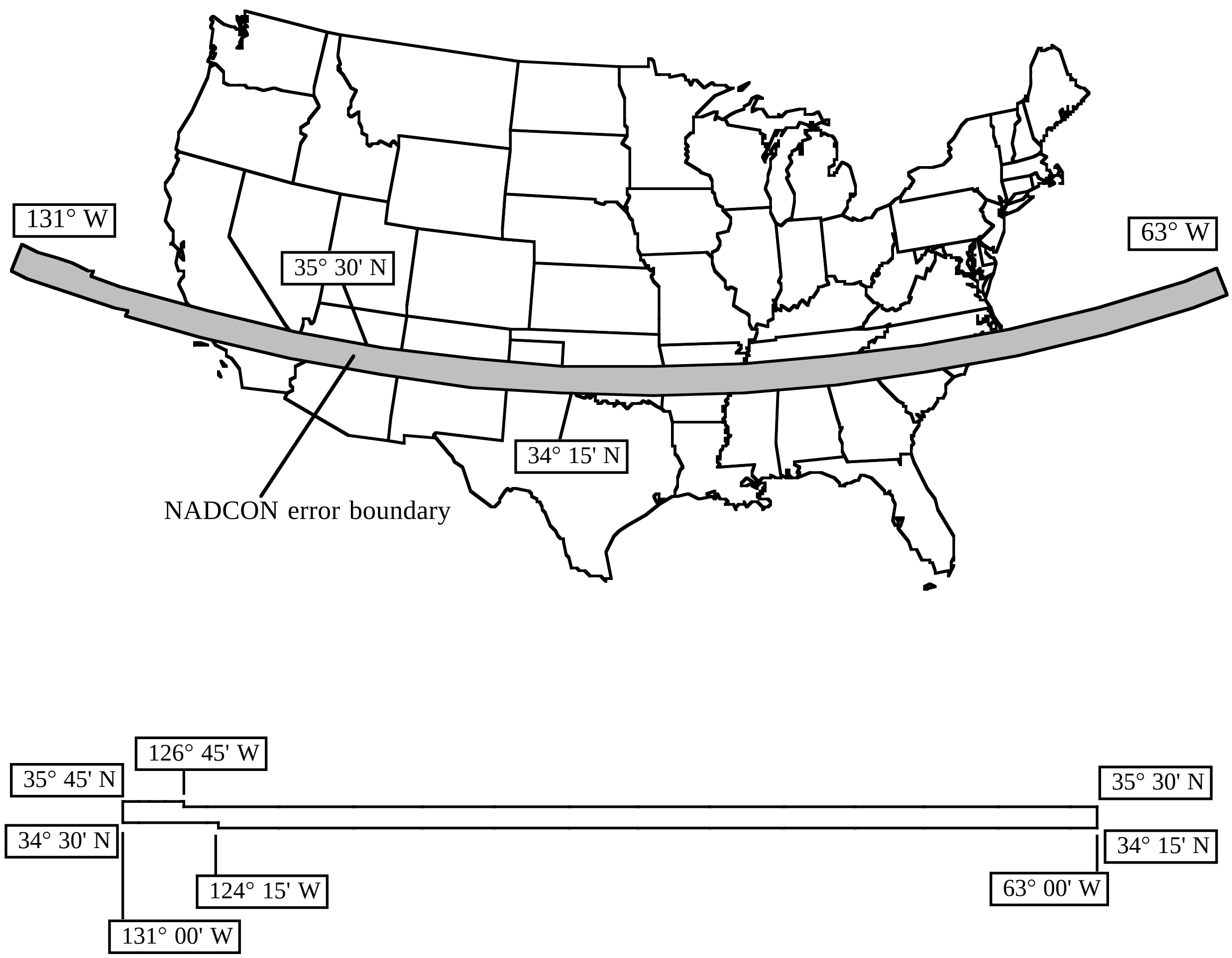

Figure 6. Map showing portion of U.S. affected by the bad NADCON data block.

NAD 83 ELEVATIONS

An issue not yet addressed by the FCC is the difference in ground elevations between the NAD 27 and NAD 83 datums. The vertical datum associated with NAD 27 is North American Vertical Datum 1929, or NAVD 29, and the vertical datum associated with NAD 83 is North American Vertical Datum 1988, or NAVD 88. The maximum difference in ground elevations between the NAVD 29 and NAVD 88 datums for the contiguous U.S. is only about 1.5 meters, but this is still enough cause 1 or 2 meter discrepancies in reported AMSL tower heights between the FCC and FAA data bases. Since even a 1-meter difference in a reported tower height can cause an application to be delayed, and possibly even dismissed, this is not a trivial additional complication.

As you might have guessed, there is an NGS program for converting between NAVD 29 and NAVD 88 elevations, called VERTCON. However, the height issue will have to await further negotiations between the FCC and FAA, and may be the subject of a successor paper.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of Mr. Michael S. Newman of C.S.I. Telecommunications, Mr. David R. Doyle, Senior Geologist, Horizontal Network Branch, NGS, and Mr. Robert P. Smith, Jr., Programmer, of Hammett & Edison, for their assistance in preparing this paper.

DO NOT REMOVE CARBONS — *Please Type or Print on This Form* — Form Approved OMB No. 2120-0001

US Department of Transportation
Federal Aviation Administration

Notice of Proposed Construction or Alteration

Aeronautical Study Number: 94-ANM-0474-OE

1. Nature of Proposal

A. Type: New Construction / Alteration *

B. Class: [X] Permanent / [ ] Temporary (Duration ______ months)

C. Work Schedule Dates: Beginning: Upon FCC approval; End: 18 mos. following

* If Alteration, provide previous FAA Aeronautical Study Number, if available:

3A. Name, address, and telephone number of individual, company corporation, etc. proposing the construction or alteration. (Number, Street, City, State, and Zip Code)

XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX
Area Code — Telephone Number

3B. Name, address and telephone number of proponent's representative, if different than 3A. above.

Gerhard J. Straub, P.E.
Hammett & Edison, Inc.
Box 280068
San Francisco, CA 94128
(415) 342-5200
Area Code — Telephone Number

2. Complete Description of Structure

Please describe, on a separate sheet of paper if necessary, the proposed construction or alteration.

A. For proposals involving transmitting stations, include effective radiated power (ERP) and assigned frequency of all proposed or modified transmitters on the structure. (If not known, give frequency band and maximum ERP).

B. For proposals involving overhead wire, transmission lines, etc., include the size and the configuration of the wires and their supporting structures.

C. For all proposals, include site orientation, dimensions, and construction materials of the proposed or altered structure.

D. Optional— Describe the type of obstruction marking and lighting system desired for your structure. The FAA will recommend appropriate marking and lighting for the structure in accordance with the standards of Advisory Circular AC 70/7460-1. An FAA marking and lighting recommendation will reflect the minimum acceptable level of conspicuity necessary to warn pilots of the presence of an object. However, the FAA, under certain circumstances, will not object to the use of a system (such as a medium intensity flashing white light system or a dual lighting system) other than the recommended standard.

910 KHz 1.0 KW

4. Location Of Structure

A. Coordinates (to hundredths of seconds, if known): Latitude 42° 02' 34"; Longitude 124° 14' 37"

B. Nearest City or Town and State: XXXXXXXXXXXXXXXX
(1). Distance to 4B: in town
(2). Direction to 4B: in town

C. Nearest public or military airport, heliport, flightpark, or seaplane base: XXXXXXXXXXXXXXXX
(1). Distance from structure to nearest point of nearest runway: 5.07 km (3)
(2). Direction from structure to airport: 301.7°T (NW)

4D. Source of coordinate information for item 4A. above: USGS 7.5' Quad Chart / Survey / Other Specify

Indicate the reference datum of the coordinates, if known: [X] NAD 27 / [ ] NAD 83 / [ ] Other Specify

4E. Describe, on a separate sheet of paper, the location of the site with respect to highways, streets, airports, prominent terrain features, existing structures, etc. Attach a copy of a U.S. Geological Survey quadrangle map 7.5 minute series (or equivalent) showing the construction site. If available, attach a copy of a documented site survey with the surveyor's certification.

5. Height and Elevation (to nearest foot)

A. Elevation of site above mean sea level: 400'

B. Height of structure including all appurtenances and lighting above ground or water: 186'

C. Overall height above mean sea level (A + B): 586'

FAILURE TO PROVIDE ALL REQUESTED INFORMATION MAY DELAY PROCESSING OF YOUR NOTICE

Notice is required by Part 77 of the Federal Aviation Regulations (14 C.F.R. Part 77) pursuant to Section 1101 of the Federal Aviation Act of 1958, as amended (49 U.S.C. app. § 1501). Persons who knowingly and willfully violate the Notice requirements of Part 77 are subject to a civil penalty of $1,000 per day until the notice is received, pursuant to Section 901(a) of the Federal Aviation Act of 1958, as amended (49 U.S.C. app § 1471(a)) as well as the fine (criminal penalty) of not more than $500 for the first offense and not more than $2,000 for subsequent offenses, pursuant to Section 902(a) of the Federal Aviation Act of 1958, as amended (49 U.S.C. app § 1472(a)).

I HEREBY CERTIFY that all of the above statements made by me are true, complete, and correct to the best of my knowledge. In addition, I agree to obstruction mark and/or light the structure in accordance with established marking & lighting standards as necessary.

Date: 5-17-94 — Typed or Printed Name and Title of Person Filing Notice: XXXXXXXXXXXXXXX — Signature: XXXXXXXXXXXXXX

FOR FAA USE ONLY — *FAA will either return this form or issue a separate acknowledgement.*

The Proposal:

[ ] Does not require a notice to FAA.
[X] is not identified as an obstruction under any standard of FAR, Part 77, Subpart C, and would not be a hazard to navigation.
[ ] is identified as an obstruction under the standards of FAR, Part 77, Subpart C, but would not be a hazard to navigation.
[ ] Should be obstruction [ ] marked [ ] lighted per FAA Advisory Circular 70/7460-1, Chapters ______
[X] Obstruction marking and lighting are not necessary.

Supplemental Notice of Construction, FAA Form 7460-2, is required any time the project is abandoned, or
[ ] At least 48 hours before the start of construction.
[ ] Within five days after the construction reaches its greatest height.

This determination expires on N.A. unless:
(a) extended, revised or terminated by the issuing office;
(b) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit is made to the FCC on or before the above expiration date. In such cases the determination expires on the date prescribed by the FCC for completion of construction, or on the date the FCC denies the application.

NOTE: Request for extension of the effective period of this determination must be postmarked or delivered to the issuing office at least 15 days prior to the expiration date.

If the structure is subject to the licensing authority of the FCC, a copy of this determination will be sent to that agency.

Remarks

NAD 83 Coordinates (Use these coordinates for any future correspondence with the FAA) — Latitude 42° 02' 33.39" — Longitude 124° 14' 41.32"

Issued in: Seattle — Signature: [signature] — Date: 6/2/94

FAA Form 7460-1 (1-93) — *Do Not Remove Carbons*

Figure 7. Example of new FAA Form 7640-1, as processed by FAA staff.

REFERENCES

[1] *World Geodetic System 1984, Its Definition and Relationships with Local Geodetic Systems*, Defense Mapping Agency, National Technical Information Service, U.S. Department of Commerce. Report No. TR 8350.2, September 30, 1987.

[2] NADCON: *The Application of Minimum Curvature-Derived Surfaces in the Transformation of Positional Data from the North American Datum of 1927 to the North American Datum of 1983*, Warren T. Dewhurst. NOAA Technical Memorandum NOS NGS-50, January, 1990.

[3] *Implementing North American Datum 1983 for the National Mapping Program*, U.S. Geological Survey, U.S. Department of the Interior, 1988.

[4] *Notice to Mariners* dated July 20, 1992, *Important Information on Latitude and Longitude Adjustments to All Chart Users and Chart-Product Users.* Published by National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS).

[5] Septetember 1, 1992, FCC Public Notice, *The Office of Enginering and Technology Presents a Tutorial on "The North American Datum."*

[6] September 1, 1992, FCC Public Notice, *The Federal Communications Commission Continues to Require Applicants to use Coordinates Based on the North American Datum of 1927.*

[7] *Maps for America*, Second Edition, by Morris M. Thompson, USGS (retired). Published by U.S. Geological Survey, U.S. Department of the Interior. U.S. Government Printing Office.

[8] *American Practical Navigator ("Bowditch")*, Defense Mapping Agency Hydrographic/Topographic Center Publication No. 9, DMA Stock No. NVPUB9V1 (Volume 1, 1984) and NVPUB9V2 (Volume 2, 1981).