HTDP USER'S GUIDE
(Software Version 3.0)
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INTRODUCTION

The HTDP (Horizontal Time-Dependent Positioning) software enables users to predict horizontal displacements and/or horizontal velocities related to crustal motion in the United States and its territories. The software also enables users to update positional coordinates and/or geodetic observations to a user-specified date. HTDP supports these activities for coordinates in the North American Datum of 1983 (NAD 83) as well as in all official realizations of the International Terrestrial Reference System (ITRS) [Altamimi et al., 2007] and all official realizations of the World Geodetic System of 1984 (WGS 84) [True, 2004]. Accordingly, HTDP may be used to transform positional coordinates between any pair of these reference frames in a manner that rigorously addresses differences in the definitions of their respective velocity fields. HTDP may also be used to transform velocities between any pair of these reference frames.

The software employs models that address both the continuous and the episodic components of crustal motion. For characterizing continuous motion, the models assume that points on the Earth's surface move with constant horizontal velocities. This assumption is generally acceptable except for the accelerated motion experienced during the years immediately following a major earthquake and for the motion associated with volcanic/magmatic activity. For characterizing the episodic motion associated with earthquakes, the models use the equations of dislocation theory [Okada, 1985]. Table 1 identifies the dislocation models that are incorporated into HTDP.

HTDP uses a model developed by Dr. Robert McCaffrey to compute horizontal velocities for points located in the western United States whose latitudes range from 31ºN to 49ºN and whose longitudes range from 100ºW to 125ºW. HTDP uses a model developed by Dr. Richard Snay to compute horizontal velocities for points located in Alaska whose latitudes range from 55ºN to 56º and whose longitudes range from 131ºW to 132ºW. Also, HTDP uses a rigid plate model, similar to NUVEL1A [DeMets et al., 1994], to compute horizontal velocities for several other areas of the world, including the eastern United States.

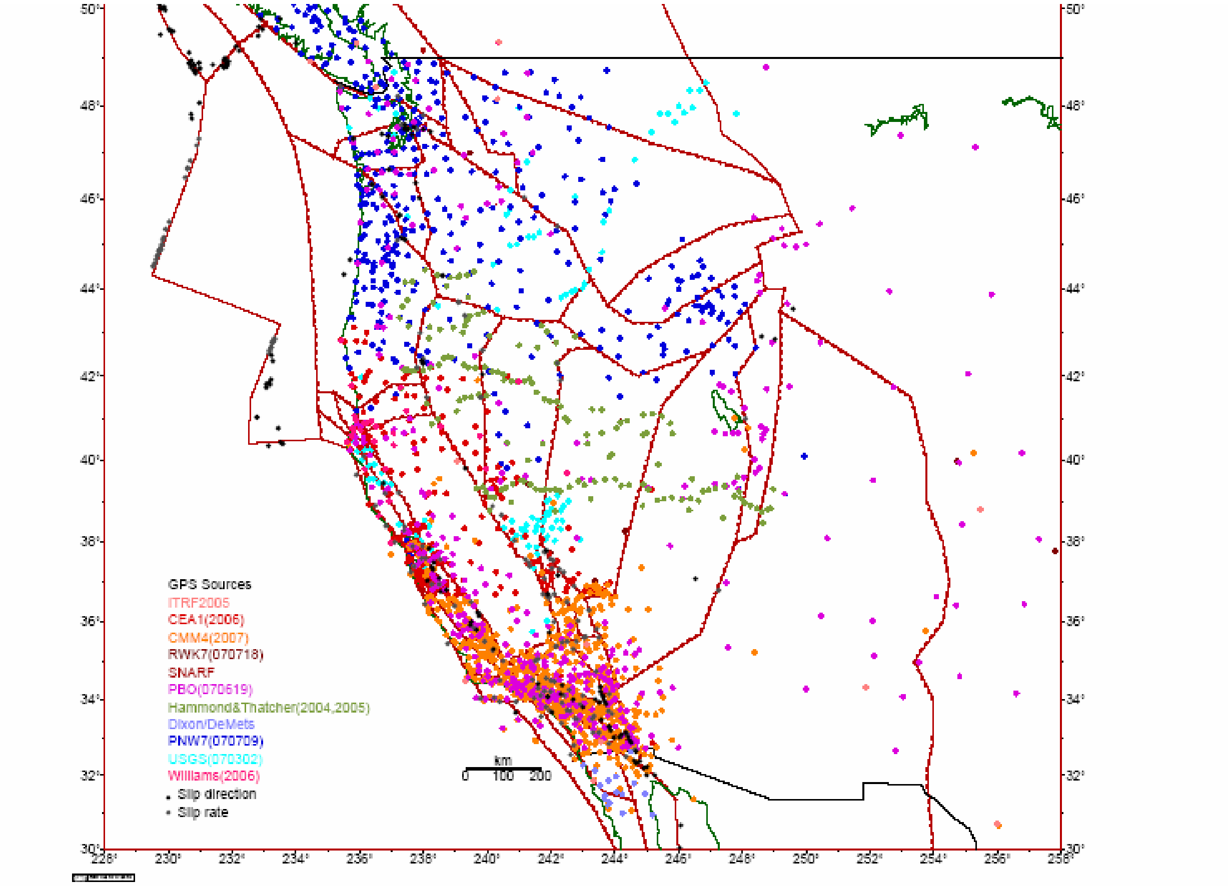

Figure 1. Map of blocks used by McCaffrey to model horizontal crustal velocity across the western United States. Colored dots identify the data included in modeling this velocity.

In his model for the western United States, Dr. McCaffrey represents the region as being comprised of a collection of elastic, rotating blocks that are separated by geologic faults (Figure 1). Friction along these faults causes elastic strain within these blocks. In addition, permanent strain within the blocks, possibly due to small-scale faulting, is represented by a spatially uniform strain rate tensor. In this manner, the deformation--even within a tectonically complex region as the western United States--can be represented by using only a relatively few number of geologically relevant parameters. To estimate the values of these parameters, Dr. McCaffrey used 4,890 horizontal velocities for a collection of sites. These velocities were derived from repeated GPS observations. He also used 170 fault slip rates inferred from geologic and paleomagnetic studies, and 258 fault slip vectors taken from both earthquake and geologic fault studies. The 4,890 horizontal velocities were assimilated from 13 separate velocity fields (Table 2). The fault slip rates and the fault slip vectors were those used in McCaffrey [2005] and McCaffrey [2007].

Internal to the software, velocities are expressed relative to the International Terrestrial Reference Frame of 2005 (ITRF2005) as defined by Altamimi et al. [2007]. Velocities relative to other reference frames are obtained from their corresponding ITRF2005 velocities using transformation equations adopted by NOAA's National Geodetic Survey. Figure 2 illustrates HTDP-predicted velocities for the western United States relative to NAD 83 (CORS96); that is, the realization of NAD 83 known as CORS96.

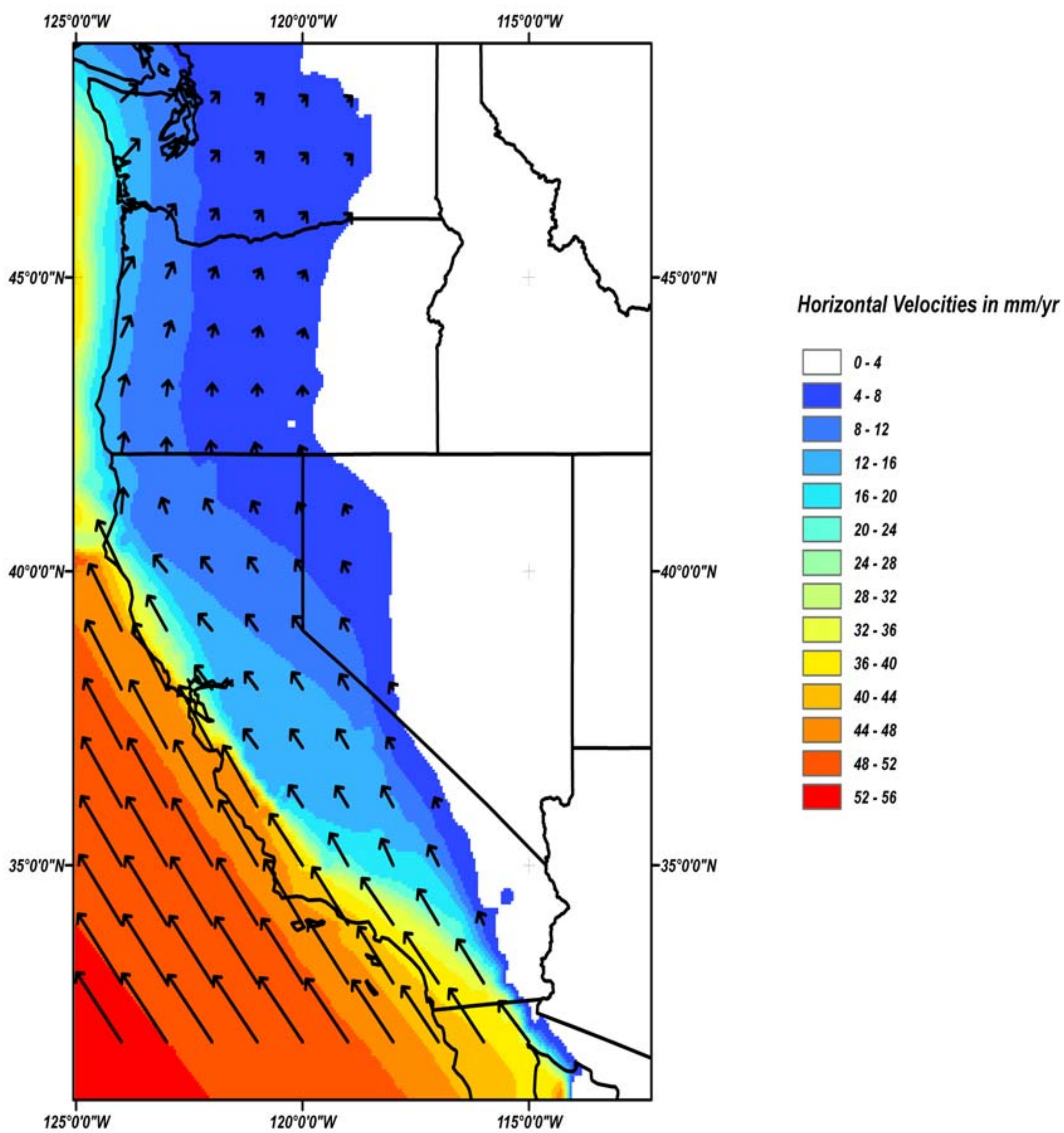

Figure 2. HTDP predicted velocities relative to NAD 83 (CORS96).

SOFTWARE CHARACTERISTICS

The source code is written in FORTRAN-77 and resides in the file, HTDP.FOR. The user needs to compile and link this source code to create executable code that is compatible with the operating system on his/her computer. For convenience, the National Geodetic Survey distributes a file called, HTDP.EXE, which contains executable code that should work on most Windows platforms.

The software is menu-driven and most information is entered interactively. Users may also enter certain information in the so-called "blue-book" format for horizontal control data [see Federal Geodetic Control Subcommittee, 2000]. For example, if requested, the software will predict displacements and/or velocities for all stations having an *80* record in an existing blue-book file. Besides predicting displacements and/or velocities for individual points, the software will predict these quantities for a set of points which defines a 2-dimensional array on the Earth's surface or which defines an equally spaced 1-dimensional array along a geodesic curve on an ellipsoid that approximates the Earth's surface. In all cases the output is written to a user-specified file.

The software also has the capability to update positional coordinates and/or geodetic observations to a user-specified date. For such an application, the user must specify the horizontal coordinates (latitudes and longitudes) and/or the observed values for one date, and the software will predict corresponding values for another user-specified date. The software can update various observational types, all of which may be encoded in blue-book format. In particular, the software accepts direction observations, angle observations, distance observations, azimuth observations, and GPS observations.

AUXILIARY INFORMATION

This User's Guide contains a set of five exercises to familiarize HTDP users with some of the applications of this software. Also, Snay [1999] discusses the HTDP software and its applications in considerable detail. Additional material on HTDP has been published by Snay [2003] and by Pearson and Snay [2008]. Moreover, the National Geodetic Survey maintains a LOG that summarizes modifications to the HTDP software in chronological order. Finally, people may run the latest version of HTDP interactively on the world-wide-web at http://www.ngs.noaa.gov/TOOLS/Htdp/Htdp.shtml .

DISCLAIMER

This software and supporting information is furnished by the Government of the United States of America, and is accepted/used by the recipient with the understanding that the U.S. Government makes no warranties, expressed or implied, concerning the accuracy, completeness, reliability, or suitability of this software, of its constituent parts, or of any supporting data.

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Table 1--Dislocation Models incorporated into HTDP

Date	Earthquake	Source of Model
	CALIFORNIA	
06-07-1934	Parkfield (M=6.0)	Segall and Du, 1993
05-17-1940	El Centro (M=6.9)	Snay and Herbrectsmeier, 1994
07-01-1941	Red Mountain (M=5.9)	Snay (unpublished)
10-21-1942	San Jacinto (M=6.6)	Snay and Herbrectsmeier, 1994
07-21-1952	Kern County (M=7.5)	Snay and Herbrectsmeier, 1994
03-19-1954	San Jacinto (M=6.4)	Snay and Herbrectsmeier, 1994
06-26-1966	Parkfield (M=5.6)	Segall and Du, 1993
04-09-1968	Borrego Mtn. (M=6.5)	Snay and Herbrectsmeier, 1994
02-09-1971	San Fernando (M=6.6)	Snay and Herbrectsmeier, 1994
03-15-1979	Homestead Valley (M=5.6)	Stein and Lisowski, 1983
08-06-1979	Coyote Lake (M=5.9)	Snay and Herbrectsmeier, 1994
10-15-1979	Imperial Valley (M=6.4)	Snay and Herbrectsmeier, 1994
05-02-1983	Coalinga (M=6.4)	Stein and Ekstrom, 1992
04-24-1984	Morgan Hill (M=6.2)	Snay and Herbrectsmeier, 1994
08-04-1985	Kettleman Hill (M=6.1)	Ekstrom et al., 1992
07-08-1986	N. Palm Springs (M=5.6)	Savage et al., 1993
07-21-1986	Chalfant Valley (M=6.2)	Savage and Gross, 1995
10-01-1987	Whittier Narrow (M=5.9)	Lin and Stein, 1989
11-24-1987	Superstition Hill (M=6.6,6.2)	Larsen et al., 1992
10-17-1989	Loma Prieta (M=7.1)	Lisowski et al., 1990
04-22-1992	Joshua Tree (M=6.1)	Bennett et al., 1995
04-25-1992	Cape Mendocino (M=7.1)	Oppenheimer et al., 1993
06-29-1992	Landers/Big Bear (M=7.5,6.6)	Hudnut et al., 1994
01-17-1994	Northridge (M=6.7)	Hudnut et al., 1996
10-16-1999	Hector Mine (M=7.1)	Peltzer, Crampe, & Rosen, 2001
12-22-2003	San Simeon (M=6.5)	Johanson, 2006
10-28-2004	Parkfield (M=6.0)	Johanson et al., 2006
	ALASKA	
03-28-1964	Prince William Sound (M=9.2)	Holdahl and Sauber, 1994
11-03-2002	Denali (M=7.9)	Elliott et al., 2007

Table 2. GPS velocity fields used by Dr. McCaffrey in developing HTDP model for the western United States.

Code	**Number of Sites**	**Weighted RMS,mm/yr**	**Data Source**
ITR5	55	0.66	Altamimi et al. 2007
SNRF	18	0.43	www.unavco.org/research_science/ workinggroups_projects/snarf/snarf.html
DXB2	16	0.85	Dixon et al. 2002
HT04	67	0.86	Hammond & Thatcher 2004
HT05	94	1.01	Hammond & Thatcher 2005
WILL	36	1.14	Williams et al. 2006
CEA1	1,285	1.33	California Earthquake Authority
CMM4	1,195	1.22	Shen et al. 2007
DMEX	12	1.07	Marquez-Azua et al. 2003
PBO7	437	0.95	PBO 4/2007
PNW7	578	0.58	McCaffrey 2007 ; Payne 2007
USGS	306	1.00	USGS website
RWK7	791	1.06	King 2007 ; D'Allesio 2005

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HTDP EXERCISES
January 2, 2008

The following set of exercises is designed to familiarize the user with several capabilities of the HTDP software. Angular brackets identify text that the user should type into the computer. For example, in response to the instruction, "enter <abc>," the
user should type "abc" and then hit the ENTER key or the RETURN key.

%%%

EXERCISE 1. Predicting velocities at individual points

1.1 Enter <htdp.exe> to start the program. Some introductory information should now be displayed on the computer's screen. Hit the ENTER key or the RETURN key to obtain the "MAIN MENU."

1.2 Enter <2> to indicate that you will be predicting velocities.

1.3 Enter a name for the file that will contain the predicted velocities (for example, vfile).

1.4 Enter <1> to indicate that velocities will be predicted relative to the NAD_83(CORS96) reference frame.

1.5 Enter <1> to indicate that you will be entering positional coordinates for individual points in an interactive manner.

1.6 Enter <alpha> for the name of the first point whose velocity will be predicted.

1.7 Enter <1> to specify that you will provide a latitude and a longitude.

1.8 Enter <38,6,12.96> to denote that the latitude of alpha is 38° 06' 12.96" N.

1.9 Enter <122,56,7.80> to denote that the longitude of alpha is 122° 56' 7.80" W.

1.10 Enter <0.> to denote that the ellipsoid height of alpha is 0. meters.

The screen should now be displaying the following information:

```
Northward velocity =  37.78 mm/yr.
Eastward velocity  = -24.48 mm/yr.
Upward velocity    =  -1.24 mm/yr.
X-dim. velocity    =  -7.33 mm/yr.
Y-dim. velocity   =   33.70 mm/yr.
Z-dim. velocity   =   28.96 mm/yr.
```

1.11 The screen should also be displaying the menu for continuing. Enter <1> to predict the velocity for another point.

1.12 Enter <beta> for the name of this second point.

1.13 Enter <1> to specify that you will provide a latitude and a longitude.

1.14 Enter <36,40,11.28> to specify the latitude of beta.

1.15 Enter <121,46,19.92> to specify the longitude of beta.

1.16 Enter <0.> to specify the ellipsoid height of beta.

The screen should now be displaying the following information:

```
Northward velocity =  37.26 mm/yr.
Eastward velocity  = -26.16 mm/yr.
Upward velocity    =  -1.20 mm/yr.
X-dim. velocity    = -10.02 mm/yr.
Y-dim. velocity    =  33.52 mm/yr.
Z-dim. velocity    =  29.17 mm/yr.
```

1.17 If you wish to predict velocities for additional points, then you may enter <1> and proceed as before. Otherwise, enter <0> to return to the main menu.

At this time, it is instructive to inspect the output file that contains the predicted velocities. This is the file whose name was specified in Step 1.3. If you have a windowing capability, then you may open another window to read this file. Otherwise, enter <0> to exit the HTDP software so that you may read this file. Note that this file contains all the information pertinent to the velocities that were predicted.

1.18 If you exited the program, enter <htdp.exe> to restart it, then hit the ENTER key, and then enter <2> to predict more velocities. If you did not exit the program, just then enter <2>.

1.19 Enter a name for a new file that will contain the additional velocities to be predicted. (Caution: if you enter the same name as was entered in Step 1.3, then the software will overwrite the previous file.)

1.20 Enter <0> to indicate that the following velocities will be calculated relative to a specified point having a specified velocity.

1.21 Enter <alpha> for the name of the reference point.

1.22 Enter <1> to specify that you will provide a latitude and a longitude.

1.23 Enter <38,6,12.96> for the latitude of alpha.

1.24 Enter <122,56,7.80> for the longitude of alpha.

1.25 Enter <0.> for the ellipsoid height of alpha.

1.26 Enter <5.> to indicate that the northward velocity of alpha is to be 5.00 mm/yr.

1.27 Enter <0.> to indicate that the eastward velocity of alpha is to be 0.00 mm/yr.

1.28 Enter <1> to indicate that you will be specifying individual points in an interactive manner.

1.29 Enter <beta> for the name of the first point whose velocity relative to alpha is to be predicted.

1.30 Enter <1> to specify that you will provide a latitude and a longitude.

1.31 Enter <36,40,11.28> for the latitude of beta.

1.32 Enter <121,46,19.92> for the longitude of beta.

1.33 Enter <0.> for the ellipsoid height of beta.

The screen should now be displaying the following information:

```
Northward velocity =   4.48 mm/yr.
Eastward velocity  =  -1.69 mm/yr.
Upward velocity    =   0.04 mm/yr.
X-dim. velocity    =  -0.04 mm/yr.
Y-dim. velocity    =   3.14 mm/yr.
Z-dim. velocity    =   3.62 mm/yr.
```

Note that 4.48 = 37.26 - 37.78 + 5.00 where
37.26 is the northward velocity of beta relative to the NAD_83 reference frame,
37.78 is the northward velocity of alpha relative to the NAD_83 reference frame, and
5.00 is to be the northward velocity of alpha in our local reference system.

Similarly, the eastward velocity of -1.69 mm/yr equals (within 0.01 mm/yr due to rounding) the difference between the eastward velocities of beta and alpha in the NAD_83 reference frame.

The astute user may recognize that this formula for computing relative velocities is not mathematically rigorous because of Earth's curvature. The error grows as a function of distance from the reference point.

1.34 Enter <0> to return to the main menu.

This concludes Exercise 1. You may find it instructive to inspect the output file whose name was specified in step 1.19.

%%

EXERCISE 2. Predicting displacements at individual points.

2.1 If needed, enter <htdp.exe> to start the program. Then hit the ENTER key to obtain the MAIN MENU.

2.2 From the MAIN MENU enter <1> to select the option for predicting displacements between two dates.

2.3 Enter <1,1,1985> to indicate that the first date is January 1, 1985.

2.4 Enter <1,1,1995> to indicate that the second date is January 1, 1995.

2.5 Enter <dfile1> for the name of the output file that is to contain the predicted displacements.

2.6 Enter <1> to specify that positions and velocities will be expressed in the NAD_83(CORS96) reference frame.

2.7 Enter <1> to indicate that you will enter individual points interactively.

2.8 Enter <beta> for the name of the first point whose displacement from January 1, 1985 to January 1, 1995 is to be predicted.

2.9 Enter <1> to specify that you will provide a latitude and a longitude.

2.10 Enter <36,40,11.28> for the latitude of beta.

2.11 Enter <121,46,19.92> for the longitude of beta.

2.12 Enter <0.> for the ellipsoid height of beta.

2.13 Enter <0> to indicate that the software will predict the velocity to be used in calculating the displacement.

The screen should now be displaying the following information:

```
Northward displacement   =  0.446 meters.
Eastward displacement    = -0.263 meters.
Upward displacement      = -0.016 meters.
```

Recall from Exercise 1 that the northward velocity of beta is 37.26 mm/yr. Thus in 10 years beta moved 0.353 meters northward as a result of its continuous motion. To this displacement, the HTDP software adds those displacements associated with major earthquakes. For example, the point beta moved northward 0.074 meters during the Loma Prieta earthquake (M=7.1) of October 18, 1989. The sum of 0.353 meters and 0.074 meters equals the total predicted displacement of 0.446 meters (with 0.001 meter rounding error) for the 10-year period from January 1, 1985 to January 1, 1995. In the following steps, the displacement that occurred at beta during the Loma Prieta earthquake will be predicted.

2.14 Enter <0> to return to the main menu.

2.15 Enter <1> to predict displacements.

2.16 Enter <10,16,1989> to indicate that the first date is October 16, 1989.

2.17 Enter <10,18,1989> to indicate that the second date is October 18, 1989.

2.18 Enter <dfile2> to name the output file that is to contain the predicted displacements.

2.19 Enter <1> to specify that positions and displacements will be expressed in the NAD_83(CORS96) reference frame.

2.20 Enter <1> to indicate that you will specify individual points interactively.

2.21 Enter <beta> for the point's name.

2.22 Enter <1> to specify that you will provide a latitude and a longitude.

2.23 Enter <36,40,11.28> for the latitude of beta.

2.24 Enter <121,46,19.92> for the longitude of beta.

2.25 Enter <0.> for the ellipsoid height of beta.

2.26 Enter <0> to indicate that the software will predict the velocity to be used in calculating the displacement.

The screen should now be displaying the following information:

```
Northward displacement   =  0.074 meters.
Eastward displacement    = -0.001 meters.
Upward displacement      = -0.004 meters.
```

Displacements associated with the Loma Prieta earthquake can now be predicted for other locations by entering <1> and responding to the prompts. When finished enter <0> to return to the main menu. You may find it instructive to inspect the output files, dfile1 and dfile2, at this time.

This concludes Exercise 2.

%%%

Exercise 3. Predicting velocities for sets of points.

For predicting velocities, the latitudes and longitudes of the points may be entered in several ways in addition to entering individual points interactively. The options include (a) specifying a grid of points, (b) specifying the name of a file that contains the positional information in blue-book format, and (c) specifying a sequence of points on a line (or more precisely, a geodesic curve on Earth's surface). These same options are available for specifying the latitudes and longitudes of points where displacements between two dates are to be predicted.

3.1 If needed, enter <htdp.exe> to start the program. Then hit the ENTER key to obtain the MAIN MENU.

3.2 Starting from the MAIN MENU, enter <2> to predict velocities.

3.3 Enter <vfile1> for the name of the output file that is to contain the predicted velocities.

3.4 Enter <1> to predict velocities relative to the NAD_83(CORS96) reference frame.

3.5 Enter <2> to indicate that the points form a regularly spaced two-dimensional grid on Earth's surface.

3.6 Enter a name to identify the grid (for example, grid1).

3.7 Enter <34,0,0> to indicate that the minimum latitude is 34°00'00" N.

3.8 Enter <35,0,0> to indicate that the maximum latitude is 35°00'00" N.

3.9 Enter <300> to indicate that the latitude spacing is 300 seconds (or equivalently, 5 minutes).

3.10 Enter <118,30,0> to indicate that the minimum longitude is 118°30'00" W.

3.11 Enter <119,10,0> to indicate that the maximum longitude is 119°10'00" W.

3.12 Enter <600> to indicate that the longitude spacing is 600 seconds (or equivalently, 10 minutes).

The screen should now be displaying the menu for specifying additional points at which velocities are to be predicted. Predicted velocities for the grid are contained in vfile1. To examine this file, enter <0> to return to the main menu (and if you do not have a windowing capability, enter <0> to exit the HTDP software).

In vfile1, the first point (the southeast corner of the grid) should have the northward velocity of 29.90 mm/yr and the eastward velocity of -24.97 mm/yr. The last point (the northwest corner) should have the northward velocity of 19.58 mm/yr and the eastward velocity of -14.93 mm/yr.

In the following steps, velocities will be predicted for a set of points in the file bfile.txt which contains data for the California High Precision Geodetic Network. This file is in blue-book format which is the format adopted by the Federal Geodetic Control Subcommittee for transferring geodetic data. For predicting velocities, the HTDP software uses only the blue-book records that have *80* in columns 7 through 10. Furthermore, the program reads only the following fields on these records

Columns	Content	FORTRAN format
15-44	name of point	A30
45-55	latitude (deg-min-sec)	I2,I2,F7.5
56	N or S latitude	A1
57-68	longitude (deg-min-sec)	I3,I2,F7.5
69	W or E longitude	A1

Before predicting velocities for the points in bfile.txt, it may be instructive to examine the contents of this file, especially the *80* records.

3.13 Follow Steps 3.1 through 3.4 as before except use the name, vfile2, for the output file that will contain the predicted velocities.

3.14 Enter <3> to indicate that the points are in a blue-book file.

3.15 Enter <bfile.txt> to specify the name of the blue-book file.

The screen should now be displaying the menu for specifying additional points at which velocities are to be predicted. Predicted velocities for the points in bfile.txt are contained in the file, vfile2.

3.16 To examine vfile2, enter <0> to return to the main menu (and if you do not have a windowing capability, enter <0> to exit the HTDP software).

In vfile2, the first point, AMBOY, should have a northward velocity of 1.23 mm/yr and an eastward velocity of 0.26 mm/yr. The last point, TOMTIT 2, should have a northward velocity of 18.06 mm/yr and an eastward velocity of -12.16 mm/yr.

In the following steps, we will predict velocities for a sequence of points that lie along a line that forms a geodesic curve on Earth's surface.

3.17 Follow Steps 3.1 through 3.4 as before except use the name, vfile3, for the output file that will contain the predicted velocities.

3.18 Enter <4> to indicate that the points lie on a line.

3.19 Enter a name to identify the line (for example, line1).

3.20 Enter <35,17,28.3> to specify the latitude of a point through which the line is to pass. We will refer to this point as the origin.

3.21 Enter <120,15,35.431> to specify the longitude of the origin.

3.22 Enter <90.> to specify that the line is to have an azimuth of 90 degrees (clockwise from north) when it passes through the origin.

3.23 Enter <-5000.,10000.> to specify that velocities will be predicted for points located between 5000 meters before the origin and 10000 meters after the origin.

3.24 Enter <5000.> to specify that the spacing between the points will be 5000 meters.

The screen should now be displaying the menu for specifying additional points at which the velocities are to be predicted. Predicted velocities for the points on the line are contained in the file, vfile3.

3.25 To examine vfile3, enter <0> to return to the main menu (and if you do not have a windowing capability, enter <0> to exit the HTDP software).

The first point in vfile3 should have a northward velocity of 32.61 mm/yr and an eastward velocity of -25.40 mm/yr. This file should contain predicted velocities for four points. The second of these points should correspond to the origin. Note that the origin has the highest latitude of the four points because the line forms a geodesic curve whose azimuth is 90 degrees when passing through the origin.

This concludes Exercise 3.

%%

Exercise 4. Updating positional coordinates at individual points.

4.1 If needed, enter <htdp.exe> to start the program. Then hit the ENTER key to obtain the MAIN MENU.

4.2 Enter <3> to specify that positions will be updated.

4.3 Enter <7,4,1995> to specify that the new coordinates are to correspond to the position of the point on July 4, 1995.

4.4 Enter <1> to specify that positions will be expressed in the NAD_83(CORS96) reference frame.

4.5 Enter <1> to specify that individual points will be entered interactively.

4.6 Enter <5,7,1991> to specify that the input coordinates are to correspond to the position of the point on May 7, 1991.

4.7 Enter <newfile> for the name of the output file that will contain the updated coordinates.

4.8 Enter <alpha> for the name of the point whose positional coordinates will be updated.

4.9 Enter <1> to specify that you will provide a latitude and a longitude.

4.10 Enter <38,6,12.96> for the latitude of alpha on May 7, 1991.

4.11 Enter <122,56,7.80> for the longitude of alpha on May 7, 1991.

4.12 Enter <0.> for the ellipsoid height of alpha on May 7, 1991.

4.13 Enter <0> to indicate that the software will predict the velocity to be used in updating the position.

The screen should now be displaying the following information:

```
Updated latitude =   38 06 12.96510N
Updated longitude = 122 56  7.80418W
Updated Ellip. Ht.=        -0.005 meters
Updated X         =  -2732250.867 meters
Updated Y         =  -4217684.284 meters
Updated Z         =   3914499.284 meters
```

4.14 Enter <n> to indicate that no more coordinates are to be updated at this time.

Examine the file, newfile, at this time. Note that newfile contains both the old and the new coordinates. Also newfile contains the velocities and the (total) displacements applied to update the positional coordinates.

This concludes Exercise 4.

%%%

Exercise 5. Update positional coordinates for points in a blue-book file and update the corresponding observations.

5.1 If needed, enter <htdp.exe> to start the program. Then hit the ENTER key to obtain the MAIN MENU.

5.2 Enter <3> to indicate that coordinates and observations will be updated.

5.3 Enter <7,4,1995> to indicate that the updated coordinates and observations are to correspond to July 4, 1995.

5.4 Enter <1> to specify that positions will be expressed in the NAD 83 reference frame.

5.5 Enter <4> to specify that both coordinates and observations are to be updated. Note that options 2 and 3 allow the user to update one without updating the other.

5.6 Enter <1> to indicate a standard blue-book file will be used.

5.7 Enter <bfile.txt> to indicate that the original coordinates and the non-GPS observations are contained in the file called bfile.txt.

5.8 Enter <newbf> for the name of the blue-book file that will contain the updated coordinates and the updated non-GPS observations.

5.9 Enter <5,7,1991> to specify that input coordinates correspond to the positions on May 7, 1991. For updating an observation, HTDP uses the date that this observation was performed as the starting date. The date of observation is specified within the blue-book file as part of the corresponding observational record.

5.10 Enter <y> to indicate the existence of a file that contains the GPS observations.

5.11 Enter <gfile.txt> to specify that the GPS observational records are contained in the file called gfile.txt.

5.12 Enter <newgf> to specify that the updated GPS records will be contained in the file called newgf.

5.13 Enter <1> to indicate that the GPS vectors are to be transformed to the NAD_83(CORS96) reference frame.

The screen should now be displaying the main menu. You may wish to examine the files, newbf and newgf, at this time. In newbf, the first *80* record is for station AMBOY. The new latitude for AMBOY should equal 34° 33' 31.04913" N. In newgf, the first C record is for a GPS observation involving the station whose ID is 8635 and the station whose ID is 8476. The updated values for this observation should be 89894.4164 meters in X, -59905.9497 meters in Y, and -16773.7910 meters in Z. Also in newgf, columns 52-53 of the first B record should read "02" to indicate that the updated GPS interstation vector has been transformed to the original WGS_84 reference frame which is equivalent to the NAD_83 reference frame. (Note that post-1994 realizations of WGS_84 are not equivalent to NAD_83.)

This concludes exercise 5.

%%%