GPS TOOLBOX - GPS SOFTWARE TOOLBOX for MATLAB®

Version 4

GPS TOOLBOX is a library of MATLAB m-file modules and programs used for the implementation of Global Positioning System (GPS) applications. GPS TOOLBOX enables you to simulate a specific GPS application quickly and easily without the need to code and test the basic GPS algorithms.

Due to the fact that this software tool is primarily addressed to a practicing engineer, effort was made to implement the most efficient algorithms available in the technical literature. When appropriate, more than one module performs the same mathematical computation by using different methods, so you can select the approach that best meets your specific requirements.

The MATLAB GPS TOOLBOX contains numerous main programs that can be modified to fit specific application needs. Once the model of the application is derived or selected, the practitioner can use the software library to implement and test the validity of the proposed GPS application.

All of more than 200 m-files are compatible with MATLAB version 5.0 and higher, and most of them are also compatible with previous versions and Student Edition of MATLAB.

A complete (more than 200-pages) user's guide and reference manual contains detailed documentation for each module/program included in the library. To facilitate the search for a specific function, module/program or input/output file, the manual contains a complete reference table by function as well as lists of all modules, programs in alphabetical order.

There are more than 31 fully explained examples (in excess of 80 pages) with input and output data, and generated plots. In addition, a complete directory containing test examples (softcopy) for all main programs is included.

The major building functions of the GPS TOOLBOX are divided in the following categories:

- GPS related constants and conversion factors
- Angle and coordinate transformations
- Specialized plotting programs
- Specialized statistics related functions
- Special signal processing and Kalman filter functions
- GPS time utilities and related functions
- GPS almanac and other data processing functions
- Trajectory and related utilities
- Satellite position and velocity computation
- Elevation and azimuth determination, and satellite visibility
- DOPs computation, satellite selection and related functions
- Pseudorange and deltarange determination, and related functions
- Determination of user’s position and related functions
- RINEX 2 data processing and position determination
- Basic and Advanced RAIM/FDE functions

- GPS receiver evaluation functions.

The MATLAB source code is royalty free, i.e. the user can incorporate this software in his/her particular application but is not permitted to resell the software **as is** or **with changes.**

Here is a summary of the most significant features of GPS Toolbox software:

- all m-file modules and programs are written in MATLAB language/environment
- all m-file modules are free of input/output statements (except, of course, for those utilities that require printed output/graph, if any)
- all m-file modules are provided with detailed documentation, including scope, usage, description of parameters, remarks/notes, references, external MATLAB macros/ modules used, and date of last update
- all m-file main/test programs are provided with detailed documentation, including scope, usage, list of inputs, list of outputs, references, external MATLAB macros/ modules used, and date of last update
- almost all main/test programs are provided with input/output reference data, and several detailed examples are given
- flexibility, user-friendly, and open-ended strategy. An open-ended strategy was followed which means that the user can either complement the GPS Toolbox services with his own functions or, alternatively, use GPS Toolbox functions as add-ons in conjunction with other libraries.

What is new in version 4 of GPS Software Toolbox

Here is the list of main upgrades and changes:

- a complete RINEX 2 data processing, including the position determination
- GPS receiver specialized functions, including pseudorange and carrier phase analysis, covariance analysis for a 5-state and 8-state GPS receiver models, pseudorange smoothing based on carrier phase data
- reorganization of RAIM/FDE function in basic and advanced sections and the inclusion of HPL/VPL and HEL/VEL determination and related functions
- additional functions in many prior subsections, e.g. satellite velocity computation, SEM almanac processing
- a complete directory containing **test examples (softcopy) for all main programs**
- an expanded section containing **more relevant GPS examples**.

Computer/Software Requirements:

- IBM hardware compatible PC/386/486 or Pentium with Windows 3.1x or higher, and 640 Kbytes of RAM memory; math coprocessor for faster operation.
- MATLAB version 5.0 or higher; most m-file modules/programs are compatible with previous versions as well as the Student Edition of MATLAB

Technical Support:

- free technical support by e-mail or fax to any licensed user
- future versions and updates to keep users current with the latest GPS TOOLBOX developments to any licensed user.

List Price: US$999. Educational discount of 20% is available

Availability: free demo

```
%==========================================================================
%       GPS TOOLBOX  -  GPS SOFTWARE TOOLBOX for Matlab® -- Version 4
%                        List of functions
%==========================================================================
%  (1) GPS related constants and conversion factors
%  convcon          most used conversion constants
%  gpscon           most used GPS constants
%  pz90con          most used PZ-90 constants
%  sgs85con         most used SGS-85 constants
%  wgs72con         most used WGS-72 constants
%  wgs84con         most used WGS-84 constants
%  xcon             main program displaying constants specified in macros
%                   convcon, gpscon, pz90con, sgs85con, wgs72con, and wgs84con
%==========================================================================
%  (2) Angle transformations
%  tadmsrad         degrees/minutes/seconds to radians
%  taraddms         radians to degrees/minutes/seconds
%  xatransf         main program executing angle transformations from/to
%                   degrees/minutes/seconds to/from radians (by selection)
%==========================================================================
%  (3) Coordinate transformations - Point transformation
%  tecefgd          ECEF to geodetic coordinates (direct method)
%  tecefgd2         ECEF to geodetic coordinates (iterative method)
%  tgdecef          geodetic to ECEF coordinates
%  xecef2gd_comp    main program executing comparison between two ECEF to
%                   geodetic transformation methods
%  xptransf         main program executing transformations from/to ECEF/geodetic
%                   to/from geodetic/ECEF coordinates
%==========================================================================
%  (4) Coordinate transformations - Matrix transformation
%  mbllw            GPS body to LLW (Local Level Wander azimuth)
%  mecefeci         ECEF (Earth Centered Earth Fixed) to ECI (Earth Centered
%                   Inertial)
%  mecefenu         ECEF (Earth Centered Earth Fixed) to ENU (East, North, Up)
%  mecefins         ECEF (Earth Centered Earth Fixed) to INS (Wander/ North,
%                   West, Up)
%  mecefllw         ECEF (Earth Centered Earth Fixed) to (Local Level Wander
%                   azimuth)
%  meciecef         ECI (Earth Centered Inertial) to ECEF (Earth Centered Earth
%                   Fixed)
%  menuecef         ENU (East, North, Up) to ECEF (Earth Centered Earth Fixed)
%  menullw          ENU (East, North, Up) to LLW (Local Level Wander azimuth)
%  minsecef         INS (Wander / North,  West, Up) to ECEF (Earth Centered Earth
%                   Fixed)
%  mllwb            LLW (Local Level Wander azimuth) to  GPS body
%  mllwecef         LLW (Local Level Wander azimuth) to ECEF (Earth Centered
%                   Earth Fixed)
%  mllwenu          LLW (Local Level Wander azimuth) to ENU (East North Up)
%  xmtransf         main program generating matrix transformations specified in
%                   the above mentioned list (by selection)
%==========================================================================
%  (5) Coordinate transformations - Vector transformation
%  vbllw            GPS body to LLW (Local Level Wander Azimuth)
%  vecefeci         ECEF (Earth Centered Earth Fixed) to ECI (Earth Centered
%                   Inertial)
%  vecefenu         ECEF (Earth Centered Earth Fixed) to ENU (East, North, Up)
%  vecefgd          ECEF (Earth Centered Earth Fixed) to Geodetic (latitude,
%                   longitude, altitude) for a given position vector and a
%                   reference point
%  vecefins         ECEF (Earth Centered Earth Fixed) to INS (Wander / North,
%                   West, Up)
%  vecefllw         ECEF (Earth Centered Earth Fixed) to LLW (Local Level Wander
%                   azimuth)
%  vecefp90         ECEF (Earth Centered Earth Fixed) to PZ-90 (Parametri Zemli
%                   1990)
%  vecefs85         ECEF (Earth Centered Earth Fixed) to SGS-85 (Soviet Geodetic
%                   System 1985)
```

```
%  veciecef        ECI (Earth Centered Inertial) to ECEF (Earth Centered Earth
%                  Fixed)
%  venuecef        ENU (East, North, Up) to ECEF (Earth Centered Earth Fixed)
%  venugd          ENU (East, North, Up)  to Geodetic (latitude, longitude,
%                  altitude) for a given position vector and a reference point
%  venullw         ENU (East, North, Up) to LLW (Local Level Wander azimuth)
%  vgdecef         Geodetic (latitude, longitude, altitude) to ECEF (Earth
%                  Centered Earth Fixed), for a given position vector specified
%                  by the external points in geodetic coordinates
%  vgdenu          Geodetic (latitude, longitude, altitude) to ENU (East, North,
%                  Up) for a given position vector specified by the external
%                  points in geodetic coordinates
%  vinsecef        INS (Wander / North, West, Up) to ECEF (Earth Centered Earth
%                  Fixed)
%  vllwb           LLW (Local Level Wander azimuth) to  GPS body
%  vllwecef        LLW (Local Level Wander azimuth) to ECEF (Earth Centered
%                  Earth Fixed)
%  vllwenu         LLW (Local Level Wander azimuth) to ENU (East North Up)
%  vp90ecef        PZ-90 (Parametri Zemli 1990) to ECEF (Earth Centered Earth
%                  Fixed)
%  vs85ecef        SGS-85 (Soviet Geodetic System 1985) to ECEF (Earth Centered
%                  Earth Fixed)
%  xvtransf        main program executing vector transformations specified in
%                  the above mentioned list (by selection)
%=========================================================================
%  (6) Specialized plotting programs
%  xpbar           bar graph for a selected column
%  xyp1            x-y graph for a selected column
%  xyp1s           x-y graph for a selected column, with statistics
%  xyp2w           x-y graph for two selected columns in two different
%                  windows/subplots, with statistics
%  xyp3w           x-y graph for three selected columns in three different
%                  windows/ subplots, with statistics
%  xypc2           x-y graph of the difference between columns (from different
%                  files), with statistics
%  xypc2rss        x-y graph for RSS (root sum square) of the difference of
%                  three columns from two files, with statistics
%  xypm            x-y graph for the selected multiple columns
%  xyprss          x-y graph for RSS (root sum square) of three selected
%                  columns, with statistics
%  xyprss2w        x-y graph for RSS (root sum square) of three selected columns
%                  corresponding to position and velocity errors, in two
%                  windows/subplots, with statistics
%  xypvstd         x-y graph for a selected column and the associated envelope
%                  (standard deviation), with statistics
%=========================================================================
%  (7) Specialized statistics related functions
%  cep             circular error probable (CEP)
%  rms             root mean square (RMS) of a sample
%  rms2            modified root mean square (RMS) of a sample (mean of the
                   sample is assumed to be zero)
%  rss             root sum square (RSS) of a three component vector sample
%  rssxy           root sum square (RSS) of a two component vector sample
%  vep             vertical error probable (VEP)
%  statup          running mean, standard deviation and root mean square (rms)
%  xcepvep         main program determining the CEP or VEP of a specified data
%                  set
%  xstat           main program testing the macros: rms, rss, rssxy, and statup
%  xstatc          main program determining the mean, standard deviation and rms
%                  of the elements of a specified column
%=========================================================================
%  (8) Specialized signal processing and Kalman filter functions
%  dcmnorm         normalization of the direction cosines matrix
%  genrn           random numbers with normal (Gaussian) distribution, with mean
%                  and standard deviation specified
%  gmp1            first order Gauss-Markov sequence
%  gmp2            second order Gauss-Markov sequence
```

```
%  kfcov           Kalman filter covariance matrix by using conventional
%                  formulation
%  kfcova          Kalman filter covariance matrix by using alternate
%                  conventional formulation
%  rwalk           random walk process
%  xgenrn          main program generating the random numbers with normal
%                  (Gaussian) distribution and plotting the generated sequence,
%                  histogram, and the normalized auto-correlation sequence
%  xgmp1           main program generating first order Gauss-Markov sequence and
%                  plotting the generated sequence and the normalized auto-
%                  correlation sequence
%  xgmp2           main program generating second order Gauss-Markov sequence
%                  and plotting the generated sequence and the normalized auto-
%                  correlation sequence
%  xkfcov          main program performing the covariance analysis by using the
%                  conventional or alternate conventional Kalman filter
%                  formulation
%  xrwalk          main program generating the random walk process and plotting
%                  the generated sequence and the normalized auto-correlation
%                  sequence
%==========================================================================
%  (9) GPS Time Utilities and related functions
%  cday            determination of the civil day (year, month, day, hour and
%                  fraction) from a specified modified Julian day (with
%                  fraction)
%  doy2ymd         determination of civil date (year, month, day) from day of
%                  year and specified year
%  gpslsec         UTC leap seconds value for a specified year between 1980 and
%                  2059
%  leapyear        determination of the leap year value
%  mjday           determination of the modified Julian day from the civil day
%                  (year, month, day, hour and fraction)
%  timetr          determination of GPS time of transmission based on time of
%                  measurement (reception)
%  ymd2doy         determination of day of year for a specified civil date
%                  (year, month, day)
%  ymd2doy2        determination of day of year for a specified civil date
%                  (year, month, day) - different algorithm
%  ymd2gps         determination of (GPS week, GPS roll number, day of week)
%                  from (year, month, day)
%  xgpslsec        main program determining UTC leap seconds value for a
%                  specified year between 1980 and 2059
%  xgpstime        main program executing GPS time related transformations
%==========================================================================
%  (10) GPS Almanac and other data processing functions
%  elimcol         elimination of a specified column of a two dimensional array
%  elimrow         elimination of a specified row of a two dimensional array
%  msc2f           symmetric matrix storage transformation from compact form
%                  (upper triangular part, column-wise, one-dimensional array)
%                  to full form (all elements, two-dimensional array)
%  msf2c           symmetric matrix storage transformation from full form (all
%                  elements, two-dimensional array) to compact form (upper
%                  triangular part, column-wise, one-dimensional array)
%  selectd         selection of the different elements from a specified array
%  xelimrc         main program testing the elimination of a specified
%                  row/column (see macros elimrow and elimcol)
%  xmisdat         main program determining the missing data into a specified
%                  column of an input data table
%  xread_sem       main program reading SEM almanac data and creating two data
%                  files
%  xread_yuma      main program reading Yuma almanac data and creating two data
%                  files
%  xsortrec        main program sorting the records based on the elements of a
%                  specified column (in ascending order)
%==========================================================================
%  (11) Trajectory and related utilities
%  gcnav           great circle navigation position, velocity, acceleration
```

```
%  geodes          geodetic data for a specified departure-destination pair
%  geoidh          WGS-84 geoid height correction
%  gridwaas        generation of longitude-latitude WAAS grid
%  hpe             horizontal position error (range) when latitude and longitude
%                  of two points are specified
%  trajs           vehicle trajectory in straight segment with constant speed
%  xgcdr           main program determining great circle dead reckoning
%                  trajectory
%  xgcnav          main program determining great circle navigation position,
%                  velocity and acceleration
%  xgeodes         main program determining geodesic when the departure and
%                  destination points are specified
%  xgeoidh         main program determining WGS-84 geoid height correction, and
%                  executing a contour map
%  xgridw          main program plotting the longitude-latitude WAAS grid
%  xhpe            main program determining the horizontal position error
%                  (range)
%  xppva           main program determining acceleration from position/velocity
%                  data, and plotting all relevant trajectory information
%  xppvaj          main program determining acceleration and jerk from  position
%                  and velocity data, and plotting all relevant trajectory
%                  information
%  xtrajs          main program determining the vehicle trajectory with straight
%                  segment and constant speed
%=========================================================================
%  (12) Satellite position and velocity computation
%  svpalm          ECEF satellite position based on almanac data
%  svpeph          ECEF satellite position based on ephemeris data
%  svpvalm         ECEF satellite position and velocity based on ephemeris data
%  xsvpalm         main program determining ECEF satellite position based on
%                  almanac data
%  xsvpcomp        main program determining RSS satellite position difference
%                  based on ephemeris and almanac data, and executing the
%                  corresponding graph
%  xsvpeph         main program determining ECEF satellite position based on
%                  ephemeris data
%  xsvpvalm        computation of ECEF satellite position and velocity based on
%                  almanac data; WGS-84 constants are used
%  xsvpvcomp       computation of RSS between ECEF satellite position/velocity
%                  based on ephemeris and almanac data
%  xsvpveph        computation of ECEF satellite position and velocity based on
%                  ephemeris data; WGS-84 constants are used
%=========================================================================
%  (13) Elevation and azimuth determination, and satellite
%                  visibility
%  eleva           elevation angle and the ECEF unit line-of-sight vector
%  elevar          elevation angle, the ECEF unit line-of-sight vector, and the
%                  range
%  elevaz          elevation angle, azimuth angle, the ECEF unit line-of-sight
%                  vector, and range
%  range           range between two position points
%  uverv           unit vertical vector for a given ECEF position vector
%  xelaz           main program determining elevation and azimuth angles for
%                  specified users, time interval, and all satellites in view
%  xpelaza         main program executing the azimuth-elevation plot for all
%                  satellites in view, and the number of visible satellites plot
%  xpelazs         main program executing graphs related to elevation and
%                  azimuth angles for a specified satellite and selected user
%                  (input file can be generated by xelaz)
%=========================================================================
%  (14) DOPs computation, satellite selection and related
%                  functions
%  dop1            dilution of precision (DOP) quantities when at least 3 line-
%                  of-sight unit vectors are specified
%  dop2            dilution of precision (DOP) quantities when 4 line-of-sight
%                  unit vectors are specified
%  gdopv           approximate geometric dilution of precision (GDOP) when four
```

```
%                 line-of-sight unit vectors are specified
%  hmat           H matrix based on line-of-sight measurements
%  hmatb          H matrix based on line-of-sight and baro measurements
%  hmatbc         H matrix based on line-of-sight, baro and clock measurements
%  hmatc          H matrix based on line-of-sight and clock measurements
%  svsel4         selection of a set of 4 satellites based on minimum GDOP
%  svsel5         selection of a set of 5 satellites based on minimum GDOP
%  svsel6         selection of a set of 6 satellites based on minimum GDOP
%  wdop1          weighted dilution of precision (WDOP) quantities when at
%                 least 3 line-of-sight unit vectors and the corresponding
%                 weighting factors are specified
%  wdop2          weighted dilution of precision (WDOP) quantities when 4 line-
%                 of-sight unit vectors and the corresponding weighting factors
%                 are specified
%  wdopv          weighted dilution of precision (WDOP) quantities when 4 line-
%                 of-sight unit vectors and the corresponding weighting factors
%                 are specified
%  xdop           main program determining dilution of precision (DOP)
%                 quantities by using 2 methods
%  xgdopv         main program determining an approximate value of the
%                 geometric dilution of precision (GDOP)
%  xhmatall       main program testing the construction of the H matrix based
%                 on line-of-sight, baro and clock measurements
%  xmapdop        main program determining repartition of number of visible
%                 satellites and the corresponding DOPs for a specified
%                 geographical area
%  xsvsel         main program executing the selection of 4, 5 or 6 satellites
%                 based on minimum GDOP, and the computation of the
%                 corresponding DOP quantities
%  xwdop          main program computing the weighted dilution of precision
%                 (WDOP) quantities when at least 3 line-of-sight unit vectors
%                 and the corresponding weighting factors are specified
%  xwdopv         main program computing the weighted dilution of precision
%                 (WDOP) quantities when 4 line-of-sight unit vectors and the
%                 corresponding weighting factors are specified
%=========================================================================
%  (15) Pseudorange and Delta range determination and related
%                 functions
%  ionoc          L1 iono correction computation by using Klobuchar model
%  ionocon        setting of Klobuchar model iono constants
%  pionoc         pseudorange measurement corrected for ionospheric effects
%                 based on L1/L2 measured pseudoranges
%  pradr          pseudorange and accumulated delta range
%  tropoc1        tropospheric correction by using a simplified model
%  uclock         user clock bias and drift
%  uercor         user earth rotation correction vector
%  xambig         main program generating ambiguity numbers
%  xionoc         main program determining iono corrections by using Klobuchar
%                 model
%  xmpath         main program generating and saving the multipath pseudorange
%                 errors
%  xpradr         main program generating pseudorange and accumulated delta
%                 range
%  xsaerr         main program generating SA errors
%  xtropoc1       main program generating tropospheric delay contours for a
%                 specified location
%  xuclock        main program generating user clock bias and clock drift
%  xuercor        main program generating and plotting the magnitude of the
%                 earth rotation correction vector for a specified longitude/
%                 latitude grid
%=========================================================================
%  (16) Determination of user's position and related functions
%  uspos4         position fix determination by using Bancroft's algorithm when
%                 4 measurements are known
%  uposdg         position fix determination by using Bancroft's algorithm when
%                 at least 4 measurements are known
%  uposit         position fix determination by using an iterative method when
```

```
%                 at least measurements are known
%  xpfwls         main program determining position fixes using weighted least
%                 squares algorithm when the user is stationary
%  xuposd4        main program determining the user's position fix by using a
%                 direct method when 4 measurements are known
%  xuposdg        main program determining the user's position fix by using a
%                 direct method when at least 4 measurements are known
%  xuposit        main program determining the user's position fix by using an
%                 iterative method when at least 4 measurements are know
%=============================================================================
%  (17) RINEX 2 data processing and position determination
%  svclockc       computation of satellite clock correction. WGS-84 constants
%                 are used.
%  xrinexn        main program reads a RINEX 2 navigation message file and
%                 writes the data into four files containing the header section
%                 main information, the complete navigation section
%                 information, the reduced ephemeris and reduced almanac data
%  xrinexo        main program reads a RINEX 2 observation message file and
%                 writes the data into two files containing the header
%                 information and the main observation data only
%  xuposr         main program computing user position based on RINEX 2
%                 navigation and observation data; no atmospheric corrections
%                 are applied
%  xuposra        main program computing user position based on RINEX 2
%                 navigation and observation data; iono and tropo corrections
%                 are applied
%  xuposrp        main program computing user position based on RINEX 2
%                 navigation and observation data; dual frequency P-code iono
%                 and tropo corrections are applied
%=============================================================================
%  (18) Basic RAIM/FDE functions
%  dhmax          delta_h_max computation (used in RAIM constant alarm rate
%                 algorithm)
%  raimfd         RAIM availability and fault detection by using the parity
%                 vector algorithm (one step implementation)
%  raimst         RAIM availability and fault detection by using the standard
%                 (constant alarm rate) algorithm
%  slopemax       slopemax computation (used in RAIM constant alarm rate
%                 algorithm)
%  xopcr          main program comparing four different implementations of RAIM
%                 decision variable computation
%  xraimda        main program determining the RAIM fault detection
%                 availability for a user selected or defined set of input data
%  xraimea        main program determining the RAIM fault exclusion
%                 availability for a user selected or defined set of input data
%  xraimfd        main program determining RAIM availability and fault
%                 detection by using the parity vector algorithm
%  xraimst        main program determining RAIM availability and fault
%                 detection by using the standard (constant alarm rate)
%                 algorithm
%  xslope         main program determining slopemax and delta_h_max for RAIM
%                 baseline standard (constant alarm rate) algorithm
%=============================================================================
%  (19) Advanced RAIM/FDE functions
%  chi2_dof       probability density function of Chi-square distribution with
%                 specified degrees of freedom
%  fdnt           fault detection normalized thresholds
%  fpbias_c       parity bias for Chi-square distribution with degree of
%                 freedom greater than 1
%  fpbias_g       parity bias for Gauss distribution with one degree of freedom
%  gauss_1        probability density function for the normal Gaussian
%                 distribution
%  heLveL1        horizontal/vertical exclusion level (HEL/VEL) by using a
%                 direct conventional method
%  heLveL2        horizontal/vertical exclusion level (HEL/VEL) by using the
%                 parity method
%  heLveL3        horizontal/vertical exclusion level (HEL/VEL) by using a new
```

```
%                   efficient method
%  hpLvpL1          horizontal/vertical protection level (HPL/VPL) by using a
%                   direct conventional method
%  hpLvpL2          horizontal/vertical protection level (HPL/VPL) by using the
%                   parity method
%  ncchis2_k        probability density function for the non-central Chi-square
%                   distribution, where k is 2 to 10 for the degree of freedom 2
%                   to 10
%  qrupa            Q-R updating algorithm of the measurement matrix when a new
%                   clock measurement is added
%  sdop             sub-dilution of precision (sub-DOP) quantities
%  swdop            sub-weighted dilution of precision (sub-WDOP) quantities
%  xfdnt            main program computing the fault detection normalized
%                   thresholds
%  xheLveL          main program determining the horizontal/vertical exclusion
%                   level (HEL/VEL) by using three different methods
%  xhpLvpL          main program determining the horizontal/vertical protection
%                   level (HPL/VPL)by using two different methods
%  xpbias           main program computing the value of the parity bias for 10
%                   degrees of freedom (dof) by using Gaussian distribution for
%                   dof = 1 and Chi-square distribution for dof > 1
%  xqrupa           main program testing the Q-R updating algorithm of the
%                   measurement matrix when a new clock measurement is added
%  xsdop            main program determining sub-dilution of precision (sub-DOP)
%                   quantities
%  xswdop           main program determining sub-weighted dilution of precision
%                   (sub-WDOP) quantities
%==========================================================================
%  (20) GPS receiver evaluation functions
%  cn0_j            equivalent carrier to noise power density ratio for a
%                   specified jamming level
%  cn0_unj          unjammed carrier to noise power density ratio
%  fom              figure of merit determination based on ICD-059 table
%  pracc_cl         pseudorange accuracy of Costas loop implementation when the
%                   equivalent carrier to noise power density ratio is known
%  prscp            carrier phase smoothed pseudorange by using a first order
%                   filter
%  xcn0_pr          main program executing graphs related to carrier-to-noise
%                   power density ratio and pseudorange accuracy
%  xebudget         main program determining GPS error budget
%  xfom             main program plotting the figure of merit versus estimated
%                   position error for a specified position error range
%  xgpsr5s          main program performing covariance analysis for the 5-state
%                   GPS receiver model (near stationary user)
%  xgpsr8s          main program performing covariance analysis for the 8-state
%                   GPS receiver model (near constant velocity user)
%  xprcp            main program performing pseudorange and carrier phase data
%                   analysis
%  xprscp           main program executing the pseudorange smoothing by carrier
%                   phase data using a first order filter
%==========================================================================
%  Copyright(C)  1996-2008 L3NAV Systems, All Rights Reserved Worldwide.
%==========================================================================
```