4. Processing Examples

The general overview of the processing procedure was given in Chapter 1 (see Figure 1.1). In this chapter we give three examples for the usage of the Bernese GPS Software Version 4. The first example is a regional, the second a local campaign. The third example illustrates the rapid static positioning with the Bernese GPS Software. It should be said that only the basic functions of the software are shown in this chapter. We do not discuss e.g. the usage of a global campaign for orbit determination purposes here. (Actually it is close to impossible to come up with better orbits than those produced by the IGS. Those, interested in orbit determination, find more information in Section 8.3). Likewise we cannot document many other options of the software in this Chapter. The examples illustrate the main steps to create very accurate station coordinates.

4.1 Example 1: Regional Campaign

We use data from six European stations of the IGS Network (Brussell, Josefoslaw, Kootwijk, Onsala, Wettzell, and Zimmerwald). The abbreviations used for the stations are given in Figure 4.1. Four stations were occupied by Rogue receivers, two stations (Josefoslaw and Zimmerwald) by Trimble 4000SSE receivers. The distances between neighboring stations are between 200 and 600 km. Let us call this example `DOCU40_1`. It may be a good idea for new users of the Bernese GPS Software to re-process these data according to the recommendations given in this Chapter. The data belonging to this campaign are available through anonymous ftp (`ubeclu.unibe.ch`) in the directory `AIUB$FTP:[BSWUSER.EXAMPLES]`.

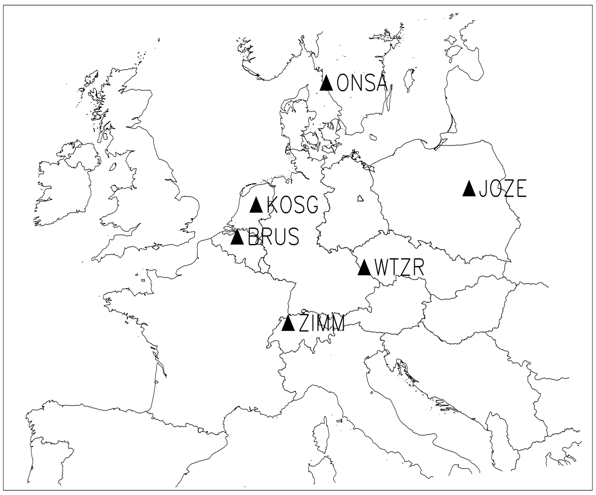

Figure 4.1: Stations used in Campaign `DOCU40_1`

Campaign Setup

The first task is the campaign definition in Menu 1.1. Start the menu system (after the initial `LOADGPS`, see Chapter 24) using the `G 1.1` command (or `G` followed by the selection of the option 1.1). You will then see something like

```
1-1                     CAMPAIGNS: DEFINITION OF NAMES

  Campaign       Start Date      End Date      Path          Comments

> EUROCLUS <   > 13-JUN-96 < > 14-JUN-96 < > C:[  < > BPE DEMO CAMPAIGN <
```

Now, you can simply repeat the line describing the EUROCLUS campaign using the F3 key and overwrite it (press the F1 key to display the corresponding help panel):

```
1-1                     CAMPAIGNS: DEFINITION OF NAMES

  Campaign       Start Date      End Date      Path          Comments

> EUROCLUS <   > 13-JUN-96 < > 14-JUN-96 < > C:[  < > BPE DEMO CAMPAIGN <
> DOCU40_1 <   > 22-JUL-96 < > * OPEN *  < > Q:[  < > EXAMPLE 1         <
```

Note, that we use the VAX/VMS format for the path specification (on Unix system you would specify the path e.g. by `Q:/` , on PC under DOS maybe by `X:\`). The meaning of the variable `Q` or `X` has to be defined in the `LOADGPS` script. After having entered the campaign you leave the panel by pressing Esc twice or the continuation key (see Chapter 3). In the next step the subdirectories for the new campaign have to be created. Use Menu 1.2 to accomplish this task. Now, you may leave the menu system (=`X`) and copy the data into the directories. At the end you should have the following directories and data:

```
Q:[DOCU40_1.ATM]
Q:[DOCU40_1.DATPAN]
                      DAT132__.PAN
Q:[DOCU40_1.OBS]
Q:[DOCU40_1.ORB]
                      R3_96165.PRE
                      R3_96166.PRE
Q:[DOCU40_1.ORX]
Q:[DOCU40_1.OUT]      EXAMP_96.165   EXAMP_96.166
Q:[DOCU40_1.RAW]
                      BRUS1650.960   KOSG1650.960   WTZR1650.960
                      BRUS1660.960   KOSG1660.960   WTZR1660.960
                      JOZE1650.960   ONSA1650.960   ZIMM1650.960
                      JOZE1660.960   ONSA1660.960   ZIMM1660.960
Q:[DOCU40_1.STA]
                      ITRF0696.CRD   EUROCLUS.FIX
                      ITRFCODE.HTR
                      ITRFCODE.STN
```

The file `DAT132__.PAN` is the session table (see below). The precise orbits are in files `*.PRE` (no broadcast navigation messages are used in this example), the raw data (in RINEX format) in `*.960` files. In the station directory `STA` there are three files: `ITRF0696.CRD` contains the a priori coordinates of the stations in the reference frame ITRF93 for epoch 15 June, 1996:

```
ITRF93 EPOCH 1993.0: ITRF93.SSC + TIDB CORR.                    23-DEC-94
--------------------------------------------------------------------------
LOCAL GEODETIC DATUM: WGS - 84          EPOCH: 1996-06-15  0:00:00

NUM  STATION NAME           X (M)          Y (M)          Z (M)     FLAG

121  BRUS 13101M004     4027893.8308    307045.7093   4919475.0352    G
117  JOZE 12204M001     3664940.3155   1409153.7644   5009571.3334    G
153  KOSG 13504M003     3899225.2287    396731.8342   5015078.3421    G
159  ONSA 10402M004     3370658.6287    711877.0401   5349786.8604    G
161  WTZR 14201M010     4075580.6570    931853.6759   4801568.0465    G
158  ZIMM 14001M004     4331297.1682    567555.7538   4633133.8601    G
```

If no a priori coordinate file was available, it would be necessary to create it using Menu 1.4.1. It would be sufficient to just create the header of the coordinate file. A priori coordinates stemming from the RINEX headers might then be written into the a priori coordinate file using the program RXOBV3 (see Panel 2.7.1).

The file `ITRFCODE.HTR` contains the translation table between the antenna heights given in RINEX files and the antenna heights actually used in the Bernese GPS Software:

```
CODE: ANTENNA HEIGHT TRANSLATION TABLE                         02-APR-93  10:00
-------------------------------------------------------------------------------

STATION NAME          RINEX FILE     BERNESE    (99.9999: TAKE VALUE FROM FILE)
****************       **.****       **.****
BRUS 13101M004          3.9702        3.9702
JOZE 12204M001          0.1980        0.1980
KOSG 13504M003          0.1050        0.1050
ONSA 10402M004          0.9950        0.9950
WTZR 14201M010          0.0710        0.0710
ZIMM 14001M004          0.0000        0.0000
```

The reason to use this file has to be seen in fact that some heights in the RINEX files may not be correct or may be measured to a different antenna reference point (this is not the case in our example). Similar problems may show up if the marker (station) names in the RINEX files differ from the names we want to use. The solution is the station name translation table file `ITRFCODE.STN`:

```
CODE: SITE NAME TRANSLATION TABLE                                  6-APR-93 12:12
--------------------------------------------------------------------------------

NUM  OLD STATION NAME  NEW STATION NAME

121  *BRU*             BRUS 13101M004
167  *JOZE*            JOZE 12204M001
153  *KOSG*            KOSG 13504M003
159  *ONSA*            ONSA 10402M004
161  *WETTZELL-1202*   WTZR 14201M010
158  *ZIMM*            ZIMM 14001M004
```

The wildcard (asterisk) may be used in the translation table to specify the old station name.

To process the GPS measurements using the Bernese GPS Software several more files containing general (e.g. not campaign-specific) data are necessary. These files are in the `X:[GEN]` (or `$X/GEN` in Unix notation) directory. The user may specify these general files in Panel 0.3.1:

```
0.3-1                        DEFAULTS: GENERAL DATASET NAMES

General Datasets:
  GEODETIC DATUM     > DATUM.       <    CONSTANTS         > CONST.      <
  PHASE CENTER ECC.  > PHAS_IGS.01  <    RECEIVER INFO     > RECEIVER.   <
  EARTH POTENTIAL    > GEMT3.       <    POLE INFORMATION  > C04_1996.ERP <
  POLE OFFSET COEF.  > POLOFF.      <    LEAP SECONDS      > GPSUTC.     <
  SAT. PARAMETERS    > SATELLIT.TTT <    MANOEUVERS ETC.   > SAT_1996.CRX <
  SINEX GENERAL FILE > SINEX.       <    STATION PROBLEMS  >             <
Extensions:
  IERS BULLETINS     > IER <      RCVR/ANT.NAME TRANSLATION TABLES  > TRN <

Path to the Datasets:           > X:[GEN]                <
Input Files:                      Path                       Extension
  N-,I-,F-FILES                 > U:[INP]                <    > INP <
  SKELETON FILES                > X:[SKL]                <    > SKL <
  PANEL UPDATE DIRECTORY LISTS  > X:[SKL]                <    > UPD <

Auxiliary Files (Scratch Files) > U:[WORK]               <    > SCR <
Error Message File (Full Name): > U:[WORK]ERROR.MSG               <
```

The files in X:[GEN] directory are included in the distribution of the Bernese GPS Software. Later on, when you process your own data, you will have to update the information concerning the pole (file C04_*.ERP) or the SATCRUX file SAT_*.CRX (see Chapter 8). You will find the newest versions of these files in our anonymous ftp directory in AIUB$FTP:[BSWUSER.GEN] (see Chapter 7). Note, that you should use the file SATELLIT.TTT if you use version 4.0 .

The file PHAS_IGS.01 contains the positions (and variations) of the phase centers for various antenna types (see Chapter 17). It is therefore important to use correct antenna and receiver names. If the information in RINEX files is not correct, it is necessary to use a translation table. You will find the file DOCU40_1.TRN in the AIUB$FTP:[BSWUSER.EXAMPLES.DOCU40_1] directory (the file has to be copied into your X:[GEN] directory):

```
RECEIVER AND ANTENNA TYPE TRANS. TABLE                          18-JUL-96 12:56
-------------------------------------------------------------------------------

OLD RECEIV. TYPE  OLD ANTENNA TYPE  NEW RECEIV. TYPE  NEW ANTENNA TYPE

ROGUE SNR-8000    DORNE MARGOLIN T  ROGUE SNR-8000    DORNE MARGOLIN T
TRIMBLE 4000SSE   4000ST L1/L2 GEO  TRIMBLE 4000SSE   4000ST L1/L2 GEO
ROGUE SNR-12 RM   DORNE MARGOLIN B  ROGUE SNR-12 RM   DORNE MARGOLIN B
ROGUE SNR-8000    DORNE MARGOLIN    ROGUE SNR-8000    DORNE MARGOLIN B
TURBOROGUE SNR-8  DORNE MARGOLIN T  ROGUE SNR-8000    DORNE MARGOLIN T
```

Now, you should have all necessary files and may proceed with the actual processing. Start the menu system again (G command) and select Menu 1.3 where you will define the sessions. Please note the usage of the wildcard string ???0 in Panel 1.3.2. The panel shows the session definition for a typical permanent campaign with 24-hours sessions.

```
1.3-2                        CAMPAIGNS: SESSION DEFINITION

SESSION NUMBER          START DATE                  END DATE

    nnnn           yy mm dd     hh mm ss       yy mm dd     hh mm ss

  > ???0 <       >          < > 00 00 00 <   >          < > 23 59 59 <
```

In the next step the user usually prepares an a priori coordinate file in Menu 1.4.1 (or only the header of this file, and the coordinates are then extracted from RINEX files using the program RXOBV3 – see Panel 2.7.1) and the station name translation table (Menu 1.4.2). We may skip these two steps because both files (ITRF0696.CRD and ITRFCODE.STN) are already in the station directory. Optionally, in Menu 1.4.3 the station name abbreviations (necessary for automatic file name generation) may be defined. If you are not interested in special abbreviations, they will automatically be generated when you run the program RXOBV3.

```
1.4-3                      STATION ABBREVIATION TABLE

    Station Name              4-Char Abbreviation     2-Char Abbreviation

  > BRUS 13101M004   <            > BRUS <                  > BR <
  > JOZE 12204M001   <            > JOZE <                  > JO <
  > KOSG 13504M003   <            > KOSG <                  > KO <
  > ONSA 10402M004   <            > ONSA <                  > ON <
  > WTZR 14201M010   <            > WTZR <                  > WT <
  > ZIMM 14001M004   <            > ZIMM <                  > ZI <
```

If you use Menu 1.4.3 to define you own abbreviations, the menu system automatically offers abbreviations but it simply takes the first four or two characters of the station name. You have to make sure that there are not two stations with same the abbreviations. In Menu 1.4.5 the receiver and antenna name translation table may be prepared. In our case you may simply copy the file DOCU40_1.TRN into the directory X:[GEN] .

Transfer Part

The campaign has now been set up and all necessary files are available. The first part of processing consists of the transfer from the RINEX into the Bernese (binary) format. In our example only the RINEX observation files have to be transferred (we do not use the broadcast orbits at all). This is the task of the program RXOBV3 in Menu 2.7.1.

```
2.7.1               TRANSFER: RINEX OBS. to BERNESE  (Main Data Panel)

  CAMPAIGN          > DOCU40_1 <  (blank for selection list)

 Input Files:
  RINEX             >          <  (blank for selection list)
  RINEX EXTENSION   > ??O <       (Wildcards allowed)
  COORDINATES       > NO       <  (NO, if no update; blank for sel.list)

 Translation Tables:
  STATION NAMES     > ITRFCODE <  (NO, if not used; blank for sel.list)
  RCVR / ANTENNA    > DOCU40_1 <  (NO, if not used; blank for sel.list)
  ANTENNA HEIGHTS   > ITRFCODE <  (NO, if not used; blank for sel.list)
  STA.NAMES: STOP   > YES <       (NO or YES, yes=stop if station not found)
  ANT.HGT. : STOP   > YES <       (NO or YES, yes=stop if ant.hgt not found)

 Output Files:
  CODE/PHASE/RANGE >           <  (blank: def.name; NO: do not create)
  RANGES (SLR)      > NO  <       (NO or YES)
```

If the user leaves the option RINEX blank, a selection list of all Q:[DOCU40_1.RAW]*.??O files will appear. Type “s” in the first column to select individual files or “Ctrl--D” to enter the system command level followed by “S ALL” to select all files at the same time.

```
2.7.1-1                    RINEX OBS.: INPUT

 Title Line:
   TITLE         >                                    <

 Signal Strength Requirements:
   MINIMUM SIGNAL STRENGTH              > 1   <    (0-9)
   ACCEPT  SIGNAL STRENGTH = 0          > YES <    (YES or NO)

 Sampling:
   SAMPLING INTERVAL                    > 30  <    (sec; blank: take all obs)
   SAMPLING OFFSET TO FULL MINUTE       > 0   <    (sec)

 Session Numbering:
   LENGTH OF SESSION NUMBERS             > 4 <     (3 or 4 characters)
```

In the two panels above all the options for RXOBV3 are specified. The program produces an output file `RXOBV3.L*` in the directory `Q:[DOCU40_1.OUT]`. This file may be browsed using the `JOB` command or Menu 5.9 . It should looks like

```
*****************************************************************************
TRANSFORMATION OF RINEX OBSERV. FILES INTO BERNESE OBSERV. FILES
*****************************************************************************
...
...
...

  11  Q:[DOCU40_1.RAW]ZIMM1650.960      Q:[DOCU40_1.OBS]ZIMM1650.CZH      2878
                                        Q:[DOCU40_1.OBS]ZIMM1650.CZO
                                        Q:[DOCU40_1.OBS]ZIMM1650.PZH      2878
                                        Q:[DOCU40_1.OBS]ZIMM1650.PZO

  12  Q:[DOCU40_1.RAW]ZIMM1660.960      Q:[DOCU40_1.OBS]ZIMM1660.CZH      2878
                                        Q:[DOCU40_1.OBS]ZIMM1660.CZO
                                        Q:[DOCU40_1.OBS]ZIMM1660.PZH      2878
                                        Q:[DOCU40_1.OBS]ZIMM1660.PZO
```

After finishing RXOBV3 the menu system automatically creates the zero difference observation lists `OBSLIST.CDZ` and `OBSLIST.PHZ` in `Q:[DOCU40_1.DATPAN]`. “Manually” these lists may be created in Menu 5.1.

Orbit part

In this processing example we use only two programs of the orbit part of the Bernese GPS Software. The first program is called PRETAB and may be accessed using Menu 3.2. This menu is common to two programs: PRETAB and BRDTAB. Which of the two is actually used depends on the type of orbits (precise or broadcast) available. We use precise orbits here. The main task of PRETAB is to create tabular files for both days of the campaign (i.e. to transform the precise orbits from the terrestrial into the celestial reference frame). The program generates a satellite clock file, too. This file will be needed in program CODSPP (see below) if no broadcast orbits are used.

```
 3.2                      ORBITS: CREATE TAB.ORBITS

  CAMPAIGN         > DOCU40_1 <     (blank for selection list)

Input File
  EPHEMERIS TYPE   > PRECISE   <    (BROADCAST or PRECISE orbits)
  BROAD./PRECISE   >          <     (blank for selection list)

Output Files
  TAB. ORBIT       >          <     (blank for same names as input orbit
                                     files)
  SATELLITE CLOCKS > DOCU40_1 <     (NO for none, with precise orbits only)

Input Options
  REFERENCE SYSTEM  > J2000 <       (B1950 or J2000)
```

```
3.2-1                 PRETAB: CREATE SATELLITE CLOCK FILE

TITLE  >                                                                    <

                               hh mm ss
INTERVAL FOR POLYNOMIALS     > 12 00 00 <

POLYNOMIAL DEGREE               > 2  <
```

The second program of the orbit part we have to use is called ORBGEN. This program is described in detail in Chapter 8. It prepares the so-called standard orbits using the satellite positions in the tabular orbit files as pseudo-observations for a least-squares adjustment.

```
 3.3                    ORBITS: GENERATE STD.ORBITS

  CAMPAIGN            > DOCU40_1 <     (blank for selection list)

Input File
  TABULAR ORBITS      > R3_96165 <     (NO in case of orbit update,
                                        blank for selection list)
  IMPROVED ORBIT ELE. > NO       <     (NO in case of orbit fit,
                                        blank for selection list)

Output File
  STANDARD ORBITS     > R3_96165 <     (NO, if not to be saved)
  RAD.PRESS. MODEL    > NO       <     (NO, if not to be saved)
  RESIDUALS           > NO       <     (NO, if not to be saved)
```

We recommend to generate one standard orbit file for each session containing satellite orbit arcs of exactly one day, which means that the program ORBGEN has to be run twice (individually for day `165` and `166`).

```
3.3-1                  GENERATE STD.ORBITS: INPUT

 General Options:
   # OF ARCS             > 1   <
   PRINT RESIDUALS       > NO  <     (NO, ALL Iterations, Iteration #)
   ORBIT PREDICTION      > NO  <     (NO, # Days)

 Numerical Integration:
   # OF ITERATIONS       > 2   <
   POLYNOMIAL DEGREE     > 10  <
   LENGTH OF INTERVAL    > 1.0 <     (hours)

 Representation of Variational Equations:
   POLYNOMIAL DEGREE     > 12  <
   LENGTH OF INTERVAL    > 6.0 <     (hours)

 Earth Potential and Time Frame:
   MAX.DEGREE OF EARTH POTENTIAL    > 8   <
   TIME FRAME OF TABULAR ORBITS     > GPS <    (GPS or UTC)
   APPLY ANTENNA OFFSET TO TAB POS  > NO  <    (YES or NO)
```

```
3.3-2                  GENERATE STD.ORBITS: INPUT

 Orbit Model Options:
   PARTIAL DERIV.        > ALLPAR <  (NONPER, DYNALL, ALLPAR)

 Parameter selection:
   D0 estimation (P0)    > YES <     (YES, NO)
   Y0 estimation (P2)    > YES <     (YES, NO)
   X0 estimation         > YES <     (YES, NO)

 Periodic Parameter selection:
   Periodic D terms      > YES <     (YES, NO)
   Periodic Y terms      > YES <     (YES, NO)
   Periodic X terms      > YES <     (YES, NO)
```

The program produces an output file `ORBGEN.L*` (for each run) which should looks like

```
*******************************************************************************
COMPUTATION OF BERNESE STANDARD ORBITS FROM TABULAR POSITIONS   18-JUL-96 14:09
*******************************************************************************
-------------------------------------------------------------------------------
LIST OF INPUT AND OUTPUT FILENAMES
-------------------------------------------------------------------------------

GENERAL CONSTANTS           :  X:[GEN]CONST.
POLE INFORMATION            :  X:[GEN]C04_1996.ERP
SATELLITE INFO              :  X:[GEN]SATELLIT.TTT
COEFFIC. OF EARTH POTENT.   :  X:[GEN]GEMT3.
SATELLITE PROBLEMS          :  X:[GEN]SAT_1996.CRX
ORBITAL ELEMENTS FILE       :   ---
STANDARD ORBITS             :  Q:[DOCU40_1.ORB]R3_96165.STD
RADIATION PRESSURE COEFF.   :   ---
PLOT FILE                   :   ---
RESIDUAL FILE               :   ---
AUX. FILE FOR RESIDUALS     :  U:[WORK]ORBGEN.COP
...
```

```
...
--------------------------------------------------------------------------------
RMS ERRORS AND MAX. RESIDUALS   ARC NUMBER:  1                    ITERATION:  2
--------------------------------------------------------------------------------

                          QUADRATIC MEAN OF O-C (M)         MAX. RESIDUALS (M)
SAT   #POS   RMS (M)     TOTAL   RADIAL  ALONG   OUT       RADIAL  ALONG   OUT
---   ----   -------     ----------------------------     --------------------

  1    96     0.04        0.03     0.02   0.01   0.06        0.03   0.02   0.11
  2    96     0.04        0.04     0.02   0.02   0.06        0.04   0.05   0.10
  3    96     0.04        0.04     0.03   0.03   0.06        0.07   0.07   0.10
  4    96     0.04        0.04     0.02   0.01   0.06        0.04   0.06   0.09

...
```

Maybe the most important information in the output file are the rms errors (see above). These should not be larger than about 5 cm if precise orbits were used (the rms errors depends on the quality of the precise orbits, on the pole file used for the transformation between ITRF and ICRF in PRETAB, and on the orbit model used in ORBGEN). The rms errors of 4 cm which you can see in our output are due to small inconsistencies between the precise orbits `R3*.PRE` and the `C04_1996.ERP` pole. Without this inconsistency (by e.g. using the `*.ERP` file, belonging to the precise orbit file – see Chapter 7) you would obtain something like

```
--------------------------------------------------------------------------------
RMS ERRORS AND MAX. RESIDUALS   ARC NUMBER:  1                    ITERATION:  2
--------------------------------------------------------------------------------

                          QUADRATIC MEAN OF O-C (M)         MAX. RESIDUALS (M)
SAT   #POS   RMS (M)     TOTAL   RADIAL  ALONG   OUT       RADIAL  ALONG   OUT
---   ----   -------     ----------------------------     --------------------

  1    96     0.01        0.01     0.01   0.01   0.01        0.01   0.02   0.04
  2    96     0.01        0.01     0.01   0.01   0.01        0.03   0.02   0.03
  3    96     0.01        0.01     0.01   0.01   0.02        0.01   0.03   0.03
  4    96     0.01        0.01     0.01   0.01   0.01        0.02   0.04   0.03
```

Processing Part

The remaining five programs which we will use are part of the processing part of the Bernese GPS Software. The first program is called CODSPP and its main task is to compute the receiver clock corrections (see Chapter 10). Because we have our orbit information in session-specific files (standard orbit files), we have to start CODSPP twice (to process both sessions, one at a time).

```
 4.2                     PROCESSING: CODE PROCESSING

   CAMPAIGN         > DOCU40_1 <

  Job Identification:
   JOB CHARACTER        >   <        (blank or character from A - Z, 0 - 9)

  Input Files:
   CODE             > ????1650 <     COORDINATES      > ITRF0696 <
   BROADCAST        > NO       <     STANDARD ORBIT   > R3_96165 <
   ECCENTRICITIES   > NO       <     SATELLITE CLOCKS > DOCU40_1 <

  Output Files:
   COORDINATES      > NO       <     RESIDUALS        > NO       <
   PHASE            >          <     RESULT SUMMARY   > NO       <

                                                        See Help Panel
```

```
 4.2-1                     CODE PROCESSING: INPUT 1

  TITLE    > DAY 165, L3 SOLUTION                                  <

  Parameters:
    FREQUENCY                > L3   <    (L1, L2 or L3)
    CLOCK POLY.DEGREE        > E    <    (max. 7, E for one offset per epoch)
    ESTIMATE COORDINATES     > YES  <    (YES or NO)

  Atmosphere Models:
    TROPOSPHERE              > SAAS <    (NO,SAAStamoinen or HOPField)
    IONOSPHERE               > NO   <    (YES or NO)

  Observation Selection:
    MIN. ELEVATION           > 10   <    degrees
    SAMPLING RATE N          > 1    <    (only every n-th observation used)
    OBSERV. WINDOW           > NO   <    (YES.., NO or ASIS)
```

```
 4.2-2                     CODE PROCESSING: INPUT 2

  Print Options:
    RESIDUALS                > NO   <     (YES or NO)
    ELEVATIONS               > NO   <     (YES or NO)

  Iterations:
    MAX. NUMBER OF ITERAT.   > 10 <       (greater than 0)

  Outlier Detection:
    OUTLIER DETECTION        > YES  <     (YES or NO)
    MAX. RESIDUAL ALLOWED    > 100.0   <  meters
    CONFIDENCE INTERVALL     > 5.0     <  (in units of one sigma)
```

If you do not have any accurate geocentric coordinates for the sites you process you should specify a coordinate output file in Panel 4.2 to save the coordinates estimated by CODSPP. For more details on the best way to obtain good *geocentric* coordinates for you local/regional network ss Chapter 10. CODSPP produces the following output:

```
******************************************************************************
COMPUTATION OF SINGLE POINT POSITION         18-JUL-96 14:17
******************************************************************************
...
...

STATION:  BRUS 13101M004   FILE:  Q:[DOCU40_1.OBS]BRUS1650.CZO
------------------------------------------------------------------------------
...
...

RESULTS:
--------

RMS OF UNIT WEIGHT  :        23.54  METERS
NUMBER OF ITERATIONS:         2

STATION COORDINATES:
--------------------

LOCAL GEODETIC DATUM:  WGS - 84

                                   A PRIORI         NEW          NEW- A PRIORI
 BRUS 13101M004    X              4027893.83      4027898.13           4.30
 (MARKER)          Y               307045.71       307045.53          -0.18
                   Z              4919475.04      4919481.87           6.83

                   HEIGHT             149.66          157.66           8.00
                   LATITUDE      50 47 52.141    50 47 52.174     0  0  0.033
                   LONGITUDE      4 21 33.183     4 21 33.157  -  0  0  0.026


CLOCK PARAMETERS:
-----------------

OFFSET FOR REFERENCE EPOCH:    0.000005546 (SEC)

CLOCK OFFSETS STORED IN PHASE OBSERVATION FILE
...
...

******************************************************************************
SUMMARY OF BAD OBSERVATIONS
******************************************************************************
...
...

NUMB FIL  STATION           TYP SAT       FROM               TO          #EP
------------------------------------------------------------------------------

   1   2  JOZE 12204M001    OUT  25  96-06-13  9:26:30  96-06-13  9:26:30
   2   2  JOZE 12204M001    OUT  21  96-06-13 11:50:00  96-06-13 11:50:00
...
...
```

The most important message in the output file is `CLOCK OFFSETS STORED IN PHASE OBSERVATION FILE`. If this message appears in the output you are sure that the receiver clock corrections δ_k (see Chapter 10) computed by CODSPP were actually stored not only in code observation files but also in the phase observation files. After this step we will no longer use the code observations. The a posteriori rms error (for each zero difference file processed) should be checked in the output file from the program CODSPP. A value of about 20–30 m is normal if Selective Availability (SA – artificial degradation of the satellite clock accuracy) is on. Without SA a value of about 3 m could be expected if P-code measurements are available. However, much worse code measurements would still be sufficiently accurate to compute the receiver clock corrections δ_k with the necessary (1 μs) accuracy (see Chapter 10).

The second processing program is called SNGDIF and may be activated through Menu 4.3. SNGDIF creates the single differences and stores them in files (for details see Chapter 10). We use the strategy `OBS-MAX` and we have to run SNGDIF independently for each session:

```
4.3                       PROCESSING: FORM SINGLE DIFF.

   CAMPAIGN                 > DOCU40_1 <  (blank for selection list)

   STRATEGY                 > OBS-MAX   < (MANUAL    (M), SHORTEST (S),
                                           AUTO-STAR (A), OBS-MAX (O), PLUS)
 Input Files:
   MEASUREMENT TYPE         > PHASE    <  (Any  : CODE or PHASE)
   ZERO DIFF. FILE 1        > ????165? <  (Any  : blank for selection list)
   ZERO DIFF. FILE 2        >          <  (M    : blank for selection list)
   COORDINATES              > ITRF0696 <  (S+A+P: blank for selection list)
   ECCENTRICITIES           > NO       <  (S+A+P: NO, blank for sel. list)
   PRE-DEFINED BASELINES    > NO       <  (S+O+P: NO, blank for sel. list)
   CLUSTER DEFINITION       > NO       <  (NO, blank for selection list)
 Output File:
   SINGLE DIFFERENCE        >          <  (Any: blank for default file name,
                                                 HEADER: Header files only)
   BASELINE DEFINITIONS     > NO       <  (NO, if not to be saved)
   CLUSTER DEFINITION       >        <    (enter only if cluster input given)
```

```
4.3-1                    FORM SINGLE DIFFERENCES: INPUT

 Simultaneous Observations:
   MAXIMUM TIME INTERVAL          > 1.50  <     SEC

 Set new Ambiguity:
   AFTER A BREAK OF               > 20    <     MIN
   WHEN CYCLE SLIP FLAG SET        > NO  <      (YES or NO)

 Optimize Baselines (Option O only):
   MAXIMUM BASELINE LENGTH        > 9000  <     KM  (Option O only)
   MINIMUM NUMBER OF OBSERVATIONS > 600   <     Scaled in 1 obs/min/freq

 Observation Filename Format
   LENGTH OF SESSION NUMBER        > 4 <        (4 or 3 characters)
```

The output of SNGDIF simply echoes the zero difference files used and the single difference files created. If the strategy `OBS-MAX` is used the following lines are included:

```
  1 BRUS 13101M004   - JOZE 12204M001   CRIT.:    7969
  2 BRUS 13101M004   - KOSG 13504M003   CRIT.:    9804  OK
  3 BRUS 13101M004   - ONSA 10402M004   CRIT.:    8990
  4 BRUS 13101M004   - WTZR 14201M010   CRIT.:    9392
  5 BRUS 13101M004   - ZIMM 14001M004   CRIT.:    9786
  6 JOZE 12204M001   - KOSG 13504M003   CRIT.:    8538
  7 JOZE 12204M001   - ONSA 10402M004   CRIT.:    7914
  8 JOZE 12204M001   - WTZR 14201M010   CRIT.:    8553  OK
  9 JOZE 12204M001   - ZIMM 14001M004   CRIT.:    8409
 10 KOSG 13504M003   - ONSA 10402M004   CRIT.:    9783  OK
 11 KOSG 13504M003   - WTZR 14201M010   CRIT.:    9813  OK
 12 KOSG 13504M003   - ZIMM 14001M004   CRIT.:   10522  OK
 13 ONSA 10402M004   - WTZR 14201M010   CRIT.:    9297
 14 ONSA 10402M004   - ZIMM 14001M004   CRIT.:    9149
 15 WTZR 14201M010   - ZIMM 14001M004   CRIT.:    9759
```

All possible pairs of zero difference files are listed with the corresponding criterion value. Baselines which were actually taken into the optimal set and created are labeled with “OK”.

The main task of the program MAUPRP is the cycle-slip screening (for details see Chapter 10). We make separate program runs for each session using the following options:

```
4.4.2           PROCESSING: LATEST MANUAL/AUTOMATIC PREPROCESSING

   CAMPAIGN           > DOCU40_1 <    (blank for selection list)

 Input Files:
   SINGLE DIFF.       > ????165? <    (blank for selection list)
   COORDINATES        > ITRF0696 <    (blank for selection list)
   STANDARD ORBIT     > R3_96165 <    (blank for selection list)
   IONOSP. MODELS     > NO       <    (NO, if not used; blank for sel.list)
   ECCENTRICITIES     > NO       <    (NO, if not used; blank for sel.list)
   SATELL. CLOCKS     > NO       <    (NO, if not used; blank for sel.list)

 Output File:
   COORDINATES        > NO       <    (NO, if not to be saved)
   RESIDUALS          > NO       <    (NO, if not to be saved)
```

```
4.4.2-1                   NEW PREPROCESSING: INPUT 1

 General Parameters:
   PROCESSING MODE         > AUTOMATIC <     (MANUAL, AUTOMATIC)
   FREQUENCY TO CHECK      > COMBINED  <     (L1,L2,BOTH or COMBINED)
   SAVE SCREENED FILES        > YES <        (YES or NO)
   ADJUST FREQ./WLFAC.        > YES <        (YES or NO)

 Change Other Options:
   CHANGE OPTIONS             > YES <        (YES.. or NO)

 Saving Coordinates:
   FIXED STATION      >                  <  (AUTO for automatic selection)
```

```
4.4.2-2                    NEW PREPROCESSING: INPUT 2

 Marking of Observations:
   USE MARKING FLAGS IN OBS FILES       > NO   <    (YES or NO)
   MARK OBSERVATIONS BELOW              > 15   <    degrees elevation
   MARK UNPAIRED OBSERVATIONS           > YES  <    (YES or NO)
   MIN.TIME INT. FOR CONTINUOUS OBS     > 301  <    seconds
   OBS STILL CONT IF GAPS SMALLER THAN  > 61   <    seconds

 Non-Parametric Screening:
   PRINTING                             > SUMM <    (NO,SUMMary or ALL)
   SINGLE DIFF. SCREEN.                 > NO   <    (YES.. NO or ASIS
   DOUBLE DIFF. SCREEN.                 > YES  <    (YES.. NO or ASIS)
   MAX. INTERVAL OF FIT                 > 2    <    minutes

 Triple Diff. Solution:
   FREQUENCY                            > L3   <    (L1,L2,L3 or L5)
   APRIORI COORD.SIGMAS                 > NO   <    (YES.. NO or ASIS)
   MAXIMUM OBSERVED-COMPUTED VALUE     > 999.0    <   meters
```

```
4.4.2-2.2         AUTOMATIC PREPROCESSING: DOUBLE DIFF. SCREENING

      Double Diff. Screening:
        POLYNOMIAL DEGREE        > 1 <
        DISCONTINUITY LEVEL     > 0.01   <     meters
```

```
4.4.2-3                    NEW PREPROCESSING: INPUT 3

 Slip Detection:
   PRINTING                           > SUMMARY <   (NO,SUMMARY or ALL)
   ACCEPT SLIPS GREATER THAN          > 10      <   cycles (half)
   TEST OBS WITH CYCLE SLIP FLAG ONLY   > NO  <     (YES or NO)
   L5 IS CLEAN (EXCEPT FLAGGED EPOCHS)  > NO  <     (YES or NO)

 Sigmas:
   L1 OBSERVATIONS                    > 0.0011  <   meters
   L2 OBSERVATIONS                    > 0.0011  <   meters

 Cycles or Half:
   SEARCH L1 FOR                      > CYCLES  <   (CYCLES or HALF)
   SEARCH L2 FOR                      > CYCLES  <   (CYCLES or HALF)

 Search Widths:
   SEARCH WIDTH L1                      > 5   <     integers
   SEARCH WIDTH L5                      > 2   <     integers
```

```
4.4.2-4                    NEW PREPROCESSING: INPUT 4

 Outlier Rejection:
   OUTLIER REJECTION                    > YES <    (YES or NO)
   MAX. OBSERV.GAP                     > 181   <   seconds
   MAX. IONOS.DIFF                     > 400   <   percents of L1 cycles

 Setting of New Ambiguities:
   - IF CYCLE SLIP FLAG SET IN FILE     > NO  <    (YES or NO)
   - IF CYCLE SLIP DETECTION PROBLEM    > YES <    (YES or NO)
   - AFTER A GAP LARGER THAN           > 181   <   seconds
   USE AMBIGUITIES FROM FILE            > NO  <    (YES or NO)
   MINIMUM TIME INTERVAL PER AMBIGUITY > 301   <   seconds
```

The output of the program MAUPRP is discussed in detail in Chapter 10 (the example given there stems from the campaign `DOCU40_1`). It should be pointed out that it is not necessary to run program MAUPRP more than once on each baseline. However, it is mandatory to run MAUPRP again if you (for whatever reason) have to re-start the program SNGDIF and re-create the baseline(s). If you do not have any accurate geocentric coordinates for the sites you process you should specify a coordinate output file in Panel 4.4.2 to save the coordinates estimated by MAUPRP. In that case we recommend not to save the changes done by MAUPRP into the observation files (option `SAVE SCREENED FILES` in Panel 4.4.2–1) but to start the program MAUPRP for the second time with the a priori coordinates stemming from the first run (now you save the observation files, of course).

The least-squares adjustment is the task of program GPSEST. It is a good idea to start GPSEST first in the session mode and to produce an ambiguity-free L_3 solution. We do not expect any final results from this run but we want to check the quality of data and save the residuals after least-squares adjustment. We use the following options:

```
 4.5                     PROCESSING: PARAMETER ESTIMATION

   CAMPAIGN          > DOCU40_1 <    (blank for selection list)

 Job Identification:
   JOB CHARACTER        >   <        (blank, or A..Z, 0..9)

 Input Files:
   PHASE S.DIFF.     > ????165? <    (NO, if not used; blank for sel.list)
   CODE  S.DIFF.     > NO       <    (NO, if not used; blank for sel.list)
   COORDINATES       > ITRF0696 <    (blank for selection list)
   STANDARD ORBIT    > R3_96165 <    (blank for selection list)
   RAD.PRESS.COE.    > NO       <    (NO, if not used; blank for sel.list)
   IONOSP. MODELS    > NO       <    (NO, if not used; blank for sel.list)
   METEO DATA        > NO       <    (NO, if not used; blank for sel.list)
   ECCENTRICITIES    > NO       <    (NO, if not used; blank for sel.list)
   SATELL. CLOCKS    > NO       <    (NO, if not used; blank for sel.list)
```

```
 4.5-0                    PAR. ESTIMATION: OUTPUT FILES

   Output Files:
     COORDINATES          > NO       <    (NO, if not to be saved)
     ORBITAL ELEMENTS     > NO       <    (NO, if not to be saved)
     TROPOSPHERE PARAM.   > NO       <    (NO, if not to be saved)
     IONOSPHERE MODELS    > NO       <    (NO, if not to be saved)
     IONOSPHERE MAPS      > NO       <    (NO, if not to be saved)
     RESIDUALS            > R3_96165 <    (NO, if not to be saved)
     COVARIANCES (COORD)  > NO       <    (NO, if not to be saved)
     COVARIANCES (ALL)    > NO       <    (NO, if not to be saved)
     NORMAL EQUATIONS     > NO       <    (NO, if not to be saved)
     EARTH ROTATION PARA. > NO       <    (NO, if not to be saved)
     POLE IN IERS FORMAT  > NO       <    (NO, if not to be saved)
     GENERAL OUTPUT       > NO       <    (NO, if standard name to be used)
```

```
4.5-1                  PARAMETER ESTIMATION: INPUT 1

  TITLE    >  AMBIGUITY FREE SOLUTION, SESSION 165               <

  Frequency:
    FREQUENCY           > L3    <    (L1,L2,L3,L4,L5,L1&L2,L3&L4,MIXED,
                                      or WUEBBena/Melbourne)
  Fixed Station(s):
    STATION      > $FIRST            <    (blank for sel.list, ALL or NONE,
  Kin.  Station(s):                         SPECIAL_FILE.. $FIRST, $LAST)
    STATION      > NONE             <    (blank for sel.list, ALL or NONE,
                                            SPECIAL_FILE.. $FIRST, $LAST)
  Ambiguities:
    RESOL. STRATEGY     > NO     <    (ROUND,SIGMA..SEARCH..ELIMIN,QIF..NO)
    INTRODUCE WIDELANE  > NO  <       (YES or NO)
    INTRODUCE L1 AND L2 > NO  <       (YES or NO)
    SAVE AMBIGUITIES    > NO  <       (YES or NO)
  Observation selection:
    MIN. ELEVATION      > 15    <    degrees
    SAMPLING RATE       > 0     <    sec (0: all observations)
    OBSERV. WINDOW      > NO    <    (YES.. NO or ASIS)
```

Please note that we do not sample the observations in this run. This is important if we want to check all observations. Consequently the program run could be time consuming. The ambiguities may not be pre-eliminated if residuals should be written into the residual output file.

```
4.5-2                  PARAMETER ESTIMATION: INPUT 2


  Atmosphere Models:
    METEO DATA          > EXTRAPOLATED <  (EXTRAPOLATED or OBSERVED)
    TROPOSPH. MODEL     > SAASTAMOINEN <  (SAASTAMOINEN,HOPFIELD,
                                           ESSEN-FROOME,DRY_SAAST,
                                           DRY_HOPFIELD, or NO)
  Statistics:
    CORRELATIONS        > CORRECT      <  (CORRECT, FREQUENCY, or BASELINE)
    CORREL. INTERVAL       > 1      <     sec
    A PRIORI SIGMA         > 0.002  <     m

  Further Options:
    PRINTING                > NO   <      (YES.. NO or ASIS)
    HELMERT                 > NO   <      (YES.. NO or ASIS)
    ORBIT ADJUSTMENT        > NO   <      (YES.. NO or ASIS)
    SPECIAL REQUESTS        > YES  <      (YES.. or NO)
```

```
4.5-2.4             PARAMETER ESTIMATION: SPECIAL REQUESTS


 Special Requests:

   A PRIORI SIGMAS FOR SITE COORDINATES        > NO   <   (YES.. NO)

   SITE-SPECIFIC TROPOSPHERE PARAMETERS        > YES  <   (YES.. NO)
   STOCHASTIC IONOSPHERE PARAMETERS            > NO   <   (YES.. NO)
   GLOBAL IONOSPHERE MODEL PARAMETERS          > NO   <   (COE.. HGT.. NO)
   EARTH ROTATION PARAMETERS                   > NO   <   (YES.. NO)
   COORDINATES OF CENTER OF MASS               > NO   <   (YES.. NO, ASIS)
   SATELLITE ANTENNA OFFSETS                   > NO   <   (YES.. NO)
   RECEIVER CLOCK ERRORS                       > NO   <   (YES.. NO)

   PARAMETER PRE-ELIMINATION                   > NO   <   (YES.. NO, ASIS)

   SATELLITE-SPECIFIC A PRIORI SIGMAS          > NO   <   (YES.. NO)
```

```
4.5-2.4.0 |     PARAMETER ESTIMATION: SITE-SPECIFIC TROPOSPHERE PARAMETERS

  General Apriori Sigma:              Special Station Sigma: (0.0: NO EST.)
    ABSOLUTE    > 0.10   <  m           ABSOLUTE     > 0.0000 <  m
    RELATIVE    > 5.00   <  m           RELATIVE     > 0.0000 <  m

  Special Station Selection:
    STATIONS    > NONE            <      (blank for selection list, NONE,
                                          SPECIAL_FILE.. $FIRST, $LAST)
  Set-up of Parameters:
    INTERPRET NEXT VALUE AS    > NUM <       (NUM: num/sess; MIN: minutes)
    # PAR/SESS OR PAR INTERVAL > 4   <       (num/sess or minutes)

    MAPPING FUNCTION           > COSZ     <  (COSZ or HOPFIELD)
```

An important information in the output file is the a posteriori rms error:

```
SIGMA OF SINGLE DIFFERENCE OBSERVATION (PART 1):
-----------------------------------------------

SIGMA OF SINGLE DIFFERENCE OBSERVATION:    0.0033 M   (CONVERTED TO L1 PHASE)
```

A posteriori rms error of about 3 mm is expected. If the rms error is higher this probably means that either your data stem from low-quality receivers or that the data were collected under extremely bad conditions or that the pre-processing step (MAUPRP, CODSPP) was not successful. If the residuals have been stored in the files (Panel 4.5–0) it is possible to screen the residuals manually using the program REDISP in Menu 5.3.1 or automatically using the program RESRMS in Menu 5.3.2. RESRMS produces an output file which may be used by the program SATMRK to mark outliers (see Chapter 10 for details).

Now, we process all baselines separately and we resolve the ambiguities using the QIF strategy (see Chapter 15). The following panels show the GPSEST options used for that purpose. Admittedly it is cumbersome to process the baselines "manually" one after the other. This baseline processing mode is necessary because of the tremendous number of parameters. To try to resolve the ambiguities in a session solution might take too much CPU and memory to be feasible. Normally we use Bernese Processing Engine (see Chapter 21) to automate this procedure.

```
 4.5      |                 PROCESSING: PARAMETER ESTIMATION

   CAMPAIGN         > DOCU40_1 <    (blank for selection list)

  Job Identification:
   JOB CHARACTER       >   <        (blank, or A..Z, 0..9)

  Input Files:
   PHASE S.DIFF.     > KOWT1650 <    (NO, if not used; blank for sel.list)
   CODE  S.DIFF.     > NO       <    (NO, if not used; blank for sel.list)
   COORDINATES       > ITRF0696 <    (blank for selection list)
   STANDARD ORBIT    > R3_96165 <    (blank for selection list)
   RAD.PRESS.COE.    > NO       <    (NO, if not used; blank for sel.list)
   IONOSP. MODELS    > NO       <    (NO, if not used; blank for sel.list)
   METEO DATA        > NO       <    (NO, if not used; blank for sel.list)
   ECCENTRICITIES    > NO       <    (NO, if not used; blank for sel.list)
   SATELL. CLOCKS    > NO       <    (NO, if not used; blank for sel.list)
```

```
4.5-0                    PAR. ESTIMATION: OUTPUT FILES

   Output Files:
     COORDINATES          > NO       <    (NO, if not to be saved)
     ORBITAL ELEMENTS     > NO       <    (NO, if not to be saved)
     TROPOSPHERE PARAM.   > NO       <    (NO, if not to be saved)
     IONOSPHERE MODELS    > NO       <    (NO, if not to be saved)
     IONOSPHERE MAPS      > NO       <    (NO, if not to be saved)
     RESIDUALS            > NO       <    (NO, if not to be saved)
     COVARIANCES (COORD)  > NO       <    (NO, if not to be saved)
     COVARIANCES (ALL)    > NO       <    (NO, if not to be saved)
     NORMAL EQUATIONS     > NO       <    (NO, if not to be saved)
     EARTH ROTATION PARA. > NO       <    (NO, if not to be saved)
     POLE IN IERS FORMAT  > NO       <    (NO, if not to be saved)
     GENERAL OUTPUT       > NO       <    (NO, if standard name to be used)
```

```
4.5-1                    PARAMETER ESTIMATION: INPUT 1
  TITLE    >  QIF AMBIGUITY RESOLUTION                             <

  Frequency:
    FREQUENCY           > L1&L2 <    (L1,L2,L3,L4,L5,L1&L2,L3&L4,MIXED,
                                      or WUEBBena/Melbourne)
  Fixed Station(s):
    STATION      > $FIRST            <    (blank for sel.list, ALL or NONE,
  Kin.  Station(s):                        SPECIAL_FILE.. $FIRST, $LAST)
    STATION      > NONE             <    (blank for sel.list, ALL or NONE,
                                           SPECIAL_FILE.. $FIRST, $LAST)
  Ambiguities:
    RESOL. STRATEGY     > QIF    <   (ROUND,SIGMA..SEARCH..ELIMIN,QIF..NO)
    INTRODUCE WIDELANE  > NO  <      (YES or NO)
    INTRODUCE L1 AND L2 > NO  <      (YES or NO)
    SAVE AMBIGUITIES    > YES <      (YES or NO)
  Observation selection:
    MIN. ELEVATION      > 15    <    degrees
    SAMPLING RATE       > 60    <    sec (0: all observations)
    OBSERV. WINDOW      > NO    <    (YES.. NO or ASIS)
```

```
4.5-1.4       PARAMETER ESTIMATION: AMBIGUITY RESOLUTION: QIF STRATEGY

 Quasi-Ionosphere-Free Ambiguity Resolution:
   MAX. NUMBER OF AMB. SOLVED IN ONE ITERATION STEP  > 1    <     (0:All)
   SEARCH WIDTH IN WIDE-LANE CYCLES                  > 0.50   <    cycles
   MAX. RMS OF RESOLVABLE NARROW-LANE AMBIGUITY      > 0.03   <    cycles
   MAX. FRACT. PART OF RESOLVABLE NL AMBIGUITY       > 0.10   <    cycles
```

```
4.5-2                    PARAMETER ESTIMATION: INPUT 2

  Atmosphere Models:
    METEO DATA          > EXTRAPOLATED <  (EXTRAPOLATED or OBSERVED)
    TROPOSPH. MODEL     > SAASTAMOINEN <  (SAASTAMOINEN,HOPFIELD,
                                           ESSEN-FROOME,DRY_SAAST,
                                           DRY_HOPFIELD, or NO)
  Statistics:
    CORRELATIONS        > CORRECT      <  (CORRECT, FREQUENCY, or BASELINE)
    CORREL. INTERVAL       > 1       <     sec
    A PRIORI SIGMA         > 0.002   <     m

  Further Options:
    PRINTING                > NO   <      (YES.. NO or ASIS)
    HELMERT                 > NO   <      (YES.. NO or ASIS)
    ORBIT ADJUSTMENT        > NO   <      (YES.. NO or ASIS)
    SPECIAL REQUESTS        > YES  <      (YES.. or NO)
```

```
4.5-2.4                PARAMETER ESTIMATION: SPECIAL REQUESTS

  Special Requests:

    A PRIORI SIGMAS FOR SITE COORDINATES        > NO   <   (YES.. NO)

    SITE-SPECIFIC TROPOSPHERE PARAMETERS        > YES  <   (YES.. NO)
    STOCHASTIC IONOSPHERE PARAMETERS            > YES  <   (YES.. NO)
    GLOBAL IONOSPHERE MODEL PARAMETERS          > NO   <   (COE.. HGT.. NO)
    EARTH ROTATION PARAMETERS                   > NO   <   (YES.. NO)
    COORDINATES OF CENTER OF MASS               > NO   <   (YES.. NO, ASIS)
    SATELLITE ANTENNA OFFSETS                   > NO   <   (YES.. NO)
    RECEIVER CLOCK ERRORS                       > NO   <   (YES.. NO)

    PARAMETER PRE-ELIMINATION                   > YES  <   (YES.. NO, ASIS)

    SATELLITE-SPECIFIC A PRIORI SIGMAS          > NO   <   (YES.. NO)
```

```
4.5-2.4.0      PARAMETER ESTIMATION: SITE-SPECIFIC TROPOSPHERE PARAMETERS

   General Apriori Sigma:              Special Station Sigma: (0.0: NO EST.)
     ABSOLUTE    > 0.10   <  m           ABSOLUTE     > 0.0000 <  m
     RELATIVE    > 5.00   <  m           RELATIVE     > 0.0000 <  m

   Special Station Selection:
     STATIONS    > NONE            <      (blank for selection list, NONE,
                                           SPECIAL_FILE.. $FIRST, $LAST)
   Set-up of Parameters:
     INTERPRET NEXT VALUE AS    > NUM <       (NUM: num/sess; MIN: minutes)
     # PAR/SESS OR PAR INTERVAL > 4   <       (num/sess or minutes)

     MAPPING FUNCTION           > COSZ     <  (COSZ or HOPFIELD)
```

```
4.5-2.4.7     PARAMETER ESTIMATION: STOCHASTIC IONOSPHERE PARAMETERS

  Stochastic Ionosphere Parameters:

    EPOCH-WISE PRE-ELIMINATION                          > YES <   (YES,NO)
    ELIMINATION OF REFERENCE IONOSPHERE PARAMETERS      > YES <   (YES,NO)

    ABSOLUTE A PRIORI SIGMA ON SINGLE DIFFERENCE LEVEL  > 0.25   < m
    RELATIVE A PRIORI SIGMA OF IONOSPHERIC RANDOM WALK  > 0.00   < m/min**1/2
```

```
4.5-2.4.8                     PARAMETER PRE-ELIMINATION

  Parameters to be Pre-Eliminated: NO= No Pre-Elimination
                                   BI= Before Inversion of Normal Eq. System
                                   AI= After  Inversion of Normal Eq. System
                                   EP= After Each Epoch

    STATION COORD.    > NO <     SAT. ANT.OFF      > NO <   (NO, BI, AI, EP)
    RECEIVER CLOCKS   > NO <     EARTH POTENTIAL   > NO <   (NO, BI, AI, EP)
    ORBIT ELEMENTS    > NO <     HILL RESONANCES   > NO <   (NO, BI, AI, EP)
    AMBIGUITIES       > NO <     EARTH ALBEDO      > NO <   (NO, BI, AI, EP)
    REC.HEIGHT.CALIB. > NO <     CENTER OF MASS    > NO <   (NO, BI, AI, EP)
    SITE TROPOSPHERE  > NO <     DIFF. IONOSPHERE  > EP <   (NO, BI, AI, EP)
    LOCAL IONOSPHERE  > NO <     PHASE CENTER VAR. > NO <   (NO, BI, AI, EP)
    GM VALUE          > NO <     GLOBAL IONOSPHERE > NO <   (NO, BI, AI, EP)
    LOCAL TROPOSPHERE > NO <     ---               > NO <   (NO, BI, AI, EP)
    EARTH ROTATION    > NO <     KIN. COORDINATES  > NO <   (NO, BI, AI, EP)
    STOCH. ORBIT      > NO <                                (NO, BI, AI, EP)
```

In the first part of the output GPSEST echoes the selected options. Then the results of the initial least-squares adjustment (ambiguities estimated as real values) are shown:

```
12. RESULTS (PART 1)
--------------------

NUMBER OF PARAMETERS (PART 1):
-----------------------------

PARAMETER TYPE                                     #PARAMETERS   #PRE-ELIMINATED
----------------------------------------------------------------------------------

STATION COORDINATES                                     3           0
AMBIGUITIES                                           100           0
TROPOSPHERE PARAMETERS FOR INDIVIDUAL STATIONS         24           0
STOCHASTIC IONOSPHERE PARAMETERS                     6472        6472  (EPOCH-WISE)

----------------------------------------------------------------------------------
TOTAL NUMBER OF PARAMETERS                           6599        6472
----------------------------------------------------------------------------------

NUMBER OF DOUBLE DIFFERENCE OBSERVATIONS (PART 1):
-------------------------------------------------

TYPE         FREQUENCY         FILE             #OBSERVATIONS
------------------------------------------------------------------------------------

PHASE           L1              ALL                  6472
PHASE           L2              ALL                  6472


SIGMA OF SINGLE DIFFERENCE OBSERVATION (PART 1):
-----------------------------------------------

SIGMA OF SINGLE DIFFERENCE OBSERVATION:    0.0031 M   (CONVERTED TO L1 PHASE)

STATION COORDINATES:                       (NOT SAVED)
-------------------

NUM  STATION NAME     PARAMETER    A PRIORI VALUE       NEW VALUE     NEW- A PRIORI
------------------------------------------------------------------------------------

161  WTZR 14201M010   X            4075580.6570       4075580.6712      0.0142
                      Y             931853.6759        931853.6809      0.0050
                      Z            4801568.0465       4801568.0409     -0.0056

                      HEIGHT           666.0089           666.0144      0.0056
                      LATITUDE     49  8 39.110742    49  8 39.110258   -0.0149
                      LONGITUDE    12 52 44.068161    12 52 44.068248    0.0018

AMBIGUITIES:
-----------
                                   REFERENCE
AMBI  FILE SAT. EPOCH FRQ WLF CLU  AMBI CLU    AMBIGUITY   RMS   TOTAL AMBIGU.
------------------------------------------------------------------------------------

   1    1   19      1  1   1    1  101  101       -36.66   0.40    -1019130.66
   2    1   19   2458  1   1    3  101  101        -3.59   0.18    17041332.41
   3    1   27      1  1   1    4  101  101       -36.63   0.35     -366132.63
   4    1   27   2579  1   1    6  101  101         8.19   0.21    14104571.19
 ...
 ...
 101    1   14   1750  1   1  101        --- REFERENCE ---           211495.
 102    1   14   1750  2   1  101        --- REFERENCE ---           216914.
```

In the next part of the output the result of the QIF ambiguity resolution algorithm is given:

```
AMBIGUITY RESOLUTION:
--------------------

STRATEGY :  QUASI-IONOSPHERE-FREE AMBIGUITY RESOLUTION (QIF)

-----------------------------------------------------------------------------------------
AMBIGUITY RESOLUTION ITERATION:     1
-----------------------------------------------------------------------------------------

                                BEST INT.    CORRECTIONS IN CYCLES
FILE AM1 CL1 #AM1 AM2 CL2 #AM2   L1   L2    L1      L2     L5      L3    RMS(L3)
-----------------------------------------------------------------------------------------

   1  46  88   1   47  91   1    27   -2   0.19    0.24  -0.053  -0.002   0.008
```

First the individual iteration steps are described (we specified that only one ambiguity may be resolved within each iteration step – see Panel 4.5–1.4 and Chapter 15). The following information is listed for each resolved double-difference ambiguity:

`FILE`	...	file number (`1` in our case; we process one baseline only),
`AM1`	...	first ambiguity number (single-difference level),
`CL1`	...	corresponding ambiguity cluster,
`#AM1`	...	number of ambiguities belonging to the same cluster,
`AM2, CL2, #AM2`	...	similar information for the second ambiguity.
`BEST INT. L1, L2`	...	are the integer corrections to the a priori values (a priori values are computed using the a priori coordinates and may be quite inaccurate).

`CORRECTIONS IN CYCLES` for carriers `L1` and `L2` give the information about the fractional parts of the L_1 and L_2 ambiguities. Much more interesting are the `CORRECTIONS IN CYCLES L5` and `L3`. `L3` is given by eqn. (15.23). The value `L5` represents the ionosphere-induced bias expressed in L_5 cycles. These values may not be greater than the maximum value specified in Panel 4.5–1.4 (option `SEARCH WIDTH IN WIDE LANE CYCLES`). `RMS(L3)` is the criterion according to which the ambiguities are sorted. It is given by eqn. 15.26. Ambiguities with L_3 rms errors larger than the value specified in Panel 4.5–1.4 (namely `0.03`) will not be resolved. The results of the ambiguity resolution are summarized in the following table:

```
                                       REFERENCE
AMBI  FILE SAT. EPOCH FRQ WLF CLU  AMBI CLU    AMBIGUITY   RMS   TOTAL AMBIGU.
-----------------------------------------------------------------------------------------

   1    1   19      1  1   1    1  101  101          -32           -1019126.
   2    1   19   2458  1   1    3   39   72           -1           17041335.
   3    1   27      1  1   1    4    5    7           -2             -366098.
   4    1   27   2579  1   1    6   39   72           11           14104574.
   5    1    2      1  1   1    7   14   23            1           -2332156.
   6    1    2   1890  1   1    9   35   65          -21           -5384982.
   7    1    2   2829  1   1   11  101  101         6.32   0.45    21316752.32
   8    1   26      1  1   1   12  101  101       -31.21   0.26     2851299.79
```

The ambiguities whose RMS is not blank in the table above were not resolved. (these ambiguities will be treated as real values in all subsequent program runs). Ambiguity resolution has an influence on other parameters. The results of the ambiguity-fixed solution are given in Part 2 of the output:

```
13. RESULTS (PART 2)
--------------------

NUMBER OF PARAMETERS (PART 2):
-----------------------------

PARAMETER TYPE                                     #PARAMETERS   #PRE-ELIMINATED

-------------------------------------------------------------------------------------

STATION COORDINATES                                      3           0
AMBIGUITIES                                             20           0
TROPOSPHERE PARAMETERS FOR INDIVIDUAL STATIONS          24           0
STOCHASTIC IONOSPHERE PARAMETERS                      6472        6472  (EPOCH-WISE)

-------------------------------------------------------------------------------------
TOTAL NUMBER OF PARAMETERS                            6519        6472
-------------------------------------------------------------------------------------

NUMBER OF DOUBLE DIFFERENCE OBSERVATIONS (PART 2):
-------------------------------------------------

TYPE         FREQUENCY         FILE             #OBSERVATIONS
-------------------------------------------------------------------------------------

PHASE           L1              ALL                   6472
PHASE           L2              ALL                   6472

-------------------------------------------------------------------------------------
TOTAL NUMBER OF DOUBLE DIFF. OBSERVATIONS            12944
-------------------------------------------------------------------------------------


SIGMA OF SINGLE DIFFERENCE OBSERVATION (PART 2):
-----------------------------------------------

SIGMA OF SINGLE DIFFERENCE OBSERVATION:    0.0034 M   (CONVERTED TO L1 PHASE)


STATION COORDINATES:                       (NOT SAVED)
-------------------

NUM  STATION NAME     PARAMETER    A PRIORI VALUE       NEW VALUE     NEW- A PRIORI
-------------------------------------------------------------------------------------

161  WTZR 14201M010   X            4075580.6570       4075580.6733      0.0163
                      Y             931853.6759        931853.6820      0.0061
                      Z            4801568.0465       4801568.0421     -0.0044

                      HEIGHT           666.0089           666.0168      0.0079
                      LATITUDE     49  8 39.110742    49  8 39.110227   -0.0159
                      LONGITUDE    12 52 44.068161    12 52 44.068277    0.0023
```

You may see from the output that from altogether 100 ambiguities 80 ambiguities could be resolved. This is not a bad result for the QIF strategy considering the fact that the baseline length Kootwijk–Wettzell is about 600 km and that no a priori ionosphere model was used. Using ionosphere models is recommended for baselines longer than about 500 km. You find an example for such a model in the directory AIUB$FTP:[BSWUSER.EXAMPLES.DOCU40_1.ATM]. You may copy the *.ION files into your ATM directory, set the corresponding option in Panel 4.5 and reprocess the baseline once more.

After the loop over all baselines is completed and the ambiguities are resolved you will use the program GPSEST in the session mode. In Panel 4.5 you now select *all* the single difference files of the corresponding session. The next panel is

```
 4.5-0                  PAR. ESTIMATION: OUTPUT FILES

   Output Files:
     COORDINATES          > R3_96165 <    (NO, if not to be saved)
     ORBITAL ELEMENTS     > NO       <    (NO, if not to be saved)
     TROPOSPHERE PARAM.   > NO       <    (NO, if not to be saved)
     IONOSPHERE MODELS    > NO       <    (NO, if not to be saved)
     IONOSPHERE MAPS      > NO       <    (NO, if not to be saved)
     RESIDUALS            > NO       <    (NO, if not to be saved)
     COVARIANCES (COORD)  > NO       <    (NO, if not to be saved)
     COVARIANCES (ALL)    > NO       <    (NO, if not to be saved)
     NORMAL EQUATIONS     > R3_96165 <    (NO, if not to be saved)
     EARTH ROTATION PARA. > NO       <    (NO, if not to be saved)
     POLE IN IERS FORMAT  > NO       <    (NO, if not to be saved)
     GENERAL OUTPUT       > NO       <    (NO, if standard name to be used)
```

We decided to store site coordinates and normal equations in a file named R3_96165.CRD and R3_96165.NEQ respectively (the extensions are automatically added). Important changes have to be made in following two panels

```
 4.5-1                  PARAMETER ESTIMATION: INPUT 1

  TITLE    >  SESSION PROCESSING                                  <

  Frequency:
    FREQUENCY           > L3    <    (L1,L2,L3,L4,L5,L1&L2,L3&L4,MIXED,
                                      or WUEBBena/Melbourne)
  Fixed Station(s):
    STATION      > NONE              <    (blank for sel.list, ALL or NONE,
  Kin.  Station(s):                         SPECIAL_FILE.. $FIRST, $LAST)
    STATION      > NONE             <    (blank for sel.list, ALL or NONE,
                                            SPECIAL_FILE.. $FIRST, $LAST)
  Ambiguities:
    RESOL. STRATEGY     > ELIMIN <   (ROUND,SIGMA..SEARCH..ELIMIN,QIF..NO)
    INTRODUCE WIDELANE  > NO  <      (YES or NO)
    INTRODUCE L1 AND L2 > YES <      (YES or NO)
    SAVE AMBIGUITIES    > NO  <      (YES or NO)
  Observation selection:
    MIN. ELEVATION      > 15    <    degrees
    SAMPLING RATE       > 240   <    sec (0: all observations)
    OBSERV. WINDOW      > NO    <    (YES.. NO or ASIS)
```

```
4.5-2.4 |                 PARAMETER ESTIMATION: SPECIAL REQUESTS

  Special Requests:

    A PRIORI SIGMAS FOR SITE COORDINATES        > YES  <   (YES.. NO)

    SITE-SPECIFIC TROPOSPHERE PARAMETERS        > YES  <   (YES.. NO)
    STOCHASTIC IONOSPHERE PARAMETERS            > NO   <   (YES.. NO)
    GLOBAL IONOSPHERE MODEL PARAMETERS          > NO   <   (COE.. HGT.. NO)
    EARTH ROTATION PARAMETERS                   > NO   <   (YES.. NO)
    COORDINATES OF CENTER OF MASS               > NO   <   (YES.. NO, ASIS)
    SATELLITE ANTENNA OFFSETS                   > NO   <   (YES.. NO)
    RECEIVER CLOCK ERRORS                       > NO   <   (YES.. NO)

    PARAMETER PRE-ELIMINATION                   > NO   <   (YES.. NO, ASIS)

    SATELLITE-SPECIFIC A PRIORI SIGMAS          > NO   <   (YES.. NO)
```

We process the ionosphere-free (L_3) linear combination. No station is kept fixed, ambiguities which have been resolved in the previous runs of program GPSEST using the QIF strategy are introduced as known, the unresolved ambiguities are pre-eliminated. It is possible to use a higher sampling rate. We did not fix any station on its a priori position in Panel 4.5–1, i.e. the coordinates of all stations will be estimated. This is very important to keep the flexibility for later changes of the reference frame (station constrains) with the program ADDNEQ. However, for numerical reasons it is necessary to constrain the coordinates of one station using the following options (the constraints may be remove in ADDNEQ again – see below):

```
4.5-2.4.B| PARAMETER ESTIMATION: A PRIORI SIGMAS: STATIONS AND DEFAULT SIGMA

   Station Selection:
      STATIONS    > $FIRST           <  (blank for selection list, SELECTED,
                                         SPECIAL_FILE.., $FIRST, $LAST)
   Default Sigma per Coordinate:
      SIGMA             > 0.0001  <    (meters)
```

The estimation of troposphere parameters is mandatory. You may try to increase the number of estimated parameters (e.g. 12 instead of 4 parameters per station and session). The output of a 1-session run of the program GPSEST should look like this:

```
12. RESULTS (PART 1)
--------------------

NUMBER OF PARAMETERS (PART 1):
-----------------------------

PARAMETER TYPE                                    #PARAMETERS   #PRE-ELIMINATED
-------------------------------------------------------------------------------------

STATION COORDINATES                                    18           0
AMBIGUITIES                                            67          67  (BEFORE INV)
TROPOSPHERE PARAMETERS FOR INDIVIDUAL STATIONS         72           0

-------------------------------------------------------------------------------------
TOTAL NUMBER OF PARAMETERS                            157          67
-------------------------------------------------------------------------------------

NUMBER OF DOUBLE DIFFERENCE OBSERVATIONS (PART 1):
-------------------------------------------------

TYPE         FREQUENCY         FILE              #OBSERVATIONS
-------------------------------------------------------------------------------------

PHASE           L3              ALL                  8079

-------------------------------------------------------------------------------------
TOTAL NUMBER OF DOUBLE DIFF. OBSERVATIONS            8079
-------------------------------------------------------------------------------------

SIGMA OF SINGLE DIFFERENCE OBSERVATION (PART 1):
-----------------------------------------------

SIGMA OF SINGLE DIFFERENCE OBSERVATION:    0.0033 M   (CONVERTED TO L1 PHASE)
```

After two runs of GPSEST in the session mode the following two normal equation files should be available in the directory `Q:[DOUC40_1.OUT]`

`R3_96165.NEQ` and `R3_96166.NEQ`

and the two coordinate file

`R3_96165.CRD` and `R3_96166.CRD`

in the directory `Q:[DOUC40_1.STA]`. We may now try to compare the coordinates stemming from sessions 165 and 166 using a 6-parameters Helmert transformation (program computing the Helmert transformation is accessible through Menu 5.4.2). The result looks like

```
RESIDUALS IN LOCAL SYSTEM (NORTH, EAST, UP)

-------------------------------------------------------------------
| NUM |      NAME        | FLG |       RESIDUALS IN METERS      |   |
-------------------------------------------------------------------
|     |                  |     |                                |   |
| 121 | BRUS 13101M004   | P P |     0.0014   -0.0003   -0.0013 |   |
| 117 | JOZE 12204M001   | P P |     0.0012    0.0005   -0.0011 |   |
| 153 | KOSG 13504M003   | P P |     0.0016    0.0000    0.0046 |   |
| 159 | ONSA 10402M004   | P P |    -0.0002    0.0007   -0.0022 |   |
| 161 | WTZR 14201M010   | P P |     0.0004   -0.0007    0.0045 |   |
| 158 | ZIMM 14001M004   | P P |    -0.0044   -0.0002   -0.0045 |   |
|     |                  |     |                                |   |
-------------------------------------------------------------------
|     | RMS / COMPONENT  |     |     0.0023    0.0005    0.0037 |   |
-------------------------------------------------------------------

NUMBER OF PARAMETERS  :  6
NUMBER OF COORDINATES : 18
RMS OF TRANSFORMATION :  0.0028 M

PARAMETERS:

TRANSLATION IN  X     :         -0.0012 +- 0.0012 M
TRANSLATION IN  Y     :          0.0004 +- 0.0012 M
TRANSLATION IN  Z     :          0.0108 +- 0.0012 M
ROTATION AROUND X-AXIS:  -  0  0  0.0045 +-  0.0006 "
ROTATION AROUND Y-AXIS:     0  0  0.0005 +-  0.0007 "
ROTATION AROUND Z-AXIS:     0  0  0.0001 +-  0.0005 "
```

From the Helmert transformation we conclude that the results of the two sessions are consistent on the millimeter level.

The last program to be used is program ADDNEQ (see Chapter 18). This program produces the final solution stacking the `*.NEQ` files. If there are two `*.NEQ` files (each file stemming from one session) and there are no correlations between the observations from different sessions, ADDNEQ gives exactly the same results as GPSEST when processing both sessions together. Processing each session separately with program GPSEST and combining the `*.NEQ` files with program ADDNEQ is much more efficient, however. To run program ADDNEQ use Menu 4.8.1 and select the following options:

```
4.8.1                        ADD NORMAL EQUATION SYSTEMS

    CAMPAIGN           > DOCU40_1 <    (blank for selection list)

  Job Identification:
    JOB CHARACTER         >   <        (blank, or characters A - Z, 0 - 9)

  Input Files:
    NORMAL EQUATIONS      >          <    (blank:  sel.list)
    UPDATE CRD.           > NO       <    (NO: not used, blank: sel.list)
    FIX ON SPEC. COORD.   > NO       <    (NO: not used, blank: sel.list)
    A PRIORI VELOC.       > NO       <    (NO: not used, blank: sel.list)
    FIX ON SPEC. VELOC.   > NO       <    (NO: not used, blank: sel.list)
    PLATE TABLE NUVEL1    > NO       <    (NO: not used, blank: sel.list)
    COV. COMPONENT INTRO  > NO       <    (NO: not used, blank: sel.list)
    PRE-DEFINED BASELINES > NO       <    (NO: not used, blank: sel.list)
    SITES FOR REPEATABIL. > NO       <    (NO: not used, blank: sel.list)
```

```
4.8.1-0            ADD NORMAL EQUATION SYSTEMS: OUTPUT FILES

  Output Files:
    COORDINATES          > FINAL    <    (NO, if not to be saved)
    VELOCITIES           > NO       <    (NO, if not to be saved)
    SINEX (CRD+VEL+ERP)  > NO       <    (NO, if not to be saved)
    ORBITAL ELEMENTS     > NO       <    (NO, file name)
    TROPOSPHERE PARAM.   > NO       <    (NO, if not to be saved)
    IONOSPHERE MODELS    > NO       <    (NO, if not to be saved)
    COVARIANCES (COORD)  > NO       <    (NO, if not to be saved)
    COVARIANCES (ALL)    > NO       <    (NO, if not to be saved)
    COVARIANCE COMPON.   > NO       <    (NO, if not to be saved)
    NORMAL EQUATIONS     > NO       <    (NO, if not to be saved)
    EARTH ROTATION PARA. > NO       <    (NO, if not to be saved)
    POLE IN IERS FORMAT  > NO       <    (NO, if not to be saved)
    PLOT FILE            > NO       <    (NO, if not to be saved)
    GENERAL OUTPUT       > NO       <    (NO, if standard name to be used)
```

```
4.8.1-1            ADD NORMAL EQUATION SYSTEMS: INPUT 1

   TITLE    > COMBINED SOLUTION FOR BOTH SESSIONS                   <

 Coordinates:
   FIXED STATIONS      > WTZR 14201M010   <   (blank: sel.list, ALL, NONE,
                                               SPECIAL_FILE, $FIRST, $LAST)
   A PRIORI SIGMAS     > NO   <               (YES, NO)
   FREE SOLUTION COND. > NO  <                (YES, NO)

 Velocities:
   FIXED STATIONS      > NONE             <   (blank: sel.list, ALL, NONE,
                                               SPECIAL_FILE, $FIRST, $LAST)
   A PRIORI SIGMAS     > NO   <               (YES, NO)
   FREE SOLUTION COND. > NO  <                (YES, NO)
   INTRODUCE VELOC.    > NO  <                (YES, NO)
```

```
4.8.1-2            ADD NORMAL EQUATION SYSTEMS: INPUT 2

 Statistics:
   A PRIORI SIGMA                      > 0.002  <     m

 Parameters:
   ORBIT ADJUSTMENT                     > NO   <   (YES, NO, ASIS)
   SITE-SPECIFIC TROPOSPHERE            > YES  <   (YES, NO, ASIS)
   EARTH ROTATION                       > NO   <   (YES, NO, ASIS)
   COORDINATES OF CENTER OF MASS        > NO   <   (YES, NO, ASIS)
   PARAMETER PRE-ELIMINATION            > NO   <   (YES, NO, ASIS)

 Special Options :
   INDIVIDUAL VAR-COVAR RMS ESTIMATION  > NO  <    (YES, NO)
   PROCESSING IN BASELINE MODE          > NO  <    (YES, NO)
```

```
4.8.1-2.2     ADD NORMAL EQUATION SYSTEMS: SITE-SPECIFIC TROPOSPHERE

 A priori Sigma:
    ABSOLUTE                           > 0.10  <    (meters)
    RELATIVE                           > 5.00  <    (meters)

 Modelling:
    CONTINUITY BETWEEN NEQS            > NO  <      (YES, NO)
    NUMBER OF PARAMETERS PER DAY       > 000 <      (0: AS IN NEQ)
```

The final results are contained in the file `FINAL.CRD`: like

```
                                                                23-JUL-96 16:15
--------------------------------------------------------------------------------
LOCAL GEODETIC DATUM: WGS - 84

NUM  STATION NAME           X (M)          Y (M)          Z (M)     FLAG

121  BRUS 13101M004     4027893.8247    307045.7060   4919475.0364    M
153  KOSG 13504M003     3899225.2180    396731.8288   5015078.3529    M
117  JOZE 12204M001     3664940.2842   1409153.7545   5009571.3113    M
161  WTZR 14201M010     4075580.6570    931853.6759   4801568.0465    F
159  ONSA 10402M004     3370658.6274    711877.0473   5349786.8697    M
158  ZIMM 14001M004     4331297.1656    567555.7358   4633133.8579    M
```

Note, that the coordinates of station Wettzell were kept fixed on their a priori values (flag “`F`”).

4.2 Example 2: Local Campaign

The second example is taken from the Turtmann campaign 1993 [*Beutler et al.*, 1995]. The GPS data were made available through the Swiss Federal Office of Topography. For our example we selected five stations and two days of measurements (27. and 28. September 1993, day of year 270 and 271). A simple sketch of the survey is given in Figure 4.2. In this figure the station names, station numbers, and the distances between the stations are included. In this example we will proceed much faster than in the previous section. Actually most of the processing is identical to the case of the regional network of Example 1. Therefore we will point out only the main differences for processing strategy and program options if data stemming from a local campaign are processed.

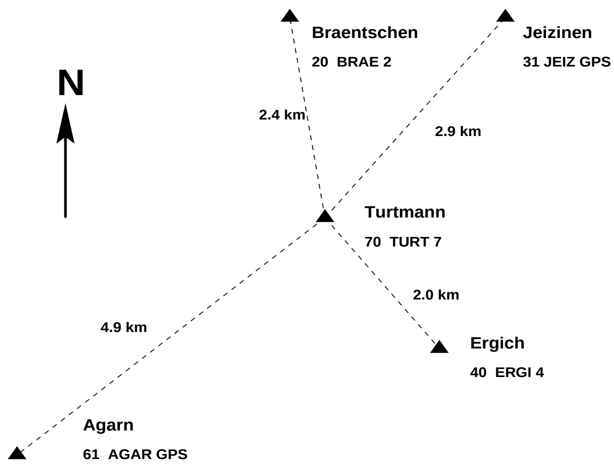

Figure 4.2: Stations used in Campaign DOCU40_2

Those who are interested in re-processing this example will find all necessary data in our anonymous ftp area (see previous section) in the directory

```
AIUB$FTP:[BSWUSER.EXAMPLES.DOCU40_2]
```

Campaign Setup

Use Menu 1.1 to define a new campaign DOCU40_2 and copy the downloaded files in corresponding directories. At the end you should have the following files:

```
Q:[DOCU40_2.ATM]
Q:[DOCU40_2.DATPAN]
                      DAT132__.PAN
Q:[DOCU40_2.OBS]
Q:[DOCU40_2.ORB]
Q:[DOCU40_2.ORX]
Q:[DOCU40_2.OUT]
Q:[DOCU40_2.RAW]
                      AGAR2700.93O  ERGI2700.93O  TURT2700.93N
                      AGAR2710.93O  ERGI2710.93O  TURT2700.93O
                      BRAE2700.93O  JEIZ2700.93O  TURT2710.93N
                      BRAE2710.93O  JEIZ2710.93O  TURT2710.93O
Q:[DOCU40_2.STA]
                      APRIORI.CRD
```

We use the broadcast instead of precise orbits in this example. The baselines are very short and therefore the accuracy of broadcast orbits is considered sufficient for this campaign. However, we use the broadcast orbits only to demonstrate the corresponding processing steps. The advantage of the IGS precise orbits is their much higher reliability and quality and we recommend to use these even for local campaigns. The station names are given in Figure 4.2 and are the same to those in the RINEX files. Therefore, we do not need any station name translation table. The same is true for antenna heights and receiver/antenna names (you will use options "NO" in Panel 2.7.1 later). Before starting the actual processing you have to check two more things: usage of a proper Earth's Rotation Parameter file (e.g. C04_1993.ERP) and the satellite problem file SAT_1993.CRX. You have to set both files in Panel 0.3.1 (both files are available through ftp in AIUB$FTP:[BSWUSER.GEN] (see Chapter 7). Looking at the file SAT_1993.CRX

```
SATELLITE PROBLEMS: MANOEUVRES OR BAD OBSERVATION INTERVALS           12-JUN-92
--------------------------------------------------------------------------------

SATELLITE  PROBLEM    ACTION           FROM                     TO
   **         *         *       YYYY MM DD HH MM SS  YYYY MM DD HH MM SS

   23         0         0       1993 09 20 11 45 00
   24         0         0       1993 09 27 11 45 00
    1         3         1       1993 10 03 23 00 00  1993 10 06 12 00 00
    5         3         1       1993 09 27 00 00 00  1993 10 01 24 00 00
   24         3         1       1993 09 27 00 00 00  1993 10 01 24 00 00
   31         0         0       1993 11 01 00 00 00

PROBLEM:  MANOEUVRE=0, PHASE=1, CODE=2, CODE+PHASE=3
ACTION :  NEW ARC=0, MARK=1, REMOVE=2
```

we see that two problems (satellite numbers 5 and 24) are relevant for our example.

Now, you are ready to start the processing. First it is necessary to define sessions in Menu 1.3. The sessions are 24 hours long and you can use exactly the same session definition as in Example 1. You do not need to prepare an a priori coordinate file in Menu 1.4.1 because such a file already exists in the directory Q:[DOCU40_2.STA] directory (file APRIORI.CRD).

Transfer Part

In Example 2 it is necessary to transfer not only the RINEX observation files into the Bernese format (Menu 2.7.1) but also the navigation messages (broadcast orbits). This has to be done in Menu 2.7.2. This program has no options, only the input files have to be specified by the user. Several files may be processed in one program run.

Orbit Part

There are several small differences in the orbit processing if broadcast orbits instead of precise orbits are used. First of all it is necessary to check the broadcast orbits in Menu 3.1.2. The description of the program BRDTST is given in Chapter 8. Apart from the input (and output) file names the program has no options. Broadcast orbits from both sessions may be checked in one program run. The following message appears in the program output:

```
 SHIFTS:
 ------
              LAST MESSAGE BEFORE SHIFT         FIRST MESSAGE AFTER SHIFT
 NUM  SAT     DATUM     TIME    WEEK   TOE      DATUM     TIME    WEEK   TOE

   1   24    93-09-27 20:00:00   716  158400.  93-09-28  0:51:44   716  175904.
```

However, do not panic. By using the correct satcrux file `SAT_1993.CRX` (see above) the problem of satellite 24 is correctly handled (the observations of satellite 24 will not be used for day 270). In Menu 3.2 (creation of tabular orbits) there are two differences: you have to specify that you are using `BROADCAST` ephemerides and therefore you cannot create a file containing satellite clocks. When running program ORBGEN (Menu 3.3) only one option should be set differently in Panel 3.3–2:

```
3.3-2                     GENERATE STD.ORBITS: INPUT

 Orbit Model Options:
   PARTIAL DERIV.        > ALLPAR <  (NONPER, DYNALL, ALLPAR)

 Parameter selection:
   D0 estimation (P0)    > YES <     (YES, NO)
   Y0 estimation (P2)    > YES <     (YES, NO)
   X0 estimation         > NO  <     (YES, NO)

 Periodic Parameter selection:
   Periodic D terms      > NO  <     (YES, NO)
   Periodic Y terms      > NO  <     (YES, NO)
   Periodic X terms      > NO  <     (YES, NO)
```

It does not make sense to introduce the full orbit model (6+9 parameters) if broadcast orbits are used. The classical (6+2) model is sufficient – see Chapter 8 and Table 8.6.

Processing Part

In program CODSPP the broadcast orbits are used instead of the standard orbits. Because of the fact that the broadcast orbits contain the information about the satellite clocks, too, no additional satellite clock file is required. Be careful to use the corresponding broadcast orbit file for each of the sessions.

```
4.2                          PROCESSING: CODE PROCESSING

   CAMPAIGN          > DOCU40_2 <

 Job Identification:
   JOB CHARACTER         >   <       (blank or character from A - Z, 0 - 9)

 Input Files:
   CODE              > ????270? <     COORDINATES      > APRIORI  <
   BROADCAST         > TURT2700 <     STANDARD ORBIT   > NO       <
   ECCENTRICITIES    > NO       <     SATELLITE CLOCKS > NO       <

 Output Files:
   COORDINATES       > NO       <     RESIDUALS        > NO       <
   PHASE             >          <     RESULT SUMMARY   > NO       <

                                                          See Help Panel
```

In program SNGDIF (Menu 4.3) the options are the same as in Example 1. However, you might try to use the strategy `AUTO-STAR` instead of `OBS-MAX`. This strategy will create the baselines according to Figure 4.2 (forming a “star” with the shortest baseline lengths).

The options of program MAUPRP (Menu 4.4.2) are described in detail in Section 10.5. The second example in that section stems from the Turtmann campaign discussed here. The only difference with respect to the options selected in Example 1 (Section 4.1) is that the strategy `BOTH` instead of `COMBINED` is specified in Panel 4.4.2–1 and that we set the maximum ionosphere difference to 30 % in Panel 4.4.2–4:

```
4.4.2-4                    NEW PREPROCESSING: INPUT 4

 Outlier Rejection:
   OUTLIER REJECTION                    > YES <    (YES or NO)
   MAX. OBSERV.GAP                     > 181   <   seconds
   MAX. IONOS.DIFF                     > 30    <   percents of L1 cycles

 Setting of New Ambiguities:
   - IF CYCLE SLIP FLAG SET IN FILE     > NO  <    (YES or NO)
   - IF CYCLE SLIP DETECTION PROBLEM    > YES <    (YES or NO)
   - AFTER A GAP LARGER THAN           > 181   <   seconds
   USE AMBIGUITIES FROM FILE            > NO  <    (YES or NO)
   MINIMUM TIME INTERVAL PER AMBIGUITY > 301   <   seconds
```

The most important part of the output of program MAUPRP is given in Section 10.5. Note the marked observations of satellite 24 due to the usage of the `SAT_1993.CRX` file.

The last two programs (GPSEST and ADDNEQ) may be used in exactly the same way as in the previous example in Section 4.1. The ambiguity resolution strategy `QIF` may be used for short baselines as well (see Table 15.1). However, processing the L_1 and L_2 frequencies directly and using the `SIGMA` ambiguity resolution strategy works perfectly for baselines up to 10 km, too (except for very short sessions). In this example you may proceed as follows:

1) Use GPSEST in the *session* mode to resolve the ambiguities. (If you do not have enough computer memory or if you exceed maximum dimensions, resolve ambiguities in the baseline mode.)

2) Use GPSEST in the *session* mode to create and store the normal equations.

3) Use ADDNEQ to combine the single-session solutions exactly in the same way as in Section 4.1.

For the first step specify the following options:

```
 4.5-1                   PARAMETER ESTIMATION: INPUT 1

   TITLE    >  SIGMA AMBIGUITY RESOLUTION                          <

   Frequency:
     FREQUENCY           > L1&L2 <    (L1,L2,L3,L4,L5,L1&L2,L3&L4,MIXED,
                                       or WUEBBena/Melbourne)
   Fixed Station(s):
     STATION      > $FIRST            <    (blank for sel.list, ALL or NONE,
   Kin.  Station(s):                        SPECIAL_FILE.. $FIRST, $LAST)
     STATION      > NONE             <    (blank for sel.list, ALL or NONE,
                                            SPECIAL_FILE.. $FIRST, $LAST)
   Ambiguities:
     RESOL. STRATEGY     > SIGMA  <   (ROUND,SIGMA..SEARCH..ELIMIN,QIF..NO)
     INTRODUCE WIDELANE  > NO  <      (YES or NO)
     INTRODUCE L1 AND L2 > NO  <      (YES or NO)
     SAVE AMBIGUITIES    > YES <      (YES or NO)
   Observation selection:
     MIN. ELEVATION      > 15    <    degrees
     SAMPLING RATE       > 240   <    sec (0: all observations)
     OBSERV. WINDOW      > NO    <    (YES.. NO or ASIS)
```

```
4.5-1.1   PARAMETER ESTIMATION: AMBIGUITY RESOLUTION

 Sigma-Dependent Ambiguity Resolution:
   MAX. NUMBER OF AMB. SOLVED IN ONE ITERATION STEP  > 0    <   (0:All)
   AMBIGUITY RESOLVABLE IF EXACTLY 1 INTEGER WITHIN  > 3    <    sigma
   MAXIMAL SIGMA OF A RESOLVABLE AMBIGUITY           > 0.07 <    cycles
   MINIMAL SIGMA OF AMBIGUITY USED FOR TESTS         > 0.05 <    cycles
```

```
4.5-2     PARAMETER ESTIMATION: INPUT 2

   Atmosphere Models:
     METEO DATA          > EXTRAPOLATED <  (EXTRAPOLATED or OBSERVED)
     TROPOSPH. MODEL     > SAASTAMOINEN <  (SAASTAMOINEN,HOPFIELD,
                                            ESSEN-FROOME,DRY_SAAST,
                                            DRY_HOPFIELD, or NO)
   Statistics:
     CORRELATIONS        > BASELINE     <  (CORRECT, FREQUENCY, or BASELINE)
     CORREL. INTERVAL       > 1      <      sec
     A PRIORI SIGMA         > 0.002  <      m

   Further Options:
     PRINTING                > NO   <      (YES.. NO or ASIS)
     HELMERT                 > NO   <      (YES.. NO or ASIS)
     ORBIT ADJUSTMENT        > NO   <      (YES.. NO or ASIS)
     SPECIAL REQUESTS        > YES  <      (YES.. or NO)
```

The only special request to be selected in Panel 4.5–2.4 is the estimation of the site-specific troposphere parameters. 4 tropospheric parameters per station are probably sufficient.

In the second step the normal equations are saved. You may use exactly the same options as in Section 4.1 (do not forget to set the option `CORRELATIONS` in Panel 4.5–2 back to `CORRECT` – option `BASELINE` was used only for ambiguity resolution in the session mode). As in Section 4.1 it is recommended not to fix any station (Panel 4.5–1) but to constrain instead the coordinates of one (arbitrary – e.g. the first) station. The only difference with respect to the options used in Section 4.1 might be the frequency which is processed. Of course, it is possible to use the ionosphere-free (L_3) linear combination again. But for very small campaigns (baselines up to 10 km) better results may be achieved if the L_1 and/or L_2 carriers are used. This is due to the higher noise on L_3. When using L_1 and/or L_2 you should use a local ionosphere model (e.g. generated in Menu 4.5 or Menu 4.7) to correct for the scale factor caused by the ionospheric delays (see Chapter 13 for details concerning the modeling of the ionosphere).

The third and last step consists of one ADDNEQ run. In this step the options are identical to those in Section 4.1. The result of ADDNEQ is a “final” coordinate file which will look like this:

```
                                                                 28-JUL-96 17:30
--------------------------------------------------------------------------------
LOCAL GEODETIC DATUM: WGS - 84          EPOCH: 1993-09-28 11:59:45

NUM  STATION NAME           X (M)          Y (M)          Z (M)     FLAG

 70  TURT               4374374.5092    591480.7579   4589368.7025    F
 61  AGAR               4377340.6500    587795.3918   4588206.3373    M
 20  BRAE               4373504.8856    590748.5292   4591508.3493    M
 40  ERGI               4375515.1932    593027.4684   4588794.8979    M
 31  JEIZ               4373208.2251    593076.6537   4591518.4151    M
```

4.3 Example 3: Rapid Static Positioning

In the third example we want to demonstrate the power of the *general search ambiguity resolution algorithm*. For detail information we refer to Chapter 15 of this documentation and to [*Frei and Beutler*, 1990]. The algorithm allows to resolve the initial phase ambiguities if one or both endpoints of a static baseline were visited only for a short time interval by a receiver (typically 1–5 minutes). The successful resolution of the ambiguities is crucial for the accuracy achieved by rapid static positioning.

Using the rapid static positioning method we have to distinguish between the single-band and the dual-band case. If you have only one observation session and if only six or fewer satellites were observed you have *no chance* to resolve your ambiguities in the single-band case. *Do not trust any results* of this type. If you have two or more short sessions of, let us say, 5 minutes each separated by about one hour (re-occupation method), you have a good chance to resolve your ambiguities even if you only have single-frequency data, provided you process all sessions for the same baseline in the same program run.

If you are processing dual-band data you have a good chance to resolve the ambiguities using the "general search" algorithm, even if you could track only four satellites for 1 to 5 minutes. But you should be aware of the fact, that the statistical tests in the general search algorithm are only valid in the case where *no* systematic influences (e.g. ionosphere induced biases) are present. Therefore extreme care should be taken if baselines longer than 10 km are processed in the rapid static mode.

We give an example based on the same data as used in Example 2 in the previous section (Turtmann 93 Campaign). It makes no sense to repeat all the steps shown there. Actually, the campaign setup, transfer part, orbit part, and pre-processing part would be exactly the same in the case of rapid static positioning. Make sure that you define sessions of at least one hour in length even if your observations merely cover a few minutes, because of the orbit integration in Menu 3.3) Therefore we start directly with the processing of one single difference file (baseline Turtmann-Agarn) with program GPSEST to demonstrate the usage of the general search ambiguity resolution algorithm. The single difference file contains the entire 24-hour session. It is not necessary (and even not recommended) to use the general search for such long sessions (static method). The QIF algorithm is superior to the general search if long sessions are used. Here, we use only 1 minute (3 observation epochs) from the single difference file. This is done by setting an observation window in Panel 4.5–1.2 (be aware that this is only an example; in real life you will probably want to use all available data – but only 1 minute may be available):

```
4.5-1.2              PARAMETER ESTIMATION: OBSERVATION WINDOWS

                   START DATE                END DATE

               yy mm dd     hh mm ss       yy mm dd     hh mm ss

             > 93 09 27 < > 12 00 00 <   > 93 09 27 < > 12 01 00 <
```

The important options are given in the following 3 panels:

```
4.5-1                    PARAMETER ESTIMATION: INPUT 1

  TITLE    >  GENERAL SEARCH AMBIGUITY RESOLUTION                 <

  Frequency:
    FREQUENCY           > L1&L2 <    (L1,L2,L3,L4,L5,L1&L2,L3&L4,MIXED,
                                      or WUEBBena/Melbourne)
  Fixed Station(s):
    STATION      > $FIRST            <    (blank for sel.list, ALL or NONE,
  Kin.  Station(s):                         SPECIAL_FILE.. $FIRST, $LAST)
    STATION      > NONE             <    (blank for sel.list, ALL or NONE,
                                            SPECIAL_FILE.. $FIRST, $LAST)
  Ambiguities:
    RESOL. STRATEGY     > SEARCH <   (ROUND,SIGMA..SEARCH..ELIMIN,QIF..NO)
    INTRODUCE WIDELANE  > NO  <      (YES or NO)
    INTRODUCE L1 AND L2 > NO  <      (YES or NO)
    SAVE AMBIGUITIES    > YES <      (YES or NO)
  Observation selection:
    MIN. ELEVATION      > 15    <    degrees
    SAMPLING RATE       > 0     <    sec (0: all observations)
    OBSERV. WINDOW      > YES   <    (YES.. NO or ASIS)
```

```
4.5-1.3            PARAMETER ESTIMATION: AMBIGUITY RESOLUTION

 General Search Strategy:
   BASELINE-WISE AMBIGUITY RESOLUTION                    > YES <  (YES,NO)

   SEARCH WIDTH IN UNIT OF STD. DEV.                    >  5    <
   MAXIMUM ALLOWED RMS(FIXED)/RMS(FLOAT)                >  2    <
   MINIMUM ALLOWED RMS(2-ND AMB)/RMS(1-ST BEST AMB)     >  1.4  <
   SEARCH WIDTH FOR GEOMETRY-FREE LC (L1 CYCLES)        >  0.1  <
```

```
4.5-2                    PARAMETER ESTIMATION: INPUT 2

  Atmosphere Models:
    METEO DATA          > EXTRAPOLATED <  (EXTRAPOLATED or OBSERVED)
    TROPOSPH. MODEL     > SAASTAMOINEN <  (SAASTAMOINEN,HOPFIELD,
                                           ESSEN-FROOME,DRY_SAAST,
                                           DRY_HOPFIELD, or NO)
  Statistics:
    CORRELATIONS        > BASELINE     <  (CORRECT, FREQUENCY, or BASELINE)
    CORREL. INTERVAL       > 1      <     sec
    A PRIORI SIGMA         > 0.002  <     m

  Further Options:
    PRINTING               > NO   <       (YES.. NO or ASIS)
    HELMERT                > NO   <       (YES.. NO or ASIS)
    ORBIT ADJUSTMENT       > NO   <       (YES.. NO or ASIS)
    SPECIAL REQUESTS       > NO   <       (YES.. or NO)
```

For more information concerning the options in Panel 4.5–1.3 we refer to the corresponding help panel and to Chapter 15. In the first part of the output of program GPSEST (ambiguity-free solution) we may read

```
NUM  STATION NAME  PARAMETER    A PRIORI VALUE       NEW VALUE     NEW- A PRIORI  RMS
-----------------------------------------------------------------------------------------
 61  AGAR          X             4377340.6652     4377340.2669     -0.3983     0.3175
                   Y              587795.3917      587795.4887      0.0970     0.2309
                   Z             4588206.3470     4588206.2934     -0.0536     0.1056
```

Taking into account that the a priori coordinates are excellent it is obvious that with 1 minute data the ambiguity-free solution really does not give satisfactory results. This is also reflected by the formal rms errors of the coordinate estimates. The real-valued estimates of the ambiguities and their formal rms errors are given in the following table:

```
                                                   REFERENCE
 AMBI   FILE SAT. EPOCH FRQ WLF CLU  AMBI CLU    AMBIGUITY   RMS   TOTAL AMBIGU.
 ---------------------------------------------------------------------------

    1     1   14      1  1   1    4    7    1         2.02   2.60      -23509.98
    2     1   15      1  1   1    6    7    1         1.42   1.68       -5258.58
    3     1   31      1  1   1    8    7    1         1.99   1.97      -10553.01
    4     1   14      1  2   1    4    8    1         1.57   2.02      -18319.43
    5     1   15      1  2   1    6    8    1         1.10   1.31       -4097.90
    6     1   31      1  2   1    8    8    1         1.55   1.54       -8223.45
```

The rms errors of the ambiguities are larger than one cycle. Therefore it is necessary to use the general search for ambiguity resolution. The general search algorithm provides the following information:

```
AMBIGUITY RESOLUTION PROTOCOL FOR GENERAL SEARCH:

NUMBER OF NON-AMBIGUITY PARAMETERS:     3  (NOT PRE-ELIMINATED)
NUMBER OF AMBIGUITY PARAMETERS    :     6
NUMBER OF DD-OBSERVATIONS         :    12

SEARCH STATISTICS
-----------------
NUMBER OF AMBIGUITY SETS=                          12.
RMS ACTUALLY COMPUTED   =                           3.
DUMMY SETS              =                           9.

 #   RMS    RMS/RMS1     AMBIGUITIES
------------------------------------

 1 0.0008    1.000     0  0  0  0  0  0
 2 0.0025    3.009     9  9  9  7  7  7
 3 0.0050    6.007    -9  0  0 -7  0  0


AMBIGUITY RESOLUTION SUCCESSFUL
RMS(FIXED)/RMS(FLOAT)              =     1.347
RMS(2-ND AMB SET)/RMS(1-ST AMB SET) =     3.009


                                                   REFERENCE
AMBI   FILE SAT. EPOCH FRQ WLF CLU  AMBI CLU    AMBIGUITY   RMS   TOTAL AMBIGU.
------------------------------------------------------------------------------

   1     1   14      1  1   1    4    7    1           0            -23512.
   2     1   15      1  1   1    6    7    1           0             -5260.
   3     1   31      1  1   1    8    7    1           0            -10555.
   4     1   14      1  2   1    4    8    1           0            -18321.
   5     1   15      1  2   1    6    8    1           0             -4099.
   6     1   31      1  2   1    8    8    1           0             -8225.

   7     1    1      1  1   1    1        --- REFERENCE ---          17232.
   8     1    1      1  2   1    1        --- REFERENCE ---          13428.
```

The ambiguity resolution was successful. The two criteria (`RMS(FIXED)/RMS(FLOAT)` and `RMS(2-ND AMB SET)/RMS(1-ST AMB SET)`) are described in Chapter 15. Please note, that only 4 satellites were tracked. This demonstrates the power of the general search algorithm. The ambiguities were resolved correctly which may be seen from the results of the ambiguity-fixed solution:

```
NUM  STATION NAME  PARAMETER    A PRIORI VALUE       NEW VALUE     NEW- A PRIORI   RMS
---------------------------------------------------------------------------------------

 61  AGAR          X             4377340.6652       4377340.6757      0.0105      0.0012
                   Y              587795.3917        587795.3986      0.0069      0.0006
                   Z             4588206.3470       4588206.3550      0.0080      0.0009
```

The accuracy of the resulting coordinates (about 1 cm, assuming that the a priori coordinates are correct) is typical for rapid static positioning. Note the change in the rms errors of the coordinate estimates with respect to the corresponding values of the ambiguity free solution.

5. Processing and Naming Defaults

The topic of this chapter are the options of the Bernese GPS Software which may be set in Menu 0 In the distributed version of the software most of these options are already set correctly and you will have to change none or only a few of them. Is is important, however, that you are aware of the default options and names.

```
0      DEFAULTS: OPTION MENU

1      PROCESSING      : Default Options for Processing
2 ..   PROGRAM NAMES   : Default Names for Programs
3 ..   DATASET NAMES   : Default Names for Datasets
4 ..   SCRIPT NAMES    : Default Names for Scripts/Command Files
```

The default options for the processing are set in Panel 0.1. This panel is accessible through the "`PRCDEF`" command, too. The options are described in detail in Chapter 3 and in the corresponding help panel. On multitasking systems you will probably want to set the option "`JOB CLASS`" according to your preferences. For special purposes you may wish to set the option "`SUBMIT JOBS`" to "`NO`" (instead of the recommended "`YES`") to be able to edit the input `I-`, `N-` and `F-`files before starting the programs (see Chapter 3).

The names of all the programs which may be started using the menu system are specified in Menu 0.2 The paths to the programs are specified, too. There is little chance that you will ever need to change these program names.

> Exception: you would e.g. like to test a version of the program GPSEST containing modifications of your own. Let us assume that this special program version has the name GPSES1. You would then have to change the program name in Panel 0.2.4 to `GPSES1` and to generate a copy of all skeleton files for the program GPSEST (copy `GPSESTI.SKL` to `GPSES1I.SKL` etc. in the directory `X:[SKL]` or `$X/SKL`, `X:\SKL` in Unix and DOS notation respectively).

Be aware, that if you destroy the settings in panels Menu 0.2, the menu system will not find the executable programs anymore, even if these are still at the right place.

In Menu 0.3 the paths and extensions of all file types used by the Bernese GPS Software are set. The file paths and and the file name extensions are used to distinguish among various kinds of information stored in files. Starting a program using the menu system the user has to specify the names of the input and output files as 8-character strings. The extensions of the file names are appended automatically by the menu system. In the same way the menu system automatically adds the full path to the files using the path to the currently processed campaign and a subdirectory of the campaign (see Chapter 6). The *file name extensions* of the various file types and the *subdirectories* to which the files belong are specified in Panel 0.3.2 – Panel 0.3.5. You may look at these panels but we recommend not to change any settings. The only exception is the Panel 0.3.1 which is accessible using the "`GENFIL`" command, too. The panel looks like

```
0.3-1                    DEFAULTS: GENERAL DATASET NAMES

General Datasets:
  GEODETIC DATUM     > DATUM.        <    CONSTANTS         > CONST.       <
  PHASE CENTER ECC.  > PHAS_IGS.01   <    RECEIVER INFO     > RECEIVER.    <
  EARTH POTENTIAL    > GEMT3.        <    POLE INFORMATION  > C04_1996.ERP <
  POLE OFFSET COEF.  > POLOFF.       <    LEAP SECONDS      > GPSUTC.      <
  SAT. PARAMETERS    > SATELLIT.TTT  <    MANOEUVERS ETC.   > SAT_1996.CRX <
  SINEX GENERAL FILE > SINEX.        <    STATION PROBLEMS  >              <
Extensions:
  IERS BULLETINS     > IER <      RCVR/ANT.NAME TRANSLATION TABLES  > TRN <

Path to the Datasets:           > X:[GEN]                  <
Input Files:                      Path                         Extension
  N-,I-,F-FILES                 > U:[INP]                  <    > INP <
  SKELETON FILES                > X:[SKL]                  <    > SKL <
  PANEL UPDATE DIRECTORY LISTS  > X:[SKL]                  <    > UPD <

Auxiliary Files (Scratch Files) > U:[WORK]                 <    > SCR <
Error Message File (Full Name): > U:[WORK]ERROR.MSG                <
```

and probably you will have to update two options, namely:

`POLE INFORMATION:` the file which contains the earth orientation parameters for the time span of the currently processed campaign, and

`MANOEUVERS ETC. :` the file which contains the information about satellite problems.

The newest versions of these files are available on our anonymous ftp account (`ubeclu.unibe.ch`) in the directory `AIUB$FTP:[BSWUSER.GEN]`. Maybe, you want to change the file containing the information about receiver antenna phase centers and their variations (option "`PHASE CENTER ECC.`"). For details see Chapter 17. We do not recommend to change the other options in Panel 0.3.1 . Be aware of the fact that these general files are used by many programs without that it is necessary to specify them explicitly when preparing a program run with the menu system. The files given in Panel 0.3.1 will be attached automatically.

There are two important programs in the Bernese GPS Software which create output file names automatically, namely RXOBV3 and SNGDIF. The first program creates zero difference observation files from RINEX files, the second program creates single-difference observation files using zero-difference files. The content of these files is described in Chapter 23. Let us present the naming convention for the observation files (the naming conventions used for RINEX files is given in Chapter 7).

There are four types of zero-difference files, distinguished by their extensions: `.PZH`, `.PZO`, `.CZH`, `.CZO` (the content of these files is explained in Chapter 23). For the 8-character names of these files we use the following convention:

`XXXXssss` or `XXXXsssn` ,

where

`XXXX`	is the 4-character abbreviation of the station name (see Panel 1.4.3 and an example in Chapter 4),
`ssss` or `sss`	is the session number (4-character session names or 3-character session names may be used – see the options of the program RXOBV3,
`n`	is the file order number within the session if there are more files belonging to one session or 0 if there is one file only.

A similar naming convention is used for the single-difference observation files (extensions `.PSH`, `.PSO`, `.CSH`, `.CSO` – see Chapter 23)

`XXYYssss` or `XXYYsssn` ,

where `XX` and `YY` are the 2-character abbreviations of the name of the first and the second station in the single-difference file (also defined in Menu 1.4.3). When transferring the RINEX data to the Bernese observation file format using the program RXOBV3, the 4-character and 2-character station name abbreviations are automatically created.

6. Campaign Setup

In the environment of the Bernese GPS Software we use the term "campaign" for a set of data which should be processed together (there is still the possibility to combine the results of various campaigns using normal equations files or SINEX files – see Chapter 18, but even then all the normal equation files to be combined have to be copied into one campaign). An alternative term to "campaign" (also commonly used) might be "project". Each campaign has its own directory and subdirectories where all the campaign-specific data are stored. While processing the campaign, the programs work on files in campaign-specific directories and (most of them) use the files from the directory `X:[GEN]` (or `X:/GEN`, `X:\GEN` in Unix and DOS notation respectively), too. The data files in `X:[GEN]` are common to all campaigns (see Chapter 23).

Before data processing can be started the campaign has to be defined, the campaign directories have to be created, the data have to be copied into these directories, and some basic information about the campaign has to be specified. This all is called "campaign setup" and is the topic of this short chapter. The campaign setup should be performed using Menu 1.

First, the name of a new campaign and the path to the campaign directories has to be specified in Panel 1.1. In Chapter 4 an example for this step is described in detail. We confine ourselves to two remarks, here: the path to the campaign is defined by a logical device or logical disk on VAX/VMS and DOS systems. Assuming that `P` is the logical device and `MYCAMP` is the campaign name, you have to specify the path by

`P:[`   (on VAX/VMS)   or   `P:\`   (on DOS)

which means, that the campaign root directory is

`P:[MYCAMP]`   (on VAX/VMS)   or   `P:\MYCAMP`   (on DOS).

The logical device `P` has to be defined (this is usually done in the `LOADGPS` script – see Chapter 24). On Unix systems there are no logical devices. In the `LOADGPS` script the variable `$P` is defined and the symbolic link `P:` is set in the user working directory `$U/WORK`. Therefore it is possible to specify the path as:

`P:/`

The second remark is relevant only for those users working on multiuser systems. In that case all the users have their own version of panels (usually in `U:[PAN]` directory. The only exception is

Panel 1.1 which is in the directory `X:[PAN]` (common to all users). Therefore all users have to have the read *and* write privileges for this panel.

After defining the campaign the campaign-specific directories have to be created. This is done in Menu 1.2 . By default the following directories will be created (assuming, that `P` is the logical device and `MYCAMP` the campaign name, and using the VAX/VMS notation):

```
P:[MYCAMP.ATM]
P:[MYCAMP.DATPAN]
P:[MYCAMP.OBS]
P:[MYCAMP.ORB]
P:[MYCAMP.ORX]
P:[MYCAMP.OUT]
P:[MYCAMP.RAW]
P:[MYCAMP.STA]
```

We refer to Chapter 23 for information on which data types belong into which directory. At the beginning at least the observation files (in receiver binary format or in RINEX format) have to be copied into the `.RAW]` directory. If you are using precise (e.g. IGS) orbits, what we strongly recommend, the precise orbit files have to be copied into the `.ORB]` directory. Otherwise, when you decide not to use precise orbits, the broadcast orbits in RINEX format have to be made available to the software in the `.RAW]` directory.

If the RINEX files (or raw receiver files) of your campaign cannot easily be divided into sessions (e.g. if you have a mixture of 24-hours files from IGS sites and some data of your own covering different time intervals, you should put the raw data into the directory `.ORX]`. Using the programs CCRINEXO in Menu 2.5.6.1 and CCRINEXN in Menu 2.5.6.2 you may then concatenate/split your RINEX observation files into well-defined sessions (the sessions already have to be defined, see next paragraph). The concatenated (or split) files will be saved in the `.RAW]` directory, ready to be used.

The next step is the session definition in Panel 1.3.2. Some useful information about the session definition strategy may be found in the corresponding help panel. An example is given in Chapter 4. Please note that the wildcard strings may be used.

Several files have to be prepared using Menu 1.4.1 – Menu 1.4.5. The meaning of the a priori coordinate file is straightforward. It is necessary to have a priori information about the station positions. However, this a priori information may be very inaccurate. You will have the possibility to improve it using programs CODSPP and/or MAUPRP – see Chapter 10. If the a priori coordinates are available in the RINEX files it is possible to prepare *only the header* of the coordinate file, and the coordinates are then extracted from the RINEX files using the program RXOBV3 – see Panel 2.7.1 . If eccentric stations were used, it is necessary to create an eccentricity file (Menu 1.4.4) in addition to the coordinate file, too (see also Chapter 23).

If you are going to process your regional/local campaign and you do not have accurate (decimeter-level) coordinates of any of your stations in the ITRF, we recommend to include at least one IGS site (near to the area of your campaign) into the processing, because the satellite positions are given in the IERS Reference System (ITRF/ICRF) and the station coordinates of the station(s) held fixed (and for numerical reason it is necessary to keep fixed – or heavily constrain – at least one station on the a priori coordinates) should be in the same reference frame. The coordinates of the IGS sites and corresponding translation tables are available from our anonymous ftp account `ubeclu.unibe.ch` (directory `AIUB$FTP:[BSWUSER.STA]`). The RINEX observation files have to be downloaded from the nearest IGS data center (see Chapter 7 and [*Gurtner and Liu*, 1995]).

In Menu 1.4.2 the translation table between the station names in the RINEX files and the station names actually used in the Bernese GPS Software may be created. Usually you do not need such a table if you process your own data. But the translation table is often important if the data were collected by a third party using different station naming conventions. An example is given in Chapter 4. There is even the possibility to translate not only the station names but the station heights given in the RINEX files, too. In that case a station height translation table has to be created, too. This cannot be done using the menu system, however. You have to edit a simple ASCII file manually. An example is given in Chapters 4 and 23.

The station name abbreviations (Menu 1.4.3) are used by the programs RXOBV3 and SNGDIF to automatically create the observation file names (see Chapters 5 and 23). If you do not create the abbreviations in Menu 1.4.3, the program RXOBV3 will do so automatically.

In Menu 1.4.5 an antenna/receiver name translation table may be created or modified. This is important because several programs require information concerning receivers and antennas (e.g. phase center variations). Therefore *unique* receiver and antenna names have to be present in the observation files. The translation table may be used by the program RXOBV3 (like the other two translation tables – see above). However, there is one difference concerning the antenna/receiver name table. Unlike the station name translation table and the station height translation table (which are in the campaign-specific `.STA]` directory), the antenna/receiver name translation table is in the directory `X:[GEN]`). The reason is that usually the same antenna/receiver name translation table may be (or should be) used for all campaigns.

In Menu 1.9 you have the possibility to delete an old campaign. On multiuser systems you have to have the write (on Unix) or delete (on VAX/VMS) privilege to be able to do that.