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WEST-EAST EUROPEAN DOPPLER OBSERVATION CAMPAIGN

WEDOC -2 - FINAL RESULTS

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WEDOC-2 - FINAL RESULTS

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P R E F A C E

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Science is international and does not recognize political or ideological borders. This applies, in particular, for geodesy which has the task to survey and to describe our regional and common living space. On the Earth and outside of it scientific geodetic activities combine the efforts of researchers in different countries to common statements. They resemble bridges across which human knowledge is exchanged for the prosperity of all partners and is, finally, combined.

The West-East European Doppler Observation Campaign, the second phase of which is the subject of this report, is one of these geodetic activities. It aims at the determination of absolute and relative positions of geodetic observatories in East and West. Therewith it contributes to the important question of how the structure of our living space changes as a function of time.

The campaign WEDOC-2 was prepared by Dr. Pesec, Graz in Western Europe and by Dr. Mihály, Budapest in Eastern Europe, respectively. They also computed the results presented in this report. Acknowledgement is expressed for their efforts which exceeded their official obligation by far.

May WEDOC-2 and the following positioning campaigns WEPOC-X contribute to a more profound knowledge about the positioning of points on our Earth with higher accuracy, in shorter time, and with less expenditure. May in that way the geodetic research and, thereby, the living conditions be promoted.

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SUMMARY :

In the region of Western and Eastern Europe common Doppler observation campaigns WEDOC-1 (May, 17-27th, 1980) and WEDOC-2 (September 6-16th, 1983) have been carried out. The campaigns have been organized by the Institute of Space Research, Graz, Austria in collaboration with the Satellite Geodetic Observatory, Penc, Hungary as well as with respective contribution of the participating countries. This report discusses the WEDOC-2 campaign.

In WEDOC-2 27 stations observed in a region of about 3000 km, 18 of them in Western and 9 in Eastern Europe. The observations have been collected in Graz and Penc and then distributed on request. The data have been processed at Graz and Penc using the GEODOP-V and the SADOSA programs, respectively. The coordinates obtained have been intercompared by a 7-parameter similarity transformation giving an rms of the residuals of $\pm 0,6$ m. The comparisons with WEDOC-1, EROSDOC and ED-79 give rms of $\pm 0,6$ m, $\pm 0,5$ m and $\pm 0,9$ m for the GEODOP-V solution and $\pm 0,6$ m, $\pm 0,6$ m and $\pm 0,7$ m for the SADOSA solution, respectively.

The coordinates and the respective correlation matrices of 26 WEDOC-2 stations are computed in a geocentric system. Permanent geodynamic stations are connected in Western and Eastern Europe, a geodetic-geodynamic Doppler system has been defined for future projects and the existing Doppler links have been controlled.

This report on WEDOC-2 discusses the objectives, organizations, field operations, data processing and computational methods. The Doppler solutions in Cartesian coordinates are given and interpreted. The results of various intercomparisons are presented, conclusions have been drawn, and future ideas are discussed.

The report contains 7 figures, 21 tables, 23 station sheets, a description of the MJV data formats for each receiver type as well as the correlation matrices of the WEDOC-2 solutions.

Zusammenfassung:

Im Bereich von West- und Osteuropa wurden gemeinsame Dopplerbeobachtungen im Rahmen der Kampagnen WEDOC-1 (17.5.-27.5.1980) und WEDOC-2 (6.9.-16.9.1983) durchgeführt. Diese Kampagnen wurden vom Institut für Weltraumforschung, Graz, Österreich in Zusammenarbeit mit dem Geodätischen Satellitenobservatorium Penc, Ungarn unter Mitwirkung der beteiligten Länder organisiert. Dieser Bericht behandelt die Kampagne WEDOC-2.

In WEDOC-2 beobachteten 27 in einem Umkreis von etwa 3000 km verteilte Stationen, davon liegen 18 in West- und 9 in Osteuropa. Die Beobachtungsdaten wurden in Graz und Penc gesammelt und auf Verlangen weitergegeben. Die Daten wurden in Graz und Penc unter Verwendung der Programme GEODOP-V (Graz) und SADOSA (Penc) ausgewertet. Die ermittelten Dopplerkoordinaten wurden über eine 7-Parameter Ähnlichkeitstransformation verglichen, der mittlere Fehler beträgt 0.6 m. Entsprechende Vergleiche der WEDOC-Lösungen mit den Kampagnen WEDOC-1, EROSDOC und dem System ED-79 ergeben mittlere Fehler von ± 0.6 m, ± 0.5 m und ± 0.9 m für die GEODOP-V Lösung sowie ± 0.6 m, ± 0.6 m und ± 0.7 m für die SADOSA Lösung.

Die Koordinaten und die entsprechenden Korrelationsmatrizen von 26 WEDOC-2 Stationen wurden in einem geozentrischen System ermittelt. Dadurch wurden permanente geodynamische Stationen in West- und Osteuropa verbunden, ein geodätisch-geodynamisches Doppler System wurde für zukünftige Projekte geschaffen sowie die bestehenden Doppler-Verbindungen kontrolliert.

Diese Veröffentlichung behandelt die Zielsetzungen, die Organisation, den Feldeinsatz, die Datenverarbeitung sowie die verwendeten Rechenmethoden. Die Dopplerlösungen werden als kartesische Koordinaten angegeben und interpretiert. Die Resultate der verschiedenen Vergleiche werden dargestellt, Schlußfolgerungen werden gezogen sowie zukünftige Ideen diskutiert.

Die Veröffentlichung enthält 7 Figuren, 21 Tabellen, 23 Stationsbeschreibungen, eine Zusammenstellung der verwendeten MJV-Datenformate für jeden Empfängertyp sowie die Korrelationsmatrizen der WEDOC-2 Lösungen.

ÖSSZEFOGLALÁS

Nyugat és Kelet Európa térségében együttes doppleres műhold megfigyelési kampányokat bonyolítottunk le WEDOC-1 /1980.május 17-27/ és WEDOC-2 /1983. szeptember 6-16/ elnevezés alatt. A kampányokat az osztrák Űrkutatási Intézet /Graz/ szervezte a magyar Kozmikus Geodéziai Obszervatóriummal /Penc/ együttműködésben és a résztvevő országok hozzájárulásával. Jelen közlemény a WEDOC-2 kampányt tárgyalja.

A WEDOC-2 kampányban 27 állomás végzett műhold megfigyelést mintegy 3000 km körzetben. Közülük 18 állomás Nyugat, 9 pedig Kelet Európában működött. Az észlelési eredmények begyűjtését Graz és Penc központok végezték. A szétosztás a beérkezett igények alapján történt. A mérési eredményeket a központok külön-külön dolgozták fel a GEODOP-V és a SADOSA elnevezésű számítógépi programmal. A számított koordinátákat 7 paraméteres hasonlósági transzformációval összehasonlítva a kétféle megoldás közötti ellentmondások négyzetes középértéke ± 0.6 m. A GEODOP-V megoldást a WEDOC-1, az EROSDOC és az ED-79 koordinátákkal összehasonlítva az ellentmondások négyzetes középértéke ± 0.6 m, ± 0.5 m és ± 0.9 m.

A SADOSA megoldás esetében a megfelelő értékek ± 0.6 m, ± 0.6 m és ± 0.7 m.

Eredményül 26 WEDOC-2 állomás koordinátáit és az azokhoz tartozó korrelációs mátrixokat kaptuk geocentrikus koordináta rendszerben. Ezzel Nyugat és Kelet Európa rendszeres geodinamikai állomásainak összekapcsolása megtörtént, egy geodéziai-geodinamikai doppleres rendszer született a jövőbeni közös munkálatok céljaira és a korábbi doppleres összemérések egy rendszerbe illeszthetők.

Jelen közlemény tárgyalja a WEDOC-2 célkitűzéseit, a szervezést, a terepi munkálatokat, az adatfeldolgozást és az alkalmazott hálózati kiegyenlítési módszereket. Közli és értelmezi a megoldásként kapott derékszögű koordinátákat, a különféle megoldásokat összehasonlítja más hálózatokkal, az eredményekből következtetéseket von le és tárgyalja a jövő elképzeléseket.

A közlemény 7 ábrát, 21 táblázatot, 23 állomás leírását tartalmaz és közreadja a vevő készülékek egyes típusaira jellemző MJV adatformátum leírását, valamint a WEDOC-2 megoldások korrelációs mátrixait.

Р Е З Ю М Е

На территории Западной и Восточной Европы завершились совместные сеансы доплеровских наблюдений под названием WEDOC-1 /17-27 мая 1980 г./ и WEDOC-2 /6-16 сентября 1983 г./. Сеансы были организованы Институтом Космических Исследований Австрии /Грац/ совместно с Обсерваторией Космической Геодезии Венгрии /Ценц/ при содействии участвующих в этих сеансах стран. В настоящем отчете освещаются вопросы сеанса WEDOC-2.

В сеансе WEDOC-2 наблюдения велись на 27 станциях, расположенных на территории с диаметром 3000 км. 18 из них работали в Западной Европе, а 9 - в Восточной Европе. Сбор результатов наблюдений и распределение их в соответствии с запросами проводились на станциях Грац и Ценц. Наблюдения обрабатывались на этих же станциях по программам GEODOP-V и SADOSA. Полученные координаты сравнивались с помощью семипараметровой пространственной трансформации. Два набора координат, полученные из вычислений по двум программам, подобны друг другу со средней квадратической ошибкой трансформации ± 0.6 м. Сравнения вычисленных программой GEODOP-V координат с идентичными координатами сетей WEDOC-1, EROSDOC и E δ -79 дают соответственно средние квадратические ошибки трансформации ± 0.6 м, ± 0.5 м и ± 0.9 м, а в случае программы SADOSA соответствующие ошибки составляют ± 0.6 м, ± 0.6 м и ± 0.7 м.

В итоге получены координаты 26 станций сети WEDOC-2 в геоцентрической системе координат и соответствующие корреляционные матрицы. Тем самым в Западной и Восточной Европе осуществлена связь геодинамических станций, создана геодезическая-геодинамическая доплеровская система для будущих работ и обеспечен контроль существующих доплеровских геодезических связей.

В данном отчете обсуждаются цели, организационные мероприятия, полевые работы, обработка измерений и вычислительные методы, связанные с сеансом WEDOC-2. Даются и интерпретируются уравненные прямоугольные координаты станций, приводятся результаты сравнений и делаются выводы. Обсуждаются и перспективы на будущее. Отчет содержит 7 рисунков, 21 таблицу, 23 листа описаний станций, описание структуры информации типа M \pm V для использованных видов приемников. В конце приведены корреляционные матрицы двух наборов координат, полученных для WEDOC-2.

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1. MOTIVATION AND OBJECTIVES

According to *RINNER 1982* the West-East European Doppler Observation Campaign WEDOC strives for the following aims :

- the geodetic connection of currently disconnected, planned or already operating permanent geodynamic stations in Europe,
- the definition of a geodetic-geodynamic uniform West-East first order Doppler system as a basis for future joint projects,
- the control of already existing Doppler links between Western and Eastern Europe and in Western Europe.
- the determination of changes in coordinates by repetition of measurements after certain time periods.

Therefore, WEDOC can be regarded as a series of successive subcampaigns WEDOC-X covering the whole region in question whenever possible.

WEDOC-1 was carried out during the period May 17th to 27th, 1980. 10 stations from Western Europe and 5 stations from Eastern Europe took part in this first effort which is described and the results of which are presented in *RINNER 1982* and *MIHALY 1982*.

About three years later the campaign WEDOC-2 was organized during the first month of the MERIT main campaign from September 6th to 16th, 1983. This time 17 stations from Western Europe and 10 stations from Eastern Europe increased the total number of participating stations to total of 27 covering nearly the whole geographical region of Europe with a net-diameter of about 3000 km (see Figure 2.1).

Like in WEDOC-1, WEDOC-2 crosses political borders and forms, according to the idea of the objectives, a link which should promote the scientific collaboration among all European countries. WEDOC-1 as well as WEDOC-2 express one aspect which the neutral Austria conceives as a mandate, namely, to act as a bridge between East and West.

For nearly all western sites station descriptions, horizontal terrestrial coordinates in ED-50 or ED-79 as well as orthometric and partly ellipsoidal heights have been submitted. In this part the computed Doppler coordinates can be compared with terrestrial values which gives a control for the quality of various solutions and allows for the analysis of the residuals.

Unfortunately, this cannot be done in the Eastern part since no terrestrial coordinates have been communicated. However, each country is now in the position to connect the respective national datum to WGS-72 and ED-79 using the WEDOC-2 solutions.

Graz undertook the general management of WEDOC-2 (Rinner). The detailed organisation in Eastern Europe was performed by the Satellite Geodetic Observatory Penc (SGO) of the Institute for Geodesy and Cartography, National Office of Lands and Mapping, on behalf of INTERCOSMOS. The western part was organized by the Institute of Space Research Graz (ISR) of the Austrian Academy of Sciences (Rinner, Pesec) the eastern part was supervised by SGO (Mihaly, Alpar).

For the computations only broadcast ephemeris were at disposal. Single-point and multipoint solutions have been computed by ISR and SGO with different programs (Pesec, Mihaly). Precise ephemeris have been requested from DMAHTC. Should they be released for WEDOC-2 a new computation is foreseen.

WEDOC-2 was prepared by the issue of 6 circulars. The planning of the campaign, the coordination of the activities and the general outlay of this report have been done by ISR Graz, the edition of this report was performed by SGO Budapest.

In WEDOC-1 and WEDOC-2 an old Austrian cooperation between East and West revives which is intimately connected with the name Doppler, for Prof. Dr. Christian Doppler, who discovered the Doppler - principle, was born in Salzburg 1803 and was a citizen of the Austrian- Hungarian monarchy. He made his fundamental investigations in Prague 1842, at that time also part of the monarchy. 1848 he was professor at the School of Mining in the Hungarian town Selmecebánya and later at the Technical University in Vienna.

The activity of Christian Doppler was thus mainly laid in the Austrian- Hungarian monarchy, a region, which is also covered by WEDOC-2. For this reason this publication is also dedicated to this famous scientist and his portrait is placed in front of this report.

2. THE ORGANISATION OF THE CAMPAIGN

The Doppler campaign WEDOC-2 was organized by the Institute of Space Research, Graz, in collaboration with the Satellite Geodetic Observatory (SGO) Penc, Hungary. The organisation benefitted from the experiences gained during WEDOC-1. All stations included in WEDOC-1 were invited for participation. In addition, most of the observatories in Europe were asked to contribute to WEDOC-2. The observation period was chosen for the first month of the MERIT- Campaign, in particular, from September 6th to September 16th, 1983. The first announcement was issued in circular No. 9 in October 1982.

By January 1984 16 stations have indicated their participation. In view of this great interest and the possibility to include the campaign into the scheme of MERIT it was decided not to restrict the number of stations. In order to obtain an optimal network the TRANET stations Brussels and Firenze were asked to participate, other countries were encouraged to add further stations which may be of interest for the MERIT main campaign. In particular, Yugoslavia, Spain, Denmark and Norway were asked to consider Doppler stations in their countries in order to fill up the gaps in this part of Europe. In Eastern Europe the Doppler network could be extended over Poland and a part of USSR.

On principle, the campaign is based on a free data exchange. The observations have been collected in two centres. Graz was responsible for the stations in Western Europe and Penc was responsible for Eastern Europe participating mainly with the INTERCOSMOS stations. The data partitions have been interchanged between the two centres and data banks have been arranged at each centre. The distribution of the data has been realized by the responsible data centres.

In particular, the Penc data centre distributed the WEDOC-2 observations in both, MJV and WEDOC format, to the Astronomical Council (USSR, Moscow), the Central Institute for Earth Physics (GDR, Potsdam), and the Astronomical Latitude Observatory (Poland, Borowiec). No requests have been made, up to now, to the Graz data bank.

In two further circulars No. 10 (January 1983) and No. 11 (July 1983) the current status of the preparations of the campaign was announced. The final stations distribution, the type of receivers used, and the approximate position of the participating stations are shown in Figure 2.1. and Table 2.1.

The organisation was facilitated by the fact that all stations were experienced in Doppler observations and that a sufficient number of receivers were available. Therefore, it was not necessary to organize Doppler receivers and their transport to the respective sites as it was the case in WEDOC-1, except for Potsdam where, due to a receiver fault, a JMR - 1A receiver was placed at disposal and operated by SGO. The only task was to determine the observation period and to define the satellite priorities in case of overlapping passes. Since about 50 percent of the recording receivers were MX - 1502 receivers, which alert the passes to be observed on a sequential time scale, it was decided not to give any priorities, but to record the first coming pass in case of overlapping.

As it was expected the collection of the data was the main problem. It was anticipated that the format of the incoming data was widely dispersed, but, it could not be foreseen that the complete data set was available in Graz only by July 1984, about 10 months after the observations. A 15-station sample was computed in Graz in single point positioning mode and multistation short-arc mode (see Chapter 5.2.) and published as a preliminary version at the International Symposium on Space Techniques for Geodynamics in Sopron, July 1984 (PESEC 1984). A similar sample was computed by SGO Penc with a different software (see Chapter 5.3) and published at the INTERCOSMOS/COSPAR Conference in Karlovy Vary, September 1984 (MIHALY 1984).

One further circular (No. 13) has been distributed in October 1984 announcing the status of computations and asking for the station documentations included in this publication. Moreover, a questionnaire was circulated in order to investigate the willingness of the organisations to provide their Doppler data to DMA Washington in exchange for precise ephemeris.

The final computations have been completed in Graz end of 1984, the results have been compared to the available terrestrial coordinates in January 1985.

The computations in Hungary have been finished in April 1985, the results have been compared to the coordinates of other solutions and networks by June 1985.

3. STATION DESCRIPTION AND FIELD OPERATIONS

Altogether 28 stations have announced to carry out Doppler observations within the WEDOC-2 campaign. 27 stations are listed in Table 2.1. The Doppler site Plana (Bulgaria), originally, agreed to participate. However, it was not possible to contact the respective authorities to submit data. Blazajenko was not included into the Graz solution since this station does not give any substantial improvement to the station configuration.

The tables in the Appendix A give a description of the participating stations. This description contains the relevant informations on the horizontal coordinates and the heights of the station reference point, the observing agency, centering elements of the Doppler antenna and, partly, a sketch of the station situation. Unfortunately, the informations are not as complete as it would be desirable for a scientific investigation.

Table 3.1 summarizes the centering elements of the Doppler antenna phase center to the monumented station pillar or antenna ground point. For some stations terrestrial coordinates have been provided for the phase center itself, in which case the centering elements are set to zero. No connection to a terrestrial reference point could be established for the stations Cagliari, Hvar, Merate, Simeiz.

No serious problems have been reported on the field work itself with one exception. For organizatorial reasons the station Trieste could only record one cassette comprizing data of about 2.5 days. All other stations reported minor data losses not exceeding 1 day or 10 % of the total amount of data (Figure 3.1).

No meteorological data have been submitted by the stations Cagliari and Simeiz. In order to get a reasonable estimate of the meteorological conditions at those stations the values have been interpolated from neighboring stations taking advantage of the stable weather condition during the observation period.

4. DATA PREPROCESSING

For the campaign WEDOC-2 8 types of receivers manufactured by 3 different firms were used (see Table 2.1). In the following a short description of the observing mode and of the data-output of these receivers is given.

4.1.1. MAGNAVOX:

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The MAGNAVOX MX-1502 receiver is a microprocessor controlled system which, in principle, can work unattended. The only manual action required is to initialize the system and to change the cassettes about every 2.5 days dependent on the distribution of the satellite passes. Satellite alerts are precomputed, during satellite gaps the receiver is working in a stand-by mode in order to save electrical power. Upon initialization a cassette with recorded data not older than 90 days can be read in from which the receiver extracts the required orbit information. If no data are available the receiver switches to the operating mode every 2 minutes until it has gathered all satellite types to be observed.

For each recorded pass the system computes a 2-D and a 3-D solution based on the a priori approximate coordinates of the station. The quality of the data can thus be controlled at any time. During a satellite pass the status of the received 400 MHz and 150 MHz signals, the tracking loop and other pertinent informations can be interrogated.

The following data are output on a cassette mounted on the receiver deck in a fixed format consisting of 86 8-bit bytes per record (octal, 4-byte floating point, or 5-byte message) (see CSTG 1983)

epoch of satellite lock on (even minutes), orbit information (14 variable and 14 fixed parameters), results of the 2-D and 3-D fix, and the Doppler information (signal status of both channels, 17-bit 400 channel Doppler count, 8-bit 150 channel Doppler count correction, time correction to the nominal time interval of 4.6006272 sec or 4.9741824 in 9.6 microsecond steps, time elapsed from the detected time mark to the first beat-frequency zero crossing for both channels).

The last byte of each record controls the checksum of the record. Up to 60 passes can be recorded on one cassette.

4.1.2 MARCONI:

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There are 3 types of equipments available. The old CMA-722B receiver has no microprocessor and no internal clock. Therefore, the whole recording mechanism is based on a frequency measurement within a receiver defined constant integration interval (constant bit rate). The counting procedure is started by the detected time mark. In order to overcome the problem to measure the time interval between the start of the integration period and the first zero crossing the beat frequency is multiplied by 100, thus giving a resolution in frequency measurement of 0.01 Hz and making the respective time interval negligible small. Output are the 4.6 second Doppler frequencies of both channels and the navigation message on a separate Digital Cassette unit in ASCII code.

The CMA-751 and CMA-761 receivers are, apart from the TRANET systems, the only receivers having a continuously running internal clock, which is synchronized at the receiver set-up with a satellite time mark. Both receivers have an internal memory. The CMA-751 allows only for manually preprogramming the start time of the desired satellite passes whereas the CMA-761 carries out, optionally, also a majority vote procedure and predicts satellite alerts. Both receivers output, in the same format, the value of the internal clock at lock on time (this clock is not reset by the first satellite time mark), signal status and Doppler counts for both frequencies (4.6 seconds), and the time interval used for counting the Doppler cycles. The method of fractional Doppler count is maintained. The data can be output to a digital cassette unit either in BCD or in ASCII code. Upon request majority voted data can also be dumped to the cassette in case of the CMA-761 receiver.

4.1.3 JMR:

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Two models of JMR-receivers were used for the WEDOC-2 campaign: JMR-1A

and JMR-4A. JMR-1A is an improved version of JMR-1 having a more precise and stable oscillator built in. JMR-4A is a new version of the JMR-1A containing a microprocessor and additional output-lines. Common to all receivers is a built-in local clock which is resynchronized by each first time mark of a satellite pass and the hardware elimination of the first order ionospheric correction. Thus, the corrected doppler count of only one channel (400 MHz) is output. Further, the following data are stored on the built-in cassette drive: value of the internal clock before resynchronization (giving the possibility to check the behaviour of the internal clock since the last satellite pass), the microsecond read out of the local clock at the moment of detection of the gating signal, fractional microseconds at the first positive zero-crossing, the signal status of both channels, and the orbital message of the satellite. This information is repeated about every 4.6 seconds. Up to 50 passes can be preselected by manual input, at the respective time epochs the receiver is turned from stand-by to operating mode. The JMR-4A receiver can, in addition, perform majority vote and 3-D calculations.

4.1.4 TRANET-2:

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The concept of TRANET receivers allows the system to track satellites without using the satellite-inferred bit patterns. Optionally, the time mark of the satellite can be detected. A frequency counter, controlled by a high precision clock (caesium standard) measures the Doppler-frequency for predefined constant time intervals (a fixed power of 2). Meteorological data are usually contained in the pass header. The 400 MHz channel is output either corrected for ionospheric delay or the ionospheric correction factor is given as a separate information. No satellite message is decoded. Therefore, the Doppler data have to be merged with orbit informations received from elsewhere (data from other stations, precise ephemeris, etc.). Additional information on the local clock can be given by displaying the clock epoch at the arrival of satellite time marks. These values are used for a time adjustment of the satellite-receiver system, the most critical value of this type of receiver.

4.2 MAJORITY VOTE OF RAW DATA

As can be seen in Table 2.1 the following receiver-types were used by the 27 participating stations:

10 receivers MX-1502, 3 receivers CMA-722B, 3 receivers CMA-751/761, 3 receivers JMR-1A, 4 receivers JMR-4A, 2 receivers TRANET-2, 1 receiver DOG-2 (a polish made Doppler receiver), 1 receiver MX-702A.

Table 4.1 gives an overview of the type of data submitted to the computing centres Graz and SGO. The last column lists the agencies where the raw data were majority voted.

All MX-1502 data were majority voted in Graz using a program which has been written in Graz 1982 and which is primarily based on the MX-1502 subroutine of the program PREDOPV (Kouba 1982). Since the original data received on mag.tape were recorded in binary or hexadecimal format some utility routines had to be written in order to convert the data from the 8-bit byte structure to the 36-bit word structure of the UNIVAC 1100/81 used in Graz. All MAGNAVOX data received on original cassettes have been converted to hexadecimal format by means of a 21MX HP-processor. Since for this processor no operating system is available the respective program was written in object coding.

All CMA data could be processed straightforward. Some minor changes were necessary in program PREDOPV to account for different formats of the pass-header. Only the raw data from Riga had to be majority voted from punch tape to a disc file.

The JMR data were converted to mag.tape in Penc and finally majority voted to Penc format by SGO. A small routine had to be written in Graz to convert the compressed JMR-4 majority voted data from Metsähövi to the standard MJV format used by SGO.

Program PREDOPV was extended by a new input subroutine which gives the possibility to read in SEF format data either in raw or MJV form. In order to handle the TRANET data submitted by San Fernando in TRANET-2 format and by Brussels in CNES format the program PREPAR (KOUBA 1975) written for

TRANET-1 data was modified for TRANET-2 format. In addition, the program CNESGEO, originally written by IFAG Frankfurt, was incorporated so that the present version of PREPAR can handle both TRANET-2 and CNES formatted data. In order to provide the necessary orbital information some new options were added so that, at present, either the decoded message set, the GEODOPV updated orbit or the precise ephemeris information can be overlaid (see Chapter 5.2).

This procedure caused some problems for the site San Fernando since due to the large spatial distance to the neighbouring Doppler stations (Grasse, Cagliari) it was difficult to find matching orbital informations. This situation will improve in case precise ephemeris data are available.

Some serious attempts were made to majority vote the MX-7o2A data from Hamburg. Since it was not possible to get the relevant information on the hardware defined Doppler count mechanism and the integration intervals the data from Hamburg are not included in this publication.

A description of all MJV formats used by SGO and Graz is given in Appendix B. The formats not described in this appendix can be found in (CSTG 1983).

Finally, all majority voted data were converted to the uniquely defined WEDOC format, which has been developed by Herzberger and Pesec, and which is, basically, a formatted version of the PREDOPV data output. These data are stored in the data banks in Graz and Budapest and are submitted, on request, to all interested agencies which have contributed to WEDOC-2 (Table 4.2).

5. COMPUTATIONAL METHODS

5.1 GENERAL REMARKS:

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Doppler positioning provides, even in our days, a reasonable method to compute accurate geocentric and relative positions of stations also in countries of high geodetic tradition like in Europe. Of course, the results cannot compete with Laser tracking systems of third generation or VLBI-methods over long distances. They are inferior to global positioning system results within small areas up to about 200 km. But, Doppler observations give a good opportunity to establish networks of medium, subcontinental size with maximum baseline length of about 3000 km with an estimated inner consistency of below 1 m remaining well under the level of 1 ppm which is attributed to terrestrial continental networks. Doppler observations can be carried out very easily, even with unskilled operators, good results can be derived without the knowledge of precise orbital parameters by using adequate methods like semi short-arc or full short-arc procedures.

A variety of programs are available for that purpose which use, more or less, the same observation equations as a starting point. This observation equation relates the measured integrated Doppler frequency interpreted as integer or fractional count to difference in the slant ranges between the observing station and the observed satellite. In order to account for systematic effects not considered in this simple approach an error model is introduced by which additional unknowns like frequency offset, frequency drift, satellite orbit biases, tropospheric refraction and time biases can be recovered and solved for. The philosophy used for treating this error model and for carrying out the adjustment procedure distinguishes between the different Doppler software.

The Doppler solutions for WEDOC-2 (see Chapter 6) have been computed by two different programs. In Graz the program package GEODOPV (Kouba 1982) was used, in Penc the program SADOSA (Mihaly 1983) was applied. A comparative description is given in Table 5.1. In the following a more detailed description of both programs is given.

5.2 PROGRAM GEODOP-V:

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Program GEODOP-V is an extension of the program GEODOP-III, which has been written in the early 1975 by Jan Kouba and collaborators and which has been widely used for the computation of different Doppler campaigns all over the world. As far as the European area is concerned the Doppler campaigns EDOC II, EROSDOC, TIMEDOC, DÖDOC and WEDOC-1 are mentioned. 2 dedicated campaigns have been carried out in small test-networks (Testnetz Harz, Testnetz Steiermark) in order to find out the limitations of GEODOP-III. In both campaigns it could be demonstrated that the accuracy of Doppler-positioning is well below 30 cm in each component for small networks (100 km diameter) provided that all program parameters are handled carefully (SCHENKE 1982, RINNER 1982a).

Program GEODOP-V shares with GEODOP-III all the utility programs which are used for file handling and editing as well as most of the subroutines included in GEODOP-III. The preprocessor program PREDOP is extended with a time analysis as well as a short arc orbit computation from an input or default (GEM 9 truncated) gravity field.

The time analysis is particularly useful for receivers with a continuously running clock like CMA-751/761 in which case a line fit over the whole observation period can be drawn. But, even for MX-1502 and JMR receivers, which are synchronized by the first time mark of a satellite pass, a fit can be performed over all time marks of the respective pass, thus reducing the jitter inherent to every time mark signal.

Two different options can be selected for the orbit representation. The first option initiates the conventional adjustment procedure of the broadcast ephemeris by Chebyshev Polynomials up to degree 9 as it is done in GEODOP-III. When the short arc orbit option is specified, only three above smoothed positions and velocities at four minutes before, 6 and 16 minutes after the lock-on time are used as initial conditions for the orbit computation. The above three positions and velocities, together with the second time derivatives evaluated at two minute intervals from the gravity field expansion, truncated at degree and order 10, are used in the 9th order Chebyshev polynomial fitting instead of the smoothed satellite

positions (2 minute intervals) used in PREDOP-III.

Furthermore, the ionospheric correction factor computed from the difference of the 400 MHz and the 150 MHz signal is output to GEODOP-V as an additional information. This information can be used to reconstruct the 150 MHz Doppler signal in GEODOP-V and to add other pertinent informations of the ionosphere.

The main reduction analysis program, GEODOP-V, incorporates many changes and improvements:

Up to 6 Keplerian orbital biases allow for a complete relaxation of the orbit. Up to 4 station biases (in frequency, time delay, tropospheric refraction, frequency drift) give the possibility to model systematic error components of the individual stations more satisfactorily. In addition to the regular two frequency ionospheric correction a model due to (CLYNCH 1979) can be used, which is particularly useful for mid-afternoon passes observed during a maximum solar activity cycle. The introduction of the tropospheric refraction scale bias per station and pass can greatly reduce the errors of the Hopfield model when the assumption of no horizontal gradients is violated (as near weather fronts). In addition, as an option, Black's model can be used with and without ray-bending.

Furthermore, an improved Doppler weighting which also includes correlation of Doppler data between different simultaneously observing stations and a nominal relativistic correction have been included.

In GEODOP-V the station coordinates are computed in a so-called phased adjustment which means that all quantities which are expected to be correlated are introduced, together with their respective weight matrix, as initial estimates for the next pass. In particular, these are the station coordinates and, as a new feature of GEODOP-V, station frequencies and time delays. Frequencies and delays undergo a straight line fit over the results of the foregoing passes, the expected values for the next pass are extrapolated.

The mathematical model is represented by the following equation, one for

each integrated Doppler count D_i :

$$F_i = (S_k - S_j) f_{gj} / c + (t_k - t_j) (f_{gj} - f_s) + s_i - (D_i + \epsilon_i) = 0 .$$

S_j and S_k are the distances from the ground station position modified for aberration due to Earth rotation; t_i and t_j are the limits of the integration interval; f_{gj} is the ground frequency (400 MHz) updated from its initial value to the current epoch and f_s is the nominal satellite frequency.

s_i denotes the systematic error model (due to orbital, instrumentation, and refraction errors). Orbital errors, synchronization and receiver delay corrections as well as refraction errors affect the slant range differences, a frequency bias accounts for oscillator short term instabilities. Up to 6 orbital biases can be introduced in the following order: a, M, i, Ω , e, ω .

D_i is the Doppler count corrected for ionospheric and tropospheric correction, for relativistic effects and for daily aberration effects. Finally, ϵ_i represents the random measurement errors of D_i .

The linearized observation equation has the following form:

$$\underline{AX} + \underline{CY} + W - V = 0 ,$$

where A and C are the design matrices obtained by differentiation of the set F of individual observation equations F_i . The vector \underline{X} includes the station coordinates while \underline{Y} is composed of the error parameters and the frequency offset unknown. The misclosure vector or quasi-observable is obtained by substitution of observed and approximate known values. It is solved by straight-forward methods.

An important feature which has been used extensively for the WEDOC-2 computations is the possibility to create an updated orbit for each pass as a by-product of the multistation solution and to clean the input data files from all those Doppler observations which have been rejected in a first cleaning single point positioning run. Since after each rejection

identified the whole adjustment procedure has to be repeated this data cleaning saves much computer time.

Correlation analysis enables the estimation of the phase (range) sigma of a single Doppler observation σ_p , the range rate sigma of a single Doppler observation σ_{rr} and the satellite error contribution σ_s . From the computed σ_o^2 of each station a corrected Doppler data variance for each station can be computed by

$$\sigma_i^2 = \sigma_o^2 (2\sigma_p^2 + \sigma_{rr}^2 \Delta t) ,$$

which leads to the phase variance of the station σ_p^2 by multiplication with the mean correlation. The range rate variance is then simply obtained as

$$\sigma_{rr}^2 = \frac{0.5}{\Delta t} (\sigma_i^2 - 2\sigma_p^2) .$$

The satellite error contribution σ_s^2 can be computed by multiplying the corrected Doppler data variance with the mean intra-station correlation which is the averaged diagonal of the cross-correlation matrix.

As a summary, the following statements can be made on program GEODOP-V:

As compared with GEODOP-III the program is much more flexible, which is an advantage, but may be also considered as a disadvantage if the \hat{a} priori weights are not assigned properly. By different choices of the \hat{a} priori constraints and options nearly every existing Doppler software can be simulated. In order to estimate the \hat{a} priori constraints a lot of preparatory work has to be carried out which is described more extensively in the next chapter. Each receiver has to be examined carefully for its instrumental values such as measuring accuracy, frequency, frequency drift, and time delay. It is no problem to achieve 1-meter consistency, nearly by the rule of thumb using the default options. But, to remain below the 50 cm level require more sophisticated considerations. The program flow is shown in Figure 5.1a, a comparative description is given in Table 5.1.

5.3 SADOSA PROGRAM :

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A complete description of the SADOSA program is given in MIHALY 1983. The basic mathematic model can be found also in BRUNELL 1982. A comparative description is shown in Table 5.1. The SADOSA program has been successfully used in processing the Hungarian National Doppler Networks of 1980 and 1982 (MIHALY 1982a, JOO 1985) as well as for WEDOC computations (MIHALY 1982). Good results of 25 - 40 cm accuracy have been obtained in comparisons with different software and with reference networks, for example in BRUNELL 1982, MIHALY 1982b. The SADOSA program flow is given by Figure 5.1b. In this section only those main features of SADOSA are described which were used for WEDOC computations.

In a station j - to - orbit k event the observational equation of i -th observation is represented by the following range difference equation:

$$a_i^T x_{kj} + l_i = v_i$$

where the vector of unknown parameters is

$$x_{kj}^T = (dX_j, dY_j, dZ_j, dE_k, da_k, dn_k, d\dot{E}_k, d\dot{a}_k, d\dot{n}_k, df_{kj}, dt_{kj}, dK_{kj})$$

and the quasi-observable is

$$l_i = \frac{c}{f_k} (N_i + \Delta N_i - \Delta f(t_i - t_{i-1})) - (\rho_i - \rho_{i-1}) - (\dot{\rho}_i - \dot{\rho}_{i-1})\tau_j - (\dot{\rho}_i \tau_i - \dot{\rho}_{i-1} \tau_{i-1})$$

In the above equations the meaning of the different terms is the following:

a_i^T - vector of coefficients; v_i - residual; dX_j , dY_j and dZ_j - corrections to the station coordinates; dE_k , da_k , dn_k , $d\dot{E}_k$, $d\dot{a}_k$ and $d\dot{n}_k$ - orbital bias parameters; df_{kj} , dt_{kj} and dK_{kj} - error model parameters; $\Delta f = f_j - f_k$ - frequency offset; f_j and f_k - receiver and satellite frequencies, respectively; N_i - doppler count; ΔN_i - sum of all Doppler count corrections; t_i and t_{i-1} - time epochs at Doppler count incrementation; ρ_i and ρ_{i-1} - slant

ranges at epochs t_j and t_{j-1} ; $\dot{\rho}_j$ and $\dot{\rho}_{j-1}$ - slant range rates;
 τ_j - receiver delay; τ_j and τ_{j-1} - time corrections.

The elements of the matrix for weighting the n observational equations of a station-to-orbit event was as follows:

$$(P_{kj})_{i,m} = \begin{cases} i(n+1-m) ((n+1)\sigma^2)^{-1} & , \text{ if } m \geq i \\ m(n+1-i) ((n+1)\sigma^2)^{-1} & , \text{ if } i > m \end{cases}$$

where σ is the residual rms divided by a priori standard deviation of unit weight.

For all over the network the system of normal equations was formed as follows

$$(A^T P A + P_X) X + A^T P L = 0 ,$$

where A is the design matrix; X and L are vectors of the unknown parameters and the quasi observables; P is the weight matrix of observational equations; P_X is the weight matrix of unknowns used for weighted constraining. In the WEDOC computations the P_X was selected as shown in Table 6.1. To avoid tremendous matrix dimensions the 2nd order partitioned structure is utilized by Brown's approach.

No weighted constraints have been applied to the station coordinates. For each station-to-orbit event a σ_{kj} residual rms was computed from which a σ_j mean value was obtained for each receiver to qualify its observation accuracy. However, the σ_j indicates also how the adjustment model reflects the reality.

As an explanation to the flow diagram on Figure 5.1b the SADOSA program system consists of the SPPENC, MERGE and SADOSA programs. The short description is as follows:

- a) At the first level the MJV data or the PREDOP output are processed by the SPPENC program separately for each station. Here the observations are filtered, unified and edited for further use at successive levels

of processing. The station coordinates are adjusted in a single point positioning mode.

- b) At the second level all the observations edited at the previous level are merged together and arranged into one file by the MERGE program for the next level. Here the union of broadcast ephemeris (or PREDOP orbit) is formed using the ephemeris (or orbits) represented by each station separately.
- c) At the third level the SADOSA program performs a multilocation network adjustment using the merged data. The main multilocational features and options of the SADOSA program system are utilized at this level.

It is worth mentioning that the SPPENC program performs single point positioning equivalent to the SADOSA single point semi-short arc solution. Therefore, in this paper or in other ones the expressions "SPPENC solution" and "SADOSA SPP solution" are equivalent to each other in case of broadcast ephemeris and PREDOP orbits.

6. THE DOPPLER SOLUTIONS

As it has been mentioned in Chapter 2 the data file of all stations prepared in Graz was the underlying material which has been used for the final computations in Graz and Penc. Since the programs used in Graz and Penc are different the necessary steps to find the final solution are described separately in the following. It is emphasized at that point that for all calculations in this paper broadcast ephemerides have been used. A pass statistics for all computations is shown in Table 6.2.

6.1 THE GEODOP-V SOLUTION:

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Starting with the majority voted data a first PREDOP run was carried out for all stations except the TRANET-stations. In this run a short-arc orbit was created and the meteorological data were merged with the Doppler data.

Some problems were connected with the stations Grybov, Jozefoslaw, Merate, and Blazajewko for which no approximate coordinates were known. By comparing the frequency differences between north- and southgoing passes and relaxing the a priori sigmas of the station coordinates to about 10 km it was possible to find a priori coordinates which were well within the linear region of the Taylor series expansion. A first single point positioning run then gave correct coordinates within 10 m. These values were used to repeat the PREDOP run with tighter constraints.

After this preparatory work a single point positioning run was carried out for all stations except San Fernando and Brussels selecting standard options displayed in Table 6.1. The results of this computation are shown in Table 6.3. As output of this single point positioning run the cleaned data (identical in format to the original input data with all Doppler counts set to zero which have been eliminated in the foregoing SP-run) have been stored on disc for further use in the short-arc multistation runs.

For the execution of the multi-station run it had to be decided in which way the 25 stations selected for the final computation should be combined. Due to core and time limitations on the UNIVAC 1100/81 it was only

possible to process 15 simultaneously observing stations in one run. As an example, a 15-station run comprising about 60 simultaneously observed satellite passes consumes about 120 K word memory and a CP time of about 1.5 hours the usual way to select some "overlapping stations" for two consecutive runs was abandoned since the quality of a block adjustment depends on the quality of the observations at the common stations. Bad quality of overlapping stations and no redundancy resulted, for instance, in the necessity to repeat the Doppler campaign DØDOC.

For that reason it was decided to use not only four overlapping stations but to use for both station-configurations the same satellite orbits updated by a preliminary 4-station multistation run. In particular the following procedure was used:

The first step was to investigate which quadruple of reasonably distributed stations for which the single point positioning runs had given the evidence of a proper operation and had a maximum of simultaneous passes in common. The second objective was to select stations for which terrestrial coordinates were available, preferably ED-79 coordinates. After examining all these conditions the quadruple Graz-Herstmonceux-Honefoss-Zimmerwald was chosen as the basic reference for which 67 simultaneous passes were recorded. With these four stations a GEODOP multistation run was carried out and the updated satellite orbits were saved on scratch file.

The second step was to merge the 67 passes with the TRANET data of Brussels and San Fernando and to form 2 blocks of stations. The first block consisted of 15 stations, the second block of 14 stations. The updated satellite orbits were superposed to both multistation files which suspended the unpleasant feature of the program MERGE that the first station in the merging process contributes with its orbit to the whole station file.

The third step was to carry out the two multistation runs with the station options determined from the individual SP-runs (Figures 6.1,6.2). Due to the large extension of the network no trimming of Doppler counts was used.

Since 4 stations were simultaneous by definition the option of a minimum number of simultaneous passes and doppler-counts was disabled, as approximate coordinates the single point solutions were introduced with a priori weights of 25 meters. In order to avoid too large displacements of the Doppler solution the 4 central stations defined by the coordinates of the previous 4-station run were supplied with higher weights of 5 meters. The results of both runs (station coordinates and variance-covariance matrix) were stored on disc.

The final step was to combine both solutions by a Helmert block adjustment. Since the same observations of the 4 central stations were introduced into this adjustment by both blocks the elements of the variance covariance matrix pertaining to these four stations were multiplied by a factor of 2 before the adjustment. The 25-station multipoint solution is shown in Table 6.4.

6.2 THE SADOSA SOLUTION

Two solutions have been computed by the program SADOSA. The semi-short arc single point solution is referred as SADOSA SPP, the short arc multilocation solution is called SADOSA ML solution. To both solutions the following remarks must be given:

When applying the 4-coefficient periodic orbital fitting method to broadcast ephemeris of the satellite 30480 (NOVA) the along track fit rms very often exceeded 10 m. Moreover, the observation rms and the correlation were unusually large and the coordinate system definition became contradictory. Oral reports on similar experiences have been given also by ZIPE, GDR. No reason for these contradictions has been found up to now. Therefore, the NOVA satellite passes have been excluded from the multilocation solution of SADOSA.

6.2.1 SADOSA SPP SOLUTION

SADOSA semi-short arc single point solutions have been computed

separately for each station. In case of 24 stations the orbits have been computed from broadcast ephemeris. For the remaining 2 TRANET stations (Brussels and San Fernando) no broadcast ephemeris was available, therefore the coordinate determination for these stations is based on updated orbits (UPD) from neighbouring stations generated in Graz by the PREDOP program applying the GEM 9-model (see Chapter 5.2).

The SADOSA SPP solution is given in Table 6.5. Here the rectangular coordinates and their standard deviations are shown. The coordinates are referred to the antenna phase-centers. The coordinates and their standard deviations for each station are obtained in an orbit-averaged BE system which is one possible realization of the NWL-10D system in each case.

6.2.2. SADOSA ML SOLUTION:

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The SADOSA short arc multilocation solution has been obtained as a network adjustment. As far as the orbits are concerned the statements in Chapter 6.2.1. are valid here, too. In addition, only orbits observed by at least two stations have been introduced. For the reason discussed above all orbits of satellite 30480 (NOVA) have been excluded from the solution.

In the network adjustment the a posteriori standard deviation of unit weights is $\sigma_0 = \pm 1.56$ and the degree of freedom is $f = 44539$. The respective values for the observations are $\sigma_0^{obs} = \pm 1.09$ and $f^{obs} = 36256$ (often called internal σ_0). In case of weighted constraints these quantities are $\sigma_0^{const} = \pm 2.80$ and $f^{const} = 8283$ (often called external σ_0). One can see that the σ_0 differs from unit (more than wanted) due to the σ_0^{const} . The large value of σ_0^{const} occurs probably because of the mixed use of BE and PREDOP orbits.

As the result of adjustment the following main quantities are obtained: Cartesian and ellipsoidal coordinates of the stations, their standard deviations, parameters of error ellipsoid at each station as well as the full variance-covariance matrix of the network and the full matrix of correlation coefficients for the network. Further, the relative positions in terms of Cartesian coordinates, the interstation distances, their

variance - covariance matrices and the standard deviations are computed. In Table 6.6. the Cartesian coordinates and the standard deviations are listed. The coordinates are referred to the antenna phase centres. The coordinates and the respective standard deviations for all stations are obtained in a BE system which is averaged over all orbits and which is uniquely defined for the network. This system is estimated to realize the NWL-10D system with an accuracy of about $\pm 2-3$ m. The correlation matrices for both GEODOP-V and SADOSA solutions, are printed in Appendix E.

How the mathematical model used is suitable for the network and for separate receivers ? Are the observations noisy or not ? These questions can be partly answered by examining the averaged value of residual rms's (σ), the averaged value of residual correlations (ρ) and their dispersions which are given below for each station.

Station	RMS in m		Correlation	
	σ	dispersion	ρ	dispersion
BLZ	± 0.08	± 0.03	0.13	± 0.26
BOR	± 0.09	± 0.04	0.09	± 0.34
BRS	± 0.14	± 0.06	0.13	± 0.30
CGL	± 0.17	± 0.04	- 0.25	± 0.24
DIO	± 0.11	± 0.04	0.16	± 0.31
EFF	± 0.09	± 0.03	0.07	± 0.30
GRS	± 0.16	± 0.08	0.11	± 0.33
GRY	± 0.10	± 0.05	0.10	± 0.28
GRZ	± 0.08	± 0.03	0.11	± 0.32
HMC	± 0.09	± 0.02	0.09	± 0.30
HON	± 0.10	± 0.05	0.26	± 0.29
HVR	± 0.10	± 0.04	0.12	± 0.27
JOZ	± 0.10	± 0.03	0.14	± 0.22
KTW	± 0.07	± 0.02	0.19	± 0.29
MAT	± 0.09	± 0.02	0.05	± 0.33
MER	± 0.10	± 0.05	- 0.07	± 0.24
MET	± 0.21	± 0.08	- 0.02	± 0.29
PDM	± 0.12	± 0.07	0.02	± 0.30
PNC	± 0.07	± 0.02	0.24	± 0.26
RIG	± 0.09	± 0.03	0.12	± 0.30
SFN	± 0.14	± 0.09	0.10	± 0.26
SIM	± 0.13	± 0.06	0.15	± 0.31
SOP	± 0.07	± 0.02	0.11	± 0.25
TRS	± 0.09	± 0.03	0.27	± 0.31
WTZ	± 0.09	± 0.03	0.25	± 0.37
ZMW	± 0.09	± 0.04	0.09	± 0.31

7. INTERCOMPARISONS

The solutions presented in the preceding chapter have been computed by different programs and by using a data set which is not completely identical. Therefore, the solutions can be regarded as, partly, independent. The solutions are not identical, there are discrepancies of more than 2 m for some stations and a systematic shift of up to 10 m. In the following it will be attempted to explain these differences. Moreover, the solutions presented in this paper will be compared with solutions of previous campaigns (WEDOC-1 and EROSDOC) and with terrestrial coordinates where available.

7.1 COMPARISON OF THE GEODOP-V AND THE SADOSA SOLUTION

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Single point solutions have been prepared by both computing centres. They can be regarded as a preparatory step for the computation of the multipoint solution. In Table 7.2 the respective single point solutions computed by GEODOP-V and SADOSA are compared. Due to the strong correlation of the displacement and the rotation parameters the translations in X and Z are cancelled by the rotation around the Y-axis, all other rotations and the scale factor are not significant. Discrepancies of up to $\pm 2\text{m}$ are well within the accuracy expected for the use of broadcast ephemeris in single point positioning mode. One reason for the large residuals in Brussels, Grasse, and San Fernando is that SGO used for these stations PREDOP-updated orbits whereas for all other stations normal majority-voted orbital data were taken.

This fact is also reflected in Table 7.1 where the singlepoint and multipoint solutions of both programs, GEODOP-V and SADOSA, are compared (see Appendix C for the definition of the similarity transformation used). SADOSA singlepoint and multipoint solutions coincide within about 3 meters which is about the accuracy of the broadcast ephemeris system. Larger discrepancies are only found for Brussels, Grasse, and San Fernando for the above mentioned reason. The large shifts in the GEODOP-V comparison is due to the fact that different orbits are used for the singlepoint and the multipoint solution.

The multipoint solution is the most reliable coordinate set which can be achieved by the use of broadcast ephemeris since errors common to all

simultaneously observing stations are dropping out for relative positions. Therefore, it is recommended to use this coordinate set for further applications. As it has been already described in Chapter 5, the most significant difference between the programs GEODOP-V and SADOSA is the method of adjustment. Whereas in GEODOP-V a phased adjustment is carried out which, basically, uses the results of the foregoing pass - after elimination of all non-correlated parameters - as an estimate for the next following pass, the program SADOSA establishes reduced normal-equations for each pass independently and solves this system of normal-equations as a final step. The advantage of the latter method is that station coordinate weights are not dominating the weights of the pass-by-pass parameters which is the case in GEODOP-V after accumulating about 20 to 30 passes. A further advantage of SADOSA is that up to 30 stations can be treated simultaneously, whereas in GEODOP-V (at least in the version used in Graz) only 15 simultaneous stations can be computed. This fact led to different strategies for the computations in Graz and Penc as explained in Chapter 6.

For the multipoint solution in Graz 63 passes - updated by the use of a quasi-fixed 4-station network - were used. These passes have nearly the quality of precise ephemeris produced orbits, however, at the expense of a drastically reduced number of usable passes (see Table 6.2) between 18 passes (San Fernando) and 63 passes. On the other hand the computations by SADOSA did not include the most stable NOVA satellite 30480 for reasons mentioned in Chapter 6.2.

These remarks explain most of the differences in the multipoint solutions of GEODOP-V and SADOSA (see Table 7.2). The large values of the transformation parameters (shift in Y and Z, rotation around Z) can be explained by the different kind of orbits used in both computations. The large residual at San Fernando is, presumably, caused by the small number of passes available for that station.

In order to check the influence of San Fernando on the whole network the multipoint solutions have been recomputed without San Fernando. Both programs show up only insignificant changes of the station coordinates (below 10 cm). Therefore, it was decided to keep San Fernando in the final solution recognizing that only the small number of observations and not bad quality data led to the poor determination of San Fernando.

No explanation can be given for the large residuals at Jozefoslaw and Grasse at the moment. However, the standard deviation of unit weight is ± 0.6 meters which is the accuracy attributed to multipoint Doppler methods over large areas.

7.2 COMPARISONS WITH PREVIOUS CAMPAIGNS

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Although many Doppler campaigns have been organized during the last decade only two of them have enough stations in common with WEDOC-2 to make a meaningful comparison. The campaign WEDOC-1 (RINNER 1982, MIHALY 1982) shares 13 simultaneous stations, the campaign EROSDOC (SCHLÜTER 1979) shares 8 stations with WEDOC-2.

Table 7.3 shows the results of the transformations of the WEDOC-1 and WEDOC-2 solutions computed in Graz and Penc. The solutions agree remarkably well with an average rms of 0.6 meters. Larger residuals occur for the heights of the stations Grasse, Dionysos, and Kootwijk which are displayed in both independently computed solutions. It should be mentioned that the WEDOC-1 solutions have been computed with GEODOP-III and with the first version of SADOSA. An improper handling of the radial orbital constraint in this first version of SADOSA accounts for the large scale factor in Table 7.3.

7 of the EROSDOC stations could be used for a comparison with WEDOC-2. Unfortunately, no centering elements are at disposal for the 8th station Cagliari. In Table 7.4 the transformation parameters and the residuals are listed for both WEDOC-2 solutions. As it was expected the station San Fernando shows up the largest residuals. Since the EROSDOC coordinates have been computed with precise ephemeris it is obvious that these large residuals have been introduced by the WEDOC-2 multipoint solution caused by an insufficient number of introduced satellite passes. Therefore, the transformation has been repeated without San Fernando. Table 7.5 shows the results with excellent agreement. The rms are between ± 0.27 and ± 0.70 m dependent on the components and the type of solution compared.

7.3 COMPARISON WITH ED-79 AND LEVALLOIS 78

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Terrestrial coordinates in the system ED-79 have been submitted for 11

stations together with mean sealevel heights (MSL). In order to obtain ellipsoidal heights geoid undulations have been extrapolated from Levallois 1978 (see Table 7.6.). The values extrapolated are uncertain by at least 1 m in Southern Europe and UK. Due to the large extension of the WEDOC-2 network (3000 km diameter) and the uncertainty of the used heights no good agreement was expected. But even the comparison with the singlepoint solutions in Table 7.7. gives a remarkable agreement with rms better than $\pm 1,5$ m for each coordinate. In Table 7.8 the WEDOC-2 multi-point solution are compared with ED-79/Levallois 78. In view of the large station separations the agreement is excellent giving an average rms of $\pm 0,7$ m in latitude and longitude and $\pm 0,9$ m in height corresponding to an overall agreement of 0,3 ppm. The larger residuals in the horizontal coordinates of Matera in Southern Italy and San Fernando in Southern Spain are not surprising in view of the fact that these points are at the edge of the ED-79 network and that San Fernando is only marginally determined by the WEDOC-2 computations. The large height residual in Kootwijk is most probably due to the terrestrial system since the comparison with EROSDOC confirms the WEDOC results.

7.4. FURTHER COMPARISONS

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In Tables 7.9 and 7.10 the interstation-vectors referred to the stations Graz and Penc are listed (hour angle, declination, distance) together with the respective standard deviations. For 12 interstation-vectors the scalar distances are compared with the results of WEDOC-1 giving the following deviations in m and ppm :

St - St	GEODOP solution		St - St	SADOSA solution	
	Deviation in			Deviation in	
	m	ppm		m	ppm
GRZ - BOR	-0,02	-0,03	PNC - BOR	-0,19	-0,04
GRZ - DIO	-0,55	-0,45	PNC - DIO	-2,94	-2,58
GRZ - EFF	-0,69	-0,93	PNC - EFF	-1,25	-1,32
GRZ - GRS	0,71	0,92	PNC - GRS	-2,43	-2,29
GRZ - HMC	-0,27	-0,23	PNC - GRZ	-0,59	-1,99
GRZ - KTW	-0,41	-0,46	PNC - HMC	-2,34	-1,66
GRZ - PNC	-0,30	-1,01	PNC - KTW	-1,06	-0,98
GRZ - PDM	-0,02	-0,03	PNC - PDM	-0,40	-0,59
GRZ - SOP	0,36	3,42	PNC - SOP	-0,21	-1,02
GRZ - TRS	-0,20	-1,04	PNC - TRS	-0,65	-1,36
GRZ - WTZ	0,25	0,83	PNC - WTZ	-0,32	-0,64
GRZ - ZMW	-0,14	-0,23	PNC - ZMW	-0,96	-1,07

The scale factors presented in Table 7.3 are well reflected in the above - table. In both the GEODOP and the SADOSA solutions the WEDOC-2 distances are systematically shorter than those of WEDOC-1. For GEODOP solution it is less than - 1 ppm with extrem value of 3.42 ppm for GRZ - SOP baseline. For SADOSA solution the systematic difference is between -1 and -2 ppm with extrem deviation of -2.58 ppm for PNC - DIO and -0.04 for PNC - BOR baselines.

Below a table is summarizing the results of 3 - parameter transformations between the different solutions and networks.

Networks	σ_0	ΔX (m)	ΔY (m)	ΔZ (m)
GEODOP SP - MP	± 1.11	- 1.35 \pm .23	- 0.43 \pm .23	8.01 \pm .23
SADOSA SP - MP	± 1.27	0.95 \pm .25	- 1.29 \pm .25	0.98 \pm .25
GEODOP SP - SADOSA SP	± 1.48	- 0.37 \pm .44	0.48 \pm .44	- 3.63 \pm .44
GEODOP MP - SADOSA MP	± 0.83	2.15 \pm .17	- 0.36 \pm .17	- 10.42 \pm .17
GEODOP MP - EROSDOC	± 1.53	2.08 \pm .58	- 0.73 \pm .58	- 9.07 \pm .58
SADOSA MP - EROSDOC	± 1.68	0.05 \pm .64	- 0.13 \pm .64	1.02 \pm .64
GEODOP SP - ED79	± 1.66	79.46 \pm .53	111.48 \pm .53	116.09 \pm .53
SADOSA SP - ED79	± 1.82	79.87 \pm .58	111.24 \pm .58	119.91 \pm .58
GEODOP MP - ED79	± 2.30	81.64 \pm .73	112.26 \pm .73	108.97 \pm .73
SADOSA MP - ED79	± 1.86	79.25 \pm .59	112.84 \pm .59	119.18 \pm .59

8. CONCLUSIONS AND OUTLOOK

8.1. The preceding chapters of this report can be summarized as follows :

- =====
- The data of WEDOC-2 have been acquired by different types of receivers (MX-1502, MARCONI, JMR, TRANET, DOG, see Table 2.1) and are, therefore, not strictly homogenous. However, the observations have been treated equivalently since no significant differences among the various types of the receivers are manifested.
 - The positions of the WEDOC-2 sites could only be computed with broadcast ephemeris (BE) by means of singlepoint (BS) and multipoint (BM) procedures. The observations have been processed by the programs GEODOP-V and SADOSA at ISP and SGO, respectively. The respective solutions agree within the accuracy attributed to Doppler methods. Some reasons for the differences in both solutions are explained in Chapter 7.1. All external comparisons have been carried out for both multipoint solutions.
 - All comparisons have used a 7 - parameter linear transformation including 3 displacements, 3 rotations and a scale factor. The respective formulas as well as the formulas used for the transformation of 3-D coordinates to ellipsoidal coordinates and used for the computation of the interstation vectors are shown in the appendices C and D.
 - The comparison between the GEODOP-V BM and the SADOSA BM solutions for WEDOC-2 gives a standard deviation of unit weight of $\sigma_0 = \pm 0,62$ m and a Z-axis rotation is detected (see Table 7.2).
 - A seven station subset of WEDOC-2 network common with EROSDOC have been transformed to the EROSDOC solution (Table 7.4). The GEODOP-V BM and the SADOSA BM solutions do not agree satisfactorily with EROSDOC ($\sigma_0(\text{GEOD}) = \pm 1.4$ m, $\sigma_0(\text{SAD}) = \pm 1.3$ m). The station San Fernando has shown the largest residual (mainly in longitude) which is probably due to too few passes involved. The omission of San Fernando surprisingly improved the similarity to ± 0.52 m for GEODOP-V BM and ± 0.57 m for SADOSA BM (Table 7.5). There are significant translations in all three components, a scale factor and a Z-axis rotation for GEODOP-V BM and significant translation in Z, a scale factor and a Z-axis rotation for SADOSA BM.

- The GEODOP-V BM and the SADOSA BM solutions have been transformed to ED-79 (Table 7.8). In the two sets of the transformation parameters the scale factors are of the same value and no rotation around Y can be observed. The residuals of multipoint solutions are such that the standard deviation of unit weight is ± 0.89 m for GEODOP-V BM and ± 0.75 m for SADOSA BM. At some stations the height residuals are large. It is probably caused by the inaccurately determined geoidal heights extrapolated graphically from Levallois 78.
- The transformation of the GEODOP solutions obtained for WEDOC-1 and WEDOC-2 yields a σ_0 of ± 0.57 m (Table 7.3). Their origins differ significantly in X and Z and some Y-rotation exists between them. The respective SADOSA solutions give a σ_0 of ± 0.63 m. However, each transformation parameter between the SADOSA BM solutions for WEDOC-1 and WEDOC-2 differs significantly from zero. Especially the scale factor is large. This fact is strongly recommended to be considered when comparing the interstation distances. In both, the GEODOP and SADOSA solutions, the coordinates of WEDOC-1 are similar to those of WEDOC-2 by ± 0.4 m in position and ± 0.9 m in height.
- The accuracy of BM WEDOC-solutions is better than 1 m corresponding to a relative accuracy of better than 1 ppm for the large size of the WEDOC-network (3000 km diameter).

8.2. Concerning the lot of Doppler campaigns having been carried out by means of the NNS system the question arises: How significant are the WEDOC-2 results ?

- Based on recent methods of geodesy, mathematics, and physics, terrestrial geodetic networks are under completion and revision with the purpose to improve their accuracy and to get 3-dimensional, uniform coordinates as a function of time or, alternatively, the proper mathematical-physical description. These informations can be used to control local, regional and more extended geodetic networks in which different national and international communities are involved all over the world.
- As a satellite geodetic approach to this problem, in last decade numerous Doppler observation campaigns have been carried out all over the world by means of the Navy Navigation Satellite System of USA. The accuracy achieved is about some decimeters and is superior to terrestrial methods only for distances more than 200 km. This method is, therefore, suitable for supporting and controlling extended networks.

The main application concerns, however, the geodetic connection of local systems and the bridging of maritime regions.

- In near future the NNSS will be replaced by the more efficient and accurate Global Positioning System (GPS) and, possibly, by similar systems of the USSR, ESA and other organizations leading to an accuracy of relative positions in the cm region. The inertial frame for relative determinations can be provided by laser ranging and VLBI methods which are in use already and enable us to achieve an accuracy of about some cm.
- On the way to achieve this geodetic dream the objects pursued by WEDOC remain entitled for a long time. For, the results of WEDOC-1 and WEDOC-2 can be considered as a first iteration for a geodetic system connecting Eastern and Western Europe, which will lead to further more accurate iterations by repeating the campaigns with better measuring systems. Thereby, a system of geodetic control points is created in the European region in which geodetic procedures developed in East and West can be tested and compared. This system can operate as a bridge for the exchange of scientific experiences and ideas as well as a tie by which the European geodetic cooperation developed in the course of a long history can be strengthened.
- Scientific and human contacts introduced by WEDOC-1/2 facilitate the exchange of experiences and promote the performance of common projects. Moreover, the introduction of global positioning systems is prepared as a basis for scientific and engineering projects.

8.3. Now the question arises in which way WEDOC should continue ?

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- For all WEDOC-2 stations 3-D coordinates are now available in a geocentric system together with the correlation matrices and the transformation parameters to ED-79 (Table 6.4 - 6.6, Appendix E, Table 7.8). For Western Europe WEDOC-2 confirms the results obtained up to now. For Eastern Europe conclusions can only be drawn with respect to previous Doppler Campaigns since the terrestrial coordinates of the stations in this region are not known. However, now the possibility exists to transform national datums to ED-79 and vice versa.

- By comparing the WEDOC results with the data of the national survey statements can be made on the accuracy of these data as well as the quality and efficiency of own or other positioning systems. By repeating WEDOC measurements with increased accuracy (possibly with other methods) statements on geodynamical processes and tectonic variations can be expected. WEDOC sites can also be considered as basic stations for local investigations.
- Since, in future, Doppler procedures will not be used any more the name of the campaign should be changed. It is proposed to replace WEDOC by the acronym WEPOC (West East European Satellite Positioning Campaign). It is also put up for discussion to set up a WEPOC commission (possibly within the IAG) in which all countries involved in WEPOC are represented and in which further activities can be discussed and decided. Due to geographical and historical reasons the political neutral Austria offers its opportunities for hosting this permanent commission.

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Finally the hope is expressed that, with the same idealistic work, the continuation of the WEDOC or WEPOC project and the realization of the idea addressed in Chapter 8. will be possible.

REFERENCES:

- Boucher 1981 : C. Boucher, P. Paquet, P. Wilson: Final Report on the Observations and Computations carried out in the Second European Doppler Observation Campaign EDOC-2 for Position Determinations at 37 Satellite Tracking Stations. DGK-Reihe B, Heft Nr. 225, Frankfurt/Main, FRG, 1981.
- Brunell 1982 : R.D. Brunell, R. Malla, I. Fejes, Sz. Mihaly: Recent Satellite Processing Software Improvements at JMR. Proceedings of the 3rd Int. Geod. Symp. on Satellite Doppler Positioning, Las Cruces, USA, 1982.
- Clynch 1979 : J.R. Clynch, R.A. Altenberg: Ionospheric Residual Range Error Model; Proc. of the 2nd Int. Symp. on Satellite Doppler Positioning, Austin, Texas, 1979.
- CSTG 1983 : Bulletin CSTG: NNSS Doppler Data Standard Exchange Format SEF. Subcommittee on Standards Publications No. 3, July, 1983.
- Joo 1984 : I. Joo, J. Adam, A. Czobor, Sz. Mihaly: Improvement of the Hungarian National Geodetic Control Network by Satellite Geodetic Doppler Positioning. Paper submitted to the Joint Meeting FIG - Study Groups 5B and 5C. July 1-3, 1985, Munich, Fed. Rep. of Germany.
- Kouba 1975 : J. Kouba, J. Boal: Programm GEODOP Documentation; Geodetic Survey of Canada, Ottawa, 1975.
- Kouba 1982 : J. Kouba: GEODOP-V Geodetic Positioning Program (Version V); Gravity, Geothermics & Geodynamics Div., Earth Physics Branch, Ottawa, May 1983.
- Mihaly 1982 : Sz. Mihaly: SADOSA Processing of WEDOC Observations. (In Hungarian). GEODINFORM No. 1-2, Budapest, Hungary, 1982.
- Mihaly 1982a : Sz. Mihaly: SADOSA Processing of the Hungarian National Doppler Network (in Hungarian). Geodezia es Kartografia 1982/2, Budapest, Hungary.

- Mihaly 1982 b :Sz. Mihaly et al.: Doppler Calibration Campaign Penc, DCCP2. Paper presented at the Intercosmos Scientific Conference, Section 6. Suzdal, USSR, September, 1982.
- Mihaly 1983 :Sz. Mihaly: SADOSA Program System (I. Mathematical Description, II. Programming Documentations, III. Operator's Manual); Hungarian Geodetic Survey/Institute of Geodesy and Cartography/Satellite Geodetic Observatory. Budapest, 1983.
- Mihaly 1984 :Sz. Mihaly, P. Pesec: West-East European Doppler Observation Campaign WEDOC 2; Preliminary Results. Paper presented at the INTERCOSMOS/COSPAR Scientific Conference. Karlovy Vary, Tschechoslovakia, September 1984.
- Pesec 1984 :P. Pesec, Sz. Mihaly: West-East European Doppler Observation Campaign WEDOC 2; Preliminary Results. Proceedings of the International Symposium on Space Techniques, Sopron, Hungary, 1984.
- Rinner 1982 :K. Rinner, P. Pesec: West-East European Doppler Observation Campaign; Final Results. Manuscripta Geodetica, Vol.7, No.2, Aug. 1982, FRG.
- Rinner 1982a :K. Rinner, P. Pesec: Über die Doppler-Kampagne TESTDOC im Testnetz Steiermark; ÖZfVuPh, Jg.70, Heft 1, 1983.
- Schenke 1982 :H.W. Schenke: Precision Doppler Satellite Observation in the German Three-Dimensional Testnet Western Harz; Proc. of the 3rd Int. Symp. on Satellite Doppler Positioning, Las Cruces, N.M., Feb. 1982.
- Schlüter 1979 :W. Schlüter, H. Seeger, P. Wilson: Final Results of the EROS-Doppler Observation Campaign. Presented at the XVII General Assembly of IUGG, Canberra, 1979.

F I G U R E C A P T I O N S

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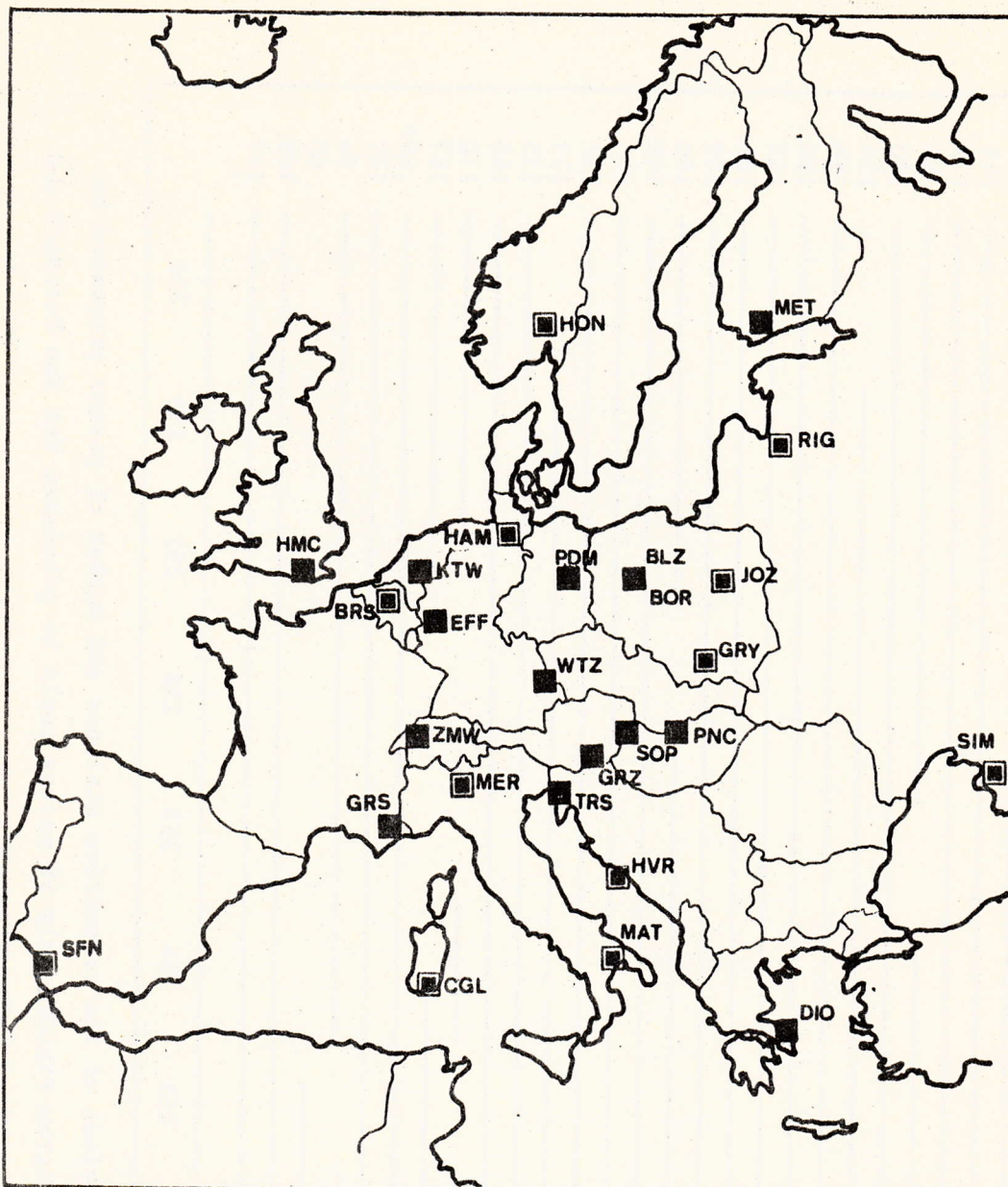


FIGURE 2.1 ■ Doppler stations participating in WEDOC-1 and WEDOC-2
▣ Doppler stations participating only in WEDOC-2

	250	251	252	253	254	255	256	257	258	259	
BLZ											139
BOR											141
BRS											179
CGL											88
DIO											130
EFF											154
GRS											156
GRZ											156
GRY											142
HMC											166
HON											249
HVR											140
JOZ											146
KTW											125
MAT											127
MER											112
MET											135
PNC											145
PDM											110
RIG											167
SFN											68+
SIM											137
SOP											94
TRS											60
WTZ											109.
ZMW											157

FIGURE 3.1: Observation periods of the respective stations and number of passes processed by the editing program PREDOP; only 68 passes could be processed for San Fernando due to the lack of orbital informations.

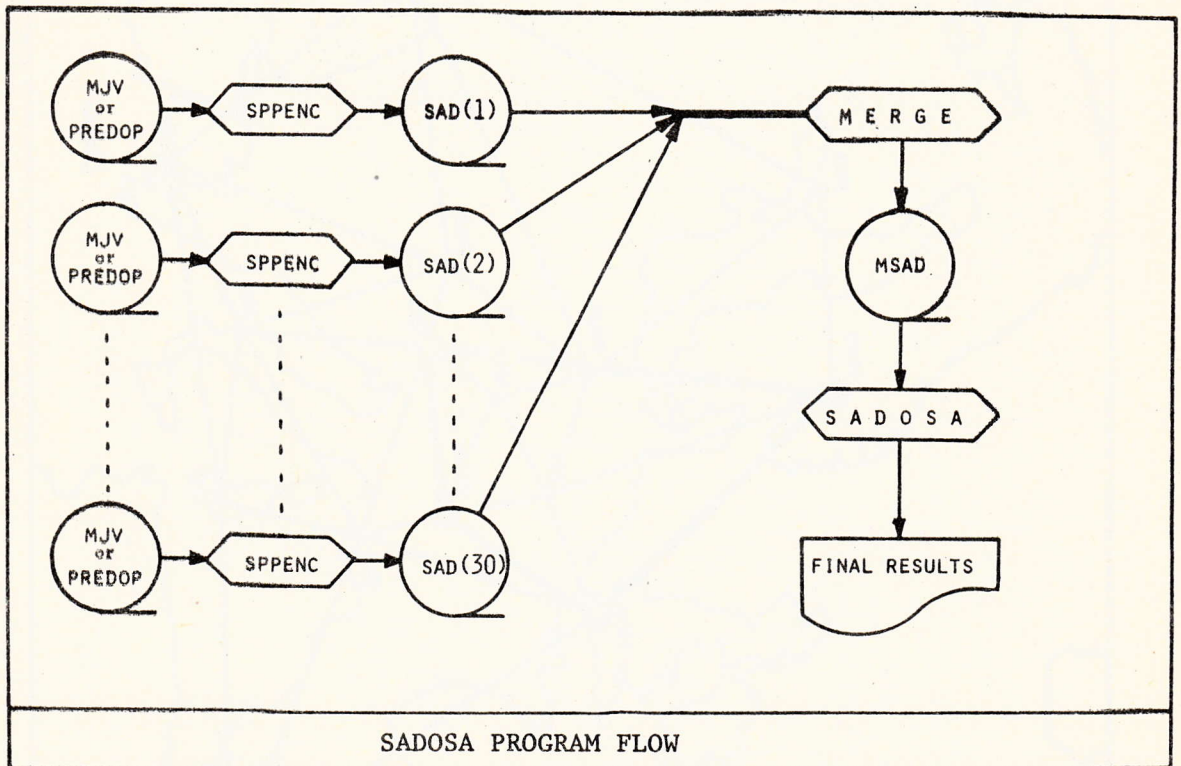
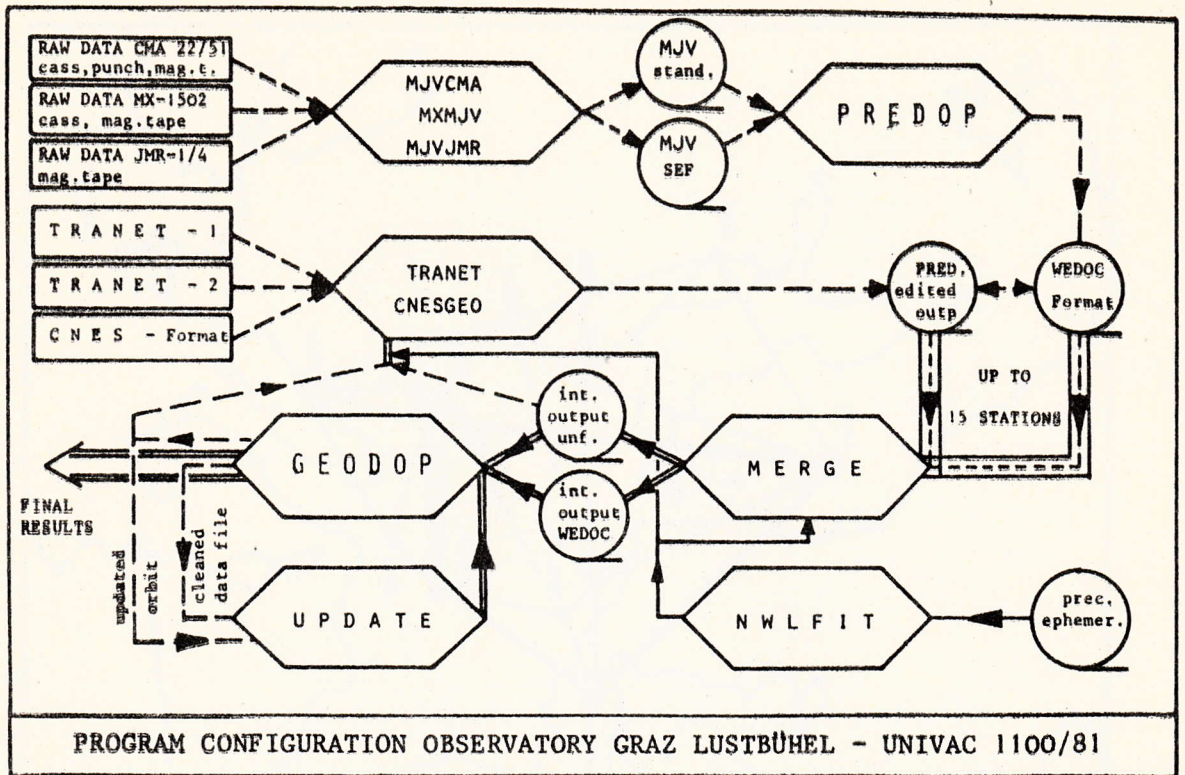


FIGURE 5.1 a,b: Program flow diagram of GEODOP-Y and SADOSA

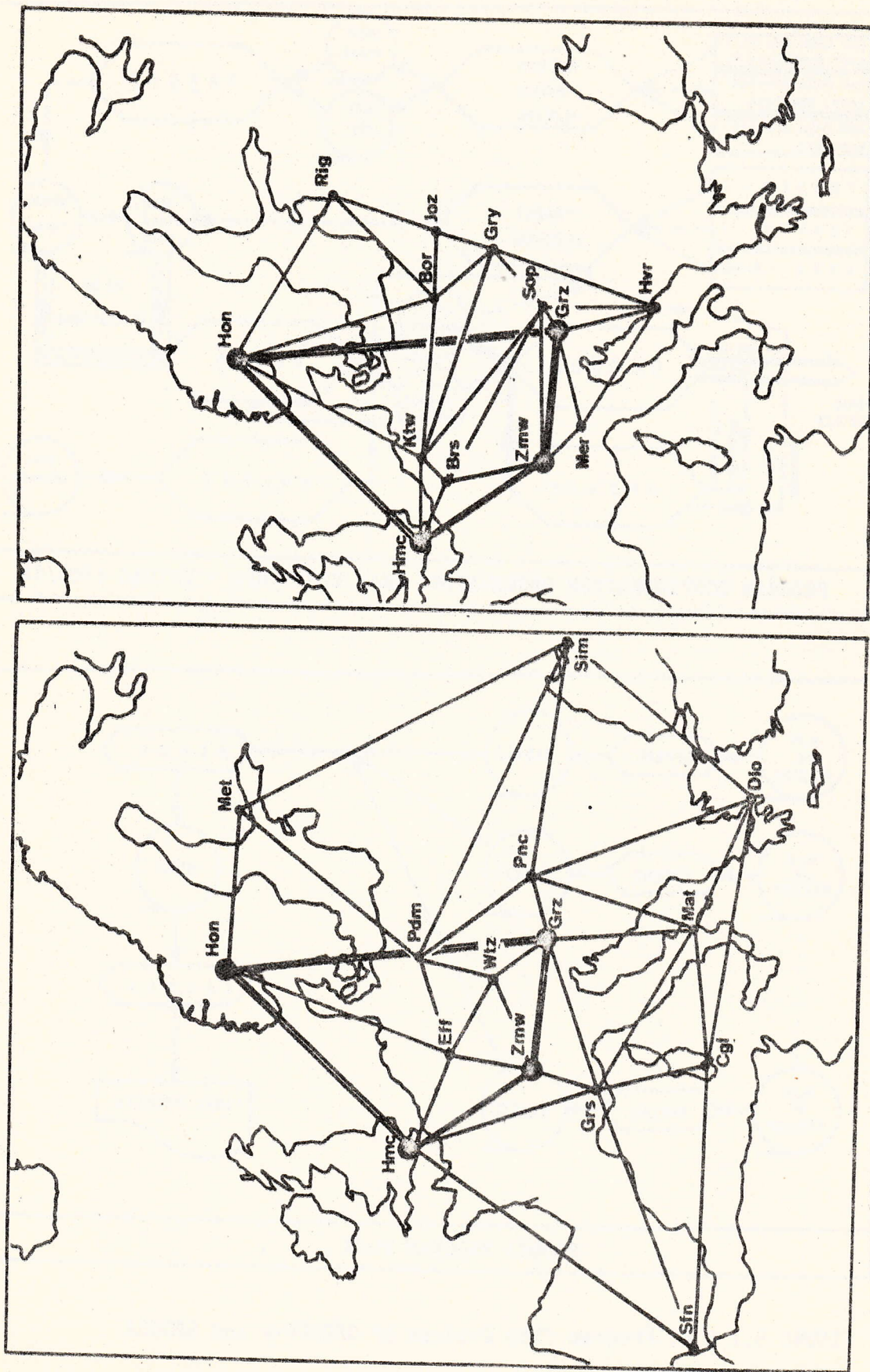


FIGURE 6.1: Station distribution for GEODOP-V block 1.

FIGURE 6.2: Station distribution for block 2.

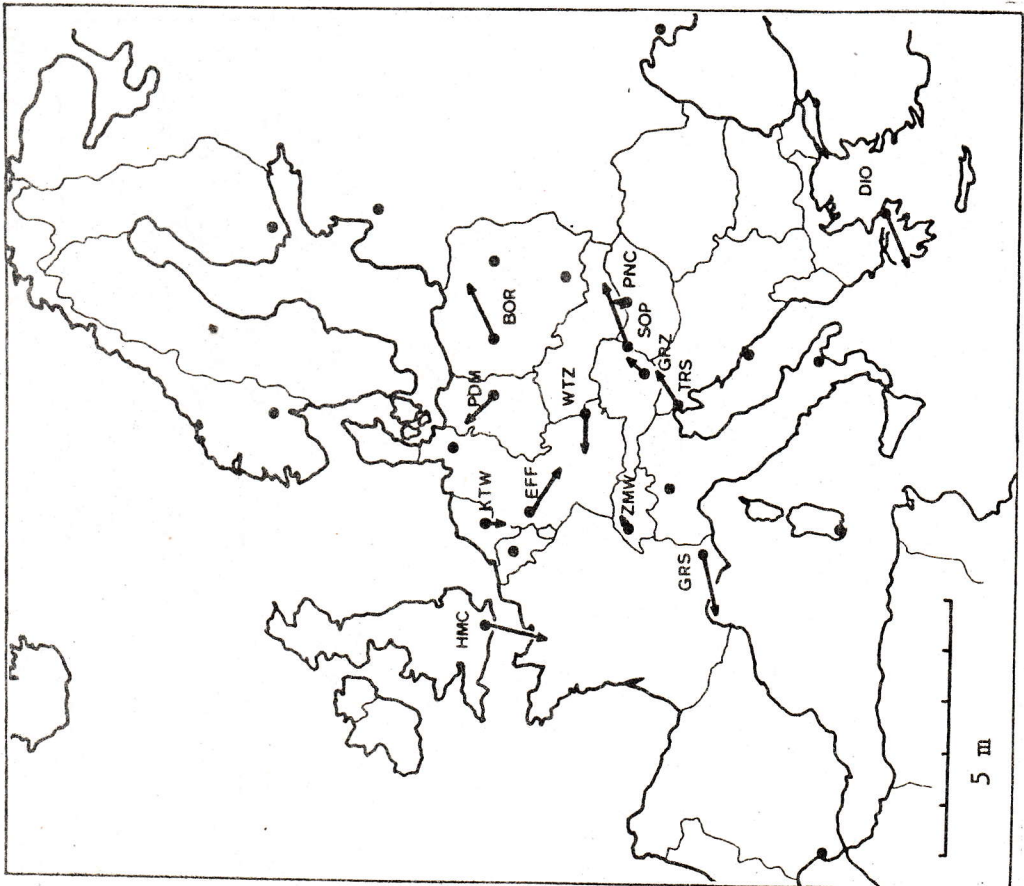
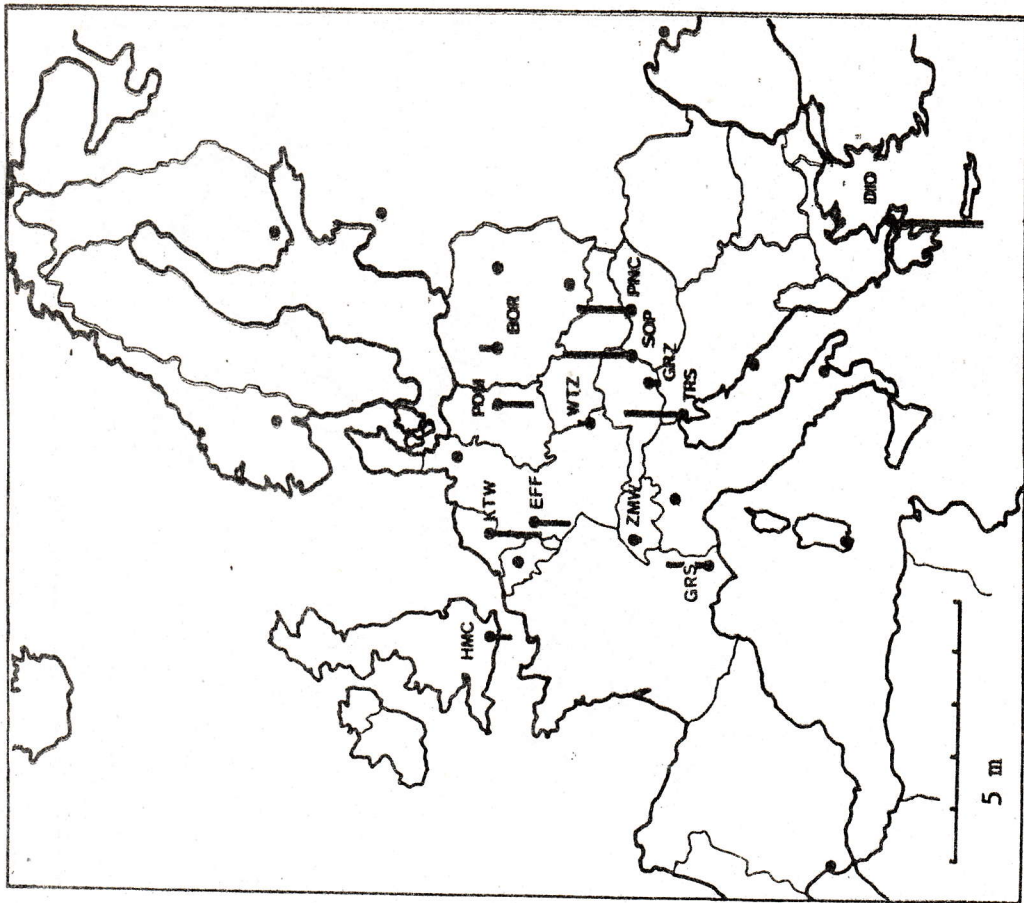


FIGURE 7.1. Computation Graz : Residuals after transformation MEDOC-2 and MEDOC-1; Positions (left figure) heights (right figure)

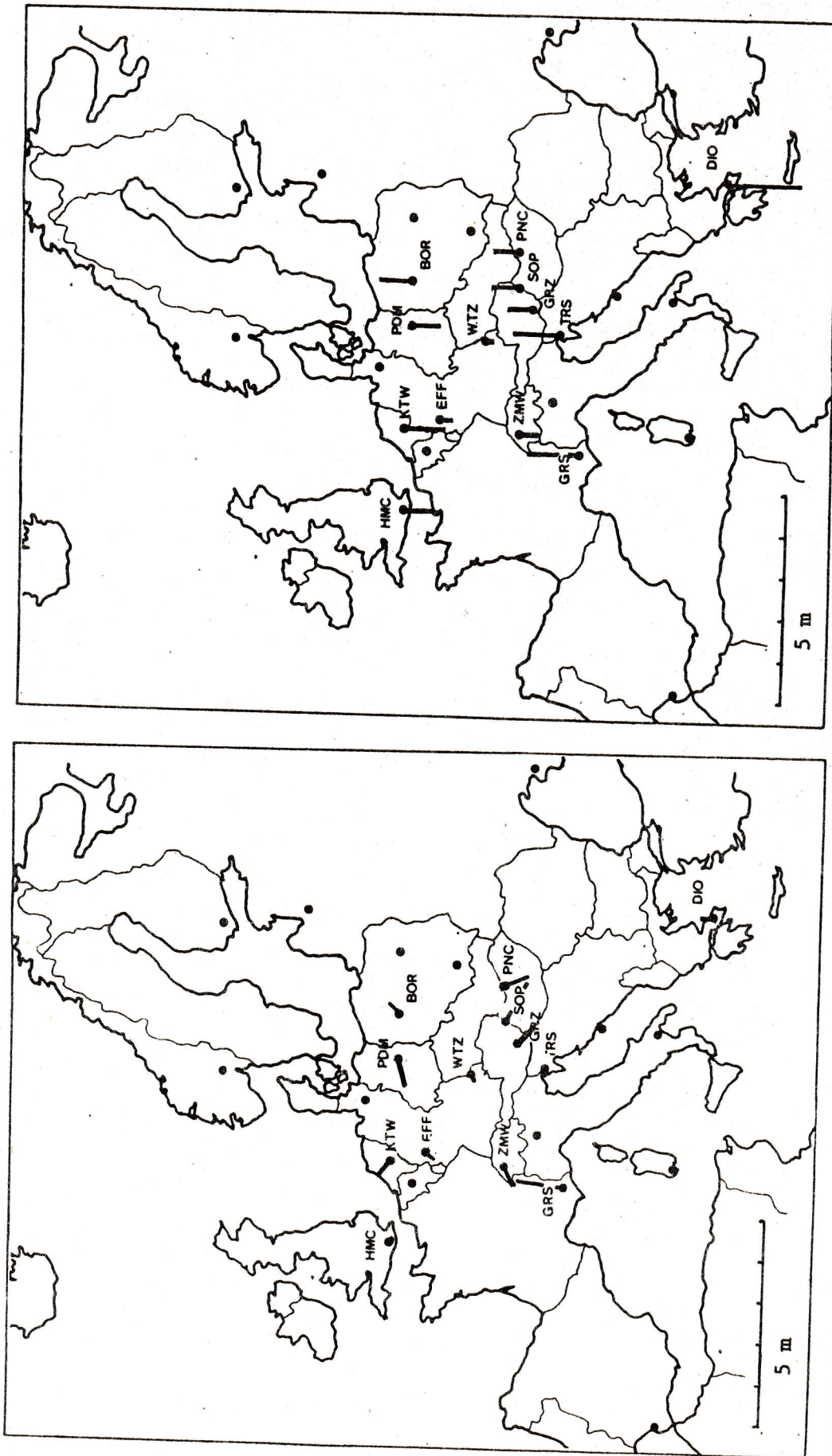


FIGURE 7.2. Computation Graz : Residuals after transformation WEDOC-2 and WEDOC-1; Positions (left figure) heights (right figure)

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- Table 7.10: Interstation vectors starting in Penc (WEDOC-2 and WEDOC-1)

STATION	CODE	REC. TYPE	APPROXIMATE COORDINATES						
			LATITUDE			LONGITUDE		HEIGHT	
			DEG	MIN	SEC	DEG	MIN		SEC
BLAZAJEWKO	BLZ	JMR-4A	52	12	2	17	6	37	66
BOROWIEC	BOR	DOG 2	52	16	39	17	4	27	79
BRUSSELS	BRS	TRANET-2	50	47	57	4	21	37	120
CAGLIARI	CGL	MX-1502	39	8	12	8	58	26	177
DIONYSOS	DIO	MX-1502	38	4	47	23	55	59	450
EFFELSBERG	EFF	MX-1502	50	34	33	6	56	45	409
GRASSE	GRS	JMR-1A	43	39	58	6	54	58	525
GRAZ	GRZ	CMA-722B	47	4	5	15	29	40	492
GRYBOV	GRY	JMR-4A	49	37	48	20	56	57	377
HAMBURG	HAM	MX-702A	53	32	49	9	58	5	89
HERSTMONCEUX	HMC	MX-1502	50	52	1	0	20	45	25
HONEFOSS	HON	CMA-751	60	8	38	10	15	2	146
HVAR	HVR	MX-1502	43	10	42	16	26	59	237
JOZEFOSLAW	JOZ	JMR-4A	52	5	53	21	1	56	111
KOOTWIJK	KTW	CMA-761	52	10	45	5	48	41	46
MATERA	MAT	MX-1502	40	38	59	16	42	19	481
MERATE	MER	MX-1502	45	42	24	9	25	46	349
METSÄHÖVI	MET	JMR-4A	60	13	4	24	23	44	49
PENC	PNC	JMR-1A	47	47	26	19	16	55	245
POTSDAM	PDM	JMR-1A	52	22	51	13	3	59	109
RIGA	RIG	CMA-722B	56	56	57	24	3	34	6
SAN FERNANDO	SFN	TRANET-2	36	28	0	- 6	12	14	-1
SIMEIZ	SIM	MX-1502	44	24	50	33	59	32	344
SOPRON	SOP	CMA-751	47	40	49	16	33	30	342
TRIESTE	TRS	MX-1502	45	38	37	13	52	35	403
WETTZELL	WTZ	CMA-722B	49	8	44	12	52	47	618
ZIMMERWALD	ZMW	MX-1502	46	52	41	7	28	0	895

TABLE 2.1: List of the Stations Participating in WEDOC-2; Types of Receivers used; Approximate Coordinates.

STATION	Δ lat	Δ long in meter	Δ height	Δ X	Δ Y in meter	Δ Z
BLZ	-45.12	6.53	-9.32	26.69	15.05	-35.02
BOR	-9.61	-19.80	-12.08	6.02	-18.86	+15.44
BRS				-35.06	-13.12	22.00
CGL	----	----	----	----	----	----
DIO	26.80	-29.59	-8.05	-8.90	-36.32	16.13
EFF	0.00	0.00	0.00	0.00	0.00	0.00
GRS	0.00	0.00	-0.44	-0.32	-0.04	-0.30
GRZ	0.00	0.00	-2.03	-1.33	-0.37	-1.49
GRY	-74.18	-103.56	-8.57	84.62	-78.49	-54.58
HAM				4.96	6.14	-7.29
HMC				-70.12	667.18	54.28
HON	-1.41	-1.66	-3.64	-0.28	-1.74	-3.86
HVR	----	----	----	----	----	----
JOZ	-34.29	-49.23	-2.72	41.36	-36.84	-23.21
KTW	0.00	0.00	-3.17	-1.93	-0.19	-2.50
MAT	0.00	0.00	0.00	0.00	0.00	0.00
MER	----	----	----	----	----	----
MET	0.00	0.00	-0.53	-0.24	-0.11	-0.46
PNC	0.00	0.00	-0.48	-0.30	-0.11	-0.36
PDM	110.51	-30.70	2.96	-76.57	-49.29	69.80
RIG	1.00	37.60	-2.75	-17.46	33.38	-1.76
SFN	-4.22	29.04	-2.99	3.24	28.86	-5.17
SIM	----	----	----	----	----	----
SOP	-1.42	-1.22	-0.06	1.32	-0.88	-1.00
TRS	0.00	0.00	0.00	0.00	0.00	0.00
WTZ	0.00	0.00	0.00	0.00	0.00	0.00
ZMW	11.93	37.02	-7.74	-18.69	34.89	2.51

TABLE 3.1: Centering elements of the stations participating in WEDOC-2. The coordinate-differences are defined as terrestrial reference point minus antenna phase centre. Dashes denote stations where no centering elements are available.

STATION	CODE	REC. TYPE	TYPE OF DATA RECEIVED	CARRIER	MJV BY
BLAZAJEWKO	BLZ	JMR-4A	raw-data original	cassettes	SGO
BOROWIEC	BOR	DOG-2	MJV-data format Graz	mag.tape	BOR
BRUSSELS	BRS	TRANET-2	raw-data CNES format	mag.tape	GRZ
CAGLIARI	CGL	MX-1502	raw-data binary hardcopy	mag.tape	GRZ
DIONYSOS	DIO	MX-1502	raw-data original binary	cassettes	GRZ
EFFELSBURG	EFF	MX-1502	raw-data binary hardcopy	mag.tape	GRZ
GRASSE	GRS	JMR-1A	raw-data hardcopy + SEF fmt.	mag.tape	GRZ
GRAZ	GRZ	CMA-722B	MJV-data format Graz	disc	GRZ
GRYBOV	GRY	JMR-4A	raw-data original	cassettes	SGO
HAMBURG	HAM	MX-702A	raw-data hardcopy	mag.tape	---
HERSTMONCEUX	HMC	MX-1502	raw-data original binary	cassettes	GRZ
HONEFOSS	HON	CMA-751	MJV-data CMA format 3	mag.tape	HON
HVAR	HVR	MX-1502	raw-data binary hardcopy	mag.tape	GRZ
JOZEFOSLAW	JOZ	JMR-4A	raw-data original	cassettes	SGO
KOOTWIJK	KTW	CMA-761	MJV-data CMA format 1	mag.tape	KTW
MATERA	MAT	MX-1502	raw-data binary hardcopy	mag.tape	GRZ
MERATE	MER	MX-1502	raw-data binary hardcopy	mag.tape	GRZ
METSÄHÖVI	MET	JMR-4A	MJV-data format JMR-4	cassettes	MET
PENC	PNC	JMR-1A	raw-data original	cassettes	SGO
POTSDAM	PDM	JMR-1A	raw-data original	cassettes	SGO
RIGA	RIG	CMA-722B	raw-data original	punchtape	GRZ
SAN FERNANDO	SFN	TRANET-2	raw-data hardcopy fmt. T-2	mag.tape	GRZ
SIMEIZ	SIM	MX-1502	raw-data original	cassettes	GRZ
SOPRON	SOP	CMA-751	MJV-data CMA format 3	mag.tape	SOP
TRIESTE	TRS	MX-1502	raw-data binary hardcopy	mag.tape	GRZ
WETTZELL	WTZ	CMA-722B	MJV-data format Graz	mag.tape	WTZ
ZIMMERWALD	ZMW	MX-1502	raw-data hexadecimal	mag.tape	GRZ

TABLE 4.1: Format of data supplied by the stations to the computing centres
Graz and SGO

(METEOROLOGICAL DATA, MAJORITY VOTED DATA AND WFD0C-FORMAT)			
NO LABEL,	EBCDIC,	1600 BPI, 80 CHAR/REC,	4000 CHAR/BLOCK
FILE 01	27 STATIONS	METEODATA	2773 RECORDS
FILE 02	STATION BLAZAJEWKO	MJV-DATA	1867 RECORDS
FILE 03	STATION BOROWIEC	MJV-DATA	3299 RECORDS
FILE 04	STATION CAGLIARI	MJV-DATA	2246 RECORDS
FILE 05	STATION DIONYSOS	MJV-DATA	3812 RECORDS
FILE 06	STATION EFFELSBERG	MJV-DATA	3870 RECORDS
FILE 07	STATION GRYBOW	MJV-DATA	1725 RECORDS
FILE 08	STATION GRAZ	MJV-DATA	2949 RECORDS
FILE 09	STATION HAMBURG	MJV-DATA	2902 RECORDS
FILE 10	STATION HERSTMONCEUX	MJV-DATA	4164 RECORDS
FILE 11	STATION HONEFOSS	MJV-DATA	6138 RECORDS
FILE 12	STATION HVAR	MJV-DATA	3960 RECORDS
FILE 13	STATION JOZEFOSLAW	MJV-DATA	1968 RECORDS
FILE 14	STATION KOOTWIJK	MJV-DATA	3124 RECORDS
FILE 15	STATION MATERA	MJV-DATA	3120 RECORDS
FILE 16	STATION MERATE	MJV-DATA	1452 RECORDS
FILE 17	STATION METSAHOVI	MJV-DATA	1953 RECORDS
FILE 18	STATION POTSDAM	MJV-DATA	2359 RECORDS
FILE 19	STATION PENC	MJV-DATA	1910 RECORDS
FILE 20	STATION RIGA	MJV-DATA	3811 RECORDS
FILE 21	STATION SIMEIZ	MJV-DATA	3058 RECORDS
FILE 22	STATION SOPRON	MJV-DATA	2222 RECORDS
FILE 23	STATION TRIFSTE	MJV-DATA	1474 RECORDS
FILE 24	STATION WETTZELL	MJV-DATA	1752 RECORDS
FILE 25	STATION ZIMMERWALD	MJV-DATA	5080 RECORDS
FILE 26	STATION BOROWIEC	WEDOC-FORMAT	3051 RECORDS
FILE 27	STATION BRUSSELS	WEDOC-FORMAT	2317 RECORDS
FILE 28	STATION CAGLIARI	WEDOC-FORMAT	2473 RECORDS
FILE 29	STATION DIONYSOS	WEDOC-FORMAT	2977 RECORDS
FILE 30	STATION EFFELSBERG	WEDOC-FORMAT	3513 RECORDS
FILE 31	STATION GRASSE	WEDOC-FORMAT	3439 RECORDS
FILE 32	STATION GRYBOW	WEDOC-FORMAT	3131 RECORDS
FILE 33	STATION GRAZ	WEDOC-FORMAT	3445 RECORDS
FILE 34	STATION HERSTMONCEUX	WEDOC-FORMAT	3821 RECORDS
FILE 35	STATION HONEFOSS	WEDOC-FORMAT	5881 RECORDS
FILE 36	STATION HVAR	WEDOC-FORMAT	3223 RECORDS
FILE 37	STATION JOZEFOSLAW	WEDOC-FORMAT	3409 RECORDS
FILE 38	STATION KOOTWIJK	WEDOC-FORMAT	2905 RECORDS
FILE 39	STATION MATERA	WEDOC-FORMAT	2927 RECORDS
FILE 40	STATION MERATE	WEDOC-FORMAT	2503 RECORDS
FILE 41	STATION METSAHOVI	WEDOC-FORMAT	2925 RECORDS
FILE 42	STATION POTSDAM	WEDOC-FORMAT	2463 RECORDS
FILE 43	STATION PENC	WEDOC-FORMAT	3217 RECORDS
FILE 44	STATION RIGA	WEDOC-FORMAT	3445 RECORDS
FILE 45	STATION SAN FERNANDO	WEDOC-FORMAT	1261 RECORDS
FILE 46	STATION SIMEIZ	WEDOC-FORMAT	3011 RECORDS
FILE 47	STATION SOPRON	WEDOC-FORMAT	2257 RECORDS
FILE 48	STATION WETTZELL	WEDOC-FORMAT	2419 RECORDS
FILE 49	STATION ZIMMERWALD	WEDOC-FORMAT	4893 RECORDS

TABLE 4.2: Structure of the data files available and prepared for data-exchange.

	Graz	Penc
Program name: origin:	GEDODOP V J. Kouba, Grav., Geoth., Geodyn. Div., Ottawa	SADOSA Sz. Mihaly, Sat. Geod. Obs. Penc, Hungary
Computer language: type:	FORTRAN 77 UNIVAC 1100 / 81	FORTRAN HWB 20/66-60/66
Model	range difference	range difference or pseudorange
Biased parameters:	dX, dY, dZ, da, dM, di, dΩ, de, dω, df, dt, dk, df	dX, dY, dZ, DE, da, dη, dE, da, dη, df, dt, dk, df
Adjustment technique:	phased adjustment with maximal 15 sim. stat. correlat. analysis	SPP, ML (max. 30 stat.), SSA, SA
Weighting:	weighting of biased parameters, input of stat. var-cov. matrix Doppler counts, sat. frequencies, etc.	variance matrix of ob- servations (convent. or time series), weighted constr. of all param.
Receivers:	all commonly used types	JMR-1/4, CMA-722B/751/ 761, MX-1502, DOG-2/3
Input format: Orbit type: fitting: representation:	all commonly used fmts BE, PE, short arc derivative fitting 10 order Chebyshev fit	MJV or WEDOC format PE, BE or PREDOP orbit 4-coeff. periodic 10 order Chebyshev
Velocity of light:	299 792.458 m/sec	299 792.458 m/sec
Earth rotation:	yes ($4.3752695 \cdot 10^{-3}$ r/m)	yes
Tropospheric model:	Black's model	Black's model
Relativistic effects:	yes	yes

TABLE 5.1: Comparative description of the software used for the WEDOC-2 computations .

OPTIONS	GEODOP - V	SADOSA
Horizon cut-off angle	7.5°	8° - 10°
Pass elevation cut-off angle	14.5°	13° - 14° ; maximum 89°
Minimum number of Doppler counts	6	10
a priori variance factor	$\sigma_o = \pm 1.4$	$\sigma_o = \pm 1.0$
Number of simultaneous orbits	at least 4	at least 2
Editing of residuals	$v_i \leq 3 \sigma$ phase(range) $\sigma = 2$ cm rangerate $\sigma = 5$ cm (norm. to 30s)	$v_i \leq 3 \sigma_{kj}$ $\sigma_{kj} < 30$ cm
Receiver delays	650 μ sec for CMA, 300 μ sec for MX-1502, 200 μ sec for JMR	500 μ sec for all receivers
Meteorological data:	measured or extrapolated	measured or extrapolated
Frequency and sigma	as determined from PREDOP	by SPENC, sigma = 1 Hz
Frequency drift and sigma	as determined from PREDOP	
Time frame	receiver time frame	receiver time frame
Time delay sigma	100 microseconds	100 microseconds
Satellite frequencies	as determined from SP-runs	by broadcast
Orbital degrees of freedom	6 biases	6 biases
Tropospheric scaling factor	10% of nominal correction	3 m
a priori station coordinate constraints	25 meters for all stations except the 4 quasi-fixed stations (5 meters)	No constraint
Orbital biases:	$d\alpha = 1.5$ m, $dM = 13.5$ m, $d\dot{\alpha} = 1.5$ m $d\Omega = 1.5$ m, $d\dot{\Omega} = 1.5$ m, $d\omega = 2.5$ m	Sigma: 26 m, 10 m, 5 m 1 cm/s, 1 cm/s, 1 cm/s

TABLE 6.1: Summary of the options used in the programs GEODOP-V and SADOSA.

STATION	NUMBER OF PASSES USED			
	GEODOPV		SADOSA	
	SINGLEPOINT	MULTIPOINT	SINGLEPOINT	MULTIPOINT
BLZ			138	97
BOR	141	41	143	104
BRS	97	28	96	52
CGL	67	39	66	35
DIO	130	38	151	107
EFF	153	50	151	102
GRS	135	47	142	102
GRZ	153	63	138	100
GRY	137	24	125	84
HMC	168	63	164	107
HON	246	63	223	157
HVR	140	36	152	101
JOZ	146	34	143	98
KTW	120	32	120	81
MAT	127	44	124	80
MER	108	30	107	73
MET	124	28	81	58
PNC	145	52	153	106
PDM	110	34	150	106
RIG	162	30	150	98
SFN	64	18	46	33
SIM	136	27	132	86
SOP	94	27	81	49
TRS	59	23	57	35
WTZ	106	32	88	77
ZMW	149	34	211	135

TABLE 6.2: Number of passes used for the singlepoint and multipoint computations with GEODOP-V and SADOSA.

	X (m)		Y (m)		Z (m)	
BLAZAJEWKO						
BOROWIEC	3738367.8	±0.6	1148159.4	±0.5	5021817.4	±0.5
BRUSSELS	4027870.5	±0.8	307011.9	±0.7	4919514.3	±0.8
CAGLIARI	4893397.4	±1.1	772650.0	±1.8	4004165.4	±2.0
DIONYSOS	4595224.1	±0.6	2039457.8	±0.5	3912614.3	±0.5
EFFELSBERG	4029174.9	±0.6	490746.2	±0.5	4904007.8	±0.5
GRASSE	4588039.8	±1.2	556429.9	±1.0	4381664.8	±1.0
GRAZ	4194431.1	±0.6	1162687.2	±0.5	4647245.5	±0.5
GRYBOV	3866022.0	±0.9	1480017.1	±0.7	4836500.2	±0.7
HERSTMONCEUX	4033658.4	±0.6	23568.3	±0.5	4924151.0	±0.5
HONEFOSS	3132542.5	±0.4	566391.4	±0.4	5508612.5	±0.4
HVAR	4468039.4	±0.6	1319143.7	±0.5	4342090.2	±0.5
JOZEFOSLAW	3664946.7	±1.0	1409124.5	±0.8	5009585.2	±0.8
KOOTWIJK	3899222.3	±0.6	396754.3	±0.5	5015073.5	±0.5
MATERA	4641968.9	±0.6	1393037.1	±0.6	4133269.3	±0.5
MERATE	4401787.0	±0.8	730944.8	±0.7	4542761.4	±0.7
METSAEHOEVI	2892588.8	±1.0	1311785.5	±1.0	5512616.9	±1.0
PENC	4052455.8	±0.6	1417627.7	±0.5	4701411.7	±0.5
POTSDAM	3800701.0	±0.8	882039.3	±0.7	5028789.8	±0.7
RIGA	3183913.4	±0.8	1421450.7	±0.7	5322809.4	±0.6
SAN FERNANDO	5105461.5	±1.2	-555147.4	±1.3	3769896.9	±1.3
SIMEIZ	3783882.2	±0.7	2551463.0	±0.7	4441268.7	±0.6
SOPRON	4123989.7	±0.7	1226070.7	±0.7	4693246.7	±0.6
TRIESTE	4336755.3	±1.2	1071249.2	±0.9	4537904.3	±1.0
WETTZELL	4075540.7	±0.9	931806.6	±0.7	4801607.9	±0.7
ZIMMERWALD	4331297.8	±0.6	567532.8	±0.5	4633138.3	±0.6

TABLE 6.3: Single point positioning results computed by GEODOP-V, Graz.
(referred to the antenna phase center)

	X (m)	Y (m)	Z (m)
BLAZAJEWKO			
BOROWIEC	3738366.08 ±.31	1148158.88 ±.28	5021826.02 ±.26
BRUSSELS	4027869.69 ±.31	307012.42 ±.33	4919521.42 ±.28
CAGLIARI	4893397.20 ±.28	772649.55 ±.32	4004174.76 ±.31
DIONYSOS	4595225.34 ±.27	2039457.20 ±.31	3912622.82 ±.32
EFFELSBERG	4029173.71 ±.29	490745.44 ±.26	4904016.13 ±.25
GRASSE	4588037.76 ±.32	556430.21 ±.38	4381672.88 ±.31
GRAZ	4194430.37 ±.28	1162686.24 ±.24	4647254.05 ±.26
GRYBOV	3866020.57 ±.32	1480016.46 ±.33	4836507.01 ±.29
HERSTMONCEUX	4033656.40 ±.28	23567.29 ±.27	4924158.95 ±.25
HONEFOSS	3132541.49 ±.31	566391.75 ±.28	5508621.19 ±.22
HVAR	4468038.91 ±.29	1319142.30 ±.27	4342098.22 ±.29
JOZEFOSLAW	3664941.77 ±.32	1409123.38 ±.32	5009591.47 ±.28
KOOTWIJK	3899221.06 ±.31	396752.79 ±.28	5015080.53 ±.26
MATERA	4641967.54 ±.27	1393036.70 ±.26	4133278.94 ±.29
MERATE	4401785.05 ±.32	730942.54 ±.33	4542770.18 ±.31
METSAEHOEVI	2892586.41 ±.42	1311786.65 ±.65	5512624.25 ±.37
PENC	4052454.99 ±.29	1417626.00 ±.27	4701420.45 ±.27
POTSDAM	3800700.77 ±.32	882039.45 ±.29	5028797.43 ±.27
RIGA	3183911.76 ±.38	1421450.61 ±.51	5322817.09 ±.32
SAN FERNANDO	5105459.86 ±.74	-555146.20 ±1.44	3769902.18 ±.64
SIMEIZ	3783883.05 ±.35	2551463.44 ±.89	4441278.41 ±.48
SOPRON	4123987.51 ±.30	1226070.92 ±.28	4693256.61 ±.28
TRIESTE	4336752.83 ±.35	1071248.52 ±.26	4537912.44 ±.36
WETTZELL	4075538.89 ±.30	931805.77 ±.27	4801616.49 ±.27
ZIMMERWALD	4331295.19 ±.28	567532.43 ±.24	4633143.9 ±.26

TABLE 6.4: Multi point positioning results computed by GEODOP-V, Graz.
(referred to the antenna phase center)

	X (m)		Y (m)		Z (m)	
BLAZAJEWKO	3744066.6	±1.6	1152657.5	±1.0	5016555.0	±0.9
BOROWIEC	3738367.4	±1.3	1148159.8	±0.9	5021815.0	±0.7
BRUSSELS	4027869.6	±1.5	307011.7	±1.1	4919512.9	±1.0
CAGLIARI	4893399.7	±2.9	772649.3	±2.5	4004162.1	±3.3
DIONYSOS	4595225.8	±1.2	2039458.2	±1.0	3912609.9	±1.3
EFFELSBERG	4029175.2	±1.6	490746.0	±1.1	4904005.6	±1.0
GRASSE	4588035.9	±1.6	556430.7	±1.3	4381665.5	±1.7
GRAZ	4194430.4	±1.2	1162687.6	±0.9	4647243.1	±0.9
GRYBOV	3866021.1	±1.7	1480018.3	±1.2	4836496.3	±1.2
HERSTMONCEUX	4033658.8	±1.5	23568.9	±1.0	4924146.9	±0.9
HONEFOSS	3132543.4	±1.2	566392.2	±0.8	5508609.1	±0.4
HVAR	4468039.2	±1.3	1319142.9	±1.0	4342087.6	±1.1
JOZEFOSLAW	3664944.5	±1.7	1409124.6	±1.2	5009578.5	±1.0
KOOTWIJK	3899222.4	±1.6	396753.8	±1.1	5015068.2	±0.9
MATERA	4641968.9	±1.5	1393038.3	±1.2	4133265.5	±1.4
MERATE	4401787.9	±1.9	730944.2	±1.3	4542759.7	±1.5
METSAEHOEVI	2892588.7	±4.0	1311786.1	±2.8	5512609.8	±1.2
PENC	4052455.2	±1.4	1417628.2	±1.0	4701408.8	±1.1
POTSDAM	3800701.4	±1.9	882041.1	±1.3	5028786.2	±1.1
RIGA	3183912.7	±1.7	1421450.8	±1.2	5322805.4	±0.7
SAN FERNANDO	5105461.4	±1.6	-555144.5	±1.6	3769895.2	±1.9
SIMEIZ	3783883.8	±1.6	2551464.9	±1.4	4441264.2	±1.7
SOPRON	4123990.6	±2.0	1226072.8	±1.4	4693243.6	±1.3
TRIESTE	4336754.6	±1.9	1071248.6	±1.4	4537902.1	±1.6
WETTZELL	4075538.6	±1.3	931806.5	±0.9	4801607.0	±0.9
ZIMMERWALD	4331297.0	±1.2	567533.1	±0.8	4633130.8	±0.9

TABLE 6.5: Single point positioning results computed by SADOSA, SGO.
(referred to the antenna phase center)

	X (m)	Y (m)	Z (m)
BLAZAJENKO	3744067.46 ±.29	1152655.79 ±.23	5016556.17 ±.24
BOROWIEC	3738368.96 ±.30	1148157.85 ±.24	5021815.86 ±.25
BRUSSELS	4027872.43 ±.30	307011.81 ±.28	4919511.43 ±.26
CAGLIARI	4893400.53 ±.36	772651.14 ±.43	4004164.07 ±.31
DIONYSOS	4595226.14 ±.30	2039458.82 ±.25	3912611.92 ±.25
EFFELSBERG	4029176.82 ±.29	490744.50 ±.24	4904005.83 ±.24
GRASSE	4588039.36 ±.30	556428.69 ±.28	4381662.84 ±.25
GRAZ	4194432.58 ±.29	1162686.61 ±.23	4647243.35 ±.24
GRYBOV	3866021.59 ±.29	1480016.26 ±.23	4836496.57 ±.24
HERSTMONCEUX	4033659.33 ±.29	23566.96 ±.25	4924148.57 ±.25
HONEFOSS	3132543.69 ±.28	566389.90 ±.23	5508610.88 ±.23
HVAR	4468040.29 ±.29	1319142.23 ±.25	4342087.63 ±.25
JOZEFOSLAW	3664944.26 ±.29	1409121.71 ±.23	5009580.06 ±.24
KOOTWIJK	3899224.08 ±.29	396751.78 ±.25	5015070.63 ±.24
MATERA	4641969.65 ±.30	1393037.00 ±.27	4133267.81 ±.26
MERATE	4401788.24 ±.29	730942.93 ±.25	4542759.86 ±.25
METSAEHOEVI	2892587.52 ±.30	1311784.79 ±.27	5512613.62 ±.25
PENC	4052456.36 ±.29	1417626.13 ±.23	4701409.68 ±.24
POTSDAM	3800703.53 ±.29	882038.36 ±.24	5028787.09 ±.24
RIGA	3183912.97 ±.29	1421449.04 ±.25	5322806.76 ±.24
SAN FERNANDO	5105462.58 ±.36	-555146.19 ±.51	3769893.51 ±.34
SIMEIZ	3783883.49 ±.33	2551465.06 ±.30	4441267.30 ±.26
SOPRON	4123989.50 ±.30	1226070.78 ±.27	4693246.13 ±.26
TRIESTE	4336754.90 ±.31	1071248.33 ±.30	4537901.68 ±.26
WETZELL	4075541.03 ±.29	931805.54 ±.24	4801606.37 ±.24
ZIMMERWALD	4331297.97 ±.29	567531.87 ±.23	4633133.56 ±.24

TABLE 6.6: Multi point positioning results computed by SADOSA, SGO.
(referred to the antenna phase center)

DOPPLER CAMPAIGN W E D O C 2		TRANSFORMATION GEODOP V SINGLEPOINT-MULTIPOINT			TRANSFORMATION SADOSA SINGLEPOINT-MULTIPOINT		
c_x (m)		0.708	± 1.745		-2.764	± 1.849	
c_y (m)		6.801	± 2.057		0.473	± 2.201	
c_z (m)		4.530	± 1.722		-1.113	± 1.827	
$d\mu$ (ppm)		0.024	± 0.224		0.584	± 0.238	
α_x (arcsec)		-0.187	± 0.060		-0.191	± 0.064	
α_y (arcsec)		0.126	± 0.064		-0.080	± 0.068	
α_z (arcsec)		0.151	± 0.056		-0.103	± 0.060	
A V E R A G E R M S (m)							
σ_{oG}	σ_{oS}	σ_{lat}	σ_{long}	σ_{height}	σ_{lat}	σ_{long}	σ_{height}
± 1.03	± 1.11	± 0.89	± 0.85	± 1.18	± 1.40	± 0.90	± 0.77
R E S I D U A L S (m)							
		d_{lat}	d_{long}	d_{height}	d_{lat}	d_{long}	d_{height}
BLAZAJEWKO					-0.18	-0.12	-0.18
BOROWIEC		0.63	0.04	0.33	-0.86	-0.48	-0.07
BRUSSELS		-1.14	1.04	0.57	-2.52	1.19	0.48
CAGLIARI		0.29	-0.18	1.31	1.57	2.22	1.19
DIONYSOS		-1.20	-1.01	0.31	0.55	0.35	0.49
EFFELSBURG		0.02	-0.24	0.99	-0.55	0.27	-0.04
GRASSE		0.44	0.90	-0.26	-3.46	-1.31	-0.52
GRAZ		-0.01	-0.60	0.42	-1.47	-0.24	0.33
GRYBOV		-0.66	-0.10	-1.45	-0.53	-0.70	-1.32
HERSTMENCEUX		0.38	-0.39	0.75	1.63	0.12	0.51
HONEFOSS		-0.31	0.61	2.03	0.64	0.58	0.05
HVAR		-0.44	-1.08	-0.31	-0.76	-0.16	-0.46
JOZEFOSLAW		1.77	0.66	-3.78	0.94	-0.93	-0.86
KOOTWIJK		-0.72	-0.98	0.10	0.75	-0.02	1.66
MATERA		1.14	0.12	0.08	1.43	-1.04	0.73
MERATE		1.13	-1.62	0.01	0.43	0.04	-0.84
METSÄHÖVI		-0.04	1.63	-0.28	1.66	1.69	0.87
PENC		0.41	-1.29	0.11	-0.41	-1.14	-0.32
POTSDAM		-1.28	0.35	0.81	-0.87	-1.15	0.35
RIGA		-0.02	0.31	-0.22	-0.33	0.29	-0.59
SAN FERNANDO		-1.63	1.60	-1.08	0.23	-0.95	-0.72
SIMEIZ		-0.34	-0.18	0.99	0.53	0.45	0.57
SOPRON		1.70	0.94	0.67	2.50	-0.32	-0.41
TRIESTE		0.80	0.13	-0.93	-0.54	0.83	-1.24
WETZELL		0.73	-0.22	0.18	-2.16	0.13	-0.21
ZIMMERWALD		-0.79	0.33	-2.27	1.85	0.15	1.52

TABLE 7.1: Comparison of the SP and MP results computed by GEODOP-V and SADOSA respectively.

DOPPLER CAMPAIGN W E D O C 2	TRANSFORMATION SINGLEPOINT SOLUTION GEODOPV - SADOSA			TRANSFORMATION MULTIPOINT SOLUTION GEODOPV - SADOSA			
c_x (m)	5.575	± 2.349		2.246	± 1.049		
c_y (m)	-0.245	± 2.789		-6.591	± 1.240		
c_z (m)	-6.326	± 2.330		-12.113	± 1.036		
$d\mu$ (ppm)	-0.209	± 0.309		0.353	± 0.135		
α_x (arcsec)	0.065	± 0.097		0.053	± 0.038		
α_y (arcsec)	0.227	± 0.088		0.019	± 0.040		
α_z (arcsec)	0.032	± 0.075		-0.259	± 0.035		
A V E R A G E R M S (m)							
σ_{oSP}	σ_{oMP}	σ_{lat}	σ_{long}	σ_{height}	σ_{lat}	σ_{long}	σ_{height}
± 1.43	± 0.62	± 1.71	± 0.92	± 1.35	± 0.68	± 0.70	± 0.40
R E S I D U A L S (m)							
	d_{lat}	d_{long}	d_{height}	d_{lat}	d_{long}	d_{height}	
BOROWIEC	0.90	-0.20	1.16	-0.58	-0.68	0.73	
BRUSSELS	1.60	-0.89	1.15	0.27	0.02	0.06	
CAGLIARI	-1.92	-1.26	0.73	-0.60	1.13	0.53	
DIONYSOS	-1.58	-0.12	0.04	-0.11	1.24	0.15	
EFFELSBURG	0.22	-0.98	1.26	-0.31	-0.43	0.20	
GRASSE	5.11	0.84	-0.45	1.25	-1.36	-0.78	
GRAZ	1.02	0.10	0.23	-0.42	0.48	0.09	
GRYBOV	0.18	0.93	-0.26	0.31	0.38	-0.17	
HERSTMONCEUX	-1.22	-0.16	-0.11	0.09	0.38	-0.38	
HONEFOSS	-0.96	-0.44	1.76	0.02	-0.38	-0.22	
HVAR	0.68	-0.85	-0.18	0.39	-0.03	-0.40	
JOZEFOSLAW	-0.20	0.22	-3.29	-1.04	-1.32	-0.40	
KOOTWIJK	-1.51	-1.33	-1.14	0.00	-0.32	0.38	
MATERA	-0.78	1.10	-0.72	-0.47	-0.06	-0.14	
MERATE	0.23	-0.81	0.0s	-0.44	0.40	0.55	
METSÄHÖVI	-1.55	-0.40	-1.60	0.37	-0.89	-0.58	
PENC	0.74	0.27	0.21	-0.08	0.45	-0.25	
POTSDAM	-0.84	0.89	0.77	-0.41	-0.55	0.29	
RIGA	0.56	-0.41	0.28	0.23	-0.36	-0.09	
SAN FERNANDO	0.36	2.32	-0.61	2.31	-0.26	-0.33	
SIMEIZ	-1.84	0.79	1.19	-1.01	1.42	0.73	
SOPRON	-0.92	1.30	1.23	-0.10	0.07	0.10	
TRIESTE	1.42	-0.81	0.05	-0.12	-0.09	-0.26	
WETTZELL	3.06	-0.22	0.61	0.19	0.15	0.18	
ZIMMERWALD	-2.68	-0.17	-3.74	0.00	-0.33	0.01	

TABLE 7.2: Comparison GEODOPV - SADOSA singlepoint and multipoint

DOPPLER CAMPAIGN W E D O C 2	TRANSFORMATION GEODOP V WEDOC 1 - WEDOC 2			TRANSFORMATION SADOSA WEDOC 1 - WEDOC 2			
	c_x (m)	-6.071	±2.890		-2.084	±2.962	
c_y (m)	-1.715	±2.523		-6.767	±2.587		
c_z (m)	14.043	±2.498		20.797	±2.561		
$d\mu$ (ppm)	-0.300	±0.300		-1.800	±0.300		
α_x (arcsec)	-0.097	±0.065		-0.162	±0.065		
α_y (arcsec)	0.130	±0.097		0.421	±0.097		
α_z (arcsec)	-0.032	±0.065		0.194	±0.065		
A V E R A G E R M S (m)							
σ_{OG}	σ_{OS}	σ_{lat}	σ_{long}	σ_{height}	σ_{lat}	σ_{long}	σ_{height}
±0.57	±0.63	±0.28	±0.41	±0.95	±0.44	±0.44	±0.90
R E S I D U A L S (m)							
	d_{lat}	d_{long}	d_{height}	d_{lat}	d_{long}	d_{height}	
BOROWIEC	0.24	0.49	0.35	0.31	0.29	0.84	
DIONYSOS	-0.27	-0.56	-1.79	0.22	0.02	-1.71	
EFFELSBURG	-0.28	0.42	-0.71	-0.31	-0.16	-0.22	
GRASSE	-0.18	-0.62	0.86	1.16	0.10	1.29	
GRAZ	0.18	0.20	-0.21	-0.39	0.32	0.59	
HERSTMONCEUX	-0.60	-0.16	-0.41	-0.08	0.08	-0.75	
KOOTWIJK	-0.21	-0.01	-1.03	0.27	-0.47	-1.03	
PENC	0.16	-0.04	1.04	-0.48	0.23	0.54	
POTSDAM	0.24	-0.26	-0.71	-0.14	-0.65	-0.70	
SOPRON	0.27	0.62	1.37	-0.38	1.03	0.69	
TRIESTE	0.27	0.36	1.17	-0.03	-0.21	1.01	
WETZELL	0.07	-0.44	0.24	-0.07	-0.23	-0.15	
ZIMMERWALD	0.06	0.15	-0.15	-0.24	-0.44	-0.41	

TABLE 7.3: Comparison of the stations participating in WEDOC-1 and WEDOC-2.

DOPPLER CAMPAIGN W E D O C 2	TRANSFORMATION GEODOPV MP - EROSDOC			TRANSFORMATION SADOSA MP - EROSDOC		
	c_x (m)	-0.778	± 3.623		-3.405	± 3.422
c_y (m)	-6.673	± 4.787		0.582	± 4.461	
c_z (m)	-7.234	± 3.786		3.502	± 3.528	
$d\mu$ (ppm)	0.200	± 0.500		0.100	± 0.400	
α_x (arcsec)	-0.292	± 0.130		-0.227	± 0.130	
α_y (arcsec)	0.097	± 0.130		0.097	± 0.130	
α_z (arcsec)	0.032	± 0.130		-0.259	± 0.130	
A V E R A G E R M S (m)						
σ_{oGE} σ_{oSE}	σ_{lat}	σ_{long}	σ_{height}	σ_{lat}	σ_{long}	σ_{height}
± 1.45 ± 1.35	± 1.05	± 1.89	± 0.51	± 1.13	± 1.70	± 0.34
R E S I D U A L S (m)						
	d_{lat}	d_{long}	d_{height}	d_{lat}	d_{long}	d_{height}
CAGLIARI						
DIONYSOS	1.42	2.34	0.55	2.19	0.72	0.01
GRASSE	-0.73	0.85	-0.39	-1.31	2.00	0.25
KOOTWIJK	-1.11	0.07	-0.18	-0.62	0.29	-0.59
METSÄHÖVI	-0.72	-1.58	-0.86	-0.84	-0.83	-0.35
SAN FERNANDO	1.40	-3.38	0.10	0.02	-3.33	0.31
WETZELL	-0.18	0.94	0.52	0.15	0.61	0.22
ZIMMERWALD	-0.56	0.57	0.52	0.05	0.72	0.14

TABLE 7.4: Transformation WEDOC-2 broadcast MP - EROSDOC precise MP

DOPPLER CAMPAIGN W E D O C 2		TRANSFORMATION GEODOPV MP - EROSDOC without San Fernando			TRANSFORMATION SADOSA MP - EROSDOC without San Fernando		
c_x (m)		2.832	± 1.691		1.242	± 1.849	
c_y (m)		-4.542	± 2.308		2.626	± 2.526	
c_z (m)		-6.528	± 1.592		6.521	± 1.741	
$d\mu$ (ppm)		-0.300	± 0.200		-0.800	± 0.200	
α_x (arcsec)		-0.065	± 0.065		-0.065	± 0.065	
α_y (arcsec)		0.065	± 0.065		0.065	± 0.065	
α_z (arcsec)		0.162	± 0.065		0.130	± 0.065	
A V E R A G E R M S (m)							
σ_{oGE}	σ_{oSE}	σ_{lat}	σ_{long}	σ_{height}	σ_{lat}	σ_{long}	σ_{height}
± 0.52	± 0.57	± 0.38	± 0.55	± 0.39	± 0.70	± 0.40	± 0.27
R E S I D U A L S (m)							
		d_{lat}	d_{long}	d_{height}	d_{lat}	d_{long}	d_{height}
CAGLIARI							
DIONYSOS		0.15	0.77	-0.01	0.75	-0.20	-0.30
GRASSE		-0.10	-0.65	-0.49	-1.29	0.51	0.21
KOOTWIJK		0.08	-0.23	0.09	0.28	-0.38	-0.38
METSÄHÖVI		-0.77	-0.07	-0.39	-0.34	0.46	0.05
SAN FERNANDO							
WETTZELL		0.24	0.51	0.53	0.35	-0.09	0.23
ZIMMERWALD		0.21	-0.43	0.26	0.35	-0.39	0.17

TABLE 7.5: Transformation WEDOC-2 broadcast MP - EROSDOC precise MP without San Fernando

STATION	LATITUDE deg min sec	LONGITUDE deg min sec	HEIGHT MSL (m)	HEIGHT GEOID	HEIGHT ELLIPSOID
BRS	50 47 56.6230	4 21 36.9920	119.90	-4.10	115.80
GRZ	47 4 4.6189	15 29 39.8114	491.26	0.90	492.16
HMC	50 52 0.5735	0 20 45.0244	33.05	-7.75	25.30
HON	60 8 38.3226	10 15 1.8680	137.25	8.55	145.80
KTW	52 10 45.0568	5 48 41.2524	47.95	-2.15	45.80
MAT	40 38 59.6215	16 42 19.0857	490.66	-9.90	480.76
MET	60 13 3.9390	24 23 43.6395	54.01	-5.00	49.01
SFN	36 27 56.6230	- 6 12 14.3873	43.15	-43.75	-0.60
TRS	45 38 37.4600	13 52 35.0230	402.97	-4.15	398.82
WTZ	49 8 44.0730	12 52 46.7490	616.45	2.00	618.45
ZMW	46 52 41.3790	7 28 0.4278	897.85	-3.15	894.70

TABLE 7.6: Terrestrial coordinates of the station reference point or the antenna phase center as indicated in the station sheets in Appendix A. Horizontal coordinates are given in datum ED-79; Vertical coordinates are M.S.L. heights. In order to derive ellipsoidal heights the geoid LEVALLOIS 1978 has been used.

DOPPLER CAMPAIGN W E D O C 2	TRANSFORMATION GEODOPV SINGLEPOINT ED 79			TRANSFORMATION SADOSA SINGLEPOINT ED 79		
	c_x (m)	88.068	± 2.815		82.002	± 3.272
c_y (m)	88.950	± 4.214		90.171	± 4.897	
c_z (m)	123.861	± 2.852		126.185	± 3.315	
du (ppm)	-1.410	± 0.420		-0.630	± 0.430	
α_x (arcsec)	-0.389	0.130		-0.356	0.130	
α_y (arcsec)	0.000	0.097		0.130	0.130	
α_z (arcsec)	0.778	0.097		0.680	0.130	
A V E R A G E R M S (m)						
σ_{oG79} σ_{oS79}	σ_{lat}	σ_{long}	σ_{height}	σ_{lat}	σ_{long}	σ_{height}
± 1.25 ± 1.41	± 0.67	± 1.22	± 1.37	± 1.50	± 0.99	± 1.18
R E S I D U A L S (m)						
	d_{lat}	d_{long}	d_{height}	d_{lat}	d_{long}	d_{height}
BRUSSELS	-0.42	0.31	1.17	-2.45	1.22	-0.20
GRAZ	-0.07	-0.74	0.00	-0.82	-1.00	-0.74
HERSTMONCEUX	1.32	-0.89	-0.60	1.95	-0.53	-0.66
HONEFOSS	0.38	0.20	1.36	0.59	-0.20	-0.37
KOOTWIJK	-0.75	-1.89	2.01	0.31	-0.68	2.96
MATERA	-0.63	-0.73	1.62	0.80	-1.60	1.50
METSÄHÖVI	-0.32	1.78	-1.02	1.21	0.81	0.49
SAN FERNANDO	0.27	2.34	-0.31	-0.09	1.31	-0.44
TRIESTE	0.50	0.43	-1.17	-0.47	1.23	-1.78
WETTZELL	0.50	-0.16	-0.67	-2.52	-0.14	-1.67
ZIMMERWALD	-0.91	-0.69	-2.39	1.69	-0.37	0.93

TABLE 7.7: Comparison of singlepoint results with ED-79 and Levallois 78.

DOPPLER CAMPAIGN W E D O C 2	TRANSFORMATION GEODOPV MULTIPOINT ED 79			TRANSFORMATION SADOSA MULTIPOINT ED 79			
	c_x (m)	90.470	± 1.992		86.885	± 1.733	
c_y (m)	81.876	± 2.982		89.605	± 2.519		
c_z (m)	116.954	± 2.019		127.388	± 1.754		
$d\mu$ (ppm)	-1.400	± 0.300		-1.400	± 0.200		
α_x (arcsec)	-0.616	± 0.097		-0.486	± 0.065		
α_y (arcsec)	-0.032	± 0.065		0.000	± 0.065		
α_z (arcsec)	0.875	± 0.065		0.648	± 0.065		
A V E R A G E RMS (m)							
σ_{oG79}	σ_{oS79}	σ_{lat}	σ_{long}	σ_{height}	σ_{lat}	σ_{long}	σ_{height}
± 0.89	± 0.75	± 0.79	± 0.65	± 0.93	± 0.52	± 0.68	± 0.85
R E S I D U A L S (m)							
	d_{lat}	d_{long}	d_{height}	d_{lat}	d_{long}	d_{height}	
BRUSSELS	0.51	-0.53	0.62	0.43	-0.49	0.55	
GRAZ	-0.03	0.21	-0.55	0.58	-0.51	-0.85	
HERSTMONCEUX	0.65	-0.30	-1.34	0.79	-0.54	-0.92	
HONEFOSS	0.57	-0.58	0.01	0.33	-0.11	0.14	
KOOTWIJK	-0.22	-0.76	2.02	-0.10	-0.39	1.61	
MATERA	-1.76	-0.19	1.00	-0.90	-0.52	0.86	
METSÄHÖVI	-0.07	-0.10	0.10	-0.74	0.59	0.40	
SAN FERNANDO	1.35	1.35	-0.21	-0.08	1.59	0.19	
TRIESTE	-0.36	0.71	-0.43	0.01	0.56	-0.36	
WETTZELL	-0.25	0.32	-0.88	-0.30	0.02	-1.20	
ZIMMERWALD	-0.29	-0.67	-0.35	0.00	-0.43	-0.42	

TABLE 7.8: Comparison of multipoint results with ED-79 and Levallois 78.

from - to	hour angle (°,',")	declination (°,',")	distance (m)
GRZ - BOR	181 49 28.086 ±.069	39 22 56.966 ±.036	590 347.22 ±.15 590 347.24 ±.13
GRZ - BRS	258 59 5.524 ±.040	17 20 42.260 ±.037	913 263.20 ±.22
GRZ - CGL	330 50 15.567 ±.057	-38 46 44.776 ±.032	1 026 759.09 ±.20
GRZ - DIO	65 26 1.026 ±.036	-37 18 31.568 ±.031	1 212 042.48 ±.18 1 212 043.03 ±.16
GRZ - EFF	256 10 58.581 ±.035	20 21 28.854 ±.028	738 065.69 ±.13 738 066.38 ±.18
GRZ - GRS	302 59 36.096 ±.064	-20 10 28.013 ±.051	770 069.16 ±.28 770 068.45 ±.38
GRZ - GRY	135 58 58.735 ±.093	22 30 35.561 ±.055	494 336.07 ±.19
GRZ - HMC	261 57 59.043 ±.022	13 32 1.398 ±.019	1 183 265.21 ±.14 1 183 265.48 ±.24
GRZ - HON	209 18 57.639 ±.022	35 16 15.779 ±.013	1 491 686.45 ±.10
GRZ - HVR	29 45 43.122 ±.098	-44 4 26.321 ±.050	438 702.87 ±.16
GRZ - JOZ	155 2 29.624 ±.067	31 48 57.217 ±.034	687 297.49 ±.17
GRZ - KTW	248 55 19.663 ±.036	24 8 14.047 ±.029	899 499.25 ±.16 899 499.66 ±.17
GRZ - MAT	27 14 6.691 ±.057	-45 35 56.294 ±.027	719 389.51 ±.14
GRZ - MER	295 39 13.318 ±.086	-12 18 22.459 ±.063	490 219.82 ±.22
GRZ - MET	173 27 58.942 ±.092	33 26 28.114 ±.037	1 570 316.60 ±.33
GRZ - PNC	119 6 48.007 ±.081	10 30 56.842 ±.068	296 791.66 ±.13 296 791.96 ±.23
GRZ - PDM	215 28 51.303 ±.069	38 16 37.784 ±.038	615 922.86 ±.17 615 922.88 ±.12
GRZ - RIG	165 38 12.671 ±.080	32 55 42.579 ±.038	1 242 776.03 ±.28
GRZ - SFN	297 56 19.125 ±.041	-24 17 6.659 ±.114	2 133 229.79 ±.1.23
GRZ - SIM	106 28 7.031 ±.047	- 8 5 41.549 ±.070	1 462 763.55 ±.76
GRZ - SOP	138 1 8.513 ±.320	25 53 40.032 ±.231	105 337.79 ±.16 105 337.43 ±.17
GRZ - TRS	327 16 49.894 ±.170	-32 52 37.767 ±.120	201 425.24 ±.21 201 425.45 ±.14
GRZ - WTZ	242 45 13.961 ±.101	30 43 38.287 ±.074	302 107.16 ±.14 302 106.91 ±.15
GRZ - ZMW	282 57 3.186 ±.033	- 1 19 24.968 ±.030	610 851.15 ±.11 610 851.29 ±.21

TABLE 7.9: Position of the WEDOC-stations relative to the Observatory Graz-Lustbühel. For all stations common to WEDOC-1 and WEDOC-2 the distances measured in WEDOC-1 are printed in the second row of the respective stations for comparison.

from - to	hour angle (°,',")	declination (°,',")	distance (m)
PNC - BLZ	220 40 10.017 ±.090	37 46 45.635 ±.049	514 422.30 ±.09
PNC - BOR	220 37 39.460 ±.097	37 44 52.691 ±.060	523 377.65 ±.12 523 377.84 .11
PNC - BRS	268 43 54.984 ±.030	11 6 27.624 ±.031	1 132 094.04 ±.26
PNC - CGL	322 30 46.966 ±.067	-33 20 27.577 ±.048	1 268 594.21 ±.29
PNC - DIO	48 53 1.519 ±.052	-43 42 4.481 ±.028	1 141 699.10 ±.11 1 141 702.04 .11
PNC - EFF	268 33 40.546 ±.030	12 19 33.336 ±.029	949 050.42 ±.21 949 051.67 .17
PNC - GRS	301 52 39.675 ±.035	-17 29 57.230 ±.030	1 063 366.46 ±.24 1.063 368.89 .33
PNC - GRY	161 29 50.122 ±.171	34 29 38.187 ±.114	238 534.94 ±.12
PNC - GRZ	299 6 48.610 ±.073	-10 30 56.768 ±.075	296 791.84 ±.19 296 792.45 .13
PNC - HMC	269 13 38.963 ±.023	9 4 37.269 ±.023	1 411 866.46 ±.23 1 411 868.80 .21
PNC - HON	222 46 46.070 ±.032	32 46 59.930 ±.019	1 490 777.05 ±.11
PNC - HVR	346 40 5.311 ±.092	-40 4 28.328 ±.053	558 141.04 ±.11
PNC - JOZ	181 15 26.003 ±.095	38 29 12.770 ±.051	495 183.74 ±.09
PNC - KTW	261 27 49.259 ±.029	16 54 3.859 ±.029	1 078 910.45 ±.21 1 078 911.51 .16
PNC - MAT	357 36 41.494 ±.079	-43 55 3.013 ±.039	819 094.46 ±.11
PNC - MER	296 57 48.636 ±.036	-11 38 9.126 ±.036	786 597.96 ±.22
PNC - MET	185 12 50.267 ±.043	34 51 25.812 ±.025	1 419 348.42 ±.12
PNC - PDM	244 49 26.928 ±.056	28 57 2.421 ±.043	676 320.72 ±.15 676 321.12 .13
PNC - RIG	179 44 52.127 ±.048	35 34 53.267 ±.027	1 067 949.70 ±.11
PNC - SFN	298 5 31.025 ±.033	-22 36 52.680 ±.029	2 422 472.93 ±.43
PNC - SIM	103 19 33.837 ±.034	-12 35 7.116 ±.030	1.193 899.56 ±.30
PNC - SOP	290 28 38.284 ±.127	- 2 17 10.595 ±.135	204 638.92 ±.24 204 639.13 .16
PNC - TRS	309 22 41.965 ±.078	-20 2 46.202 ±.077	477 009.55 ±.25 477 010.20 .13
PNC - WTZ	272 43 13.690 ±.049	11 38 26.286 ±.047	496 582.24 ±.20 496 582.56 .14
PNC - ZMW	288 9 36.506 ±.027	- 4 21 50.714 ±.028	897 259.45 ±.21 897 260.41 .16

TABLE 7.10 : Position of the WEDOC - stations relative to the SGO, Penc.
For all stations common to WEDOC-1 and WEDOC-2 the distances measured in WEDOC-1 are printed in the second row of the respective stations for comparison.

A P P E N D I X A

S T A T I O N D E S C R I P T I O N S

Remarks :

Station descriptions are enclosed for all stations which have submitted the circulated station - questionnaire.

For the following stations no station sheets are enclosed: Cagliari, Hvar, Merate, Simeiz.

The terrestrial coordinates refer to the station reference point (sometimes reduced to the antenna phase center, see " remarks ").

Mean sea level heights (MSL) have been communicated by all stations, the geoid undulations have been determined by Graz from Levallois '78. Ellipsoidal heights have been computed by Graz referred to the International Ellipsoid.

Station	Code	Country	Receiver	Organisation
Cagliari	CGL	Italy	MX-1502	Stazione Astronomica Internazionale di Latitudine, Via Ospedale 72, I-09100 Cagliari
Hvar	HVR	Yugoslavia	MX-1502	Observed by Trieste/see station sheet for Trieste/, Geodetski Fakultet, Kaciceva 26, 41000 ZAGREB
Merate	MER	Italy	MX-1502	No information available
Simeiz	SIM	USSR	MX-1502	Astronomical Council of the Academy of Sciences of the USSR, 48 Pjatnitskaja St., Moscow 109017

List of stations which did not submit the circulated station questionnaire

DOPPLER CAMPAIGN WEDOC -2

- 67/-

Station Information

STATION NAME : BLAZAJEWKO

CODE : BLZ COUNTRY : Poland

RECEIVER: TYPE: JMR-4A SER.NO: _____

ANTENNA: _____ SER.NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: _____

LATITUDE : 52° 12'

LONGITUDE : 17° 07'

VERTICAL COORDINATES OF REF. POINT

HEIGHT ABOVE MSL: _____ GEOID : _____

ELLIPSOIDAL HEIGHT: 66 m GEOID SEPARATION : _____

CAMPAIGN EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)

WEDOC-2 26.69 / 15.05 / -35.02

AGENCY

GEOKART Poland
Pl. Jednosci Robotniczej 1
00-661 Warszawa

Remarks

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : BOROWIEC
CODE : BOR COUNTRY : Poland

RECEIVER: TYPE: DOG-2 SER.NO: 01
ANTENNA: _____ SER.NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: _____
LATITUDE : _____
LONGITUDE : _____

VERTICAL COORDINATES OF REF. POINT
HEIGHT ABOVE MSL: 80.234 GEOID : LEVALLOIS 78
ELLIPSOIDAL HEIGHT: _____ GEOID SEPARATION : -1.70

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>		
WEDOC - 2	6.02	/	-18.86 / -15.44
WEDOC - 1	-5.52	/	- 5.53 / -8.98
MERITDOC	6.02	/	-18.86 / -15.44

<u>AGENCY</u> Space Research Center, Astronomical Latitude Obs. Borowiec, P.O.B. 62-035 Körnük, Poland	<u>Remarks</u> Height referred to water level gage Amsterdam
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DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>BRUSSELS</u>	
CODE : <u>BRS</u>	COUNTRY : <u>BELGIUM</u>
RECEIVER : TYPE : <u>TRANET - 2</u>	SER. NO : <u>547A = SN 105</u>
ANTENNA : _____	SER. NO. : _____
<u>HORIZONTAL COORDINATES OF REF. POINT</u> DATUM : <u>ED 79</u> +	
LATITUDE : <u>50° 47' 56".623</u>	
LONGITUDE : <u>4° 21' 36".992</u>	
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : <u>119.90</u>	GEOID : <u>LEVALLOIS 78</u>
ELLIPSOIDAL HEIGHT : <u>115.80</u>	GEOID SEPARATION : <u>-4.10</u>
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC - 2	-35.06 / -13.12 / 22.00
WEDOC - 1	- 1.01 / - 0.08 / - 1.24
EDOC - 1	- 0.19 / - 0.31 / - 0.54
EDOC - 2	- 0.48 / 0.62 / - 2.23
<u>AGENCY</u>	<u>Remarks</u>
Observatoire Royal de Belgique 3 avenue Circulaire, 1180 Bruxelles	+ ED-79 and MSL coordinates are referred to the WEDOC-2 antenna phase center

DOPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : DIONYSOS
CODE : DIO COUNTRY : GREECE

RECEIVER: TYPE: MX-1502 SER. NO: 24
ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED - 50
LATITUDE : 38^o 04' 47"018
LONGITUDE : 23^o 55' 59"183

VERTICAL COORDINATES OF REF. POINT
HEIGHT ABOVE MSL : 474.68 GEOID : LEVALLOIS 78
ELLIPSOIDAL HEIGHT: 462.18 GEOID SEPARATION : - 12.50

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>		
WEDOC - 2	-8.90	/	-36.32 / 16.13
WEDOC - 1	-14.45	/	-14.51 / 15.35
IGDOC	-9.90	/	-36.32 / 16.13
ERIDOC	-14.45	/	-14.51 / 15.35

<u>AGENCY</u> Dionysos Satellite Tracking Center, National Technical University of Athens	<u>Remarks</u> additional campaigns: EDOC-2: -16.91 / -15.60 / 13.24 TIMEDOC: -17.57 / -15.90 / 12.68
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DOPPLER CAMPAIGN WEDOC-2

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Station Information

STATION NAME : <u>EFFELSBERG</u>	
CODE : <u>EFF</u>	COUNTRY : <u>Fed.Rep.of. Germany</u>
RECEIVER: TYPE: <u>MX-1502</u>	SER.NO: <u>083</u>
ANTENNA: _____	SER.NO.: <u>129 / 118</u>
HORIZONTAL COORDINATES OF REF. POINT DATUM: <u>ED - 50</u>	
LATITUDE : <u>50° 34' 33"0574</u>	
LONGITUDE : <u>6° 56' 44"6120</u>	
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : <u>408.37</u>	GEOID : <u>LEVALLOIS 78</u>
ELLIPSOIDAL HEIGHT: <u>409.02</u>	GEOID SEPARATION : <u>0.65</u>
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	0.00 / 0.00 / 0.00
WEDOC-1	0.00 / 0.00 / 0.00
<u>AGENCY</u>	<u>Remarks</u>
Geodätisches Institut der Universität Bonn Nußallee 17, D-53 Bonn	ED-50 coordinates and MSL heights are referred to the WEDOC-2 antenna phase center

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : GRASSE

CODE : GRS COUNTRY : FRANCE

RECEIVER: TYPE : JMR-1A SER. NO : 75237 GRGS

ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED - 50

LATITUDE : 43° 39' 58"6576

LONGITUDE : 6° 54' 58"4669

VERTICAL COORDINATES OF REF. POINT

HEIGHT ABOVE MSL : 532.94⁺ GEOID : LEVALLOIS 78

ELLIPSOIDAL HEIGHT : 523.99 GEOID SEPARATION : -8.95

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>		
WEDOC - 2	-0.316	/	-0.038 / -0.304
WEDOC - 1	-0.316	/	-0.038 / -0.304
EROSDOC	-6129.391	/	165.789 / 7414.156
EDOC - 2	-6165.524	/	-111.482 / 7489.798

AGENCY

GRGS, CERGA
Avenue Copernic, 06130
Grasse, France

Remarks

⁺ Nivellement générale de la France

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : GRAZ

CODE : GRZ COUNTRY : AUSTRIA

RECEIVER: TYPE: CMA-722B SER.NO.: 504

ANTENNA: portable SER.NO.: 221

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED - 79

LATITUDE : 47° 04' 04".6189

LONGITUDE : 15° 29' 39".8114

VERTICAL COORDINATES OF REF. POINT

HEIGHT ABOVE MSL : 491.26 GEOID : LEVALLOIS 78

ELLIPSOIDAL HEIGHT: 492.16 GEOID SEPARATION: 0.90

CAMPAIGN EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)
WEDOC - 2 -1.33 / -0.37 / -1.49 +

Continuous observations since 1978-01-01 on the same point.

AGENCY

Institute of Space Research
Dept. Satellite Geodesy,
Austrian Academy of Sciences
Lustbühelstrasse 46,
A-8042 Graz

Remarks

+
All campaigns measured since April
1977 have the same excentricities.

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>GRYBOV</u>	
CODE : <u>GRY</u>	COUNTRY : <u>Poland</u>
RECEIVER: TYPE: <u>JMR-4A</u>	SER. NO: _____
ANTENNA: _____	SER. NO.: _____
<u>HORIZONTAL COORDINATES OF REF. POINT DATUM:</u>	
LATITUDE : <u>49° 38'</u>	_____
LONGITUDE : <u>20° 57'</u>	_____
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : _____	GEOID : _____
ELLIPSOIDAL HEIGHT: <u>377 m</u>	GEOID SEPARATION : _____
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	84.62 / -78.49 / -54.58
<u>AGENCY</u> GEOKART Poland Pl. Jednosci Robotniczej 1 00-661 Warszawa	<u>Remarks</u>

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>HAMBURG</u>	
CODE : <u>HAM</u>	COUNTRY : <u>FRG</u>
RECEIVER: TYPE: <u>MX 702A-3⁺</u>	SER. NO: <u>179</u>
ANTENNA: _____	SER. NO.: _____
HORIZONTAL COORDINATES OF REF. POINT DATUM: <u>NSWC9ZE</u>	
LATITUDE : <u>53°32'48".714</u>	
LONGITUDE : <u>9°58'05".255</u>	
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : <u>60</u>	GEOID : _____
ELLIPSOIDAL HEIGHT: <u>88.6</u>	GEOID SEPARATION : _____
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	4.96 / 6.14 / -7.29
TIMEDOC	0 / 0 / 0
<u>AGENCY</u>	<u>Remarks</u>
German Hydrographic Institute Postfach 220 D-2000 Hamburg 4 BRD	+ HP 5065A rubidium frequency standard

DOPPLER CAMPAIGN WEDOC -2

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Station Information

STATION NAME : HERSTMONCEUX

CODE : HMC COUNTRY : UNITED KINGDOM

RECEIVER: TYPE: MX-1502 SER. NO: S/N 328

ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED 79

LATITUDE : 50°52'00"5735

LONGITUDE : 0°20'45"0244

VERTICAL COORDINATES OF REF. POINT

HEIGHT ABOVE MSL : 33.05 GEOID : _____

ELLIPSOIDAL HEIGHT: 33.05⁺ GEOID SEPARATION : 0⁺

CAMPAIGN EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)

WEDOC-2 -70.116 / 667.180 / 54.282

WEDOC-1 -69.734 / 667.152 / 54.578

AGENCY

Royal Greenwich
Observatory
Herstmonceux Castle
Hailkam, East Sussex
Bn27 IRP.
England

Remarks

+ OSGB-70 datum (Airy ellipsoid)

DOPPLER CAMPAIGN WEDOC-2

Station Information

STATION NAME : HØNEFOSS
CODE : HON COUNTRY : NORWAY

RECEIVER: TYPE: CMA-751 SER. NO.: 103
ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED 79
LATITUDE : 60°08'38".3226
LONGITUDE : 10°15'01".8680

VERTICAL COORDINATES OF REF. POINT
HEIGHT ABOVE MSL : 137.35 GEOID : LEVALLOIS 78
ELLIPSOIDAL HEIGHT: 145.80 GEOID SEPARATION : 8.55

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	-0.28 / -1.74 / -3.86
NORSNET	-0.31 / -1.74 / -3.91
NORDOC-83	-0.29 / -1.74 / -3.87
SVEDOP-81	-0.28 / -1.74 / -3.86

<u>AGENCY</u>	<u>Remarks</u>
Geographical Survey of Norway Monserudveien, Hønefoss 3500 Hønefoss	

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>JOZEFOSLAW</u>	
CODE : <u>JOZ</u>	COUNTRY : <u>Poland</u>
RECEIVER: TYPE: <u>JMR-4A</u>	SER. NO: _____
ANTENNA: _____	SER. NO.: _____
<u>HORIZONTAL COORDINATES OF REF. POINT DATUM:</u>	
LATITUDE : <u>52° 06'</u>	_____
LONGITUDE : <u>21° 02'</u>	_____
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : _____	GEOID : _____
ELLIPSOIDAL HEIGHT: <u>111 m</u>	GEOID SEPARATION : _____
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	41.36 / -36.84 / -23.21
<u>AGENCY</u> GEOKART Poland Pl. Jednosci Robotniczej 1 00-661 Warszawa	<u>Remarks</u>

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>KOOTWIJK</u>	
CODE : <u>KTW</u>	COUNTRY : <u>NETHERLANDS</u>
RECEIVER: TYPE: <u>CMA 761</u>	SER. NO: <u>S/N 118</u>
ANTENNA: _____	SER. NO.: _____
<u>HORIZONTAL COORDINATES OF REF. POINT DATUM: ED 79</u>	
LATITUDE : <u>52°10'45"0568</u>	
LONGITUDE : <u>5°48'41"2524</u>	
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL: <u>47.947 (A)</u>	GEOID : <u>Levallois 1978</u>
ELLIPSOIDAL HEIGHT: <u>45.647</u>	GEOID SEPARATION : <u>-2.3</u>
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	-1.93 / -0.19 / -2.50
WEDOC-1	-1.93 / -0.19 / -2.50
RETDOC	-1.93 / -0.19 / -2.50 +
MERITDOC	-1.93 / -0.19 / -2.50
<u>AGENCY</u>	<u>Remarks</u>
Department of Geodesy Technical Highschool Delft Afdeling of Geodesie Thijsseweg 11 2629 JA Delft	+ NEDOC , ERIDOC , SEATOC , EROSDOC , all with same excentricity

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>MATERA</u>	
CODE : <u>MAT</u>	COUNTRY : <u>ITALY</u>
RECEIVER: TYPE: <u>MX-1502</u>	SER. NO: _____
ANTENNA: _____	SER. NO.: _____
<u>HORIZONTAL COORDINATES OF REF. POINT DATUM: <u>ED 79</u></u>	
LATITUDE : _____	<u>40°38'59".6215</u>
LONGITUDE : _____	<u>16°42'19".0857</u>
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL: <u>490.66 (G)⁺</u>	GEOID : <u>LEVALLOIS 78</u>
ELLIPSOIDAL HEIGHT: <u>480.76</u>	GEOID SEPARATION : <u>-9.90</u>
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
<u>WEDOC - 2</u>	<u>0.00 / 0.00 / 0.00</u>
<u>AGENCY</u>	<u>Remarks</u>
Istituto Geografico Militare, Firenze Servizio Technico Divisione Geodetica I- 50100 Firenze ITALY	+ Genua Terrestrial coordinates are referred to the antenna phase center

DOPPLER CAMPAIGN WEDOC-2

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Station Information

STATION NAME : METSÄHÖVI

CODE : MET COUNTRY : FINLAND

RECEIVER: TYPE: JMR-4AT SER. NO: 60N15027

ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED 79

LATITUDE : 60°13'03".9390

LONGITUDE : 24°23'43".6395

VERTICAL COORDINATES OF REF. POINT

HEIGHT ABOVE MSL: 54.013 (B)⁺ GEOID : LEVALLOIS 78

ELLIPSOIDAL HEIGHT: 49.01 GEOID SEPARATION : -5.0

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	-0.24 / -0.11 / -0.46
ERIDOC	-3.99 / -1.85 / -1.80
SCANDOC	32.08 / 4.16 / -20.82 +
SEATOC	-0.68 / -0.38 / -1.31

<u>AGENCY</u>	<u>Remarks</u>
The Finnish Geodetic Institute Ilmalankatu 1 A. SF - 00240 Helsinki Finland	+ EROSDOC -0.68 / -0.38 / -1.31

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>PENC</u>	
CODE : <u>PNC</u>	COUNTRY : <u>HUNGARY</u>
RECEIVER: TYPE : <u>JMR-1A</u>	SER. NO : <u>547</u>
ANTENNA: _____	SER. NO.: _____
<u>HORIZONTAL COORDINATES OF REF. POINT DATUM: <u>National</u></u>	
LATITUDE : <u>47°47'</u>	
LONGITUDE : <u>19°17'</u>	
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : <u>242.95</u>	GEOID : _____
ELLIPSOIDAL HEIGHT: <u>300</u>	GEOID SEPARATION : _____
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	-0.30 / -0.11 / -0.36 ++
WEDOC-1	85.51 / 110.15 / -117.38
MERTTDOC	-0.30 / -0.11 / -0.36 ++
DÖDOC /compl./	-11.62 / 58.21 / -1.44 +
<u>AGENCY</u>	<u>Remarks</u>
Institute for Geodesy and Cartography Guszev u.19. H-1051 Budapest, Hungary	+ Continuous observations from April 1977 until december 1980 with the same excentricity ++ Countinuous observations from April 1, 1982 with the same excentricity

DOPPLER CAMPAIGN WEDOC - 2

Station Information

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STATION NAME : POTS DAM

CODE : PDM COUNTRY : GDR

RECEIVER: TYPE: JMR-1A SER. NO: 166

ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: _____

LATITUDE : 52°22'51"446

LONGITUDE : 13°03'58"928

VERTICAL COORDINATES OF REF. POINT

HEIGHT ABOVE MSL : _____ GEOID : _____

ELLIPSOIDAL HEIGHT: 107.80 GEOID SEPARATION : _____

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	-76.564 / -49.285 / 69.797 +
WEDOC-1	-76.564 / -49.285 / 69.797 +
MERITDOC	30.042 / 79.871 / -45.246 ++

AGENCY

Zentralinstitut für
Physik der Erde
Telegrafenberg A17
15 Potsdam DDR

Remarks

+ Antenna phase center until Dec.1983
++ Antenna phase center since Jan. 1984

DOPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>RIGA</u>	
CODE : <u>RIG</u>	COUNTRY : <u>USSR</u>
RECEIVER : TYPE : <u>CMA-722B</u>	SER. NO : _____
ANTENNA : _____	SER. NO. : _____
<u>HORIZONTAL COORDINATES OF REF. POINT DATUM:</u>	
LATITUDE : <u>56° 57'</u>	_____
LONGITUDE : <u>24° 04'</u>	_____
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : _____	GEOID : _____
ELLIPSOIDAL HEIGHT : <u>6. m</u>	GEOID SEPARATION : _____
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
<u>WEDOC-2</u>	<u>-17.46 / 33.38 / -1.76 +</u>
<u>AGENCY</u>	<u>Remarks</u>
Astronomical Council of the Academy of Sciences, USSR, 48, Pjatnitskaja St. Moscow 109017	+ referred to the geodetic monument under the AFU camera

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : SAN FERNANDO

CODE : SFN COUNTRY : SPAIN

RECEIVER: TYPE: TRANET 2 SER. NO: 121

ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED 79

LATITUDE : 36°27'59".6681

LONGITUDE : -6°12'14".3873

VERTICAL COORDINATES OF REF. POINT

HEIGHT ABOVE MSL : 43.154 GEOID : Levallois 1978

ELLIPSOIDAL HEIGHT: -1.846 GEOID SEPARATION : -45.

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	3.24 / 28.86 / -5.17
SHORT MERIT	2.65 / 27.47 / 0.79
EROSDOC	-128.38 / 123.00 / 219.29
MERIT	3.24 / 28.86 / -5.17

AGENCY

Instituto y Observatorio
de Marina

Remarks

DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : SOPRON

CODE : SOP COUNTRY : HUNGARY

RECEIVER: TYPE: CMA-751 SER. NO.: 204

ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED 79

LATITUDE : 47°40'49"3316

LONGITUDE : 16°33'30"4108

VERTICAL COORDINATES OF REF. POINT

HEIGHT ABOVE MSL : 340.243 (A) + GEOID : LEVALLOIS 78

ELLIPSOIDAL HEIGHT: 341.34 GEOID SEPARATION : 1.10

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	1.32 / -0.88 / -1.00
WEDOC-1	1.32 / -0.88 / -1.00

AGENCY

Geodetic and Geophysical
Research Institute of the
Hungarian Academy of Sciences,
Sopron
Museum u.6.
Hungary

Remarks

+ Adriatic
339.568 Baltic

DOPLER CAMPAIGN WEDOC-2

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Station Information

STATION NAME : <u>TRIESTE</u>	
CODE : <u>TRS</u>	COUNTRY : <u>ITALY</u>
RECEIVER : TYPE : <u>MX-1502</u>	SER. NO : <u>018</u>
ANTENNA : _____	SER. NO. : _____
<u>HORIZONTAL COORDINATES OF REF. POINT DATUM</u> : <u>ED 79</u>	
LATITUDE : _____	<u>45°38'37".460</u>
LONGITUDE : _____	<u>13°52'35".023</u>
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : <u>402.97 (G)⁺</u>	GEOID : <u>Levallois 1978</u>
ELLIPSOIDAL HEIGHT : <u>398.82</u>	GEOID SEPARATION : <u>-4.15</u>
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	0.00 / 0.00 / 0.00
WEDOC-1	0.00 / 0.00 / 0.00
ALGEDOP	0.00 / 0.00 / 0.00
SWISSDOC	0.00 / 0.00 / 0.00
<u>AGENCY</u>	<u>Remarks</u>
Istituto di Geodesia e Geofisica Università di Trieste Via dell'Università 2, I- 34100 Trieste, Italy	+ Genova The terrestrial coordinates are referred to the antenna phase center

DOPPLER CAMPAIGN WEDOC - 2

Station Information

STATION NAME : WETTZELL
CODE : WTZ COUNTRY : FRG

RECEIVER: TYPE: CMA722B SER. NO: 602
ANTENNA: _____ SER. NO.: _____

HORIZONTAL COORDINATES OF REF. POINT DATUM: ED 79
LATITUDE : 49⁰08' 44"073
LONGITUDE : 12⁰52' 46"749

VERTICAL COORDINATES OF REF. POINT
HEIGHT ABOVE MSL : 616.45 GEOID : LEVALLOIS 78
ELLIPSOIDAL HEIGHT: 618.45 GEOID SEPARATION : 2.00

<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>		
WEDOC-2	0.00	/	0.00 / 0.00
WEDOC-1	0.00	/	0.00 / 0.00
EDOC-2	0.00	/	0.00 / 0.00 ++

<u>AGENCY</u> Institut für Angewandte Geodäsie Frank- furt, DGFI Abt. 2.	<u>Remarks</u> ++ DÖDOC , EROS-DOC , SEATOC , NORSDOC , TIMEDOC , HOTDOC Terrestrial coordinates are referred to the antenna phase center
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DOPPLER CAMPAIGN WEDOC - 2

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Station Information

STATION NAME : <u>ZIMMERWALD</u>	
CODE : <u>ZMW</u>	COUNTRY : <u>SWITZERLAND</u>
RECEIVER : TYPE : <u>MX-1502</u>	SER. NO : <u>234</u>
ANTENNA : _____	SER. NO. : _____
<u>HORIZONTAL COORDINATES OF REF. POINT DATUM : <u>ED 79</u></u>	
LATITUDE : <u>46°52'41".3790</u>	
LONGITUDE : <u>7°28'00".4278</u>	
<u>VERTICAL COORDINATES OF REF. POINT</u>	
HEIGHT ABOVE MSL : <u>897.84</u>	GEOID : <u>LEVALLOIS 78</u>
ELLIPSOIDAL HEIGHT : <u>894.70</u>	GEOID SEPARATION : <u>3.14</u>
<u>CAMPAIGN</u>	<u>EXCENTRICITY ELEMENTS ($\Delta x, \Delta y, \Delta z$) (terr. ref. point - phase center)</u>
WEDOC-2	-18.69 / 34.89 / 2.51
WEDOC-1	-18.16 / 34.96 / 3.08
EDOREF	-18.69 / 34.89 / 2.51 +++
MERITDOC	-18.69 / 34.89 / 2.51
<u>AGENCY</u>	<u>Remarks</u>
ETH Zürich Astronomical Institute, University of Berne Sidlerstraße 5 CH-3012 Bern	+++ EROSDOC , EDOC-2 -18.09 / 35.61 / 3.75

APPENDIX B: List of Majority Vote Formats used

In the following all formats are described which have been used for the exchange of data except those formats which are already contained in CSTG 1983. (basically raw data formats specified by the manufacturers):

B.1 JMR- Format for Majority Voted Data

Record 1:	2 - 19	A18	Comments
	21 - 24	F4.0	Temperature in C ⁰
	25 - 28	F4.0	Pressure in mbar
	29 - 30	F2.0	Relative humidity in %
	31 - 34	F4.0	Day of the year of lock on time
	35 - 36	F2.0	Hour of lock on time (UT)
	37 - 38	F2.0	Minute of lock on time
	39 - 47	F9.0	Microsecond read out before synchronization
	48 - 50	F3.0	2 digit microsecond read out of first zero crossing (f.z.c.)
	51 - 57	F7.0	"Doppler count" at lock on
	58 - 60	I3	Signal status at lock on
Record 2:	7(1X,I9)		Satellite variable data (1 - 7). The 2nd message word defines the lock on time
Record 3:	7(1X,I9)		Satellite variable data (8 - 14)
Record 4:	7(1X,I9)		Satellite fixed parameters (1 - 7)
Record 5:	7(1X,I9)		Satellite fixed parameters (8 - 14)
Record 6:	1 - 6	I6	Clock microsecond read out at end of interv.
	7 - 9	I3	Fractional part of read out (f.z.c.)
	11 - 12	2I1	Signal status on both channels
	13 - 20	F8.0	Accumulated Doppler count (appr. 30 sec)
	21 - 26	I6	Clock microsecond read out at end of 2. int.
	27 - 29	I3	Fractional part of read out (microseconds)
	31 - 32	2I1	Signal status of both channels
	33 - 40	F8.0	Accumulated Doppler count
	41 - 46	I6	Clock microsecond read out at end of 3. int
	47 - 49	I3	Fractional part of read out (microseconds)
	51 - 52	2I1	Signal status on both channels
	53 - 60	F8.0	Accumulated Doppler count
	61 - 66	I6	Clock microsecond read out at end of 4. int
	67 - 69	I3	Fractional part of read out (microseconds)
	71 - 72	2I1	Signal status on both channels
	73 - 80	F8.0	Accumulated Doppler count

All records starting with 7 have the same structure as record 6. The end of the pass is indicated by a negative Doppler count (-1)

B.2 Majority Voted Format for CMA-722B and DOG-2 Receivers

=====

Record 1:	1 - 10	A10	Station name
	11 - 13	I3	Satellite number
	14 - 18	I5	Day of the year of lock on time
	19 - 22	I4	Hour of lock on time (UT)
	23 - 25	I3	Minute of lock on time
	26 - 37	3A4	Comments
	40 - 46	F7.1	Pressure in millibar or Torr
	47 - 53	F7.1	Temperature in C ^o
	54 - 60	F7.1	Humidity in %
	79 - 80	I2	Number of 30-sec Doppler counts (optional)
Record 2:			Dummy record
Record 3:	1X,6(1X,I9)		Satellite variable data (2 - 7). The 2nd message word defines the lock on time
Record 4:	1X,6(1X,I9)		Satellite variable data (8 - 13)
Record 5:			Dummy record
Record 6:	1X,7(1X,I9)		Satellite fixed parameters (1 - 7)
Record 7:	1X,7(1X,I9)		Satellite fixed parameters (8 - 14)
Record 8:			Dummy record
Record 9:	3 - 11	F9.2	Doppler count 400 MHz (7 x 4.6)
	12 - 20	F9.2	Doppler count 150 MHz (7 x 4.6)
	22 - 30	F9.2	Doppler count 400 MHz (6 x 4.6)
	31 - 39	F9.2	Doppler count 150 MHz (6 x 4.6)
	42 - 50	F9.2	Doppler count 400 MHz (7 x 4.6)
	51 - 59	F9.2	Doppler count 150 MHz (7 x 4.6)
	61 - 69	F9.2	Doppler count 400 MHz (5 x 4.6)
	70 - 78	F9.2	Doppler count 150 MHz (5 x 4.6)

All the records starting with 10 have the same structure as record 9. The end of the pass is indicated by two additional dummy records

Remarks: The integration interval is internally set to the following values: 0.536786250 min. / 0.460102500 min /,
0.536786350 min. / 0.466328958 min /.

In Graz now a new version of MJV is used since the CMA-722B receiver cannot handle NOVA-type satellite messages properly. This new version provides 14 variable parameter as described in the JMR-Format.

B.3 Majority Voted Format for CMA-751 and CMA-761 Receivers

Record 1:		Version A
1 - 14	A14	Comments
15 - 16	I2	Satellite number
17 - 21	I5	Day of the year of lock on time
22 - 25	I4	Hour of lock on time (UT)
26 - 28	I3	Minute of lock on time
35 - 38	I4	Temperature (in coded form) (see CSTG 83)
39 - 42	I4	Pressure in millibar
43 - 44	I2	Humidity in %
45 - 61	F19.0	5 MHz clock read out at lock on

Record 1:		Version B
1 - 3	I3	Satellite number
4 - 8	I5	Day of the year of lock on time
9 - 12	I4	Hour of lock on time (UT)
13 - 15	I3	Minute of lock on time
18 - 21	I4	Station number
22 - 25	I4	Temperature (in coded form)
26 - 29	I4	Pressure in millibar
30 - 31	I2	Humidity in %
32 - 48	F17.0	5 MHz clock read out at lock on

Record 2:	2X,7I10	Satellite variable data (1 - 7). The 3rd message word defines the lock on time
Record 3:	2X,7I10	Satellite variable data (8 - 14).
Record 4:	2X,7I10	Satellite fixed parameters (1 - 7)
Record 5:	2X,7I10	Satellite fixed parameters (8 - 14)
Record 6-13:	1X,8F9.0	Up to 32 pairs of Doppler counts consisting of 400 MHz and 150 MHz counts respectively
Record 14-21:	1X,4F7.0	Time intervals pertaining to the pairs of Doppler counts in records I - 8
	2X,8I5	Signal strength of the 400 MHz and 150 MHz channel of record I - 8.

Remarks: There are some other formats in use in which the first column of the records 2 - 21 is omitted.

In addition, there exists a format where the first word of the satellite variable data belongs to $t_0 - 6$. That means that the 4th variable message word defines the lock on time (eg. Honefoss)

B.4 Majority Voted Format for MX-1502 Receivers

=====

Record 1:	1 - 10	A10	Station name
	19 - 20	I2	Satellite number
	21 - 25	I5	Day of the year of lock on time
	26 - 30	I5	Hour of lock on time (UT)
	31 - 35	I5	Minute of lock on time
	36 - 40	I5	Number of the 30-seconds intervals
	41 - 45	I5	Year of the observation
	46 - 50	I5	Serial number of the receiver
	51 - 65	F15.10	Fractions of minutes of lock on time (optionally)
Record 2:	7I10		Satellite variable data (1 - 7). The 3rd message word defines the lock on time
Record 3:	7I10		Satellite variable data (8 - 14)
Record 4:	7I10		Satellite fixed parameters (1 - 7)
Record 5:	7I10		Satellite fixed parameters (8 - 14)
Record 6:	8F10.2		Pairs of Doppler counts consisting of 400 MHz and 150 MHz counts respectively.
Record 6+N:	4F10.7		Time intervals pertaining to the respective pairs of Doppler counts starting with record 6 in minutes.
Record 6+2N:			Dummy record, end of pass

Remarks: This type of majority vote format has been proposed by Graz in order to circumvent the problem either to send binary raw data or to send readable integer numbers which are very extensive.

The number N is defined as follows:

$$N = M/8 \quad \text{if} \quad M(\text{mod } 8) = 0$$
$$N = M/8 + 1 \quad \text{if} \quad M(\text{mod } 8) \neq 0$$

where M is the number read in in record 1, columns 36 - 40.

B.5 WEDOC Data Exchange Format

=====

Record 0:			Tape header
	1 - 10	A10	Name of the figure
	12 - 13	I2	Chebyshev fit order
	15 - 18	I4	Year of file generation
	20 - 21	I2	Month of file generation
	23 - 24	I2	Day of file generation
	26 - 27	I2	Number of stations involved in the figure
	29 - 38	A10	Type of ephemeris used
	40 - 43	I4	Year of observation
Record 1:	1 - 10	A10	Name of the figure
	12 - 21	A10	Type of ephemeris used
	23 - 29	I7	Satellite number
	31 - 37	I7	Last satellite injection (min. of year)
	39 - 45	I7	Ephemeris lock on (minutes of the year)
	47 - 49	I3	Satellite ephemeris span (minutes)
	51 - 58	F8.1	Satellite frequency (corr. to 400 MHz)
	60 - 61	I2	Number of stations involved in this pass
Record 2:	1 - 11	F11.6	Time interval since time of t_p (min)
	12 - 22	F11.6	Mean motion (rad/min)
	23 - 33	F11.6	Eccentricity
	34 - 44	F11.6	Arg. of perigee at t_p (rad)
	45 - 55	F11.6	Right asc. of asc. node (rad)
	56 - 66	F11.6	Right asc. of Greenwich (rad)
	67 - 77	F11.6	Inclination (rad)
	78 - 80	I3	Fit-parameter code
Record 3:	4F19.11		Chebyshev-coefficients X (1-4)
Record 4:	4F19.11		Chebyshev-coefficients X (5-8)
Record 5:	4F19.11		Chebyshev-coefficients Y (1-4)
Record 6:	4F19.11		Chebyshev-coefficients Y (5-8)
Record 7:	4F19.11		Chebyshev-coefficients Z (1-4)
Record 8:	4F19.11		Chebyshev-coefficients Z (5-8)
Record 9:	1515		Number of Doppler counts for maximal 15 simultaneous observing stations.
Record 10:			Station header of first station
	1 - 10	A10	Name of the first station
	12 - 18	I7	Lock on time (minutes of the year)
	19 - 32	F14.11	Lock on time (fractions of minute)
	34 - 39	F6.1	Pressure (millibar)
	41 - 45	F5.1	Dry temperature C_0
	46 - 50	F5.1	Partial vapour pressure
	51 - 52	I2	Pass geometry code
	53 - 55	I3	Receiver type if available
	56 - 59	I4	Serial number of the receiver
	61 - 65	F5.1	Receiver frequency offset from 400 MHz(Hz)
	66 - 68	I3	Number of time intervals

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	72 - 74	I3	Day of lock on
	75 - 77	I3	Hour of lock on (UT)
	78 - 80	I3	Minute of lock on
Record 11:	6F13.5		400 MHz Doppler counts corrected for first order ionospheric effects
.....		
Record 11+N:	6F13.10		Time intervals in minutes
.....		
Record 11+2N:			Next station starting with record 10.
.....		

The next pass starts with record 1.

Remarks: This format has been created in collaboration with the Institut für Angewandte Geodäsie Frankfurt (Herzberger)

It is, like the now installed SEF-format, a receiver-type independent format which does not affect the original input data and only performs the first order ionospheric correction.

APPENDIX C : Similarity Transformation

Two 3-D coordinate systems can be connected by the following similarity transformation for i-th point common to both systems:

$$\begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix}_i = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + (1 + \mu) \begin{bmatrix} 1 & \alpha_z & -\alpha_y \\ -\alpha_z & 1 & \alpha_x \\ \alpha_y & -\alpha_x & 1 \end{bmatrix} \begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix}_i + \begin{bmatrix} v_X \\ v_Y \\ v_Z \end{bmatrix}_i$$

where ΔX , ΔY and ΔZ are translation parameters, μ is the scale factor, α_z , α_y and α_x are rotation parameters and v_X , v_Y and v_Z are the residuals.

Having more than 3 points the above transformation can be solved for the transformational parameters by means of least squares adjustment. The standard deviation of unit weight is computed by

$$\sigma_0 = \sqrt{\frac{\sum (v_X^2 + v_Y^2 + v_Z^2)}{n - 7}}$$

The residual rms in a given direction, let us say by X, is computed

$$\sigma_{X,Y,Z} = \sqrt{\frac{\sum v_{X,Y,Z}^2}{n}}$$

The v_X , v_Y , v_Z residuals are transformed into the horizontal systems v_x , v_y , v_h by

$$\begin{bmatrix} v_x \\ v_y \\ v_h \end{bmatrix}_i = \begin{bmatrix} -\sin\phi \cos\lambda & -\sin\phi \sin\lambda & \cos\phi \\ -\sin\lambda & \cos\lambda & 0 \\ \cos\phi \cos\lambda & \cos\phi \sin\lambda & \sin\phi \end{bmatrix} \begin{bmatrix} v_X \\ v_Y \\ v_Z \end{bmatrix}_i$$

APPENDIX D : Transformation Cartesian - Polar System

The 3-D cartesian coordinate system X, Y, Z can be transformed to the polar coordinate system δ (declination), t (hour angle), s (distance). The formulas for transforming respective coordinate differences are the following:

$$\begin{aligned} \Delta X &= s \cos \delta \cos t & \delta &= \arctan \left(\frac{\Delta Z}{\sqrt{\Delta X^2 + \Delta Y^2}} \right) \\ \Delta Y &= s \cos \delta \sin t & t &= \arctan \left(\frac{\Delta Y}{\Delta X} \right) \\ \Delta Z &= s \sin \delta & s &= \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2} \end{aligned}$$

$$\begin{bmatrix} d\Delta X \\ d\Delta Y \\ d\Delta Z \end{bmatrix} = \begin{bmatrix} -\sin \delta \cos t & -\sin t & \cos \delta \cos t \\ -\sin \delta \sin t & \cos t & \cos \delta \sin t \\ \cos \delta & 0 & \sin \delta \end{bmatrix} \begin{bmatrix} s \, d\delta \\ s \cos \delta \, dt \\ ds \end{bmatrix}$$

The Q-matrices in both systems are connected by

$$\underline{Q}_{\Delta x} = \underline{E} \underline{Q}_e \underline{E}^T \quad \text{or} \quad \underline{Q}_e = \underline{E}^T \underline{Q}_{\Delta x} \underline{E}$$

where \underline{E} is the transformation matrix defined in the last formula above. (see RINNER 1982).

A P P E N D I X E

Correlation matrices of the multipoint computations

GEODOP (Graz) and SADOSA (Penc)

	BOR			BRS			CGL			DIO		
BOR	1000	51	-376	804	130	-327	766	91	-370	769	-45	-402
	51	1000	-29	-40	633	-144	-18	562	-99	101	638	0
	-376	-29	1000	-340	6	786	-261	11	788	-220	-49	791
BRS	804	-40	-340	1000	55	-369	752	31	-364	719	-96	-422
	130	633	6	55	1000	-67	83	490	-63	175	512	3
	-327	-144	786	-369	-67	1000	-245	-78	758	-257	-133	723
CGL	766	-18	-261	752	83	-245	1000	-6	-393	746	-118	-374
	91	562	11	31	490	-78	-6	1000	-73	122	500	19
	-370	-99	788	-364	-63	758	-393	-73	1000	-302	-114	775
DIO	769	101	-220	719	175	-257	746	122	-301	1000	-38	-359
	-45	638	-49	-96	512	-133	-118	500	-114	-38	1000	37
	-402	0	791	-422	3	723	-374	19	775	-359	37	1000
EFF	848	-22	-346	841	81	-318	825	49	-399	794	-93	-457
	140	765	9	51	674	-118	81	623	-81	193	640	-2
	-337	-128	854	-325	-76	832	-274	-65	845	-280	-134	809
GRS	728	-27	-269	721	66	-246	727	30	-313	689	-100	-371
	90	502	10	34	442	-72	51	438	-46	120	428	9
	-336	-114	754	-325	-74	735	-279	-65	760	-282	-118	729
GRZ	888	37	-319	852	140	-324	838	94	-382	850	-69	-417
	70	842	-25	-12	694	-154	2	643	-112	136	735	4
	-370	-59	901	-384	-23	837	-312	-14	857	-272	-77	865
GRY	818	80	-299	768	148	-326	736	108	-359	752	-23	-381
	-4	736	-26	-70	544	-138	-56	491	-98	46	575	-7
	-343	22	831	-376	16	734	-296	24	745	-245	-20	762
HMC	853	-74	-387	868	25	-330	819	8	-416	764	-118	-486
	191	770	21	105	716	-102	139	622	-69	233	633	-5
	-376	-196	838	-336	-148	857	-294	-122	837	-328	-166	782
HON	877	-3	-370	866	97	-350	827	61	-424	808	-73	-472
	119	825	8	10	706	-137	47	616	-90	193	678	15
	-252	-85	885	-252	-26	843	-189	-23	836	-172	-107	812
HVR	836	46	-280	793	139	-294	763	95	-335	773	-51	-365
	45	756	-13	-24	608	-136	-10	547	-93	100	620	2
	-372	-48	858	-390	-25	789	-308	-14	793	-273	-68	796
JOZ	842	78	-317	792	149	-340	757	109	-378	771	-23	-402
	-1	788	-30	-75	580	-149	-57	520	-107	52	608	-10
	-347	37	857	-379	27	752	-299	33	765	-245	-12	783
KTW	845	-31	-359	842	72	-328	784	41	-387	754	-92	-443
	140	744	7	56	679	-108	85	566	-74	193	595	5
	-334	-140	843	-317	-78	833	-252	-68	803	-258	-130	770
MAT	825	37	-257	789	136	-270	813	94	-326	851	-100	-360
	52	729	-24	-16	610	-131	-21	615	-107	106	736	28
	-380	-56	843	-391	-28	787	-332	-12	833	-281	-67	859
MER	795	1	-318	780	101	-301	736	63	-351	722	-69	-395
	98	612	0	34	541	-100	53	467	-66	144	499	5
	-357	-101	808	-353	-56	779	-282	-46	766	-272	-101	749
MET	655	52	-249	630	119	-256	622	75	-316	653	-21	-327
	-32	388	-21	-73	311	-82	-64	271	-52	15	408	30
	-203	73	545	-229	73	482	-192	54	509	-120	88	579
PNC	840	61	-293	803	152	-306	808	101	-369	849	-54	-388
	24	764	-47	-48	631	-159	-43	594	-122	89	767	13
	-363	-26	856	-381	-1	790	-323	3	828	-259	-27	871
PDM	803	13	-313	783	107	-305	774	69	-376	773	-70	-415
	84	729	-15	3	621	-132	23	572	-96	149	647	2
	-302	-74	819	-307	-30	774	-252	-26	794	-225	-94	790
RIG	731	80	-273	687	134	-296	656	100	-330	669	-10	-349
	-27	555	-6	-90	398	-97	-72	356	-63	9	424	8
	-272	114	695	-308	66	588	-242	69	604	-182	42	632
SFN	216	-7	-122	231	7	-93	209	4	-124	183	4	-148
	-23	65	82	-35	67	62	-17	60	68	-20	50	76
	-62	3	162	-41	0	182	-40	2	178	-62	25	148
SIM	610	156	-216	562	192	-257	562	128	-289	684	131	-222
	-97	298	-45	-117	223	-79	-127	213	-57	-96	449	39
	-343	118	472	-363	75	413	-345	69	457	-262	289	604
SOP	835	44	-299	794	135	-310	760	93	-351	767	-47	-382
	49	777	-18	-24	614	-139	-8	548	-98	102	621	-3
	-346	-37	858	-367	-13	783	-286	-4	786	-250	-61	789
WTZ	827	14	-310	805	112	-303	799	70	-372	800	-79	-415
	90	756	-16	9	645	-136	27	601	-99	152	669	1
	-331	-81	842	-336	-38	796	-278	-31	819	-253	-101	818
ZMW	872	-23	-345	863	87	-318	836	51	-387	805	-99	-447
	142	807	4	54	716	-126	82	654	-84	195	672	2
	-374	-127	877	-363	-76	852	-300	-64	856	-300	-130	826

Computation Cruz: Correlation Matrix.

	EFF			GRS			GRZ			GRY		
BOR	848	140	-337	728	90	-336	888	70	-370	818	-4	-343
	-22	765	-128	-27	502	-114	37	842	-59	80	736	22
	-346	9	854	-269	10	754	-319	-25	901	-299	-26	831
BRS	841	51	-325	721	34	-325	852	-12	-384	768	-70	-376
	81	674	-76	66	442	-74	140	694	-23	148	544	16
	-318	-118	832	-246	-72	735	-324	-154	837	-326	-138	734
CGL	825	81	-274	727	51	-279	838	2	-312	736	-56	-296
	49	623	-65	30	438	-65	94	643	-14	108	491	24
	-399	-81	845	-313	-46	760	-382	-112	857	-359	-98	745
DIO	794	193	-280	689	120	-282	850	136	-272	752	46	-245
	-93	640	-134	-100	428	-118	-69	735	-77	-23	575	-20
	-457	-2	809	-371	9	729	-417	4	865	-381	-7	762
EFF	1000	74	-392	790	50	-358	921	4	-405	813	-59	-381
	74	1000	-101	60	561	-96	148	861	-30	164	664	26
	-392	-101	1000	-278	-60	817	-347	-141	924	-331	-128	801
GRS	790	60	-278	1000	-7	-323	792	-6	-319	697	-60	-302
	50	561	-60	-7	1000	-48	94	569	-13	105	436	21
	-358	-96	817	-323	-48	1000	-347	-128	820	-329	-112	710
GRZ	921	148	-347	792	94	-347	1000	65	-395	862	-15	-352
	4	861	-141	-6	569	-128	65	1000	-71	98	750	5
	-405	-30	924	-319	-13	820	-395	-71	1000	-354	-68	857
GRY	813	164	-331	697	105	-329	862	98	-354	1000	66	-402
	-59	664	-128	-60	436	-112	-15	750	-68	66	1000	48
	-381	26	801	-302	21	710	-352	5	857	-402	48	1000
HMC	925	10	-372	791	10	-369	912	-46	-439	811	-98	-423
	137	865	-77	116	566	-79	206	858	-19	210	659	27
	-370	-183	923	-289	-114	817	-386	-211	904	-377	-181	781
HON	927	97	-381	792	63	-381	938	27	-430	841	-42	-403
	37	863	-114	26	558	-107	121	894	-35	150	716	31
	-269	-39	924	-199	-21	808	-248	-89	937	-246	-98	826
HVR	840	146	-302	722	95	-304	889	71	-329	818	-8	-312
	-11	737	-118	-18	486	-107	39	823	-52	70	687	19
	-397	-28	853	-314	-13	758	-374	-58	902	-353	-54	824
JOZ	838	165	-349	719	106	-346	885	99	-375	830	31	-337
	-61	706	-138	-62	463	-121	-12	792	-74	40	751	24
	-386	39	823	-306	29	729	-355	18	881	-321	41	844
KTW	876	66	-348	751	44	-347	892	-1	-405	806	-64	-393
	82	777	-89	66	510	-87	150	805	-28	163	636	19
	-330	-104	881	-254	-62	778	-331	-145	892	-331	-138	785
MAT	869	147	-296	756	95	-300	908	63	-312	800	-12	-289
	-2	770	-125	-17	523	-116	43	842	-58	75	647	0
	-425	-39	881	-337	-14	790	-389	-63	919	-363	-63	804
MER	816	99	-317	701	65	-316	845	28	-360	768	-40	-352
	52	634	-81	40	419	-77	104	676	-27	116	534	15
	-364	-73	831	-285	-43	737	-355	-110	858	-347	-106	765
MET	692	129	-282	591	77	-286	714	76	-298	635	13	-271
	-71	389	-78	-66	247	-63	-41	434	-38	-15	347	-2
	-247	82	542	-196	51	479	-209	81	585	-187	54	522
PNC	886	166	-337	761	103	-337	921	90	-351	815	9	-322
	-37	797	-156	-44	524	-136	12	877	-84	50	681	-17
	-413	-7	886	-329	1	787	-373	-29	930	-345	-38	816
PDM	859	110	-339	736	71	-340	875	39	-370	774	-27	-344
	21	787	-120	11	513	-110	85	824	-52	109	640	7
	-335	-43	866	-260	-24	764	-307	-83	885	-291	-83	772
RIG	727	150	-304	623	97	-302	766	97	-327	713	36	-292
	-80	487	-88	-75	318	-75	-42	546	-39	1	528	38
	-313	90	647	-249	61	573	-281	85	703	-245	115	688
SFN	248	-1	-112	207	-4	-108	226	12	-143	202	-10	-132
	-33	88	75	-19	66	63	-22	66	88	-19	52	79
	-54	-4	195	-47	-10	180	-71	20	170	-67	6	148
SIM	623	211	-283	529	128	-273	669	194	-262	600	107	-228
	-123	279	-82	-116	184	-66	-121	339	-57	-85	275	-25
	-393	85	462	-333	57	422	-371	138	518	-322	109	468
SOP	839	143	-319	721	92	-319	884	70	-349	817	-6	-329
	-10	741	-124	-17	488	-112	42	823	-59	77	706	14
	-373	-13	848	-293	-4	752	-349	-45	896	-330	-45	825
WTZ	887	115	-339	760	74	-338	903	39	-367	798	-29	-343
	26	824	-126	15	539	-114	90	859	-54	115	664	6
	-367	-52	893	-286	-27	789	-337	-92	912	-319	-88	795
ZMW	926	81	-348	797	54	-347	939	3	-398	836	-63	-383
	80	879	-104	62	585	-100	150	904	-33	165	700	21
	-388	-98	931	-303	-58	826	-379	-139	942	-366	-127	825

Computation Graz: Correlation Matrices continued.

	HMC			HON			HVR			JOZ		
BOR	853	191	-376	877	119	-252	836	45	-372	842	-1	-347
	-74	770	-196	-3	825	-85	46	756	-48	78	788	37
	-387	21	838	-370	8	885	-280	-13	858	-317	-30	857
BRS	868	105	-336	866	10	-252	793	-24	-390	792	-75	-379
	25	716	-148	97	706	-26	139	608	-25	149	580	27
	-330	-102	857	-350	-137	843	-294	-136	789	-340	-149	752
CGL	819	139	-294	827	47	-189	763	-10	-308	757	-57	-299
	8	622	-122	61	616	-23	95	547	-14	109	520	33
	-416	-69	837	-424	-90	836	-335	-93	793	-378	-107	765
DIO	764	233	-328	809	193	-172	773	100	-273	771	52	-245
	-118	633	-166	-73	678	-107	-51	620	-68	-23	608	-12
	-486	-5	782	-472	15	812	-365	2	796	-402	-10	783
EFF	925	137	-370	927	37	-269	840	-11	-397	838	-61	-386
	10	865	-183	97	863	-39	146	737	-28	165	706	39
	-372	-77	923	-381	-114	924	-302	-118	853	-349	-138	823
GRS	791	116	-289	792	26	-199	722	-18	-314	719	-62	-306
	10	566	-114	63	558	-21	95	486	-13	106	463	29
	-369	-79	817	-381	-107	808	-304	-107	758	-348	-121	729
GRZ	912	206	-386	938	121	-248	889	39	-374	885	-12	-355
	-46	858	-211	27	894	-89	71	823	-58	99	792	18
	-439	-19	904	-430	-35	937	-329	-52	902	-375	-74	881
GRY	811	210	-377	841	150	-246	818	70	-353	830	40	-321
	-98	659	-181	-42	716	-98	-8	687	-54	31	751	41
	-423	27	781	-403	31	826	-312	19	824	-337	24	844
HMC	1000	55	-381	937	-35	-295	836	-53	-435	838	-105	-430
	55	1000	-179	155	872	-14	200	738	-23	213	702	41
	-381	-179	1000	-400	-202	915	-347	-181	843	-393	-195	801
HON	937	155	-400	1000	61	-312	863	8	-428	869	-44	-408
	-35	872	-202	61	1000	-54	124	772	-33	152	767	48
	-295	-14	915	-312	-54	1000	-213	-76	870	-262	-107	851
HVR	836	200	-347	863	124	-213	1000	44	-396	836	-5	-313
	-53	738	-181	8	772	-76	44	1000	-53	71	718	30
	-435	-23	843	-428	-33	870	-396	-53	1000	-374	-59	845
JOZ	838	213	-393	869	152	-262	836	71	-374	1000	46	-408
	-105	702	-195	-44	767	-107	-5	718	-59	46	1000	32
	-430	41	801	-408	48	851	-313	30	845	-408	32	1000
KTW	901	123	-364	902	26	-273	830	-15	-410	831	-67	-398
	17	822	-172	101	819	-33	149	705	-31	165	677	31
	-348	-84	901	-361	-121	897	-300	-128	839	-347	-150	806
MAT	847	199	-337	877	122	-194	827	41	-310	821	-10	-291
	-41	760	-179	17	787	-78	52	711	-52	77	685	11
	-453	-32	856	-446	-39	883	-340	-52	847	-384	-69	825
MER	827	156	-346	838	68	-241	798	5	-364	786	-39	-354
	6	654	-145	68	658	-38	107	614	-23	117	562	23
	-390	-60	837	-396	-84	842	-319	-97	817	-365	-111	782
MEY	681	170	-309	708	119	-198	651	54	-293	653	16	-273
	-95	379	-105	-61	435	-63	-33	369	-32	-16	369	3
	-275	85	513	-249	115	569	-177	69	537	-199	57	540
PNC	864	217	-376	896	148	-233	839	63	-347	837	13	-324
	-78	782	-209	-15	831	-111	22	740	-75	51	721	-6
	-445	0	855	-428	0	896	-323	-23	855	-366	-42	839
PDM	852	165	-363	870	82	-248	797	20	-364	796	-27	-347
	-30	779	-186	42	818	-69	87	701	-46	110	680	19
	-361	-24	845	-352	-49	878	-265	-69	815	-309	-90	794
RIG	727	192	-342	758	140	-225	722	72	-331	738	44	-293
	-113	480	-129	-69	544	-72	-35	487	-26	1	590	57
	-353	85	622	-327	111	677	-248	89	682	-260	135	721
SFN	270	10	-90	251	-6	-96	206	0	-136	211	-12	-134
	-49	96	57	-38	77	81	-17	62	80	-22	56	83
	-32	-3	225	-58	-2	187	-62	9	160	-68	4	152
SIM	597	242	-320	640	239	-189	610	151	-260	616	116	-227
	-130	270	-89	-111	312	-82	-104	286	-49	-86	291	-22
	-410	75	447	-393	128	460	-324	114	477	-336	114	482
SOP	839	196	-361	865	121	-233	838	45	-351	835	-4	-329
	-55	746	-187	9	784	-82	50	757	-47	75	739	24
	-412	-5	836	-401	-17	870	-310	-29	857	-347	-52	844
WTZ	876	173	-364	893	87	-243	823	20	-362	821	-28	-346
	-24	811	-193	49	837	-72	93	730	-49	116	704	17
	-392	-34	870	-385	-59	897	-292	-76	840	-338	-96	817
ZMW	935	146	-366	938	43	-260	867	-14	-397	861	-64	-388
	16	897	-191	100	888	-45	151	787	-32	167	741	33
	-407	-79	934	-418	-112	933	-336	-121	881	-386	-137	847

	KTW			MAT			MER			MET		
BOR	845	140	-334	825	52	-380	795	98	-357	655	-32	-203
	-31	744	-140	37	729	-56	1	612	-101	52	388	73
	-359	7	843	-257	-24	843	-318	0	808	-249	-21	545
BRS	842	56	-317	789	-16	-391	780	34	-353	630	-73	-229
	72	679	-78	136	610	-28	101	541	-56	119	311	73
	-328	-108	833	-270	-131	787	-301	-100	779	-258	-82	482
CGL	784	85	-252	813	-21	-332	736	53	-282	622	-64	-192
	41	566	-68	94	615	-12	63	467	-46	75	271	54
	-387	-74	803	-326	-107	833	-351	-66	766	-316	-52	509
DJO	754	193	-258	851	106	-281	722	144	-272	653	15	-120
	-92	595	-130	-100	736	-67	-69	499	-101	-21	408	88
	-443	5	770	-360	28	859	-395	5	749	-327	30	579
EFF	876	82	-330	869	-2	-425	816	52	-364	692	-71	-247
	66	777	-104	147	770	-39	99	634	-73	129	389	82
	-348	-89	881	-296	-125	881	-317	-81	831	-282	-78	542
GRS	751	66	-254	756	-17	-337	701	40	-285	591	-66	-196
	44	510	-62	95	523	-14	65	419	-43	77	247	51
	-347	-87	778	-300	-116	790	-316	-77	737	-286	-63	479
GRZ	892	150	-331	908	43	-389	845	104	-355	714	-41	-209
	-1	805	-145	63	842	-63	28	676	-110	76	434	81
	-405	-28	892	-312	-58	919	-360	-27	858	-298	-38	585
GRY	806	163	-331	800	75	-363	768	116	-347	635	-15	-187
	-64	636	-138	-12	647	-63	-40	534	-106	13	347	54
	-393	19	785	-289	0	804	-352	15	765	-271	-2	522
HMC	901	17	-348	847	-41	-453	827	6	-390	681	-95	-275
	123	822	-84	199	760	-32	156	654	-60	170	379	85
	-364	-172	901	-337	-179	856	-346	-145	837	-309	-105	513
HON	902	101	-361	877	17	-446	838	68	-396	708	-61	-249
	26	819	-121	122	787	-39	68	658	-84	119	435	115
	-273	-33	897	-194	-78	883	-241	-38	842	-198	-63	569
HVR	830	149	-300	827	52	-340	798	107	-319	651	-33	-177
	-15	705	-128	41	711	-52	5	614	-97	54	369	69
	-410	-31	839	-310	-52	847	-364	-23	817	-293	-32	537
JOZ	831	165	-347	821	77	-384	786	117	-365	653	-16	-199
	-67	677	-150	-10	685	-69	-39	562	-111	16	369	57
	-398	31	806	-291	11	825	-354	23	782	-273	3	540
KTW	1000	75	-398	825	-7	-413	812	45	-375	659	-70	-241
	75	1000	-87	146	707	-33	106	624	-67	130	363	85
	-398	-87	1000	-274	-123	837	-313	-88	823	-261	-78	517
MAT	825	146	-274	1000	26	-379	783	103	-297	681	-40	-175
	-7	707	-123	26	1000	-65	18	589	-93	57	388	72
	-413	-33	837	-379	-65	1000	-368	-30	807	-316	-31	569
MER	812	106	-313	783	18	-368	1000	131	-397	621	-50	-207
	45	624	-88	103	589	-30	131	1000	-14	94	299	65
	-375	-67	823	-297	-93	807	-397	-14	1000	-280	-56	501
MET	659	130	-261	681	57	-316	621	94	-280	1000	-127	-209
	-70	363	-78	-40	388	-31	-50	299	-56	-127	1000	302
	-241	85	517	-175	72	569	-207	65	501	-209	302	1000
PNC	840	165	-312	891	61	-367	796	119	-333	700	-24	-187
	-39	732	-152	4	816	-77	-10	609	-117	38	449	83
	-402	-1	842	-314	-20	903	-355	-5	811	-292	-10	593
PDM	817	113	-314	833	23	-390	767	77	-340	665	-49	-214
	16	719	-121	84	745	-54	46	591	-89	87	400	82
	-327	-36	824	-255	-74	848	-291	-38	783	-246	-53	540
RIG	722	149	-303	711	75	-335	677	105	-319	568	-10	-171
	-84	465	-98	-38	473	-35	-61	380	-67	-14	262	49
	-324	73	629	-229	67	658	-285	60	615	-212	36	444
SFN	238	6	-100	198	19	-144	212	5	-117	174	-11	-85
	-35	76	69	-15	62	78	-25	60	71	-23	28	56
	-48	0	182	-72	25	163	-54	2	166	-58	12	101
SIM	591	216	259	650	161	-264	501	167	-264	527	94	-76
	-118	261	-80	-137	320	-45	-105	220	-62	-68	292	88
	-379	91	441	-348	139	526	-342	80	439	-266	196	445
SOP	834	146	-319	821	52	-359	792	101	-338	649	-32	-190
	-16	715	-135	43	712	-58	10	608	-100	56	372	66
	-387	-16	837	-287	-41	840	-344	-14	808	-273	-28	536
WTZ	841	118	-312	862	21	-386	791	81	-339	681	-53	-213
	22	746	-125	89	783	-54	52	616	-93	91	402	77
	-357	-45	847	-283	-82	877	-318	-44	807	-271	-55	553
ZMW	899	88	-329	881	-4	-413	842	55	-363	696	-71	-239
	70	825	-111	149	807	-38	103	683	-78	129	399	82
	-387	-90	903	-321	-122	895	-352	-82	856	-305	-73	550

	PNC			PDM			RIG			SFN		
BOR	840	24	-363	803	84	-302	731	-27	-272	216	-23	-62
	61	764	-26	13	729	-74	80	555	114	-7	65	3
	-293	-47	856	-313	-15	819	-273	-6	695	-122	82	162
BRS	803	-48	-381	783	3	-307	687	-90	-308	231	-35	-41
	152	631	-1	107	621	-30	134	398	66	7	67	0
	-306	-159	790	-305	-132	774	-296	-97	588	-93	62	182
CGL	808	-43	-323	774	23	-252	656	-72	-242	209	-17	-49
	101	594	3	69	572	-26	100	356	69	4	60	2
	-369	-122	828	-376	-96	794	-330	-63	604	-124	68	178
DIO	849	89	-259	773	149	-225	669	9	-182	183	-20	-62
	-54	767	-27	-70	647	-94	-10	424	42	4	50	25
	-388	13	871	-415	2	790	-349	8	632	-148	76	148
EFF	886	-37	-413	859	21	-335	727	-80	-313	248	-33	-54
	166	797	-7	110	787	-43	150	487	90	-1	88	-4
	-337	-156	886	-339	-120	866	-304	-88	647	-112	75	195
GRS	761	-44	-329	736	11	-260	623	-75	-249	207	-19	-47
	103	524	1	71	513	-24	97	318	61	-4	66	-10
	-337	-136	787	-340	-110	764	-302	-75	573	-108	63	180
GRZ	921	12	-373	875	85	-307	766	-42	-281	226	-22	-71
	90	877	-29	39	824	-83	97	546	85	12	66	20
	-351	-84	930	-370	-52	885	-327	-39	703	-143	88	170
GRY	815	50	-345	774	109	-291	713	1	-245	202	-19	-67
	9	681	-38	-27	640	-83	36	528	115	-10	52	6
	-322	-17	816	-344	7	772	-292	38	688	-132	79	148
HMC	864	-78	-445	852	-30	-361	727	-113	-353	270	-49	-32
	217	782	0	165	779	-24	192	480	85	10	96	-3
	-376	-209	855	-363	-186	845	-342	-129	622	-90	57	225
HON	896	-15	-428	870	42	-352	758	-69	-327	251	-38	-58
	148	831	0	82	818	-49	140	544	111	-6	77	-2
	-233	-111	896	-248	-69	878	-225	-72	677	-96	81	187
HVR	839	22	-323	797	87	-265	722	-35	-248	206	-17	-62
	63	740	-23	20	701	-69	72	487	89	0	62	9
	-347	-75	855	-364	-46	815	-331	-26	682	-136	80	160
JOZ	837	51	-366	796	110	-309	738	1	-260	211	-22	-68
	13	721	-42	-27	680	-90	44	590	135	-12	56	4
	-324	-6	839	-347	19	794	-293	57	721	-134	83	152
KTW	840	-39	-402	817	16	-327	722	-84	-324	238	-35	-48
	165	732	-1	113	719	-36	149	465	73	6	76	0
	-312	-152	842	-314	-121	824	-303	-98	629	-100	69	189
MAT	891	4	-314	833	84	-255	711	-38	-229	198	-15	-72
	61	816	-20	23	745	-74	75	473	67	19	62	25
	-367	-77	903	-390	-54	848	-335	-35	658	-144	78	163
MER	796	-10	-355	767	46	-291	677	-61	-285	212	-25	-54
	119	609	-5	77	591	-38	105	380	60	5	60	2
	-333	-117	811	-340	-89	783	-319	-67	615	-117	71	166
MET	700	38	-292	665	87	-245	568	-14	-212	174	-23	-56
	-24	449	-10	-49	400	-53	-10	262	36	-11	28	12
	-187	83	593	-214	82	540	-171	49	444	-85	56	101
PNC	1000	25	-386	850	108	-292	726	-22	-253	211	-22	-75
	25	1000	-58	-7	788	-104	54	501	57	16	53	33
	-386	-58	1000	-372	-22	863	-318	-16	673	-147	86	155
PDM	850	-7	-372	1000	57	-378	691	-51	-277	216	-25	-67
	108	788	-22	57	1000	-80	103	473	74	8	63	16
	-292	-104	863	-378	-80	1000	-268	-54	631	-119	79	159
RIG	726	54	-318	691	103	-268	1000	-133	-273	184	-19	-57
	-22	501	-16	-51	473	-54	-133	1000	180	-20	43	1
	-253	57	673	-277	74	631	-273	180	1000	-109	69	121
SFN	211	16	-147	216	8	-119	184	-20	-109	1000	-834	691
	-22	53	86	-25	63	79	-19	40	69	-834	1000	-785
	-75	33	155	-67	16	159	-57	1	121	691	-785	1000
SIM	676	188	-230	612	197	-228	536	61	-162	151	-18	-54
	-114	389	-26	-107	300	-69	-70	207	6	-12	21	13
	-344	199	556	-356	119	462	-289	94	401	-108	50	98
SOP	834	23	-342	795	86	-283	722	-31	-260	209	-20	-63
	65	743	-29	22	706	-74	80	509	92	0	62	7
	-323	-64	849	-341	-34	811	-304	-21	678	-129	80	160
WTZ	877	-10	-371	838	57	-303	712	-53	-276	220	-22	-72
	111	815	-24	59	779	-72	109	487	74	23	55	29
	-322	-112	887	-335	-78	852	-295	-57	648	-140	90	156
ZMW	894	-39	-402	865	24	-324	746	-82	-314	243	-30	-53
	167	827	-7	113	808	-47	151	506	83	1	91	-2
	-362	-150	898	-367	-117	873	-337	-85	665	-121	76	192

Computation Graz: Correlation Matrices continued.

	SIM			SOP			WTZ			ZMW		
BGR	610	-97	-343	835	49	-346	827	90	-331	872	142	-374
	156	298	118	44	777	-37	14	756	-81	-23	807	-127
	-216	-45	472	-299	-18	858	-310	-16	842	-345	4	877
BRS	562	-117	-363	794	-24	-367	805	9	-336	863	54	-363
	192	223	75	135	614	-13	112	645	-38	87	716	-76
	-257	-79	413	-310	-139	783	-303	-136	796	-318	-126	852
CGL	562	-127	-345	760	-8	-286	799	27	-278	836	82	-300
	128	213	69	93	548	-4	70	601	-31	51	654	-64
	-289	-57	457	-351	-98	786	-372	-99	819	-387	-84	856
DIO	684	-96	-262	767	102	-250	800	152	-253	805	195	-300
	131	449	289	-47	621	-61	-79	669	-101	-99	672	-130
	-222	39	604	-382	-3	789	-415	1	818	-447	2	826
EFF	623	-123	-393	839	-10	-373	887	26	-367	926	80	-388
	211	279	85	143	741	-13	115	824	-52	81	879	-98
	-283	-82	462	-319	-124	848	-339	-126	893	-348	-104	931
GRS	529	-116	-333	721	-17	-293	760	15	-286	797	62	-303
	128	184	57	92	488	-4	74	539	-27	54	585	-58
	-273	-66	422	-319	-112	752	-338	-114	789	-347	-100	826
GRZ	669	-121	-371	884	42	-349	903	90	-337	939	150	-379
	194	339	138	70	823	-45	39	859	-92	3	904	-139
	-262	-57	518	-349	-59	896	-367	-54	912	-398	-33	942
GRY	600	-85	-322	817	77	-330	798	115	-319	836	165	-366
	107	275	109	-6	706	-45	-29	664	-88	-63	700	-127
	-228	-25	468	-329	14	825	-343	6	795	-383	21	825
HMC	597	-130	-410	839	-55	-412	876	-24	-392	935	16	-407
	242	270	75	196	746	-5	173	811	-34	146	897	-79
	-320	-89	447	-361	-187	836	-364	-193	870	-366	-191	934
HON	640	-111	-393	865	9	-401	893	49	-385	938	100	-418
	239	312	128	121	784	-17	87	837	-59	43	888	-112
	-189	-82	460	-233	-82	870	-243	-72	897	-260	-45	933
HVR	610	-104	-324	838	50	-310	823	93	-292	867	151	-336
	151	286	114	45	757	-29	20	730	-76	-14	787	-121
	-260	-49	477	-351	-47	857	-362	-49	840	-397	-32	881
JQZ	616	-86	-336	835	75	-347	821	116	-338	861	167	-386
	116	291	114	-4	739	-52	-28	704	-96	-64	741	-137
	-227	-22	482	-329	24	844	-346	17	817	-388	33	847
KTW	591	-118	-379	834	-16	-387	841	22	-357	899	70	-387
	216	261	91	146	715	-16	118	746	-45	88	825	-90
	-259	-80	441	-319	-135	837	-312	-125	847	-329	-111	903
MAT	650	-137	-348	821	43	-287	862	89	-283	881	149	-321
	161	320	139	52	712	-41	21	783	-82	-4	807	-122
	-264	-45	526	-359	-58	840	-386	-54	877	-413	-38	895
MER	567	-105	-342	792	10	-344	791	52	-318	842	103	-352
	167	220	80	101	608	-14	81	616	-44	55	683	-82
	-264	-62	439	-338	-100	808	-339	-93	807	-363	-78	856
MET	527	-68	-265	649	56	-273	681	91	-271	696	129	-305
	94	292	196	-32	372	-58	-53	402	-55	-71	399	-73
	-76	88	445	-190	66	536	-213	77	553	-239	82	550
PNC	676	-114	-344	834	65	-323	877	111	-322	894	167	-362
	188	389	199	23	743	-64	-10	815	-112	-39	827	-150
	-230	-26	556	-342	-29	849	-371	-24	887	-402	-7	898
PDM	612	-107	-356	795	22	-341	838	59	-335	865	113	-367
	197	300	119	86	706	-34	57	779	-78	24	808	-117
	-228	-69	462	-283	-74	811	-303	-72	852	-324	-47	873
RIG	536	-70	-289	722	80	-304	712	109	-295	746	151	-337
	61	207	94	-31	509	-21	-53	487	-57	-82	506	-85
	-162	6	401	-260	92	678	-276	74	648	-314	83	665
SFN	151	-12	-108	209	0	-129	220	23	-140	243	1	-121
	-18	21	50	-20	62	80	-22	55	90	-30	91	76
	-54	13	98	-63	7	160	-72	29	156	-53	-2	192
SIM	1000	-130	-249	607	153	-241	626	194	-249	628	218	-296
	-130	1000	633	-100	288	-47	-120	301	-68	-127	291	-78
	-249	633	1000	-332	110	472	-365	113	479	-392	93	477
SOP	607	-100	-332	1000	32	-400	820	91	-311	864	146	-354
	153	288	110	32	1000	-69	22	734	-81	-12	788	-125
	-241	-47	472	-400	-69	1000	-338	-36	835	-373	-17	873
WTZ	626	-120	-365	820	22	-338	1000	80	-388	893	118	-364
	194	301	113	91	734	-36	80	1000	-76	29	848	-121
	-249	-68	479	-311	-81	835	-388	-76	1000	-355	-55	900
ZMW	628	-127	-392	864	-12	-373	893	29	-355	1000	87	-419
	218	291	93	146	788	-17	118	848	-55	87	1000	-109
	-296	-78	477	-354	-125	873	-364	-121	900	-419	-109	1000

	BLZ			BOR			BRS			CGL		
BLZ	1000	114	-589	901	155	-589	866	171	-599	729	100	-480
	114	1000	-212	157	647	-202	129	492	-247	116	315	-205
	-589	-212	1000	-605	-201	854	-633	-103	792	-528	-88	677
BOR	901	157	-605	1000	111	-525	840	161	-580	706	94	-465
	155	647	-201	111	1000	-171	120	464	-234	109	295	-193
	-589	-202	854	-525	-171	1000	-597	-97	754	-499	-84	643
BRS	866	129	-633	840	120	-597	1000	136	-490	701	81	-466
	171	492	-103	161	464	-97	136	1000	-96	126	264	-90
	-599	-247	792	-580	-234	754	-490	-96	1000	-478	-106	649
CGL	729	116	-528	706	109	-499	701	126	-478	1000	-8	-195
	100	315	-88	94	295	-84	81	264	-106	-8	1000	-32
	-480	-205	677	-466	-193	643	-466	-90	649	-195	-32	1000
DIO	860	209	-608	830	198	-576	778	165	-613	673	111	-476
	160	576	-248	158	537	-231	161	388	-245	121	262	-225
	-617	-167	847	-601	-157	801	-629	-92	733	-524	-64	647
EFF	912	138	-655	885	129	-618	891	142	-585	741	91	-481
	205	613	-141	192	577	-134	146	547	-180	151	337	-125
	-628	-258	858	-608	-245	816	-596	-124	834	-505	-104	696
GRS	865	134	-636	839	126	-600	848	143	-564	721	77	-458
	171	488	-119	162	458	-113	136	448	-152	121	298	-109
	-616	-257	844	-597	-244	802	-583	-116	826	-485	-105	704
GRY	916	183	-612	884	175	-580	838	176	-605	711	103	-479
	147	684	-239	145	634	-223	133	447	-250	112	290	-218
	-628	-189	892	-611	-177	844	-645	-102	768	-538	-83	665
GRZ	928	162	-632	898	153	-580	865	174	-605	742	101	-477
	173	673	-197	164	630	-187	141	480	-229	112	327	-197
	-620	-221	898	-603	-208	852	-626	-95	803	-515	-82	698
HMC	878	131	-666	852	121	-629	884	111	-574	716	83	-484
	203	530	-108	192	498	-100	160	533	-118	161	298	-77
	-633	-257	795	-612	-244	756	-574	-158	816	-504	-114	661
HON	927	143	-645	899	132	-609	894	144	-589	725	95	-493
	195	693	-155	184	651	-148	119	553	-213	137	299	-156
	-646	-247	883	-626	-234	841	-627	-128	827	-538	-105	674
HVR	905	169	-622	875	161	-589	840	175	-600	730	108	-466
	159	613	-190	152	570	-179	137	435	-216	104	308	-188
	-607	-210	877	-591	-197	830	-614	-88	783	-504	-70	690
JOZ	925	183	-614	892	174	-582	849	177	-605	715	102	-483
	148	711	-246	147	659	-229	131	463	-259	115	296	-223
	-635	-192	899	-618	-179	850	-652	-107	773	-545	-89	664
KTW	905	133	-655	879	124	-618	889	136	-581	730	87	-483
	198	574	-127	185	542	-120	142	532	-159	146	306	-113
	-632	-261	844	-612	-248	804	-594	-130	831	-508	-107	684
MAT	886	167	-610	855	159	-577	817	170	-593	716	110	-455
	152	563	-181	147	523	-170	138	398	-201	101	288	-178
	-584	-200	847	-569	-188	802	-592	-84	753	-482	-61	672
MER	901	141	-639	874	132	-603	867	154	-852	742	94	-465
	180	577	-146	168	541	-140	138	485	-182	131	347	-130
	-607	-247	857	-589	-235	815	-589	-107	812	-485	-90	700
MET	870	176	-571	840	167	-540	801	167	-560	658	90	-458
	106	593	-233	105	551	-218	92	381	-234	98	235	-191
	-605	-183	815	-587	-170	773	-616	-118	697	-523	-100	586
PDM	920	153	-632	893	143	-596	873	161	-590	731	96	-479
	178	672	-173	168	631	-165	126	499	-217	120	316	-170
	-614	-229	878	-596	-227	835	-610	-104	801	-510	-91	680
PNC	923	181	-622	891	171	-589	849	178	-610	724	106	-482
	161	696	-229	157	648	-215	142	468	-249	116	312	-216
	-634	-199	905	-617	-187	856	-647	-98	789	-539	-82	684
RIG	909	194	-599	877	181	-569	834	177	-593	691	95	-481
	123	658	-253	123	612	-236	108	425	-255	107	267	-213
	-640	-180	868	-622	-170	819	-653	-117	741	-551	-101	627
SFN	657	113	-569	637	109	-542	685	61	-478	551	44	-395
	53	206	-49	47	196	-49	75	189	-20	56	103	6
	-499	-199	574	-482	-187	541	-450	-144	598	-400	-101	517
SIM	740	225	-544	714	209	-516	670	139	-552	560	80	-439
	137	419	-264	136	392	-246	146	298	-229	129	197	-206
	-636	-163	771	-617	-154	728	-635	-124	665	-539	-93	573
SOP	886	162	-598	854	153	-567	822	167	-577	704	98	-455
	148	583	-176	142	541	-166	121	406	-203	97	275	-175
	-581	-203	847	-566	-190	803	-590	-92	750	-487	-77	652
TRS	853	144	-589	826	135	-556	803	159	-554	696	92	-433
	139	511	-144	131	477	-138	112	382	-171	86	267	-147
	-568	-212	821	-552	-200	778	-568	-85	749	464	-75	655
WTZ	923	151	-636	893	142	-601	874	166	-594	741	94	-477
	176	642	-171	165	601	-164	131	493	-209	116	326	-170
	-625	-240	894	-607	-226	848	-620	-101	820	-514	-91	702
ZMW	912	142	-663	884	133	-625	888	150	-593	750	88	-482
	209	604	-151	197	566	-143	160	528	-186	151	353	-133
	-638	-263	870	-618	-249	827	-607	-119	841	-507	-105	715

Computation Penc: Correlation Matrix.

	DIO			EFF			GRS			GRY		
RLZ	860	160	-617	912	205	-628	865	171	-616	916	147	-628
	209	576	-167	138	613	-258	134	488	-257	183	584	-189
	-608	-248	847	-655	-141	858	-636	-119	844	-612	-239	892
BOR	830	158	-601	885	192	-608	839	162	-597	884	145	-611
	198	537	-157	129	577	-245	126	458	-244	175	634	-177
	-576	-231	801	-618	-134	816	-600	-113	802	-580	-223	844
BRS	778	161	-629	891	146	-596	848	136	-583	838	133	-645
	165	388	-92	142	547	-124	143	448	-116	176	447	-102
	-613	-245	733	-585	-180	834	-564	-152	826	-605	-250	768
CGL	673	121	-524	741	151	-505	721	121	-485	711	112	-538
	111	262	-64	91	337	-104	77	298	-105	103	290	-83
	-476	-225	647	-481	-125	696	-458	-109	704	-479	-218	665
DIO	1000	72	-511	823	209	-640	789	179	-617	875	180	-591
	72	1000	-186	165	481	-264	153	397	-275	154	607	-229
	-511	-186	1000	-652	-123	794	-632	-89	799	-593	-186	870
EFF	823	165	-652	1000	138	-588	886	148	-609	885	140	-667
	209	481	-123	138	1000	-181	162	538	-170	214	556	-136
	-640	-264	794	-588	-181	1000	-600	-146	876	-633	-266	833
GRS	789	153	-632	886	162	-600	1000	99	-549	841	135	-648
	179	397	-89	148	538	-146	99	1000	-142	176	448	-114
	-617	-275	799	-609	-170	876	-549	-142	1000	-618	-268	824
GRY	875	154	-593	885	214	-633	841	176	-618	1000	85	-576
	180	607	-186	140	556	-266	135	448	-268	85	1000	-210
	-591	-229	870	-667	-136	833	-648	-114	824	-576	-210	1000
GRZ	871	150	-624	913	209	-633	875	177	-616	917	143	-638
	214	563	-146	149	599	-240	136	491	-244	189	632	-176
	-595	-263	861	-647	-134	869	-624	-107	864	-607	-250	891
HMC	785	173	-658	916	136	-617	868	130	-606	847	141	-677
	175	431	-102	185	616	-107	185	496	-100	198	488	-113
	-648	-248	737	-607	-207	856	-588	-173	844	-642	-254	770
HON	830	171	-645	933	172	-626	876	155	-622	901	142	-656
	215	499	-143	140	665	-211	145	500	-205	218	623	-139
	-661	-250	797	-653	-176	885	-638	-148	855	-648	-256	858
HVR	868	140	-606	888	212	-627	855	181	-606	900	145	-624
	196	549	-134	142	545	-227	126	457	-235	170	586	-172
	-570	-260	861	-635	-125	848	-612	-93	851	-591	-241	875
JOZ	871	161	-600	895	216	-633	848	175	-621	923	156	-610
	187	601	-195	138	574	-275	137	459	-274	159	702	-223
	-605	-230	865	-674	-141	838	-656	-122	824	-615	-217	908
KTW	814	165	-652	926	158	-620	880	143	-610	878	137	-667
	194	452	-115	161	630	-154	160	501	-150	205	521	-124
	-646	-259	779	-623	-184	879	-601	-154	864	-638	-265	819
MAT	861	128	-591	865	209	-619	834	180	-596	883	140	-611
	182	526	-125	143	499	-211	126	419	-219	159	545	-163
	-540	-252	843	-611	-117	817	-588	-85	822	-567	-230	849
MER	826	153	-636	912	182	-613	877	155	-596	879	136	-650
	198	462	-114	152	604	-180	140	511	-179	190	526	-137
	-605	-270	808	-610	-152	873	-585	-127	871	-607	-264	838
MET	799	162	-565	843	203	-588	792	160	-583	861	157	-570
	152	442	-192	98	471	-249	107	370	-241	119	582	-212
	-587	-212	767	-639	-153	754	-623	-137	735	-590	-196	821
PDM	841	162	-629	916	191	-622	871	163	-611	900	144	-641
	211	519	-139	140	617	-221	135	491	-220	197	615	-155
	-612	-255	815	-633	-146	863	-612	-123	848	-610	-249	860
PNC	881	150	-605	896	217	-638	855	180	-621	921	152	-621
	195	617	-175	149	583	-264	140	474	-268	171	679	-209
	-597	-244	882	-670	-134	854	-649	-109	848	-615	-230	908
RIG	845	171	-589	878	214	-621	827	171	-614	902	167	-597
	165	516	-208	115	526	-272	122	415	-265	134	648	-231
	-613	-219	826	-677	-154	801	-659	-137	784	-623	-200	873
SFN	598	144	-551	701	72	-522	672	61	-505	636	125	-573
	44	174	-36	66	211	-29	73	166	-18	49	196	-49
	-495	-202	550	-480	-188	622	-466	-174	630	-500	-198	564
SIM	749	200	-471	705	177	-579	668	140	-563	749	216	-518
	114	413	-264	152	368	-248	152	298	-252	128	432	-266
	-591	-164	810	-662	-160	717	-642	-131	714	-618	-161	797
SOP	830	147	-590	867	201	-604	829	170	-588	874	142	-604
	181	486	-134	127	505	-214	119	413	-216	161	552	-156
	-558	-241	810	-609	-127	812	-589	-101	806	-569	-228	843
TRS	797	137	-582	846	186	-581	816	160	-562	839	130	-595
	169	426	-105	117	471	-179	105	397	-183	153	475	-129
	-551	-248	788	-587	-127	806	-565	-97	809	-560	-235	812
WTZ	849	156	-633	920	196	-624	879	167	-610	904	141	-645
	210	512	-132	142	610	-215	133	499	-216	194	589	-155
	-618	-268	841	-642	-145	885	-619	-117	876	-620	-262	878
ZHW	833	160	-659	931	173	-629	899	150	-609	887	141	-675
	223	489	-120	175	648	-184	164	569	-180	218	552	-144
	-644	-277	820	-633	-174	899	-604	-142	901	-641	-273	849

	GRZ			HMC			HON			HVR		
BLZ	928	173	-620	878	203	-633	927	195	-646	905	159	-607
	162	673	-221	131	530	-257	143	693	-247	169	613	-210
	-632	-197	898	-666	-108	795	-645	-155	883	-622	-190	877
BOR	898	164	-603	852	192	-612	899	184	-626	875	152	-591
	153	630	-208	121	498	-244	132	651	-234	161	570	-197
	-580	-187	852	-629	-100	756	-609	-148	841	-589	-179	830
BRS	865	141	-626	884	160	-574	894	119	-627	840	137	-614
	174	480	-95	111	533	-158	144	553	-128	175	435	-88
	-605	-229	803	-574	-118	816	-589	-213	827	-600	-216	783
CGL	742	112	-515	716	161	-504	725	137	-538	730	104	-504
	101	327	-82	83	298	-114	95	299	-105	108	308	-70
	-477	-197	698	-484	-77	661	-493	-156	674	-466	-188	690
DIO	871	214	-595	785	175	-648	830	215	-661	868	196	-570
	150	563	-263	173	431	-248	171	499	-250	140	549	-260
	-624	-146	861	-658	-102	737	-645	-143	797	-606	-134	861
EFF	913	149	-647	916	185	-607	933	140	-653	888	142	-635
	209	599	-134	136	616	-207	172	665	-176	212	545	-125
	-633	-240	869	-617	-107	856	-626	-211	885	-627	-227	848
GRS	875	136	-624	868	185	-588	876	145	-638	855	126	-612
	177	491	-107	130	496	-173	155	500	-148	181	457	-93
	-616	-244	864	-606	-100	844	-622	-205	855	-606	-235	851
GRY	917	189	-607	847	198	-642	901	218	-648	900	170	-591
	143	632	-250	141	488	-254	142	623	-256	145	586	-241
	-638	-176	891	-677	-113	770	-656	-139	858	-624	-172	875
GRZ	1000	121	-599	876	205	-641	917	197	-658	919	153	-608
	121	1000	-186	144	517	-240	160	631	-227	174	626	-187
	-599	-186	1000	-659	-97	807	-644	-160	878	-608	-193	896
HMC	876	144	-659	1000	112	-540	916	106	-654	849	141	-646
	205	517	-97	112	1000	-170	182	597	-124	202	471	-90
	-641	-240	807	-540	-170	1000	-611	-240	841	-638	-225	787
HON	917	160	-644	916	182	-611	1000	114	-622	887	154	-635
	197	631	-160	106	597	-240	114	1000	-199	202	553	-156
	-658	-227	878	-654	-124	841	-622	-199	1000	-658	-215	847
HVR	919	174	-608	849	202	-638	887	202	-655	1000	80	-559
	153	626	-193	141	471	-225	154	553	-215	80	1000	-180
	-608	-187	896	-646	-90	787	-635	-156	847	-559	-180	1000
JOZ	922	189	-612	858	202	-641	915	220	-646	901	171	-598
	147	645	-256	138	503	-263	138	658	-268	152	590	-246
	-649	-181	893	-685	-118	774	-661	-138	870	-635	-177	874
KTW	905	145	-648	912	175	-602	933	128	-650	878	141	-637
	201	557	-121	130	588	-187	164	642	-158	202	505	-113
	-638	-243	854	-617	-118	894	-625	-222	878	-634	-228	831
MAT	903	169	-594	824	192	-632	862	197	-647	897	148	-574
	144	577	-187	146	437	-206	152	495	-201	142	565	-174
	-583	-179	868	-623	-85	757	-613	-150	812	-534	-172	869
MER	909	148	-628	885	198	-610	904	161	-648	889	137	-615
	185	578	-136	136	534	-201	160	580	-178	191	537	-122
	-608	-230	874	-615	-91	827	-619	-188	861	-598	-220	858
MET	857	180	-577	813	196	-591	873	213	-593	832	161	-567
	114	514	-235	97	411	-237	88	574	-253	122	458	-224
	-620	-183	797	-646	-132	699	-622	-130	801	-612	-181	776
PDM	920	160	-627	887	197	-620	929	174	-643	896	152	-616
	175	639	-178	123	538	-234	148	679	-211	183	579	-166
	-621	-213	881	-641	-101	809	-627	-169	883	-613	-203	860
PNC	928	187	-615	858	202	-647	907	214	-658	912	168	-598
	155	668	-240	150	510	-255	155	634	-252	156	626	-230
	-641	-181	910	-681	-107	791	-662	-147	872	-626	-175	896
RIG	898	192	-603	844	202	-627	906	227	-628	874	174	-592
	127	578	-260	115	461	-258	106	630	-274	135	517	-249
	-654	-184	851	-684	-133	743	-661	-132	843	-644	-182	830
SFN	657	118	-563	723	58	-470	688	82	-564	639	113	-550
	51	205	-42	61	253	-32	58	204	-56	50	189	-35
	-504	-193	587	-449	-169	648	-488	-184	585	-499	-184	578
SIM	732	200	-546	681	152	-576	727	220	-592	719	179	-524
	143	394	-267	155	329	-231	142	393	-246	142	366	-268
	-649	-168	768	-659	-138	675	-649	-146	732	-637	-161	763
SOP	892	165	-591	832	195	-612	874	192	-626	874	150	-577
	141	571	-183	124	437	-212	135	541	-203	145	538	-172
	-585	-186	855	-621	-94	753	-605	-148	824	-573	-177	840
TRS	864	147	-577	813	189	-587	845	174	-608	850	130	-563
	136	517	-146	113	409	-183	128	483	-169	137	489	-135
	-568	-196	836	-597	-83	753	-589	-154	808	-556	-190	825
WTZ	928	158	-628	889	203	-626	923	178	-652	906	147	-616
	175	634	-171	128	528	-227	153	636	-205	182	584	-157
	-628	-220	906	-651	-97	828	-643	-176	890	-618	-211	887
ZHW	919	147	-652	910	193	-618	924	153	-665	899	135	-639
	214	604	-140	152	585	-211	183	628	-185	219	563	-126
	-640	-248	887	-631	-104	860	-642	-210	885	-631	-237	872

	JOZ			KTW			MAT			MER		
BLZ	925	148	-635	905	198	-632	886	152	-584	901	180	-607
	183	711	-192	133	574	-261	167	563	-200	142	577	-247
	-614	-246	899	-655	-127	844	-610	-181	847	-639	-146	857
BOR	892	147	-618	879	185	-612	855	-147	569	874	168	-589
	174	659	-179	124	542	-248	159	523	-188	132	541	-235
	-582	-229	850	-618	-120	804	-577	-170	802	-603	-140	815
BRS	849	131	-652	889	142	-594	817	138	-592	867	138	-589
	177	463	-107	136	532	-130	170	398	-84	154	485	-107
	-605	-259	773	-581	-159	831	-593	-201	753	-852	-182	812
CGL	715	115	-545	730	146	-508	716	101	-482	742	131	-485
	102	296	-89	87	306	-107	118	288	-61	94	347	-90
	-483	-223	664	-483	-113	684	-455	-178	672	-465	-130	700
DIO	871	187	-605	814	194	-646	861	182	-540	826	198	-605
	161	601	-230	165	452	-259	128	526	-252	153	462	-270
	-600	-195	865	-652	-115	779	-591	-125	843	-636	-114	808
EFF	895	138	-674	926	161	-623	865	143	-611	912	152	-610
	216	574	-141	158	630	-184	209	499	-117	182	604	-152
	-633	-275	838	-620	-154	879	-619	-211	817	-613	-180	873
GRS	848	137	-656	880	160	-601	834	126	-588	877	140	-585
	175	459	-122	143	501	-154	180	419	-85	155	511	-127
	-621	-274	824	-610	-150	864	-596	-219	822	-596	-179	871
GRY	923	159	-615	878	205	-638	883	159	-567	879	190	-607
	156	702	-217	137	521	-265	140	545	-230	136	526	-264
	-610	-223	908	-667	-124	819	-611	-163	849	-650	-137	838
GRZ	922	147	-649	905	201	-638	903	144	-583	909	185	-608
	189	645	-181	145	557	-243	169	577	-179	148	578	-230
	-612	-256	893	-648	-121	854	-594	-187	868	-628	-136	874
HMC	858	138	-685	912	130	-617	824	146	-623	885	136	-615
	202	503	-118	175	588	-118	192	437	-85	198	534	-91
	-641	-263	774	-602	-187	894	-632	-206	757	-610	-201	827
HON	915	138	-661	933	164	-625	862	152	-613	904	160	-619
	220	658	-138	128	642	-222	197	495	-150	161	580	-188
	-646	-268	870	-650	-158	878	-647	-201	812	-648	-178	861
HVR	901	152	-635	878	202	-634	897	142	-534	889	191	-598
	171	590	-177	141	505	-228	148	565	-172	137	537	-220
	-598	-246	874	-637	-113	831	-574	-174	869	-615	-122	858
JOZ	1000	100	-593	889	207	-638	883	161	-575	886	190	-610
	100	1000	-214	135	539	-275	148	545	-236	139	539	-270
	-593	-214	1000	-674	-129	824	-623	-169	845	-659	-143	839
KTW	889	135	-674	1000	139	-588	854	142	-614	903	145	-612
	207	539	-129	139	1000	-155	197	462	-107	175	555	-137
	-638	-275	824	-588	-155	1000	-626	-211	800	-617	-189	858
MAT	883	148	-623	854	197	-626	1000	57	-503	870	191	-587
	161	545	-169	142	462	-211	57	1000	-158	136	498	-208
	-575	-236	845	-614	-107	800	-503	-158	1000	-591	-111	832
MER	886	139	-659	903	175	-617	870	136	-591	1000	121	-551
	190	539	-143	145	555	-189	191	498	-111	121	1000	-150
	-610	-270	839	-612	-137	858	-587	-208	832	-551	-150	1000
MET	874	159	-574	839	195	-591	809	155	-547	824	171	-574
	116	626	-211	93	446	-251	124	407	-214	107	437	-239
	-590	-196	835	-637	-138	745	-603	-174	744	-629	-161	747
PDM	910	144	-648	913	184	-624	874	148	-593	902	170	-606
	197	639	-158	132	584	-228	181	528	-157	149	575	-205
	-611	-258	866	-632	-130	853	-602	-192	828	-619	-152	857
PNC	925	157	-630	888	207	-643	897	157	-573	892	194	-611
	172	695	-211	146	545	-264	150	585	-220	145	557	-260
	-620	-236	911	-670	-121	840	-612	-167	871	-652	-133	861
RIG	914	169	-601	874	208	-625	854	163	-570	863	185	-602
	132	690	-231	109	495	-273	133	467	-238	121	487	-265
	-623	-204	886	-675	-138	791	-632	-175	799	-665	-159	798
SFN	644	126	-579	702	66	-519	621	114	-530	676	79	-521
	50	202	-53	67	199	-32	47	175	-32	64	190	-26
	-501	-203	565	-476	-172	616	-491	-173	558	-483	-178	607
SIM	755	226	-526	702	169	-582	705	163	-499	695	155	-557
	129	449	-265	149	345	-245	138	341	-262	152	350	-252
	-620	-163	800	-659	-147	708	-626	-157	743	-653	-156	720
SOP	881	143	-611	860	192	-610	859	140	-553	861	179	-581
	159	562	-164	123	473	-215	141	498	-164	128	487	-205
	-572	-238	843	-611	-115	799	-559	-170	814	-593	-128	816
TRS	844	134	-603	837	180	-586	831	127	-541	845	166	-557
	152	485	-134	115	436	-181	137	443	-126	117	469	-169
	-564	-242	814	-589	-113	792	-545	-179	798	-569	-126	815
WTZ	912	142	-653	912	188	-629	887	141	-592	912	171	-605
	193	605	-160	135	567	-222	179	538	-149	146	585	-201
	-622	-270	883	-643	-130	871	-605	-201	857	-626	-152	884
ZMW	896	142	-683	924	169	-632	877	136	-614	917	153	-615
	218	566	-151	168	607	-192	218	513	-117	187	611	-162
	-643	-281	852	-633	-152	887	-621	-222	842	-622	-181	890

	MET			PDM			PNC			RIG		
BLZ	870	106	-605	920	178	-614	923	161	-634	909	123	-640
	176	593	-183	153	672	-229	181	696	-199	194	658	-180
	-571	-233	815	-632	-173	878	-622	-229	905	-599	-253	868
BOR	840	105	-587	893	168	-596	891	157	-617	877	123	-622
	167	551	-170	143	631	-227	171	648	-187	181	612	-170
	-540	-218	773	-596	-165	835	-589	-215	856	-569	-236	819
BRS	801	92	-616	873	126	-610	849	142	-647	834	108	-653
	167	781	-118	161	499	-104	178	468	-98	177	425	-117
	-560	-234	697	-590	-217	801	-610	-249	789	-593	-255	741
CGL	658	98	-523	731	120	-510	724	116	-539	691	107	-551
	90	235	-100	96	316	-91	106	312	-82	95	267	-101
	-458	-191	586	-479	-170	680	-482	-216	684	-481	-213	627
DIO	799	152	-587	841	211	-612	881	195	-597	846	165	-613
	162	442	-212	162	519	-255	150	617	-244	171	516	-219
	-565	-192	767	-629	-139	815	-605	-175	882	-589	-208	826
EFF	843	98	-639	916	140	-633	896	149	-670	878	115	-677
	203	471	-153	191	617	-146	217	583	-134	214	526	-154
	-588	-249	754	-622	-221	863	-638	-264	854	-621	-272	801
GRS	792	107	-623	871	135	-612	855	140	-649	827	122	-659
	160	370	-137	163	491	-123	180	474	-109	171	415	-137
	-583	-241	735	-611	-220	848	-621	-268	848	-614	-265	784
GRY	861	119	-590	900	197	-610	921	171	-615	902	134	-623
	157	582	-196	144	615	-249	152	679	-230	167	648	-200
	-570	-212	821	-641	-155	860	-621	-209	908	-597	-231	873
GRZ	857	114	-620	920	175	-621	928	155	-641	898	127	-654
	180	514	-183	160	639	-213	187	668	-181	192	578	-184
	-577	-235	797	-627	-178	881	-615	-240	910	-603	-260	851
HMC	813	97	-646	887	123	-641	858	150	-681	844	115	-684
	196	411	-132	197	538	-101	202	510	-107	202	461	-133
	-591	-237	699	-620	-234	809	-647	-255	791	-627	-258	743
HON	873	88	-622	929	148	-627	907	155	-662	906	106	-661
	213	574	-130	174	679	-169	214	634	-147	227	630	-132
	-593	-253	801	-643	-211	883	-658	-252	872	-628	-274	843
HVR	832	122	-612	896	183	-613	912	156	-626	874	135	-644
	161	458	-181	152	579	-203	168	626	-175	174	517	-182
	-567	-224	776	-616	-166	860	-598	-230	896	-592	-249	830
JOZ	874	116	-590	910	197	-611	925	172	-620	914	132	-623
	159	626	-196	144	639	-258	157	695	-236	169	690	-204
	-574	-211	835	-648	-158	866	-636	-211	911	-601	-231	886
KTW	839	93	-637	913	132	-632	888	146	-670	874	109	-675
	195	446	-138	184	584	-130	207	545	-121	208	495	-138
	-591	-251	745	-624	-228	853	-643	-264	840	-625	-273	791
MAT	809	124	-603	874	181	-602	897	150	-612	854	133	-632
	155	407	-174	148	528	-192	157	585	-167	163	467	-175
	-547	-214	744	-593	-157	828	-573	-220	871	-570	-238	799
MER	824	107	-629	902	149	-619	892	145	-652	863	121	-665
	171	437	-161	170	575	-152	194	557	-133	185	487	-159
	-574	-239	747	-606	-205	857	-611	-260	861	-602	-265	798
MET	1000	-23	-473	857	186	-569	860	170	-582	869	131	-575
	-23	1000	-178	102	-532	-240	121	559	-222	119	655	-184
	-473	-178	1000	-615	-159	785	-605	-200	818	-571	-187	831
PDM	857	102	-615	1000	120	-580	909	155	-645	894	117	-651
	186	532	-159	120	1000	-179	195	639	-160	201	590	-159
	-569	-240	785	-580	-179	1000	-617	-243	878	-598	-262	833
PNC	860	121	-605	909	195	-617	1000	102	-599	903	135	-637
	170	559	-200	155	639	-243	102	1000	-217	182	628	-201
	-582	-222	818	-645	-160	878	-599	-217	1000	-607	-244	874
RIG	869	119	-571	894	201	-598	903	182	-607	1000	49	-578
	131	655	-187	117	590	-262	135	628	-244	49	1000	-205
	-575	-184	831	-651	-159	833	-637	-201	874	-578	-205	1000
SFN	607	101	-542	668	96	-551	643	129	-578	632	115	-573
	50	167	-59	55	200	-45	49	206	-46	51	186	-57
	-464	-172	509	-492	-185	578	-505	-202	579	-489	-192	544
SIM	716	187	-491	722	201	-557	749	221	-529	756	211	-511
	118	412	-231	143	385	-252	132	421	-275	121	441	-254
	-570	-140	745	-644	-156	735	-632	-167	801	-597	-154	796
SOP	819	111	-586	876	174	-589	884	154	-607	859	123	-618
	153	450	-161	137	551	-190	159	579	-163	164	505	-161
	-539	-220	754	-589	-162	829	-577	-219	858	-563	-242	805
TRS	783	105	-579	849	155	-575	851	138	-597	822	115	-610
	141	382	-142	129	493	-155	148	509	-132	152	432	-140
	-533	-219	724	-572	-170	812	-566	-229	831	-556	-243	774
WTZ	853	105	-622	919	161	-620	916	150	-648	891	120	-658
	181	491	-165	161	625	-184	192	622	-157	194	548	-165
	-584	-246	792	-628	-195	886	-626	-256	899	-612	-271	843
ZHW	838	108	-648	917	144	-640	901	147	-676	874	124	-686
	199	460	-168	197	606	-155	223	584	-139	212	513	-168
	-601	-249	761	-633	-225	875	-644	-273	873	-633	-274	812

	SFN			SIM			SOP			TRS		
BLZ	657	53	-499	740	137	-636	886	148	-581	853	139	-568
	113	206	-199	225	419	-163	162	583	-203	144	511	-212
	-569	-49	574	-544	-264	771	-598	-176	847	-589	-144	821
BOR	637	47	-482	714	136	-617	854	142	-566	826	131	-552
	109	196	-187	209	392	-154	153	541	-190	135	477	-200
	-542	-49	541	-516	-246	728	-567	-166	803	-556	-138	778
BRS	685	75	-450	670	146	-635	822	121	-590	803	112	-568
	61	189	-144	139	298	-124	167	406	-92	159	382	-85
	-478	-20	598	-552	-229	665	-577	-203	750	-554	-171	749
CGL	551	56	-400	560	129	-539	704	97	-487	696	86	464
	44	103	-101	80	197	-93	98	275	-77	92	267	-75
	-395	6	517	-439	-206	573	-455	-175	652	-433	-147	655
DIO	598	44	-495	749	114	-591	830	181	-558	797	169	-551
	144	174	-202	200	413	-164	147	486	-241	137	426	-248
	-551	-36	550	-471	-264	810	-590	-134	810	-582	-105	788
EFF	701	66	-480	705	152	-662	867	127	-609	846	117	-587
	72	211	-188	177	368	-160	201	505	-127	186	471	-127
	-522	-29	622	-579	-248	717	-604	-214	812	-581	-179	806
GRS	672	73	-466	668	152	-642	829	119	-589	816	105	-565
	61	166	-174	140	298	-131	170	413	-101	160	397	-97
	-505	-18	630	-563	-252	714	-588	-216	806	-562	-183	809
GRY	636	49	-500	749	128	-618	874	161	-569	839	153	-560
	125	196	-198	216	432	-161	142	552	-228	130	475	-235
	-573	-49	564	-518	-266	797	-604	-156	843	-595	-129	812
GRZ	657	51	-504	732	143	-649	892	141	-585	864	136	-568
	118	205	-193	200	394	-168	165	571	-186	147	517	-196
	-563	-42	587	-546	-267	768	-591	-183	855	-577	-146	836
HMC	723	61	-449	681	155	-659	832	124	-621	813	113	-597
	58	253	-169	152	329	-138	195	437	-94	189	409	-83
	-470	-32	648	-576	-231	675	-612	-212	753	-587	-183	753
HON	688	58	-488	727	142	-649	874	135	-605	845	128	-589
	82	204	-184	220	393	-146	192	541	-148	174	483	-154
	-564	-56	585	-592	-246	732	-626	-203	824	-608	-169	808
HVR	639	50	-499	719	142	-637	874	145	-573	850	137	-556
	113	189	-184	179	366	-161	150	538	-177	130	489	-190
	-550	-35	578	-524	-268	763	-577	-172	840	-563	-135	825
JOZ	644	50	-501	755	129	-620	881	159	-572	844	152	-564
	126	202	-203	226	449	-163	143	562	-238	134	485	-242
	-579	-53	565	-526	-265	800	-611	-164	843	-603	-134	814
KTW	702	67	-476	702	149	-659	860	123	-611	837	115	-589
	66	199	-172	169	345	-147	192	473	-115	180	436	-113
	-519	-32	616	-582	-245	708	-610	-215	799	-588	-181	792
MAT	621	47	-491	705	138	-626	859	141	-559	831	137	-545
	114	175	-173	163	341	-157	140	498	-170	127	443	-179
	-530	-32	558	-499	-262	743	-553	-164	814	-541	-126	798
MER	675	64	-483	695	152	-653	861	128	-593	845	117	-569
	79	190	-178	155	350	-156	179	487	-128	166	469	-126
	-521	-26	607	-557	-252	720	-581	-205	816	-557	-169	815
MET	607	50	-464	716	118	-570	819	153	-539	783	141	-533
	101	167	-172	187	412	-140	111	450	-220	105	382	-219
	-542	-59	509	-491	-231	745	-586	-161	754	-579	-142	724
PDM	668	55	-492	722	143	-644	876	137	-589	849	129	-572
	96	200	-185	201	385	-156	174	551	-162	155	493	-170
	-551	-45	578	-557	-252	735	-589	-190	829	-575	-155	812
PNC	643	49	-505	749	132	-632	884	159	-577	851	148	-565
	129	206	-202	221	421	-167	154	579	-219	138	509	-229
	-578	-46	579	-529	-275	801	-607	-163	858	-597	-132	831
RIG	632	51	-489	755	121	-597	859	164	-563	822	152	-556
	115	186	-192	211	441	-154	123	505	-242	115	432	-243
	-573	-57	544	-511	-254	796	-618	-161	805	-610	-140	774
SFN	1000	108	-177	526	135	-537	623	103	-531	613	83	-511
	108	1000	-96	44	131	-47	48	173	-42	50	158	-33
	-177	-96	1000	-431	-184	510	-480	-169	547	-462	-151	550
SIM	526	44	-431	1000	-100	-421	702	181	-508	667	149	-505
	135	131	-184	-100	1000	-125	135	340	-252	135	296	-246
	-537	-47	510	-421	-125	1000	-614	-145	728	-604	-131	700
SOP	623	48	-480	702	135	-614	1000	36	-500	817	137	-542
	103	173	-169	181	340	-145	36	1000	-163	129	430	-174
	-531	-42	547	-508	-252	728	-500	-163	1000	-545	-132	782
TRS	613	50	-462	667	135	-604	817	129	-545	1000	-12	-438
	83	158	-151	149	296	-131	137	430	-132	-12	1000	-147
	-511	-33	550	-505	-246	700	-542	-174	782	-438	-147	1000
WTZ	668	55	-496	720	146	-651	882	133	-590	858	129	-572
	96	201	-184	186	374	-160	170	538	-159	156	500	-161
	-558	-41	598	-565	-262	754	-597	-199	848	-580	-159	839
ZMW	700	67	-487	706	156	-671	872	126	-615	854	115	-591
	79	204	-195	177	365	-166	296	509	-132	192	485	-129
	-530	-26	634	-582	-258	736	-611	-221	829	-587	-184	827

	WTZ			ZMW		
BLZ	923	176	-625	912	209	-638
	151	642	-240	142	604	-263
	-636	-171	894	-663	-151	870
BOR	893	165	-607	884	197	-618
	142	601	-226	133	566	-249
	-601	-164	848	-625	-143	827
BRS	874	131	-620	888	160	-607
	166	493	-101	150	528	-119
	-594	-209	820	-593	-186	841
CGL	741	115	-514	750	151	-507
	94	326	-91	88	353	-105
	-477	-170	702	-482	-133	715
DIO	849	210	-618	833	223	-644
	156	512	-268	160	489	-277
	-633	-132	841	-659	-120	820
EFF	920	142	-642	931	175	-633
	196	610	-145	173	648	-174
	-624	-215	885	-629	-184	899
GRS	879	133	-619	899	164	-604
	167	499	-117	150	569	-142
	-610	-216	876	-609	-180	901
GRY	904	194	-620	887	218	-641
	141	589	-262	141	552	-273
	-645	-155	878	-675	-144	849
GRZ	928	175	-628	919	214	-640
	158	634	-220	147	604	-248
	-628	-171	906	-652	-140	887
HMC	889	128	-651	910	152	-631
	203	528	-97	193	585	-104
	-626	-227	828	-618	-211	860
HON	923	153	-643	924	183	-642
	178	636	-176	153	628	-210
	-652	-205	890	-665	-185	885
HVR	906	182	-618	899	219	-631
	147	584	-211	135	563	-237
	-616	-157	887	-639	-126	872
JOZ	912	193	-622	896	218	-643
	142	605	-270	142	566	-281
	-653	-160	883	-683	-151	852
KTW	912	135	-643	924	168	-633
	188	567	-130	169	607	-152
	-629	-222	871	-632	-192	887
MAT	887	179	-605	877	218	-621
	141	538	-201	136	513	-222
	-592	-149	857	-614	-117	842
MER	912	146	-626	917	187	-622
	171	585	-152	153	611	-181
	-605	-201	884	-615	-162	890
MET	853	181	-584	838	199	-601
	105	491	-246	108	460	-249
	-622	-165	792	-648	-168	761
PDM	919	161	-628	917	197	-633
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	-620	-184	886	-640	-155	875
PNC	915	192	-626	901	223	-644
	150	622	-256	147	584	-273
	-648	-157	899	-676	-139	873
RIG	891	194	-612	874	212	-633
	120	548	-271	124	513	-274
	-658	-165	843	-686	-168	812
SFN	668	96	-558	700	79	-530
	55	201	-41	67	204	-26
	-496	-184	598	-487	-195	634
SIM	720	186	-565	706	177	-582
	146	374	-262	156	365	-258
	-651	-160	754	-671	-166	736
SOP	882	170	-597	872	206	-611
	133	538	-199	126	509	-221
	-590	-159	848	-615	-132	829
TRS	858	156	-580	854	192	-587
	129	500	-159	115	485	-184
	-572	-161	839	-591	-129	827
WTZ	1000	106	-597	924	200	-633
	106	1000	-187	141	614	-221
	-597	-187	1000	-647	-153	901
ZMW	924	141	-647	1000	130	-609
	200	614	-153	130	1000	-198

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