A NEW SOFTWARE FOR THE SOLUTION OF CONTROL NETWORKS IN CLOSE RANGE PHOTOGRAMMETRY

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ABSTRACT

This paper deals with a new software package supporting the treatment of topographic data needed by a stereoplotter working in close range photogrammetry.
The main characteristics of each program and their way of working are here briefly presented.

INTRODUCTION

The software MILANO is made by 6 programs. It leads the user, step by step, through the different phases of solution of a topographic control network for close range photogrammetry.
The approximate values of the points coordinates are automatically evaluated through an empirical adjustment.
Besides, it is possible to run a rigorous least squares adjustment and to plot a planimetric view or an altimetric section of the network (with error ellipses).
All the points coordinates of the network can be rotated and translated in the space according to the needs of the stereoplotter. A methodology for the determination of the approximate values of the external orientation parameters of each taken is given. For this purpose a sketch of the main geometrical characteristics of each taken must be provided.
The drawing is then read by the computer through a graphic table.
The operator is thus guided by the program from the solution of the topographic network to the determination of the approximate values of the external orientation parameters of each photogrammetric taken.

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1. AIM OF THE SOFTWARE MILANO

The project MILANO was born from the need to have an appropriate tool of data treatment made apt to the solution of problems of close range photogrammetry.
The ability of solving topographic networks, of rotating coordinates in the space and of determining approximate values for the external orientation parameters of the camera is usually demanded to several programs, having often big problems of relative interface (data format, etc..) and use by the operator.
For this reason MILANO is made by a sequence of programs able to solve all these situations without the above mentioned problems.

2. PROBLEMS IN CLOSE RANGE PHOTOGRAMMETRY

The stereoplotters used in close range photogrammetry are projected for working in aerophotogrammetry.
The software supporting these instruments thus envisages the axis of the quote of the object surveyed, being turned towards the camera and coincident with the topographic one.
Furthermore the external orientation of the camera in aerophotogrammetry, regarding its angular parameters, is easily and well approximable.
Not the same occurs in close range photogrammetry.
In this case the axis of the heights coming out of the ideal plan on which we suppose the surveyed object lies, doesn't usually coincide with the topographic one.
Beside the geometries of each taken can be very particular and consequently also the determination of the approximate values of the external orientation parameters can be of complex evaluation.
The use of a steroplotter instrument for close range photogrammetry requests a well-done data pre-treatment.
The software MILANO runs this phase of restitution work in such a way as to facilitate the work of the operator.
This semplicity of use implies in any case that the operator has to master a good knowledge of photogrammetry; without that, the program obviously becomes unusable.
An adequate formation of the operators thus remains an absolute necessity.

3. MAIN CHARACTERISTICS OF THE MILANO SOFTWARE

MILANO is composed by 6 programs: PUNT, TOPO, TOPL, PERT, ROTA, TAVO programmed using different languages.
The software runs on a Ms-Dos compatible computer; a coprocessor is needed.
To test the program a 80386 computer, a Calcomp 1023 plotter and an HPGL compatible plotter have been utilized.

On fig.1 the main characteristics of the software, dimension in byte, number of subdirectories, language of programming, are shown:

		Dimension KByte	Language	Sub.
MILANO	PUNT	229	Q.BASIC	23
	PERT	132	Q.BASIC	21
	TOPO	293	FORTRAN	7
	TOPL	47	FORTRAN & C	9
	ROTA	132	Q.BASIC	11
	TAVO	168	Q.BASIC	18

Fig.1

The communication among the different programs of MILANO is made by using ASCII files. In this way the user can easly read the files and use them also for different purposes not already planned by the program maker.
On the other hand any operation made in these data files, without using the video-windows provided by the program, can of course damage the file itself. For this reason the manipulation of the data files is recommended to expert operators only.

4. INTERFACING WITH THE SOFTWARE

Further to the reading of the manual, no particular other training is required for working on MILANO and learning software's commands and options.
Through suitable windows the user is lead to the use of each program (Fig.2-3).
No necessity of remembering any command; the operator is simply asked to answer to the particular questions posed by the computer, to choose with the cursor the options or to insert data into the right boxes as requested.
Such a way of working reduces to a minimun the possibilities of making mistakes in the data input and allows more operators to make use of this software.
Moreover, several tests are implemented into each program. More difficult is thus the chance of wrong operations or of insertion of incongruous measurements, making quite rare the case of not convergence of the adjustment programs.

```
GALILEO
12/09/1991  17:19:23                                    C:\TEST\APPOGGIO.GAL

                          MENU' PRINCIPALE

              Scelta del File
              Dati: inserimento e variazione
              Conversione dati forniti da registratori

              Libretto di campagna
              Elaborazione e controlli

              Visualizzazione rete topografica
              Plottaggio rete topografica

              Uscita al DOS

              Selezione del file o scelta di un nuovo file
  Selezionare la voce prescelta con ↑↓ o con l'iniziale -  RETURN per conferma
```

Fig. 2

```
GALILEO
12/09/1991  17:12:36                                    File NON selezionato

Directory corrente:
C:\TEST
APPOGGIO GAL      4817   6/11/91   11:12
SOSPESOL GAL     16609  30/10/91   12:05
..           Directory superiore

                                          File selezionato:

                                            APPOGGIO.GAL

Selezionare il file o la directory con i tasti ↓↑ PagUp PagDn  e premere INVIO
F1=Nuovo file   F2=Copia file   F3=Cambio drive   F9=Cancella file   ESC=Esce
```

Fig. 3

5. STRUCTURE OF THE SOfTWARE

Each program of MILANO has a specific function schematically shown in fig.4 More details about each program have been also provided in the following paragraphes.

5.1 PUNT

The acquisition of the measurements, made in PUNT, can be done automatically from the data recorders of the most popular topographic instruments or manually through appropriated video masks (Fig.5-6-7).
The fig.8 shows the typologies of measurements admitted by the programm that fulfil the tests of data input:

Azimut	Zenit	Distance	ADMITTED
X			Yes
X	X		Yes
X	X	X	Yes
	X	X	No
X		X	No
		X	No
	X		No

Fig.8

The points are divided in PUNT into two categories: station points and control ones (See fig.9).

The connections among station points must be done with all the three typologies of measurements (Azimut, Zenit, Distance).
After the data acquisition an empirical adjustement of station point network solving all the polygonals going through the fixed points is made.
If the closing of the polygonals correspond to the tolerance decided at the beginnig of the work, taking into account the instrument precision, the software evaluates the coordinates of the control points, otherwise points out mistake.
At each calculated coordinate value, in case of superabundant determination, an indication of the precision is also given.
As output it is also provided:

- A plot of the network on video or on paper.

- An ASCII file containing all the measurements (fig.10).

- An ASCII file containing the adjusted coordinates of each point (fig.11) and the solution of any polygonal (fig.12).

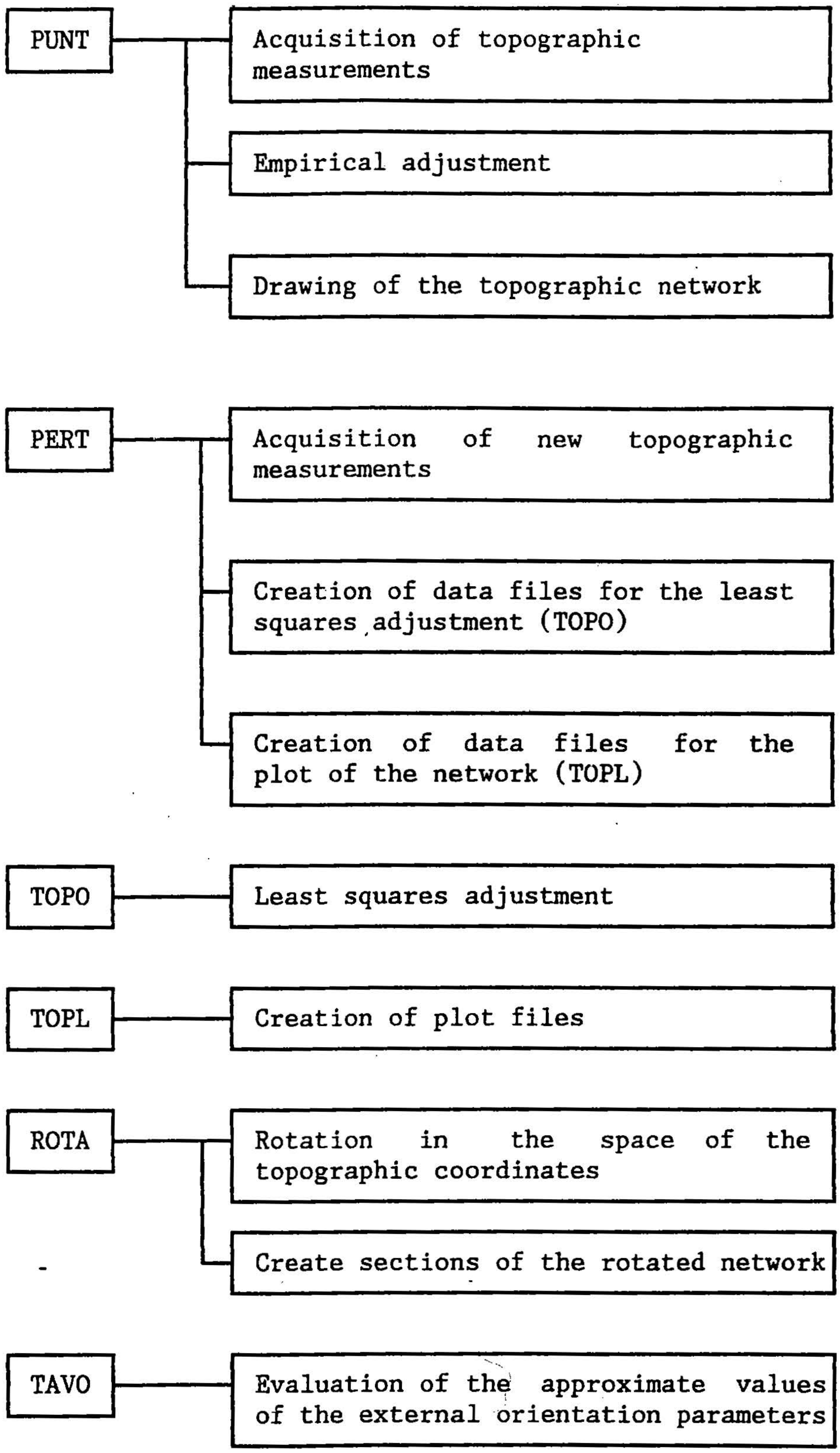
PUNT
Acquisition of topographic measurements
Empirical adjustment
Drawing of the topographic network
PERT
Acquisition of new topographic measurements
Creation of data files for the least squares adjustment (TOPO)
Creation of data files for the plot of the network (TOPL)
TOPO
Least squares adjustment
TOPL
Creation of plot files
ROTA
Rotation in the space of the topographic coordinates
Create sections of the rotated network
TAVO
Evaluation of the approximate values of the external orientation parameters

Fig. 4

```
GALILEO
12/09/1991   17:17:38                                    C:\TEST\APPOGGIO.GAL
==============================================================================

Punto Stazione -    6          PIL.MET.    ======== PUNTO STAZIONE ========
         Punto -    quattro4   399.99260  |                                |
         Punto -    7103       254.38524  | Nome del punto:      6         |
         Punto -    7303       262.19566  |                                |
         Punto -    7403       265.72291  | Descrizione:         PIL.MET.  |
         Punto -    7503       269.04540  |                                |
         Punto -    7603       272.24887  | Altezza strumentale:    .237   |
         Punto -    7703       275.36071  |                                |
         Punto -    7803       278.38274  |                                |
         Punto -    103        281.28767  |                                |
         Punto -    203        284.28809  ==================================
         Punto -    303        287.47900    84.48238              0.0000
         Punto -    403        290.85626    85.11936              0.0000
         Punto -    503        294.43359    85.67939              0.0000
         Punto -    603        298.15830    86.18468              0.0000
         Punto -    703        301.89051    86.60411              0.0000
         Punto -    803        305.64079    86.95001              0.0000
==============================================================================

             Muoversi con ↑↓ o return - ESC per terminare
```

Fig. 5

```
GALILEO
12/09/1991   17:14:36                                      C:\TEST\APPOGGIO.GAL
================================================================================

Specifiche      - RETE TOPOGRAFICA PER LA DEFINIZIONE DI PUNTI D'APPOGGIO - IN
Dati Generali   - U.M.: m    - Asse x: E - Asse y: N - Asse z: Q
Punto Stazione  -    quattro4  PIL.MET.      .2375
         Punto  -    7103          226.88624     85.28886                0.0000
Altra Misura    -  quattro4  6              -0.0334     94.5990   0.0000  0.0000
         Punto  -    7303          232.84147     85.74436                0.0000
         Punto  -    7403          235.79341     85.98105
         Punto  -    7503          238.72566     86.21595                0.0000
         Punto  -    7603          241.69290     86.44954                0.0000
         Punto  -    7703          244.69668     86.68330                0.1233
         Punto  -    7803          247.73189     86.91752                0.0000
         Punto  -    103           250.74418     87.14030                0.0000
         Punto  -    203           253.86173     87.34752                0.0000
         Punto  -    303           257.16046     87.52376                0.0000
         Punto  -    403           260.63040     87.66218                0.0000
         Punto  -    503           264.29234     87.76290                0.0000
         Punto  -    603           268.07598     87.82603                0.0000
================================================================================
1 Help          2 Ins Stazio     3 Ins Collim     4 Modifica       5 Elimina
                                                  8 Abbandona      9 Fine
```

Fig. 6

GALILEO
12/09/1991 17:18:33 C:\TEST\APPOGGIO.GAL

Punto -	7803	247.73189
Punto -	103	250.74418
Punto -	203	253.86173
Punto -	303	257.16046
Punto -	403	260.63040
Punto -	503	264.29234
Punto -	603	268.07598
Punto -	703	271.85974
Punto -	803	275.64405
Punto -	903	279.42948
Punto -	1003	283.21020
Punto -	1103	286.98463
Punto -	6	199.99289
Punto -	2	299.99250
Punto -	502	263.98348
Punto -	802	275.83526
Punto -	902	279.78236

PUNTO COLLIMATO

Dal punto stazione:	quattro4
Nome del punto:	2
Direzione:	299.99249
Angolo Zenitale:	100.00466
Distanza inclinata:	105.4150
Altezza strumentale:	0.2380

92.07282 216.618 0.0000

Muoversi con ↑↓ o return - ESC per terminare

Fig. 7

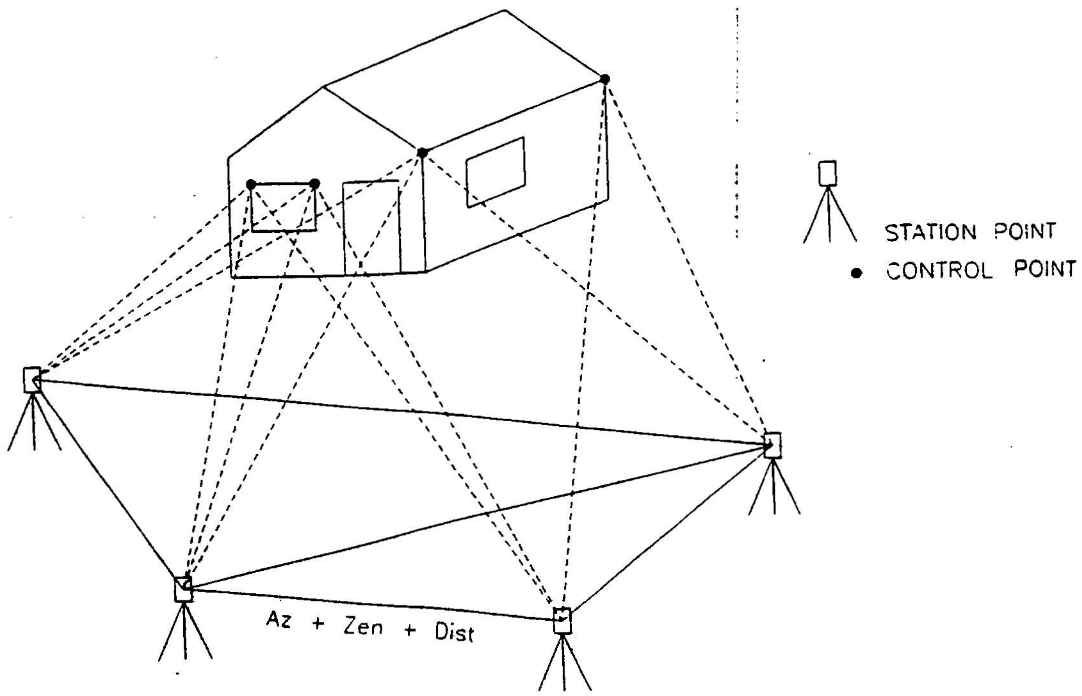

Fig. 9

```
Titolo lavoro     RETE TOPOGRAFICA PER LA DEFINIZIONE DI PUNTI D'APPOGGIO
Tipo lavoro       INTERSEZIONE SEMPLICE E MULTIPLA IN  AVANTI  E CON DISTANZE
Data              11 GENNAIO 1990
Committente       POLITECNICO DI MILANO  -   DIP. I.I.A.R.
Unita' e assi     m    E    N    Q
Tolleranze        0.0050    0.0210
Punto riferi 1    6          100.0000  100.0000  100.0000    0.0000
Punto riferi 2
    1   quattro4  PIL.MET.    0.2375
    2   7103        226.88624     85.28886                   0.0000
    8 quattro4  6           -0.0334     94.5990    0.0000    0.0000
    2   7303        232.84147     85.74436                   0.0000
    2   7403        235.79341     85.98105                   0.0000
    2   7503        238.72566     86.21595                   0.0000
    2   7603        241.69290     86.44954                   0.0000
    2   7703        244.69668     86.68330                   0.0000
    2   7803        247.73189     86.91752                   0.1233
    2   103         250.74418     87.14030                   0.0000
    2   203         253.86173     87.34752                   0.0000
    2   303         257.16046     87.52376                   0.0000
    2   403         260.63040     87.66218                   0.0000
    2   503         264.29234     87.76290                   0.0000
                                                             0.0000
```

Fig. 10

Titolo: PROVE OPERATIVE DEL NUOVO PACCHETTO SOFTWARE "MILANO"
Tipo di lavoro: RETE D'APPOGGIO TOPOGRAFICO
Data lavoro: 11 LUGLIO 1991
Committente: POLITECNICO DI MILANO - DIP. I.I.A.R.
Studio: Ditta: Paolo Rossi e C.

Punto	X (m)	Num. Det.	Diff.max (m/1000)	Y (m)	Num. Det.	Diff.max (m/1000)	Z (m)	Num. Det.	Diff.max (m/1000)
7103	-39.2499	1		1.7614	1		140.3381	2	3.74
7303	-52.8566	3	6.82	12.3061	3	3.91	140.3674	4	6.41
7403	-59.4730	3	1.31	18.0888	3	0.94	140.3660	6	1.42
7503	-65.9492	3	3.61	24.2089	3	1.77	140.3677	6	0.34
7603	-72.3383	3	2.23	30.8015	3	5.74	140.3734	6	8.41
7703	-78.6136	3	5.71	37.8940	3	2.54	140.3789	6	2.44
7803	-84.7503	3	1.91	45.4805	3	0.80	140.3859	6	2.41
103	-90.5526	3	6.28	53.4411	3	2.47	140.4053	6	9.45
203	-95.8237	3	3.87	62.2023	3	5.06	140.4043	6	6.31
303	-100.4188	3	2.88	71.9902	3	4.29	140.4033	6	9.08
403	-104.0616	3	7.29	82.7450	3	8.17	140.4207	6	9.72
503	-106.5666	3	2.54	94.4517	3	8.94	140.4514	6	4.64

Fig. 11

```
Poligonale numero: 1

Stazione          E            N              Q            Orientamento
                 (m)          (m)            (m)             (GRAD)
2              -5.4106      99.9924       100.0134          0.0002
5             138.3128      53.3818       100.0219          0.0005
Chiusura angolare (GRAD)=  -0.00043    Tolleranza (GRAD)=   0.01559
Chiusura laterale  (m)  =   0.00131    Tolleranza  (m)  =   0.05196
```

```
Poligonale numero: 2

Stazione          E            N              Q            Orientamento
                 (m)          (m)            (m)             (GRAD)
2              -5.4105      99.9923       100.0126          0.0002
5             138.3133      53.3816       100.0204          0.0004
8              -5.3573       5.3548       100.0347          0.0005
1             -43.2417      52.9432       100.0227          0.0007
6             100.0118       5.4093       100.0381          0.0009
Chiusura angolare (GRAD)=  -0.00087    Tolleranza (GRAD)=   0.02205
Chiusura laterale  (m)  =   0.00436    Tolleranza  (m)  =   0.07348
```

Fig. 12

```
GALILEO
22/09/1991  13:54:43                                    C:\TEST\APPOGGIO.GAL

 Dati Generali    - PROVE OPERATIVE DEL NUOVO PACCHETTO SOFTWARE "MILANO" - RETE
 Specifiche       - U.M.: m    - Asse x: X - Asse y: Y - Asse z: Z
 Punto Stazione   -  4          PIL.MET.                         .2375
 Dist.  Disliv.   -  7303       7603          26.8650    0.0070  0.0000   0.0000
          Punto   -  7103       226.88624   85.28886             0.0000
          Punto   -  7303       232.84147   85.74436             0.0000
          Punto   -  7403       235.79341   85.98105
          Punto   -  7503       238.72566   86.21595             0.0000
          Punto   -  7603       241.69290   86.44954             0.0000
          Punto   -  7703       244.69668   86.68330             0.0000
          Punto   -  7803       247.73189   86.91752             0.0000
          Punto   -  103        250.74418   87.14030             0.0000
          Punto   -  203        253.86173   87.34752             0.0000
          Punto   -  303        257.16046   87.52376             0.0000
          Punto   -  403        260.63040   87.66218             0.0000
          Punto   -  503        264.29234   87.76290             0.0000
          Punto   -  603        268.07598   87.82603             0.0000

 1 Azinut+zenit  2 dist Obliqua  3 dist+Zenit  4 Modifica     5 Elimina
 6 dist+Disliv   7 dist.oRizzo   8 disLivello  9 Fine         0 Quit
```

Fig. 13

- An ASCII file describing a list of points of the network with the corrisponding coordinates.

Obiously the solution obtained from the adjustment it is not a completely rigorous one, because resulting from an empirical process.
In any case when a much better accurancy is needed and when a much variegated complex typology of measurements is present, it is possible to run a rigorous 3D least squares adjustement (TOPO).

5.2 PERT-TOPO-TOPL

Through PERT three data files necessary to run TOPO program are automatically created and a much bigger typology of measurements can be added to those ones already typed through PUNT.
In particular differences in height, isolated distances connections among station points, also uncompleted ones, are now admitted as input for the rigorous adjustment (Fig.13-14).
In this way all the measurements made on the object can be stored together into one file and unitarily managed. Vincula of the network, the instruments precisions and the characteristics of the plot of the network can also be automatically inserted in the data file through the video-windows of PERT.
Several tests controlling the congruency of the new measurements with those ones previously inserted in PUNT are also present (Fig.15).
The approximate values of the unknowns needed by TOPO are taken from the results of the PUNT adjustment.
In the present paper it is not specifically detailled the modality of empirical and least squares adjustment hereby used.
At this regard please consider the enclosed references and the papers of next publication, which will consider in details the algorithms of data treatment present in the programs of the software MILANO.
As a result of the rigorous adjustment all the points coordinates and the angles of orientation of the station points are obtained.
To every adjusted value of the unknowns it is associated a rigorous m.s.e.
It is obviously possible to run not only a planoaltimetric adjustment of the network but simply a planimetric one too. All the solutions are printed on a specific file or directly sent to a LPT1 parallel port (Fig.16).
The parameters of the network plot, scales, spacial rotation, pens colours, kinds of measurement connection to be plotted, are set in PERT that automatically prepares a file usable by TOPL to create the drawing (Fig.17).
For every point of the network, using the values of the covariance and variance, are valuated the values for the plot of the error ellipses.
TOPL creates 2 plot files.

```
GALILEO
22/09/1991  13:53:56                                        C:\TEST\APPOGGIO.GAL

Dati Generali     - PROVE OPERATIVE DEL NUOV== DIST. ORIZZONT. e DISLIVELLO ==E
Specifiche        - U.M.: m     - Asse x: X -
Punto Stazione    - 4           PIL.MET.        Punto A:              7303
Dist.  Disliv.    - 7303        7603                                            O
         Punto    - 7103        226.88624    8  Punto B:              7603
         Punto    - 7303        232.84147    8
         Punto    - 7403        235.79341    8  Dist. orizzontale:    26.8650
         Punto    - 7503        238.72566    8
         Punto    - 7603        241.69290    8  Dislivello:            0.0070
         Punto    - 7703        244.69668    8
         Punto    - 7803        247.73189    8  Altezza strumento A:   0.0000
         Punto    - 103         250.74418    8
         Punto    - 203         253.86173    8  Altezza strumento B:   0.0000
         Punto    - 303         257.16046    8
         Punto    - 403         260.63040    8
         Punto    - 503         264.29234    8
         Punto    - 603         268.07598    87.82603              0.0000

          Muoversi con ↑↓ o return - F1=Help - ESC per terminare
```

Fig. 14

```
GALILEO
22/09/1991  14:01:29                                        C:\TEST\APPOGGIO.GAL

Dati Generali     - PROVE OPERATIVE DEL NUOV======= DISTANZA OBLIQUA=========E
Specifiche        - U.M.: m     - Asse x: X -
Punto Stazione    - 4           PIL.MET.        Punto A:              7303
         Punto    - 7103        226.88624    8
         Punto    - 7303        232.84147    8  Punto B:              7803
         Punto    - 7403        235.79341    8
         Punto    - 7503        238.72566    8  Distanza obliqua:     47.1230
         Punto    - 7603        241.69290    8
         Punto    - 7703        244.69668    8  Altezza strumento A:   0.0000
         Punto    - 7803        247.73189    8
         Punto    - 103         250.74418    8  Altezza strumento B:   0.0000
Dist.  Obliqua    -
         Punto    - 203         253.86173    8
         Punto    - 303         257.16046    8
         Punto    - 403         260.63040    8
         Punto    - 503         264.29234    8
         Punto    - 603         268.07598    87.82603              0.0000

          Muoversi con ↑↓ o return - F1=Help - ESC per terminare
Errore su Distanza > 10 volte la tolleranza. Distanza =  46.0190
```

Fig. 15

Titolo:	PROVE OPERATIVE DEL NUOVO PACCHETTO SOFTWARE "MILANO"
Tipo di lavoro:	RETE D'APPOGGIO TOPOGRAFICO
Data lavoro:	11 LUGLIO 1991
Committente:	POLITECNICO DI MILANO - DIP. I.I.A.R.
Studio:	Ditta: Paolo Rossi e C.

Coordinate compensate e SQM

Punto	Coordinata X(m)	SQM (mm)	Coordinata Y(m)	SQM (mm)	Coordinata Z(m)	SQM (mm)
4	100.0000	.0	100.0000	.0	100.0000	.0
6	51.8558	2.2	18.5684	1.3	100.0322	1.8
2	9.2586	.3	153.6499	.2	100.0079	1.9
7103	-39.2445	9.7	1.7599	5.8	140.3372	5.7
7303	-52.8573	5.3	12.3023	5.2	140.3726	4.2
7403	-59.4726	5.4	18.0835	5.1	140.3695	4.2
7503	-65.9514	5.6	24.2063	5.1	140.3716	4.2
7603	-72.3392	5.9	30.7972	5.1	140.3772	4.3
7703	-78.6156	6.2	37.8905	5.0	140.3823	4.4
7803	-84.7531	6.5	45.4779	5.0	140.3892	4.4
103	-90.5551	6.9	53.4376	4.9	140.4084	4.5

Fig. 16

GALILEO
22/09/1991 13:50:00 C:\TEST\APPOGGIO.GAL

DEFINIZIONE DEI PARAMETRI DI PLOTTAGGIO

Visione Planimetrica o Altimetrica (P/A): P

Formato del foglio (0=A0, 1=A1, 2=A2, 3=A3, 4=A4): 3
Angolo rotazione del disegno (gradi): 0.00
Fattore di scala asse X: 1: 581.695
Fattore di scala asse Y: 1: 618.430
Fattore di scala assi ellisse di errore: 1: 1.0000
Fattore di scala asse ellisse in quota: 1: 1.0000

Numeri penne per le parti del disegno:

cornice:	1	SQM in quota:	1
linea distanze:	1	punti collimati:	1
tratteggio azimut:	1	punti stazione:	1
tratteggio zenit:	1	nomi punti:	1
ellissi di errore:	1	testi:	1

Muoversi con ↑↓ - Completare i campi - ESC=Fine

Fig. 17

The first one is an HPGL ASCII file (Fig.18), the second is a Binary one readable through CAD systems to permit more interesting manipulations of the drawing.

5.3 ROTA

The coordinates values obtained using PUNT or the more sophisticated program PERT can be rotated in the space using ROTA.
This program solves the problem of transforming the coordinates obtained from the topographic convention to a coordinate system congruent to that one used by the stereoplotters.
In order to carry out this operation, the operator is not expected to know the rotation angles. He has simply first to identify the ideal plan on which he wants the object to be considerd liying; then he has to indicate the direction of the axis coming out from the object. Everything is done in an easy and well understandable way.
The user has just to select three points of the network and to indicate their relative position.
At first he is asked the position of one point, called 'A', then he has to say if the second point 'B' lies on the left or right hand side with respect to A.
At last he is asked if the third point, 'C', is located above or below the A-B segment.
In this way the roto-translation can be done.
The Z axis is oriented towards the observer, the X axis along the direction A-B with versus from A to B and the Y axis orthogonal to the plan X-Z (Fig.19).
The rotation parameters are memorized so that at the end of the restiution work the coordinates calculated through stereoplotter can be written back to the terrestrial topographical coordinates system.

5.4 TAVO

The TAVO program deals with the determination of the external orientation parameters of the photogrammetric takens.
The possibility of carrying out such a determination is subordinated to the solution of the previous phases. For the evaluation of these parameters it is planned the acquisition of the geometries of each taken through some draft read by the computer trough a graphic table.
The drawings can be of two different kinds:

- The first one, planimetric, aims to the definition of the outline of the surveyed object, the approximate position of the taken and the direction of the line of the sight camera-object. It is also requested the scale of the draft and the planimetric coordinates of one point, in order to fix the translation in the space, and also the same data for a second point in order to bind its rotation on the plan.

```
IN; PS 3; SP 1; IP       0      0 16000 10919; SC         .000     40.000       .000
SP  1;
PU       .000       .000;
PD     40.000       .000;
PD     40.000     27.300;
PD       .000     27.300;
PD       .000       .000;
PU     37.000       .000;
PD     37.000     27.300;
PU     37.500       .200;
SI    .14667    .22000; DI       .0000     1.0000;
LBPROVE OPERATIVE DEL NUOVO PACCHETTO SOFTWARE "MILANO"♥
PU    .37.900       .200;
SI    .14667    .22000; DI       .0000     1.0000;
LBRETE D'APPOGGIO TOPOGRAFICO♥
PU     38.600       .200;
SI    .14667    .22000; DI       .0000     1.0000;
LB11 LUGLIO 1991♥
PU     39.300       .200;
SI    .14667    .22000; DI       .0000     1.0000;
LBPOLITECNICO DI MILANO -   DIP. I.I.A.R.♥
PU     39.700       .200;
```

Fig. 18

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GALILEO
22/09/1991  13:48:59                                    C:\TEST\APPOGG1O.RES

                      DEFINIZIONE ROTOTRASLAZIONE

              Nome del punto A: 7303
              Nome del punto B: 7403
              Nome del punto C: 103

     Posizione del punto B rispetto al punto A: D (D/S)

 Posizione del punto C rispetto al segmento AB: A (A/B)

                  Coord. X        Coord. Y        Coord. Z
 Punto 7303   :  -52.8573 m      12.3023 m      140.3726 m
 Punto 7403   :  -44.0718 m      12.3023 m      140.3695 m
 Punto 103    :    2.5972 m      18.4699 m      140.3726 m

  Muoversi con ↑↓ - Completare i campi richiesti - F1=Help - ESC=Fine
```

Fig. 19

It is also possible to omit the scale of the draft, providing simply the coordinates of the two points.

-the second drawing scheme on the other hand must allow the observation of the altimetric scheme, thus in section, of the taken.
It is in details requested a section of the surveyed element, the approximate position of the point where the picture has been taken and the inclination of the line of the sight camera-object. Further to that it is asked to know the height of a point of the outline of the surveyed element and the drawing scale or to know the coordinates of two points of it.
The drafts of the takens are digitalized through a graphic table and acquired by the PC. The operation is visualized in real time on the computer screen and guided with a mouse.
The so acquired data are then elaborated providing the approximate values of the coordinates X,Y,Z and the angular parameters Omega, Phi, Kappa of the takens.

6. CONCLUSIONS

MILANO turns up to be a valid support to operations of close range photogrammetric surveys.
In particular all the measurements carried out on the object can be stored in the software and thus managed in a, also metrically speaking, rigorous way.
Both the empirical and the rigorous compensation, the possibility of rototranslation in the space, the determination of the parameters of external orientation of the taken, though rigorously managed, are usable also by any photogrammetric operator.
MILANO exemplifies the fact that methodological rigour is not synonimous of complexity of use; also the everyday operator can be thus made acquainted with high-quality systems of data management and treatment.

REFERENCES:

BARBARELLA M., BETTI B., BROVELLA M.A., DOMINICI D. (1990):Verifiche e controlli tra programmi di reti tridimensionali. In Atti del 7 Convegno Nazionale del GNGTS del CNR, 30 nov.-2 dic. 1988, Roma

GUZZETTI F., MONTI C.(1988):Calcolo e rappresentazione di reti per l'appoggio cartografico. Rivista del Catasto e dei SS.TT.EE., n.2-3, Roma

MONTI C., GUZZETTI F. (1988): Esperienze fotogrammetriche con l'apparato Rollei. Bollettino Sifet, n.2, Roma

GIUSSANI A., GUZZETTI F., MONTI C., SAIBENE C. (1986): Operazioni di rilevamento delle inserterie eseguite nella centrale nucleare di Montalto di Castro, mediante l'utilizzo della fotogrammetria dei vicini. L'Energia Elettrica, n.10, Milano

FORLANI G., MUSSIO L. (1984): Il calcolo di una compensazione ai minimi quadrati. In: Ricerche di geodesia,topografia e fotogrammetria, vol.4, CLUP, pp. 1-34, Milano.

FORSTNER W. (1986): Reliability, Error Detection and Selfcalibration. In: Int. Arch. of Photogrammetry and Remote Sensing, vol.26, part 3/4: Program of the ISPRS Commission III on Statistical Concepts For Quality Control, ISPRS, Rovaniemi, Session 2, pp.1-34.

INGHILLERI G.(1974): Topografia Generale. UTET, Torino.

WOLF P.(1974): Elements of photogrammetry. Mc Graw Hill, New York.

KUBIK K. (1970): The estimation of the weights of measured quantities within the method of least squares. Buletin Geodesique, n.95, pp.21-40,