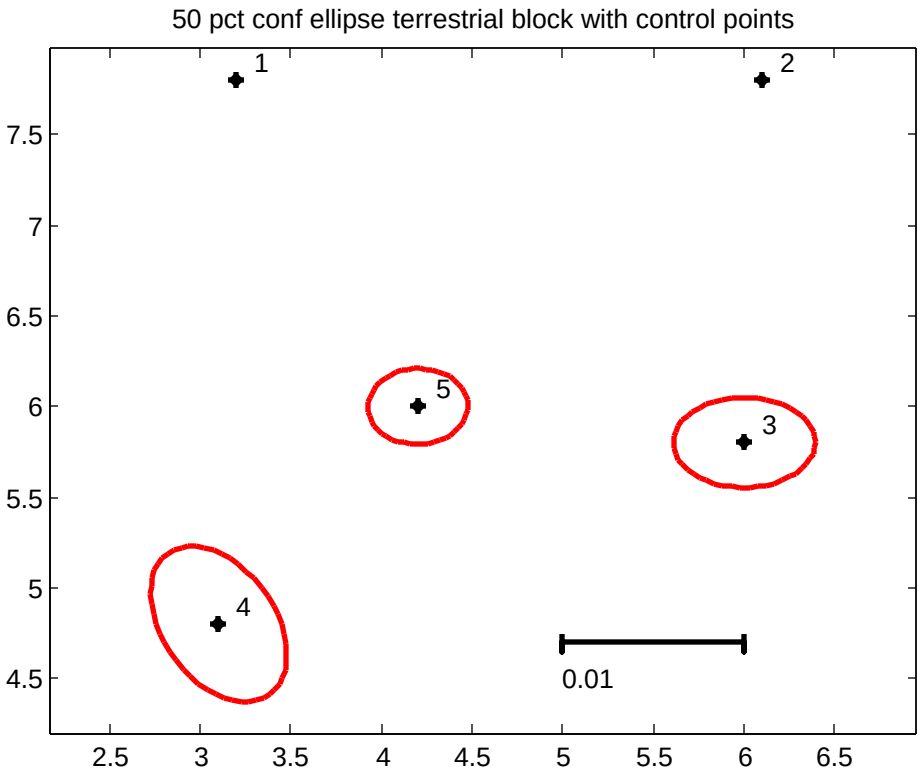

50 pct conf ellipse terrestrial block with control points
1
2
3
4
5
0.01
7.5
7
6.5
6
5.5
5
4.5
2.5
3
3.5
4
4.5
5
5.5
6
6.5

```
hw2b_sol
linear intersection results
XYZ =
       3.1576       7.7045      0.37989
       6.2034       7.9431      0.40863
       6.2816       6.0239       3.5941
       3.1399       4.8571       3.7917
       4.2539       6.0626       1.5752
nobs =
    15
iter =
     1
parameter values
XL =
          0.4          2.3          4.5
YL =
          3.9          0.6          2.4
ZL =
          1.5          1.6          1.5
omega =
       1.4773       1.5139       1.6057
phi =
     -0.97536     -0.40084            0
kappa =
    -0.077436    -0.022212            0
XYZ =
       3.1576       7.7045      0.37989
       6.2034       7.9431      0.40863
       6.2816       6.0239       3.5941
       3.1399       4.8571       3.7917
       4.2539       6.0626       1.5752
matrices
B =
  Columns 1 through 6
      -6.0712      -39.635       6.9557        6.724      -4.9174     -0.14803
       30.695      -5.3175      -12.633       1.6294        1.099       7.7444
      -4.4187      -34.907       3.5383         2.81      -4.0345   -0.0038545
       20.204      -2.7881     -0.52435      0.62475       0.4214       4.8833
       12.157      -37.482      -14.178       2.0391       -5.725     0.079179
       15.178      -6.7849       8.9955      -1.7188      -1.1593       6.0032
       29.562      -38.217      -31.772       4.3215      -12.821      0.18797
       27.342       -13.66       9.6361      -9.2382      -6.2313       13.647
       0.5985      -35.148      -2.4341       3.9103      -6.9696     0.034359
       17.269      -2.9207       2.8849     -0.11301    -0.076229       7.9828
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
  Columns 7 through 12
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
      -1.3223      -37.895        4.337       5.2145      -0.6425    -0.075785
       36.602      -2.0323      -10.034      0.34751      0.81869       5.0114
      -2.2138      -35.249        3.175       3.7228      -1.9759     0.019085
       31.302     -0.50806       3.0397      0.23449      0.55242       4.1732
```

7.0035	-37.078	-12.695	4.4968	-3.3261	0.068377
33.113	-3.9283	8.4074	-0.65854	-1.5514	5.5347
3.1691	-36.522	-20.45	8.5219	-1.632	-0.095775
46.253	3.3682	-7.5512	-1.7603	-4.1471	8.7298
-0.15099	-35.107	-1.6841	5.706	-2.0411	-0.018379
33.087	-0.68141	-2.0316	0.010129	0.023862	6.0569
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Columns 13 through 18

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
2.2135	-37.278	8.6769	6.6513	1.6957	0.059215
37.151	-2.2135	-8.9284	0	1.4158	6.7048
-2.5294	-38.355	8.1695	6.3617	-1.9685	-0.068742
36.907	2.5294	10.837	0	1.262	6.4097
8.9818	-43.138	-18.627	9.4728	-4.565	-0.15941
44.913	-8.9818	16.877	0	-5.369	9.2911
-16.323	-45.07	-30.43	13.803	7.3997	0.2584
61.457	16.323	-18.774	0	-12.476	13.376
0.033798	-35.158	0.50314	9.555	0.64147	0.022401
35.007	-0.033798	-2.3511	0	-0.19619	9.554

Columns 19 through 24

-6.7239	4.9173	0.14803	0	0	0
-1.6294	-1.099	-7.7444	0	0	0
0	0	0	-2.81	4.0345	0.0038545
0	0	0	-0.62475	-0.4214	-4.8833
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
-5.2145	0.6425	0.075785	0	0	0
-0.34751	-0.81869	-5.0114	0	0	0
0	0	0	-3.7228	1.9758	-0.019085
0	0	0	-0.23449	-0.55242	-4.1732
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
-6.6513	-1.6957	-0.059215	0	0	0
0	-1.4158	-6.7048	0	0	0
0	0	0	-6.3617	1.9685	0.068742
0	0	0	0	-1.262	-6.4097
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Columns 25 through 30

```
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
   -2.0391     5.725 -0.079179         0         0         0
    1.7188    1.1593   -6.0032         0         0         0
         0         0         0   -4.3214    12.821  -0.18797
         0         0         0    9.2382    6.2312   -13.647
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
   -4.4967    3.3261 -0.068377         0         0         0
   0.65854    1.5514   -5.5347         0         0         0
         0         0         0   -8.5218     1.632  0.095775
         0         0         0    1.7603    4.1471   -8.7298
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
   -9.4728     4.565   0.15941         0         0         0
         0     5.369   -9.2911         0         0         0
         0         0         0   -13.803   -7.3997   -0.2584
         0         0         0         0    12.476   -13.376
         0         0         0         0         0         0
         0         0         0         0         0         0
  Columns 31 through 33
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
   -3.9103    6.9696 -0.034359
   0.11301  0.076229   -7.9828
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
    -5.706    2.0411  0.018379
 -0.010129 -0.023862   -6.0569
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
    -9.555 -0.64147 -0.022401
         0   0.19619   -9.554
f =
    1.5852
    1.9673
   0.48965
    1.6337
  0.028466
    1.6851
 -0.0089054
    2.4127
   0.36993
    1.5991
   -1.9909
     -1.03
   -1.4883
    -1.102
   -1.3576
  -0.84509
   -1.8142
```

```
     0.050897
      -1.6166
      -0.7619
       1.0756
    -0.084917
       1.4916
     -0.38946
       2.8638
     -0.84199
       3.0949
      -1.7827
       1.8839
     -0.67814
C =
  Columns 1 through 13
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
  Columns 14 through 26
     0     0     0     0     0     1     0     0     0     0     0     0     0
     0     0     0     0     0     0     1     0     0     0     0     0     0
     0     0     0     0     0     0     0     1     0     0     0     0     0
     0     0     0     0     0     0     0     0     1     0     0     0     0
     0     0     0     0     0     0     0     0     0     1     0     0     0
     0     0     0     0     0     0     0     0     0     0     1     0     0
     0     0     0     0     0     0     0     0     0     0     0     1     0
  Columns 27 through 33
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     1     0     0     0     0     0     0
g =
     0.042369
     0.095514
     0.020111
     -0.10341
     -0.14311
     0.091368
    -0.094108
sol =
      0.08387
    -0.026047
     0.069126
      0.12545
     0.090009
     0.020441
    -0.041629
     0.040034
    -0.012042
    -0.063472
   -0.0086293
      0.13512
     0.014621
    -0.030888
   -0.0011864
     0.026738
      0.10753
    -0.088636
     0.042369
     0.095514
     0.020111
     -0.10341
     -0.14311
     0.091368
     -0.28111
      -0.2288
    -0.094108
     -0.02103
    -0.061235
    -0.081666
    -0.044852
    -0.067283
```

```
     0.032633
 -3.7011e-008
 -9.3223e-009
 -3.1677e-008
   5.504e-008
 -2.3672e-008
  6.3197e-008
 -2.8868e-008
corrections
ans =
      0.49277      0.59594      0.31989
iter =
     2
parameter values
XL =
      0.52545       2.2365       4.5267
YL =
         3.99      0.59137       2.5075
ZL =
       1.5204       1.7351       1.4114
omega =
       1.5612       1.4723       1.6203
phi =
      -1.0014     -0.36081    -0.030888
kappa =
     -0.00831    -0.034253   -0.0011864
XYZ =
          3.2          7.8          0.4
          6.1          7.8          0.5
       6.0005       5.7951          3.5
       3.1189       4.7959         3.71
       4.2091       5.9953       1.6078
matrices
B =
  Columns 1 through 6
      -5.7235      -40.904       8.9167       7.1762      -5.0432    -0.019146
       32.154      -3.9629       -14.34       1.7779       1.1356       8.1055
      -4.3756      -35.032       5.1074        2.925      -4.2803    -0.002068
       20.158     -0.45086      -1.0541      0.66009      0.42102       5.1779
       12.201      -37.332      -12.613       2.0276      -6.1573    0.0067925
       13.738       -3.566        8.984      -1.8776      -1.2036       6.2906
       29.136      -37.727      -29.575       4.1197      -13.301     0.015839
       24.178       -8.652       9.6494      -9.4931      -6.0803       13.482
      0.64599      -35.176     -0.91265       4.0106      -7.3672    0.0010282
       16.789     -0.35581        2.484     -0.14627    -0.096045       8.3681
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
  Columns 7 through 12
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
      -1.6345      -36.867       3.3017       4.9587     -0.68138     -0.10054
       35.845      -1.9706      -8.0747      0.31876      0.84922       4.8152
      -2.1206      -35.552       2.0699       3.8017      -2.0284     0.053367
```

31.256	-0.93595	4.5153	0.22617	0.60397	4.2325
7.1057	-37.828	-13.547	4.8711	-3.5752	0.15294
34.064	-5.153	9.758	-0.60903	-1.5961	6.0048
2.9179	-35.808	-20.401	8.5935	-1.7445	-0.12541
45.983	1.7422	-5.7475	-1.5034	-3.95	9.0811
-0.28345	-34.984	-2.4549	5.7287	-2.0912	-0.0032009
33.042	-1.1741	-0.43429	0.044392	0.12773	6.1115
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Columns 13 through 18

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
2.1466	-37.871	8.5868	6.7969	1.7186	0.077183
37.395	-2.5019	-10.018	0.059065	1.317	6.8141
-2.3525	-37.494	7.7494	6.5623	-1.9689	-0.10546
36.412	2.0262	9.3479	0.053117	1.1353	6.6845
8.3743	-40.559	-19.637	10.071	-4.3694	-0.2287
45.556	-7.8742	13.937	-0.16467	-6.2195	9.9058
-19.474	-48.875	-32.415	15.146	8.8932	0.42316
65.695	20.35	-22.056	-0.4075	-14.479	14.164
-0.063279	-35.522	-0.23184	10.085	0.91666	0.033496
35.117	-0.0132	-4.2764	0.0098645	-0.56451	10.037

Columns 19 through 24

-7.1762	5.0432	0.019146	0	0	0
-1.7779	-1.1356	-8.1055	0	0	0
0	0	0	-2.925	4.2803	0.002068
0	0	0	-0.66009	-0.42102	-5.1779
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
-4.9587	0.68138	0.10054	0	0	0
-0.31876	-0.84922	-4.8152	0	0	0
0	0	0	-3.8017	2.0284	-0.053367
0	0	0	-0.22617	-0.60397	-4.2325
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
-6.7969	-1.7186	-0.077183	0	0	0
-0.059065	-1.3169	-6.8141	0	0	0
0	0	0	-6.5623	1.9689	0.10546
0	0	0	-0.053117	-1.1353	-6.6845
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Columns 25 through 30

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
-2.0276	6.1573	-0.0067925	0	0	0
1.8776	1.2036	-6.2906	0	0	0
0	0	0	-4.1197	13.301	-0.015839
0	0	0	9.4931	6.0802	-13.482
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
-4.8711	3.5752	-0.15294	0	0	0
0.60903	1.5961	-6.0048	0	0	0
0	0	0	-8.5934	1.7445	0.12541
0	0	0	1.5034	3.95	-9.0811
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
-10.071	4.3694	0.2287	0	0	0
0.16467	6.2194	-9.9058	0	0	0
0	0	0	-15.146	-8.8931	-0.42316
0	0	0	0.4075	14.479	-14.164
0	0	0	0	0	0
0	0	0	0	0	0

Columns 31 through 33

0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
-4.0106	7.3672	-0.0010282
0.14627	0.096045	-8.3681
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
-5.7287	2.0912	0.0032009
-0.044392	-0.12773	-6.1115
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
-10.085	-0.91665	-0.033496
-0.0098645	0.56451	-10.037

f =

-0.12181
0.0062918
-0.040116
0.064557
0.017049
0.11974
0.004437
0.21612
-0.030951
0.07765
-0.031653
0.0053338
-0.012714
0.0030815
-0.0070196
0.0072801

```
     -0.01046
    0.0017404
    -0.019291
    0.0089158
    -0.014468
    0.0051573
    0.0028644
     0.030614
    -0.075945
      0.16839
     -0.18705
      0.20175
    -0.041371
     0.056843
C =
  Columns 1 through 13
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
  Columns 14 through 26
     0     0     0     0     0     1     0     0     0     0     0     0     0
     0     0     0     0     0     0     1     0     0     0     0     0     0
     0     0     0     0     0     0     0     1     0     0     0     0     0
     0     0     0     0     0     0     0     0     1     0     0     0     0
     0     0     0     0     0     0     0     0     0     1     0     0     0
     0     0     0     0     0     0     0     0     0     0     1     0     0
     0     0     0     0     0     0     0     0     0     0     0     0     0
  Columns 27 through 33
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
     1     0     0     0     0     0     0
g =
     0
     0
     0
     0
     0
     0
     0
sol =
    0.0084219
   -0.0022404
    0.0070922
    -0.024304
     0.010891
    -0.017383
    0.0039847
   -0.0041272
   0.00014189
    -0.034905
    0.0085997
    -0.028833
    0.0028549
   -0.0035767
    0.0022741
    -0.023978
   -0.0072674
    -0.011442
            0
  2.6464e-019
            0
            0
            0
            0
    0.0021296
     0.006748
            0
    -0.015824
    0.0048591
   -0.0084616
   -0.0083684
```

```
    0.0046953
   -0.0075189
  8.8261e-008
 -2.4771e-008
  2.3013e-008
 -5.9181e-008
  4.1021e-008
 -3.6068e-008
  1.0146e-008
corrections
ans =
     0.026322     0.016302      0.01598
iter =
     3
corrections
ans =
  9.7075e-005    0.0002258   0.00011299
iter =
     4
corrections
ans =
  2.1125e-007  6.1557e-008  4.1647e-008
iter =
     5
corrections
ans =
  1.4859e-010  2.1145e-010  2.0451e-010
iter =
     6
corrections
ans =
  4.7807e-011  7.9609e-011  3.0322e-011
test =
       2.7355
cv1 =
      0.48442
cv2 =
       11.143
v =
   0.00052567
  7.0299e-005
  -0.00030612
     0.002723
  -0.00066946
   -0.0029516
  -0.00040432
    0.0011455
   0.00082659
   -0.0013805
   -0.0017588
   -0.0018469
   0.00041784
    -0.001218
    0.0018746
    0.0024171
   0.00097771
   -0.0023938
   -0.0020534
    0.0034274
   0.00079137
    0.0011863
  -0.00032469
   -0.0013461
    -0.001172
   0.00035338
   4.333e-005
   0.00046042
   0.00080208
  -0.00094664
diary off
```

```
% hw2b_sol.m 15-feb-09
% 3-photo bundle block adj.
% approx as given in the problem
% adjust the linear intersection to divide by
% Y-YL instead of Z-ZL since the latter was near
% zero for at least one point

x0=0;
y0=0;
foc=35;



degrad=180/pi;
omega=zeros(1,3);
phi=zeros(1,3);
kappa=zeros(1,3);
% initial approximations

thz=-56/degrad;
thx=87/degrad;
m=m1(thx)*m3(thz);
p=asin(m(3,1));
w=atan2(-m(3,2)/cos(p),m(3,3)/cos(p));
k=atan2(-m(2,1)/cos(p),m(1,1)/cos(p));
omega(1)=w;
phi(1)=p;
kappa(1)=k;

thz=-23/degrad;
thx=87/degrad;
m=m1(thx)*m3(thz);
p=asin(m(3,1));
w=atan2(-m(3,2)/cos(p),m(3,3)/cos(p));
k=atan2(-m(2,1)/cos(p),m(1,1)/cos(p));
omega(2)=w;
phi(2)=p;
kappa(2)=k;

thz=0/degrad;
thx=92/degrad;
m=m1(thx)*m3(thz);
p=asin(m(3,1));
w=atan2(-m(3,2)/cos(p),m(3,3)/cos(p));
k=atan2(-m(2,1)/cos(p),m(1,1)/cos(p));
omega(3)=w;
phi(3)=p;
kappa(3)=k;

XL=[0.4 2.3 4.5];
YL=[3.9 0.6 2.4];
ZL=[1.5 1.6 1.5];

% temp
%plot(XL,YL,'b+');
%hold on

% ok now intersect for the object space coordinates


obs=[   1    1    -14.218     -8.923;
        1    2     -1.014     -5.172;
        1    3      8.967     12.493;
        1    4      9.645     29.359;
        1    5      2.515      0.835;
        2    1     -8.043     -3.307;
        2    2      4.528     -2.073;
        2    3      9.765     13.540;
        2    4     -5.737     20.399;
        2    5     -0.415      2.446;
        3    1    -10.004     -8.592;
        3    2      9.345     -7.780;
        3    3     14.013     19.469;
        3    4    -21.869     32.213;
        3    5     -4.235      0.175];

XYZ=zeros(5,3);
B=zeros(6,3);
f=zeros(6,1);
```

```
% use linear algorithm and pseudo LS
for i=1:5
  for j=1:3
    idx=i+(j-1)*5;
    x=obs(idx,3);
    y=obs(idx,4);
    iv=[x-x0;y-y0;-foc];
    m=m3(kappa(j))*m2(phi(j))*m1(omega(j));
    %if(i==1)
    %  disp('rot matrix');
    %  j
    %  m
    %  end
    %m
    uvw=m'*iv;
    %uvw0=m'*[0;0;-foc];

    % temp
    %ip=[uvw(1);uvw(2)];
    %lip=sqrt(ip(1)^2 + ip(2)^2);
    %ip=(ip/lip)*2;
    %ip(1)=ip(1) + XL(j);
    %ip(2)=ip(2) + YL(j);
    %if(i==5)
    %  plot(ip(1),ip(2),'r.');
    %  end
    %ip=[uvw0(1);uvw0(2)];
    %lip=sqrt(ip(1)^2 + ip(2)^2);
    %ip=(ip/lip)*2;
    %ip(1)=ip(1) + XL(j);
    %ip(2)=ip(2) + YL(j);
    %if(i==5)
    %  plot(ip(1),ip(2),'r+');
    %  end
    %if(i==1)
    %  uvw
    %  end
    c1=uvw(1)/uvw(2);
    c2=uvw(3)/uvw(2);
    row=(j-1)*2+1;
    B(row,:)=  [1 -c1 0];
    B(row+1,:)=[0 -c2 1];
    f(row)=  XL(j)-c1*YL(j);
    f(row+1)=ZL(j)-c2*YL(j);
    end
  %if(i==1)
  %  B
  %  f
  %  end
  sol=inv(B'*B)*B'*f;
  %disp('linear intersection');
  %cond(B'*B)
  XYZ(i,:)=[sol(1) sol(2) sol(3)];
  end
disp('linear intersection results');
XYZ

% temp
%plot(XYZ(:,1),XYZ(:,2),'g*');
%axis equal

% ok now we have all approximations - do the bundle block

% sigma0 squared is (0.005)^2
% then W=I
nobs=15
for iter=1:6
  B=zeros(30,33);
  iter
  for i=1:nobs
    row=(i-1)*2 + 1;
    phn=obs(i,1);
    ptn=obs(i,2);
    x=obs(i,3);
    y=obs(i,4);
    w=omega(phn);
    p=phi(phn);
    k=kappa(phn);
    X=XYZ(ptn,1);
```

```
    Y=XYZ(ptn,2);
    Z=XYZ(ptn,3);
    res=lincoll(x,y,w,p,k,XL(phn),YL(phn),ZL(phn),X,Y,Z,x0,y0,foc);
    colpho=(phn-1)*6 + 1;
    colpnt=18  + (ptn-1)*3 + 1;
    B(row:row+1,colpho:colpho+5)=res(1:2,2:7);
    B(row:row+1,colpnt:colpnt+2)=res(1:2,8:10);
    f(row:row+1)=-res(1:2,1);
    end
  N=B'*B;
  t=B'*f;
  C=zeros(7,33);
  g=zeros(7,1);
  C(1,19)=1;
  C(2,20)=1;
  C(3,21)=1;
  C(4,22)=1;
  C(5,23)=1;
  C(6,24)=1;
  C(7,27)=1;
  g(1)=-(XYZ(1,1)-3.2);
  g(2)=-(XYZ(1,2)-7.8);
  g(3)=-(XYZ(1,3)-0.4);
  g(4)=-(XYZ(2,1)-6.1);
  g(5)=-(XYZ(2,2)-7.8);
  g(6)=-(XYZ(2,3)-0.5);
  g(7)=-(XYZ(3,3)-3.5);
  zer77=zeros(7,7);
  NE=[-N C'; C zer77];
  NEv=[-t; g];
  %keyboard
  M=inv(NE);
  sol=inv(NE)*NEv;
  del=sol(1:33); % this is the delta vector
  if(iter <= 2)
    disp('parameter values');
    XL
    YL
    ZL
    omega
    phi
    kappa
    XYZ
    disp('matrices');
    B
    f
    C
    g
    sol
    end

  avgx=abs(sol(19))+abs(sol(22))+abs(sol(25))+abs(sol(28))+abs(sol(31));
  avgy=abs(sol(20))+abs(sol(23))+abs(sol(26))+abs(sol(29))+abs(sol(32));
  avgz=abs(sol(21))+abs(sol(24))+abs(sol(27))+abs(sol(30))+abs(sol(33));
  disp('corrections');
  [avgx avgy avgz]
  omega=omega + [sol(1) sol(7) sol(13)];
  phi  =phi   + [sol(2) sol(8) sol(14)];
  kappa=kappa + [sol(3) sol(9) sol(15)];
  XL=XL + [sol(4) sol(10) sol(16)];
  YL=YL + [sol(5) sol(11) sol(17)];
  ZL=ZL + [sol(6) sol(12) sol(18)];
  XYZ(1,:)=XYZ(1,:) + [sol(19) sol(20) sol(21)];
  XYZ(2,:)=XYZ(2,:) + [sol(22) sol(23) sol(24)];
  XYZ(3,:)=XYZ(3,:) + [sol(25) sol(26) sol(27)];
  XYZ(4,:)=XYZ(4,:) + [sol(28) sol(29) sol(30)];
  XYZ(5,:)=XYZ(5,:) + [sol(31) sol(32) sol(33)];
  % parameter order
  % w  p  k  XL YL ZL w  p  k XL YL ZL w  p  k  XL YL ZL x  y  z  x  y  z  x  y  z  x  y  z
  % 1  2  3   4  5  6 7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
  % with 7 constraints, full normals are 40 x 40
  end

% error prop
alpha=M(1:33,1:33);
Qdd= -alpha;
v=f - B*del;
nphopnt=15;
vx=[v(1);v(3);v(5);v(7);v(9);v(11);v(13);v(15);v(17);v(19);v(21);v(23);v(25);v(27);v(29)];
```

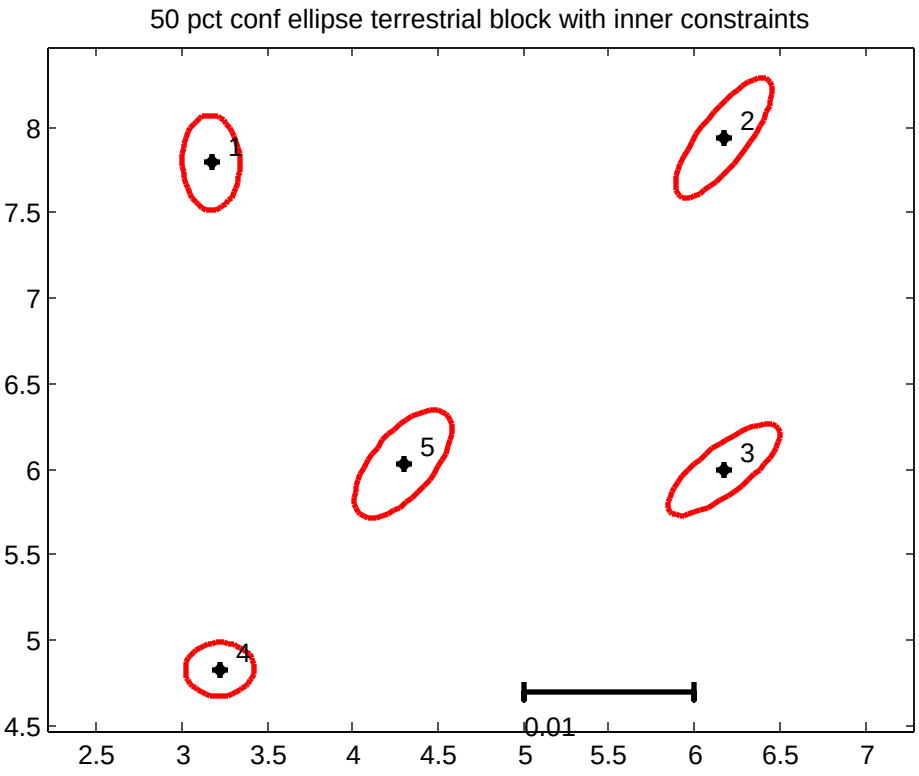
```
vy=[v(2);v(4);v(6);v(8);v(10);v(12);v(14);v(16);v(18);v(20);v(22);v(24);v(26);v(28);v(30)];
rmsx=vx'*vx/nphopnt;
rmsy=vy'*vy/nphopnt;
W=eye(30);
Q=eye(30);
Qvv=Q - B*Qdd*B';
trQvv=trace(Qvv);
% ok this last statement confirms that r=4
r=4;
sigma0_sqr=0.005^2;
test=v'*v/sigma0_sqr;
P1=.025;
P2=.975;
cv1=chi2inv(P1,r);
cv2=chi2inv(P2,r);
test
cv1
cv2

% ok pass, scale Qdd by prior sigma0_sqr

Sdd=sigma0_sqr*Qdd;
for i=1:5
  idx=19 + (i-1)*3;
  cov=Sdd(idx:idx+1,idx:idx+1);
  glob=1; % pass
  prob=0.5;
  factr=100;
  plot_conf_ell(cov,glob,r,prob,XYZ(i,1),XYZ(i,2),factr);
  plot(XYZ(i,1),XYZ(i,2),'k*','linewidth',2);
  hold on
  nudge=0.1;
  text(XYZ(i,1)+nudge,XYZ(i,2)+nudge,num2str(i));
  end

sb0x=5;
sb0y=4.7;
sb1x=sb0x + 1;
y1=sb0y-0.05;
y2=sb0y;
y3=sb0y+0.05;
x=[sb0x sb0x sb0x sb1x sb1x sb1x];
y=[y3 y1 y2 y2 y1 y3];
plot(x,y,'k-','linewidth',2);
text(5,4.5,'0.01');

title('50 pct conf ellipse terrestrial block with control points');
axis equal
zoomout;
v
```


50 pct conf ellipse terrestrial block with inner constraints
1
2
3
4
5
0.01
8
7.5
7
6.5
6
5.5
5
4.5
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7

```
hw2b_solic
B =
            1     -0.66425            0
            0      0.34574            1
            1     -0.17594            0
            0      0.14604            1
            1      0.28357            0
            0      0.20878            1
f =
      -2.1906
       2.8484
       2.1944
       1.6876
       5.1806
       2.0011
linear intersection results
XYZ =
       3.1576       7.7045      0.37989
       6.2034       7.9431      0.40863
       6.2816       6.0239       3.5941
       3.1399       4.8571       3.7917
       4.2539       6.0626       1.5752
nobs =
    15
iter =
     1
B =
  Columns 1 through 6
      -6.0712      -39.635       6.9557        6.724      -4.9174     -0.14803
       30.695      -5.3175      -12.633       1.6294        1.099       7.7444
      -4.4187      -34.907       3.5383         2.81      -4.0345   -0.0038545
       20.204      -2.7881     -0.52435      0.62475       0.4214       4.8833
       12.157      -37.482      -14.178       2.0391       -5.725     0.079179
       15.178      -6.7849       8.9955      -1.7188      -1.1593       6.0032
       29.562      -38.217      -31.772       4.3215      -12.821      0.18797
       27.342       -13.66       9.6361      -9.2382      -6.2313       13.647
       0.5985      -35.148      -2.4341       3.9103      -6.9696     0.034359
       17.269      -2.9207       2.8849     -0.11301    -0.076229       7.9828
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
  Columns 7 through 12
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
            0            0            0            0            0            0
      -1.3223      -37.895        4.337       5.2145      -0.6425    -0.075785
       36.602      -2.0323      -10.034      0.34751      0.81869       5.0114
      -2.2138      -35.249        3.175       3.7228      -1.9759     0.019085
       31.302     -0.50806       3.0397      0.23449      0.55242       4.1732
       7.0035      -37.078      -12.695       4.4968      -3.3261     0.068377
       33.113      -3.9283       8.4074     -0.65854      -1.5514       5.5347
       3.1691      -36.522       -20.45       8.5219       -1.632    -0.095775
       46.253       3.3682      -7.5512      -1.7603      -4.1471       8.7298
     -0.15099      -35.107      -1.6841        5.706      -2.0411    -0.018379
       33.087     -0.68141      -2.0316     0.010129     0.023862       6.0569
```

```
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
Columns 13 through 18
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
    2.2135     -37.278      8.6769      6.6513      1.6957    0.059215
    37.151     -2.2135     -8.9284           0      1.4158      6.7048
   -2.5294     -38.355      8.1695      6.3617     -1.9685   -0.068742
    36.907      2.5294      10.837           0       1.262      6.4097
    8.9818     -43.138     -18.627      9.4728      -4.565    -0.15941
    44.913     -8.9818      16.877           0      -5.369      9.2911
   -16.323      -45.07      -30.43      13.803      7.3997      0.2584
    61.457      16.323     -18.774           0     -12.476      13.376
  0.033798     -35.158     0.50314       9.555     0.64147    0.022401
    35.007   -0.033798     -2.3511           0    -0.19619       9.554
Columns 19 through 24
   -6.7239      4.9173     0.14803           0           0           0
   -1.6294      -1.099     -7.7444           0           0           0
         0           0           0       -2.81      4.0345   0.0038545
         0           0           0    -0.62475     -0.4214     -4.8833
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
   -5.2145      0.6425    0.075785           0           0           0
  -0.34751    -0.81869     -5.0114           0           0           0
         0           0           0     -3.7228      1.9758   -0.019085
         0           0           0    -0.23449    -0.55242     -4.1732
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
   -6.6513     -1.6957   -0.059215           0           0           0
         0     -1.4158     -6.7048           0           0           0
         0           0           0     -6.3617      1.9685    0.068742
         0           0           0           0      -1.262     -6.4097
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
Columns 25 through 30
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
   -2.0391       5.725   -0.079179           0           0           0
    1.7188      1.1593     -6.0032           0           0           0
```

```
         0         0         0   -4.3214    12.821   -0.18797
         0         0         0    9.2382    6.2312    -13.647
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
   -4.4967    3.3261 -0.068377         0         0         0
   0.65854    1.5514   -5.5347         0         0         0
         0         0         0   -8.5218     1.632  0.095775
         0         0         0    1.7603    4.1471   -8.7298
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
   -9.4728     4.565   0.15941         0         0         0
         0     5.369   -9.2911         0         0         0
         0         0         0   -13.803   -7.3997   -0.2584
         0         0         0         0    12.476   -13.376
         0         0         0         0         0         0
         0         0         0         0         0         0
Columns 31 through 33
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
   -3.9103    6.9696 -0.034359
   0.11301  0.076229   -7.9828
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
    -5.706    2.0411  0.018379
 -0.010129 -0.023862   -6.0569
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
         0         0         0
    -9.555 -0.64147 -0.022401
         0   0.19619    -9.554
f =
    1.5852
    1.9673
   0.48965
    1.6337
  0.028466
    1.6851
 -0.0089054
    2.4127
   0.36993
    1.5991
   -1.9909
     -1.03
   -1.4883
    -1.102
   -1.3576
  -0.84509
   -1.8142
  0.050897
   -1.6166
   -0.7619
    1.0756
 -0.084917
    1.4916
```

```
     -0.38946
       2.8638
     -0.84199
       3.0949
      -1.7827
       1.8839
     -0.67814
corrections
ans =
      0.29011      0.18353      0.20642
iter =
     2
corrections
ans =
     0.015069     0.013022     0.013574
iter =
     3
corrections
ans =
  4.5149e-005   3.049e-005  3.9339e-005
iter =
     4
corrections
ans =
  3.7692e-009  9.2136e-009  5.4528e-009
we converged
rmsx =
    0.0010447
rmsy =
    0.0018622
test =
       2.7355
cv1 =
      0.48442
cv2 =
       11.143
v =
   0.00052566
  7.0296e-005
  -0.00030611
     0.002723
  -0.00066947
   -0.0029516
  -0.00040432
    0.0011455
   0.00082659
   -0.0013805
   -0.0017588
   -0.0018469
   0.00041784
    -0.001218
    0.0018746
    0.0024171
   0.00097771
   -0.0023938
   -0.0020534
    0.0034274
   0.00079137
    0.0011863
  -0.00032469
   -0.0013461
    -0.001172
   0.00035339
  4.3331e-005
   0.00046042
   0.00080208
  -0.00094664
diary off
```

```
% hw2b_solic.m 15-feb-09
% 3-photo bundle block adj.
% approx as given in the problem
% adjust the linear intersection to divide by
% Y-YL instead of Z-ZL since the latter was near
% zero for at least one point
% for this version use inner constraints with the object points

x0=0;
y0=0;
foc=35;



degrad=180/pi;
omega=zeros(1,3);
phi=zeros(1,3);
kappa=zeros(1,3);
% initial approximations

thz=-56/degrad;
thx=87/degrad;
m=m1(thx)*m3(thz);
p=asin(m(3,1));
w=atan2(-m(3,2)/cos(p),m(3,3)/cos(p));
k=atan2(-m(2,1)/cos(p),m(1,1)/cos(p));
omega(1)=w;
phi(1)=p;
kappa(1)=k;

thz=-23/degrad;
thx=87/degrad;
m=m1(thx)*m3(thz);
p=asin(m(3,1));
w=atan2(-m(3,2)/cos(p),m(3,3)/cos(p));
k=atan2(-m(2,1)/cos(p),m(1,1)/cos(p));
omega(2)=w;
phi(2)=p;
kappa(2)=k;

thz=0/degrad;
thx=92/degrad;
m=m1(thx)*m3(thz);
p=asin(m(3,1));
w=atan2(-m(3,2)/cos(p),m(3,3)/cos(p));
k=atan2(-m(2,1)/cos(p),m(1,1)/cos(p));
omega(3)=w;
phi(3)=p;
kappa(3)=k;

XL=[0.4 2.3 4.5];
YL=[3.9 0.6 2.4];
ZL=[1.5 1.6 1.5];

% temp
%plot(XL,YL,'b+');
%hold on

% ok now intersect for the object space coordinates


obs=[   1    1    -14.218     -8.923;
        1    2     -1.014     -5.172;
        1    3      8.967     12.493;
        1    4      9.645     29.359;
        1    5      2.515      0.835;
        2    1     -8.043     -3.307;
        2    2      4.528     -2.073;
        2    3      9.765     13.540;
        2    4     -5.737     20.399;
        2    5     -0.415      2.446;
        3    1    -10.004     -8.592;
        3    2      9.345     -7.780;
        3    3     14.013     19.469;
        3    4    -21.869     32.213;
        3    5     -4.235      0.175];

XYZ=zeros(5,3);
B=zeros(6,3);
```

```
f=zeros(6,1);
% use linear algorithm and pseudo LS
for i=1:5
  for j=1:3
    idx=i+(j-1)*5;
    x=obs(idx,3);
    y=obs(idx,4);
    iv=[x-x0;y-y0;-foc];
    m=m3(kappa(j))*m2(phi(j))*m1(omega(j));
    uvw=m'*iv;
    c1=uvw(1)/uvw(2);
    c2=uvw(3)/uvw(2);
    row=(j-1)*2+1;
    B(row,:)=  [1 -c1 0];
    B(row+1,:)=[0 -c2 1];
    f(row)=  XL(j)-c1*YL(j);
    f(row+1)=ZL(j)-c2*YL(j);
    end
  if(i==1)
    B
    f
    end
  sol=inv(B'*B)*B'*f;
  XYZ(i,:)=[sol(1) sol(2) sol(3)];
  end
disp('linear intersection results');
XYZ

% temp
%plot(XYZ(:,1),XYZ(:,2),'g*');
%axis equal

% ok now we have all approximations - do the bundle block

% sigma0 squared is (0.005)^2
% then W=I
nobs=15
W=eye(30);
Q=eye(30);
prior_qf=1.0e06;
keep_going=1;
iter=0;
while(keep_going == 1)
  iter=iter+1
  B=zeros(30,33);
  for i=1:nobs
    row=(i-1)*2 + 1;
    phn=obs(i,1);
    ptn=obs(i,2);
    x=obs(i,3);
    y=obs(i,4);
    w=omega(phn);
    p=phi(phn);
    k=kappa(phn);
    X=XYZ(ptn,1);
    Y=XYZ(ptn,2);
    Z=XYZ(ptn,3);
    res=lincoll(x,y,w,p,k,XL(phn),YL(phn),ZL(phn),X,Y,Z,x0,y0,foc);
    %phn
    %ptn
    %x
    %y
    %w
    %p
    %k
    %XL(phn)
    %YL(phn)
    %ZL(phn)
    %X
    %Y
    %Z
    %res(1)
    %pause
    colpho=(phn-1)*6 + 1;
    colpnt=18  + (ptn-1)*3 + 1;
    B(row:row+1,colpho:colpho+5)=res(1:2,2:7);
    B(row:row+1,colpnt:colpnt+2)=res(1:2,8:10);
    f(row:row+1)=-res(1:2,1);
    end
```

```
  if(iter == 1)
    B
    f
    end
  N=B'*B;
  t=B'*f;
  C=zeros(7,33);
  g=zeros(7,1);
  for i=1:5
    idx=18 + (i-1)*3 + 1;
    X=XYZ(i,1);
    Y=XYZ(i,2);
    Z=XYZ(i,3);
    C(:,idx:idx+2)=[ 1 0 0;
      0 1 0;
      0 0 1;
      0 Z -Y;
      -Z 0 X;
      Y -X 0;
      X Y Z];
    end
  g=zeros(7,1);

  zer77=zeros(7,7);
  NE=[-N C'; C zer77];
  NEv=[-t; g];
  %keyboard
  M=inv(NE);
  sol=inv(NE)*NEv;
  del=sol(1:33); % this is the delta vector
  avgx=abs(sol(19))+abs(sol(22))+abs(sol(25))+abs(sol(28))+abs(sol(31));
  avgy=abs(sol(20))+abs(sol(23))+abs(sol(26))+abs(sol(29))+abs(sol(32));
  avgz=abs(sol(21))+abs(sol(24))+abs(sol(27))+abs(sol(30))+abs(sol(33));
  disp('corrections');
  [avgx avgy avgz]
  omega=omega + [sol(1) sol(7) sol(13)];
  phi  =phi   + [sol(2) sol(8) sol(14)];
  kappa=kappa + [sol(3) sol(9) sol(15)];
  XL=XL + [sol(4) sol(10) sol(16)];
  YL=YL + [sol(5) sol(11) sol(17)];
  ZL=ZL + [sol(6) sol(12) sol(18)];
  XYZ(1,:)=XYZ(1,:) + [sol(19) sol(20) sol(21)];
  XYZ(2,:)=XYZ(2,:) + [sol(22) sol(23) sol(24)];
  XYZ(3,:)=XYZ(3,:) + [sol(25) sol(26) sol(27)];
  XYZ(4,:)=XYZ(4,:) + [sol(28) sol(29) sol(30)];
  XYZ(5,:)=XYZ(5,:) + [sol(31) sol(32) sol(33)];
  % parameter order
  % w  p  k  XL YL ZL w  p  k XL YL ZL w  p  k  XL YL ZL x  y  z  x  y  z  x  y  z  x  y  z
  % 1  2  3   4  5  6 7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
  % with 7 constraints, full normals are 40 x 40
  % check convergence
  v=f - B*del;
  qf=v'*W*v;
  if(abs(qf - prior_qf)/qf < 0.00001)
    keep_going=0;
    disp('we converged');
    end
  if(iter > 10)
    keep_going=0;
    disp('no convergence');
    end
  prior_qf=qf;
  end

% error prop
alpha=M(1:33,1:33);
Qdd= -alpha;
v=f - B*del;
nphopnt=15;
vx=[v(1);v(3);v(5);v(7);v(9);v(11);v(13);v(15);v(17);v(19);v(21);v(23);v(25);v(27);v(29)];
vy=[v(2);v(4);v(6);v(8);v(10);v(12);v(14);v(16);v(18);v(20);v(22);v(24);v(26);v(28);v(30)];
rmsx=sqrt(vx'*vx/nphopnt)
rmsy=sqrt(vy'*vy/nphopnt)
Qvv=Q - B*Qdd*B';
trQvv=trace(Qvv);
% ok this last statement confirms that r=4
r=4;
sigma0_sqr=0.005^2;
test=v'*v/sigma0_sqr;
```

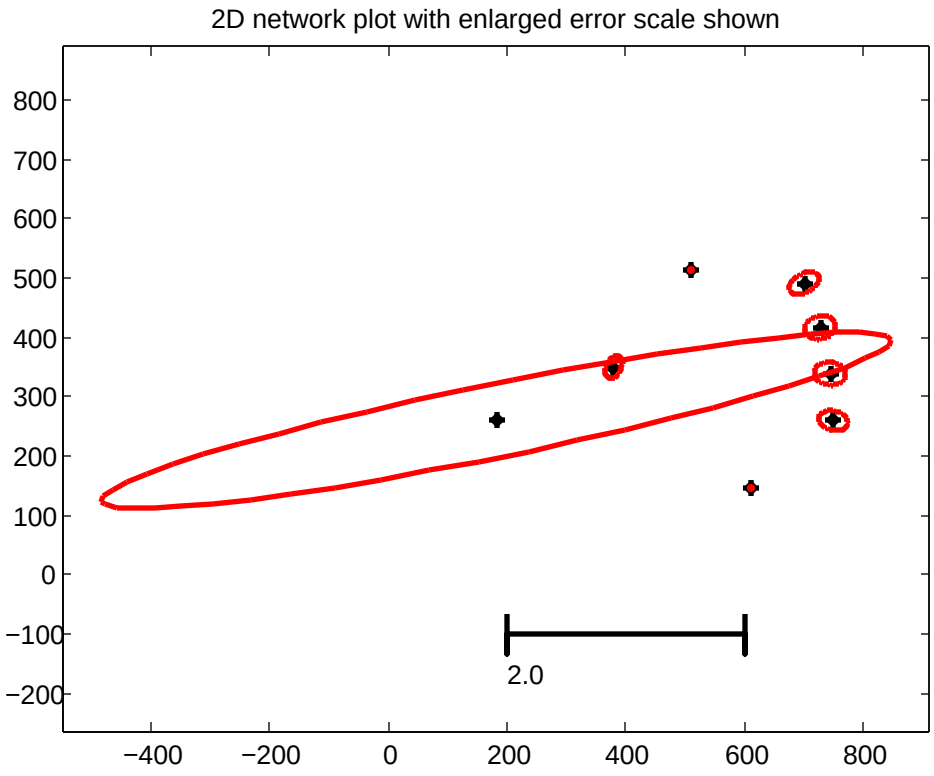
```
P1=.025;
P2=.975;
cv1=chi2inv(P1,r);
cv2=chi2inv(P2,r);
test
cv1
cv2

% ok pass, scale Qdd by prior sigma0_sqr

Sdd=sigma0_sqr*Qdd;
for i=1:5
  idx=19 + (i-1)*3;
  cov=Sdd(idx:idx+1,idx:idx+1);
  glob=1; % pass
  prob=0.5;
  factr=300;
  plot_conf_ell(cov,glob,r,prob,XYZ(i,1),XYZ(i,2),factr);
  plot(XYZ(i,1),XYZ(i,2),'k*','linewidth',2);
  hold on
  nudge=0.1;
  text(XYZ(i,1)+nudge,XYZ(i,2)+nudge,num2str(i));
  end

sb0x=5;
sb0y=4.7;
sb1x=sb0x + 1;
y1=sb0y-0.05;
y2=sb0y;
y3=sb0y+0.05;
x=[sb0x sb0x sb0x sb1x sb1x sb1x];
y=[y3 y1 y2 y2 y1 y3];
plot(x,y,'k-','linewidth',2);
text(5,4.5,'0.01');

title('50 pct conf ellipse terrestrial block with inner constraints');
axis equal
zoomout;
v
```


2D network plot with enlarged error scale shown
800
700
600
500
400
300
200
100
0
−100
−200
−400
−200
0
200
400
600
800
2.0

```
net2d_ap_final
iter =
     1
iter =
     2
iter =
     3
convergence OK
v =
  2.3378e-005
  -0.00012332
  -0.00016911
  -0.00011501
 -1.7663e-005
  -0.00011854
  -0.00033107
   0.00039221
 -3.7008e-005
  9.7852e-005
 -3.4269e-005
   0.00010475
   0.00039252
  -0.00033758
   0.00010558
vdms =
            0
            0
       4.8221
vdms =
            0
            0
      -25.437
vdms =
            0
            0
      -34.881
vdms =
            0
            0
      -23.722
vdms =
            0
            0
      -3.6433
vdms =
            0
            0
       -24.45
vdms =
            0
           -1
      -8.2875
vdms =
            0
            1
       20.899
vdms =
            0
            0
      -7.6335
vdms =
            0
            0
       20.183
vdms =
            0
            0
      -7.0685
vdms =
            0
            0
       21.606
vdms =
            0
            1
       20.963
vdms =
            0
           -1
```

```
       -9.631
vdms =
            0
            0
       21.778
final coordinates and radius
P =
          510
          515
       380.04
       350.17
          610
          145
       750.05
       259.99
       744.54
       339.32
       728.01
       417.13
       700.79
       491.86
        181.5
       260.37
       568.55
post adj statistics - 2-sided F-test alpha 0.05
test_stat =
       7.5358
cv1 =
       1.2373
cv2 =
       14.449
we pass
Sdd =
  Columns 1 through 6
  4.3082e-019  4.4437e-019  2.7126e-019  1.0766e-018            0            0
            0            0            0            0            0            0
 -7.0473e-019  1.8702e-018    0.0034942    0.0015893            0            0
 -3.0358e-018  1.9651e-019    0.0015893    0.0064773            0            0
 -5.9469e-019  -5.618e-019  6.4152e-021 -5.0082e-019            0            0
            0            0            0            0            0            0
 -4.3368e-019  1.6263e-018   1.703e-005 -4.5711e-005            0            0
  3.2526e-019 -4.3368e-019 -8.1998e-005 -2.1497e-005            0            0
            0  1.9516e-018   0.00018933   8.887e-006            0            0
  2.1684e-019 -2.6021e-018   0.00034964   0.00019748            0            0
  1.7347e-018  3.2526e-018  9.1659e-005 -4.6385e-006            0            0
            0 -3.0358e-018   0.00068041   0.00026211            0            0
            0   1.301e-018  -0.00021733 -1.8959e-005            0            0
  4.3368e-019  1.7347e-018   0.00081964   0.00016144            0            0
 -8.5001e-017 -5.1174e-017    0.0089478    0.0024917            0            0
  1.2143e-017  5.6379e-018    0.0021906   0.00076012            0            0
  Columns 7 through 12
 -4.5729e-019 -3.7198e-019 -2.7194e-019 -7.9852e-019 -5.9653e-019 -8.2399e-019
            0            0            0            0            0            0
   1.703e-005 -8.1998e-005   0.00018933   0.00034964  9.1659e-005   0.00068041
 -4.5711e-005 -2.1497e-005   8.887e-006   0.00019748 -4.6385e-006   0.00026211
  -8.431e-018  7.5515e-019 -9.2721e-018  1.2122e-018 -1.3483e-017 -1.8857e-018
            0            0            0            0            0            0
      0.01109    -0.001565    0.0098588    0.0001659    0.0079213    0.0017174
    -0.001565    0.0051969   -0.0029362     0.004053   -0.0030967     0.002408
    0.0098588   -0.0029362     0.012893  -0.00054816     0.012046    0.0020431
    0.0001659     0.004053  -0.00054816    0.0067237  -0.00092337    0.0049024
    0.0079213   -0.0030967     0.012046  -0.00092337     0.012728    0.0011826
    0.0017174     0.002408    0.0020431    0.0049024    0.0011826    0.0068449
    0.0052537   -0.0020139    0.0072264  -0.00093323    0.0093304   0.00071092
    0.0030228   0.00090186    0.0039836    0.0030309    0.0040886    0.0049614
     0.021414    -0.040565      0.16997    0.0076599      0.15552     0.033173
   -0.0078615   -0.0083818     0.032092     0.002163     0.038588    0.0093855
  Columns 13 through 16
 -5.7548e-019 -1.0948e-018   7.649e-018  1.5292e-018
            0            0            0            0
  -0.00021733   0.00081964    0.0089478    0.0021906
 -1.8959e-005   0.00016144    0.0024917   0.00076012
  -5.844e-018 -2.4345e-018 -1.1393e-016 -2.8582e-017
            0            0            0            0
    0.0052537    0.0030228     0.021414   -0.0078615
   -0.0020139   0.00090186    -0.040565   -0.0083818
    0.0072264    0.0039836      0.16997     0.032092
  -0.00093323    0.0030309    0.0076599     0.002163
    0.0093304    0.0040886      0.15552     0.038588
```

```
                                        net2d_ap_final_lst.lst
   0.00071092    0.0049614     0.033173    0.0093855
     0.011202     0.003424    -0.020436     0.011279
     0.003424    0.0065641     0.019713     0.010999
    -0.020436     0.019713       7.9643       1.6133
     0.011279     0.010999       1.6133      0.39824
diary off
```

```
% net2d_ap_final.m 28-mar-09
% use added parameters for some of the constraints
% to solve hw2 #2
% first solve with conventional constraints and no a.p.'s
% under this scenario we have B:(15 x 14+3)=(15 x 17), C:(4+4 x 14+3)=(8 x 17)
% N:(17 x 17), Z:(8 x 8)
% taken from the program below - allow for general constraints for testing
% solve by [ -N  CT ][Del] = [-t]
%          [  C   0 ][kc ]   [g ]
% allow for fixed points, inner constraints, etc. with general plotting
% strategy
%1 1 7 6 17 15 31.0
%2 1 6 5 12 39 57.7
%3 1 5 4 9 54 20.6
%4 1 4 3 28 9 7.8
%5 1 3 2 53 22 45.6
%6 2 1 7 27 55 11.1
%7 2 7 6 12 57 33.2
%8 2 6 5 12 34 31.2
%9 2 5 4 11 59 37.7
%10 2 4 3 28 2 12.6
%11 3 2 1 33 8 18.6
%12 3 1 7 29 47 11.1
%13 3 7 6 8 45 12.8
%14 3 6 5 11 16 22.8
%15 3 5 4 15 54 25.9

% (hw4_sol.m  3-nov-08)
% (solve braced quad for hw4)

X=[510;380;610;750;744.453;727.919;700.721;180];
Y=[515;350;145;260;339.329;417.113;491.840;260];
R=570;
P=[X(1);Y(1);X(2);Y(2);X(3);Y(3);X(4);Y(4);X(5);Y(5);X(6);Y(6);X(7);Y(7);X(8);Y(8);R];
% 17 x 1 parameter vector X(8),Y(8),R are center and radius of circle

degrad=180/pi;

% obs: seq_num at from to D M S
obs=[1 1 7 6 17 15 31.0;
2 1 6 5 12 39 57.7;
3 1 5 4 9 54 20.6;
4 1 4 3 28 9 7.8;
5 1 3 2 53 22 45.6;
6 2 1 7 27 55 11.1;
7 2 7 6 12 57 33.2;
8 2 6 5 12 34 31.2;
9 2 5 4 11 59 37.7;
10 2 4 3 28 2 12.6;
11 3 2 1 33 8 18.6;
12 3 1 7 29 47 11.1;
13 3 7 6 8 45 12.8;
14 3 6 5 11 16 22.8;
15 3 5 4 15 54 25.9];

n=15;
n0=9;
% 2 angles from endpoints of known baseline to each other point
% except only 1 angle needed to the 4th point on circle
r=6;
c=15;
u=17;
s=8;
% c+s=23, r+u=23 check

siga=(60/3600)/degrad;
sa2=siga^2;
sigma0_sqr=1;
w=ones(1,15);
w=w/sa2;
W=diag(w);

th=zeros(15,1);
for i=1:15
  D=obs(i,5);
  M=obs(i,6);
  S=obs(i,7);
  th(i)=(D+M/60+S/3600)/degrad;
  end
```

```
pidx=[1 3 5 7 9 11 13 15];

keep_going=1;
iter=0;
while(keep_going == 1)
  iter=iter+1
  B=zeros(n,u);
  f=zeros(n,1);
  rwidx=0;

  for i=1:15
    rwidx=rwidx+1;
    at=obs(i,2);
    from=obs(i,3);
    to=obs(i,4);
    rs=angle2d(th(i),at,from,to,X,Y);
    B(rwidx,pidx(at))    =rs(2);
    B(rwidx,pidx(at)+1)  =rs(3);
    B(rwidx,pidx(from))  =rs(4);
    B(rwidx,pidx(from)+1)=rs(5);
    B(rwidx,pidx(to))    =rs(6);
    B(rwidx,pidx(to)+1)  =rs(7);
    f(rwidx)=-rs(1);
    end

  % ok do not need to eliminate columns as before !!
  % will have singular N

  N=B'*W*B;
  t=B'*W*f;

  % ok now define the constraint equations into C matrix and g
  % first we do conventional (hw4-08) approach

  C=zeros(8,17);
  g=zeros(8,1);
  C(1,1)=1;
  g(1)=-(X(1)-510);
  C(2,2)=1;
  g(2)=-(Y(1)-515);
  C(3,5)=1;
  g(3)=-(X(3)-610);
  C(4,6)=1;
  g(4)=-(Y(3)-145);
  rs=distance2d(R,8,4,X,Y);
  C(5,pidx(8))  =rs(2);
  C(5,pidx(8)+1)=rs(3);
  C(5,pidx(4))  =rs(4);
  C(5,pidx(4)+1)=rs(5);
  C(5,17)=1;
  g(5)=-rs(1);
  rs=distance2d(R,8,5,X,Y);
  C(6,pidx(8))  =rs(2);
  C(6,pidx(8)+1)=rs(3);
  C(6,pidx(5))  =rs(4);
  C(6,pidx(5)+1)=rs(5);
  C(6,17)=1;
  g(6)=-rs(1);
  rs=distance2d(R,8,6,X,Y);
  C(7,pidx(8))  =rs(2);
  C(7,pidx(8)+1)=rs(3);
  C(7,pidx(6))  =rs(4);
  C(7,pidx(6)+1)=rs(5);
  C(7,17)=1;
  g(7)=-rs(1);
  rs=distance2d(R,8,7,X,Y);
  C(8,pidx(8))  =rs(2);
  C(8,pidx(8)+1)=rs(3);
  C(8,pidx(7))  =rs(4);
  C(8,pidx(7)+1)=rs(5);
  C(8,17)=1;
  g(8)=-rs(1);


  z88=zeros(8,8);
  Mx=[-N C'; C z88];
  vc=[-t; g];
```

```
  fulldell=inv(Mx)*vc;
  del=fulldell(1:17,1);
  %keyboard
  P=P+del;

  X=[P(1) P(3) P(5) P(7) P(9) P(11) P(13) P(15)];
  Y=[P(2) P(4) P(6) P(8) P(10) P(12) P(14) P(16)];
  R=P(17);
  if(all(abs(del) < 0.00001))
    keep_going=0;
    disp('convergence OK');
    end
  if(iter > 10)
    keep_going=0;
    disp('failed to converge');
    end
  end

v=f-B*del
for i=1:15
  vdms=raddms(v(i))
  end

disp('final coordinates and radius');
P

% ok now post-adjustment statistics

iMx=inv(Mx);
Qdd=-iMx(1:16,1:16);
disp('post adj statistics - 2-sided F-test alpha 0.05');
test_stat=v'*W*v/1.0
cv1=icdf('chi2',0.025,r)
cv2=icdf('chi2',0.975,r)
if((test_stat > cv1) & (test_stat < cv2))
  pass=1;
  disp('we pass');
  Sdd=sigma0_sqr*Qdd
else
  disp('we do not pass');
  pass=0;
  sigma0_sqr_hat=v'*W*v/r;
  Sdd=sigma0_sqr_hat*Qdd
  end

% plot the points

plot([X(1) X(2) X(3) X(4) X(5) X(6) X(7) X(8)],[Y(1) Y(2) Y(3) Y(4) Y(5) Y(6) Y(7)
Y(8)],'k*','linewidth',2);
hold on

% plot the errors

err_factor=200;
for i=1:8
  %disp('plot error, point =');
  %i
  idx=(i-1)*2 + 1;
  cov(1:2,1:2)=Sdd(idx:idx+1,idx:idx+1);
  prob=0.5;
  plot_conf_ell(cov,pass,r,prob,X(i),Y(i),err_factor);
  end


% proper aspect ratio
axis equal

% adjust scale
lmt=axis;
xrange=lmt(2)-lmt(1);
yrange=lmt(4)-lmt(3);
x5pct=0.05*xrange;
y5pct=0.05*yrange;
axis([lmt(1)-x5pct lmt(2)+x5pct lmt(3)-y5pct lmt(4)+y5pct]);

% network scale bar
%barx1=lmt(1) + x5pct;
%bary1=lmt(3) + y5pct;
%barx2=barx1 + 100;
```

```
%bary2=bary1;
%tick=10;
%pxvec=[barx1 barx1 barx1 barx2 barx2 barx2];
%pyvec=[bary1+tick bary1-tick bary2 bary2 bary2-tick bary2+tick];
%plot(pxvec,pyvec,'b-','linewidth',2);
%textx=barx2 + 0.5*x5pct;
%texty=bary2;
%text(textx,texty,'100 m Network');

% error scale bar
%barx1=lmt(1) + x5pct;
%bary1=lmt(3) + 2*y5pct;
%barx2=barx1 + 0.1*err_factor;
%bary2=bary1;
%tick=15;
%pxvec=[barx1 barx1 barx1 barx2 barx2 barx2];
%pyvec=[bary1+tick bary1-tick bary2 bary2 bary2-tick bary2+tick];
%plot(pxvec,pyvec,'r-','linewidth',2);
%textx=barx2 + 0.5*x5pct;
%texty=bary2;
%text(textx,texty,'0.1 m Errors');

%title('Plot of Braced Quad: Network and Errors');

% error scale bar
sb0x=200;
sb0y=-100;
sb1x=sb0x + 2*err_factor;
tick=xrange/40;
y1=sb0y-tick;
y2=sb0y;
y3=sb0y+tick;
x=[sb0x sb0x sb0x sb1x sb1x sb1x];
y=[y3 y1 y2 y2 y1 y3];
plot(x,y,'k-','linewidth',2);
text(sb0x,sb0y-2*tick,'2.0');

title('2D network plot with enlarged error scale shown');
```