Data description (Phase 1)

The test consist of two phases. The first phases deals with the system calibration based on two calibration flights followed by the direct determination of the exterior orientation without using any ground control and tie-points, the second phase deals with the integrated bundle block adjustment of GPS/IMU and AT with a minimum of GCP.
This document describes the test data for phase 1 only.

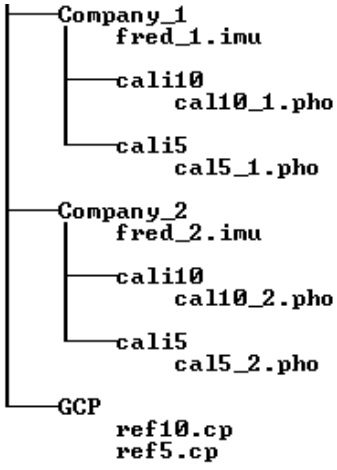
Two systems were used for data acquisition: The POS/AV DG-510 from Applanix of Toronto, Canada flown by Fotonor AS and the AEROControll II from IGI mbH Hilchenbach, Germany flown by Fjellanger WiderØe AS. Botch companies flew two so called Calibration Flights over the well distributed test field Fredrikstad, one in image scale 1:5000 and another one in the image scale 1:10000. After the two Calibration Flights the actual Test Flight in 1:5000 was carried out.

The first flying Company (Company_1, with the image number ID 1001 until 1283) captured the aerial images at a flying height of approximately 1600 m (corresponding to an image scale 1:10000) followed by images at a flying heights of around 800m (equivalent to an image scale 1:5000), followed by the Test Flight 1:5000.

The second flying company (Company_2, image number 2004 until 2455) flew the first Calibration Flight in image scale 1:5000 and then the second Calibration Flight in the image scale 1:10000, followed by the actual Test Flight 1:5000.

File structure:

The test data is contained in a file "archive" created with the archive utility for Windows95/98/2000 and NT[1], namely WINZIP (see www.winzip.com). This file is called ***gps-imu.exe*** and is a self-extracting ZIP file created with the WinZip Self extractor. A self-extracting ZIP file is an executable program file that includes a ZIP file and software to extract the contents of the ZIP file. You can execute a self-extracting ZIP file just as any other WINDOWS-program. After the extraction of the ZIP-file, directories and files in the "unzip to" directory the following file structure should be available. The format for all data is the ASCII/DOS (carriage return with CR/LF) format.



[1] If you use another operating system, please notify us at wegmann@ipi.uni-hannover.de for further instruction. Don't forget to name the operating system you are using.

description (non-italic = Directory; italic = File):

Company_1(2):	Test data for the first TEST-PHASE from the first (second) GPS/IMU system.
Fred_1(2).imu	Initial values of exterior orientation for each image exposure time from the first (second) GPS/IMU-system (Reference station: FREDRIKSTAD situated in the test field).
Cali10:	The Test data for the Test Flight 1:10000.
Cal10_1(2).pho	The image coordinates of GCP and tie points (see also Image Coordinates) for the first (second) company.
Cali5:	Test-Data for the Test Flight 1:5000.
Cal5_1(2).pho	The image coordinates of GCP and tie points for the first (second) company.
GCP:	The Ground Control Points
Ref10.cp	The GCP UTM/EUREF89 coordinates and ellipsoidal heights for the Calibration flight 1:10000 (see also Ground Control Points).
Ref5.cp	The GCP UTM/EUREF89 coordinates and ellipsoidal heights for the Calibration Flight 1:5000

GPS/IMU data

This file contains the initial positions of the camera perspective centre and the roll, pitch and yaw angles [UTM/EUREF89], all determined by the GPS/IMU systems, for each image acquired during the complete mission.

Processing of the raw GPS/IMU data into flight trajectories of the camera projection centre as well as roll, pitch and yaw as a function of time with 200 Hz were performed by Applanix and IGI, respectively. They also provided the instant of exposure of each image. The interpolation of the initial perspective centre position and the values roll, pitch and yaw for each image from these data was carried out at Institute for Photogrammetry and Engineering Surveys (IPI), University of Hanover using linear interpolation. Thus, GPS/IMU test data consist of the initial perspective centre position and the values roll, pitch and yaw for each image exposure time (approximately 0.5Hz) from the GPS/IMU-systems given in the mapping frame UTM/EUREF89[2]. The position is defined in meters and the attitude is defined in degrees[3]. The sequence of the rotations is roll (primary), pitch (secondary) and yaw (tertiary) from the body frame and the mapping frame.

Format for GPS/IMU data:

<image_no.><UTM East [m]><UTM North [m]><Ellip. Height [m]><GPS time [sec]><ROLL[deg.]><PITCH[deg.]> <YAW[deg.]>

An example with 4 GPS/IMU data from Company_2:

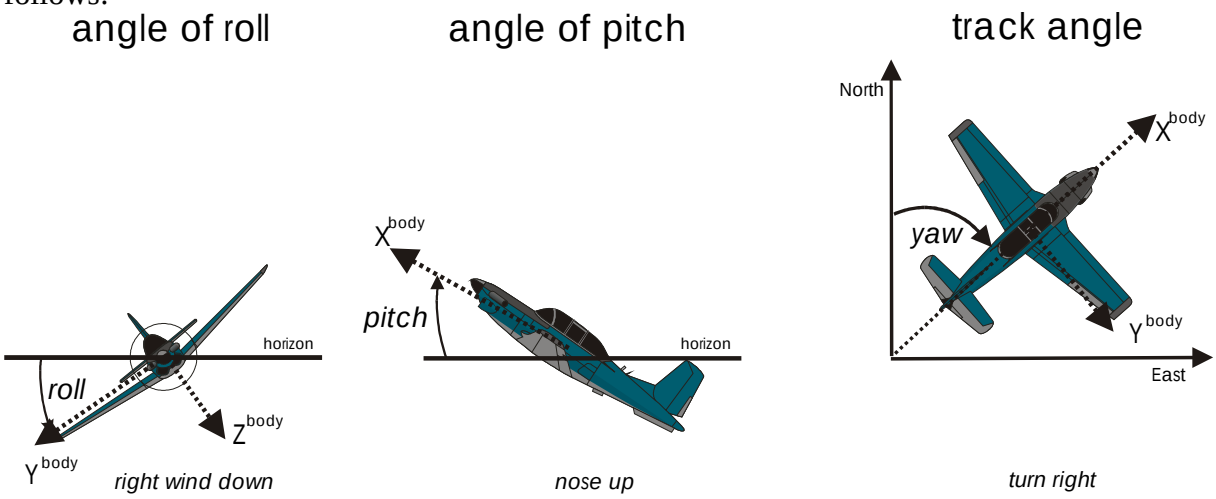
[2] For precise computation it is advantageous to transform the UTM coordinates and the values for roll, pitch and yaw into a local cartesian coordinate system prior to system calibration. The final results should be transformed back into the UTM system (Note that Geographic North and UTM North differ by the meridian convergence angle).

[3] 360 degrees equal a full circle, fraction of a degree are given in the decimal system, NOT in minutes and seconds.

Integrated Sensor Orientation
data description

No.	East	North	Height	time	roll	pitch	yaw
2010	608148.575	6566178.423	844.352	376773.234	-1.50577	-0.04527	22.98447
2011	608341.709	6566601.014	844.071	376779.159	-0.86239	-0.00251	22.79260
2012	608538.242	6567022.097	844.031	376785.085	0.12929	-0.07859	23.20116
2013	608739.945	6567441.021	842.810	376791.010	0.76162	0.00443	23.84783

The definition (according to ARINC 705) of the roll-, pitch- and yaw angles is defined as follows:



The body frame is defined as:

- X^{body} = roll axis, positively forward
- Y^{body} = pitch axis, positively to the right
- Z^{body} = yaw axis, positively downward

Note that in order to use the yaw-angle as an initial value for kappa, 180 degrees must be added for the data of company_2, because the camera was mounted with the x-axis of the image coordinate system pointing to the back of the aircraft.

Ground Control Points (GCP)

The test field Fredrikstad near the capital Oslo has well distributed signalised GCP with UTM/EUREF89 coordinates and ellipsoidal heights known better than 1 cm accuracy and is maintained by the Department of Mapping Sciences (IKF), Agricultural University of Norway in Ås.
The Calibration Flight 1:5000 contains 13 GCP. Both strips (east/west and north/south) consist of 7 GCP. The Calibration Flight 1:10000 contains 13 regularly space GCP.

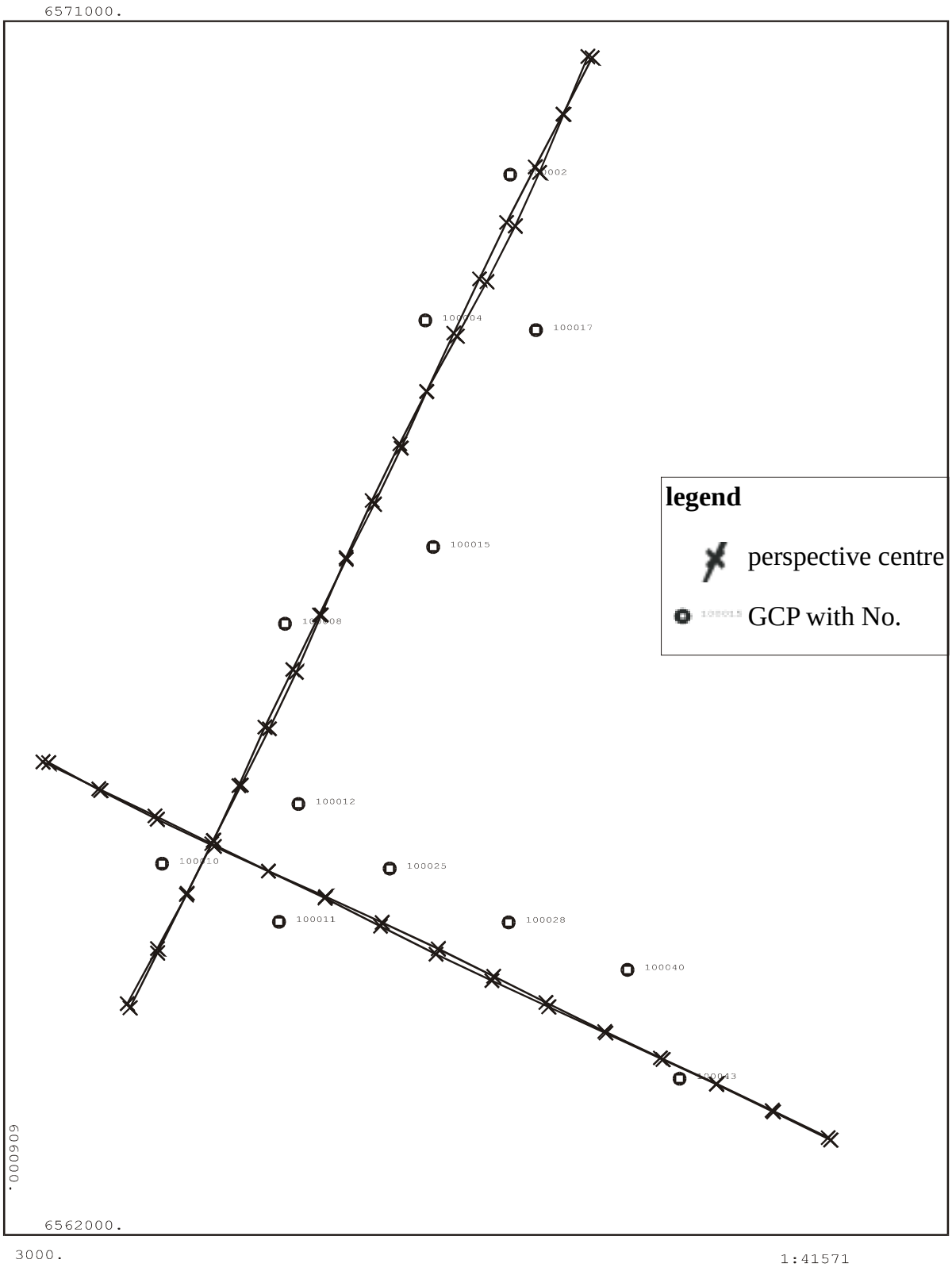
Format for ground control points:

<Point No.> <UTM East [m]> <UTM North [m]> <Ellip. Height [m]>

An example with 2 GCP:

100002	609754.080	6569860.890	75.177
100004	609122.879	6568780.318	82.488

Calibration Flight
1:5000



Calibration Flight
1:10000

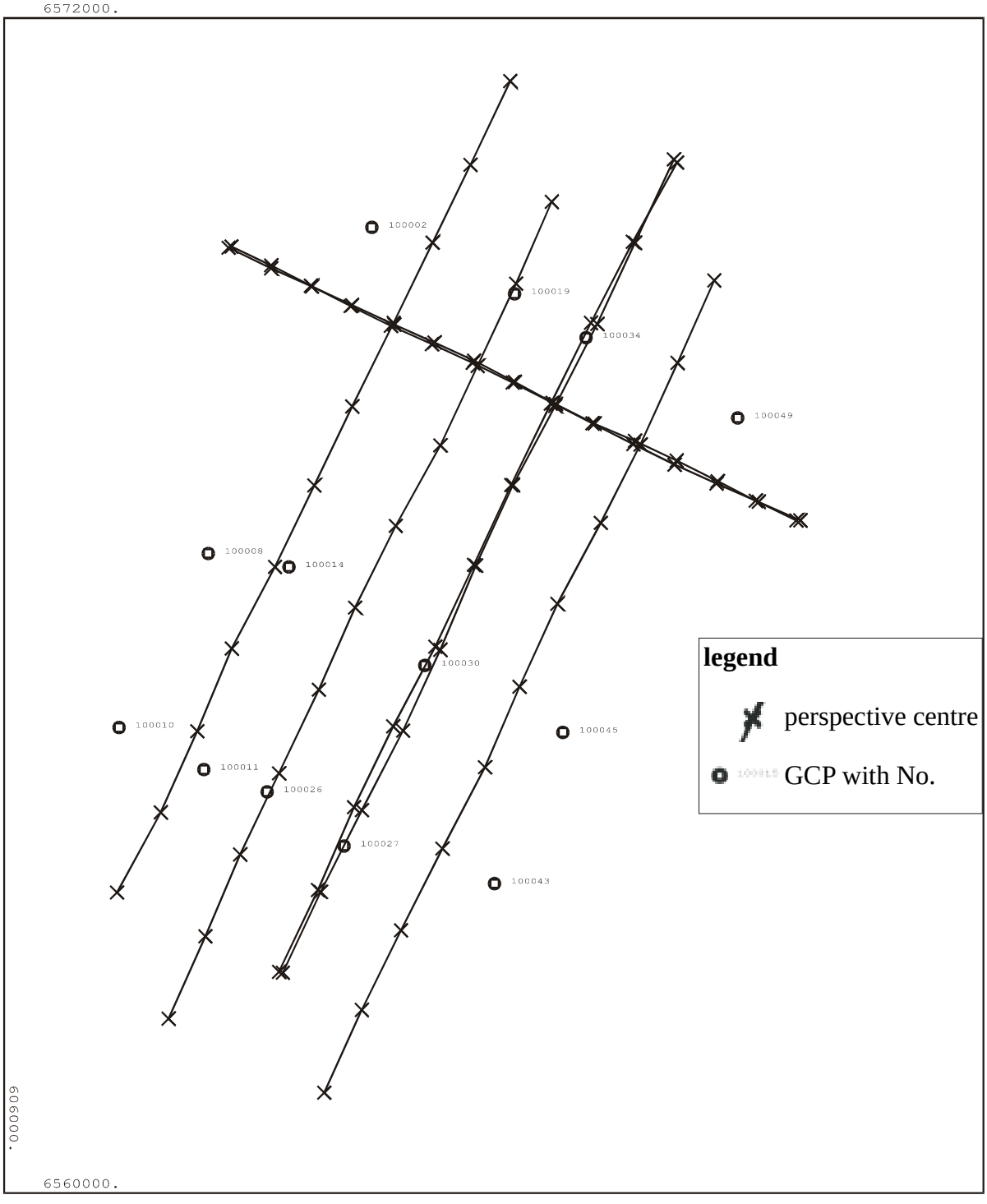


Image Coordinates

The IPI measured the image coordinates of the GCP and additional tie points in the Calibration Flight images using an analytical plotter (Zeiss P1). The origin of the image coordinate system is the principal point of autocollimation (PPA). The image coordinates have been corrected for lens distortion, but not for refraction and earth curvature.
The unit of image coordinates is microns. Behind the image number the focal length is located (also in microns) followed by the image coordinates in mono arrangement and the end symbol –99.

Format for Image coordinates:

<image_number> <focal_length in microns> .0

<point_number> <x_coord in microns> <y_Coord. in microns>
...
-99 .0 .0
<image_number> <focal_length in microns> .0
...
-99 .0 .0

An example with two images (number 101 and 102) and 7 conjugate points is given next:

```
101   153689.0        .0
2002   -7327.0    96739.0
3004    8848.0    54816.0
3006   -5714.0     -271.0
3007   -3866.0   -58076.0
3008   -4836.0  -104457.0
2009   48608.0  -104627.0
2011   41321.0   -59549.0
-99       .0        .0
102   153689.0        .0
2002 -106159.0    96076.0
2004  -88728.0    53029.0
2006  -99296.0    -2451.0
2007  -97630.0   -59844.0
2008  -99301.0  -105170.0
2009  -43429.0  -104367.0
2011  -53145.0   -60830.0
-99       .0        .0
```

Participant's results be delivered back to the pilot centre

The results of each participants consist of

- The computed parameters of the system calibration and a detailed report, clarifying which input data has been used for the calibration.
- The computed exterior orientations (elements in UTM/EUREF89) for each image exposure time of the two flights contained in fred_1(2).imu.

- A detailed description of the employed mathematic model and strategy for the determination of the system calibration parameters (GPS shifts, boresight misalignment, possibly additional parameters).
- Comments on the potential and/or problems of the direct sensor orientation with these test data and on the test data set (GCP distribution, tie-points distribution, test flight configuration etc.).
- The filled out questionnaire. The questionnaire will be sent to the test participants at the beginning of October.

These results should be communicated back to the pilot centre on floppy disk or via email in ASCII Format.

Format requirements

System calibration parameters:

- The computed **GPS shift parameters** in meter in the following format
  <East[m]> <North[m]> <Height[m]>
- **Boresight misalignment**, the 3 angles of difference between IMU and camera- axis in degree (specify definition in attached report)
- **The additional calibrations parameters**, as described in the report, with appropriate units.

The **exterior orientations** for each image exposure time given in file fred_1(2).imu.

- XYZ Position in meter
  <Image no.> <X[m]> <Y[m]><Z[m]>
- Omega, phi, kappa in degrees with
  omega(primary), phi (secondary), kappa (tertiary)

Deadline for delivery of results

October 31st, 2000