PROCEDURES FOR FAST ORIENTATION OF LEICA ADS40 IMAGERY
EXTENDED ABSTRACT

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ABSTRACT

Every year environmental disasters such as storms, floods and earthquakes cause thousands of deaths and a great deal of damage around the world; the price to pay in terms of human lives and material damages is always considerable. The scientific community is involved in the endeavour for preventing disaster, monitoring environmental problems and supporting rescue efforts.
Geomatics is heavily concerned with all the aspects of disaster management. The paper focuses on the Leica ADS40 digital camera as a tool for performing post-disaster rapid mapping: in particular, the direct georeferencing mode is analyzed. The camera's main characteristics are depicted. Three different case studies are taken into consideration. Productivity and geometric accuracy are assessed.

1. INTRODUCTION

Many different surveying systems are used to support disaster and crisis management: according to the sensor type, optical, radar and laser devices; concerning the platform carrying the sensor, terrestrial, airborne and space-borne. Within aerial optical sensors, many solutions are available, depending on the format of the camera used and on the aerial vehicle adopted.
Large-format digital aerial cameras can be effectively used for crisis management and present some advantages: very high acquisition rates, image quality, very accurate exterior orientation parameters (EOPs) measured by GPS/IMU systems.
The ADS40 camera (produced and delivered by Leica Geosystems, Switzerland) and its successors, ADS40-SH52 and ADS80 can be useful for crisis management. They can operate at several thousand meters and the corresponding image footprint can be as large as 10 km, cross track; they acquire at the same time the panchromatic (PAN), RGB and near-infrared (NIR) channels, so that the panchromatic, colour and colour-infrared (CIR) images can be formed; finally they are equipped with very accurate and reliable GPS/IMU devices which directly measure EOPs.
The paper focuses on fast orientation methodologies for the Leica ADS40-SH52 camera, therefore the direct georeferencing methodology is uniquely considered. Mainly, geometric accuracy is investigated.

Block name	Average flying height [m]	GSD [cm]	Block size [Km^2]
L'Aquila	2500	25	572
Emilia	6800	68	5000
Pavia	2000	20	67

Table 1. Essential parameters of the considered blocks.

Three datasets are taken into consideration, acquired by the BLOM-CGR Company, located in Parma, Italy. The Company is equipped with several aerial cameras, analogue and digital, including two second-generation ADS40 cameras; it has a fleet of 9 aircrafts including a pressurized Lear Jet 25C, which can operate at high flying altitudes and allows for quickly reaching the areas to be surveyed.

Table 1 summarizes most essential parameters of the datasets considered. The *L'Aquila* dataset was acquired above the L'Aquila city after the April 2009 earthquake, so it refers to a real disaster management situation. The *Emilia* block covers a large region: productivity, in terms of square kilometres acquired per hour of flight, is assessed, as well as geometric accuracy, even though with a limited number of check points. The *Pavia* dataset was acquired above a photogrammetric test site and a rigorous geometric accuracy assessment of direct georeferencing is performed.

2. THE *L'AQUILA* DATASET

L'Aquila is the capital of Abruzzo, a region situated in central Italy. On 6^{th} April 2009, at 3:32 local time, an earthquake of 5.8 on the Richter scale was registered. The epicentre was near L'Aquila, which, together with surrounding villages, suffered most damage. Three-hundred and seven people died, making this the deadliest earthquake that has hit Italy in the last 30 years.
A few hours after the earthquake, BLOM-CGR started the operations in order to acquire a photogrammetric coverage above the city and the surrounding area. Figure 1 shows the damage to the dome of the Chiesa delle Anime Sante, while Figure 2 shows a rural building which has collapsed in a suburb of the city.

Figure 1. Detail of the old town of L'Aquila - Chiesa delle Anime Sante, Piazza Duomo.

Figure 2. Detail of a suburban area of L'Aquila.

3. THE *EMILIA* CASE STUDY

Every three years, since 1988, the BLOM-CGR (formerly CGR) Company has regularly acquired images of the whole Italian territory, within the TerraItaly project. The first flights were performed with analogue cameras, while more recently the ADS40 has been used. The average relative flying height of the project is 6000 m, corresponding to a ground resolution of 60 cm.
The TerraItaly flying configuration appears well suited for disaster management, when the hit territory is region-sized. The *Emilia* block was acquired in July 2008 above the western part of Emilia. The flight consists of eight East-West strips embracing an area larger than 5000 km^2: each strip is approximately 120 km long. The territory imaged in the dataset is varied and contains flat areas, mountains and the sea, so it is very challenging for data processing.
The whole block was acquired in roughly two hours, therefore productivity is 3100 square kilometres per hour and, considering the Lear Jet plane autonomous flight, it is possible to survey at least 6000 square kilometres per flight, if the airport is not too far.

4. THE *PAVIA* DATASET

In mid March 2008 a test flight was performed by the CGR Company with a Casa 212 plane equipped with a second-generation Leica ADS40 camera with an SH52 sensor head. Three sub-blocks were acquired at the 800 m, 2000 m and 6000 m flying heights above the Pavia test site.
The 2000 m block was depicted for proper assessment of geometric issues and consists of four East-West strips and a cross one. GSD value is approximately 20 cm.
The Pavia Test Site was established by the Geomatics Laboratory, University of Pavia, Italy. It is equipped with 186 artificial control points (AGCPs), represented by white squares having a size of 35 cm painted on the pavement, and 56 natural control points (NGCPs). Also, there are 50 larger artificial markers (BAGCPs) having a size of 60 cm, created in order to support ADS40 experiments. The various control points homogeneously cover the whole test-site, which is 6 x 4.5 km wide.

5. GEOEMTRIC ACCURACY ASSESSMENT OF DIRECT GEOREFERENCING FOR THE *EMILIA* AND *PAVIA* DATASETS

Only direct georeferencing is assessed, as the paper is concerned with rapid mapping.
For the sake of clarity, we remind the reader that direct georeferencing implies the *direct* use of the exterior orientation parameters coming from the GPS/IMU system, without any refinement; no ground control points (GCPs) nor tie points (TPs) are used.
Data processing was performed with the commercial software supplied by Leica: GPro 3.3 and Orima 9.1. This is the same configuration used by the BLOM-CGR company which supplied the data.
The assessment procedure is summarized: check points (CKPs) are inserted into the bundle-block adjustment as tie points, so that their object-space coordinates are determined within the adjustment. These object coordinates are then compared with those measured by GPS. We can say that DG has been performed because aerial triangulation was run assigning very high constraints on the given trajectory values.

5.1 Assessment of the *Emilia* dataset

The block, consisting of 8 East-West strips, was acquired for industrial purposes and not for science. There is a limited number of check points and their accuracy is not very high, but sufficient. Nevertheless, there are 14 CKPs, 6 known in all components and 8 only in z.
Table 2 shows results for both CKP sets: for the 6 full control points, the RMSEs are, in GSD units, respectively 0.8, 1.5 and 1.3 for the x, y and z components; for the 8 altimetric ones, the RMSE is, for z only, 0.7.

Set	# CKP	Comp	mean [m]	std [m]	rmse [m]
DG 3D CKP	6	**x**	-0.033	0.469	0.470
		y	-0.845	0.249	0.881
		z	0.612	0.508	0.795
DG Z CKP	8	**x**	-	-	-
		y	-	-	-
		z	0.302	0.276	0.409

Table 2. Geometric accuracy assessment of the *Emilia* dataset.

5.2 Assessment of the *Pavia* dataset

The block consists of 5 strips. As described earlier, 40 signalized check points are available for accuracy assessment. Table 3 shows geometric accuracy results: the RMSEs are, in GSD units, 0.65 in planimetry (X,Y) and 1.1 in altitude (Z).

Set	# CKP	Comp	mean [m]	std [m]	rmse [m]
DG	40	**x**	0.078	0.110	0.135
		y	-0.022	0.130	0.131
		z	0.107	0.192	0.220

Table 3. Geometric accuracy assessment of the *Pavia* dataset.

Geometric accuracy proves to be almost within pixel size, for all the components and this is a very good result for direct georeferencing.

6. CONCLUSION

The paper deals with the use of the Leica ADS40-SH52 camera for rapid mapping in disaster management. Therefore, only fast orientation methodologies are considered, such as direct georeferencing. For the *Emilia* block, geometric accuracy is below 1.5 GSD, for all the components. For the Pavia block accuracy figures are not greater than 1 GSD.
The Leica ADS40 camera has several strengths for disaster management: it acquires 5 radiometric channels at a time and three stereoscopic images; it is highly productive, with respect to the GSD; it has a good geometric accuracy even in the direct georeferencing mode.