EuroSDR initiative on camera certification
May 2009

European Digital Airborne Camera Certification – EuroDAC²

ICC Barcelona, April 1-2, 2009

Meeting Notes (Status, May 07, 2009)

Attendees

- R. Alamus (ICC Barcelona, Spain)
- L.-E. Blankenberg (Blom Geomatics, Norway)
- M. Pierrot Desseilligny (IGN France)
- M. Cramer (Universität Stuttgart, Germany)
- G. Grenzdörffer (Universität Rostock, Germany)
- E. Honkavaara (FGI Finland, Masaala)
- Additional support from experts from ICC Barcelona, namely
  - J. Talaya & W. Kornus (for discussions on geometry)
  - R. Arbiol, L. Martinez & A. Ruiz (for discussions on radiometry)

Status

The EuroDAC² initiative was officially launched in May 2007. First meeting of the core competence group took place in Castelldefels, Spain at January 30, 2008, parallel to the EuroCOW workshop. Second meeting then was held at IGN Paris, September 24-25, 2008. The latest 3rd meeting took place at ICC Barcelona, April 1-2, 2009. Goal of this meeting was discussion of latest project progress, alignment of activities and definition of future project steps. During the IGN meeting in fall 2008 three main activities were identified, whose status will be reported in the following:

1. Guidelines for the design of test fields and processes for geometric system performance verification/validation/certification
2. Guideline for the design of test fields and processes for the radiometric system performance verification/validation/certification
3. Current projects on digital airborne camera certification/standardization
4. Support from EU / ESA

Working Package Geometry

The work focusing on geometric aspects is mainly driven by team members L.-E. Blankenberg, S. Bovet and G. Grenzdörffer. Some thoughts on the future design of geometric test sites were presented by G. Grenzdörffer ().

Calibration processes have to be automatic in almost all parts not only to speed up the processes but mainly to guarantee for objective results. This relates to the in-site calibration. Today the camera manufactures have different intervals for the sensor re-calibration: The Intergraph DMC system is only re-calibrated on request, whereas the Vexcel Imaging Ultracam should be re-calibrated every year. This most likely relates to their manufacturer related lab calibration process. The calibration is only one step within the system process chain. By calibration report the quality of this one process step is proven, but finally the quality of the sensor products is of concern.

It is not yet fixed which information has to be delivered in the manufacturers' calibration reports. The role of the calibration protocols obviously has changed. In the past this protocol was used to deliver the fiducial mark coordinates and the distortion of the analogue mapping camera. Today the report on digital camera calibration is more or less a check list which camera tests successfully have been passed within the calibration process. Different levels of calibration protocols are offered to users – the extended report for experienced operators or a short version report for standard users.

Obviously there is an increasing demand in higher resolved airborne images and products. In Finland the ortho photos are flown with 30cm GSD, ICC Barcelona just recently has changed from 50cm GSD to 25cm GSD. In Norway 10cm GSD is used for urban areas, ortho photos in open landscape are done with 20cm GSD. Similar situation can be seen in Germany. In some parts of the USA 1-inch images are already requested. All this is of influence on the layout of GCP signalisation, the size of the calibration field and the number of control and check points.

In order to serve as reference points the control point accuracy should be determined 10 times better than the expected accuracy of object point determination. With increasing resolutions control point reference accuracy better than 1cm will become necessary. Accuracy of image point measurements in the range of 0.05 – 0.1pix can be easily achieved. This is by far good enough – corresponding values cannot be reached in object space.

Coded targets, which are standard for close range applications, may also help to automate airborne sensor in-site calibration processes. Nevertheless, restrictions due to maximum size of targets (related to the aspired GSD ranges) and the increased effort in maintenance (especially when using complex target structures) have to be considered. For automatic point measurements targets size between 5-25 pix diameter are necessary, which yields in 2.5m targets (max.) even when relatively high resolved 10cm GSD is considered. From practical point of view the size of signalised targets on the ground should not exceed 1m.

The number of control and check points relates to the level of calibration: standard, advanced and complete, i.e. in how much detail the system is analysed. Is the flight only done for the verification of the system performance or should system parameters re-calibrated from the flight? According to the calibration levels the calibration flight pattern and the size of the calibration site is different. A number of 50/60 signalized points seems to

be appropriate, a sub-set of them being used as independent check points. Still the question how the check points are finally used in quality estimation has to be answered. Since check points are typically signalized points, they are manually measured in all available images. This might be different for points which are obtained from automatic image matching. Dependent on the quality of the matching software such automatic points are not matched in all participating images. Thus, not all possible available image rays are used for object point determination. Since the number of image rays influences the geometric performance of object point determination the estimations from signalized check points might be too optimistic. One may discuss to only use 2-3 ray check points for check point analysis.

The optical resolving power of is an important quality factor and also was determined in former analogue mapping camera lab calibrations. Besides the optical part itself, the resolving power is also influenced by flying height, atmosphere, FMC/TDI, stabilized mount, pre-processing of image data (digital image development). Line targets or Siemens star resolution targets are popular targets to determine the resolving power of the system.

Working Package Radiometry

The second main topic is dealing with the radiometric performance and calibration of digital airborne cameras. This work is mainly done by E. Honkavaara supported by R. Reulke and M. Pierrot Desseilligny. Parallel to the EuroDAC² initiative the EuroSDR project on radiometric performance of digital airborne sensors is also co-chaired by E. Honkavaara. This project also was presented and discussed besides the development of guidelines for the radiometric system calibration. The ICC radiometry team (R. Arbiol, L. Martinez and A. Ruiz) also presents the findings from the Banyoles test flights with DMC and CASI systems. A full paper was already published at the Geomatics Week in Barcelona 2009 (). This data is also part of the EuroSDR project on radiometric performance of digital airborne sensors. The presentation from E. Honkavaara on this EuroSDR project can be accessed (). The later presentation on first ideas on the development of guidelines for radiometric testing of systems in test fields is available ().

Although radiometric processing and analysis of digital airborne sensors show improvements still the same basic questions are discussed like in 2004/05. Radiometric processing requires considerable labour. The whole process chain has to be considered to obtain quantitative imagery, including the data recording from several available sensors, the sensor calibrations and the data (pre-)processing, where different settings are possible.

There is a clear need for future investigations on transparent documentations, calibration and processing, certification and standardizations.

The ICC radiometric test flights in Banyoles (2005 & 2008) have shown that radiometric and colorimetric calibration is possible using DMC and CASI hyper-spectral scanner simultaneously. The most recent data will be used to improve the radiometric calibration with radiance and reflectance method. During the flights colour targets of plastic-textile fabrics with approximate size of 3x3m² have been used. Their spectral responses were measured by spectrometers, besides additional natural targets. Several profiles in each area have to be measured then. Such targets may also be used for later validation.

For spectral band classification coarser pixel resolutions are typically used; this is different for object based classifications.

The radiometric potential of digital airborne cameras should be used to add more value to the image data, for example results from (automated) land use classifications (only few 3-5 basic classes considered). Such is already done in the US and may help to increase acceptance of digital sensor technologies.

First experimental radiometric bundle block adjustment approaches are available. In the ICC approach one set of image parameters is estimated per image since different radiometry is possible due to the different camera settings for individual images. Modelling of physical situation is prefered, others rely on pure statistical methods (image dodging).

The complexity of radiometric system calibration and certification is obvious; during the meeting just a very first outline for a future guideline for radiometric system performance assessment was discussed.

Such guideline has to deal with radiometric validation, spectral validation, colorimetric validation, and PSF/spatial resolution measurement. Sensor wavelengths ranging from 400-2500nm and spatial resolutions of 0.03-1m have to be considered.

Future test field have to be equipped with ground measurement sensors which will collect reference data. The sensors should be monitored through the internet and all data can be loaded by the remote user directly. Even though, the effort for maintenance should stay within just a few days for each flight season.

Main problems to be faced, when designing radiometric guidelines, are like follows: The requirements have to be defined based on the requirements of (nonexistent) applications, (improving, largely unknown) reasonable performance of systems and natural uncertainty of the task! All this has to be solved in future work.

Current other activities in Standardization / Certification

German Standards Organization DIN

The activities of the German Standards Organization (DIN) have already been mentioned. The DIN has developed a series of standards (DIN 18740 – Photogrammetric Products), whose first 4 parts are currently extended by three new parts. The DIN task force "Photogrammetry and Remote Sensing" coordinated by R. Reulke is responsible for these developments:

- Part 1: Requirements on image flights and analogue airborne images
- Part 2: Requirements on scanned airborne images
- Part 3: Requirements on ortho photos
- Part 4: Requirements on digital airborne cameras and digital airborne images (available fall 2007)

In progress / preparation:

- Part 5: Requirements on classification of optical remote sensing data (in final compilation phase already)

- Part 6: Requirements on digital height models (planned)
- Part 7: Requirements on geometrical data fusion (planned)

The USGS Quality Assurance Plan

The USGS has prepared a first draft version on the design of geometric test fields, which is open for discussion and can be accessed through http://calval.cr.usgs.gov/documents/InSituCalibrationRangeRequirementsV02.doc . As presented during the last ASPRS spring meeting 2009 about 6 geometrical test sites should be installed distributed throughout the US. The first and largest one will be close to Sioux Falls. The others will most likely be located in Oregon, Pennsylvania, Nevada, Georgia and Texas. Some of them may become quite large, sizes of 50km x 80km have been discussed. Obviously they also should be made available for calibration of satellite systems. The progress of USGS quality assurance can also be seen from their internet online presence: http://calval.cr.usgs.gov/digital_aerial_imaging_quality_assurance.php. Currently the following digital airborne cameras systems have been type certified: Applanix DSS 322 (Dec 2006), DSS 422 & DSS 439 (Sep 2007), Microsoft Vexcel Ultracam D (Dec 2006), Ultracam X (Jul 2008), Intergraph/ZI DMC (Dec 2006) and Leica ADS 40 (SH40, SH51, SH52) (Aug 2007).

ISO/TC 211 Geographic Information / Geomatics

In second half of 2008 activities of ISO/TC 211 in the field of remotely sensor calibration and validation started. After confirmation from EuroDAC² core group and USGS representatives W. Kresse applied for coordinator of this new working activity. Mid of December 2008 a new work item proposal on "Calibration, validation and certification of remote sensing sensors and data" was compiled and distributed through ISO. It was positively evaluated by ISPRS, EuroSDR, USGS, Australia, Canada, Japan and Great Britain. From that a first rough draft was proposed which has to be extended to a more substantial form till May 2009. It is mainly the sections on calibration, validation and certification where EuroDAC² input is desired and requested. The idea is to first prepare a technical specification which then will be changed to world-wide standard after 3-5 years.

EuroDAC² participation in EU / ESA activities

European Association of National Metrology Institute (EURAMET)

The European Union was requested to support the EuroDAC² initiative. This request finally was forwarded to the European Association of National Metrology Institute (EURAMET), see http://www.euramet.org/index.php?id=homepage. EURAMET coordinates the cooperation of National Metrology Institutes (NMI) of Europe in fields like research in metrology, traceability of measurements to the SI units, international recognition of national measurement standards and of the Calibration and Measurement Capabilities (CMC) of its members. Technical collaboration in EURAMET is organised within 12 Technical Committees, TCs are the forum for scientific and technical cooperation in the respective fields. The EuroDAC² initiative may firstly belong to

- Technical Committees TC-L (length) @ BEV Austria, contact person Michael Matus (http://www.euramet.org/index.php?id=tc-l)
- Technical Committee TC-PR (photometry and radiometry) @ METAS Switzerland, contact person Peter Blattner (http://www.euramet.org/index.php?id=tc-p)

The organization is responsible for the elaboration and execution of a European Metrology Research Programme (EMRP). This new programme is still under approval at EU, final decision expected within next 2-3 months. With appropriate call projects will become possible (information obtained from EURAMET Vice Chair A. Leitner).

ESA Earth Observation Market Development (EOMD)

ESA Earth Observation Market Development (EOMD) is an activity within the ESA Earth Observation Envelope Program (EOEP), see http://www.eomd.esa.int/about/overview.asp , headed by S. Coulson (Head of Industry Section, Directorate of EO Programs). From ESA point of view quality, standards & certification of Earth Observation (EO) derived information is becoming an increasingly important issue in growing the acceptance by users of EO-based solutions. EOMD is currently preparing a preliminary study looking at if (and how) certification processes could be introduced into the world of production, sales and delivery of EO information services. If preliminary study shows that there are concrete things to be done that would improve the position of EO service suppliers (mostly small companies) and reduce risk for potential customers, then ESA could take this further later this year with additional activities in EOMD. On the basis of this, ESA will explore if there are opportunities to work more closely together with EuroDAC² in the future.

It has to be checked, whether the EuroDAC² initiative also might be of interest for the European technology transfer network EUREKA.

Ongoing and updated action items

- WP Geometry (▶ S. Bovet, L.-E. Blankenberg, **G. Grenzdörffer**)
  - Based on the presentations and discussion at the ICC meeting the **WP Geometry will compile a „white paper“** which includes remarks on the optimal design of geometrical test sites for camera calibration and validation. This will also be a first draft of guidelines for geometrical test site design and processes.
  - **Deadline: First half of May 2009**

- WP Radiometry (▶ **E. Honkavaara**, M. Pierrot Desseilligny, R. Reulke)
  - Based on the first results from the EuroSDR project on radiometric performance of digital photogrammetric camera systems a reviewed article on “State of the art in radiometric sensor data processing and evaluation” will be prepared. Publication in open journal is scheduled for May 2009 already. This report will not only close the first theoretical phase of the project but also include basic information which is also of

relevance for the next EuroDAC² steps. This theoretical first phase is then completed by a practical part, where real data sets are distributed to interested project participants. The description of this data will be finished within end of April 2009.

  - A first **preliminary draft of guidelines for radiometric test site design and processes** will be prepared for the next EuroDAC² meeting
  - **Deadline: mid/end of August 2009**

  - An **internal meeting at DLR Berlin** should be considered to force project progress and to again discuss open topics which could not be solved so far. Meeting arrangements have to be discussed by radiometry team members.

- The detailed **analysis of currently available digital camera calibration protocols** was already defined as one action item after the first core team meeting in Castelldefels but not considered so far. Now ▶ **R. Alamus** supported by L.-E. Blankenberg, S. Bovet and others will compile a **„white paper"** to work on transparent, unique, comparable and unambiguous presentation of calibration results in calibration protocols.
  - **Deadline: October 2009**

- The EuroDAC² findings should also be used as valuable input for ongoing **standard developments**. This is followed by ▶ M. Cramer.

- The acquisition of external funding sources has to be done continously. The first established contacts to EU / ESA have to be deepened. This task is followed by ▶ M. Cramer.

- The **next meeting of the EuroDAC² core competence group will be aligned with the Photogrammetric Week 2009 in Stuttgart, Germany**, September 7-11, 2009. System providers will also be invited to discuss and comment on the current status of the EuroDAC² approach. The schedule is planned like follows:
  - Internal EuroDAC² core team meeting
    Wednesday, September 9, 13:00 – 18:00 h
  - Meeting together manufacturers on
    Thursday, September 10, 14:00 – 15:30 h
  - Internal EuroDAC² sum-up meeting
    Thursday, September 10, 15:45 – 17:00 h

Agenda EuroDAC² Core Team Meeting at ICC Barcelona

Wednesday – Thursday, April 1 – 2, 2009

Tuesday, March 31

19.30 h	Informal meet-and-greet, meeting in lobby Hotel Sant Agusti

Wednesday, April 1

09.00 h	Arrival & ICC Welcome
09.00 – 11.00 h	Work Package Geometry *Görres Grenzdörffer, Leif Erik Blankenberg (and others)*
11.00 – 13.30 h	Work Package Radiometry *Eija Honkavaara, Marc Pierrot-Deseilligny (and others)*
15.00 – 16.30 h	ICC experiences *Roman Arbiol (ICC, Head of Remote Sensing Department)*
16.30 – 18.00 h	Guideline Compilation and concept *all*
Evening	Dinner

Thursday, April 2

09.00 – 11.00 h	Standards developments and possible funding sources *Michael Cramer (and others)*
11.00 – 13.00 h	EuroDAC² sum-up and future steps *all*
13.00 h	Lunch