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European Digital Airborne Camera Certification – EuroDAC²

Position Paper

Officially accepted by the EuroSDR Science Committee and Board of Delegates
Rotterdam, The Netherlands, May 24, 2007

Abstract

This position paper describes a new initiative on the certification of digital airborne cameras on a European level. In addition to its information content, this paper encourages the reader to support the initiative with his expertise and individual requirements for such future such certification or standard. The responsible project team invites all persons involved in the acquisition, processing and use of such digital airborne sensor data and products to actively participate in the European certification process. Support this with your individual experiences, recommendations and ideas! In this way the initiative should lead to a European certification, which avoids solutions specific to a single country and thus becomes accepted not only by users but also by system suppliers. Based on this, the project team has already established close contact with other world-wide certification approaches in order to align all such activities as much as possible.

Zusammenfassung

Dieses Positionspapier informiert über die neue Initiative zur Zertifizierung digitaler Luftbildkameras auf europäischer Ebene. Neben der reinen Information wird der Leser aufgefordert diese Initiative mit seinen individuellen Anforderungen für eine derartige Zertifizierung zu unterstützen. Die verantwortliche Projektleitung lädt daher alle Personen, die in die Erfassung, Auswertung und Verwendung derartiger digitaler Sensordaten und deren Produkten involviert sind, aktiv an diesem europäischen Zertifizierungsprozess teilzunehmen. Unterstützen Sie uns mit Ihren individuellen Erfahrungen, Empfehlungen und Ideen! Diese Initiative soll zu einer europaweiten Zertifizierung führen, die länderspezifische Einzellösungen vermeidet und damit nicht nur bei Nutzern sondern auch seitens der Systemhersteller eine hohe Akzeptanz haben wird. Basierend darauf hat die Projektleitung bereits enge Kontakt zu anderen Zertifizierungsansätzen welt-weit geknüpft, um diese Aktivitäten zu einer größtmöglichen Übereinstimmung zu bringen.

Résumé

Le présent document constitue une information relative à la nouvelle initiative européenne de certification des chambres de prises de vue aéroportées numériques. Par-delà cet objectif informatif, le lecteur est invité à soutenir cette initiative en communiquant ses propres attentes envers une telle certification. La direction du projet prie donc toutes les personnes qui sont impliquées dans la saisie, le traitement et l'utilisation de données provenant de tels capteurs numériques et de produits dérivés à participer activement à ce processus de certification européen. Soutenez-nous en nous faisant part de vos expériences personnelles, de vos recommandations et de vos idées ! Cette initiative doit aboutir à une certification s'appliquant à l'ensemble de l'Europe, permettant d'éviter les solutions locales isolées et qui devrait dès lors rencontrer un large soutien non seulement auprès des utilisateurs, mais aussi auprès des fabricants. Dans cette perspective, la direction du projet a déjà noué, à l'échelle mondiale, des contacts étroits avec d'autres processus de certification similaires, afin de garantir une convergence aussi large que possible de toutes ces démarches.

Executive summary

This position paper addresses the development of a European based digital airborne mapping camera certification process called EuroDAC² (European Digital Airborne Camera Certification). EuroSDR is in charge of the project initiation and coordination between the European National Mapping and Cadastre Agencies (NMCAs) while cooperating closely with all relevant digital airborne mapping camera suppliers. This initiative will finally lead to a European wide accepted certification procedure for the new digital mapping cameras. The procedure will substitute the traditional analogue mapping camera certification, which was based almost exclusively on laboratory calibration which cannot be transferred to the new digital camera environments.

The new EuroDAC² project is developed as a five step procedure, as follows:

(1) Investigation of **users needs** / expectations based mainly on the input of the European NMCA representatives.

(2) Analysis of **camera production process** with support from individual camera system manufacturers.

(3) **Definition** of the European Digital Camera Certification process.

(4) **Acceptance** phase of EuroDAC², again with input and comments from NMCAs and manufacturers, as well as others.

(5) European wide **implementation** of EuroDAC².

EuroSDR has already installed a EuroDAC² core competence group that will start its work immediately. Other certification activities are already under way, mainly pushed by the impact of the US Geological Survey. A European initiative is necessary to avoid a solely US specific approach becoming a quasi-standard for the European countries as well, even though this approach might be non optimal, in part, for the European environment.

Situation

In recent years digital airborne imaging has undergone a significant increase in importance for all kinds of mapping applications. It has become evident that large format digital cameras can not only fully compete with the traditional analogue mapping cameras, for some applications they are clearly of superior performance.

Different to the well known analogue systems, the available digital cameras are of very different system design: The products currently available differ in

- imaging principle, i.e. line based versus frame based sensor layouts,
- optics design, i.e. single head versus multi-head solutions,
- image recording concept, i.e. synchronous versus syntopic image data acquisition,

besides in addition to several other specifications. All this precludes the new systems from the classical certification process, as it was established for analogue mapping frame cameras. In addition a significant increase in medium format digital cameras, often used in combination with airborne laser scanning, may be observed. In many cases the availability of a recent calibration report has become a mandatory requirement for mapping applications, at least when the mapping has to conform to national rules.

Action required

For digital airborne cameras an individual camera specific certification process is not currently available. Some national activities are already established dealing with new concepts and processes of digital airborne camera certification. The strongest impact is driven by the investigations of the United States Geological Survey (USGS). Within Europe no initiative on this topic is evident to date. **EuroSDR decided to initiate and coordinate a project on the Certification of Digital Airborne Cameras in an international European context. Europe has to identify its own needs for digital airborne camera certification and based on that a certification process has to be defined accepted not only in single countries but throughout Europe.** All this must be done as soon as possible, otherwise the situation might emerge that the USGS quality assurance plan is adopted by European and other countries almost automatically without possibly considering the full consequences or taking account of the specific European requirements and conditions.

Background

Traditional laboratory camera calibration is done by camera manufacturers (like Zeiss RMK series at Zeiss Oberkochen and Wild/Leica RC series at Wild/Leica Herrbrugg). The hardware and the processes are sometimes certified in conformity with national rules/organizations (like Deutscher Kalibrierdienst in Germany). In addition to system suppliers, national agencies are themselves responsible for such calibrations, as is the case for the USGS in camera calibration in the United States. In the United Kingdom laboratory calibrations were also performed until 2006 at the commercial company BLOM Simmons Aerofilms.

Obviously, this calibration of airborne film mapping cameras, which simultaneously certifies the systems' performance, cannot be transferred to the new digital airborne camera systems. It is one of the most important findings of the EuroSDR Camera Calibration Network activities that, for today's digital sensors, not only the camera but the whole data processing chain is of major impact on the obtained quality of final results. Thus, new ways of system certification covering the whole data generation process have to be identified and implemented.

In 2005 the USGS began an initiative focussing on quality assurance of digital imaging sensors and data. Differing from the former laboratory analogue camera calibration, certification is shifted from individual sensor certification to the certification of the whole sensor's product line (**type certification**). From the USGS point of view individual system certification is no longer within the scope of system suppliers. To a certain extent the individual system related certification is shifted to data providers (i.e. the companies flying an individual camera system and/or processing its data to obtain the final product). The data provider element also might include quality tests for individual cameras obtained from calibration flights in photogrammetric test sites (additional details on the USGS approach are given in the appendix).

So far the USGS has type certified three commercial digital airborne cameras (as of May 2007). These are

- the Digital Mapping Camera DMC from Intergraph/ZI-Imaging, US/Germany,
- the Digital Sensor System DSS-322 from Applanix, Canada and
- the UltracamD from Microsoft/Vexcel, US/Austria.

Additional manufacturer certifications for the Airborne Digital Sensor ADS40 (Leica Geosystems, Switzerland) and the Digital Modular Airborne Camera DiMAC (Dimac Systems, Luxembourg) are currently in progress or scheduled.

Thus, in today's situation USGS certified systems and non USGS certified systems are in use and competing against each other. Non certified systems are still accepted for mapping applications in the US, although the USGS certification will obviously become a mandatory requirement for future projects in the US.

European digital camera certification

EuroSDR in general agrees and underlines the high relevance and impact of the USGS quality assurance plan. Nevertheless, there is a need to at least thoroughly check whether this certification approach is also regarded as adequate for the analogue mapping camera certification from a European point of view. The following issues, different to the US situation, obviously might be of impact for a European based certification approach:

- Comparing the typical flight project parameters and requirements significant differences from the US environment are obvious: There is a large variety of different applications for airborne mapping in Europe. Typically the projects are of smaller extent with more regional sized projects compared to the state-wide projects in the US. In many cases the demands on sensor resolution and accuracy are more stringent. It should be discussed whether different accuracy classes are required for European users.

- The new technology of digital airborne imaging was principally developed by European based companies. A very large number of current digital airborne sensor systems originated in Europe, such as ADS40 (Leica, sensor hardware development from Switzerland), DMC (Intergraph, hardware development originated from Zeiss/Intergraph, Germany), Ultracam (major developments and system designs from Vexcel, Austria), DiMAC (from DIMAC Systems, Luxembourg), JAS-150 (from JenaOptronik, Germany), HRSC (from DLR, Germany), AIC (from Rollei, Germany), DigiCAM (from IGI, Germany), IGN camera (France) and others. The accepted use of those systems throughout Europe should be based on their European wide certification.
- Similar to the development of the Galileo Global Navigation Satellite System (GNSS) or the Global Monitoring for Environment and Security (GMES) project Europe has already defined its own solutions for other projects of larger impact. This has not to be seen as pure competition to other existing initiatives (such as GPS from the US or Glonass from Russia in the case of satellite navigation). In its ideal case different systems might support each other. The synthesis of both is more than the single systems running in parallel.

The general idea to start a camera certification concept in a European context was presented at the 109th EuroSDR Science Committee and Board of Delegates meeting in Lisbon / Portugal (October 25-27, 2006). All attending delegates agreed and supported this activity. As NMCAs from eighteen states are currently members of EuroSDR most European NMCAs are involved in this project.

This certification initiative is based on the experiences of the successfully established EuroSDR network of “Digital Camera Calibration and Validation”. This network has been active for more than the last two years. It consists of experts from system or data users, representatives from academia and the system manufacturers themselves. Thus, a network of competence which is essential for the upcoming definition of certification steps is already available and working to a large extent. Additionally, a close cooperation with the USGS was established lasting recent years to share experiences and to align both certification processes as much as possible.

Process steps and schedule

The design of the future European certification process and its later implementation can only be done in a step-wise approach. The following process steps have been developed by a certain number of EuroSDR representatives, forming the EuroDAC² core competence group.

(1) The European National Mapping and Cadastre Agencies are one major group using data and products from digital mapping cameras. Firstly, therefore, NMCAs have to define their individual expectations and demands on the future

certification process of digital mapping cameras. How is certification currently done in the analogue mapping world of each country? Digital camera certification in its first approach might be close to the former standard national rules and the country specific certification procedures. Nevertheless it is highly aspired to define the future certification process on a European wide base. This is advantageous not only for the system suppliers but also for the data providers and flying companies and therefore will automatically lead to a much wider acceptance. Additionally, the NMCA representatives must look carefully at the USGS quality assurance approach.

(2) In addition the camera system suppliers must be deeply involved in the EuroDAC² process. This has to be done from the very beginning to guarantee broad acceptance and support of the certification process design. It is quite obvious that the system suppliers (at least those that have already undergone the USGS type certification process) will try to minimize additional effort and costs for the European certification. This for example would be the case if major parts of the EuroDAC² are aligned with the USGS quality assurance plan. Besides, there seems to be the need to visit the individual system suppliers and their main production facilities. This will be done by the core group members. EuroSDR expects to benefit in this regard from the well established contacts arising from the Digital Camera Calibration Network. It is assumed that on site visits will each take about one to two days.

(3) The synthesis of the results from these first two steps will lead to a detailed draft of the future EuroDAC² process. The main technical issues will already be part of this draft. This draft must then be circulated within the group of EuroSDR NMCAs and supporting camera manufacturers. Again comments from them and any other experts will be used to refine the draft document.

(4) The modified draft resulting from step 3 must then be accepted by all NMCAs involved. It is quite obvious that this could become a very demanding step, since the new EuroDAC² process will establish a new certification process for digital airborne cameras. If such a process is already available nationally EuroDAC² will complement such existing procedures for such type of cameras. All this has to be accepted in a political dimension.

(5) Implementation of the EuroDAC² process is the final step. The organization responsible for this implementation step has to be defined.

The EuroDAC² process in brief can be seen from the following table. The groups principally involved in each step are highlighted. It is expected to complete this process fully within the next two-and-a half year period.

#	Process step
(1)	Evaluation of users needs / expectations *Action*: (mainly) **NMCAs** and others
(2)	Input from camera manufacturers *Action*: (mainly) **system suppliers** and others
(3)	Definition of EuroDAC² process *Action*: (mainly) **EuroDAC² core group**
(4)	Acceptance of EuroDAC² process *Action*: (mainly) **NMCAs, system suppliers** and others
(5)	Implementation of EuroDAC² process

Table 1: The EuroDAC² process steps

Financial aspects and budgets

This EuroSDR initiative is, by its nature, different from other projects conducted under the leadership of EuroSDR. Due to the project dimensions and its European wide impact and influence its funding should not be exclusively provided from EuroSDR resources. Thus financial support will be sought. Support is mainly necessary for the regular meetings / travel expenses of the EuroDAC² core competence group. In addition, the principal person responsible should be paid for a limited time. EuroSDR also anticipates limited financial support from those manufacturers, whose systems will be part of the certification process. Administrative assistance in organizing meetings and other activities will be provided by the EuroSDR Secretariat.

The total budget will be estimated at a later stage.

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Sources and relevant links

G. Stensaas, G.Y.G. Lee, J. Christopherson (2007): The USGS Plan for Quality Assurance of Digital Aerial Imagery, available at http://calval.cr.usgs.gov/documents/The_USGS_and_IADIWG_Plan8.doc, last access May 20, 2007.

USGS web site to post current information on the activities of their working group http://calval.cr.usgs.gov/digital_aerial_imaging_quality_assurance.php, last access March 20, 2007.

The EuroSDR network on digital camera calibration and validation – progress, reported activities and available documents accessed via http://www.ifp.uni-stuttgart.de/eurosdr/index.html, last access May 20, 2007.

General information on the EuroSDR organization available via http://www.eurosdr.net/, last access May 20, 2007.

Appendix – The USGS quality assurance plan in brief

Since the beginning of the 1970s the (North-American) mapping community has relied on the USGS (US Geological Survey), to provide necessary (analogue) camera calibrations to ensure quality of final products. In the developing digital world similar standards and certifications are also expected for the digital sensors and products. This motivates the USGS in activities in assessment of existing calibration standards and new digital camera/sensor technologies. In 2000 USGS and ASPRS (American Society of Photogrammetry and Remote Sensing) established an expert group from industry, academics and governmental organizations to address such digital sensors calibration topics. In 2005 an Inter-Agency Digital Imagery Working Group (IADIWG) was formed by USGS including the main government agencies involved in airborne imaging. The purpose of this group is to identify requirements and issues relating to digital imagery acquisition, guidelines, and policies that are common to all agencies and to work together toward solutions (IADIWG 2006). The USGS activities in quality assurance of digital imaging sensors, described below, are approved and supported by the IADIWG.[1]

In 2005 the USGS began an initiative focussing on quality assurance of digital imaging sensors and data. This USGS plan goes far beyond the simple replacement of the traditional calibration report issued for aerial mapping film cameras. The plan covers the whole data generation and data procurement domain. It asks that consistent processes and standards be used by those buying and using data, and it expects that high standards for quality be demonstrated by those involved with the production of digital aerial data.

The USGS plan is composed of four phases and can be viewed as a continuum of best practices which contribute to the overall quality of end-products. Two major processes are covered with four different steps.

(1) Data production

- Manufacturers' certification
- Data Providers' certification

(2) Data Purchasing & Acceptance

- Contract selection process and digital specifications
- Inspection and acceptance of deliverables

[1] The following text is supposed to give a brief insight into the concept that is proposed and already followed by USGS for their digital airborne mapping camera calibration processes. Main text sequences are originated from several USGS publications or documents, most of them available from http://calval.cr.usgs.gov/. The support from USGS is gratefully acknowledged.

The USGS chain of interaction is depicted in Figure 1. It is interesting to note that, in addition to this, education and training of the end-users is also considered.

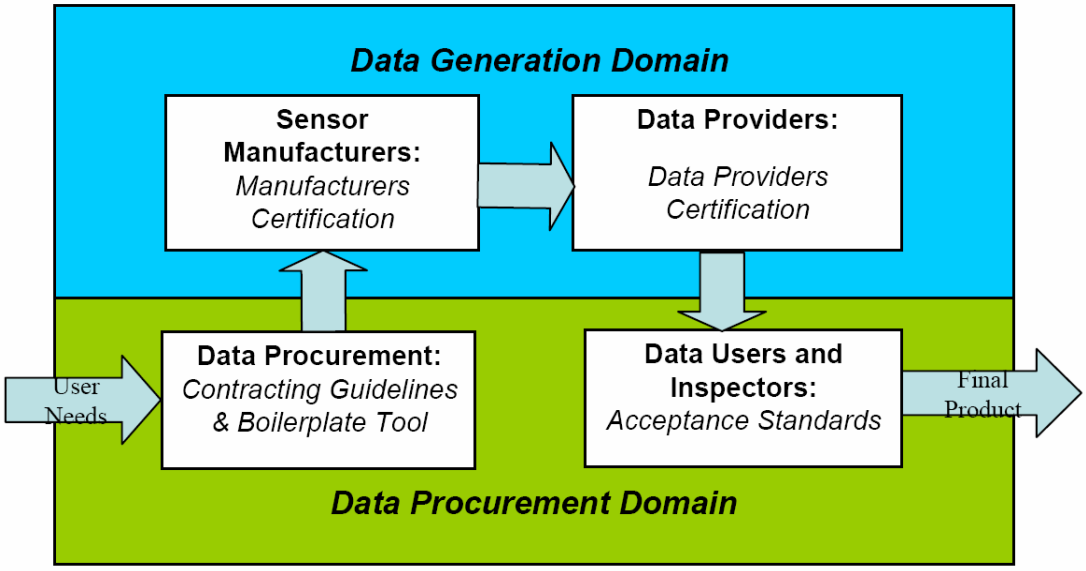

Figure 1: The USGS plan for quality assurance of digital airborne sensors.

Within this paper's context, the quality of the sensor's manufacturing process as part of the data generation domain is of major concern. This certification step might be compared to the former laboratory calibration of analogue cameras, although now the whole production process is considered. In order to evaluate and finally certify the sensor's production line a clear understanding of the individual sensor specifications and the calibration steps performed is necessary. Thus, a special USGS digital sensor certification team was formed to review and carefully analyse the materials provided by the different manufacturers, such as sensor specific user documentation and recommendations for the data providers. In addition to that a factory inspection of the manufacturer's calibration process is undertaken for a detailed understanding of the design, development and calibration of the individual sensor type. It is obvious that, in contrast to the former individual sensor's laboratory certification, now the complete process of manufacturing and calibration of a certain type of digital sensor is covered. Therefore, certification is shifted from each individual sensor of one sensor family to a type certification of the whole digital sensor's product line. Thus individual system certification is no longer within the scope of system suppliers but to a certain extent shifted to the data providers (i.e. the companies flying an individual camera system and/or processing its data to obtain the final product).

Type certification is defined as follows (USGS): "Type certification covers all identical systems. Thus once a particular make and model digital aerial system is 'type certified', all copies of that item, whether made prior to certification or following, are

also considered to be certified. However, systems that differ significantly in how they operate or produce data are not covered under the 'type certification' given for a different sensor model." Type certification eliminates the burden of calibration of each particular sensor itself. There is no longer the need to provide custom-built calibration set-ups for certification institutions like USGS.

"It should be noted that this USGS type certification is intended to ensure that the sensor system made by the manufacturer has been designed to reliably, repeatedly, and routinely deliver an output product of consistent quality. The certification will provide customers and users of digital imagery a verification of manufacturer specifications and claims. **This type certification does not imply that systems produced by different manufacturers, each receiving this certification, are capable of delivering data of identical quality or characteristics.** The USGS has steered clear of attempting to judge the capability of systems; that is for the free market to decide what mix of capabilities, usability, and value best meet the needs of Data Providers. Rather, the USGS type certification simply endorses that the system, when operated in accordance with the manufacturer's parameters, has a high likelihood of reliably producing products that meet the claims of the manufacturer for that system" (Stensaas et al, 2007).

So far three system suppliers have undergone the USGS manufacturer certification for three commercial digital airborne cameras (as of March 2007). These are

- the Digital Mapping Camera DMC from Intergraph/ZI-Imaging, US/Germany,
- the Digital Sensor System DSS from Applanix, Canada and
- the UltracamD from Microsoft/Vexcel, US/Austria

All three of them have successfully passed the certification process and the certification document was delivered. The document certifies that the "camera system … meets the claims of the manufacturer and is capable of providing quality, consistent image data to support civil government mapping and ortho-photography product development. The USGS provides this certificate … for successful completion of the USGS Manufacturer Certification process which included presenting and providing all appropriate information to address the certification requirements as defined in the USGS Quality Assurance of Digital Aerial Imagery plan and the USGS Manufacturer Certification Checklist. This certification is valid for all … systems that match the system type evaluated by the USGS during the … site inspection. Any design changes that change the effective output of the system will require additional evaluation and re-certification if necessary." This passage is cited from the certification sheet. As an example the Intergraph/ZI-Imaging DMC certification is included (see Figure 2, page 14). The certification document is augmented by a summary report, which is for public release.

Additional manufacturer certifications for the Airborne Digital Sensor ADS40 (Leica Geosystems, Switzerland) and the Digital Modular Airborne Camera DiMAC (Dimac Systems, Luxembourg) are currently underway or scheduled.

The certification of the data providers is the second process in the data generation domain. During this certification step the USGS will inspect the data provider's processes from mission planning and flying, down to product generation and final delivery processes. This certification assures potential contracting persons that this company has a high likelihood of repeatedly delivering consistent quality data. It ensures that the individual data providers (i.e. companies flying the digital sensors only and/or processing the data to obtain the final product) are operating the digital sensors in accordance with the manufacturer's guidelines and certain quality procedures are followed. The sensor is within its specifications and remains in good calibration and operation conditions. It also might include quality tests for individual cameras obtained from calibration flights in photogrammetric test sites.

Procedures used for quality assurance and control have to be provided for all process steps. Similar to the independent certification of camera manufacturers, the data provider's certification is of positive influence on the data provider's capabilities. The certification also serves to demonstrate the sensor's ability to achieve accuracy levels for a specific product or range of products.

The second major process in quality assurance is the data purchasing and acceptance domain. The new concepts and features of digital airborne sensors are not able to adapt to the standard contracting guidelines used so far. In addition, there is no information on how to judge the performance of the digital data and products. Obviously, there is a certain lack of knowledge at the user's side on how to contract such new sensors for their upcoming projects and whether these new technologies are capable of fulfilling their performance needs. Many typical aerial imagery users do not possess a detailed understanding of the strengths and (maybe) weaknesses in specific applications. This might generate some sort of barriers to use those new technologies with their (at least) equivalent and quite often superior quality performance compared to the traditional analogue image based data processing.

Arising from that, USGS has begun to develop contracting guidelines, using standardized terms and descriptions to make the contracting process easier and more uniform. Furthermore, the use of clear definitions and standardized performance measures will allow for non-ambiguous descriptions of user's needs. This will increase the acceptance of digital sensors and encourage digital imaging. The previously described manufacturers and data provider's certification documents will support a large reduction in proposal documentation. In its final stage these contracting guidelines will become available as a web based tool that enables potential customers of digital aerial sensors and products to use those pre-defined text passages to generate parts of their contract documents.

The ultimate assurance of quality is the inspection and acceptance of deliverables. There is a need for uniform definitions and approaches to evaluate the quality of image data. So far, a different terminology is used from different users or data providers and issues are sometimes ambiguous and interpreted differently. USGS together with IADIWG is working on the development of acceptance standards, which finally should be offered as a web based tool illustrating the quality problems, measurement techniques and standards. All this leads to more consistent acceptance/rejection criteria among contract agencies, helps to minimize false expectations, ensures high quality products and increases the customer's satisfaction and data acceptance.

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
National Center for Earth Resources Observation and Science
Sioux Falls, South Dakota 57198

12/15/06

Subject: Successful Completion of the USGS Manufacturer Certification Process for the Intergraph Digital Mapping Camera (DMC)

The United States Geological Survey (USGS) certifies that the Digital Mapping Camera (DMC) system manufactured by the Intergraph Corporation (Zeiss/Intergraph), in Aalen, Germany meets the claims of the manufacturer and is capable of providing quality, consistent image data to support civil government mapping and ortho-photography product development.

The USGS provides this certificate to Intergraph Corporation for successful completion of the USGS Manufacturer Certification process which included presenting and providing all appropriate information to address the certification requirements as define in the USGS Quality Assurance of Digital Aerial Imagery plan and the USGS Manufacturer Certification Checklist.

This certification is valid for all Intergraph DMC systems that match the system type evaluated by the USGS during the 2006 site inspection. Any design changes that change the effective output of the system will require additional evaluation and re-certification if necessary.

To discuss manufacturer certification, please contact the manufacturer, or the USGS certification team via the following web mail link - http://calval.cr.usgs.gov/.

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Figure 2: USGS Intergraph DMC Manufacturer Certification document (kindly provided by K. Neumann, Intergraph / ZI-Imaging, Feb 2007).