DEVELOPMENT OF AN INTERNATIONAL STANDARD FOR CALIBRATION AND VALIDATION OF REMOTE SENSING IMAGERY SENSORS AND DATA

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Ad-hoc Group on Standards

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ABSTRACT:

Within the last decade digital aerial cameras have practically completely replaced the former aerial film cameras. However, this new technology has introduced a large variety of technical solutions regarding image size, dynamics (grey values), spectral resolution, multi camera head setups, focal length, speed etc. This variety has fostered a strong demand for the development of standardized systems and procedures.

The ISO/TC 211 '"Geographic information / Geomatics" has launched the project ISO 19159 "Calibration and Validation of remote sensing imagery sensors and data". This intended standard shall incorporate aerial cameras as well as airborne laser scanners, imaging radar, and water borne sonar systems. An addition the validation of calibration data and remotely sensed data will be a part of the standard.

Presently technical investigations are being performed in various groups, namely in Europe and in the United States. The outcome of those works will become an essential base for the standard's development.

The paper will present the ongoing works, explain their meaning to the development of the new standard, and give an outlook towards additional topics such as the camera certification.

1. INTRODUCTION

Calibration and validation have been potential topics of an ISO standard for many years. However, the standardization project was not launched before 2009. It might be speculated about the reasons for the long waiting. Probably, the topic was not mature enough in earlier years as many of the modern sensors have been introduced into daily operation not long ago, like the digital aerial cameras starting in the year 2000. A second reason is the process of the standardization for geographic information itself. Starting in the mid 1990s it took a decade until the ISO/TC 211 "Geographic information / Geomatics" had completed a full set of basic standards. During the years afterwards a supplemental set of standards was developed that is covering photogrammetry and remote sensing, for instance the ISO/TS 19101-2 "Reference model – Part 2: Imagery". This standard is one of the important foundations for the new ISO/TS 19159 "Calibration and validation of remote sensing imagery sensors and data", shortly named CalVal standard.

The new sensor types of the first decade of the 21st century have a manifold of characteristics that did not exist with former sensors. Examples are the high radiometric dynamics, the multi-head systems, and the high geometric resolution from space. Furthermore, new sensor types conquered the market such as airborne laser scanners and airborne line sensors.

Last, but not least, a huge variety of system suppliers and builds are in place. This results in a confusing multiplicity of technical solutions that can hardly be evaluated in a responsible way.

This present situation fostered the demand for an international standard for calibration and validation.

2. ISO/TS 19159, "CALIBRATION AND VALIDATION OF REMOTE SENSING IMAGERY AND DATA"

2.1 Scope

The ISO/TS 19159 was approved as an international standardization project in November 2009 und must thus be completed by the end of 2014 at latest. The published output will be a Technical Specification (TS).

The scope of the standard defines the field of work of the project team. The ISO/TS 19159 defines the calibration and validation of airborne and space borne remote sensing imagery sensors and data. The term calibration refers to geometry and radiometry, and includes the instrument calibration in a laboratory as well as in-situ calibration methods. The validation methods are split into process- and product-validation, and include the prerequisites for installing a validation environment. The ISO/TS 19159 will also cover the associated metadata that has not been defined in other ISO geographic information standards.

The members of the project team tend to interpret the term "imagery sensors" in a wide sense as it shall include airborne laser scanning (ALS) and sonar (bathymetric measurements).

2.2 Outline

The content of the standard depends on the contributions of the members of the project team. When the standard

was approved in 2009 22 out of 32 responding national standardization bodies confirmed the importance of the standardization project and 9 of them ensure their participation. Consequently the following countries will be present in the project team: Canada, China, Finland, France, Germany, Italy, Japan, Thailand, and the USA. Taking in account the affiliation of the nominated experts it can be expected that airborne and space borne cameras, airborne laser scanning, and hydrographic sonar will be addressed in the document.

Together with the request for vote on the New Work Item Proposal an outline of the standard was distributed. The outline was structured according to the template for ISO standards. Therefore, only the peculiarities of the CalVal-standard are mentioned here.

A prerequisite for a good standardization work is a clear terminology. The chapter 4 of the outline "Terms and definitions" defines more than 100 terms compiled from the ISO Guides 98 and 99, from existing ISO 19100 standards, from CEOS documents, and from an unofficial translation of the DIN-standard for digital cameras (Germany).

The chapter 6 "Calibration" addresses potential areas for standardization, of which a few are mentioned in the following list:

- Geometry
- Instrument calibration (frame camera, line camera)
- Calibration environment (laboratory, test-field)
- Wavelength dependent issues
- Time (calibration date, time-dependent parameters, striking events, e.g. launch)
- Radiometry
- Type (absolute or relative radiometric calibration)
- Reference standard

The chapter 7 "Validation" addresses potential aspects of validation. The ISO 9000:2005 defines validation as the "confirmation by providing of an objective proof that the requirements for a specific intended use or a specific intended application were fulfilled". The ISO/TS 19101-2:2008 defines validation as the "process of assessing, by independent means, the quality of the data products derived from the system outputs". Given that validation may play a role for standardization of sensors and data in the following fields:

- Validation of the traceability of data products via instrumentation to SI units
- Validation of the functional model, algorithms and software
- Validation of a camera calibration

The annex B "Metadata" is normative and shall contain those metadata that have not been standardized before.

The annex C "Level definitions for Earth Observation products" is normative and provides an example list for the start of the discussion.

The annex D "Approach for certification" is informative and shall contain aspects that are necessary for the certification of the calibration and validation work.

The certification itself cannot be a topic of an ISO-standard, because ISO's role is the definition of "rules" while an independent body shall do the certification according to those rules. In former times aerial cameras were calibrated and certified by national laboratories which often passed the practical work to private labs, mostly attached to the camera manufacturers. Today, it is strongly recommended to organize calibration and certification on an international level. The intended CalVal standard will support this approach.

2.3 Participation

A successful standard cannot be developed from scratch. Necessary prerequisites are the demand from the user's side and a thorough investigation of technical alternatives. The technical work has been done by only a few expert groups worldwide. The following list shows those groups. However, others may also have developed valuable contributions that are not yet visible on the international arena.

- EuroSDR / EuroDAC²
- CEOS
- USGS
- University of Calgary
- Canadian Hydrographic service
- Camera manufacturers
- EuroCOW

EuroSDR stands for European Spatial Data Research. Among its several commission and groups namely the Commission 1 titled "Sensors, Primary Data Acquisition and Georeferencing" and the "Inter-Commission Working Group on Standards" have conflated the contributions of the European academics, camera manufacturers and space administrations.

EuroDAC² stands for European Digital Airborne Camera Certification. It is a competence group under the auspices of EuroSDR set in place in 2007. This group is small as it is a pure experts group and thus allowing for an efficient work.

The USGS (United States Geological Survey) has a long experience in calibration, validation, and certification of photogrammetric and remote sensing sensors. Site of major importance are the calibration laboratories at the Stennis Space Center, Mississippi, and the calibration field in the Sioux Falls area, South Dakota. The USGS-experts stay in close touch with the ISO project team.

CEOS stands for Committee on Earth Observation Satellites and is an international organization representing the national space administrations that operate civil space borne remote sensing systems. Their expertise has been amalgamated in an elaborate set of documents titled "A Quality Assurance Framework for Earth Observation" (QA4EO). Those have already provided a valuable input to the CalVal-standard.

The Department of Geomatics Engineering at the University of Calgary is a fore-front development site for calibration and validation standards of Airborne Laser Scanning (ALS). ALS is planned to become a major part

of the CalVal-standard while the number of experts world-wide is not that big.

The Canadian Hydrographic Service (CHS) administers the second longest coastline in the world. They bring in their expertise in measuring and modeling bathymetry and will play the leading role of the sonar-part of the standard.

Many of the camera manufacturers have disclosed details of their company-own calibration and validation procedures and thus given a valuable input for a standard that could really meet the state-of-the-art technology.

EuroCOW is the European Calibration and Validation Workshop held biannually in Castelldefels near Barcelona, Spain, under the umbrella of the ISPRS and EuroSDR. This important meeting gathered experts from all over the world, especially from Europe and North America. The presentations gave a push to the CalVal standardization project.

2.4 Questionnaire

The EuroCOW 2010 opened the chance for asking the almost 50 participants from the industry, the administration, and the academia for their attitude towards an international CalVal-Standard. This was done using a simple one-page questionnaire on paper that was handed out and returned during the workshop. Two thirds of the participants responded.

Summarizing everybody supported the development of a CalVal-standard. Almost everybody marked digital aerial cameras, space borne cameras, Lidar sensors, and SAR/InSAR. Other sensors such as thermal cameras were mentioned as well.

The questions regarding the depth of standardization brought to light some concerns about a too far reaching standard. One answer said: "Standards should not be restrictive / detailed that new (and maybe better) methods will not fit the definitions."

A calibration standard does not fulfill its purpose unless a procedure is defined that certifies the results. Therefore the final question asked for potential certification bodies. The proposals ranged from "private" like the ISPRS to "government" like the European Association of Metrology Institutes EURAMET. The definition of a certification body is still open. However, the respected institution shall guarantee a sustainable status and shall be independent of private companies.

Unfortunately nobody gave a clue of "how" to write the CalVal-standard. So it remained open, which details shall be standardized and which other details may be left open to specific solutions. This obviously is a difficult topic that can only be solved by an experienced standardization committee.

The detailed analysis of the questionnaire is in the annex.

3. RELATED STANDARDIZATION PROJECTS

This section provides an overview over other standards for photogrammetry and remote sensing published by the ISO/TC 211 and the Open Geospatial Consortium (OGC).

The ISO/TC 211 has completed four standards: The above mentioned reference model for imagery (ISO/TS 19101-2), the metadata for imagery (ISO 19115-2), the georeferencing of imagery (ISO/TS 19130) and a small framework standard (ISO/TS 19129).

Currently the ISO/TS 19130-2 "Imagery sensor models for geopositioning – Part 2: SAR, InSAR, Lidar, and Sonar" is being developed. It is a supplement to the ISO 19130 covering those sensors that have left out during the former work on the ISO 19130 because of the lack of expertise in the project team. Probably the ISO 19130-2 is also going to include the metadata for the aerial triangulation.

The OGC has aggregated its imagery activities in the Sensor Web Enablement (SWE). As the name implies the focus of SWE are sensor networks. Consequently the individual standards cover related components such as Observations and Measurements, the observation service, and the alert service. Photogrammetric and remote sensing sensors only play a minor role within the Sensor Modeling language (SensorML) as well as in the Transducer Language (TML).

4. CONCLUSION

The scope of the CalVal-standard includes the calibration and validation of airborne and space borne remote sensing imagery sensors and data. The term calibration refers to geometry and radiometry, and includes the instrument calibration in a laboratory as well as in-situ calibration methods. The validation methods are split into process- and product-validation. The term "imagery sensors" is interpreted in a wide sense and shall include airborne laser scanning (ALS) and sonar (bathymetric measurements).

The standard will not address certification, but certification will be built upon this standard.

The involved expert groups include EuroSDR/EuroDAC², CEOS, USGS, the University of Calgary, the Canadian Hydrographic Service, and many camera manufacturers.

The standard must be completed not later than 2014.

ANNEX: QUESTIONNAIRE

A.1 Do we need a standard for the calibration of the geometry?

Digital aerial cameras: 26 yes, 1 no
Space borne cameras: 18 yes, 2 no
Lidar sensors: 24 yes, 1 no
SAR/InSAR: 13 yes, 2 no

Other proposed sensors: Thermal cameras, Multi- and Hyperspectral cameras, Navigation sensors, Terrestrial cameras, UAV, light weight

Comments: Any method cannot be standardized; better standardize test procedures to test calibrated systems.

There are many cases where a certification process needs to be incorporated. Also, the standards should not be restrictive/detailed that new (and maybe better) methods will not fit the definitions.

A.2 What shall be standardized?

Degree of integration (component, multi-head systems etc.): 7 yes, 7 no
Calibration environment (laboratory, in-situ): 19 yes, 3 no
Test site calibration (real-time/post processing): 17 yes, 3 no
Reliability: 18 yes, 1 no
Wavelength dependent issues (bands, spectral resolution etc.): 18 yes, 3 no
Time (calibration date, influence of striking events, e.g. launch): 14 yes, 4 no

Other standardization topics: Atmospheric condition: pressure, AOT (Aerosol Optical Thickness), visibility, relative humidity, wind speed; models: MODTRAN, 6S etc.; Time and location

A.3 Do we need a standard for the calibration of the radiometry?

Do we need this standard: 15 yes, 1 no
Calibration type (absolute radiometric, spectral, vicarious, others)? 17 yes, 0 no
Reference standard (desert test site, moon, water bodies, artificial standards for the lab, lab-conditions): 10 yes, 2 no

Other aspects: Targets with known reflection, Radiometric situation at time of acquisition, Calibration environment, Distribution format of calibration results, e.g. TIFF-header, Coefficients (gain, offset)

A.4 Do we need a standard for validation?

Do we need this standard? 9 yes, 2 no
Qualification: 14 yes, 2 no
Process: 18 yes, 0 no
Product / Product type: 15 yes, 2 no
Others: Procedures, Product standards

A.5 Which should be the certification body?

Independent Research Institutes on behalf of ISPRS, IGARSS, EuroSDR …
Team of end-users, service providers, and manufacturers
Independent European or global institute
Government
EUFAR
EURAMET

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