GROUP ON EARTH OBSERVATIONS

A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

A guide to establishing quantitative evidence of traceability to underpin the Quality Assurance requirements of GEO

QA4EO-QAEO-GEN-DQK-007

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QA4EO guide: QA4EO-QAEO-GEN-DQK-007 **Community Approved**

A guide to establishing quantitative evidence of traceability to underpin the Quality Assurance requirements of GEO

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Version 3.0 now includes edits and comments made on version 2.0 by GSICS in March 2009.

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1 Abstract

The key guidelines within the Group on Earth Observation (GEO)'s Quality Assurance Framework for Earth Observation (QA4EO) provide guidance on the generic requirements and the means to achieve and document the information necessary to establish a Quality indicator (QI) for Earth Observation (EO) data products in a harmonised way. In principle, if followed, these guidelines provide the evidence needed to support any derived QI. This key guideline summarises the type of evidence needed, the means to achieve it and guidance to any "approving authority" on how to assess its adequacy.

2 Scope

A key requirement driving the data quality assurance aspects of the Group on Earth Observation (GEO)'s Quality Assurance Framework for Earth Observation (QA4EO) is the need for interoperability and the means to allow all stakeholders to be able to readily assess (on receipt) the suitability of a data (or derived) product for their particular application. This requires a "quality indicator" (QI), which must be unequivocal and universal in terms of its definition and derivation. In practise there is likely to be a wide range of actual descriptors and terms used (e.g. text or numeric) depending on the specific application or user needs, but all should be based upon a statistically derived value. This value should be the result of an assessment of its traceability to an agreed "reference standard" (ideally SI) as propagated through the data processing chain.

Key QA4EO guidelines QA4EO-QAEO-GEN-DQK-001 to QA4EO-QAEO-GEN-DQK-006 provide guidance to the community on how best to achieve the above objective. Of these, QA4EO-QAEO-GEN-DQK-002 provides the core structure and requirements with the others providing detailed guidance on the information needed to complete it. These guidelines emphasise the use of comparisons or calibrations and the implementation of formal quality management systems as the best means to obtain and demonstrate the necessary evidence to support the Quality Assurance (QA) process. However, in developing QA4EO, it was recognised that, whilst a strategy of regular comparisons might be considered an overall goal in the long-term, it is often not practical to implement quickly in a comprehensive manner. This does not mean that efforts should not be made to move toward this overall goal; on the contrary, the needs of the Global Earth Observation System of Systems (GEOSS) should provide a stimulus to the

community to establish the tools, infrastructure and encouragement to ensure rapid progress. To ensure that this happens in an harmonised manner, it will be important for the community to seek a high level of consistency and transparency in the interpretation of the guidelines and evidence to support traceability.

This document provides this guidance, concentrating on the types of evidence that any "reviewer", funding agency or customer should consider before using or accepting a service or data product. In practise, it is anticipated that the level of detail needed by each stakeholder should decrease as the product or service moves outward from the originator. They should be able to assume that if a QI exists, then the previous "reviewer" has taken responsibility and that the evidence is adequate. However, to ensure that this process is reliable, it must be possible for an end user to trace all the quality information back conceptually to the digital count measured at the originating sensor. This must incorporate all underpinning concepts as well as the associated models and algorithms used during processing and dissemination.

3 Terminology

All terms within this document are based on internationally-agreed definitions that are in many cases, derived directly from formal standardising bodies such as the International Organization for Standardization (ISO). These agreed definitions can be found on the QA4EO website (http://QA4EO.org).

4 Background and Context

This key guideline is written as part of a set, based on the adoption of existing best practise, to form a Quality Assurance Framework for Earth Observation (QA4EO). The QA4EO was developed to meet the current and aspirational needs of the societal themes of the Group on Earth Observation (GEO)'s Global Earth Observation System of Systems (GEOSS). It was prepared as a direct response to GEO task DA-06-02 (now DA-09-01-a) to "Develop a GEO data quality assurance strategy, beginning with space-based observations and evaluating expansion to *in situ* observations, taking account of existing work in this arena".

5 Outcomes

This document facilitates the harmonisation of implementation of the QA4EO and acts as a placeholder for information and requirements that will evolve with time as the process matures.

6 Inputs

This document provides a summary of types of "supporting evidence" that are the inputs needed by any reviewer.

7 Standards and Traceability

This procedure forms part of the QA4EO set of key guidelines, which can be considered "standard procedures" in this context. The reader is referred to a range of ISO standards on quality management, e.g. ISO 9001 and ISO 17025, which provide more detailed generic guidance on establishing and reviewing evidence. The QA4EO website (http://QA4EO.org/) should also be reviewed for supplementary advice on evidence as accumulated from the combined efforts of the GEO community.

1. QA4EO endorsed vocabulary: http://QA4EO.org/
2. http://www.iso.org/

8 Evidence to Support a Quality Indicator

8.1 Introduction

When considering the adequacy of evidence to support a quality statement, it should be noted *a priori* that demonstrable compliance with any formal, appropriate ISO, International Electrotechnical Commission (IEC) or other international standardising

body should be considered automatically acceptable. Care should be taken to ensure that the detailed scope of any claim is consistent with the stated documentary standard.

In considering suitability of evidence (this must always be considered in the context of the intended application), it is important to recognise that the organisation or individual providing the evidence should have some basic quality management system in place. The most fundamental requirement stemming from this, and underpinning QA as a whole, is that any decision and its reasoning (even if its basis is arbitrary) must be recorded. This is emphasised in QA4EO-QAEO-GEN-DQK-002, but it is applicable to **all** activities.

Implementation of QA4EO is the responsibility of individual entities. It is for them to determine how best to assess any evidence to support a declared QI. There is no formal requirement for that process to involve an audit, either by visit or any other means. However, it is clearly important that entities (or their proxy) establish some mechanism to facilitate data and service providers with the opportunity to demonstrate compliance with the guidelines and provide evidence to support their declared QI. Simply documenting and following a technical procedure, even if it is one that has been endorsed by a relevant authorising body, does not mean that the results obtained will be as predicted. Therefore, some evidence to confirm satisfactory implementation of the process and, where appropriate, maintained performance is needed to give full confidence.

In particular, there needs to be a means to demonstrate (where appropriate) validated control of:

- Documents, including technical procedures, quality policy and work instructions.
- Mathematical models.
- Data, including calibration data for reference standards.
- Equipment, including clear indication of equipment status and its suitability for use, e.g., calibrated and due date, indicator only, etc.
- Software.
- Prevention of the use of out-of-date information. The information should include method, mathematical model and data validation (including documentation of the actual process for the validation, the results, analysis and conclusion) – QA4EO-QAEO-GEN-DQK-005.
- Evidence of participation in appropriate comparisons, with acceptable results – QA4EO-QAEO-GEN-DQK-004; QA4EO-QAEO-GEN-DQK-003.

- Justified uncertainty budgets – QA4EO-QAEO-GEN-DQK-006; QA4EO-QAEO-GEN-DQK-003.
- Technical procedures covering both routine and non-routine work (these may be in the form of stand-alone documents or modules or a combination of these) – QA4EO-QAEO-GEN-DQK-002.
- Clear identification of the technical procedures used for particular jobs, including the version number.
- Procedures and their ready availability to appropriate staff (these may be web-based, electronic files or paper documents) – QA4EO-QAEO-GEN-DQK-002.
- Demonstrable and robust traceability to the SI for equipment and material standards (as far as possible) – QA4EO-QAEO-GEN-DQK-002; QA4EO-QAEO-GEN-DQK-003.
- Documented justification for non-calibration of equipment, if appropriate, e.g. indicator only equipment.
- Information about equipment, including assessment of suitability for purpose, re-calibration intervals, records of history, assessment of performance / acceptability, data processing, etc.
- Documented justification for decisions – QA4EO-QAEO-GEN-DQK-002.
- Records of staff training and competence to undertake particular tests or activities, etc.
- Procedures or policy related to sampling (where appropriate) and documented evidence of the sampling process for relevant tests.
- Records of the environmental / accommodation conditions during tests if appropriate.
- Evidence of Internal audits

In some cases, there is more detail in the appropriate QA4EO key guideline indicated.

8.2 Comparisons / Calibrations

As highlighted throughout, all the key guidelines, the principle source of "evidence", should be based on comparison or calibration. This is discussed in more detail in QA4EO-QAEO-GEN-DQK-004 so only the key issues will be presented here.

- Where possible, all instrumentation and sub-systems used within the development of an EO data product should be fully traceable via appropriate reference standards to international community agreed standards, ideally SI (QA4EO-QAEO-GEN-DQK-003), and used with an agreed documented method (QA4EO-QAEO-GEN-DQK-002).
    - Calibrations should be repeated as needed to remove the possibility of drift.
    - A reference standard should have a smaller uncertainty than that which it is being used to calibrate (ideally a factor of ten).
- If a key comparison (QA4EO-QAEO-GEN-DQK-004) has been organised, it is expected that all appropriate potential participants take part. Failure to take part will mean that any dependent QI will no longer be considered endorsed.
- If a relevant comparison (QA4EO-QAEO-GEN-DQK-004) has been organised within the geographical region of a particular participant, then it is recommended that they take part. Non-participation will need to be justified to any subsequent user or review of any dependent services or processes. If the comparison is in another region and no "local" version is planned, they should be encouraged to take part in the one being organised as it will provide good evidence of performance.
- Every effort should be made to facilitate the participation of any organisation in any comparison.
- If a participant in a comparison obtains a result that is not considered representative of their normal performance capabilities, efforts should be made to allow them to take part in a bilateral.
- Agencies and community representative organisations should seek to identify and establish an appropriate number of key comparisons to test the integrated performance of key aspects of the EO data processing chain. They should also organise supplementary comparisons on an "as needed" basis to facilitate more detailed sampling of all the processes within the EO processing chain.
    - Reference standards need to be established, characterised and maintained to ensure that comparisons, in particular key comparisons, can be organised effectively.
- Results of comparisons should be available for review by all stakeholders in a convenient manner. Such results should be accessible through the QA4EO

website to the EO community. They should also be appropriately identified and linked to enable readers to ascertain the current status of equivalence of any participating organisation. This is particularly important where an organisation may have taken part in a bilateral following an earlier comparison exercise.

8.3 Extant processes

In many situations, organisations will have been carrying out a particular activity or process for many years. In such cases, they may not have all the detailed evidence necessary or have the possibility for a comparison. In these cases, any other evidence can be considered to support a QI. This is likely to include things such as:

- Historical repeatability,
- Peer reviewed publications,
- Comparisons of derived or dependent products,
- Knowledge of process or ability to estimate uncertainties retrospectively,
- Level of dependency on unknown parameters, or
- Level of documentation.

However, the most important aspect is to document and make available the justification for the basis of any decision.

8.4 Other Evidence

During the transitional phase from the present to a fully implemented and operational QA system, a range of evidence (some of which may be subjective in nature) will need to be considered by approving organisations. Peer review will play a significant role in this process. Proposals from implementing bodies will be peer reviewed and subsequently considered for community endorsement. After endorsement, any new acceptable form of evidence will be incorporated into the QA4EO guidance documents.

8.5 Infrastructure and Review

To facilitate the QA process, organisations and, in particular, community representative bodies should consider establishing databases of procedures, reference standards and comparisons. They may also consider, as a means of encouragement, some form of "recognition" or "endorsement" that an organisation can use if they demonstrate compliance. This may, for example, lead to another database of "approved suppliers".

Although there is no requirement for audit, some agencies may consider this an appropriate mechanism. Others may establish systems of peer review where organisations can demonstrate evidence to their peers in a discussion-like forum. In other cases, evidence may be submitted to "quality review teams" as part of a normal contractual process. Another mechanism might be to establish a system of "random sampling" of delivered products through regular comparisons.

The above are simply examples of processes that entities may consider as a means to implement the data quality aspects of QA4EO. Discussion forums for agencies and/or organisations to develop appropriate methodologies and to ensure that an appropriate internationally-consistent level of rigour is applied will assist the process.

9 Conclusion

This document has summarised the principle evidence that should be considered necessary to "endorse" or accept a QI for an EO data product or related process. In addition to a basic quality management system, documented evidence of traceability via comparison is considered a core requirement. However, comparisons can only be used to sample the process, so, when they are organised, participation should be considered mandatory.