

QA4E  | A QUALITY ASSURANCE
FRAMEWORK FOR
EARTH OBSERVATION

**A guide to content of a documentary procedure to
meet the Quality Assurance requirements of GEO**

QA4EO-QAEO-GEN-DQK-002

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Community Approved

A guide to content of a documentary procedure to meet the Quality Assurance requirements of GEO

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Version 4.0 incorporates edits and comments made on version 3.0 by WMO and GSICS August – November 2009.

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1 Abstract

This document provides guidance on the recommended content, together with an example structure, for a written “procedure”, which will facilitate the demonstration of compliance with the data quality aspects of the Group on Earth Observations (GEO)’s Quality Assurance Framework for Earth Observation (QA4EO). The requirement driving QA4EO is the need to assign to all data / information products a Quality Indicator (QI), which will allow all stakeholders to unequivocally evaluate the products’ suitability for a particular application. This requires that the basis for such a QI must be transparent, internationally consistent and independent of sensor or application domain. The QI and evidence to support its “value” must also be fully traceable back through the processing chain to the original source data / measurement. This processing chain can be considered as a set of linked activities or processes (e.g. data collection, correction / conversion algorithm, dissemination, etc.), some operating in a direct linear path, others providing ancillary information to aid the next processing step. The purpose of this “key guideline” is to provide an example template (referencing other appropriate key guidelines) to aid its user in establishing and documenting the evidence needed to assign a QI to each step of the processing chain. This covers both the written procedure to develop and carry out any particular activity or process and the written evidence and its derivation to support the value of any assigned QI. This guideline can be considered the core of QA4EO and the user / reader can have confidence in any output resulting from processes carried out that are fully compliant with its content. This key guideline is written and structured in the style of the document it is providing guidance on, so in places it may appear repetitive, but has been maintained to be illustrative of a full document.

2 Scope

This document provides guidance on the recommended content, together with an example structure, for a written “procedure”, which will facilitate the demonstration of compliance with the data quality aspects of the Group on Earth Observations (GEO)’s Quality Assurance Framework for Earth Observation (QA4EO). The scope of this document covers all Quality Assurance (QA) and Quality Control (QC) aspects of data and derived knowledge information products including data collection, processing, dissemination and archiving. Although this guideline is not directly written for more generic documentary or communication based activities, it can easily be adapted to meet their needs. The GEO stakeholder community requires ready access to “useable information” from an

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“operational” Global Earth Observation System of Systems (GEOSS). Data from all sources thus needs to be harmonised and have the capacity to be easily combined and interchanged in a manner that is transparent to the end user. Delivered information products should also have associated with them some form of QI to allow users to assess the products’ suitability for a particular application, i.e. its “fitness for purpose”.

In the context of this document, “procedure” is used as a generalised term that incorporates other descriptors such as methodology, protocol, guidelines, etc. The sometimes-subtle distinction of the different uses of these terms is largely the level of detail in their content.

The level of detail contained within any individual document written following this key guideline is likely to vary considerably, depending on:

- the type of activity covered,
- its degree of maturity,
- complexity,
- relative criticality to the user of the intermediate “result” (of the activity) and / or
- its overall role / contribution to the final delivered Earth Observation (EO) data product.

However, it is expected that all “procedures” written following the principles outlined in this guide should at least make clear that they have considered the issues described as “core content” within this document, even if that results in a simple “not relevant” statement.

This guideline provides the template for **all** the information required to be compliant with QA4EO. However, in many cases it will defer to other key guidelines to give additional specific detailed guidance on particular aspects. This document is written to reflect the content and style intended of documents that follow its guidance and so in places may seem repetitive. For example, section 4 (Background and Context) contains much of what is contained in this section.

The following set of headers outlines the required “core contents” for a procedure to ensure that all key requirements are met. The descriptions associated with these headers will be expanded upon later in this document.

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Identifier: alphanumeric

Title: concise but explanatory

Author: owner, point of contact (POC)

Authority: authority under which the document is issued

Issue / Version number / Date: indicate if superseding a previous version

Abstract: concise overview (one or two paragraphs) including keywords to aid automated searching

Overview / Scope: extension of abstract to enable rapid assessment of purpose and content of the document; can be considered as an “executive summary” of the document.

Terminology / Definitions: key terms used; not for establishing new definitions

Background / Context / Requirement: information to place the activity in the context of addressing a requirement

Outcomes: possible and/or expected results of the activity, with uncertainty, and referenced to standards

Inputs: the entities with which the activity operates

Standards and Traceability: the “standards” to which the outcomes are referenced and the linkage / comparison pathway

Task Description: details of the activity to enable reproduction and assess its suitability for a particular purpose

Evaluation of Performance: quantitative assessment of the results of the activity, to establish confidence levels for the outcomes

Evidence to Support a Performance Indicator: documentation to justify and/or support the Evaluation of Performance

Review of Process: results of internal / external user evaluations

In many cases, procedures will not only serve to document a specific activity but will also provide guidance and/or tutorial material for the community as a whole. It should be noted that all communication formats are allowable, e.g. text, video, Powerpoint, etc.

Some procedures, written following this guide, will have been subject to formal peer review within the GEO community. In these cases they may be endorsed by an appropriate community representative body as an example of “best practise” and a

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recommended method. However, this does not mean that those not carrying this status are not approved or recommended, simply that they have not been through this rigorous peer review process. In some cases, only one “best practise” may exist; in others, there may be several or none.

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 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”. Calibration and validation (Cal/Val) is critical to QA and therefore data usability. The Committee on Earth Observation Satellites (CEOS)’s Working Group on Calibration and Validation (WGCV), in partnership with the Institute of Electrical and Electronics Engineers (IEEE), were therefore natural leads to carry out this task for space-based observations. By taking a generic approach and building on broad-based, non EO specific QA best practices that utilise, amongst others, the expertise of the national standards laboratories of the UK and USA, these organisations sought to encompass the needs of the wider GEO community into a single QA framework. That framework is evolving to take account of the needs of the SBAs and to involve the wider community in the evolution and implementation of QA4EO into GEOSS.

The key guidelines contained within QA4EO provide the means to facilitate the ready acceptance of data and derived products from all stakeholders within the community at face value, independent of national borders or sensor type. The practical realisation of

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this goal will be the result of specific activities and procedures implemented and written following these key guidelines.

In addition to “availability” and “accessibility”, each data product needs to have ascribed to it a Quality Indicator (QI) that provides sufficient information to allow all users to readily evaluate the products’ suitability for their particular application, i.e. its “fitness for purpose”. This, in turn, places an equivalent requirement on all steps and activities within the data processing chain, from collection and processing to delivery. A key underpinning principle of this strategy is “appropriateness” and “consistency” and that it is not judgemental.

It has been agreed that a QI should be based on a quantifiable assessment of evidence demonstrating the level of traceability to internationally community agreed (where possible SI) reference standards (in some cases such standards may be intrinsic in nature). This documented evidence should include a description of the processes involved together with an uncertainty budget (or other appropriate quality performance measure as described in the key guidelines).

Products or processes following the guiding principles indicated above will be able to apply for formal QA4EO “endorsement” if required. Where documents are less generic in nature, other community-specific organisations can serve as the endorsing body, although formal endorsement is not a requirement. Funding agencies and/or users of information that originate from sources declaring compliance to QA4EO should evaluate the evidence presented using this document as a guide and/or others where appropriate.

This document seeks to provide its reader / user with guidance on core content, together with an indicative structure on the writing of procedures, needed to meet the above objectives. This covers those written during the development of a process and their subsequent adaptation to provide documentary evidence of the QI. Procedures seeking endorsement by QA4EO to support GEO will be required to follow the key guidelines that constitute QA4EO and, in particular, the content of this document (QA4EO-QAEO-GEN-DQK-002). It is also recommended that, as “best practise”, the guidance in this document should be adopted by anyone initiating a new process or activity. In some cases, the headers and content outlined in this document will not be fully relevant. However, for consistency and clarity, it is advised that authors make such declarations when writing documents to emphasise that they have been considered. It is anticipated that a procedure is written before starting on the activity itself. However, in some cases this may only be in outline form with details completed as the process is developed.

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This key guideline and those it references have been drafted to take account of “best practise” already carried out within the EO sector together with that practised within wider public and commercial sectors. It particularly draws on guidance contained within the documentary standards of formal quality management systems such as those developed by the ISO, e.g. ISO 9001 (Quality management systems — Requirements) and ISO 17025 (General requirements for the competence of testing and calibration laboratories). Often the activities proposed here are already being carried out within organisations, although this may not always be documented in a transparent manner that facilitates easy review by a third party. This document sets out to establish a common framework to enable this. The “template” format indicated here is not compulsory and readers would not be expected to change any existing documentation simply to match that provided here. It is also not anticipated that the requirements indicated in this document can or should be applied retrospectively, unless the activity has significant impact in future projects and would thus be worth the effort. Even in these cases only the missing information would be expected. However, for new activities it is hoped that this will be followed (in terms of content at least) and that it will not in reality add significant additional burden on any user.

In many cases detailed procedures, written following this guide, will not only serve to document a specific activity but will also provide guidance or tutorial material for the community as a whole. It should be noted, particularly in this context, that authors should consider making use of a range of potential communication formats and not feel constrained to the conventional text based document. For example, Powerpoint slides, video and recorded oral material are all perfectly valid formats, and in some cases may provide a more efficient and effective medium than text alone.

It is assumed that procedures written following this guide will, as a default, require any user of it to produce a report stating its use and reporting the details and results of the performance assessment sections. This will constitute the evidence to support the QI assessment. Ideally such reports should be made widely accessible through the QA4EO website (<http://QA4EO.org/>) and other appropriate portals, e.g. the GEO/CEOS Cal/Val portal (<http://calvalportal.ceos.org/>) for EO Cal/Val data.

5 Outcomes

There are no direct outcomes stemming from the activities described in this key guideline other than as an input to a set of QA4EO procedures and the ability to assign a QI to the

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result of any process following it. In procedural terms, its objective is to provide guidance to authors and reviewers on the appropriate content and analysis required to meet the needs of QA4EO. Ideally it can be considered as a template upon which technical procedures can be based. Similarly, there are no target quantitative measures that can be attributed to these.

6 Inputs

There are no specific identifiable inputs required by this key guideline to enable the outcomes to be achieved, other than the other QA4EO key guidelines.

7 Standards and Traceability

The process outlined in this document has no quantitatively assessable outcomes and there are no appropriate reference standards to which traceability should be demonstrated. However, this document will make reference to the use of existing documentary standards (where appropriate) within its guidance, e.g., vocabulary [1], Uncertainty analysis [2] and SI traceability [3]. As time progresses, new documentary standards and “best practises” may be developed and adopted that are applicable to the activities described in this document.

Therefore, it is recommended that the latest version of this document be reviewed for changes prior to its use. Current standards and terminology information can be accessed via the following:

1. QA4EO (<http://QA4EO.org/>)
2. ISO
(http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=45315)
3. BIPM MRA (<http://www.bipm.org/>).

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8 Recommended content of a documentary procedure

8.1 Introduction

The following set of headers and associated descriptions outline the key requirements for any document written to describe an activity or process within the EO sector to ensure that it meets with QA4EO data QA guidelines. The level of detail required under each header will vary significantly depending on the process or activity involved and its level of maturity, complexity and intended purpose. For example, considerably more detail will be required for a procedure to describe how one should repeatably carry out a task, e.g., calibrate an instrument, compared to describing a methodology that might provide a generic set of options and processes, e.g., the evaluation of the radiometric performance of a land imaging sensor. In this latter case, the document might simply refer to the need to carry out the process, what options exist and how the results should be reported, whilst referencing more detailed procedures for any one specific method, e.g., Rayleigh scattering, reference test site, etc. It should of course be noted that this process also applies to a procedure that might refer to the whole process chain and, in essence, be a collection of linked procedures, each one having their own associated documentation.

The author should judge, from their intended readership and level of usage, an appropriate style for the content. For example, in some cases a simple set of bulleted points would be adequate, in others it might be more appropriate to have detailed examples showing how the procedure has been used: sample outputs, previous results, etc. However, in all cases the most effective documents are short and concise, containing only the necessary information for the described task.

8.2 Procedure content

The following set of headers outlines the required “core contents” for a procedure to ensure that all key requirements are met. Associated with each “header” is some descriptive text to provide further guidance on this content. Whilst authors are encouraged to use similar headers and structure for ease of the generic reader, this is not obligatory and in some cases, e.g. where different media formats are used, this may be difficult to reproduce. However, authors should ensure that they cover the specified information and appropriately link it together to be referenceable as a single entity. Other headers and associated content may be considered useful, such as a list of acronyms and a summary or conclusion.

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8.2.1 Identifier

Each document should be assigned a unique (alphanumeric) identifier. Ideally these should be structured to take account of common themes, for example, sensor specificity or aspect of characterisation. Where the approving authority is community-specific this should be reflected in the identifier prefix

8.2.2 Title

This should be concise but as informative as possible, providing the reader with guidance on the topic contained within but starting from the most generic aspect. For example “A guide to evaluating optical sensor radiometric gain using Rayleigh scattering” rather than “Rayleigh scattering method for evaluating radiometric gain”.

8.2.3 Author

The author or group of authors and associated contact details allow clarity and define ownership or point for communication of any issues, revisions, etc. In some cases, a committee and its chair or designated contact point can be used. An email address, phone number and/or fax number should be provided.

8.2.4 Authority

All documents need to make clear under whose (body, organisation) authority the document is issued. This may be, e.g., a space agency, a company or another GEO member organisation. It may, in many cases, be a nested set of authorities. It should be noted that QA4EO and its management structure operates under the overall authority of GEO.

8.2.5 Issue, Version number, Date

It must be clear if the document is the first issue or if it supersedes a previous version. This is best carried out by using an explicit phrase such as “replacing version 1.1” rather than simply a new number.

8.2.6 Abstract

This should be concise, typically no longer than one or two paragraphs. It should also contain appropriate key words to aid in any automated search programme.

8.2.7 Overview, Scope

This should be considered as an extended abstract or an executive summary to allow a reader to rapidly assimilate the purpose and content of the document. Such text should be

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concise but also contain sufficient detail to allow its reader to ascertain the full scope of the task described within it. It should describe the limitations of the document as well as its intended purpose.

8.2.8 Key terminology, Definitions

Any special terms or concepts should be clearly defined. The author should not seek to define new terms or definitions where they already exist. To make it easier for the reader, the author may choose to include them in the document. Dictionaries of recommended vocabulary are available through the QA4EO website (<http://QA4EO.org/>).

8.2.9 Background, Context, Requirements

The requirement for the procedure (activity) described in the document should be indicated. This should include any essential background to put the activity into context. If the activity follows practises that have previously been followed, or even a novel approach to an established activity, there should also be some discussion of this and reference to the current state-of-the-art. If the driver for the document has been stimulated by a particular “user group” or for a particular application, e.g., a mission requirements document, this should be made clear. However, where such requirements have been generalised or if the procedure being described has wide applicability, this should also be made clear here. In some cases the theoretical basis underpinning the procedure may be well proven and documented and any appropriate references should be included here or in section 8.2.13 as appropriate.

Use should be made of accessible, maintained reference material and web links. Only a brief overview should be needed within the document itself.

8.2.10 Outcomes

This should describe the expected / desired results of the process in a quantified way, where appropriate. Quantification should be in terms of all appropriate performance parameters, e.g., time or uncertainty (boundaries or absolute), with a reference to what they are “referenced to”, e.g., reference standard, SI, repeatability, etc. The driver and originator of the performance specification and any priority between potential competing parameters should be made clear. In this section it is important to make clear to the reader whether the outcomes are demanding (state-of-the-art) or not, so that the applicability of the method to a particular user need can be quickly evaluated.

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In a document with more “procedural based outcomes” (such as this), these may be specified as “aims and objectives”.

8.2.11 Inputs

This section should contain references to all the inputs from which the process / activities described in the subsequent document act upon (or with) to derive the outcomes. Inputs may be, e.g., digital signal counts, the output of a previous process, variables or constants needed within an algorithm, etc. The source of these inputs, together with their associated set of “quality characteristics”, e.g., uncertainty (and the evidence to support it or what is required of them), should be included here. N.B., in general it is expected that any key input will have associated with it a written report that documents the results of a procedure carried out following the guidance outlined in this document.

The inputs stated may be generic, in others they may be prescribed quantities. For example, in a process containing a radiative transfer code relates to a satellite sensor. In this instance, the CEOS reference solar irradiance spectrum could be considered a prescribed input.

8.2.12 Standards and Traceability

In this section reference should be made to any “standards”, in particular, those to which traceability should be defined and demonstrated. Standards can be documents or physical artefacts / processes that would be needed as part of the activity to evaluate performance (artefacts might be natural or manmade and can be surfaces, solids, liquids and gasses). If there are no formal community-endorsed standards available, or if they are not considered applicable, the author should identify what they propose to use to demonstrate performance and traceability. It may, for example, simply be based on consistency with previous results that use a different method, or that tests will be performed at some later stage in the overall process. However, it must be made clear what will be done and for what reasons. Some reference standards may appear to be intrinsic (based on a well-defined physical process as opposed to an “artefact”) and in these cases it is important to ensure that the means of their usage is documented.

This section is largely for approvers of a process to ensure that an appropriate test plan has been considered. It is also useful for the author of the procedure to ensure that any specific preparations for testing are considered well in advance. This may lead to a revision of the ideal test process and could lead to the need for the implementation of an alternative strategy earlier in the process.

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For each “standard” it will also be essential to describe what method will be used to provide linkage or comparison to it.

The reader is referred to QA4EO-QAEO-GEN-DQK-003 and QA4EO-QAEO-GEN-DQK-007 for more detailed guidance.

8.2.13 Description of Task

This section (which is likely to consist of subsections) should provide the details of the process or activity being carried out. The level of detail and format can vary according to the complexity and scope of the process. For example, a tutorial-based document would benefit from step by step schematics and/or video to complement any text. Similarly, the description of a more generic methodology is unlikely to have as much prescriptive detail as one which details a production process.

In all cases there should be enough detail to allow the informed reader to carry out the activity themselves (noting that they may need specialised algorithms or instrumentation) and/or assess the adequacy of the outputs for their application. In the former case, this might simply be to choose which method to use for a particular activity, directing the reader to a more specific detailed procedure.

In describing the steps, it is important for the author to guide and explain why a specific approach was taken and, if a choice was made, what reasoning was used. This is important even if the choice was *ad hoc*, so that clarity is maintained. Where there is already proven justification for the underpinning methodology this should be referenced.

In describing the task, it is important to make clear to users that a “final report” detailing the use of the procedure, together with the results, is part of the task. If there are specific skills or training required to perform any of the activities specified in the procedure, these should be identified and referenced in the final report. The procedure itself does not need to be reproduced in this “final report”, only reference to it or to any variations from it.

8.2.14 Evaluation of Performance

This section should contain details summarising how the outcomes (described above) should be evaluated, against what standards and through what methods. It is likely to consist of a simplified model of the process or activity to identify sensitivities and an example uncertainty table. This table should be broken down into its constituent parts with descriptions of the variables / parameters and, where possible, examples of the likely values.

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In the “procedure document” the evaluation of performance section will be a description of what is needed and so will allow an appropriate test plan to be devised. When written as a “final report” as evidence to support the QA of an activity carried out following the procedure, it will be one of the most critical sections. In this latter case, it will be important that the confidence level associated with each uncertainty component is declared and that they are combined according to the internationally agreed best practise (see QA4EO-QAEO-GEN-DQK-004 and associated references).

In this section of any “final report”, any deviation from the original planned outcomes should be evaluated and discussed. This should include an analysis of where effort needs to be optimally directed to improve the situation. This effort is not necessarily targeted at the largest uncertainty component as others may be more readily addressable.

This section is unlikely to be required for a procedural document but critical for one involving data or data products including their processing.

QA4EO-QAEO-GEN-DQK-005, QA4EO-QAEO-GEN-DQK-006 and QA4EO-QAEO-GEN-DQK-007 are likely to be of assistance here to the reader.

8.2.15 Evidence to Support a Performance Indicator

In the “evaluation of performance” section a quantitative assessment of performance / uncertainty will have been carried out according to described methods and against defined standards. This section should provide guidance on the requirements for, and means of obtaining, supporting evidence to defend the assessment as reasonable and justified.

Ideally this evaluation should be carried out through some independent means. For example, the best way to confirm the above assessment unequivocally is to carry out a comparison with another group or method. This may be performed on the direct results of the process or on results from previous use of the process, combined with evidence of consistency in the use of the procedure.

Examples of acceptable evidence for different generic processes are available from QA4EO (see QA4EO-QAEO-GEN-DQK-001, QA4EO-QAEO-GEN-DQK-005, QA4EO-QAEO-GEN-DQK-006 and QA4EO-QAEO-GEN-DQK-007) and include:

- Accreditation to an appropriate formal Quality standard, e.g., ISO
- Compliance with appropriate quality standard (review by external technical auditor)

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- Participation in and obtaining statistically consistent results in a comparison with an external (independent) organisation
- Reproducibility
- Repeatability

The degree of rigour associated with, and type of, supporting evidence will depend on the performance indicator and the requirements of the user's application. In some of the most demanding cases significant evidence will be required; in others, less so.

A generic procedure should provide the reader with guidance on what should or could be done. In documents describing the results of the procedure's use (final report), the actual evidence, or at least reference to it, should be provided.

This section is unlikely to be required for a procedural document but is critical for one involving data or data products including their processing.

8.2.16 Review of the Process

Users of a procedure should be encouraged to carry out a continuous review of the process to evaluate potential improvements. Such reviews should be documented and, where appropriate, communicated to the author and/or issuing authority. It should be emphasised that procedures, even when designated "best practises", are living entities and are subject to evolution as knowledge matures and new techniques are established. This section will only have meaningful content when "reports on using the procedure" are written.

8.3 Reporting and Documentary Evidences

A key requirement of QA4EO is that there is documentary evidence to support any quality statement. This documentary evidence needs to include a description of the process and a quantitative assessment of the associated quality parameters. The latter should be based on traceability to international community agreed standards.

Section 8.2 of this document describes the principle content and processes required to meet the requirement for "documentary evidence". This section simply emphasises that it is the report on carrying out these tasks (and the results of any analysis or assessment) that constitutes the required documentary evidence. Such a "final report" should, in practise, mimic that described in Section 8.2, except by providing observed results rather than examples. The description of the process can refer to the existing procedure rather than a replication of text except where there are variations. In addition, the final report

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should include information relating to dates when tasks were carried out, who performed them and, where appropriate, a *curriculum vitae(s)* (to indicate the appropriate level of training) and any other key identification criteria specific to the task (instrumentation, serial number, etc.).

Approved “final reports” should be made accessible to all potential users of the results of the process being carried out. Clear robust linkage (tracking) to the delivered product or result should be ensured so that long-term evidence of traceability can be maintained. Where possible, authors of procedures and of final reports derived from using them are encouraged to give open access to the GEO community through the QA4EO website (<http://QA4EO.org/>) or via community-specific portals, e.g., the CEOS Cal/Val portal (<http://calvalportal.ceos.org/>). In this way, full transparency of the processes being carried out guide others in undertaking similar activities.

9 Conclusion

This document has defined the guiding principles, in terms of content and analysis, for authors of “procedures” and those using them to ensure that they are compliant with the data QA strategy of GEO as implemented through QA4EO. This strategy was devised to provide adequate information to the users of the outputs of such procedures so that they can make informed decisions as to the suitability and “fitness for purpose” for specific applications.

This key guideline has been written in the same style as it proposes for its users. However, as a “procedural document” it does not contain sections on performance evaluation, etc.