

**Group on Earth Observations /
Committee on Earth Observation Satellites**

**Quality Control and Calibration & Validation
Processes Best Practices Guidelines**

Workplan

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1 Introduction

The Committee on Earth Observation Satellites (CEOS) has become a much more efficient and active coordination body within GEO in working towards the establishment of an operational Global Earth Observation System of Systems (GEOSS). GEO coordinates global activities by making these mechanisms and their priorities clearer and easier to understand at a political level. GEOSS is not in itself a tool dedicated to a single application but a collection of 'systems' serving a multitude of disparate applications. For GEOSS to be fully successful, the calibration, validation and intercalibration between all instruments is of key importance. GEOSS is for users and decision makers, not for scientists, and as such the data needs to be trusted and reliably used without the risk of basing a wrong decision upon it.

The GEOSS 10-year implementation plan identifies that 'The success of GEOSS will depend on data and information providers accepting and implementing a set of interoperability arrangements.' However, data accessible does not necessarily mean data usable. Cal/Val is critical to data quality assurance and data usability. GEO task DA-06-02 is led by the WGCV and the Institute of Electrical and Electronics Engineers (IEEE) and aims to 'Develop a GEO data quality assurance strategy, beginning with space-based observations and evaluating expansion to *in situ* observation, taking account of existing work in the area'. This task is much more cross-cutting than many of the other GEO tasks. The importance of the task has been recognised within CEOS and has been inserted into the CEOS implementation plan.

GEOSS is a global coordinated, comprehensive and sustained system of observing systems that attempts to bring the community together. GEOSS is a global distributed system, including satellite observation systems, global *in situ* networks and systems, and local and regional *in situ* networks. GEOSS will deliver the benefits of EO to both data and information providers and consumers worldwide. GEO is a voluntary process and we should develop 'adaptor plugs' to accept all (properly documented) data no matter what form it takes. GEOSS aims to allow the provision of, and the access to, the Right Information, in the Right Format, at the Right Time, to the Right People, to Make the Right Decisions.

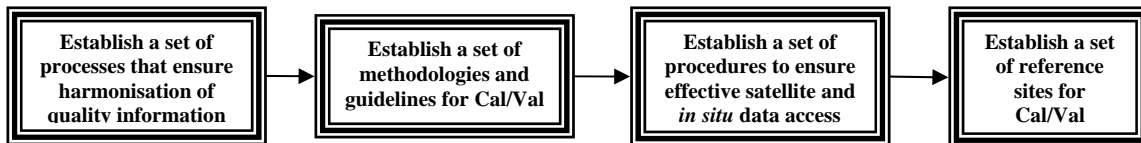
For any method / endorsement there needs to be a way of demonstrating its fitness for purpose. This should be a living practise and that there should be room for research and development. One could start with a limited set of scenarios and develop a standard set of protocols and methodologies for these scenarios. These protocols and methodologies would be current 'best practise' and could, with time, be improved upon. They are not intended as required practises but 'suggested practises', which could be used and at least provide a baseline for comparing against and provide good guidance to newcomers.

The ultimate requirement, as identified by the CEOS WGCV Cal/Val community, is the need to establish a set of Cal /Val guidelines based on the adoption of ‘best-practises’ that can be endorsed by CEOS under the auspices of GEO and for implementation by the agencies. In this context, Cal/Val is concerned with all technical disciplines and all activities processed throughout a data products lifetime ranging from data collection, through processing and to distribution and archiving.

There are three main ways to initially address GEOSS Cal/Val needs:

- Define or identify test scenarios (aka “sites”) for Cal/Val of Earth Observation (EO) measurements
- Establish best practices procedures incorporating internationally recognised standards
- Populate and evolve a GEO/CEOS Cal/Val portal

This document sets out the current context and identifies plans in place to begin drafting a set of CEOS-endorsed quality control and Cal/Val processes best practices guidelines. The document is laid out across four main themes (see figure below), the activities and results from each theme directly influencing the other three, with some activities cross-cutting.



2 Harmonisation of Quality Information

2.1 Context

Harmonisation is of key importance in the frameworks of GEO, CEOS and GMES, who all aim to achieve more harmonisation and standardisation in their activities. Traceability of processes and guidelines is important to ensure that all Cal/Val data can be easily used for intercomparison across missions and to assure data quality. The definition of quality product information and quality indices that could be applied across missions would be a great step forward towards a more harmonised way of operating. Harmonisation and standardisation of quality control information and processes across missions and between agencies / organisations is also desirable and is the ultimate goal for GEOSS.

2.2 Objective

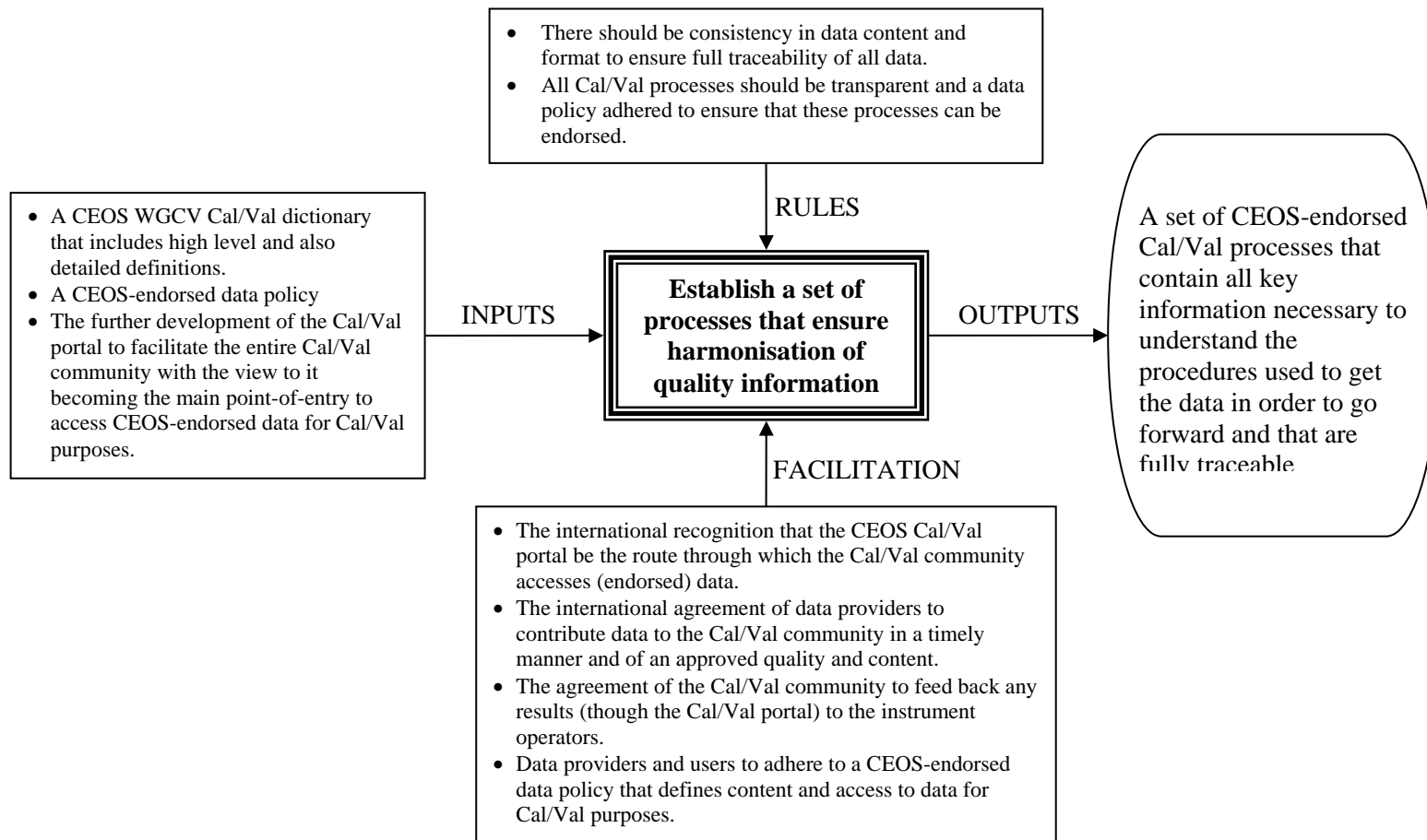
Harmonisation within the Cal/Val community involves not just harmonisation within the methodologies but also in the quality information. A harmonised process should be fit for purpose and there should be room for it to evolve and allow people to do things together. An agreement on the content of the Cal/Val process is the key factor, not the methodology. All processes need to contain all the key information needed to understand the procedures used to get the data in order to go forward. Once the processes adhere to this, they can then be endorsed (by CEOS).

A key contributor to the effective implementation of a more harmonised way of ensuring quality information flow throughout Cal/Val processes will be the use of a dedicated 'portal' for Cal/Val. A web portal that provides a window to Cal/Val data over a set of preliminary Cal/Val 'test' sites has already been established and is to be further developed to allow its evolution into the main hub for access to (eventually) CEOS-endorsed data.

2.3 Value Provided

A more harmonised way of tackling Cal/Val will be of great benefit to the Cal/Val community, which to date is somewhat disjointed in its approach, mainly concentrating on mission-specific campaigns only. A first and key step towards harmonisation across the global EO cal/val community will be the development of a dedicated CEOS WGCV Cal/Val portal. This will facilitate the implementation of these activities on behalf of GEOSS in its mission to achieve harmonisation of quality assurance processes.

2.4 Process Description



2.5 Performance Measures

An ISO-type of documentary standard for the endorsement of Cal/Val processes and quality information is sought. Ways of implementing this are currently being investigated through actions laid down at the GEO/CEOS Workshop on Cal/Val Processes held in Geneva from 02 to 04 October 2007:

Number	Action	Responsibility	Due Date
11	Establish a committee to explore options on how we are able to establish authority for the endorsement of best practices for cal/val.	WGCV Chair	05-Oct-07
12	Include a discussion at the joint WGCV / WGISS meeting in February 2008 on the idea of adopting a standard set of best practices and the means to establish an authority to endorse them, possibly with a CEOS, ISO or similar stamp.	WGCV Chair	WGCV-28

2.6 Outstanding Issues

The following specific tasks related to harmonisation of quality information were laid down at the GEO/CEOS Workshop on Cal/Val Processes held in Geneva from 02 to 04 October 2007:

Number	Action	Responsibility	Due Date
5	Formulate a request to the Constellation leads to evaluate their requirements for cal/val needs.	Bojkov, Stensaas, Campbell, Cao	01-Nov-07
6	Investigate Jim Butler's CEOS Information Server (http://spsosun.gsfc.nasa.gov/calval/index.html) and see if it contains any useful for the portal	ESA	02-Nov-07
7	Establish & define key cal/val terminology as an input into a WGCV dictionary.	WGCV Subgroups	WGCV-28
8	Draft a recommendation regarding the need to maintain long-term archives of cal/val process data to support EO.	Fleig	01-Nov-07
13	Define wish list of requirements for functionality from the cal/val portal and feedback to the cal/val portal maintainers (ESA).	WGCV Subgroups	WGCV-28

2.7 Proposition

**** To be initially defined after WGCV-28 ****

3 Methodology and Guidelines for Cal/Val

3.1 Context

For Cal/Val, a set of endorsed methodological best practices would provide the community with a benchmark upon which to plan and execute their activities. Currently, activities are somewhat disjointed and there would be great benefit in the use of a common set of information (a check list) and full documentation of methodologies used. In essence, there should be enough information for someone to really understand the process and procedure used in order to show that the Cal/Val requirements are being met in a common way. Should this be achieved, the global Cal/Val community would be able to function and communicate much more effectively.

3.2 Objective

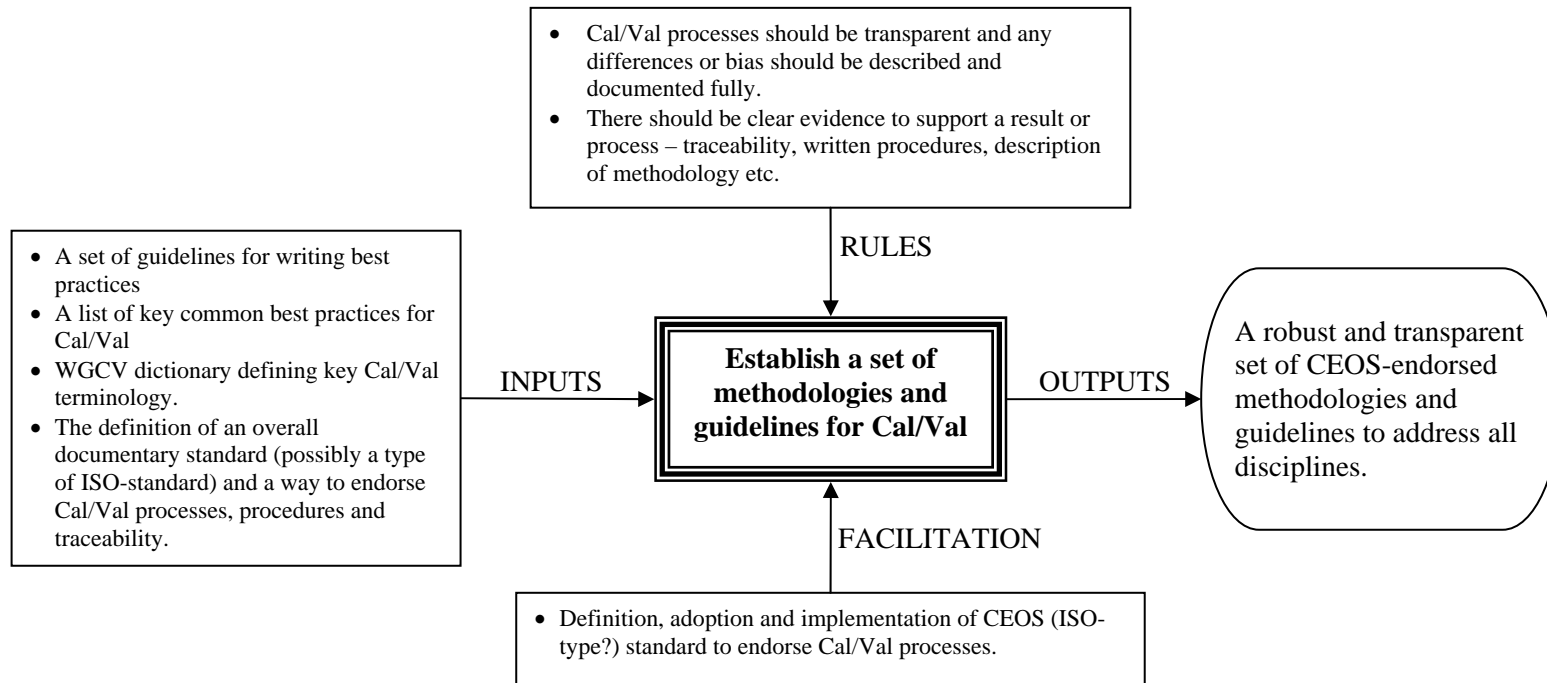
It is important to make the results of comparisons visible to all and this would demonstrate transparency. Comparison in this context is the ability to demonstrate that the number one gets out from the end process is the same as the number someone else achieves when doing the same thing. More importantly, it is imperative that we know what the difference, or bias, is and that we can describe this bias. Ideally, there has to be some umbrella organisation / body that convenes these people together to do this and ensure consistency, best practise of approach, and it is suggested that this should be done under the auspices of CEOS. CEOS (WGCV) is the body responsible for space of GEOSS and, as such, should scope the whole of the EO field. Detailed implementation should be carried out regionally by national bodies or groups of national agencies but under the auspices of the CEOS subgroups. The subgroups would ensure that comparisons are linked between geographical regions and that the results are made visible. A best practise guidance on the organisation and analysis of comparisons should be developed and it was suggested that this could be based on one developed by national standards laboratories.

‘Traceability’ requires an unbroken chain of comparisons / calibrations to an internationally agreed reference standard each with an associated uncertainty. In order to achieve this at an internationally recognised level, the WGCV have agreed to establish a dictionary of key Cal/Val terminology to assist this process and ensure effective communication at all levels throughout the Cal/Val process. Concerning the sort of evidence that would be acceptable to support a result or process, there needs to be, as a minimum, full traceability, written procedures and a description of the methodology used. Evidence needed to support a claim needs to contain a description and provide traceability with comparisons being a good mechanism to show traceability. This method could be used in conjunction with models and algorithms also.

3.3 Value Provided

A set of endorsed methodological best practices would provide the community with a benchmark upon which to plan and execute their activities. The global Cal/Val community would be able to function and communicate much more effectively as a whole and this would be a major step forwards towards a successful and operational GEOSS.

3.4 Process Description



3.5 Performance Measures

An ISO-type of documentary standard for the endorsement of methodologies for Cal/Val is sought. Ways of implementing this are currently being investigated through actions laid down at the GEO/CEOS Workshop on Cal/Val Processes held in Geneva from 02 to 04 October 2007:

Number	Action	Responsibility	Due Date
11	Establish a committee to explore options on how we are able to establish authority for the endorsement of best practices for cal/val.	WGCV Chair	05-Oct-07
12	Include a discussion at the joint WGCV / WGISS meeting in February 2008 on the idea of adopting a standard set of best practices and the means to establish an authority to endorse them, possibly with a CEOS, ISO or similar stamp.	WGCV Chair	WGCV-28

3.6 Outstanding Issues

The WGCV's Infrared and Visible Optical Sensors (IVOS) subgroup have agreed to draft together a set of guidelines for writing best practices. Using this as a template, and incorporating the specific needs of their communities, the individual subgroups are then to draft together a list of key common best practices for Cal/Val. These specific issues, alongside other relevant tasks, were set as actions at the GEO/CEOS Workshop on Cal/Val Processes held in Geneva from 02 to 04 October 2007:

Number	Action	Responsibility	Due Date
5	Formulate a request to the Constellation leads to evaluate their requirements for cal/val needs.	Bojkov, Stensaas, Campbell, Cao	01-Nov-07
7	Establish & define key cal/val terminology as an input into a WGCV dictionary.	WGCV Subgroups	WGCV-28
8	Draft a recommendation regarding the need to maintain long-term archives of cal/val process data to support EO.	Fleig	01-Nov-07
9	Draft guidelines for writing best practice	IVOS/FOX	30-Nov-07
10	Formulate a draft list of key common best practices for cal/val.	WGCV Subgroups	WGCV-28
13	Define wish list of requirements for functionality from the cal/val portal and feedback to the cal/val portal maintainers (ESA).	WGCV Subgroups	WGCV-28

3.7 Proposition

**** To be initially defined after WGCV-28 ****

4 Satellite and *in situ* Cal/Val data access

4.1 Context

Key satellite and *in situ* data needs to become freely available to the Cal/Val community to ensure that all EO data is effectively calibrated and validated. The establishment of a set of Cal/Val sites endorsed by CEOS and maintained for the benefit of the global community would assist this process by ensuring that sharing of important Cal/Val data is undertaken across CEOS member agencies and beyond. The establishment of a dedicated Cal/Val portal to provide the mechanism to distribute data governed by a CEOS code of practice would also assist the process and be an improvement on the current disjointed process in operation today.

4.2 Objective

The objective is to allow free and effective access of satellite and *in situ* data for Cal/Val purposes to the Cal/Val community. In the specific issue of Cal/Val data, totally open access can hurt the Cal/Val activity dramatically if users erroneously ‘re-do’ calibrations, and so it would be important to clearly define who is part of the Cal/Val community. This would ensure that the input would be two-way with both data provider and data user feeding back into the process. The access to data would have to be governed by a dedicated Cal/Val data policy (code of use) that would ensure both the quality and traceability of the ‘raw’ data and also any results from using these data in an analytical way.

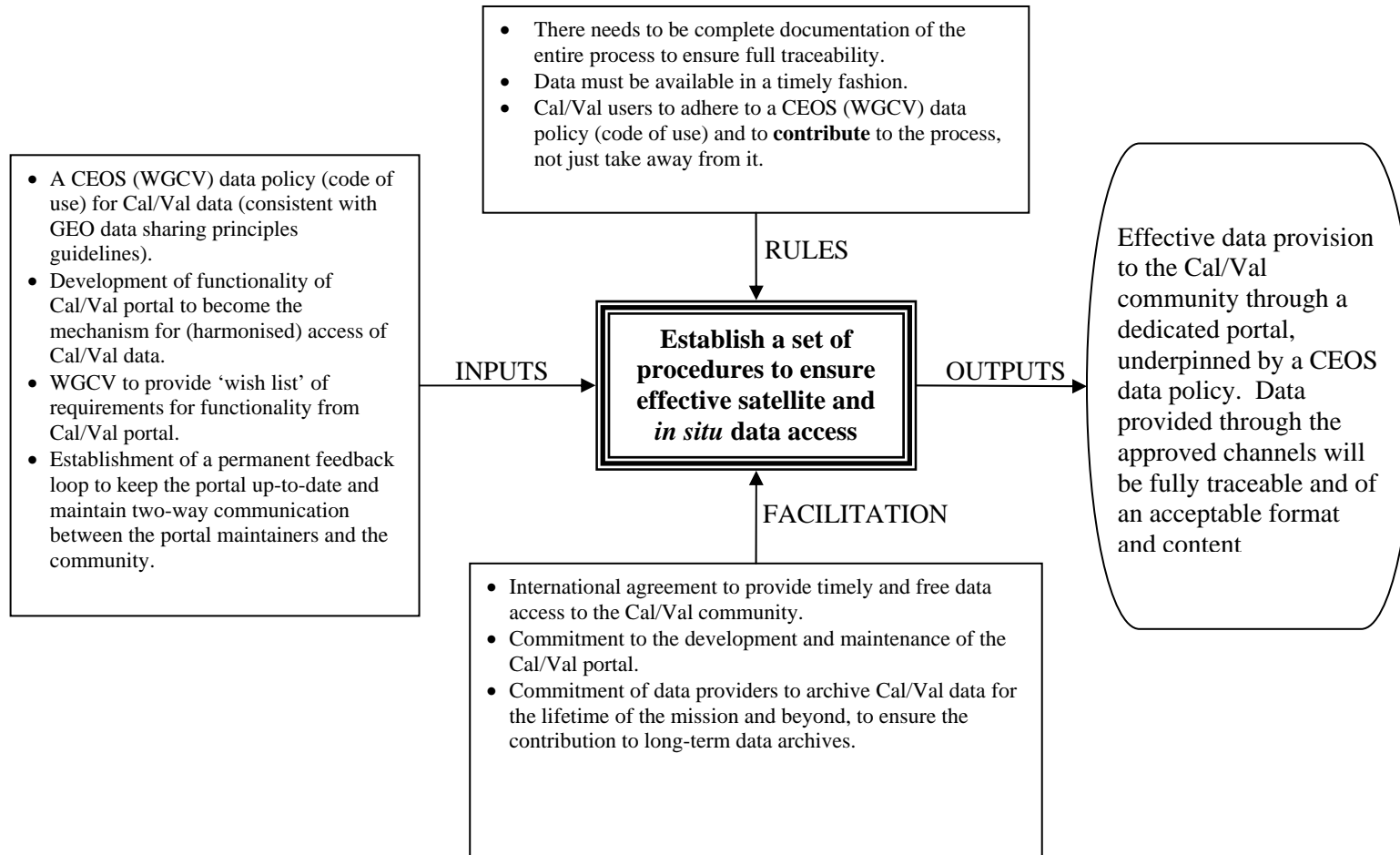
Given an effective data policy, there would be no inhibition from new countries contributing to the process merely because their data does not fully meet standards. Indeed, any data could effectively be contributed to the process as long as it contains a full traceability chain and its limitations are clearly defined. The CEOS data policy should be in line with the GEO data principles already published.

The provision of Cal/Val data to the community is proposed through a dedicated centralised ‘portal’. This will be a managed system that will source endorsed Cal/Val data and provide easy access to it for the dedicated Cal/Val user (i.e. those who have signed up to the CEOS data policy). The data will include complete documentation of the entire process to ensure that there is full traceability. There should also be caveats attached to early release data and if people want access to this data on the premise of Cal/Val then it should be a default that they need to feed their results back for comment and review by the mission team. The employment of a dedicated Cal/Val portal would ensure that datasets are not duplicated unduly and would ensure efficient and secure knowledge transfer.

4.3 Value Provided

Free and effective access to Cal/Val data acquired over a set of CEOS-approved sites and underpinned by a CEOS data policy (code of use) would ensure that Cal/Val data is accessible to those best placed to undertake the analysis. Each new mission dealing in satellite data should include some Cal/Val data acquisition planning and once the mechanism for effective access to endorsed and fully traceable data through a dedicated portal has been established within the global EO community this will more likely become a reality.

4.4 Process Description



4.5 Performance Measures

CEOS (WGCV) are the responsible body for the drafting and maintenance of a Cal/Val data policy that should underpin access to data for Cal/Val purposes. This data policy will drive the more logistical aspects such as the actual mechanism for data provision (through a dedicated Cal/Val portal), and it is thus a most important part of the framework. At the GEO/CEOS Workshop on Cal/Val Processes held in Geneva from 02 to 04 October 2007 an action was identified to start the drafting of this key document:

Number	Action	Responsibility	Due Date
16	Draft a WGCV data policy (code of use) for cal/val data that will be consistent with the GEO data sharing & principles guidelines.	Stensaas, Bojkov	WGCV-28

4.6 Outstanding Issues

Issues outstanding concerning satellite and *in situ* data access primarily concern the data policy (addressed in section 3.5) and the establishment of a dedicated Cal/Val portal with the view to it becoming the path to all CEOS endorsed Cal/Val data.

The following items were set up as actions at the GEO/CEOS Workshop on Cal/Val Processes held in Geneva from 02 to 04 October 2007:

Number	Action	Responsibility	Due Date
5	Formulate a request to the Constellation leads to evaluate their requirements for cal/val needs.	Bojkov, Stensaas, Campbell, Cao	01-Nov-07
6	Investigate Jim Butler's CEOS Information Server (http://spsosun.gsfc.nasa.gov/calval/index.html) and see if it contains any useful for the portal	ESA	02-Nov-07
8	Draft a recommendation regarding the need to maintain long-term archives of cal/val process data to support EO.	Fleig	01-Nov-07
13	Define wish list of requirements for functionality from the cal/val portal and feedback to the cal/val portal maintainers (ESA).	WGCV Subgroups	WGCV-28

4.7 Proposition

*** To be initially defined after WGCV-28 ***

5 Cal/Val Sites

5.1 Context

There is a need for a set of internationally-approved and widely-distributed sites for the Cal/Val of present and future missions to ensure continuity, particularly in the context of climate change issues. Data needs to be freely available to the Cal/Val community and there should be timely delivery to ensure the effective calibration and validation of EO data.

Specifically, there is a requirement to define a set of global Cal/Val reference (test) sites that span a variety of conditions. Regular monitoring of all necessary information across the site and a clear understanding of the specific characteristics of the site itself would be part of the remit. Knowledge of the variability of the site (cloud cover, etc.) would also be important in order to understand what that site would be good for, depending on the changing environment in and around the site.

5.2 Objective

The objective is to establish a set of internationally-approved and fully-maintained Cal/Val sites that seek to serve all sectors of the Cal/Val community and that are endorsed by CEOS. The sites should span the specific needs of the different EO instruments / specialities requiring Cal/Val.

In this (Cal/Val) context, a reference site could either be a single site or may well be a series of linked (by common protocols and facilities) 'sites', e.g. the Network for Detection of Atmospheric Climate Change (NDACC) series would be regarded as a 'reference site'.

Within the process, there would be the requirement that the site owners would maintain the site and make the data freely available to Cal/Val users. Unless the data is freely available for Cal/Val purposes the site should not be endorsed. The site would also have to be reviewed frequently (perhaps annually) in order to ensure that continued endorsement is justified.

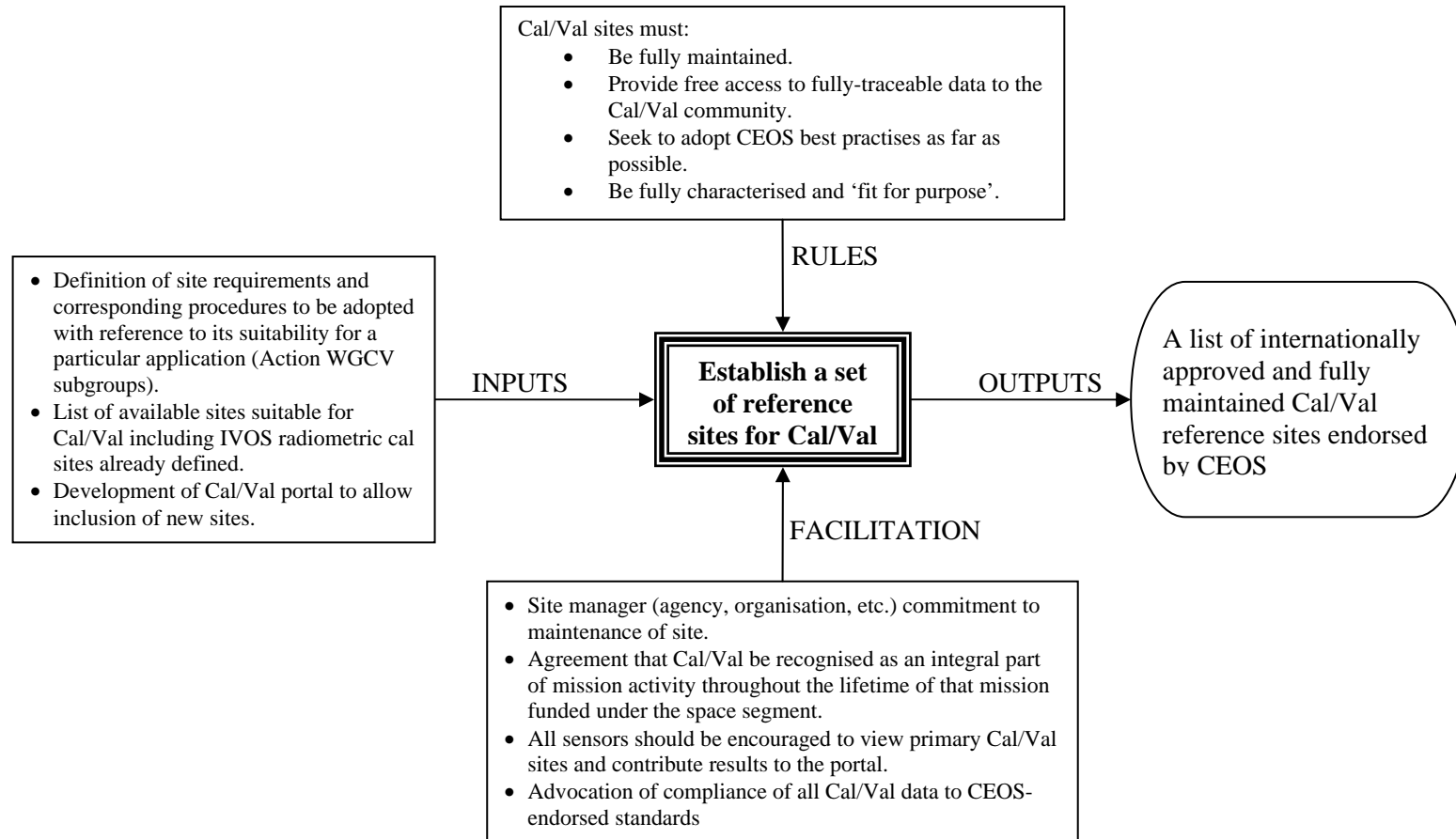
The Cal/Val component should be recognised as an integral part of the mission activity throughout the lifetime of that mission funded under the space segment. All sensors should be encouraged to view a set of key reference sites and contribute the data and any results to the Cal/Val process, potentially via a dedicated Cal/Val portal.

The number of sites and the priorities that are attached to them (for specific applications and performance) should be limited to a core list. It is noted, however, that it is the processes, characteristics and facilities that is being emphasising for a particular site, and some of these can be subject to change over time.

5.3 Value Provided

Having a list of endorsed sites would help the agencies to invest their money in a more appropriate way and make it obvious where there are any gaps. Cal/Val data could be tested against dedicated and endorsed sites specifically chosen to for a particular instrument / application. Internationally approved sites with controlled access to quality assured traceable data would be a valuable contribution to the Cal/Val process.

5.4 Process Description



5.5 Performance Measures

CEOS could endorse the sites (including networks of sites if relevant) based on a particular set of demonstrated characteristics and criteria and thus give users the confidence in their use and application. The WGCV subgroups are best placed to define the key characteristics that a site should have and if that site meets those characteristics then it can be endorsed.

An ISO-type of documentary standard for the endorsement of Cal/Val sites is sought. Ways of implementing this are currently being investigated through actions laid down at the GEO/CEOS Workshop on Cal/Val Processes held in Geneva from 02 to 04 October 2007:

Number	Action	Responsibility	Due Date
11	Establish a committee to explore options on how we are able to establish authority for the endorsement of best practices for cal/val.	WGCV Chair	05-Oct-07
12	Include a discussion at the joint WGCV / WGISS meeting in February 2008 on the idea of adopting a standard set of best practices and the means to establish an authority to endorse them, possibly with a CEOS, ISO or similar stamp.	WGCV Chair	WGCV-28

5.6 Outstanding Issues

Outstanding issues related to the definition of Cal/Val sites include questions over the actual availability of sites and the accessibility of data acquired over / at those sites to the Cal/Val community. At a basic level, the question “What makes a site good” has still to be defined and, to address this, all relevant communities need to be involved in the dialogue. A further issue of the endorsement of sites and the quality assurance and full traceability of data provided is also of key concern.

The following items were set up as actions at the GEO/CEOS Workshop on Cal/Val Processes held in Geneva from 02 to 04 October 2007:

Number	Action	Responsibility	Due Date
1	Categories for the test site catalogue to be transformed into “equipped and maintained” and “non-equipped and non-maintained” rather than use “absolute cal”, “pseudo-invariant cal” and “cross-cal”.	Chander, IVOS Subgroup	01-Nov-07

2	Provide the current IVOS cal/val site list & baseline characteristics list as an example to the other subgroups	Chander	15-Oct-07
3	Review & establish test site template to define (best practices) requirements for test site identification within the subgroup domain.	WGCV Subgroups	WGCV-28
4	Define criteria for test site classification for suitability for a particular application.	WGCV Subgroups	Next workshop
5	Formulate a request to the Constellation leads to evaluate their requirements for cal/val needs.	Bojkov, Stensaas, Campbell, Cao	01-Nov-07
13	Define wish list of requirements for functionality from the cal/val portal and feedback to the cal/val portal maintainers (ESA).	WGCV Subgroups	WGCV-28

5.7 Proposition

As a starting point, the following site selection criteria have been proposed for the CEOS WGCV Infrared and Visible Optical Sensors (IVOS) radiometric calibration sites. These criteria will be refined to provide a framework for other subgroups to follow.

1. The site should have high spatial uniformity, relative to the pixel size, to minimise the effects of scaling radiometric data to the size of the entire test site. This is especially important for cross-calibration between instruments because it minimises the effects of misregistration. The site should also be centred in an area large enough to accommodate the sampling of a large number of pixels and to minimise atmospheric adjacency effects due to light scattered from outside the target region.
2. The site should have a surface reflectance greater than 0.3 in order to provide higher signal-to-noise ratio (SNR) and reduce uncertainties due to the atmospheric path radiance.
3. The surface of the site should have flat spectral reflectance. This becomes important if the multiple instruments involved in cross-calibration have spectral bands with different response profiles.
4. The surface properties of the site (reflectance, BRDF, spectral) should be temporally invariant. Otherwise, adequate accuracy would be obtained only if these properties were measured for every calibration. This implies that the site should have little or no vegetation.
5. The surface of the site should be horizontal and have nearly Lambertian reflectance to minimise uncertainties due to differences in solar illumination and observation geometries. It should also be flat to minimise slope-aspect effects.
6. The site should be located at high altitude (to minimise aerosol loading and the uncertainties due to unknown vertical distribution of aerosols), far from the ocean (to

minimise the influence of atmospheric water vapour), and far from urban and industrial areas (to minimise anthropogenic aerosols).

7. The site should be in an arid region to minimise the probability of cloudy weather and precipitation that could change the soil moisture and hence the surface reflectance. The low probability of cloud coverage also increases the probability of the satellite instruments imaging the test site at the time of overpass.

Each WGCV subgroup (representing each major thematic EO specialisation) is currently tasked to define their requirements for Cal/Val sites and the characteristics that they should exhibit in order to define a list of sites within each subgroup domain. In addition to characterisation best practices and test site requirements, the WGCV subgroups have also been asked to define their criteria for site classification with reference to its suitability for a particular application.