# Position Paper on Options for Future of Land Imaging Coordination within CEOS

## Purpose and Scope

At the 29th Meeting of the CEOS Strategic Implementation Team (SIT-29), it was determined that “Options on the future of land imaging coordination within CEOS will be developed for discussion at the SIT Workshop.” The purpose of this paper is to explore these options and propose a position “on how to address CEOS contributions to Land Surface Imaging Agencies” (SIT29-4).

For the purposes of this paper, “land imaging” has been interpreted as creation and use of satellite data and products to support land surface-related applications. This paper is not about the current Land Surface Imaging Virtual Constellation (LSI-VC) or what activities have occurred since the creation of the LSI-VC. The paper is written from the perspective that any future CEOS support relating to coordination of land imaging should be justified in absolute terms as competing demand for CEOS support increases. The ‘do nothing’ option explored in this paper is very real. In fact, the case to ‘do something’ must be made.

The scope of this paper is restricted to CEOS-supported mechanisms. As always, agencies are free to negotiate more targeted bilateral and multilateral agreements seen as being in their mutual interest. This paper aims to determine whether there is a prima facie case that justifies CEOS support, identifies a framework for assessing options for providing that support, assesses those options, and proposes a way of moving forward.

This document was developed with input from a small group of volunteers. It is important to note that the volunteer group does not include representatives from some of the key agencies whose participation would be critical to the success of any future CEOS-supported mechanism.

## Context

The primary objectives of CEOS include optimising the benefits of space-based Earth observation through development of complementary systems, and coordination of space-based Earth observation activities.

CEOS is a ‘best efforts’ organisation, and does not seek to impose on member programs, nor to supersede current or potential agreements made by members. CEOS acts by bringing agencies together to identify and agree strategic objectives and priorities, and by providing organisational mechanisms that encourage and support agencies to align and progress their work in a manner that supports those objectives and priorities.

In a practical sense, the rate at which progress is made towards these objectives, and the areas receiving focus, is largely determined by agency resourcing and priorities at a given point in time. The influence CEOS can have by defining “top down” objectives and priorities is real; such objectives can be used by agency staff to feed into agency planning and budgeting processes, and can provide valuable evidence to support business cases to justify new and continued projects. However, no amount of “top down” influence is effective unless there is an underlying “bottom up” will to be harnessed and directed.

There are any number of noble goals that CEOS could pursue, and even some that CEOS ‘should’ pursue from a theoretical standpoint. However, as noted above, CEOS is “best efforts” in nature. Recognising this, the CEOS *New Initiatives Process Paper*, endorsed in May 2014, notes the importance of balancing existing work with new work to ensure the relevance, sustainability and success of CEOS. These points apply equally to existing initiatives. The strategic guidance and organisational support CEOS can provide is both valuable and finite. The risk of CEOS becoming overextended is very real, and attempting to retain too many activities will ultimately be to the detriment of CEOS objectives.

## Land Surface Imaging Today

The value to society of land surface-related applications is clear, and accordingly the value to CEOS of supporting such applications is clear. The land surface is where people live, communities exist, and where much economic activity takes place. An understanding of the land surface, and how it is changing, is critical to all of the GEO Societal Benefit Areas.

Since the launch of the first Landsat satellite in 1972, 34 sovereign states and geopolitical groups have chosen to support land cover mapping missions and 197 individual satellites with global land cover capabilities have been successfully launched. According to a study by Belward *et al*.[[1]](#footnote-2), 98 missions (but not all with global coverage) were still in operation in 2013. The average operational life has almost tripled since the 1970s, going from 3.3 years to 8.6 years and is still lengthening. The average number of launches has increased from 2 to 12 per year. Spatial resolution of images acquired has increased from 80m to 1m for multispectral, and to sub meter for panchromatic. SAR resolution has progressed from 25m to 1m. As a result, more people in more countries have access to data at a greater range of spatial resolution for a wide variety of researches and applications.

Users of land surface imaging data have seen the importance of the versatility and flexibility of the acquired data. That versatility has enabled users and CEOS to be highly responsive to the changing priorities in a way that would not be otherwise possible, however, that versatility and flexibility do raise issues. Many space agencies may consider supporting more application-specific (and presumably cheaper) missions.

There are several categories of systems, whether they are government owned, government licensed (commercial) or respond to military/intelligence needs. Civilian and commercial systems can be grouped – but military systems have to be considered as a class apart. While military systems are not available for civilian use, the opposite does not always apply – some civilian systems are used by military (dual use – e.g. the French Pleiades series or the Italian Cosmo-Skymed system).

Reasons why sovereign states are investing in Earth observation satellites include the need for better information, national security, commercial opportunities, international cooperation and compliance with international laws. Four additional factors – innovation, securing independent data supply, falling mission costs and changing technology, and last but not least, national identity and pride – also concur to this (over-)abundance of land imaging satellites. This latter factor principally affects “newcomers” and results in the limited capabilities of many new and small land imaging satellites.

## The LSI-VC

The Land Surface Imaging Virtual Constellation (LSI-VC) was first led by G. Bryan Bailey (USGS), and devoted its first years to set the stage for the mid-resolution imaging in the optical domain. As reported to the 20th CEOS Plenary in 2007, the primary objectives of the Land Surface Imaging (LSI) Constellation are: “*to define a broad range of rather detailed characteristics (or standards) that describe optimal, end-to-end capabilities (and policies) to acquire, receive, process, archive, and distribute space-acquired land surface image data to the global user community*” and “*to address current and shorter-term problems and issues facing the land remote sensing community today, such as seeking ways to work more cooperatively in the operation of existing land surface imaging systems and helping to accomplish tangible benefits to society through application of land surface image data*.”

The most recent LSI-VC Terms of Reference include the following statements:

* **Purpose**: The LSI-VC primary role is to promote the efficient, effective, and comprehensive collection, distribution, and application of EO data of the global land surface, especially to meet societal needs of the global population, such as those addressed by the Group on Earth Observations (GEO) societal benefit areas (SBAs).
* **Scope**: The remit of LSI-VC is to coordinate and focus land EO contributions from CEOS agencies supporting CEOS and GEO initiatives.

## The Challenge

In view of effort by the international space community to date, three remarks could be formulated:

* The availability of the vast majority of this data for the development of operational applications for societal benefit is very limited. Outside of a few notable exceptions (Landsat, Sentinels), the operation of land surface imaging satellite missions is restricted to the security or commercial sectors;
* On the other hand, from a systems perspective and assuming data was made available, one may wonder whether such a large number of land imaging missions is “really” needed, and whether it largely exceeds the reasonable level of redundancy that is required in an operational system.
* Many recent land imaging satellites have at best a regional or even only a national focus. This includes imaging efforts focused on one zone and national data availability.

A more rational use of resources in this domain should lead to increased cooperation as it has in other fields, thus avoiding excessive duplication, saving scarce resources and offering opportunities for the development of other, missing systems.

Effective international coordination is required to ensure that:

1. The data actually get used, addressing real user requirements across a wide variety of domains and promoting and encouraging openness and inclusivity among data providers.
2. Use of land imaging assets (satellites, ground stations, communications and data storage) is coordinated and optimised.
3. Potentially conflicting acquisition priorities are effectively managed across domains.
4. Agency programs are sustainable in the long-term, maximising the likelihood of long-term continuity of the data required to deliver current and future societal benefit.

## The Current LSI-VC and the Challenge

As indicated above, the scope of the LSI-VC has historically been broad, with an “end to end’ remit. The VC framework was, in part, established to address this sort of challenge. In the case of land surface imaging, the potential benefits of ‘end to end’ coordination are very significant.

However, as discussed at the 2014 SIT-29 the other VCs have relatively specific single issue scope, making the coordination task relatively straightforward. In the case of ‘land surface imaging, an ‘end to end’ solution requires a lot of people, and a lot of activity, across a lot of upstream and downstream subject matter domains, to be coordinated.

This requires considerable commitment and resourcing, over a long period, particularly from those agencies most likely to provide the ‘core’ assets into which ‘supplementary’ capacity, such as that from nations wishing to make an appropriately scaled contribution to international efforts, can be incorporated. This commitment and resourcing has not been forthcoming.

It also requires a clear understanding of the user requirements which provide the ‘desired state’ against which activity can be planned and coordinated. It is not clear that such a holistic understanding of user requirements exists, and although inroads are being made through initiatives such as GEO it would be risky to assume it is likely to exist in the near future.

In light of this, it is unclear that efforts to promote an LSI-VC with a comprehensive ‘end to end’ scope will be successful at addressing the challenge outlined above in the short or medium terms.

## Other CEOS Entities

Any action that is proposed to address the challenge should build on, support and complement existing activities that already have momentum. CEOS has two permanent working level mechanisms for coordinating the assets of CEOS Agencies on a long-term basis: Working Groups and Virtual Constellations. CEOS also has Ad Hoc Teams that can be created by Plenary to address short-term objectives. This section describes some of the connections with existing Ad Hoc Teams and permanent Working Groups.

CEOS has continued to evolve its strategic objectives and the mechanisms it provides to support progress towards those objectives. A number of significant developments have occurred in recent years that have changed the context within which any future land surface imaging coordination will occur, and it is important that any future approach is reflective of what exists now rather than what may have existed in the past, or what may exist in the future.

### Ad Hoc Teams (GEOGLAM, SDCG for GFOI)

As noted below, a key challenge in coordination is defining an ‘end state’ to coordinate towards. These teams have worked iteratively with user communities to identify ‘useful’ products and to coordinate acquisition of the relevant data from existing assets to support them, at least to a ‘pilot’ stage. This process has been successful by capitalising on the top-down “push’ in particular areas by external groups such as GEO to build political momentum, engage communities, and entrain resources.

However, there are questions about how sustainable this model will be into the future, once requirements stabilise and attention moves to the next “priority area”. Although the model is successful in determining requirements and proving concepts, without a suitable transition to a “business as usual” model CEOS could be left with a proliferation of ‘ad hoc’ teams that exist forever, or with the risk of a reputation as a group that “does the exciting bit, but can’t follow through”.

Moreover, inevitably such teams will make potentially conflicting ‘calls’ on the same sets of space and ground assets, and potentially request creation of similar (but not quite the same) fundamental data products. This will create challenges for operators seeking to arbitrate between competing priorities without any framework for doing so, and seeking to keep a handle on product development and processing costs. Such an approach could well drive the development of more domain-specific approaches, an outcome that is potentially undesirable when budgets are under pressure and drives for ‘data fusion’, ‘flexibility’, ‘reliability’ and ‘redundancy’ are increasing.

Any way forward for land surface imaging should seek to support the work of Ad Hoc teams by ensuring there is a ‘business as usual’ home through which well-defined stable sets of user requirements can be sustainably met by coordination of existing and future space assets and reliable production of common ‘fundamental’ data products to support value-add.

### Working Groups (WGISS, WGCV, WGCapD, WGDisasters, CEOS-CGMS WGClimate)

There are both similarities and differences between the Ad Hoc Teams and permanent working-level mechanisms for coordinating CEOS Agencies’ multilateral activities. Working Groups typically address topics that are cross-discipline, as well as thematic topics such as climate and disasters, which are shared across a wide range of Earth observation domains. Their status as formal Working Groups assures their longevity, meaning that some of the challenges of ensuring continuity of service are less relevant than with Ad Hoc Teams. Working Group activities are intimately connected with, and complementary to, the work of Virtual Constellations.

Like the Ad Hoc Teams, these Groups are working with user communities to define user requirements. This work to establish requirements will provide highly valuable information for agencies operating land surface imaging assets, and should be harnessed as it should be in the case of the Ad Hoc Teams.

However, as with the Ad Hoc Teams, ultimately the task of meeting such requirements on an ongoing basis will result in potentially conflicting ‘calls’ on the same sets of space assets. It may also result in requests for similar (but not quite the same) fundamental data products. As with Ad Hoc Teams, this will ultimately create sustainability challenges of the sort CEOS was established to address.

#### Working Group on Information Systems and Services (WGISS)

WGISS is turning its attention to challenges to do with EO data itself, including architectures that enable ‘big data’ of different types to be distributed, stored, processed and managed in way that can flexibly meet diverse, and frequently changing, end user requirements. This is almost universally recognised as a challenge, and these efforts are likely to entrain resources from a wide variety of agencies. This means that there is great potential to be capitalised on.

Such approaches will best support CEOS objectives if they are relatively ‘generic’ and avoid development of ‘stove-piped’ systems to get data from one specific satellite to one specific user community. Such ‘generic’ approaches are particularly suited to land surface imaging, where the sources of data are diverse and the applications they are put to diverse also.

Any way forward for land surface imaging should seek to support the work of WGISS by avoiding overlap, aligning relevant agency resources to support WGISS projects, and where possible encouraging operators to implement systems compatible with WGISS solutions.

#### Working Group on Calibration and Validation (WGCV)

WGCV is a mature working group with a well-defined scope, clear work plan, and mature structures. Any way forward for land surface imaging should seek to support, and leverage, the work of WGCV.

WGCV provides the logical mechanism through which technical issues of cross-sensor compatibility and data quality assessment should be pursued, with the added benefit that such issues will be dealt with more ‘generically’, at the level of fundamental geophysical measurements, than they would if undertaken in a land surface imaging-specific context.

The WGCV Land Product Validation Subgroup also has significant potential to contribute infrastructure, approaches and techniques to validate that the products being delivered to users (for example through Ad Hoc Teams) are robust. This is critical in protecting the reputation of agencies and CEOS itself. Effective protocols that ensure LPVS is aware of identified priorities, enabling the group to structure their activities and priorities accordingly, are required.

#### Working Group on Capacity Building and Data Democracy (WGCapD)

Land surface applications are amongst the most important areas to support capacity building, having such a direct impact on day-to-day life in communities.

 Some of the data relevant to land surface applications, such as traditional ‘visible’ optical data, is amongst the most accessible and easy to use. However, many land surface applications are best served by inclusion of data from more ‘challenging’ sources such as SAR and thermal. Where WGCapD wishes to empower end users in relation to land surface applications its aim is to support end users with expert advice covering the spectrum of sensor types suited to land surface applications, and on approaches for integrating this data to produce products that meet local conditions. Any way forward for land surface imaging should seek to support the goals of WGCapD by promoting availability of this technical expertise to its initiatives.

#### CEOS-CGMS Working Group on Climate (Joint WGClimate)

Joint WGClimate land imaging activities focus mainly on the evaluation of terrestrial Essential Climate Variables (ECVs) time-series through coordination of Member Agencies’ initiatives and activities, complementary with existing entities and roles. The Joint WGClimate is working with CEOS VCs to ensure a coherent and consistent approach to the provision of climate records across their various topical areas, including land/terrestrial.

#### Working Group on Disasters (WGDisasters)

WGDisasters is increasing and strengthening the contribution of Earth observation satellite data to the various disaster risk management phases. Space Agencies are implementing pilot demonstrators to demonstrate how satellite data and derived information can be useful to the full cycle of disaster risk management for seismic hazards, volcanoes and floods to start with, at global and regional/local scales. The long-term vision is to transition to the sustained provision of data and services.

## The Need

The challenge identified above was to establish effective international coordination to ensure that:

1. The data actually get used, addressing real user requirements across a wide variety of domains and promoting and encouraging openness and inclusivity among data providers.
2. Use of land imaging assets (satellites, ground stations, communications and data storage) is coordinated and optimised.
3. Potentially conflicting acquisition priorities are effectively managed across domains.
4. Agency programs are sustainable in the long-term, maximising the likelihood that long-term continuity of the data required to deliver current and future societal benefit.

The discussion above identifies many areas where CEOS entities already exist that are well positioned to help address these problems, particularly with greater clarity of roles and enhanced coordination. The Ad Hoc Teams and Working Groups are clarifying real user requirements and translating them into EO product definitions, WGISS is developing frameworks that will enable the data and products to support them can get to users, and WGCapD is working to ensure users have the skills they need to use the data. These initiatives should be built on, and supported.

As noted above, the concept of land imaging is quite broad, and the space assets quite versatile. It is desirable to keep it that way, meaning that the unmet need is in the ‘upstream’ side:

* Planning and coordination of acquisition on an ongoing basis, managing conflicts and priorities.
* Ensuring data from the assets feeds into broader data distribution and access systems in a way that supports **diverse** user communities.
* Coordination of future programs to minimise gaps, balancing requirements defined by different user communities.
* Promotion of increased compatibility of fundamental data products across instruments, to try and ‘abstract away’ the technical detail to enable as many user communities as possible to benefit from as much data as they can.

## Options

The following primary options have been identified:

* Option 1 – Do nothing (i.e. allow the Land surface imaging VC to dissolve)
* Option 2 – Land surface imaging VC – end to end
* Option 3 – Land surface imaging VC – space segment and associated land imaging assets
* Option 4 – Multiple VCs (optical land, radar land, thermal land)

These options are intended to be illustrative, rather than exhaustive. Further refinement of these options will be discussed by a small group of representatives who have been chosen to participate in the evaluation team, which will meet from mid-September to mid-October.

All of the ‘do something’ options involve the use of the VC construct. This reflects the discussion above that there is no real ‘gap’ in relation to the sorts of activities that would be undertaken through Ad Hoc or WG constructs, and that the challenge to be addressed primarily relates to the space segment and those parts of the ground segment most closely related to it: the ‘upstream’ side.

The concept of having an option centred around ‘regional’ focus points (such as an ‘Asia Pacific’) was raised and considered. However, it was felt that was more an issue for the ‘internal’ governance of any future Virtual Constellation, and should be discussed once the overall role of that Virtual Constellation was clear. The issue of ‘inclusivity’ and the likelihood of encouraging broad participation, however, was determined to be very important and is highlighted in the analysis of the different options outlined below.

## Analysis

The team involved with preparing this paper undertook an initial analysis of the options to determine if a process based on evaluating those options against a common set of criteria would help provide clarity to the future of land imaging coordination within CEOS.

The options were assessed based on both ‘top down’ and ‘bottom up’ criteria. The ‘top down’ criteria used were:

* How well are the CEOS objectives supported?
* How much benefit is there likely to be to internal stakeholders?
* How much benefit is there likely to be to external stakeholders?
* Does the approach align with the defined roles of Working Groups and Virtual Constellations?
* Does it address an unmet need in the existing organisational mechanisms?

The ‘bottom up’ criteria used were:

* Does it address a real and pressing issue that needs action right now?
* Do agencies possess the necessary personnel and fiscal resources to support the initiative?
* Will a critical mass of key agencies support it, and does it provide feasible avenues for other agencies to participate?
* How well does it leverage, and support, existing activities and mechanisms?
* Is there a logical pathway to ‘kick off’ and ‘ramp up’ the new initiative?

The table below is illustrative of a template that could be used to evaluate the criteria. A scoring system would need to be developed with the range of scores for each criteria clearly defined (e.g. 0 = no benefit to internal stakeholders; max pts for substantial benefit to internal stakeholders) :

|  |
| --- |
| **Option**  |
| **Description** | This option involves …. |
| **‘Top Down’ assessment** |
| How well are the CEOS objectives supported? | Reasoning behind given score. | Score out of a possible max score |
| How much benefit is there likely to be to internal stakeholders? |  | Score out of a possible max score |
| How much benefit is there likely to be to external stakeholders? |  | Score out of a possible max score |
| Does the approach align with the defined roles of Working Groups and Virtual Constellations? |  | Score out of a possible max score |
| Does it address a logical ‘gap’ in the existing organisational mechanisms? |  | Score out of a possible max score |
| ***Sub-total*** | ***Sum of above scores*** |
| **‘Bottom up’ assessment** |
| Does it address a real and pressing issue that needs action right now? |  | Score out of a possible max score |
| Do agencies possess the necessary personnel and fiscal resources to support the initiative? |  | Score out of a possible max score |
| Will a critical mass of key agencies support it, and does it provide feasible avenues for other agencies to participate? |  | Score out of a possible max score |
| How well does it leverage, and support, existing activities and mechanisms?  |  | Score out of a possible max score |
| Is there a logical pathway to ‘kick off’ and ‘ramp up’ the new initiative? |  | Score out of a possible max score |
| ***Sub-total*** | ***Sum of bottom-up scores*** |
| ***Total score*** | ***Sum of sub-totals*** |

## Summary of Results

The results from the above analysis may be summarized in a table such as the one below where colors could be defined in such a way where red indicates ineffective and green indicates most effective:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Top-Down Score** | **Bottom-Up Score** | **Total Score** |
| **Option a** | x | **x** | x’ |
| **Option b** | x | x | x’ |

An initial analysis only included input from a relatively small group, but showed that there is a prima facie case that a land surface imaging VC focused on ‘upstream’ coordination would work and that further investigation is justified. That being said, the analysis also showed that the ‘do nothing’ option is very real.

The implication is that the approach is valid, but that input from a broader group, to validate issues and moderate scores, is critical in moving forward.

## Next Steps

#### Phase One

To be meaningful, analysis of the identified options (still to be finalized) based on the top-down and bottom-up criteria (still to be approved) would likely need input from between 10-12 representatives covering Ad Hoc Teams, Working Groups, and those agencies who would need to contribute to make any future option work. This group would be considered the “evaluation team.”

In the interests of timeliness, this evaluation team needs to meet as soon as possible. A feasible timeframe would be to identify the representatives of the evaluation team during the SIT Technical Workshop. The evaluation team would perform their analysis by mid-October, with the results of the analysis presented at the Plenary at the end of October. The aim of the presentation at Plenary would be to secure top-level agreement on the way forward from the broader CEOS community ***and the key agencies whose participation would be essential to success of the proposal.*** The SIT Chair should be in direct consultation with the evaluation team.

#### Phase Two

Pending the outcome of this process, a second phase of work would then be required to:

* Prepare draft terms of reference,
* Identify CEOS Agencies willing to provide leadership over the medium term,

This work should be undertaken by a second team consisting of representatives from the key space agencies whose participation would be critical to the success of the entity, and other willing participants. This process would explore more detailed design questions such as sub-groups, regional focus, etc. This work should be completed in time for consideration at SIT-30.

It is also important to note that nothing is static. The preferred option is the preferred option now. Should it be implemented successfully, and gain momentum, it is always possible that subsequent analysis would reveal that a broader scope may represent the best way forward.

1. A. S. Belward and J. O. Skøien (2014): Who launched what, when and why; trends in global land-cover observation capacity from civilian earth observation satellites. ISPRS Journal of Photogrammetry and Remote Sensing, 10.1016/j.isprsjprs.2014.03.009 [↑](#footnote-ref-2)