**CEOS SELF-STUDY**

***INPUT FROM THE STUDY TEAM ON   
THE VIRTUAL CONSTELLATIONS***

**30th September 2011**

# Introduction

In preparation for its forthcoming chairmanship of the CEOS Strategic Implementation Team (SIT) and recognising that the latest phase of CEOS organisational development may be reaching its end, NASA has taken the initiative to lead a CEOS Self-Study with the objectives of:

* identifying, articulating and evaluating CEOS successes and strengths in achieving real coordination in space-based Earth observations for societal benefit;
* identifying successes and areas for improvement;
* identifying potential new CEOS initiatives for the next 5-7 years.

The discussion at the SIT-26 meeting in Frascati (May 2011) noted a number of other objectives for the exercise, including the need to filter and prioritise proposals for such new initiatives – for which there is no shortage of good ideas.

This note has been prepared by a Study Team focused on the subject of the CEOS Virtual Constellations. It reviews the heritage of the activity since its inception and presents conclusions and recommendations for the way forward, in support of the study objectives.

# Heritage & Context

It is important to understand the context in which the concept of the CEOS Virtual Constellations was proposed in order to fully understand their purpose and evolution. The last major strategic review of CEOS and its objectives and activities was in 2005 – the CEOS Task Force. This was in response to the emergence of GEO and the concept of the GEOSS, which, it was clear at the time, would have significant and long-lasting implications for the mandate and direction of CEOS. The CEOS Task Force activity and report to CEOS was a particularly effective exercise, inspired by the renewed focus which GEO presented and the opportunity for CEOS to take leadership on implementation of the space segment of the GEOSS. The recommendations of the Task Force have underpinned the most productive 4-5 years in the history of CEOS as a coordination body, these being:

* that CEOS affirm itself as the primary space agency forum and responsible for implementation of the space component of the GEOSS;
* to be able to monitor and demonstrate real progress, CEOS should develop a *CEOS Implementation Plan for Space-based Observations for GEOSS*. Execution of this plan and its various components should drive the annual activities and meetings of CEOS and its reporting to GEO and other relevant bodies;
* SIT Chair should oversee the implementation of the Plan and should be the primary interface to GEO, reporting on status of CEOS agency commitments to the Plan;
* The CEOS Calendar was reconfigured and defined to clarify roles of Plenary and SIT;
* The role of the CEO was established and the concept of the Troika formalised;
* A multi-year resource plan was proposed (which eventually became an annual plan developed and reported by CEOS Chair to help manage the SEC process).

About the same time, the first version of the GCOS Implementation Plan and Satellite Supplement appeared and provided further stimulus for both focus and rigour in a sustained and monitored progress of CEOS coordination activities.

In the immediate wake of these significant new activities and proposals, ESA took on the SIT Chairmanship in November 2005, and began the deliberations as to how to respond to the challenges laid down by the Task Force, including in particular that:

*“The proposed CEOS Implementation Plan should be the focus for a new planning process which takes account of international users and their requirements from the outset of satellite projects.”*

The CEOS Virtual Constellations Concept paper was developed by the ESA SIT team in the months following CEOS Plenary and was presented to, and well received by, the SIT-18 meeting in March, 2006 in ESRIN. The SIT team worked with interested agencies to propose a number of prototypes to apply the VC Concept, and provided an update to SIT-19 in Sept, 2006. The report to that meeting provides a useful reminder of the initial motives behind the concept:

* *the desire to move CEOS efforts and agendas from the generic to the specific;*
* *to provide a new planning process to inspire and manage broader participation in CEOS efforts by all space agencies – developed and developing;*
* *to focus CEOS outputs on the major needs expressed in the GEOSS Implementation Plan;*
* *to seek realism in coordination – recognising that individual agency needs and schedules will continue to dominate implementation – but seeking synergies and agreements on key issues to create optimal conditions for all agencies to contribute to a common objective (such as a Fundamental Climate Data Record or continuity of a certain data service).*

*The focus is on common efforts towards a specific data set, product or service – not on standardisation of space hardware.*

The 4 prototypes which emerged from that meeting (and their leads – at the time) were:

Ocean Surface Topography: NOAA & EUMETSAT

Atmospheric Composition: NASA

Land Surface Imaging: USGS

Precipitation: JAXA & NASA

These were selected to give balance across different domains and geographies, and perhaps most importantly with an eye on leverage of international linkages to support continuity of funding for missions at the time which were under some threat (Jason, LDCM and GPM in particular).

It is fair to say that there was considerable enthusiasm and some relief among CEOS agencies at being able to focus coordination and planning discussions on specific topic with a tangible outcome – after years of activity on an extremely broad front. The VCs proved to be an easily identifiable and communicable instrument or brand for CEOS to explain its objectives and achievements. The concept was quickly picked up by GEO, which specified a new task (DA-07-03 – Virtual Constellations) in the GEO Work Plan, with CEOS indicated as responsible.

Recognising that the VC concept and initial prototypes would likely expand and require some formalisation in process, the next SIT Chair, NOAA, led development of a ‘Process Paper’ (November, 2008) which lays out some simple but effective procedural rules governing the development of new VC proposals, their approval by CEOS, and their implementation. At the same time, proposals emerged, and were subsequently adopted, for two additional VCs to add to the existing four, with the following initial leadership:

Ocean Surface Vector Winds (OSVW): NOAA, EUMETSAT & ISRO

Ocean Colour Radiometry (OCR): EC, NASA, ESA, ISRO

both with core goals of ensuring continuity and interoperability of essential measurements consistent with operational and/or climate data record requirements.

The only other event of significance in the trajectory of the VCs which may merit a mention is the discussion at SIT-24 (September 2009) regarding ‘Lessons Learned to Date’ led by a number of the VC leads – which was a useful exchange but without a specific outcome.

In 2011 we have 6 Virtual Constellations in implementation phase engaging a large number of CEOS Members. Leadership is provided by the following agencies (with some agencies leading multiple VCs): ESA, EUMETSAT, INPE, ISRO, JAXA, NASA, NOAA. Many more agencies are engaged in the implementation of these VCs. A proposal for a seventh VC (Sea Surface Temperature – SST) has emerged in 2011 (co-led by ESA and NOAA) and is anticipated to move to implementation phase at CEOS Plenary in November 2011.

# Status and Outlook for the Seven Virtual Constellations

The table below summarises some of the key facts related to each of the Constellations – namely the original motive which was at least partly behind the proposal for a given VC, the main activities and outcomes to date, and a brief SWOT (Strengths, Weaknesses, Opportunities and Threats) assessment for each of the five current constellations – with Sea Surface Temperature (in approval process) added for completeness. The status and outlook for each of the Constellations is discussed in turn below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **VC** | **Original (partial) motive** | **Main achievements & outcomes** | **Strengths** | **Weaknesses** | **Opportunities** | **Threats** |
| **AC** | Improved coordination of multiple (ozone) sensors | Requirements & gap analysis. Geostationary Air Quality coordination white paper. Aviation volcanic advisory project. | Active community with significant contributions from academia and other research establishments. | Broad scope – with correspondingly large number of measurements and missions and user communities. | Moving to consider harmonised ECV production. Participation from China which has an expanding AC satellite constellation is desirable. | AC not well aligned with GCOS-IP actions on clouds or radiation budget. Where do these communities fit within CEOS? |
| **LSI** | Landsat series potential data gap | FCT optical data coordination. Medium res payload guidelines. LSI portal. | USGS-INPE coordination on free & open data policy. Role in FCT coordinated acquisitions. | Participation patchy. LSI Portal not serving us well. Radar systems not included. | Land surface ECVs are a hot topic in post-Kyoto, REDD+, and agricultural monitoring framework discussions. Launch of LDCM and Sentinel-2 offer unprecedented capacity for coordination through VC. | FCT role will migrate to GFOI framework. |
| **PC** | GPM funding risk & continuity with TRMM | Effective forum for increasing PC participation (eg ISRO, CNES, EUMETSAT). Conical scanning microwave imager gap analysis. X-Cal Working Group for microwave radiometers. Reduced Megha-Tropiques data latency. | Coherent framework for sustaining and improving space-based precipitation measurement and advocating open data sharing. | Lacking universal participation (eg China, Russia). Deficiencies in precipitation measurements at mid-latitudes and light and solid precipitation measurements in polar regions. | Leveraging new partnerships and technologies for the post-GPM era PC. | Shortfall in post-GPM era of space-borne precipitation radars and conical scanning microwave imagers. |

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| --- | --- | --- | --- | --- | --- | --- |
| **OST** | **Jason series funding risk Improved Coordination (eg orbit choices, overlap etc...)** | **Effective OST continuity advocacy forum. Jason funding success. OST Constellation Mission Requirements Doc.** | **Focused with strong user requirements & community. Coordinating research and operational agencies has been key to success.** | **Still lacking universal participation** | **Solidify support for SWOT and next generation technology – combining operational and research interests. Strong US/Europe cooperation ready to be enlarged.** | **Fragile funding prospects for operational systems. Lack of evolution and involvement of new supply agencies.** |
| **OSVW** | Continuity guarantee, timely and easy access to data of all missions | Joint training workshop efforts. Mutual support for science teams. | Strong link with science/producer community | Still lacking universal participation | Product innovation and harmonization, timely and easy access, inter-calibrations | Fragile funding prospects for operational systems,  Unclear boundaries and tasking, maybe too high expectations |
| **OCR** | ECV development and coordination | Focused on OCR ECV and technical coordination and continuity in support. | Focused with strong user requirements & community | Involvement of agencies with emerging OCR capabilities | Develop international framework, “INSITU-OCR” for ECV assessment and quality control | OCR calibration needs more attention -collaborate with WGCV/QA4EO/GSICS |
| **SST** | Continuity of SST for applications in short, medium, and decadal time scales in the most cost-effective and efficient manner – taking full advantage of the existing and mature GHRSST. | This VC is still in proposal but anticipate - fully functional NRT delivery of standard products and services via GHRSST, ECV development, scientific and technical coordination with strong continuity and support. | Focused with strong user requirements & community. Significant resources committed via GHRSST mechanism, extensive and active user/producer community buy-in already evident | Full involvement of critical CEOS Agencies is not achieved yet.  Sustained capability for Constellation-critical Passive Microwave SST not guaranteed.  Multitude of ‘new’ coordination bodies | Use of existing GHRSST framework allows rapid progress.  Coordination of SST for ECV and inputs to WG-Climate.  Inputs to WGEdu  Optimisation of physical SST constellation (satellites) over the next 20 years | How will the SST-VC work with CEOS to solve problems (decisions and recommendations?)   Insufficient traction for VC recs in CEOS - ignored or used sub-optimally. |

***AC – Atmospheric Composition***

The AC Constellation was in fact originally proposed to be focused on Ozone monitoring coordination (noting the many and diverse plans in place), but subsequently became broader to consider Atmospheric Chemistry and then again to be named Atmospheric Composition. It cites its main objective as being to ‘establish a framework for long term collaboration among CEOS agencies..’. And the main activities and outcomes include a requirements and gap analysis (including recommendations to CEOS Plenary to fill certain gaps). Specific projects relating to data coordination for particular applications (eg in relation to **Aviation Alerts for Volcanic Eruptions). The Constellation also offers coordination support regarding implementation of CEOS tasks responding to the GCOS IP.**

**The AC has recently indicated that it will move to study harmonised ECV production – in line with the move to systematise such efforts within CEOS as part of the WGClimate activities.**

NASA and DLR have invested effort in preparing a portal for AC information and datasets – putting a CEOS badge on resources of the World Data Centre for Remote Sensing of the Atmosphere.

***LSI – Land Surface Imaging***

The LSI Constellation was partly motived by the potential Landsat continuity gap and the need to fill it through improved international coordination. The main objectives of the LSI are: coordination on mid-­resolution land surfacing imaging satellite systems (and development of guidelines in support of that coordination – due for completion later in 2011 under SEO leadership); and the support of production of climate data records for GEO and CEOS priorities. A significant effort has been invested by LSI leads (essentially USGS and INPE) in support of the optical data coordination requirements of the GEO Forest Carbon Tracking National Demonstrators and the CEOS space-date role therein. And is contemplating a similar role should the JECAM task emerge as an active CEOS priority. The GEO FCT data coordination role is anticipated to become an operational activity and to be undertaken within the GFOI Project Office in due course. The need will remain however and indeed intensify for coordination on the development of related climate data records and ECVs. An LSI Portal has been developed in collaboration with WGISS.

***PC – Precipitation***

The Precipitation Constellation was partly motived by the risk to GPM funding and extension of the TRMM mission. The Precipitation Constellation efforts continue to leverage the development of the GPM constellation of satellites, which unifies and extends the capabilities of space-borne precipitation measurements evolved during the TRMM era. The multi-national, multi-agency GPM mission will be the first formal instantiation of the CEOS PC to establish a new reference standard for precipitation measurements from space and provide next-generation 3-hr global precipitation data products for scientific research and societal applications. This GPM phase of the PC also offers an integrated framework for international cooperation on inter-calibration of satellite precipitation sensors, remote-sensing algorithms, ground validation, data dissemination, and data utilisation. In addition to the realisation of the GPM mission (a constellation itself), the objectives of the Precipitation Constellation include support towards climate data records. The team supports various studies in support of requirements for precipitation products from space, including several characterised in the GEO WP (eg a study of the availability of conical scanning microwave imagers). The PC is currently studying the establishment of a data portal through which users can directly access all PC member produced precipitation data.

***OST – Ocean Surface Topography***

The Ocean Surface Topography Constellation was partly motived by the risk to continuity in Jason series funding and operation. Its objective is to implement a sustained, systematic capability to observe the surface topography of global oceans. A relatively small number of CEOS agencies fund and operate such observations and importantly all are actively represented in the Constellation (except Chinese agencies) – CNES, ESA, EUMETSAT, ISRO, NASA, NOAA. The Constellation has maintained a very strict focus on the requirements of the main operational and climate user communities and the data characteristics they require, including in relation to mission overlap, accuracy and calibration.

This focus has fostered discussions around required programming and provided leverage for funding of national activities – and can claim some of the credit around successes in securing the necessary continuity of observations for the time being. The Constellation has become established as a visible and respected advocacy group for that purpose with a strong user pull. Publication of the OST Constellation User requirements document is seen as a major achievement, as is the execution of the training courses to improve product exploitation in developing countries.

The AVISO & RADS portals provide easy access to inter-calibrated, integrated data for research use

***OSVW – Ocean Surface Vector Winds***

The Ocean Surface Vector Wind Constellation was in the second wave of constellation proposals – inspired by the success of the likes of OST Constellation in providing an expression of important continuity and data characteristics for key user communities in the domain. Focus and approach are very similar to the OST Constellation, engaging the small club of CEOS agencies that fund and operate such observations (CNES, ESA, EUMETSAT, ISRO, NASA, NOAA) – all of whom are actively represented in the Constellation (except Chinese agencies). The Constellation has maintained a very strict focus on the requirements of the main operational and climate user communities and the data characteristics they require, including in relation to mission orbits, data integration, accuracy and calibration. Training courses have been provided to promote use of satellite wind & wave products in marine forecasting.

***OCR – Ocean Colour Radiometry***

The Ocean Colour Radiometry Constellation also belongs to the second wave of constellation proposals, and picks up where IOCCG has laboured for years in ensuring coordination and continuity in this specialised class of instruments aimed at ocean colour and their importance in global carbon and climate studies. The Constellation has a strong focus on implementation of the OCR ECV and has defined a number of activities in support of that, including in relation to sensor inter-comparison, product validation, and the fundamental gap analyses relating to continuity of adequate supply. The Constellation has been led by EC-JRC, NASA and JAXA (now transitioning to ESA, NASA and ISRO) and is supported by all agencies with a significant ocean colour observations programme (including CNES, CSA, ESA, EUMETSAT, ISRO, INPE, Korea, NOAA).

***SST – Sea Surface Temperature***

Sea Surface Temperature is the newest of the Constellations and remains in proposal stage as of September 2011 - with the expectation of approval to implementation at CEOS Plenary in November 2011. It is focussed on: the continuity of SST for applications in short, medium, and decadal time scales in the most cost effective and efficient manner; improvement of the SST ECV; providing a focused vehicle for the coordination of data continuity, integration, calibration; and the overall ECV Data Processing Framework. It is proposed to implement the SST Constellation by building on the existing Group for High Resolution SST (GHRSST) framework which has developed, implemented and operates a Regional/Global Task sharing framework in which SST data products are provided - according to user requirements in a common format with uncertainty estimated in NRT. Some 100 Million products have been delivered to date over a 5 year period. The Constellation is led by ESA and NOAA and is supported by all agencies with a significant SST observations programme. This Constellation has a solid foundation and is working at ‘the sharp end’ of data products and ECVs, and fully interacts with the scientific and operational user communities.

**Matrix of active participation and domain**

The table below summarises the domain (atmosphere, ocean, terrestrial) relevant to each of the Constellations, as well as an indication of which agencies are truly actively engaged in support of the Constellation objectives (as opposed to the long list of CEOS Members that might be identified as participating but may not in fact be active). Leads are indicated with a solid circle.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **VC** | **Domain** | **CNES** | **CSA** | **ESA** | **EUM.** | **INPE** | **ISRO** | **JAXA** | **NASA** | **NOAA** | **USGS** |  | **Other** |
| **AC** | Atmosphere | O | O |  | O |  |  | O |  | O |  |  | DLR, academics |
| **LSI** | Terrestrial |  |  | O |  |  |  |  | O | O |  |  |  |
| **PC** | Atmosphere | O |  |  | O | O | O |  |  | O |  |  |  |
| **OST** | Ocean | O |  | O |  |  | O |  |  | O |  |  |  |
| **OSVW** | Ocean | O |  | O |  |  | O | O | O |  |  |  |  |
| **OCR** | Ocean | O | O |  |  | O |  | O |  | O |  |  | EC, Korea |
| **SST** | Ocean | O |  |  | O |  | O | O | O |  |  |  |  |

It is interesting to note that:

* + in the GCOS Implementation Plan, the Atmosphere (9) and Terrestrial (10) domains dominate the Essential Climate Variables which are supported by space-based observations (compared to 7 of the Ocean);
  + conversely, the Ocean domain is the subject of 4 of the 7 active Constellations, whilst Terrestrial has just 1 and Atmosphere 2 (albeit one with an extremely broad scope at present); this may reflect a proactive approach by the relevant communities to what they saw as the effectiveness of the OST Constellation process and the opportunity to raise the profile of ocean observing requirements within CEOS and its agencies. Regardless, CEOS should no doubt consider the balance of effort across the constellations and whether they properly reflect the policy imperatives of the day;
  + the largest CEOS agencies (both research and operational: ESA, EUMETSAT, ISRO, JAXA, NASA and NOAA) dominate the active membership and leadership of the VCs (although cited, ISRO have been commented as not always active in several of the teams).

# Assessment

**The Constellations Concept & Process**

1. The Constellations concept freed CEOS from a paralysis resulting from the enormous scope of the challenge it faced – after years of discussion on coordination across a very broad front. The concept provided a new vehicle for a focused conversation on coordination and for its reporting to CEOS on progress and challenges. This was badly needed and quite timely with the coincident arrival of GEO, as well as the GCOS IP.
2. The Virtual Constellations are a highly effective ‘brand’ and vehicle for CEOS and its Members. The concept is widely known and discussed as an illustration of the more focused and effective nature of CEOS activities in the GEO-era. The concept may be popular since it is easily understandable and maps well into the way specific user communities are organised and mobilise their advocacy efforts. This mapping in fact seems key to success and provides strong counterparts and drivers for progress and outcomes by the Constellations. CEOS has performed best when presented thus with a strong counterpart - which sets down a challenge to CEOS of common interest to its Members. GEO and the GCOS IP being other examples. The GEO community has responded strongly and positively to the concept of the Constellations and woven the concept in as a highlight of the work plan.
3. It appears that the brand of the Constellations is sometimes stronger than awareness of the substance, with few people outside of the teams actually being aware of their detailed objectives and activities – whilst still being extremely positive about the Constellations (or their image of them).
4. The Constellations are seen within the community as having significant promise as a vehicle for focused discussions on harmonisation of programmes and plans of participating agencies in support of a common goal – be that continuity of observations for a particular operational community or in support of a particular ECV over many years and decades. To date, that concept has not fully realised this promise since the early Constellations have sometimes focused on coordination of the programmatics – the scheduling of the launches etc. To realise its full potential, the Constellations concept should embrace inclusion of the physical results of coordination – the ‘sharp end’, such as the **ECVs and data products themselves**. These are the currency and language of the policy makers, of governments and the treaties and protocols they use to define common information needs.
5. The Constellations were ‘born’ at a time of significant and rapid organisational change for CEOS and for GEO and their scoping, and guidance on implementation were perhaps fuzzier than they could have been. The process aspects were corrected somewhat later with the development of the Constellations process paper, but the scoping and outcomes of the individual Constellations were not addressed, and the time is perhaps right with this CEOS Self Study to tackle these. Feedback from the Constellation teams suggests that the more specific and focused the Constellation objectives are, the more direction and sense of purpose the individual Constellation team has, and the general impression of progress by the community is more tangible.
6. Four of the seven active Constellations are focused on the ocean domain. CEOS has no process for prioritising the selection of new Constellation topics or for ensuring balance in topic across the full set of Constellations. This may or may not be necessary, but a partial solution could be possible in the form of the requirements and priorities being driven by the WGClimate and by any subsequent Climate Architecture, which is the subject of current discussions. The Constellations have the potential to be a productive instrument of implementation for the Climate Architecture.
7. CEOS (Plenary or SIT) has no formal mechanism for following through and responding to the gap analysis results presented by the Constellation leads which may raise continuity or coverage challenges. The more specific the recommendations can be, and the clearer the impact of supply shortages on the constellation outcomes (like an ECV or operational service supply) the more likely it is that CEOS and its agencies can respond – but there remains a need for a formal follow-up process which directly engages the critical supply agencies at the appropriate level and considers solutions, prospects and alternatives as part of an impact assessment.

The Constellations process will only by effective if there is traction within individual funding agency planning processes – which we all know are subject to multiple influences. But it seems clear that the benefits of international collaboration as communicated by clear messaging from the Constellations can and does have an impact. [Although this report focuses on the VCs, similar conclusions can be drawn in this regard for the recommendations put forward by the CEOS Working Groups.]

1. CEOS has completed a highly productive phase of its organisational development, thanks to the efforts of the CEOS Task Force in 2006 and the emergence of a strong counterpart and customer in GEO. The current situation might be characterised as CEOS being a victim of its perceived recent success – with many opportunities being presented for more intensive coordination of data acquisitions and supply, and with subsequent uncertainty as to how to prioritise and how to resource these many demands. It should be recalled that the Constellations were a remedy to the difficulty of progress by CEOS on a very broad front, bringing focus and expert leadership on specific challenges and opportunities. There may be no definable limit as to how many Constellations are practically supportable by CEOS, with hopefully the requirements of leadership as defined in the Process paper being sufficient to limit proposals to only those with well-resourced leaders and a common purpose. The question of priorities and limit of resources remains however an open issue for CEOS to address in 2011 given the current environment and emergence of new ideas – and applies equally to the Constellations.
2. Several of the Constellations have pioneered new partnerships between research and operational space agencies and these have significantly strengthened the prospects for continuity of observations. This is an important benefit of the Constellations, as a vehicle for developing such partnerships, and should be taken into account in future planning. It has been noted that the existence of the GCOS IP, and of the CEOS Constellations, has given some assurance to the user communities that there now exists a systematic framework, engaging all the key players, in ensuring that requirements are understood and mechanisms are in place for ensuring the necessary supply and continuity into the future.
3. Noting: the success of the research and operational agency partnerships in the Constellations; the suggestion that the Constellations concept should embrace physical results such as ECVs and data products; the emergence of an overarching Climate Architecture as a framework for more effective coordination of both research and operational space agency mission planning – encompassing efforts of CEOS, CGMS and WMO Space Programme. There would appear to be a real opportunity and growing goodwill with respect to the coordination opportunities, for the Constellations process to be an effective implementation vehicle welcomed by all relevant coordination bodies.

**Individual Constellations**

1. One of the original motives behind the Constellations concept - using leverage of international collaboration and common purpose to secure domestic budget guarantees - is as valid as ever in these days of lean government budgets. But the specific motives related to some missions which may have inspired selection of original set of 4 Constellations may no longer apply and the time is right for a systematic consideration of the scope and objectives of each Constellation and whether any refocusing is required.

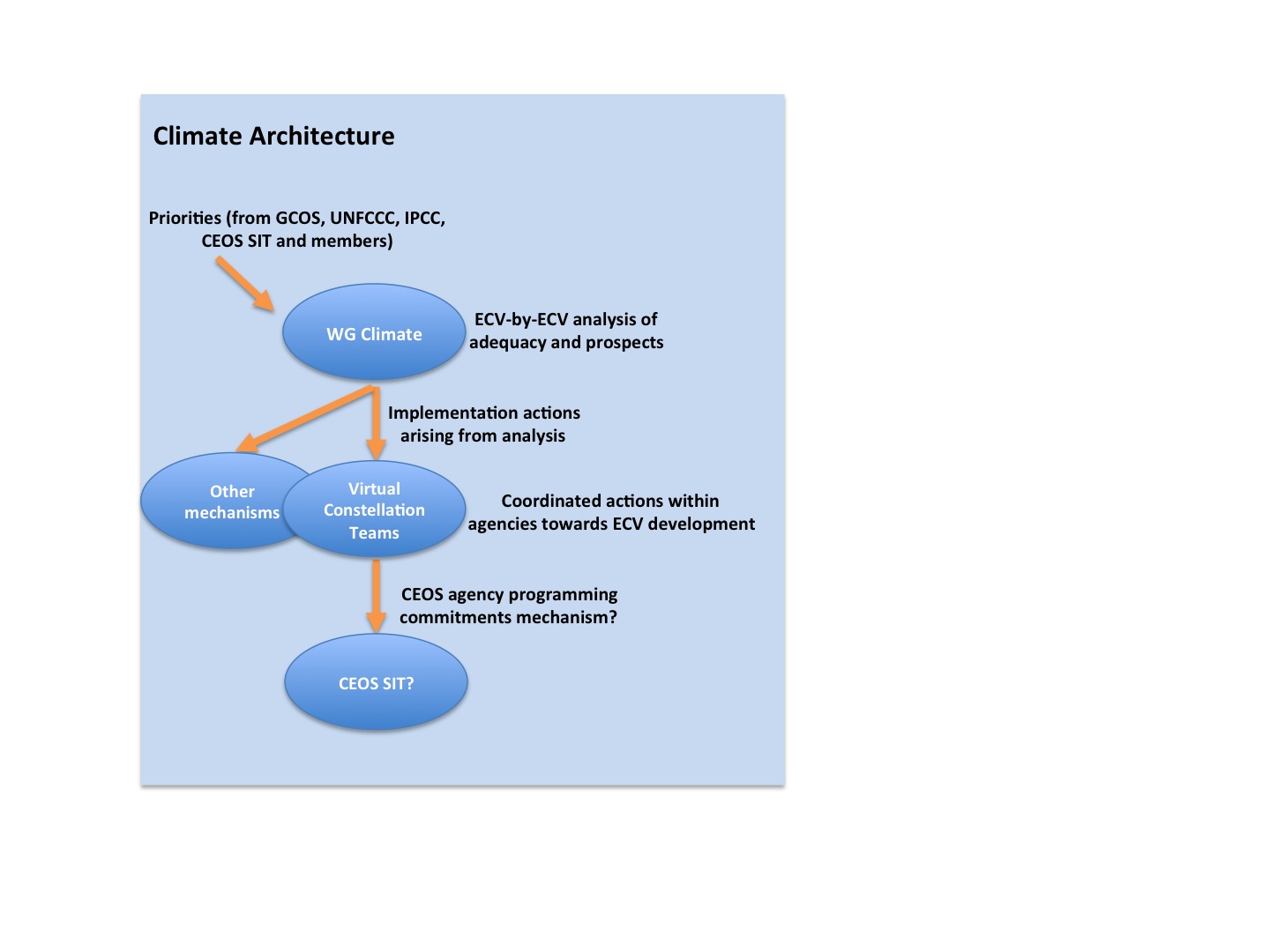
**Implementation potential**

1. We have heard a number of calls during 2011, suggesting that the Virtual Constellations become more focused on implementation and product delivery, and thereby to become a key instrument in the space segment of the climate architecture, and a mechanism for delivery of coordinated ECVs – in concert with the systematic analytical efforts within WGClimate. The foundations exist for the Constellations to be used in this way – indeed some Constellations cite the coordinated development of one or more ECVs as their principal objective (particularly the more recent Constellations).

Some would require a refocusing of their objectives, and probably a corresponding change in membership to ensure experience and responsibility relevant to agency ECV activities, and to engage the community outside space agencies which is active in ECV support and development. Further, CEOS would require a process for prioritisation of new Constellations to be consistent with Climate Architecture priorities and to ensure a suitable mapping of activities anticipated under the Climate Architecture and WGClimate. An effective partnership between the Constellations and the WGClimate would lie at the heart of this implementation mechanism for CEOS and its agencies. It would represent a new level of systematic and implementation-focused coordination by CEOS in the climate domain. This is suggested in the schematic below. Specific roles and responsibilities would need to be clarified.

Specifically, the VCs can have a role in encouraging agencies to establish consistent frameworks for production and maintenance of the ECVs within their domains (potentially in collaboration with WGClimate). VCs could maintain a role in support and coordinating the agency activities from the international perspective after the definition of the framework.

A significant majority of VC leads interviewed in the course of developing this report expected that the VCs, or some evolution of them, could and should serve this implementation role for CEOS – subject to recognition and assignment of the additional resources and membership expertise.



1. On the matter of an implementation response to the Constellation outputs (like recommendations from gap analyses), there is general recognition that the consequences or objective must be framed in terms which are consistent with national policies and requirements to be relevant and compelling to space agencies sufficiently to consider impacting their programming. It is not sufficient to point out that (eg) ozone column continuity is at risk in 5 years. This approach is appropriate for operational communities (like OSTC and OSVW) but less so for other communities. In this regard, the use of ECVs or CDRs to provide a focus of interest to the key supply agencies is appealing. (Some VC leads cautioned that CEOS not put all its eggs in the climate basket, whilst recognising the potential of collaborative ECV targets as a systematic and long-term framework which can direct national mission planning and prioritisation in the way which is needed).
2. It was pointed out in the CEOS Response to the GCOS IP in 2006, that CEOS has an on-going role with respect to UNFCCC now to coordinate and report on the space-based observations in support of the GCOS IP. But the institutional heritage and traditional roles of many CEOS space agencies do not lend themselves to consideration of the data aspects of ECV development – which often involve very different communities, outside space agency staff. Indeed WGClimate was inspired by this very fact, and some agencies now have their own programmes aimed at expanding their roles to include ECV development – but this is not universally the case. Some Constellation Leads pointed out that the respective roles of the Constellations and of WGClimate would have to be very careful defined in any proposed implementation mechanism in support of a Climate Architecture. WGClimate comprises the right skill set related to data aspects of ECVs, whilst the Constellations are strong in relation to the space hardware and the programmatics of providing the required missions and observations. Any solution would be advised to reflect these natural strengths and to play to them.
3. Constellation Leads have in the past come to CEOS (SIT or Plenary) with results of their gap analyses and appeals for coordinated solutions. CEOS Plenary is not a traditionally productive venue for receipt of such challenges and has no formal mechanism to follow up and implement the kind of focused discussions among space agency staff responsible for budgets and programming that might influence plans in response to the challenges highlighted. To ensure the final yards of the paths to implementation are paved for CEOS it should consider new mechanisms to address this.

Constellation outputs, like the Air Quality White Paper from the ACC, represent a portion of one item amidst around 30 items on increasingly busy SIT meeting agendas. It is hard for Principals to isolate what is new and important from what is not or is routine reporting. SIT has become more like CEOS Plenary in attendance and format – having originally been envisioned as a small group of the most senior space agency representatives with implementation authority, being asked to debate specific implementation challenges.

It is very difficult for individual Constellation Leads (or indeed WG Chairs) to gain attention of assembled CEOS Principals given so many competing agenda items - with no real guidance to Principals on what might be important. For the Constellations to evolve to realise any potential as an implementation mechanism (for ECVs or indeed any objective) – this deficiency needs to be urgently addressed. A new approach to SIT agendas may be the solution, with the SIT Chair team working in advance with Constellation Leads (and other groups that input to SIT meetings?) to identify recommendations with implications for implementation by CEOS agencies and to elevate these such that their importance is stressed to CEOS Principals when raised in the SIT meetings – or in special sessions therein. This step does not guarantee an implementation outcome, which is dependent on national programming changes and budgets and therefore ultimately beyond the influence of a voluntary coordination framework , but would in itself be a significant improvement in the efficacy of CEOS efforts, and within its sphere of influence.

1. Constellation Leads have been asked whether it is desirable to impose more specific terms of reference on the Constellations to ensure more consistency in purpose across the different teams. There is strong resistance from Constellation Leads to any suggestion of a ‘one size’ template to be imposed on existing or new Constellations – with the belief that the Constellations process can be and should be applied to a range of different challenges for CEOS and its agencies. From space segment coordination, through to ECV development support. It seems advantageous to CEOS to allow Constellations to continue to support activities other than directly related to a physical output and in support of requirements other than climate – reflecting the diverse nature of the GEOSS stakeholders and of CEOS member interests beyond climate. This would include continued support to operational communities through the likes of OSVW.
2. Four of the seven active Constellation teams relate to ocean observations – this is indicative of the need for a process for prioritisation of new Constellations and to ensure balance consistent with CEOS, GEO and GCOS priorities.
3. Given the opportunity of this CEOS Self Study, Constellation Leads were polled and asked to consider - in light of the on-going discussions regarding use of the Constellations as an implementation vehicle and with a strong focus on physical outputs, notably in support of the Climate Architecture – how they might refocus their activities and objectives. The conclusions are summarised in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **VC** | **Activities & outcomes to ‘prune’** | **Activities & outcomes in next 3 years** | **Notes** |
| **AC** | Portal is not core business. Gap analyses not productive without CEOS response mechanism. | Improved volcanic aviation forecasts. Updated AQ Constellation Paper. 1 or more harmonised ECV activities (starting with total ozone). Implementation of CEOS Carbon Strategy of interest. | Some discussion on addressing aerosols and/or clouds – but this would further broaden ACC scope. Interest in increased collaboration with WGCV Atmospheric Composition Subgroup. |
| **LSI** | LSI Portal – subject to context of CEOS reviews. | Mid resolution guidelines document will be finalised soon. Use models will be developed in support. Re-focused LSI portal. On-going support to FCT/GFOI and JECAM. | LSI portal enhancements to be discussed and relationship to WGISS activities. Portal in limbo at present pending CEOS review of portals. |
| **PC** | None | Deployment of GPM phase constellation satellites and maintaining continuity with TRMM. Advocacy of post-GPM phase PC . Possible PC portal under study. | Opportunities and challenges of transitioning measurements to operational systems and agencies. Opportunities and challenges to improve measurements through new technologies. |
| **OST** | None | Evolution towards incorporation of surface water hydrology into OST. Looking at lakes and rivers as well – bringing in research systems (SWOT) combined with operational. Jason-3 realised and Jason-CS conceptual plan.  Prepare users for new products (SAR mode, coastal products) and new technology (SWOT). Continue to ensure improved access and use of constellation products. | Roles and responsibilities re ECVs need to be understood. There are many other networks (including in-situ) and measurements related to sea level that would need to be considered. |
| **OSVW** | None | Second and likely a third training workshop.  Demonstration of a single point-of-access for data. | Cal/Val is the task of the individual agency and likely more in the realm of science teams and science advisory groups. |
| **OCR** | Having only recently started, OCR-VC has already recently prioritized its activities to focus on ECV implantation and assessment. | Establishment of INSITU-OCR.  Report of the OCR product uncertainty |  |
| **SST** | None | SST ECV development. Continuation of GHRSST NRT delivery capabilities. | In proposal stage at present (Sept 2011) |

# Recommendations

1. The Constellations are the main tool through which CEOS pursues domain-specific coordination. Participation by key CEOS data provider agencies is not universal in the Constellation teams and should be tackled directly.
2. Four of the seven Constellation teams are in support of ocean observations and some prioritisation process may be needed to ensure a future balance of effort is guaranteed – consistent with CEOS priorities. This may be provided by the engagement proposed with WGClimate and possibly the Climate Architecture, amongst others.
3. Constellation partnerships between research and operational space agencies have significantly strengthened the prospects for continuity of observations and this model should be taken into account in future planning of new Constellations. The willingness to embrace a comprehensive coordination framework through the Climate Architecture may provide a path for effective engagement of both research and operational space agencies, and their respective coordination bodies, in Constellation activities and objectives.
4. To realise its full potential as an implementation mechanism for the GEOSS, the Constellations efforts should give greater emphasis to the physical results of coordination – the ‘sharp end’, such as data products and ECVs. There is an immediate demand for such implementation support – aiding the ECV inventory and coordination efforts of the WGClimate. This will require real resources and may require additional membership for Constellation teams.
5. The SST-VC has volunteered to serve as a pilot for the demonstration of the implementation partnership between Constellations and WGClimate.
6. As the Climate Architecture effort evolves from a badgeless activity to considering which existing assets and processes might be engaged or adapted in support of the functional and physical architectures, the role for the Constellations should be carefully considered.
7. The Constellations address a range of different coordination and implementation issues, reflecting the diversity of real-world challenges for CEOS in realising the space segment of the GEOSS. Any change in terms of reference or to the Constellations Process Paper should recognise the value of such diversity and not ‘over-standardise’ in a way which might restrict contribution of the Constellations to CEOS objectives.
8. The SIT process and meetings should be redesigned to identify, and escalate as appropriate, important outputs from the Constellations which have implementation implications, and to guarantee debate between Principals with supporting observation programmes.
9. It is beyond the scope of this study to consider the effectiveness of the Constellation recommendations, through CEOS, in influencing the mission budgeting and programming decisions of individual space agencies. It has been noted however that

agencies need a goal to subscribe to that reflects their national policies and requirements and the Constellations have made progress this direction. Their attention to ECVs may provide a focus to which agencies and governments can subscribe and communicate back home to implement programming decisions.

1. The Constellation teams should have more direct representation on the CEOS SEC meetings to ensure that Constellation-related business stays on the management radar throughout the year. This could be via a nominated representative responsible for collating and distilling inputs from the Constellations to SEC.
2. Constellation teams have catalogued their planned outputs for the next few years in the course of this CEOS Self Study. CEOS should review this output and determine whether these achievements reflect the organisation’s ambitions. A dialogue between SIT Chair and Constellations to this end would be a logical next step.

**REFERENCES**

1. CEOS task force on future relations with GEO and the implications for CEOS: Final Report – July 2005

2. The CEOS Virtual Constellation Concept (S Ward and D Vidal-Madjar) – March 2005

3. CEOS Constellations Presentation @ SIT-28 – March 2005

4. CEOS Constellations for GEO – Process Paper – November 2008