CGMS

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REVISION OF THE GOS BASELINE FOR LEO SATELLITES

The present paper details the background and the implications of the draft “Vision of the GOS to 2025” regarding LEO satellites (See WMO-WP-06). According to this draft vision, the LEO component of the space-based GOS should be reconfigured and expanded in order to address additional missions. This change of baseline, once endorsed, would have to be reflected in the CGMS Global Contingency Plan.

A distinction can be made between core imagery and sounding missions in sun-synchronous polar-orbit and the other LEO missions.

The first category is a heritage of current operational missions in polar-orbit that are currently addressed in the CGMS Global Contingency Plan and requires in-orbit back-up. The proposed new baseline is a three-orbital plane constellation with 13:30, 17:30 and 21:30 as nominal Equatorial Crossing Times (ECT) with redundancy.

The second category includes additional LEO missions for which continuity is needed as well (e.g. for NWP or climate monitoring), however, the requirement for continuity has not yet been precisely defined and will not necessarily entail in-orbit back-up.

The CGMS Working Group on Contingency Planning is invited to consider the new baseline that is being developed for LEO satellites, in particular the core constellation, and its future bearing on the CGMS Global Contingency Plan. Preliminary comments from CGMS would be an important input to the process of refining the new “Vision of the GOS to 2025”.

REVISION OF THE GOS BASELINE FOR LEO SATELLITES

1 INTRODUCTION

WMO-WP-06 contains the highlights of the new vision that is being developed in the context of optimization and re-design of the space-based GOS.

According to this draft vision, the LEO component of the space-based GOS should be reconfigured and expanded in order to address additional missions. This change of baseline, once endorsed, would have to be reflected in the CGMS Global Contingency Plan.

The present paper indicates possible implications of this change of baseline and focuses on the recommended configuration of the core imagery and IR/MW sounding constellation, which is the direct heritage of the current operational LEO constellation.

2 LEO COMPONENTS OF THE PROPOSED NEW GOS

The proposed new GOS would have the following components in LEO:

N°	Mission addressed	Orbit type	Comment
1	Core multispectral imagery and IR-MW sounding	sun-synchronous, 3 orbital planes (13:30-17:30 -21:30)	"Core constellation" Heritage of current mission
2	Radio Occultation Sounding	Clusters with different orbit inclinations a priori not sun-synchronous	New constellation, COSMIC heritage
3A	Ocean altimetry (2-component constellation)	Precise non sun-synchronous (e.g. 1336 km, 66° inclined orbit)	Jason follow-on
3B		Sun-synchronous, 2 well separated orbital planes	
4	Ocean surface wind vector (2 scat + 2 MWI)	Sun-synchronous (TBC)	Can be flying with mission 1 satellites
5A	Global Precipitation	65° inclination	GPM Core spacecraft
5B		Sun-synchronous and non-sun synchronous	GPM MWI constellation
6	Earth Radiation Budget	TBD	
7	Atmospheric composition	TBD	
8	Specific Imagery	TBD	

Table 1. Summary of the considered missions in LEO

For the purpose of this paper we will designate by "core constellation" the fleet of comparable instruments contributing to the multi-spectral imagery and IR-MW sounding mission flying on sun-synchronous polar-orbiting spacecraft (Mission N°1 in Table1 above), the other components being named "additional" missions.

Some additional instruments may be flying on the same spacecraft as the core constellation, but this will not be the case for all the additional instruments because of different orbit requirements. Moreover, even if an additional instrument is flying with the core constellation, we assume that it would not be required to be present aboard all satellites of this constellation. (Otherwise one should consider re-defining the core constellation so as to systematically include this instrument).

It is understood that in the future contingency planning would need to be addressed separately for the different constellations, having regard to their specific mission requirements and implementation approach. Although some continuity is required for all the missions listed in Table 1 above, the details of this continuity requirement is not yet defined (e.g. need for in-orbit back-up, or maximum acceptable gap) for the “additional” missions; we will thus only consider here the core constellation for the time being.

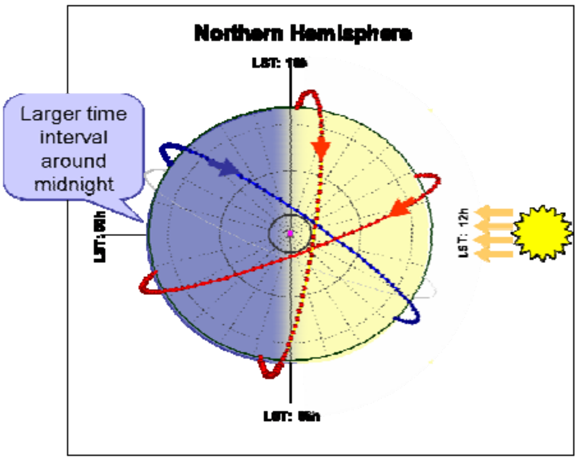
3 CORE CONSTELLATION BASELINE

The current baseline for the core constellation is described in Chapter 4 of the WMO Manual on the GOS and in Section 5.4 of the CGMS Global Contingency Plan that is reproduced in the Annex. It foresees four operational LEO sun-synchronous satellites optimally spaced in time, two in a.m. and two in p.m.; and two other spacecrafts as in-orbit back-up.

It is envisaged as a new baseline that the core constellation be deployed over three orbital planes around 13:30, 17:30 and 21:30 Equatorial Crossing Time (ECT) in Local Solar Time (LST). This should ensure regular sampling of the atmosphere avoiding too large a temporal gap around dawn and dusk, in order to satisfy as far as possible the observing cycle requirements from NWP and climate monitoring as concerns atmospheric temperature and humidity profiles. In addition, in-orbit redundancy should be available around these orbital planes, to the extent possible.

A three-orbit configuration with ECT at 13:30, 17:30 and 21:30 ensures regular temporal sampling with an average four-hour observing cycle at the equator; the average observing cycle being shorter at high latitudes because of the overlap between consecutive passes. This satisfies the threshold requirements but is still far from the goal; therefore every attempt should be made to implement in-orbit redundancy around each of the three orbital planes, not only to provide a back-up in contingency cases, but also to provide operational data in parallel and thus improve the temporal coverage.

In this respect, it can also be noted that for a three-orbit configuration with ascending orbits at 13:30, 17:30 and 21:30 LST; the time interval between the ascending 21:30 orbit and the descending 13.30 orbit is larger around midnight in the Northern Hemisphere, as an effect of the opposite inclinations, as shown in Figure 1. Inversely, the interval is smaller around noon. For a similar reason, the time interval is larger around noon in the Southern Hemisphere between the descending 21:30 orbit and the ascending 13:30 orbit, and smaller around midnight, as shown in Figure 2. (This effect is only significant at mid-latitudes, since it is counterbalanced at higher latitudes by the overlapping of consecutive swaths.)



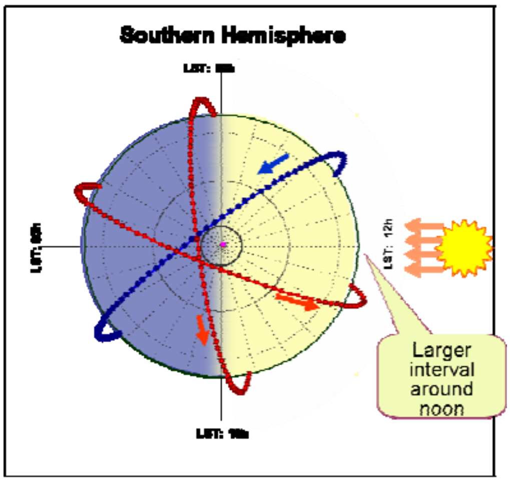


Figure 1 and 2: Distribution of three orbital planes at 13:30, 17:30 and 21:30 (ascending) over the Northern Hemisphere (left) with a larger time interval around midnight, and over the Southern Hemisphere (right). with the larger time interval around noon.

Recalling the current plans of the Russian Federation to launch a Meteor-M spacecraft on a mid-morning ascending orbit, it is worth mentioning that this would nicely complement the Metop and FY-3 satellites flying on a mid-morning descending orbit and allow a regular temporal sampling at midnight and noon as illustrated in Figure 3 below. Generally speaking it would be desirable that, among the various missions that all together will provide the core constellation, there is at least one ascending and one descending around 21:30.

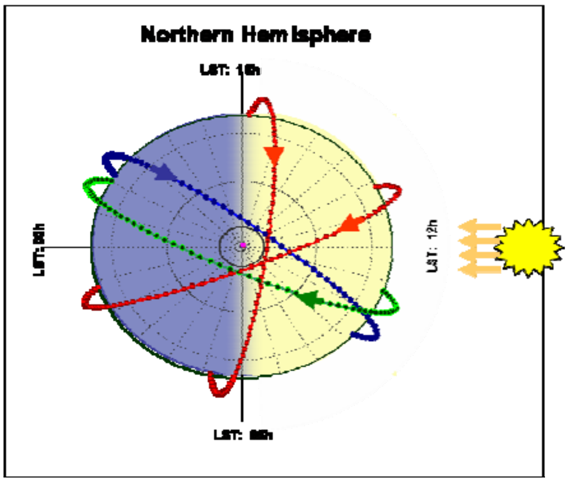


Figure 3. Example of a three-orbit configuration with in-orbit redundancy on the mid-morning orbit. The green orbit, ascending at 09:30 and the blue orbit ascending at 21:30 complement each other, thus avoiding a large midnight-noon gap.

5 CONCLUSIONS

The CGMS Working Group on Contingency Planning is invited to consider the proposed new baseline for LEO satellites, and its future bearing on the CGMS Global Contingency Plan, in particular as concerns the core constellation that would include a full imagery and sounding package on three regularly spaced orbital planes. CGMS is invited to note the considerations provided on Equatorial Crossing Times and optimization of in-orbit redundancy through combined use of ascending/descending 9:30 orbits.

CGMS comments would be an important input to the process of refining the new “Vision of the GOS to 2025”.

ANNEX

CHAPTER 5.4 EXTRACTED FROM THE CGMS GLOBAL CONTINGUENCY PLAN

5.4 Contingency planning for LEO satellite missions

In order to meet WMO's requirement for a continuous operation of four operational sun-synchronous polar-orbiting satellites, the nominal constellation includes six polar-orbiting satellites:

- two in an AM orbit, i.e., with ascending Equatorial Crossing Time (ECT) between 18:00 and 24:00 Local Solar Time (LST), thus descending ECT between 6:00 and 12:00 LST, with a third capable of serving as a back-up to these two;

- two in a PM orbit, i.e., with ascending ECT between 12:00 and 18:00 LST, with a third capable of serving as a back-up to these two.

CGMS satellite operators will seek to define their satellite missions in polar orbit with a view of optimizing temporal coverage of the globe through an optimal spacing of the ECT of sun-synchronous satellites.

Provisions will be made to reduce or avoid significant drift in the ECT in order to maintain an optimal sampling and ensure long-term consistency of the observation times.

With regard to polar orbiting contingency planning, in a constellation of four polar-orbiting satellites, two in the AM orbit will be capable of serving as backup to each other and two in the PM orbit will also be capable of serving as backup to each other.