CGMS

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REVISION OF THE GOS BASELINE FOR GEOSTATIONARY SATELLITES

The present paper details the background and the implications of the recommendation, included in the draft Vision of the GOS to 2025, stipulating that geostationary satellites should be nominally distributed with no more than 60 degrees difference between the longitudes of adjacent locations.

This recommendation goes beyond the current requirement, stated in the CGMS Global Contingency Plan, to cover all latitudes below 50 degrees with a zenith angle not higher than 70 degrees.

Bearing in mind that, in past occasions, geostationary satellites have been maintained or operated at various locations differing from the nominal ones, for example during contingency situations, it is suggested to explore the feasibility of adjusting the nominal locations towards a more regular distribution that would either satisfy, or be close to satisfying the recommendation.

REVISION OF THE GOS BASELINE FOR GEOSTATIONARY 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. As concerns the operational geostationary satellite constellation, the provisional recommendation is to ensure no more than 60 degrees longitude difference between adjacent geostationary locations. The present paper details the implications of such a recommendation.

The nominal locations of the operational geostationary satellite constellation were initially determined for a five-satellite constellation, which implies an average interval of 72 degrees longitude between adjacent locations. In practice, the angular distances between adjacent nominal locations were ranging between 60 degrees and 85 degrees, as can be seen in Table 1, a priority being given to locations allowing a proper monitoring of continents with respect to the monitoring of oceanic areas.

Table 1: Nominal geostationary locations and corresponding angular distances in the former five-satellite baseline

Nominal longitudes	135°W	75°W	0°	76°E	140°E	
Distance from neighbour	85°	60°	75°	76°	64°	85°

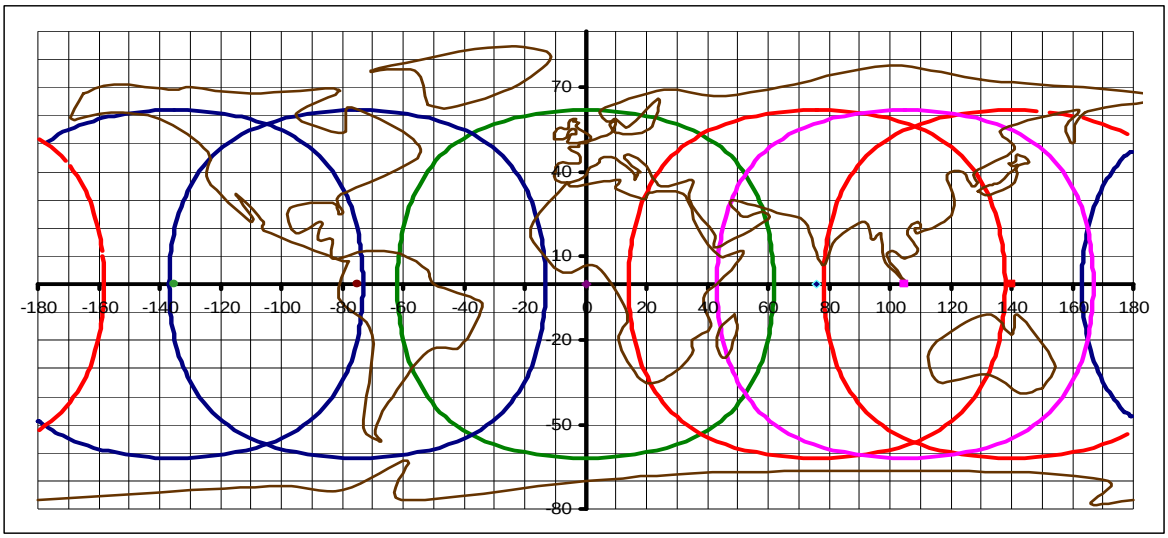
This baseline was then upgraded to a six-satellite configuration, as now recorded in the Manual for the GOS. When developing the first CGMS Global Contingency Plan in November 2005, CGMS recorded this sixth location in addition to the five pre-existing ones. The resulting nominal locations are indicated in Table 2. It shows a large difference between the maximum and the minimum longitude interval (highlighted in Table 2).

Table 2: Nominal geostationary locations and corresponding angular distances in the current six-satellite baseline

Nominal longitudes	135°W	75°W	0°	76°E	105°E	140°E
Distance from neighbour	85°	60°	75°	76°	29°	35°	

The implications of this distribution are illustrated on Figure 1 that shows that the fields of views are overlapping over Asia, where this interval is minimal, and there is a gap over the Pacific above 50° latitude north and south, where the interval is maximal.

Figure 1: Coverage provided by the current baseline with 70 degrees zenith angle.



2 CURRENT REQUIREMENTS ON COVERAGE AND ZENITH ANGLE

At present, WMO requirements are not very precise as concerns the geostationary coverage.

The Manual on the GOS stipulates: *"The number of satellites in geostationary orbit should be sufficient to obtain observations, typically at 30 or 15 minutes intervals, throughout a field of view between 60° S and 60° N. This implies the availability of at least 6 satellites, near-equally spaced around the equator."*

The latter statement implicitly assumes that the zenith angle should not exceed a maximum value. In theory, if a zenith angle of up to 85 degrees was acceptable all latitudes between 60°S and 60°N could be covered with three satellites only, however images are useless to derive products at such high zenith angles. With a maximum zenith angle of 75 degrees at least five satellites are required. If the maximum zenith angle is 73 degrees, the maximum longitude interval is of the order of 60 degrees and six equally-spaced satellites are required. The provisions of the Manual on the GOS for the baseline could thus be interpreted as: "*all latitudes between 60° N and 60°S are observed with a zenith angle that does not exceed 73 degrees".*

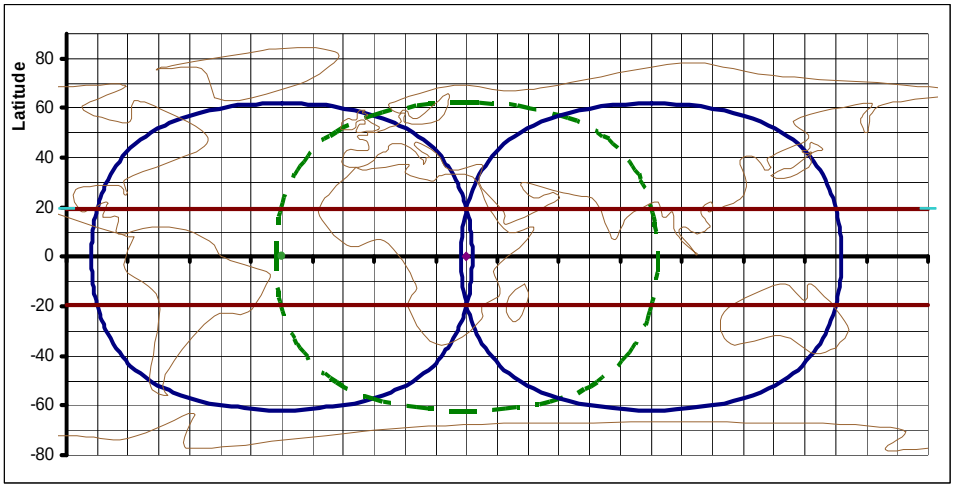
The CGMS Global Contingency Plan stipulates: *"Images taken under a zenith angle not higher than 70 degrees are available over all latitudes lower than 50 degrees"*. This requirement can be satisfied if the longitude interval between adjacent satellites does not exceed 85 degrees. This requirement was formulated at a time when the baseline included only five satellites, and it may need to be reviewed. It should be noted however that, in the current baseline, this requirement is just satisfied without any margin because of the large interval over the Pacific between GOES-W and MTSAT.

If the six locations were regularly distributed along the equator with an interval of 60 degrees, all latitudes up to $\pm$ 57 degrees would be covered with a zenith angle not exceeding 70 degrees.

3 ADVANTAGES OF A 60° INTERVAL

One advantage of maintaining the interval between adjacent satellites below 60 degrees longitude is to optimize the coverage by a six-satellite constellation; it ensures that all latitudes up to 60° north or south are covered with a zenith angle below 73 degrees (or that all latitudes between 57 degrees north and south are covered with a zenith angle below 70 degrees). A further advantage is that it minimizes the impact of temporary failure of one satellite; when the remaining adjacent satellites are separated by no more than 120 degrees, they still provide at least coverage of the inter-tropical region between 19° N and 19°S, as illustrated in Figure 2 below.

Figure 2: Adjacent fields of view of satellites with a 120 deg longitude interval, in a contingency situation. With a maximum zenith angle of 70 deg, the degraded coverage includes latitudes between 19°S and 19°N. Longitudes are not significant in this diagram.



4 ALTERNATIVE GEOSTATIONARY LOCATIONS USED

Although nominal locations have been defined as indicated in Tables 1 and 2, a number of other locations have been or are currently used for the operation of geostationary satellites within the GOS. A (non exhaustive) list of these locations in indicated in Table 3 below and shows that, depending on the needs, CGMS Members have been able to operate their satellites in a number of locations in addition to the nominal ones.

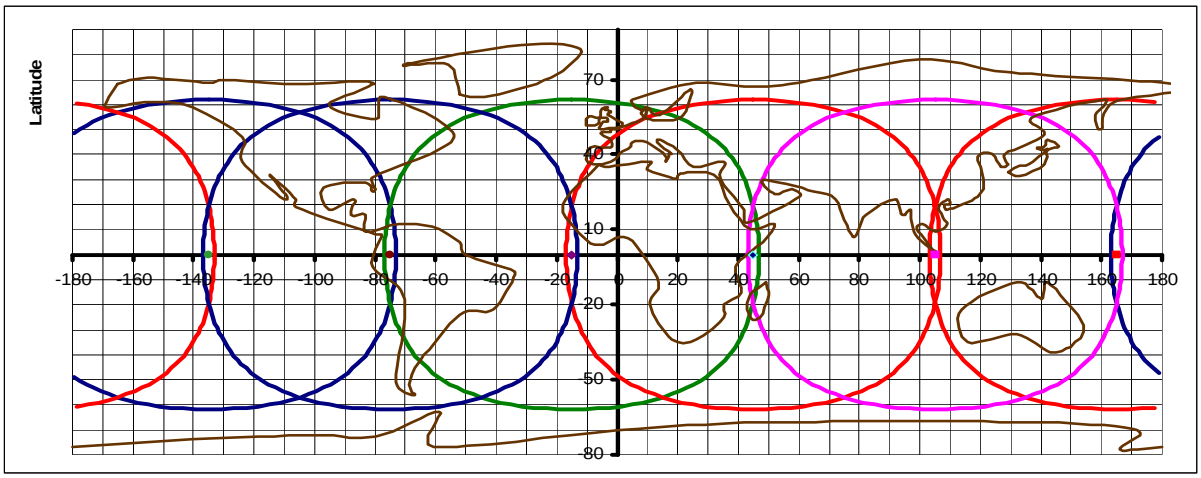
Table 3: Locations used by geostationary GOS satellites

Satellite series	Nominal locations	Alternative locations used for stand-by satellites, for commissioning, or for specific missions (e.g. back-up, rapid scan)
GOES	135 W; 75 W	105 W; 89.5 W; 60 W (South-America coverage); 155 E (MTSAT back-up)
Meteosat	0	75 W and 50 W (ADC); 3.4 W; 10 W; 10 E; 57.5 E , 63 E and 67 E (IODC)
FY-2	105 E	86 E; 123.5 E
MTSAT	140 E	145 E

5 TOWARDS OPTIMIZED COVERAGE

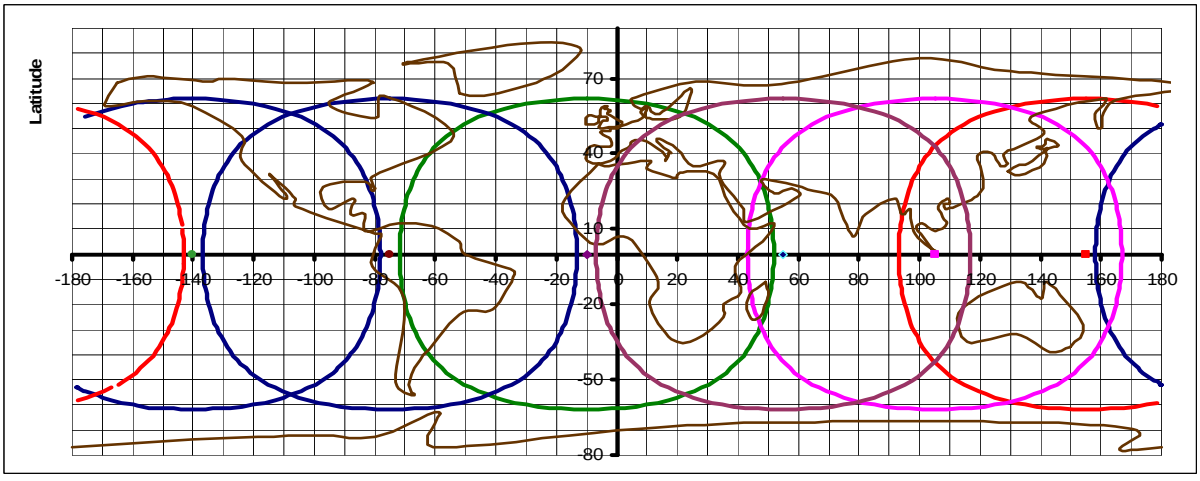
In terms of area covered, optimizing the geostationary baseline would imply that the nominal locations are regularly distributed, hence a 60 degree longitude interval between adjacent locations. Such a theoretical coverage is illustrated in Figure 3.

Figure 3: Theoretical coverage with 70 ° maximum zenith angle and 60° longitude interval. In this example, the origin is at 135 W and three locations are preserved (135 W, 75 W, 105 E) while three locations are departing from the current baseline (15 W, 45 E, 165 E).



Recognizing the legitimate requirement of satellite operators to cover in priority the territories of their stakeholders, and in order to minimize disruption from the current baseline, an intermediate target could be considered. As a basis for discussion, Figure 4 provides an example of locations that would be distant from one another by no more than 65 degrees.

Figure 4: Example of six-satellite baseline ensuring a longitude interval not exceeding 65 degrees (140W, 75W, 10W, 55 E, 105E, 155E). Latitudes between 56 °N and 56° S are covered with a zenith angle below 70 degrees.



6 CONCLUSIONS

Achieving a regular distribution of the nominal geostationary locations would optimize the area covered.

CGMS Members are invited to comment on the feasibility of adjusting the current nominal locations of the operational geostationary satellites in order to get closer to a regular distribution.