CGMS

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THE DATA COLLECTION SYSTEM IN MTG: PRELIMINARY CONSIDERATIONS

This Working Paper presents a summary technical description of the Meteosat Third Generation - MTG - characteristics for the Data Collection System as defined at the time of the end of the Phase A of the EUMETSAT MTG Preparatory Programme. The final MTG payload complement is to be decided by EUMETSAT Member States in the fall of 2008 and therefore the information collected here is based on the payload complement assumptions used for the Phase A.

Continuity of services is a mandatory requirement for MTG and, when applied to the DCS system, special care has been placed on ensuring that seamless continuity is provided. Nevertheless, through the technical definition of the MTG satellites, three main differences have been identified when comparing the previous MTP and MSG DCS systems and the concepts considered in the Phase A for MTG. These three main differences are related to the downlink from the MTG satellite towards the receiving station of EUMETSAT (Primary Ground Stations for MTP and MSG) and are as follows:

- **Physical layer: DCP downlink is no longer in L-Band but assumed to be in K-Band (18.1-18.4 GHz) and using a steerable pencil beam with a limited footprint (approx 820 Km at sub-satellite point)**
- **Link Layer: DCP signal is digitalised on board and down-linked using a bit stream service of the CCSDS packet TM service stack.**
- **Mission analysis. The use of K-Band in the downlink means that the satellite vs. receiving Ground Station geometry (i.e. elevation angle) influences the link budget margin because of the atmospheric conditions and the associate slant path loses (specially in the troposphere).**

These three differences do not affect the technical requirements for the DCP platforms using the MTG system, because they do not imply any modification on the user segment for using the DCS in MTG, but represent a definitive departure from the previous technical characteristics for the satellite downlink signal (MTP and MSG use L-Band bent-pipe transponders) complicating the possibility of cross-support.

Finally, the Working Paper briefly addreses the initial frequency plan for the MTG DCS transponder (uplink). Subsequently, and in view of the current and future plans of the different GEO and non-GEO DCS operators of DCS systems, as indicated in WP-15, the progress made at SFCG-28 (September 2008) is presented regarding an agreement between DCS operators based on a proposal made by EUMETSAT for segmenting the MetSat band 401-403 MHz. CGMS members are invited to consider this proposal in view of their current and future needs and to provide their views confirming their agreement to the proposed segmentation.

The Data Collection System in MTG: Preliminary considerations

1 INTRODUCTION

The objective of the MTG mission is to provide Europe's National Meteorological Services and, by extension, the International Users and Science Community, with an operational satellite system able to support better and more accurate prediction of meteorological phenomena and the monitoring of climate and air composition through operational applications for the period of time between 2015 and 2035.

The detailed analysis of mission objectives, in account of the needs expressed by operational application users which can be satisfactorily fulfilled (within acceptable technological and programmatic risks) by means of a geo-stationary earth observation satellite system, led to the identification of four observations missions[1]:

- Full Disk High Spectral resolution Imagery (FDHSI);
- High Resolution Fast Imagery (HRFI);
- Infra-red Sounding (IRS);
- Lightning Imagery (LI)

In addition, the baseline MTG system will comprise the following associated missions and services:

- Level 2 product extraction mission associated to the observation missions (L2P);
- Data Collection System (DCPs);
- External Data Collection (EDC);
- Archiving and cataloguing of all MTG data and products;
- On-line services to users (both real-time and non real-time services).

It should be noted that the final MTG payload complement is planned to be decided by EUMETSAT Member States in the fall of 2008 and therefore the information collected here is based on the payload complement assumptions and the related technical solutions used for the Phase A studies.

At the time of generating this working paper for CGMS 36, EUMETSAT is finalising all activities related to the Phase A of the MTG System, which will be completed with the System Preliminary Requirements Review. The review process is planned for the period of November-December 2008.

2 MTG SYSTEM PRELIMINARY BASELINE (PHASE-A STATUS)

The baseline used for the feasibility assessment done in the Phase A includes the following:

[1] GMES Sentinel 4 (UVN) implemented as an additional sounder is TBC and treated as an option at system level.

- Twin Satellite concept with four imager satellites and two sounder satellites;
- No Direct Dissemination mechanism will be accommodated on any of the satellites (i.e. dissemination is based on commercial/alternative services);
- Based on 3-axis stabilized platforms;
- Based on common platform for imager and sounder mission;
- Using a collocation strategy (2 imagers and one sounder).

Currently, two parallel studies are being completed at space segment level using the above features. In both cases the technical analysis derived from the requirements related to the observational missions has concluded that the data rates associated to the instrument data are in the range of 70 Mbps for the imagers (2 imaging satellites) and in the range of 200 Mbps for the sounder.

Instrument data has been traditionally down linked in L-Band for the previous generations of EUMETSAT geostationary satellites (MOP, MTP and MSG). However, with these new data rates (70+70+200 = 340 Mbps), the bandwidth available in L-Band (1675 – 1710 MHz) or even in X-Band (7450 – 7550 MHz for the MetSat downlink) is clearly not suitable using already well proven technologies based on CCSDS Bandwidth Efficient Modulation schemes. Even the MetSat downlink service in K-Band (18.1 – 18.3 GHz) it is not wide enough to accommodate the expected bandwidth needs for the three different satellite carriers down-linking the instrument data. Consequently, EUMETSAT requested that WRC-07 discuss the possibility to expand this MetSat K-Band allocation by 100 MHz and, as reported in CGMS-36 WP 15, the outcome of WRC-07 has confirmed this expansion (18.1 – 18.4 GHz for Region 1).

The Phase A level studies at space segment level have been performed with this premise and the design of the satellites has assumed that K-Band is the baseline for the system. Regarding the MTG Ground System, the baseline is that there will be a Primary Ground Station for receiving all satellite downlinked data (as for MTP and MSG). The technical implementation on board therefore assumes that no K-Band beam shaping/forming is necessary and a steerable pencil beam antenna is being considered (i.e. standard reflector antenna with normal feed and associated antenna pointing mechanism). In line with the preliminary budget estimates, the satellite antenna size is estimated to be around 0.9 m. (≈1.3° for the 3 dB beamwidth) and therefore only a limited part of Europe will be illuminated, in K-Band, by the MTG satellites (a circle of around 820 Km diameter at sub-satellite point –SSP–).

3 MTG DCP CONSIDERATIONS DUE TO SATELLITE DESIGN (PHASE-A)

Regarding the Data Collection System, the implementation in previous programmes has always included a specific bent-pipe DCP transponder, and antenna system, that have provided turn-around frequency conversion and amplification from the UHF (402 MHz) uplink from the DCP platforms to the 1675 MHz downlink towards the MTP or MSG Primary Ground Stations. Therefore, in the MTP and MSG satellite cases, the downlink signal has shared some of the RF H/W, e.g. HPAs and the main antenna system, used for instrument data downlink (also in L-Band).

In the case of MTG, the instrument data downlink, as explained above, is performed in K-Band, and therefore, maintaining the L-Band downlink just for the DCP downlink towards the MTG Primary Ground Station will not benefit of any satellite hardware sharing. The different possible configurations have been traded off during the first part of Phase A, at satellite level, and the baseline retained for the rest of Phase A has been agreed to implement the DCP signal downlink also in K-Band to maintain commonality and share some of the satellite RF H/W (i.e. MTG DCP downlink is not implemented in L-Band). On the other hand, for the uplink, the MTG case maintains the same system specification, in terms of uplink signal modulation and platform EIRP, as used for MTP and/or MSG (including HRDCP), since continuity of the existing service is paramount to EUMETSAT.

Likewise, also for the DCP transponder implementation, a second trade-off analysis has been performed between using a traditional bent-pipe transponder approach (like MTP and MSG) vs. an on-board digitisation of the DCP signals. Mainly because of phase noise considerations (for the bent-pipe case from 402 MHz to 18.3 GHz) the corresponding system trade-off concluded on the use of a digital transponder (i.e. on-board analogue to digital conversion of the DCP signal in UHF and downlink of this digitised signal in one of the available virtual channels in the K-Band downlink master channel, e.g. using a bit stream service). The digitisation of the DCP Band (in UHF) is estimated to result in an aggregate of around 40 Mbps (on top of the instrument data rate) but will only be implemented on the imaging satellites and, as in the MSG case, only one DCP transponder will be active in support of the full regional DCS (downlink rate 70+40 $\approx$110 Mbps for the imager with active DCP, 70 Mbps for the additional imager and 200 Mbps for the sounder, i.e. 110+70+200 = 380 Mbps in the downlink from the MTG satellites).

Therefore, when considering system evolutions, potential for reusability and service continuity and/or cross-support possibilities, it needs to be clear that there is a basic incompatibility between the MTG and MSG downlinks as the downlink from the satellite is different in the following aspects:

a) Frequencies are different implying that MTG DCP reception needs a K-Band antenna and that the corresponding satellite antenna (instrument data and DCP) has to be pointed to the receiving earth station.
b) Downlink signal formatting/conditioning is different: MSG uses the standard DCP modulation scheme for the 100 bps or the HR DCP (i.e. the MSG satellite does not modify the uplinked modulation). MTG K-Band downlink is different and the first thing that needs to be done is to recover the original signal (either in digital or analogue form) from the digitised samples (grouped in transfer frames) for subsequent demodulation and recovering of the DCP message from the reconstructed signal. This implies that the receiving station has to be furnished with specific MTG DCP data demultiplexers and, if relevant, digital to analogue converters, as well as with the adequate DCP receivers (either analogue or digital).
c) Link budget margin for DCP downlink depends on the satellite to receiving ground station geometry. The system is being optimised for a receiving station in Europe and the MTG satellite at 0° as the "operational" location for the Meteosat satellites. Operating the satellite, for instance, at 50° W or 61° E while still using the same receiving station in Europe, constraints, on the one hand, the possible locations for the ground stations to cover all these satellite orbital locations and, on the other hand, adds significant atmospheric loses which influences the link budget margin due to the associated slant path loses (specially in the

troposphere) for low ground station elevation angles with satellites at the edge of its orbital arc.

These differences between the MTG and MSG satellite downlink, and their derived limitations and constraints on the potential of compatibility for the associated ground segment receiving front-ends, need to be considered in the future plans for cross-support between EUMETSAT and any other CGMS organisation.

4 MTG DCP FREQUENCY PLAN (PHASE-A)

At the time of starting the MTG Phase A, the frequency allocation for the DCP transponder was initially established to be the band 401.701 – 403 MHz. During the Phase A, this has been re-evaluated in consideration with other DCS operators, their future regional system needs and the potential for interference that overlapping bands in neighboring regional systems might imply.

In addition, as indicated to CGMS-36 in EUM-WP-15, at SFCG-27, held in September 2007, CNES presented a frequency declaration for the ARGOS-4 system in which 5 so called “beams” were identified with frequency bands in the range 401 – 403 MHz (Beam-1: 401.275 – 401.580 MHz, Beam-2: 401.690 – 402.400 MHz, Beam-3: 402.521 – 402.650 MHz, Beam-4: 402.850 – 403 MHz and Beam-6: 401 – 401.225 MHz). In bilateral discussions between CNES and EUMETSAT/NOAA it was concluded that overlapping frequency use between ARGOS-4 on non-geostationary MetSat systems and DCS use on current geostationary MetSat systems would result in mutual harmful interference.

Aside from the issue of coexistence between next generation non-GSO and GSO Data Collection Systems in the frequency range 401 – 403 MHz, plans for expansion of the frequency spectrum requirements for next generation GSO MetSat systems require to re-coordinate or re-segment the full spectrum resource among the operators in order to allow an effective and interference-free use of the band (as is successfully demonstrated today by the in place agreement for the part of the band segmented among the geostationary MetSat operators).

In view of the information on current and future planned use of the band 401 – 403 MHz by non-geostationary and geostationary MetSat systems for DCS, EUMETSAT has made a proposal, presented at SFCG-28 for discussion (as reported to CGMS-36 in EUM-WP-15), aiming to achieve a common operational agreement for segmenting the full DCP band that should eliminate/minimise the potential of interference between non-GSO and GSO systems as well as establish the band assignments between neighboring GSO DCP systems.

The issue has been discussed in September 2008 at SFCG-28, among all Space Agencies having an interest in the topic (except for the Chinese and Indian Space Agencies which were not present at SFCG-28), and the following, in line with the original proposal of EUMETSAT, constitutes the basis for further discussions to come to a final agreement:

1) For the band 401.701 – 402.001 MHz and 402.1 - 402.435 MHz, SFCG concluded that overlapping frequency use, as would be the case for Beam-

2 (401.690 – 402.400 MHz) between ARGOS-4 on non-geostationary MetSat systems and regional DCP and IDCS use on current geostationary MetSat systems, would result in mutual harmful interference. Therefore, the band 401.701 - 402.435 MHz should remain available only for DCS using geostationary MetSat systems in cross-support between the regions. This would also avoid interference into neighbouring MetSat systems.

2) The band 402.435 – 402.85 MHz could be designated for DCS using geostationary MetSat systems and split-up in two sub-bands (402.435 – 402.635 MHz and 402.635 – 402.850 MHz) in similar fashion as done for the current regional DCP bands in order to avoid interference into neighboring MetSat systems. The concept of cross-support between the regions could also be applied.

<u>Note:</u> For the partitioning for regional DCP use and cross support among GSO MetSat operators no conclusion could be drawn at SFCG-28 as such a split would not provide the amount of spectrum which is planned for GOES-R.

This specific part of the proposal is pending NOAA's, and potentially other GSO MetSat operator's (Russia, India), support of the proposed partitioning.

3) Within the band 402.435 – 402.850 MHz, that could be designated for regional DCP use on GSO MetSat systems, 100 kHz could be designated for an ARGOS-GEO component, ideally made available on a global basis by all geostationary MetSat operators. If the concept of cross-support would be applied, these 100 kHz could be positioned across both sub-bands (e.g. 402.585 – 402.685 MHz), or in one of the two sub-bands. CNES and EUMETSAT are currently arranging a test at which ARGOS platform messages are relayed via geostationary MetSat system.

4) For the band 401.1 – 402.4 MHz which is currently used by FY-2 satellites, no conclusion could be drawn whether or not this sub-band should be designated for DCS using geostationary MetSat systems or non-geostationary systems, or both, as CNES and CMA are currently in coordination negotiations and CMA was not present at the SFCG-28 meeting.

5) The remaining portions of the band 401 – 403 MHz, namely 401- 401.1 MHz, 401.4 – 401.7 MHz and 402.850 – 403 MHz, could be designated to the ARGOS LEO component, if there are no other requirements identified by CMGS.

CGMS is invited to consider the attached overview and the above proposal and status of discussions at SFCG for a coordinated future use of the band 401 – 403 MHz by DCS. In order to provide planning security for the development of DCS systems on future meteorological satellites, an agreement at CGMS-36 among MetSat operators on as many as possible of the above described elements would be beneficial, aiming at a final agreement at SFCG-29 in June 2009.

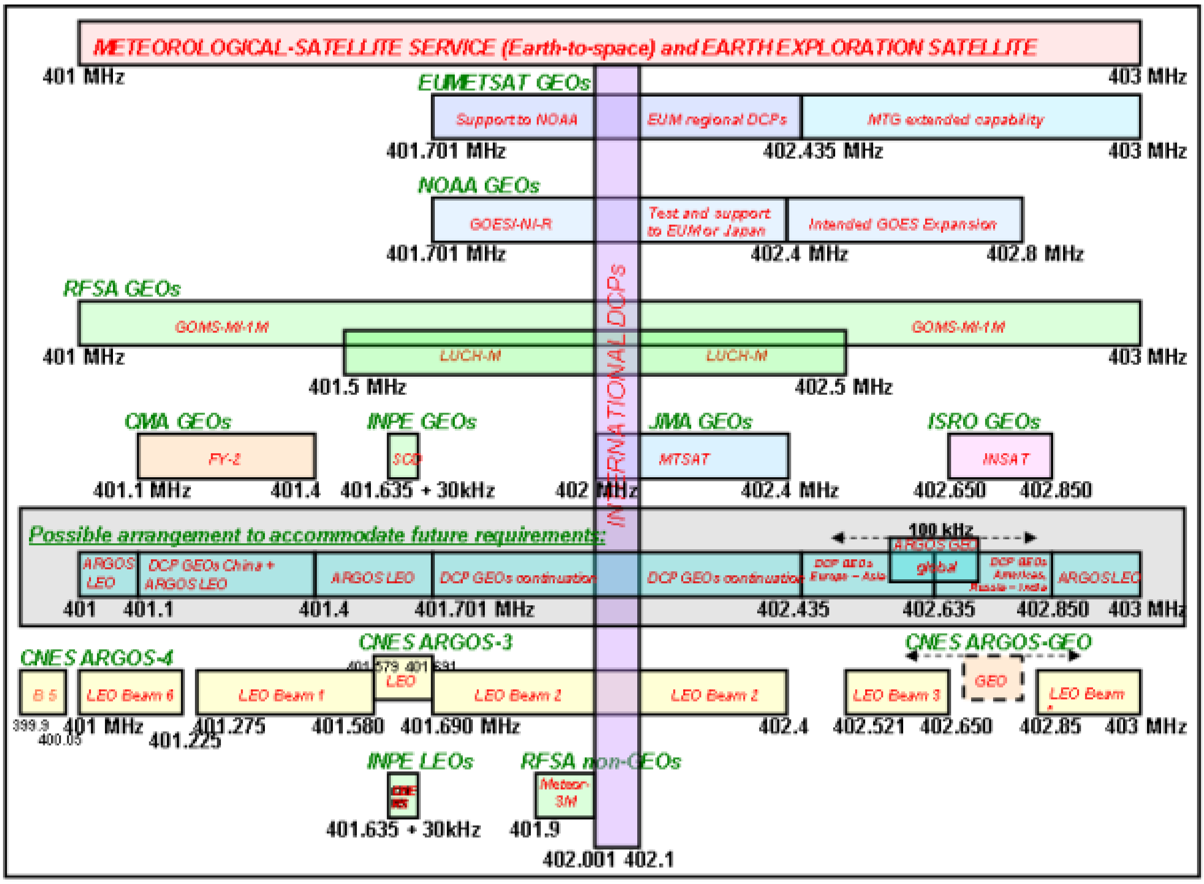

Figure 1 - DCS Band occupancy among service operators in current and planned future systems and proposal for coordinated Band segmentation for minimising potential of interference.