CGMS

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FREQUENCY DECLARATION FOR THE ARGOS-4 SYSTEM

NOAA-WP-40 presents a summary of frequency declarations for the Argos-4 system.

FREQUENCY DECLARATION FOR THE ARGOS-4 SYSTEM

1. BACKGROUND

Argos is an international program with a long lasting co-operation, now close to thirty years, between CNES (Centre National d'Etudes Spatiales) and several space agencies.
The first co-operation was carried out with the National Oceanography and Atmospheric Agency (NOAA) and the National Aeronautic and Space Agency (NASA). Since the first launch in 1978, 13 instruments (Argos-1 and Argos-2 generations) on the TIROS satellites have ensured the continuity of the Argos mission.
The co-operation has been enlarged to involve the European Organisation for the exploitation of meteorological satellites (EUMETSAT) since the successful launch of the METOP-A satellite in October 2006 which embarks the first Argos-3 instrument. The next Argos-3 instruments will be launched with the NOAA-N' in 2009, METOP-B in 2011, and METOP-C in 2015. In addition, a new co-operation with the Indian Space Research Organisation (ISRO) has been agreed. The Indian satellite, called SARAL, is a polar orbiting satellite and will embark an Argos-3 instrument, the launch is planned in the end of 2009.
CNES defines and provides the instruments, the other agencies provide the satellite and its operation, as well as the raw data recovery from their high latitude ground stations.

The Argos system is today in a new step of its existence. CNES is currently developing the Argos-4 instrument that will be flown on the new generation of the NOAA satellites called NPOESS-C1 and NPOESS-C2. Some other Argos-4 instruments could also fly on NPOESS-C3 and NPOESS-C4 or on EUMETSAT Post-EPS satellites depending on the future agreements.

During the life of the system, constant technical improvements were performed in order to better satisfy the user needs.
- The first generation of the Argos system (Argos-1) demonstrated the feasibility of a highly sensitive instrument capable of processing several uplinks from terrestrial or maritime platforms. Processing and distribution of the collected data were also organised during this phase.
- With a wealth of experience behind it, the second generation (Argos-2) improved the sensitivity and the system capacity.
- The third generation (Argos-3) takes into account the evolving user needs, and proposes new high data volume platforms and new very low power transmitting platforms in addition to the existing ones. The system capacity is also increased. The Argos-3 system offers, thanks to the downlink channel, new services allowing the users to download information towards their platforms. In addition, the downlink channel can be used to improve the data collection service by acknowledging each burst emission and avoid burst repetition emissions.

- Today, CNES is designing the Argos-4 system. This system will be compatible with the Argos-3 system to ensure the processing of the uplinks and the downlink channel. Furthermore the system capacity will be significantly increased for the uplinks but also for the downlink channel.
This paper presents the ITU frequency declaration that is required for the completeness of the Argos-4 mission.

2. THE ARGOS-B NOTIFICATION

As explained in section 1, the Argos system has been continuously improved in order to reach the scientific user needs and to cover more and more environmental applications. As a result the ITU frequency declaration has been updated as necessary to take into account since 1978 the frequency band requirements to perform the Argos mission. The frequency band of the Argos system until Argos-3 is notified in the ITU by the name Argos-B. According to this notification it is recalled that the platforms are installed only after obtaining agreement from the authorities of host countries for performing earth exploration by satellite services as defined by the ITU. The main emission characteristics (earth to space) are summed up in the Table-1 below:

Frequency Range (MHz)	Necessary bandwidth (kHz)	Total peak power (dBW)	EIRP (dBW)
401,579 – 401,691	112	7	7

Table-1: Main uplink characteristics of Argos-B.

Taking into account the Doppler effect caused by the relative speed between the platform and the satellite, the frequency received by the instrument may deviate up to a maximum of +/-10kHz in relation to the carrier frequency. This effect has been considered in the frequency range defined in the previous table.

As regards the downlink channel, the main characteristics are given in the Table-2 below:

Frequency Range (MHz)	Design of emission bandwidth (kHz)	Total peak power (dBW)	EIRP (dBW)
465,987 – 465,988	1	7	7

Table-2: Main downlink characteristics of Argos-B.

From the Table-2 elements and the transmitting antenna gain pattern (maximum and average gain in circular polarisation) it is possible to evaluate the power flux density at ground level. It can be shown from the satellite EIRP that the power flux density (PFD) at ground level does not overpass the limit of -125 dBW/m² in 4 kHz. The figure-1 depicts the PFD in 4 kHz band against the elevation angle. As can be seen the maximum power flux density is equal to -127,5 dBW/m².

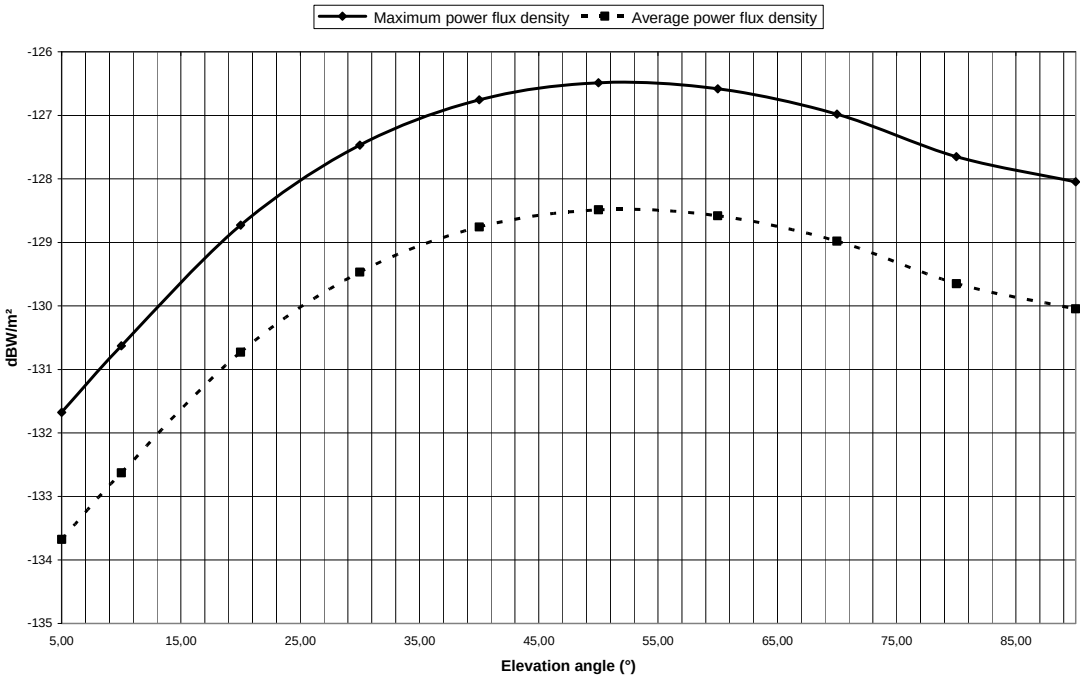

Figure-1: PFD (maximum and average) at ground level for the 465,9875 MHz channel.

3. THE ARGOS-4 MISSION

The Argos-4 system has to be compliant with the Argos-3 system and therefore has to process the overall Argos-3 platforms. Today the Argos-3 platforms are 2-ways and are able to transmit bursts to the satellite at 400 bps or at 4800 bps and to receive information or acknowledgements through the downlink channel at 400 bps.
The Argos-4 system has to continue to enhance the unique capabilities of the Argos system as regards the size, the mass and the power consumption at platform level which are very low but also by keeping the easy way to operate the system. It is considered that a specific band will be allocated to the low power applications only as animal tracking for instance where transmitter output power is less than 500 mWatt. The power range between 50 mWatt and 100 mWatt is often reached by these types of application.
In addition more and more user requests are non environmental (as homeland security, humanitarian or low enforcement) and could not be taken into account by the Argos-3 system. To cope with these user needs another band dedicated to non environmental applications will be added in the new system.
The Argos-4 system capacity will be significantly increased compared to Argos-3 (in average 20 bursts will be simultaneously present for Argos-4 instead of 5 for Argos-3) leading to an important increase of both the uplink bandwidth and the downlink channel bit rate (1200 bps instead of 400 bps). The secure transmitting service available with Argos-3 will be kept and due to the capacity improvement more and more platforms can be used in this service. As a result the data bit rate of the downlink channel has been increased up to 1200 bps.
As proposed by the Argos-3 system, the downlink messaging service will be used by an Argos-4 user to send messages to its platform in order to modify for instance the system parameters as the frequency emission or the repetition period. Furthermore,

the all-cast messaging service will be also available. This service consists in broadcasting system information as UTC time, the constellation status or some satellite ephemeris.

4. ARGOS-4 DECLARATION

The request for the advance publication of the Argos-4 system was sent to the ITU in July 2007 by the French Frequency Agency "Agence Nationale des Fréquences".
This preliminary Argos-4 declaration includes earth to space and space to earth beams. They are defined in section 4.1 for the uplink beams and in section 4.2 for the downlink beam.

4.1 The Argos-4 Uplink beams:

As presented in section 3, the capacity of the Argos-4 system has been increased compare to Argos-3. As a result four beams have been proposed in the 401-403 MHz band for LEO satellites, they are presented below from the Table-3 to Table-6.

Frequency Range (MHz)	Necessary bandwidth (kHz)	Total peak power (dBW)	EIRP (dBW)
401,275 – 401,580	305	7	7

Table-3: Main uplink characteristics of Argos-4 beam number 1.

Frequency Range (MHz)	Necessary bandwidth (kHz)	Total peak power (dBW)	EIRP (dBW)
401,690 – 402,400	710	7	7

Table-4: Main uplink characteristics of Argos-4 beam number 2.

Frequency Range (MHz)	Necessary bandwidth (kHz)	Total peak power (dBW)	EIRP (dBW)
402,521 – 402,650	129	7	7

Table-5: Main uplink characteristics of Argos-4 beam number 3.

Frequency Range (MHz)	Necessary bandwidth (kHz)	Total peak power (dBW)	EIRP (dBW)
402,850 – 403	150	7	7

Table-6: Main uplink characteristics of Argos-4 beam number 4.

One additional beam (see Table-7) has been also added outside the 401-403 MHz band for non environmental applications. The use of this 150 kHz band is for mobile - satellite services and is limited to non-geostationary satellite systems.

Frequency Range (MHz)	Necessary bandwidth (kHz)	Total peak power (dBW)	EIRP (dBW)
399,900 – 400,050	150	7	7

Table-7: Main uplink characteristics of Argos-4 beam number 5.

The Argos-4 instrument is currently under design in order to be able to process several frequency band within the overall uplink beams recalled through Table-3 to Table-6. Their central frequency will be modified as necessary to minimise the inter system interferences.
Some GEO satellite systems are already present inside the frequency band described in Table-4 but the power flux density received by a GEO satellite coming an Argos platform is very low. The figure 2 displays the power flux coming from a typical Argos platform (with a whip antenna, half wavelength monopole) versus its latitude position for a GEO satellite located at 0°. It can be seen that the power flux does not exceed -153 dBW/m². In addition the power flux is also given for an hemispherical radiation pattern with a gain of 0 dBiL (in linear polarisation).

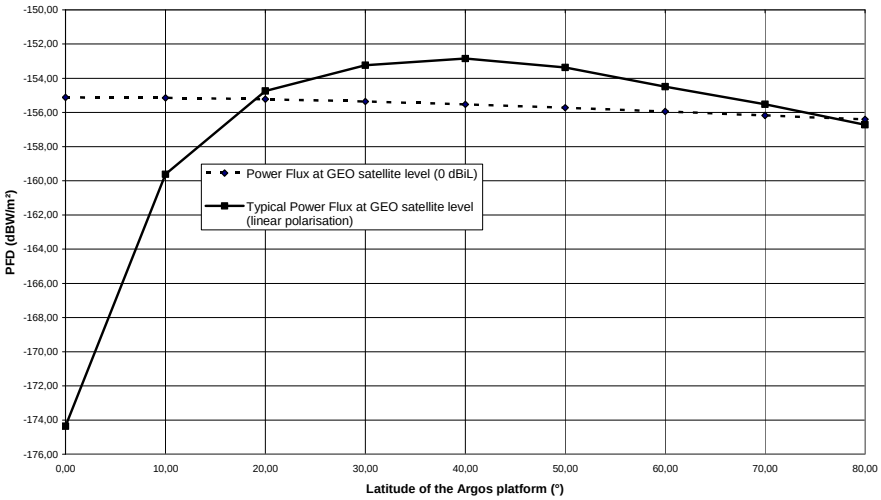

Figure-2: power flux from an Argos platform received (401,650 MHz) by a GEO satellite located at 0°.

4.2 The Argos-4 Downlink beam:

The power flux density in 4 kHz bandwidth at ground level for the Argos-3 system is given in section 2, Figure-1. This power flux density takes into account both the downlink waveform spectrum and the antenna gain pattern.
The Argos-4 downlink waveform has been designed in order to be compliant with the current channel used in the Argos-3 system but also in terms of power flux density. As presented in section 3, the data rate requirement for the Argos-4 downlink is 1200 bps. The Argos-4 waveform takes into account two channels one at 400 bps (channel 1, compliant with the Argos-3 system) and the second one (channel 2) at 800 bps

using the same frequency carrier as the channel 1 and a sub-carrier at 4800 Hz. The Argos-3 and the Argos-4 power spectrum densities are given in Figure-3.

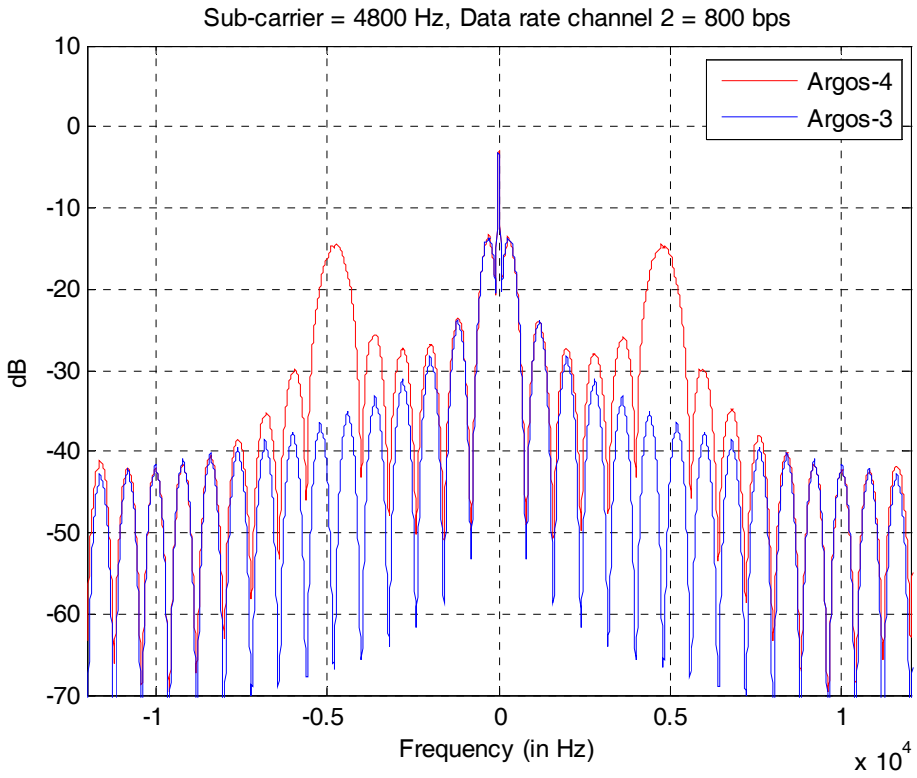

Figure-3: power spectrum densities of the Argos-3 and the Argos-4 downlink waveforms.

Although the power of the Argos-4 downlink signal at power amplifier output has been increased by a factor of two compared with the Argos-3 downlink signal, the Argos-4 downlink waveform design ensures that the maximum of the integrated power in 4 kHz bandwidth is similar to Argos-3. Therefore the power flux density in 4 kHz bandwidth at ground level for the Argos-4 system will be the same as the Argos-3 system.

The power spectrum density of the Argos-3 and the Argos-4 downlink signals integrated over a sliding frequency band of 4 kHz wide are given in Figure-4. These curves are normalised by the total power P of the Argos-3 downlink signal expressed by the formula:

$P = \int_{f=-\infty}^{+\infty} S_{A3}(f) \cdot df$, where $S_{A3}(f)$ is the power spectrum density of the Argos-3 modulated signal. The x-axis represents the value of the central frequency of the sliding frequency window of 4 kHz wide. As can be seen the maximum of the power integrated over a 4 kHz bandwidth is obtained when the central frequency of the sliding window is situated on the frequency carrier. The maximum value of the integrated power coming from the Argos-4 downlink spectrum is similar to the Argos-3 downlink spectrum (0,1 dB higher in theory in favour of Argos-4).

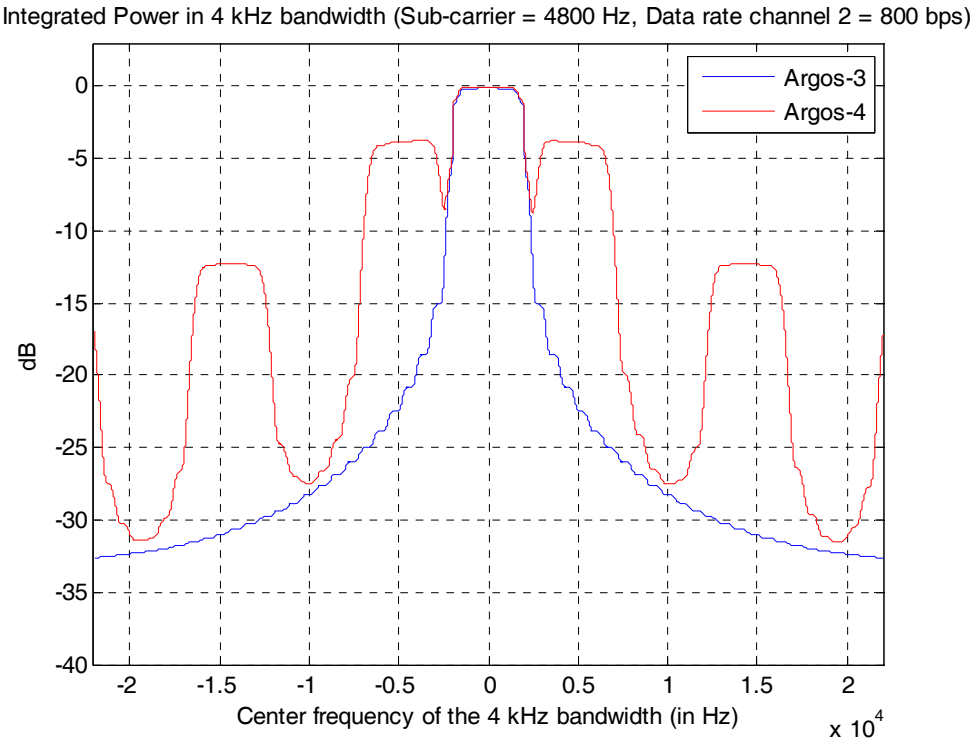

Figure-4: integrated power of the Argos-3 and the Argos-4 spectrum densities of the downlink over a 4 kHz bandwidth.

As can be seen from Figure-3, the Argos-4 downlink spectrum is wider than Argos-3. This is due to the power flux density optimisation but also to avoid any jamming between the two channels. As a result the Argos-4 declaration of the downlink channel is an updated version of the Argos-3 characteristics regarding the frequency bandwidth, the total peak power and the EIRP as presented in Table-8 below:

Frequency Range (MHz)	Design of emission bandwidth (kHz)	Total peak power (dBW)	EIRP (dBW)
465,9775 – 465,9975	20	10	10

Table-8: Main downlink characteristics of Argos-4.

5. CONCLUSION

The Argos-4 declaration is fully described in section 4. It has been recalled that the Argos-4 instrument is under development in order to be able to process several frequency bands in the 401-403 MHz band. Thanks to this flexibility it will be possible in the Argos-4 system to configure at instrument level these bands to minimise inter system interferences. The frequency emission at platform level will be managed by the downlink channel to take into account the Argos-4 channels. It has been also demonstrated that the downlink signal waveform has been optimised to avoid exceeding the maximum power flux density at ground level as we have today with the Argos-3 downlink in spite of increasing the output power of the transmitter by a factor of 2.

6. ACTION REQUIRED

The SFCG members are then invited to consider the frequency declaration of the new Argos system called Argos-4 (note that the request for advance publication for the Argos-4 system was sent to the ITU in July 2007) and propose some recommendations for the future co-ordinations.

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