CGMS XXXIII NOAA-WP-22
Prepared by NOAA
Agenda Item: IV/1.1

Report on the Analysis of the Study Result Concerning Interference Between Polar –orbiting Meteorological Satellites - Interference Analysis between NPOESS and METOP at X-Band

NOAA’s assessment of interference between NPOESS and METOP at X-band indicates interference occurs less than ~16 min per year. NOAA believes METOP's selection of center frequency and modulation precludes minimizing interference with other systems and does not efficiently use the 7750 - 7850 MHz band per Resolves 1 of SFCG Resolution 19-7R2. Consequently, NOAA believes METOP should tolerate some limited interference from NPOESS. Eumetsat has agreed per telefax from Cohen to Cunnigham/Mignogno dated 22 December 2004

NOAA expects to update its interference analysis as the as-built characteristics of the NPOESS satellite become available. NOAA also welcomes the opportunity to update its

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Report on the Analysis of the Study Result Concerning Interference Between Polar –orbiting Meteorological Satellites - Interference Analysis between NPOESS and METOP at X-Band

1. Introduction

At the CGMS XXXII Meeting in Sochi, Russian Federation, 17-20 May 2004, NOAA received the following two actions relating to interference from the NPOESS HRD downlink to the METOP GDS downlink:

> Action 32.06: NOAA and CMA to develop operational procedures to avoid interference of their direct broadcasts into the main data dump transmissions of Metop in the frequency band 7750-7850 MHz.
> Deadline: CGMS XXXIII
>
> Action 32.07: NOAA to report back on the analysis of study results [by EUMETSAT] concerning potential interference between polar orbiting meteorological satellites.
> Deadline: 31 December 2004.

EUMETSAT's analysis of interference between the NPOESS HRD downlink and the METOP GDS downlink at X-band indicated the NPOESS and METOP orbits would overlap every 113 days, and interference from NPOESS would result in data loss to METOP for up to 0.23% of the time, which METOP claimed was unacceptable. Unfortunately, this analysis did not represent the current NPOESS design.

NOAA repeated this analysis for the current NPOESS design using the METOP space and ground parameters provided by EUMETSAT, and this analysis showed significantly less interference. NOAA requested that EUMETSAT provide any updates to the METOP space and ground parameters, and since NOAA hasn't received any additional information, NOAA assumes the previously provided parameters are accurate and correct. The purpose of this document is to present the results of the interference analysis performed by NOAA.

2. Orbital Parameters

Both NPOESS and METOP are in sun synchronous orbits. METOP has one satellite in the 21:30 LTAN, and NPOESS has three satellites in the 21:30, 17:30, and 13:30 LTANs. The characteristics of the NPOESS and METOP orbits are shown in Table 2-1.

Table 2-1. NPOESS and METOP Orbital Parameters

	NPOESS	METOP
Orbit	**Sun Synchronous**	**Sun Synchronous**
Number of Satellites	**3**	**1**
Repeating Ground Track	**Yes**	**Yes**
Repeat Cycle (Days)	**17**	**29**
Repeat Cycle (Orbits)	**241**	**412**
LTAN	**2130, 1730, 1330**	**2130**
In-Plane Phasing (deg)	**280, 0, 80**	**NA**
Altitude (km)	**827.768**	**817.455**
Period (hrs) **Period (min)**	**1.6929** **(101.577)**	**1.6893** **(101.359)**

Interference can occur between the 21:30 NPOESS satellite and the 21:30 METOP satellite since these satellites are in the same orbit plane but at difference altitudes. The 21:30 METOP and 21:30 NPOESS satellites can be spatially aligned every ~33 days.

3. NPOESS and METOP RF Characteristics

The NPOESS and METOP RF characteristics are summarized in Table 3-1. The METOP GDS downlink is operated into Svalbard, Norway; and the NPOESS HRD downlink is operated worldwide. Based on previous discussions with EUMETSAT, NPOESS has selected a downlink frequency and bandwidth-efficient pulse shaping so its downlink spectrum is located at the upper edge of the 7750 MHz to 7850 MHz band. In comparison, METOP is located in the center of the 7750 MHz to 7850 MHz band and employs conventional unshaped square pulses. The NPOESS program is procuring HRD hardware consistent with the characteristics shown in Table 3-1 and no longer has the opportunity to change the HRD design.

Table 3-1. NPOESS and METOP RF Parameters

	NPOESS	METOP
Carrier Frequency (MHz)	**7834**	**7800**
Modulation	**SQPSK**	**QPSK**
Information Rate (Mbps)	**NA**	**70.0**
Signaling Rate (Msps)	**20.0**	**35.0**
Pulse Shaping	**SRRC, α = 0.5**	**Square Pulses**
Detection Filter	**NA**	**Integrate & Dump**
Minimum Elevation Angle (deg)	**5.0**	**5.0**
GS Location	**Worldwide**	**Svalbard**
GS Antenna Pattern	**NA**	**RR Appendix 8**
GS Antenna Peak Gain (dBi)	**NA**	**55.0**
GS System Noise Temperature	**NA**	**180.0**
Threshold E_b/N_o (dB) Theory (dB) Tx Implementation Loss (dB) Rx Implementation Loss (dB) ESA Margin (dB)	**NA**	**11.5** 7.0 1.0 2.5 1.0

4. Interference Assessment Methodology

Conventional interference analyses are usually based on assessing C/(N+I) or I/N without regard to the transmit spectrum or receiver detection filter characteristics. This is shown in Figure 4-1, where it is assumed the transmit spectrum and receiver detection filter responses are flat. Since the NPOESS transmit spectrum and the METOP receiver detection filter are not flat, this conventional method provides an unrealistically pessimistic assessment.

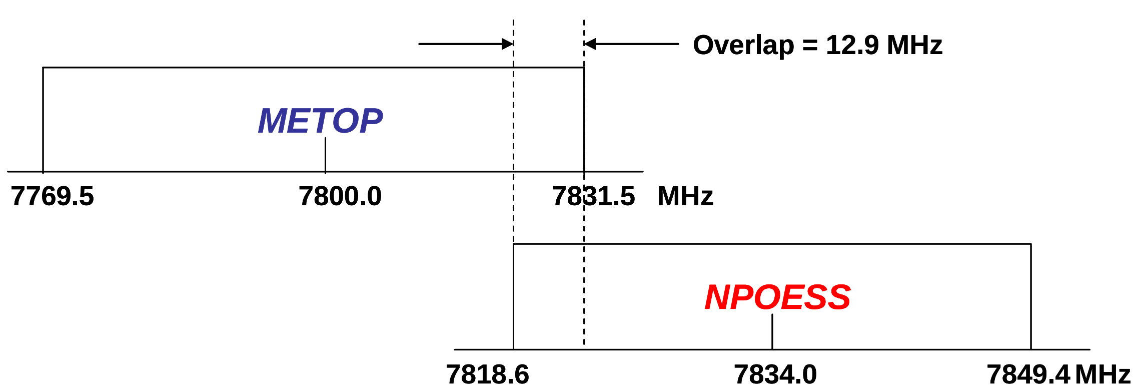

Figure 4-1. Conventional Interference Analysis

5. NPOESS Transmit Spectrum

The NPOESS HRD transmit spectrum and the METOP GDS detection filter frequency response are shown in Figure 5-1. The NPOESS HRD transmit spectrum was obtained by simulation.

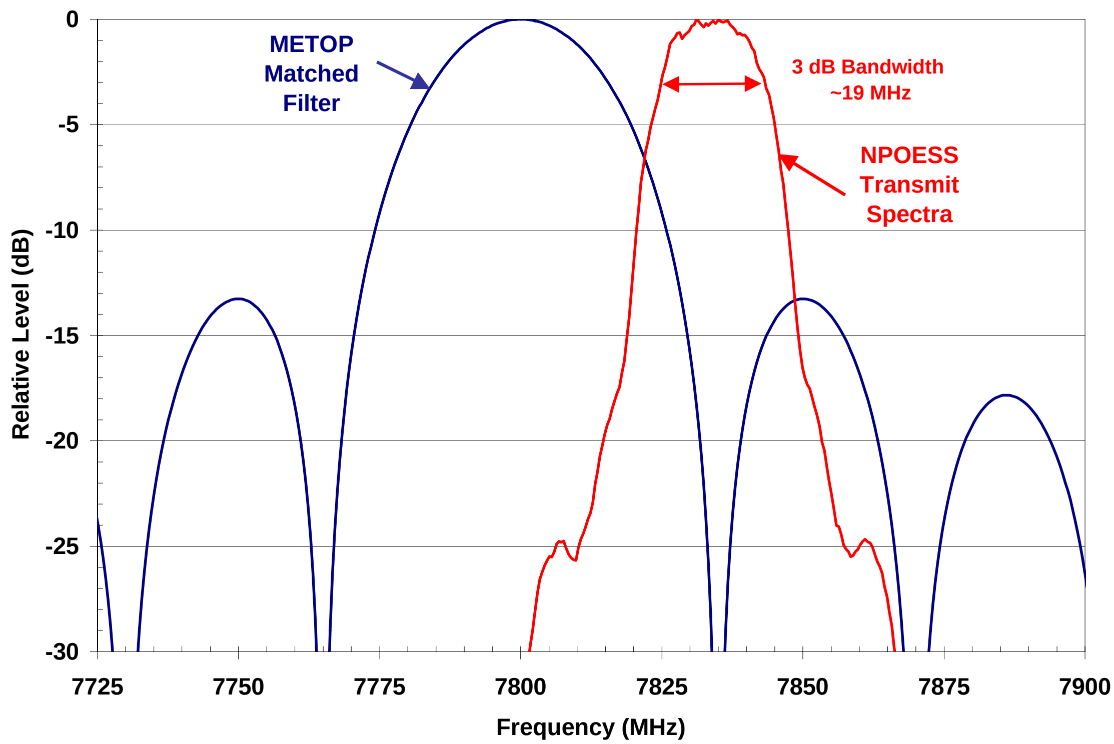

Figure 5-1. NPOESS Transmit Spectra and METOP Detection Filter Responses

6. NPOESS EIRP vs. Nadir Angle

The NPOESS EIRP vs. nadir angle specification is shown in Figure 6-1.

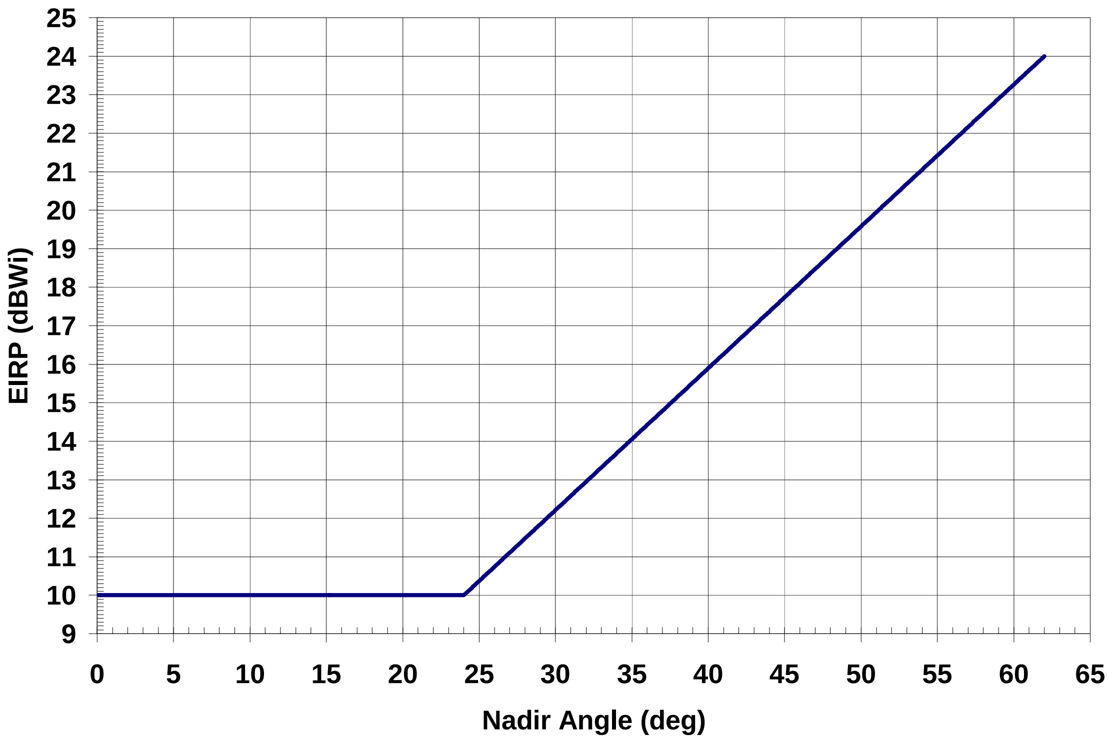

Figure 6-1. NPOESS HRD EIRP vs. Nadir Angle

7. METOP EIRP vs. Nadir Angle

The METOP “spec” and “expected” EIRP were obtained from the *METOP Space to Ground Interface Specification* (MO-IF-MMT-SY0001, Issue 07 Rev. B, dated 29/10/2003) as shown in Figure 7-1.

8. Modeled METOP Co-pol Antenna Patterns

The METOP co-pol antenna pattern was modeled using Appendix 8 of the ITU-R Radio Regulations, assuming a peak antenna gain of 55 dBi.

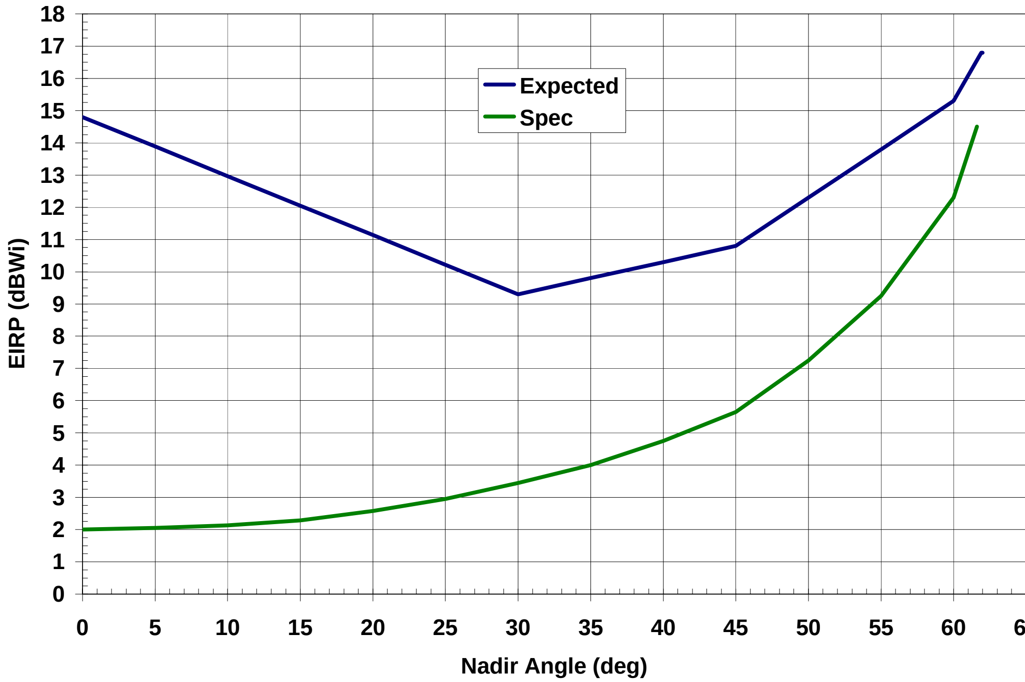

Figure 7-1. METOP GDS Spec and Expected EIRP

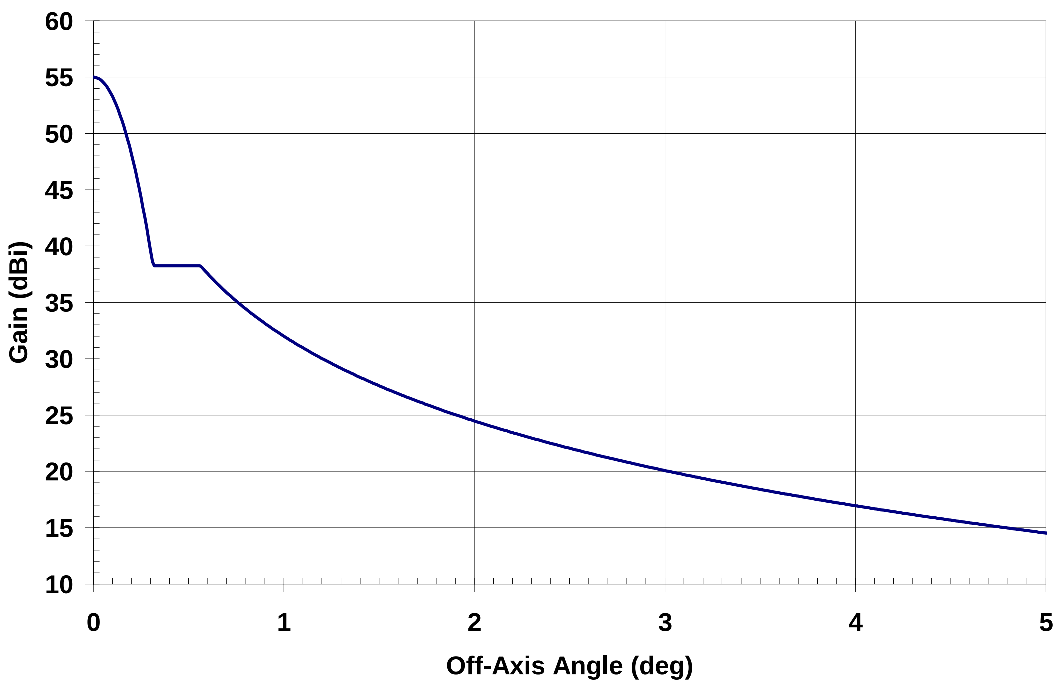

Figure 8-1. Modeled METOP GDS Receive Antenna Co-pol Antenna Pattern

9. Interference Assessment

Based on this model, NOAA assessed the interference from three NPOESS satellites to one METOP satellite for both the METOP spec and expected EIRP. This simulation was run for a period of one year in one second increments. The outage time, measured as a percentage of the on time, is the percentage of time the E_b/N_o or $E_b/(N_o+I_o)$ is less than or equal to the abscissa. The on time is the time the elevation angle from Svalbard to the METOP satellite is greater than or equal to 5 deg.

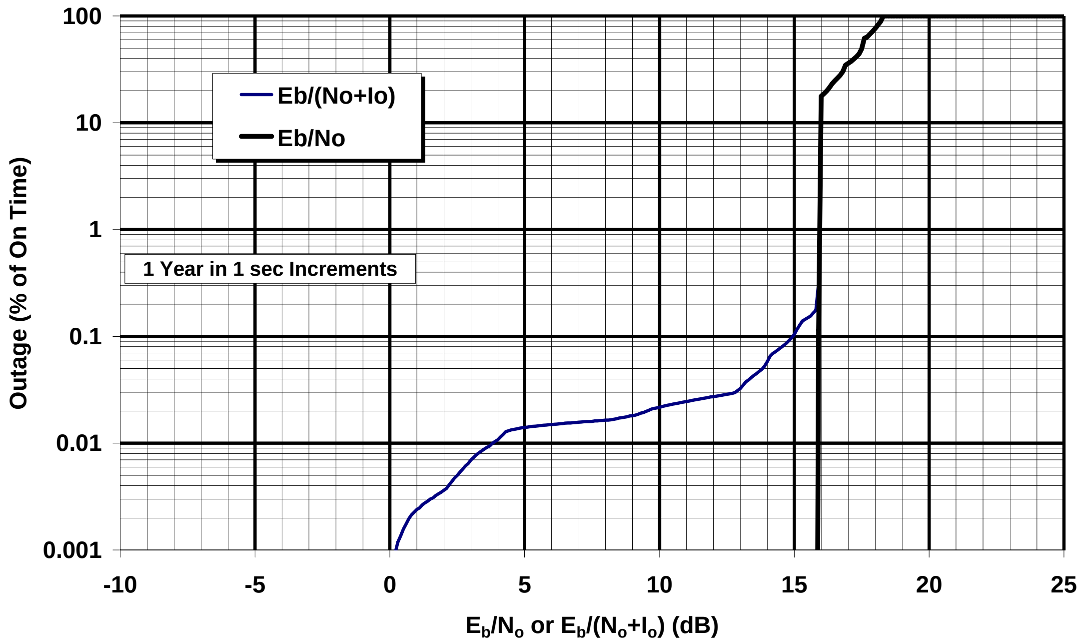

Figure 9-1. Outage Time for METOP Spec EIRP

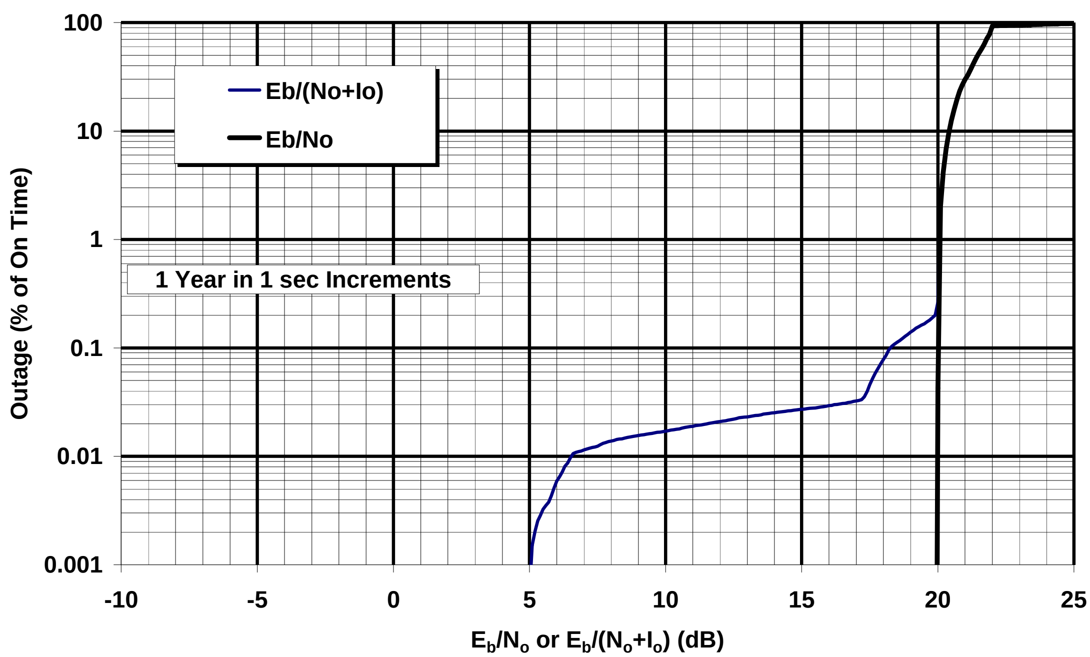

Figure 9-2. Outage Time for METOP Expected EIRP

For the METOP spec EIRP and an $E_b/(N_o+I_o)$ threshold of 11.5 dB, the outage time is 0.0277% of the visible time at Svalbard. Since the METOP spacecraft is visible to Svalbard (i.e., above an elevation angle of 5 deg) for 10.7% of the time, the net outage time is 0.000277 x 0.107 x 525,600 = 15.6 min/year.

For the METOP expected EIRP and an $E_b/(N_o+I_o)$ threshold of 11.5 dB, the outage time is 0.0199% of the visible time at Svalbard. Since the METOP spacecraft is visible to Svalbard (i.e., above an elevation angle of 5 deg) for 10.7% of the time, the net outage time is 0.000199 x 0.107 x 525,600 = 11.2 min/year.

10.Discussion

NOAA is committed to adhering to SFCG Resolution 19-7R2, which says:

RESOLVES

1. *that space agencies planning and operating Metsats develop procedures for efficient use of the 7750-7850 MHz band that allow interference-free reception of vital meteorological and environmental data;*

2. *that direct readout transmissions be turned-off during passes of CDA stations when in conflict with downlinks of stored mission data (data dump transmissions);*

NOAA designed the NPOESS HRD downlink to facilitate efficient use of the 7750 – 7850 MHz band. In particular, the HRD downlink: 1) utilizes square-root raised cosine (SRRC) pulse shaping to minimize bandwidth occupancy, and 2) is located at the upper bandedge to allowing sharing with other Metsats.

EUMETSAT made technical selections that do not facilitate efficient use of the 7750 - 7850 MHz band making it difficult to share the band with other Metsats. In particular, the METOP GDS downlink: 1) utilizes unfiltered QPSK, and 2) is located in the center of the band.

NOAA believes METOP's selection of center frequency and modulation does not efficiently use the 7750 - 7850 MHz band per Resolves 1 of SFCG Resolution 19-7R2. Consequently, NOAA believes METOP should tolerate some limited interference from NPOESS.

NOAA expects to update its interference analysis as the as-built characteristics of the NPOESS satellite become available. NOAA also welcomes the opportunity to update its interference analysis based on updated characteristics of the METOP satellite and the Svalbard ground station.
