Purpose:
This memorandum is an attachment to the Orbital Sciences Corporation FCC experimental radio license application for the NG-12 Cygnus spacecraft.

Scope:
This memorandum provides a data summary in support of the FCC Office of Engineering and Technology (OET) e-File system application. The data is submitted in support of the following application:

Description	Number
FCC File Number:	1465-EX-ST-2019

The attached data supplements the FCC e-File STA application file, 1465-EX-ST-2019, and provides information on the emissions in the DSN band of 2290-2300 MHz for the RF communication links during the mission which do not meet the criteria defined by ITU-R SA1157-1 and SFCG 14-R1 but satisfy the agreements made between Orbital Sciences Corporation and the NASA JSC spectrum manager to allow transmissions when in view of DSN sites (New Norcia, Goldstone, Madrid, and Canberra).

Background:
The Cygnus-to-ISS links with emission designators of 4M98G1D and 5M93G1D operating at 2203.2 MHz are fully compliant to the DSN protection criteria defined by ITU-R SA1157-1 and SFCG 14-R1 and are not addressed in this attachment.

The Cygnus transmissions which do not meet the ITU and SFCG requirements and which are planned for use over DSN sites are those with emission designator 6M16G1D which are addressed in the following paragraphs.

Requirements:
Orbital Sciences Corporation has worked with NASA JSC spectrum management to develop an alternate requirement which allows the removal of operational restrictions and allow transmissions when in view of DSN sites (New Norcia, Goldstone, Madrid, and Canberra).

The modified requirement is as follows and is being documented in PIRN (Preliminary Interface Requirements Notification) 50885-NA-0068B:

> **“E.3.3.7.1.2.7 RADIO INTERFERENCE**
>
> B. The Cygnus vehicle radio links shall produce an Out-of-Band power flux density not to exceed levels specified in SSP 50808, 3.3.7.1.2.7, except the Cygnus Vehicle’s TDRS 6MHz spread spectrum return link on 2287.5 MHz shall produce a power spectral density

(PSD) of less than -222 dBW/Hz from 2293 – 2300 MHz, referenced at the input of the DSN ground station receiver and using a DSN antenna gain of +32 dBi.

Note: The ISS Program approved Cygnus out-of-band emissions requirements do not comply with the US regulations. The Cygnus vehicle will accept and comply with constraints imposed in the FCC Conventional Experimental license not relieved through the coordination process.

Acceptance Rationale:

Recognizing that the existing Space Network return link service at 2287.5 MHz, spread 3 Mcps, from LEO spacecraft to the TDRS is unable to satisfy the 2290 – 2300 MHz deep space protection criteria, a modified protection level for TDRS 2287.5 MHz spread return link was agreed by NASA DSN as stated in the exception above.

Measured transmit output spectrum from the Cygnus spread spectrum TDRS return link at 2287.5 MHz must show compliance to the modified protection level agreed by NASA DSN; therefore, no operational restriction will be required on the TDRS operation. ISS Program agreements are in place to accept the COTS Vehicle implementation, pending formal RF system verification testing.

This exception does not guarantee FCC license approval, does not exempt the Cygnus from any FCC regulatory requirements, and the Cygnus will obtain an FCC license on a mission-by-mission basis, provide system impacts to any constraints imposed by those licenses, and will comply with any licensing restrictions."

Additionally, Orbital Sciences Corporation has implemented the filtering recommended in the Space Network Users' Guide (450-SNUG) in Appendix D, Figure D-6. That recommended filtering profile is reproduced in Figure 1 for reference.

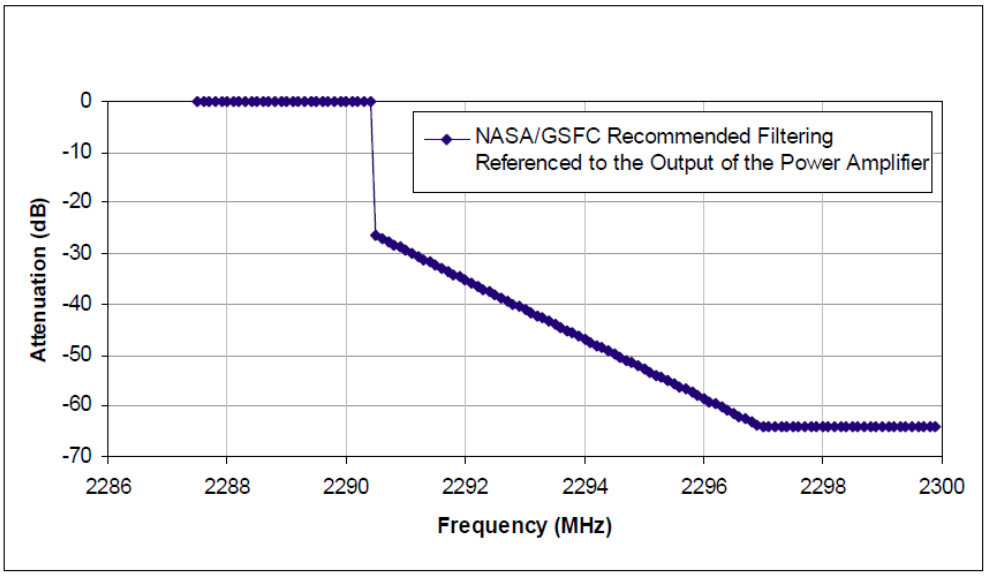

Figure 1 Spectral Output for NASA/GSFC Recommended Filtering Referenced to the Output of the Power Amplifier (Reproduced from 450-SNUG Figure D-6)

Performance:

The following plots show the measured performance of the NG-12 primary and redundant TDRS transmitters relative to the requirement in PIRN 50885-NA-0068B and the filtering recommended by Figure D-6.

All plots assume Cygnus is directly overhead of a DSN site (altitude=slant range) and the peak Cygnus antenna gain is used to present a true worst-case PSD at the DSN receiver input. The DSN antenna gain used is +32 dBi as per PIRN 50885-NA-0068B.

Figure 2 shows the performance of the NG-12 scheduled primary transmitter when operating at an ERP of 3.67 W. The altitude used to determine the PSD at the DSN receiver input is 200km, based on transmitter turn-on following spacecraft separation from the payload faring.

Figure 3 shows the performance of the NG-12 scheduled redundant transmitter when operating at an ERP of 3.67 W. The altitude used to determine the PSD at the DSN receiver input is 200km, to allow possible use of the redundant transmitter following spacecraft separation from the payload faring.

Figure 4 shows the performance of the NG-12 scheduled primary transmitter when operating at an ERP of 5.82 W. The altitude used to determine the PSD at the DSN receiver input is 400km, based on usage of this higher ERP mode only being planned for the mission phase following departure from the ISS.

Figure 5 shows the performance of the NG-12 scheduled redundant transmitter when operating at an ERP of 5.82 W. The altitude used to determine the PSD at the DSN receiver input is 400km, based on usage of this higher ERP mode only being planned for the mission phase following departure from the ISS.

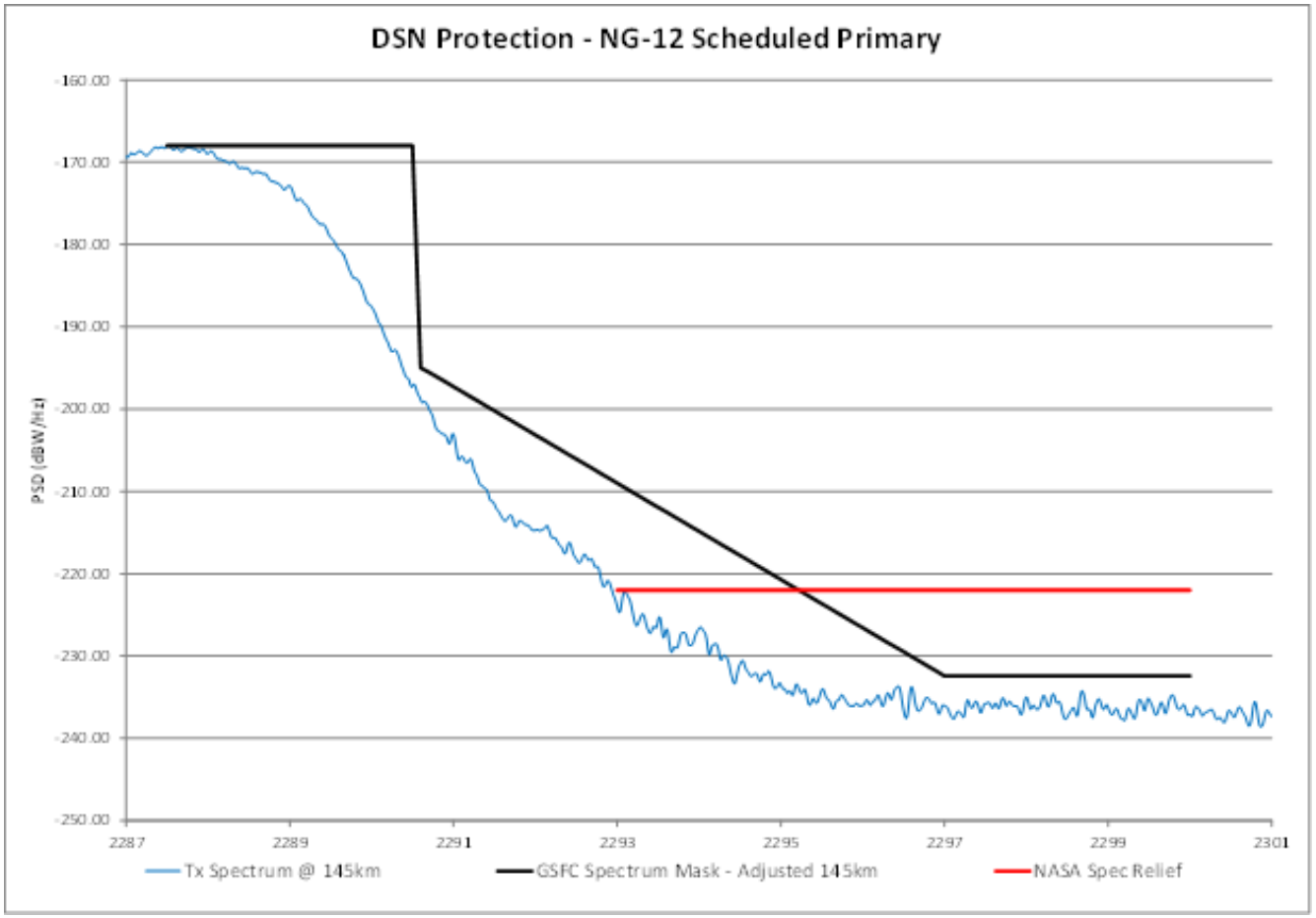

Figure 2 DSN Performance of Emission Designator 6M16G1D with ERP of 3.67 W – Primary Transmitter

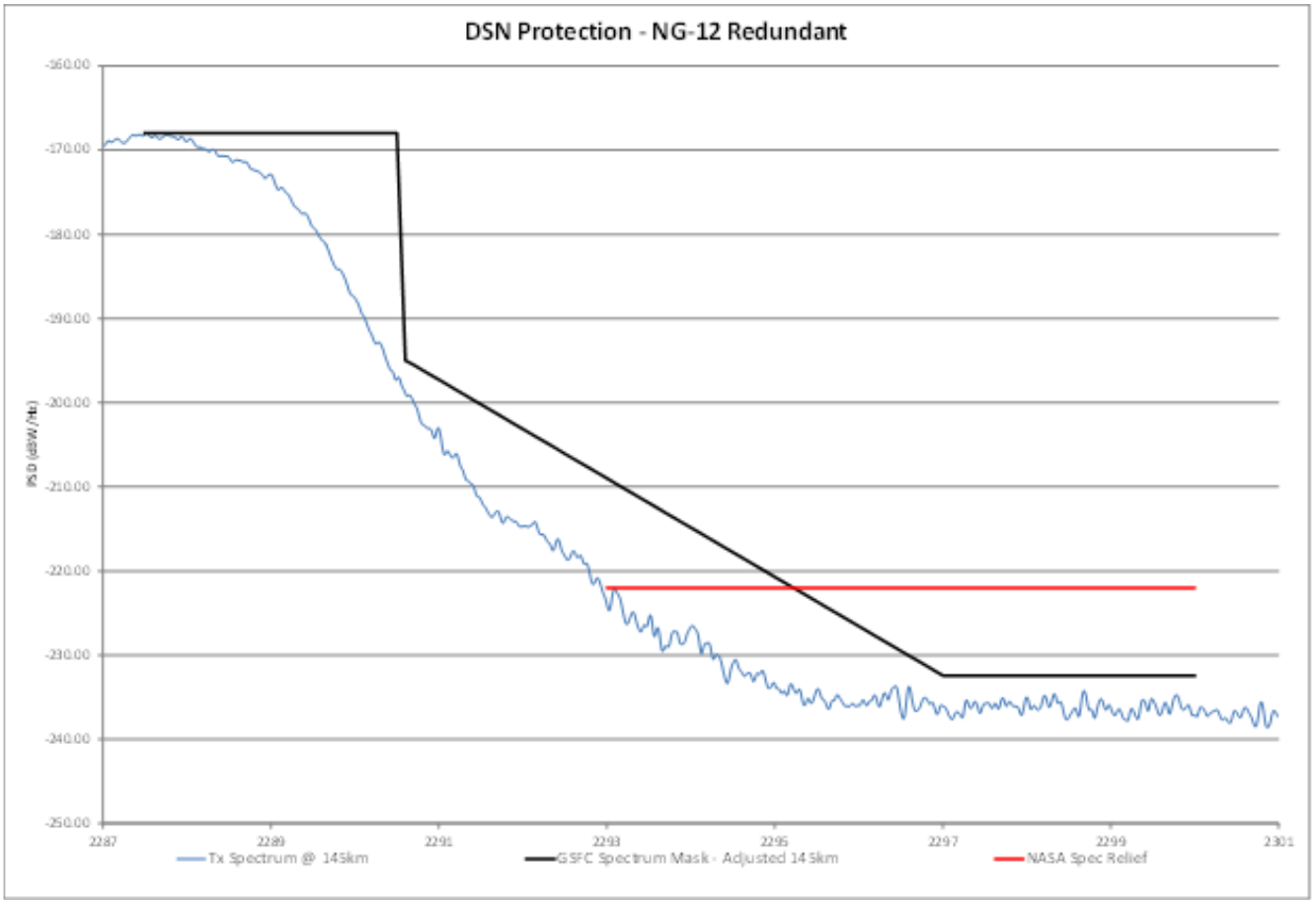

Figure 3 DSN Performance of Emission Designator 6M16G1D with ERP of 4.00 W – Redundant Transmitter

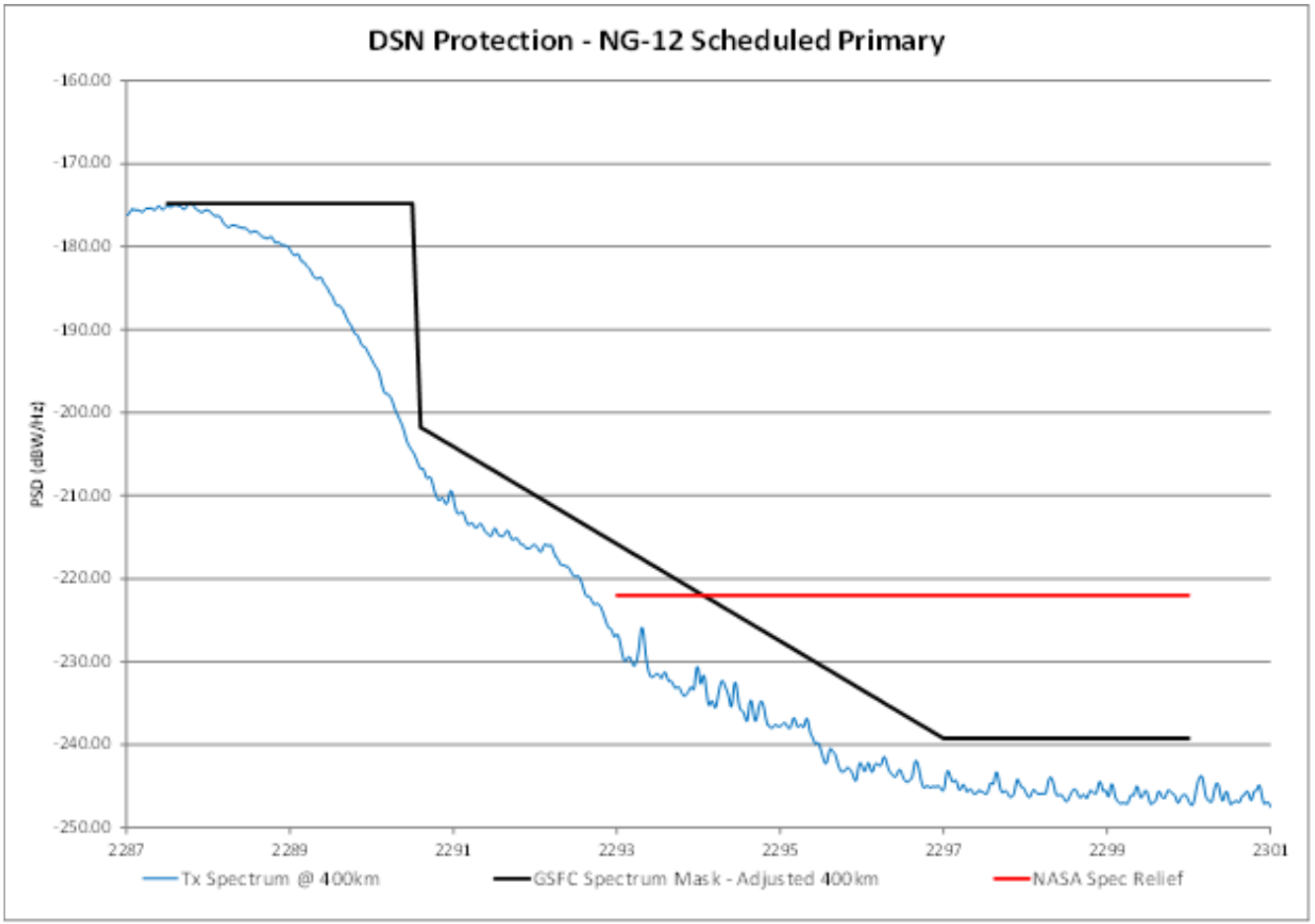

Figure 4 DSN Performance of Emission Designator 6M16G1D with ERP of 5.82 W – Primary Transmitter

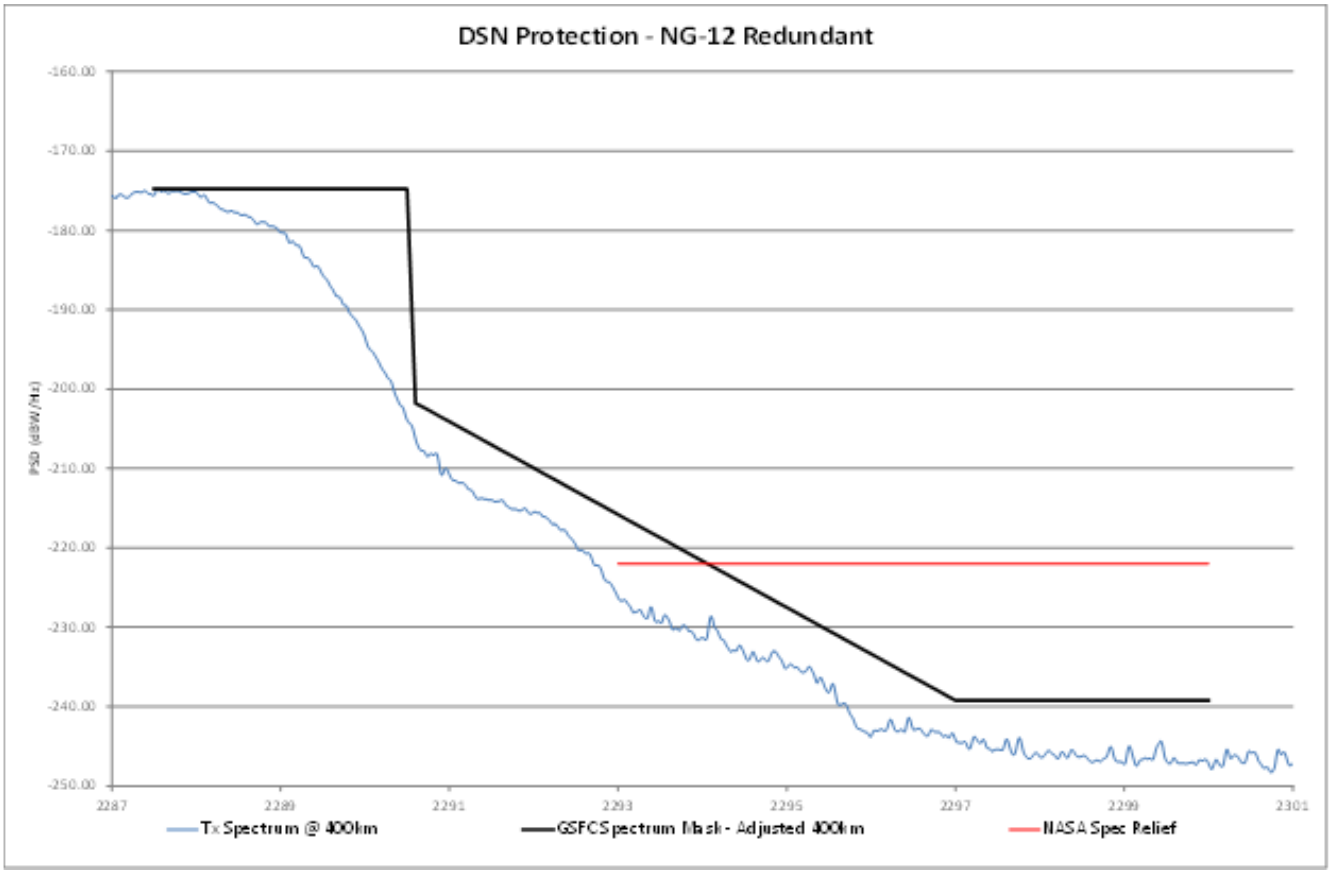

Figure 5 DSN Performance of Emission Designator 6M16G1D with ERP of 5.82 W – Redundant Transmitter

Conclusion:
The Cygnus transmissions under emissions designator 6M16G1D do not meet the strict ITU and SFCG requirements for DSN compliance in the frequency band from 2290-2300 MHz. Orbital Sciences Corporation has worked with the NASA JSC spectrum manager to define a new performance requirement that allows for transmissions over DSN sites if met. The data included in this attachment is taken from final system testing and captures the measured performance of the NG-12 spacecraft and is being submitted to the FCC as verification of compliance.