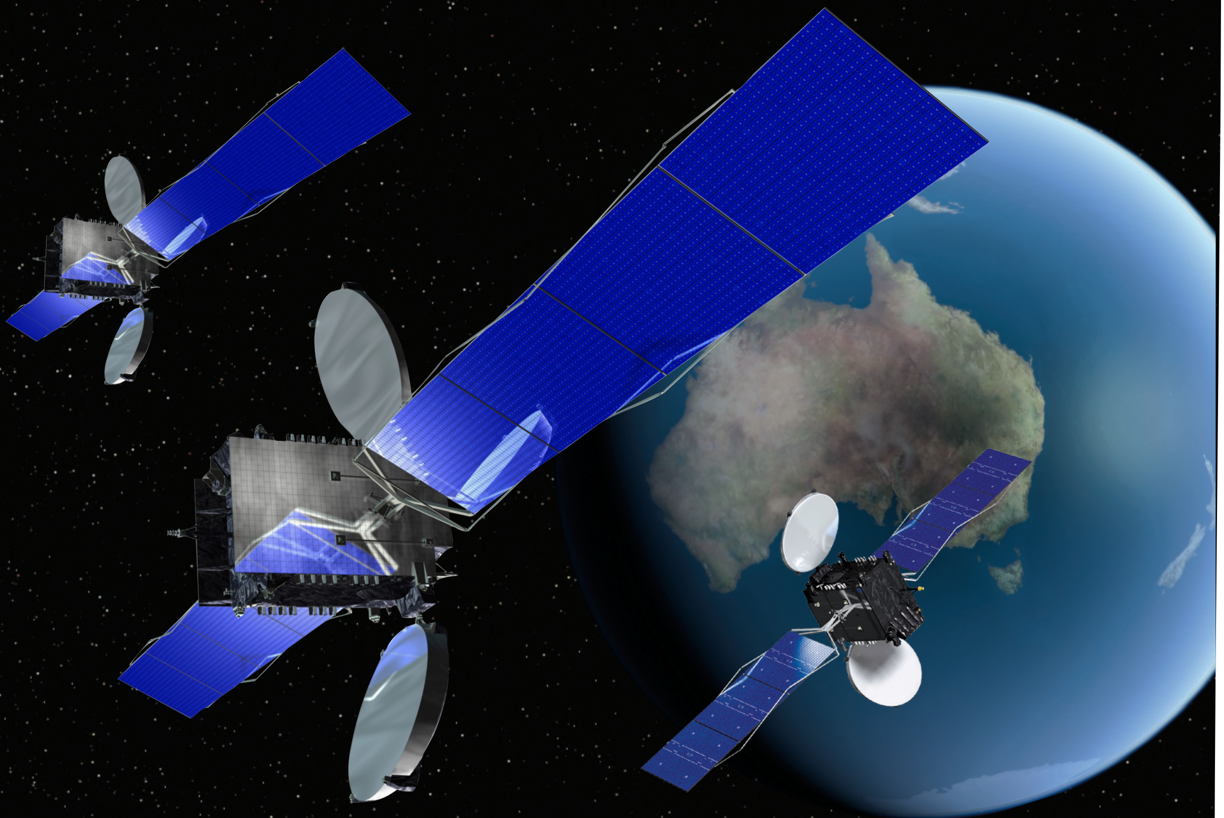


D SERIES SATELLITE

PAYLOAD INFORMATION

OPTUS yes

D SERIES SATELLITE PAYLOAD INFORMATION

CONTENTS PAGE NO.

1.0	**Introduction**	**1**
1.1	Satellite System Management	2
2.0	**The Optus D Series Satellites**	**2**
2.1	Satellite Summary	2
2.2	Satellite Orbital Positions	3
2.3	Station Keeping Performance	3
3.0	**D1 and D2 Satellites**	**4**
3.1	D1 and D2 Commercial Communications Payload Overview	5
4.0	**D1 and D2 Ku-Band Communications Payload**	**6**
4.1	D1 and D2 Frequency Plan	6
4.2	D1 and D2 Frequency Translation Characteristics	8
4.3	D1 and D2 Satellite Beam Information	8
4.3.1	Receive Beams	8
4.3.2	Transmit Beams	8
4.3.3	D1 and D2 Transponder and Beam Connectivity	9
4.3.3.1	Simulcast Mode	10
4.4	D1 and D2 Satellite Beam Performance Levels	10
4.5	D1 and D2 Transponder Gain Control	11
4.5.1	Fixed Gain Mode (FGM)	11
4.5.2	Variable Gain Mode (VGM)	12
4.5.3	TDMA Operation	12
4.6	D1 and D2 Amplitude Transfer Characteristics.	13
4.7	D1 and D2 Satellite Cross Polarisation Discrimination	14
4.8	D1 and D2 Satellite Co Polarisation and Cross Polarisation Isolation	14
4.9	D1 and D2 Satellite Beacons	14
4.9.1	Telemetry Beacons	15
4.9.2	Uplink Power Control Beacon	15
4.10	D1 and D2 Uplink Power Control Operation	16
5.0	**D3 Satellite**	**17**
5.1	D3 Commercial Communications Payload Overview	17
6.0	**D3 Ku-Band Communications Payload**	**19**
6.1	D3 Frequency Plan	19
6.2	D3 Frequency Translation Characteristics	22
6.3	D3 Satellite Beam Information	22
6.3.1	Receive Beams	22
6.3.2	Transmit Beams	22
6.3.3	D3 Transponder and Bean Connectivity	23
6.4	D3 Satellite Beam Performance Levels	24
6.5	D3 Transponder Gain Control	24
6.5.1	Fixed Gain Mode (FGM)	24
6.5.2	Variable Gain Mode (VGM)	25

6.5.3 TDMA Operation 25
6.6 D3 Amplitude Transfer Characteristics 26
6.7 D3 Satellite Cross Polarisation Discrimination 27
6.8 D3 Satellite Co Polarisation and Cross Polarisation Isolation 27
6.9 D3 Satellite Beacons 27
6.9.1 Telemetry Beacons 28
6.9.2 Uplink Power Control Beacon 28
6.10 D3 Uplink Power Control Operation 28

TABLES

3.1 D1 Satellite Summary 4
3.2 D2 Satellite Summary 4
4.1 D1 and D2 Satellite Translation Frequency Characteristics 8
4.2 D1 and D2 Satellite Receive Beams 8
4.3 D1 and D2 Satellite Transmit Beams 8
4.4 D1 and D2 Satellite Transponder and Beam Connectivity 9
4.5 D1 and D2 Satellite FGM Transponder C/T Range 11
4.6 D1 and D2 Satellite Receive Co Polarisation Isolation 14
4.7 D1 and D2 Satellite Transmit Co Polarisation Isolation 14
4.8 D1 and D2 Satellite Telemetry Beacons 15
4.9 D1 and D2 Satellite UPC Beacons 15
5.1 D3 Satellite Summary 17
6.1 D3 Satellite Translation Frequency Characteristics 22
6.2 D3 Satellite Receive Beams 22
6.3 D3 Satellite Transmit Beams 22
6.4 D3 Transponder and Beam Connectivity 23
6.5 D3 Satellite FGM Transponder C/T Range 24
6.6 D3 Satellite Receive Co Polarisation Isolation 27
6.7 D3 Satellite Transmit Co Polarisation Isolation 27
6.8 D3 Satellite Telemetry Beacons 28
6.9 D3 Satellite UPC Beacon 28

FIGURES

2.1 Optus D Series Satellites 2
3.1 D1 and D2 Satellite Communications Payload Block Diagram 6
4.1 D1 and D2 Satellite Frequency, Polarisation & Connectivity 7
4.2 D1 and D2 Satellite Simulcast Configuration 10
4.3 Typical D1 and D2 Satellite Amplitude Transfer Characteristic 13
4.4 Typical D1 and D2 Satellite Transponder Gain Characteristic 13
5.1 D3 Satellite Communications Payload Block Diagram 19
6.1 D3 Satellite Frequency, Polarisation and Connectivity 20
6.2 Typical D3 Satellite Amplitude Transfer Characteristic 26
6.3 Typical D3 Satellite Transponder Gain Characteristic 26

D SERIES SATELLITE PAYLOAD INFORMATION

ATTACHMENT 1
D1 SATELLITE BEAM CONTOURS FOR THE KU-BAND COMMUNICATIONS PAYLOAD

Figure A1-1 D1 FNB Beam Receive Gain On Temperature (G/T) Australia
Figure A1-2 D1 FNB Beam Receive Gain On Temperature (G/T) Mcmurdo Sound
Figure A1-3 D1 FNANZ Beam Receive Gain On Temperature (G/T)
Figure A1-4 D1 FNZB Beam Receive Gain On Temperature (G/T)
Figure A1-5 D1 FNB Beam Effective Isotropic Radiated Power (Eirp) Australia
Figure A1-6 D1 FNB Beam Effective Isotropic Radiated Power (Eirp) Mcmurdo Sound
Figure A1-7 D1 FNA Beam Effective Isotropic Radiated Power (Eirp)
Figure A1-8 D1 FNANZ Beam Effective Isotropic Radiated Power (Eirp)
Figure A1-9 D1 FNZB Beam Effective Isotropic Radiated Power (Eirp)
Figure A1-10 D1 FNZA Beam Effective Isotropic Radiated Power (Eirp)

ATTACHMENT 2
D2 SATELLITE BEAM CONTOURS FOR THE KU-BAND COMMUNICATIONS PAYLOAD

Figure A2-1 D2 FNB Beam Receive Gain On Temperature (G/T) Australia
Figure A2-2 D2 FNB Beam Receive Gain On Temperature (G/T) Mcmurdo Sound
Figure A2-3 D2 FNANZ Beam Receive Gain On Temperature (G/T)
Figure A2-4 D2 FNZB Beam Receive Gain On Temperature (G/T)
Figure A2-5 D2 FNB Beam Effective Isotropic Radiated Power (Eirp) Australia
Figure A2-6 D2 FNB Beam Effective Isotropic Radiated Power (Eirp) Mcmurdo Sound
Figure A2-7 D2 FNA Beam Effective Isotropic Radiated Power (Eirp)
Figure A2-8 D2 FNANZ Beam Effective Isotropic Radiated Power (Eirp)
Figure A2-9 D2 FNZB Beam Effective Isotropic Radiated Power (Eirp)
Figure A2-10 D2 FNZA Beam Effective Isotropic Radiated Power (Eirp)

ATTACHMENT 3
D3 SATELLITE BEAM CONTOURS FOR THE KU-BAND COMMUNICATIONS PAYLOAD

Figure A3-1 D3 BNA Beam Receive Gain On Temperature (G/T) Australia
Figure A3-2 D3 BNB Beam Receive Gain On Temperature (G/T) Australia
Figure A3-3 D3 BNANZ Beam Receive Gain On Temperature (G/T) Aust & NZ
Figure A3-4 D3 BNBNZ Beam Receive Gain On Temperature (G/T) Aust & NZ
Figure A3-5 D3 FNZB Beam Receive Gain On Temperature (G/T) NZ Only
Figure A3-6 D3 BNA Beam Effective Isotropic Radiated Power (Eirp) Australia
Figure A3-7 D3 BNB Beam Effective Isotropic Radiated Power (Eirp) Australia
Figure A3-8 D3 BNANZ Beam Effective Isotropic Radiated Power (Eirp) Aust & NZ
Figure A3-9 D3 BNBNZ Beam Effective Isotropic Radiated Power (Eirp) Aust & NZ
Figure A3-10 D3 FNZB Beam Effective Isotropic Radiated Power (Eirp) NZ Only

YOUR EYE IN THE SKY

1.0 Introduction

A SATELLITE FLEET TO BE PROUD OF

WITH OVER 25 YEARS OF EXPERIENCE, OPTUS IS A LEADER IN SATELLITE COMMUNICATIONS WITHIN AUSTRALIA. OVER THAT TIME WE'VE SUCCESSFULLY LAUNCHED NINE OPTUS OWNED SATELLITES AND OPERATED THIRTEEN SPACECRAFT.

THAT'S A CUMULATIVE TOTAL OF NEARLY 120 SPACECRAFT YEARS, CONSISTING OF 92 YEARS OF FULL STATION KEPT OPERATIONS AND 25 YEARS OF EXPERIENCE IN SATELLITE SERVICES.

What we manage

We look after an Australian domestic satellite system that provides coverage over continental Australia, Tasmania, and New Zealand. This also includes parts of Papua New Guinea, Norfolk Island, Lord Howe Island, Cocos Island, Christmas Island, McMurdo Sound, East Asia and Hawaii. Services are currently provided in Ku and L band.

In addition to the D series of satellites the Optus satellite fleet consists of the B3 and C1 satellites.

What's in this book?

You find a rundown of the D Series satellites' service capabilities including commercial payloads and performance characteristics. The information you'll read is intended for use as a technical guide only and doesn't mean that any particular service may be available.

The D Series satellites consist of three satellites, D1, D2 and D3, each of which operates in the Ku band with coverage for Australia and New Zealand. The D1 and D2 satellites also provide coverage of McMurdo Sound in Antarctica and Papua New Guinea. The D1 and D2 satellites operate in the Fixed Satellite Services band (FSS) and the D3 satellite will operate in the Fixed Satellite Services band (FSS) for New Zealand services and the Broadcasting Satellite Services (BSS) band for Australia and New Zealand. Currently the BSS band is not coordinated for operation in New Zealand.

The same operational requirements for the D Series satellites apply as per our other existing Optus satellites. This includes ensuring transmit earth stations conform to minimum performance standards. Information on the requirements for earth stations accessing Optus satellites is outside the scope of this satellite guide.

D SERIES SATELLITE PAYLOAD INFORMATION

1.1 Satellite System Management

All Optus satellites are operated within parameters which are dependent on the satellite performance capability and the requirements of the communication services. The specific nature and application of the technical requirements is dependent on many factors such as the service technology, the amount of satellite capacity used and the transponder in which the service is operated. All these factors are interdependent and need to be managed to ensure the quality of all services is preserved over the life of the satellite. As the owner, operator and manager of the satellite system, Optus controls the performance of all satellite services and is responsible for determining transponder allocations and setting operating characteristics that meet the requirements of each user, while ensuring minimal interference to other services.

Satellite system management is not a simple task and in some cases Optus may need to apply special conditions to a service that will ensure the performance integrity of the satellite system is preserved.

2.0 THE OPTUS D SERIES SATELLITES

2.1 Satellite Summary

The D Series Satellites were manufactured under contract to Orbital Sciences Corporation.

A diagram of the D Series satellites in the deployed configuration is shown in **Figure 2.1.**

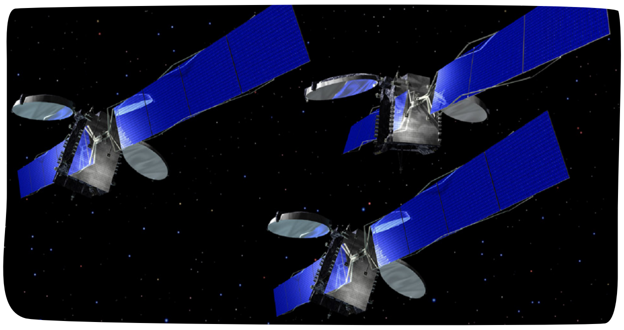


FIGURE 2.1 OPTUS D SERIES SATELLITES

D SERIES SATELLITE PAYLOAD INFORMATION

The D Series satellites utilise a common space platform or “spacecraft bus” which provides various support systems that are required to control and maintain the satellites in orbit and operate the on-board communications system. The reliability of the platforms is designed to be extremely high, and extensive protection from platform failures is provided by built-in redundancy and by extensive emergency operating procedures which have been developed to counter any foreseeable on-station emergency situation. The platform includes the power supply (solar cells and battery) which have been designed with an adequate margin for successful in-orbit operation extending well beyond the nominal design life of the satellites.

The D1 and D2 satellite payloads are functionally identical. The payloads each comprise a Ku Band repeater designed to operate in the Fixed Satellite Services (FSS) band to Australia, New Zealand and Papua New Guinea. A total of twenty-four active linearised transponders are provided. Five beams are possible via each of the D1 and D2 satellites providing connectivity to the National Australia A (FNA), National Australia B (FNB) which includes coverage of Papua New Guinea and McMurdo Sound in Antarctica, National Australia and New Zealand (FNANZ), New Zealand A (FNZA) and New Zealand B (FNZB). These beams operate with frequency reuse through orthogonal polarisations and spatial isolation. Each uplink beam operates in the polarisation orthogonal to its corresponding downlink beam.

The D3 satellite payload comprises a Ku Band repeater designed to operate in the Broadcast Satellite Services (BSS) band to Australia and New Zealand. Backup Fixed Satellite Services (FSS) to New Zealand is also provided from the D3 satellite. The satellite supports New Zealand coverage in the BSS band if required in the future. A total of twenty-four active linearised BSS transponders are provided with eight additional FSS transponders for New Zealand back up. Four BSS beams are possible via the D3 satellite providing connectivity to the National Australia A (BNA), National Australia B (BNB), National Australia A and New Zealand (BNANZ), and National Australia B and New Zealand (BNBNZ). One FSS beam provides connectivity to New Zealand (FNZB). The BSS beams operate with frequency reuse through orthogonal polarisations and spatial isolation. Each uplink beam operates in the polarisation orthogonal to its corresponding downlink beam. The FSS beams operate with its uplink beam in the polarisation orthogonal to its corresponding downlink beam.

Telemetry and control of the D Series satellites will be provided by Optus Satellite Operations staff from Sydney Satellite Facility at Belrose, with back up from Perth Satellite Facility at Lockridge.

2.2 Satellite Orbital Positions

The Optus D1 satellite replaced the B1 satellite located at 160° East in November 2006. The D2 satellite replaced the B3 satellite at 152° East in December 2007.

The Optus D3 satellite provides additional capacity at the Australian “Hotbird” location having being co-located with the C1 satellite at 156° East in 2009.

During the lifetime of any of the Optus satellites it could be moved to an alternate orbit location, subject to the necessary regulatory considerations, should the needs of the business dictate.

2.3 Station Keeping Performance

A satellite in a “geostationary” orbit will gradually change its orbit position primarily due to the combined gravitational effects of the sun, moon and earth. Optus employs two forms of station-keeping to maintain the nominal satellite position. These are Geostationary and Inclined Orbit operation.

The D Series satellites are designed to operate in geostationary mode. During their normal lifetimes, the D1 and D2 satellites will be maintained in orbit with a tolerance of ±0.05° in latitude and longitude about the sub-satellite point. (The sub-satellite point is the point on the earth’s surface directly below the nominal satellite position.). The D3 satellite in conjunction with the C1 satellite at 156° East will be maintained in orbit with a tolerance of ±0.07° in latitude and longitude about the sub-satellite point.

Earth station antennas of up to about 7m in diameter accessing the Optus satellites in the Ku-band frequencies of 14/12GHz and 17/11GHz generally do not require tracking capability.

D SERIES SATELLITE PAYLOAD INFORMATION

3.0 D1 AND D2 SATELLITES

The main characteristics of the Optus D1 satellite are listed in **Table 3.1** below.

	D1 Satellite
Physical Structure	Rectangular Prism body with solar wings
Dimensions	17 metres across extended solar panels
Dry Mass	1006 kg
Antenna	Two 2.3m Dual Shell front Gridded Shaped Reflectors
Stabilisation Method	Zero Momentum, 3 Axis Stabilised
Solar Power Capacity	4700 watts (at end of life)
Battery Capacity	Full operation during eclipse
Geostationary Life	15 years
Inclined Life Extension	5yrs (nominal)
Number of Transponders	24 Ku-Band
Transponder Power	150 watts saturated RF power per transponder Tpdrs 1-16 44 watts saturated RF power per transponder Tpdrs NZ9-NZ16
Transponder Bandwidth	8 Transponders 54MHz Aust only with simulcast to NZ option (B pol) 4 Transponders 54 MHz uplink Aust and NZ, downlink Aust or Aust and NZ (A pol) 4 Transponders 54 MHz uplink Aust and NZ, downlink Aust and NZ or NZ only (A pol) 8 Transponders 54 MHz NZ only with simulcast option from Aust (B pol)
Communications payloads	Ku-Band communications UPC Beacon (Ku-Band)

TABLE 3.1 D1 SATELLITE SUMMARY

The main characteristics of the Optus D2 satellite are listed in **Table 3.2** below.

	D2 Satellite
Physical Structure	Rectangular Prism body with solar wings
Dimensions	21.4 metres across extended solar panels
Dry Mass	1060 kg
Antenna	Two 2.3m Dual Shell front Gridded Shaped Reflectors
Stabilisation Method	Zero Momentum, 3 Axis Stabilised
Solar Power Capacity	6400 watts (at end of life)
Battery Capacity	Full operation during eclipse
Geostationary Life	15 years
Inclined Life Extension	5yrs (nominal)
Number of Transponders	24 Ku-Band
Transponder Power	125 watts saturated RF power per transponder Tpdrs 1-16 44 watts saturated RF power per transponder Tpdrs NZ9-NZ16
Transponder Bandwidth	8 Transponders 54MHz Aust only with simulcast to NZ option (B pol) 4 Transponders 54 MHz uplink Aust and NZ, downlink Aust or Aust and NZ (A pol) 4 Transponders 54 MHz uplink Aust and NZ, downlink Aust and NZ or NZ only (A pol) 8 Transponders 54 MHz NZ only with simulcast option from Aust (B pol)
Communications payloads	Ku-Band communications UPC Beacon (Ku-Band)

TABLE 3.2 D2 SATELLITE SUMMARY

D SERIES SATELLITE PAYLOAD INFORMATION

3.1 D1 and D2 Commercial Communications Payload Overview

A simplified block diagram of the D1 and D2 satellite communications payload is shown in **Figure 3.1.**

The Ku-band payload of the D1 and D2 satellites is divided into three repeaters called A, B and NZ. The A repeater consists of eight transponders whose uplinks are from the combined National Australia A plus NZ beam. Four of the A repeater transponders are switchable to allow transmission to Australia or Australia plus NZ beams. The other four A repeater transponders are switchable to allow transmission to Australia plus NZ or NZ only beams. The B repeater consists of eight transponders which are normally connected into the National Australia B uplink and downlink beams. The B repeater can also operate in simulcast mode with individual uplinks from the National Australia B beam simultaneously transmitting into the National Australia B and NZ beams without loss of RF power into both beams. The NZ repeater consists of eight transponders which are normally connected into the NZ beam. The transponders receive and transmit on orthogonal linear polarisations. Transponders 1 to 8 are identified as repeater A and receive on horizontal polarisation and transmit on vertical polarisation. Transponders 9 to 16 are identified as repeater B and receive on vertical polarisation and transmit on horizontal polarisation. Satellite transponders NZ9 to NZ16 are identified as repeater NZ and receive on vertical polarisation and transmit on horizontal polarisation.

The Ku-band payload of the D1 and D2 satellites can be conveniently divided into eight sections described below:

i) Receive and Transmit Antennas

The receive and transmit antennas consist of two 2.3 metre dual shell gridded shaped reflectors, illuminated with separate feeds mounted on the spacecraft body. These provide highly shaped uplink and downlink beams: 3 receive and 4 transmit beams.

ii) Receivers

The receiver section contains four receivers in a 4-for-2 redundancy ring for the Australia and Australia plus NZ beams, and two receivers in a 2-for-1 redundant pair for the New Zealand only beam. The receivers amplify the entire 500MHz spectrum and translate it by 1748MHz from the 14GHz band to the 12GHz band.

iii) Input Hybrids

The receivers are followed by the 1:2 input hybrids. One hybrid is provided for each receive beam. The hybrids divide the received signal for presentation to the input multiplexers.

iv) Input Multiplexer (IMUX)

Each hybrid is followed by an input multiplexer (IMUX). The IMUX is a filter bank which divides or “channelises” the receive band into a number of Ku-band channels. In each repeater eight Ku-Band channels are derived. The Australia B repeater and the NZ repeater can operate as straight channels or are able to be operated in simulcast mode. Simulcast operation is implemented via a hybrid and uplink selection switch. See **Section 4.3.3.1** for information on operation under the Simulcast mode.

v) Hybrid/Uplink Selection Switch Section

Each output from the input multiplexer for transponders 9-16 is routed via a 1:2 hybrid and an uplink selection switch to allow simulcasting of these eight B repeater transponders. Simulcasting refers to National Australia B and NZ beams. See **Section 4.3.3.1** for information on operation under Simulcast mode.

vi) Channel Amplifiers

Each channel amplifier section consists of a Channel Control Unit (CCU) followed by a Travelling Wave Tube Amplifier (TWTA). The CCU controls the transponder gain setting and is discussed in **Section 4.5.**

All transponders in D1 repeaters A & B have the same saturated RF power output - 150W. All transponders in D2 repeaters A & B have the same saturated RF power output - 125W. All transponders in the D1 and D2 NZ repeaters have the same saturated RF power output - 44W.

Input and output redundancy switching is provided for the channel amplifiers such that the A and B repeaters have access to a ring providing 20-for-16 redundancy. On the NZ repeater a separate ring provides 10-for-8 redundancy.

vii) Transmit beam switch matrices (TSM)

Following the channel amplifiers are the transmit beam switch matrices (TSM). These are configured by ground command to select a particular transmit beam for a particular transponder.

viii) Output Multiplexers (OMUX)

All transponders switched to a given transmit beam are recombined into a 500MHz spectrum in an output multiplexer (OMUX) bank before being fed to the transmit antenna. An OMUX bank is provided for each downlink beam. The OMUX banks provide channel filtering plus harmonic filters to absorb and reject TWTA harmonics.

Communications Payload (Ku-Band)

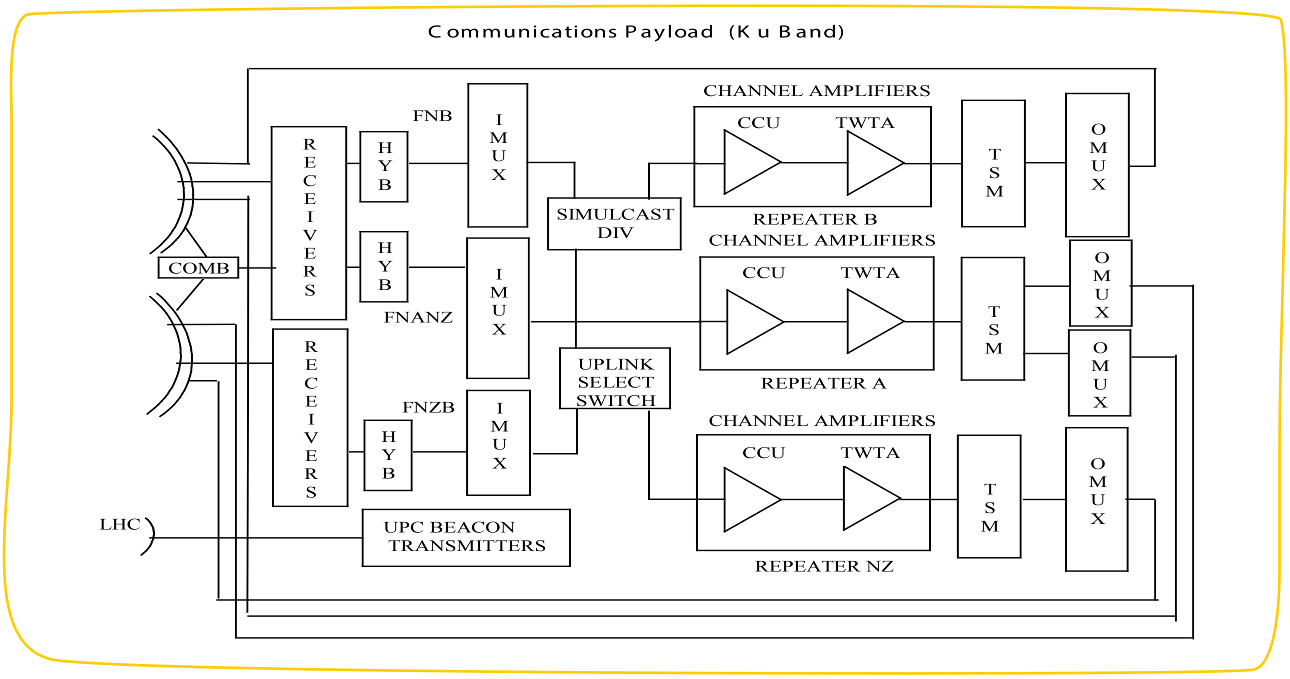


FIGURE 3.1 D1 AND D2 SATELLITES COMMUNICATIONS PAYLOAD BLOCK DIAGRAM.

4.0 D1 AND D2 KU-BAND COMMUNICATIONS PAYLOAD

The Optus D1 satellite can provide twenty-four active 14/12 GHz transponders operating in a dual polarisation frequency re-use scheme with sixteen transponders in frequency re-use mode on one polarisation and eight transponders on the other polarisation.

4.1 D1 and D2 Frequency Plan

The D1 and D2 satellites will receive and transmit at the following Ku-Band frequencies:

Receive 14,000-14,500 MHz	(14.00-14.50 GHz)
Transmit 12,250-12,750 MHz	(12.25-12.75 GHz)

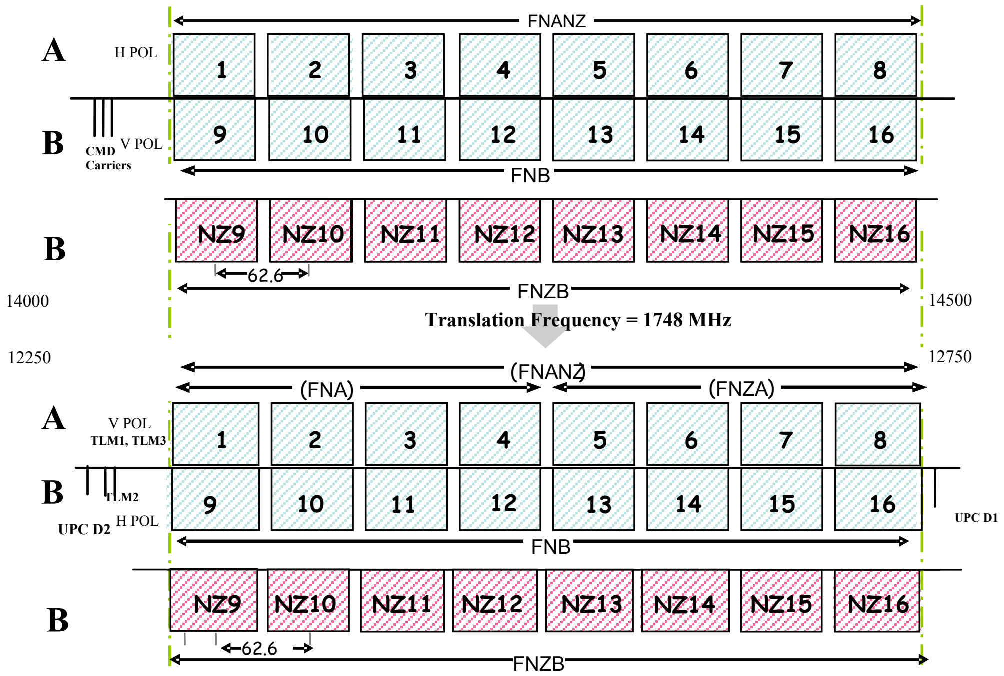
The transponder channel plan is shown in **Figure 4.1.**

The frequency plan uses the following spacing of transponder centre frequencies

Separation between transponder centre frequencies:

(adjacent 54 MHz transponders)	62.6 MHz
Frequency Offset (Repeater A to Repeater B)	Nil

D SERIES SATELLITE PAYLOAD INFORMATION



FSS Australia Centre Frequencies (MHz)			
Channel	Uplink	Downlink	
1	14029.90	12281.90	
2	14092.50	12344.50	
3	14155.10	12407.10	
4	14217.70	12469.70	
5	14280.30	12532.30	
6	14342.90	12594.90	
7	14405.50	12657.50	
8	14468.10	12720.10	
9	14029.90	12281.90	
10	14092.50	12344.50	
11	14155.10	12407.10	
12	14217.70	12469.70	
13	14280.30	12532.30	
14	14342.90	12594.90	
15	14405.50	12657.50	
16	14468.10	12720.10	
TLM1		12243.25	D1
TLM2		12245.25	D1
TLM3		12243.25	D1
UPC		12749.50	D1
TLM1		12243.75	D2
TLM2		12245.75	D2
TLM3		12243.75	D2
UPC		12200.10	D2

FSS NZ Centre Frequencies (MHz)		
Channel	Uplink	Downlink
NZ9	14029.90	12281.90
NZ10	14092.50	12344.50
NZ11	14155.10	12407.10
NZ12	14217.70	12469.70
NZ13	14280.30	12532.30
NZ14	14342.90	12594.90
NZ15	14405.50	12657.50
NZ16	14468.10	12720.10

FIGURE 4.1 D1 AND D2 SATELLITE FREQUENCY, POLARISATION AND CONNECTIVITY

D SERIES SATELLITE PAYLOAD INFORMATION

4.2 D1 and D2 Frequency Translation Characteristics

Satellite frequency translation characteristics for the Ku band communications payload, including expected stability performance, are as follows:

D1 and D2 Satellite Parameter	Performance Measure
Translation Frequency	1,748 MHz
Short-term Drift	±1.75 kHz/month
Long-term Drift (over satellite life)	±15 kHz

TABLE 4.1 D1 AND D2 TRANSLATION FREQUENCY CHARACTERISTICS

4.3 D1 and D2 Satellite Beam Information

Each of the D1 and D2 satellites has several receive and transmit beams on both horizontal and vertical polarisation.

Receive and transmit connectivity may be configured by ground command from the Optus Satellite Control Centre to match system operational requirements as they evolve throughout the life of each satellite.

4.3.1 Receive Beams

The receive beams for the D1 and D2 satellites are as follows:

Transponders	D1 and D2 Satellite Receive Beams
Transponders 1-8	FNANZ
Transponders 9-16	FNB
Transponders NZ9-NZ16 Standard mode	FNZB
Transponders NZ9-NZ16 Simulcast mode	FNB

TABLE 4.2 D1 AND D2 SATELLITE RECEIVE BEAMS

4.3.2 Transmit Beams

The transmit beams for the D1 and D2 satellites are as follows:

Transponders	D1 and D2 Satellite Receive Beams
Transponders 1-4	FNA or FNANZ
Transponders 5-8	FNANZ or FNZA
Transponders 9-16 Standard mode	FNB
Transponders 9-16 Simulcast mode	FNB and FNZB
Transponders NZ9-NZ16	FNZB

TABLE 4.3 D1 AND D2 SATELLITE TRANSMIT BEAMS

D SERIES SATELLITE PAYLOAD INFORMATION

4.3.3 D1 and D2 Transponder and Beam Connectivity

Transponder connectivity may be configured by ground command from the Optus Satellite Control Centre to match system operational requirements as they evolve throughout the life of each satellite.

The connectivity available on the D1 and D2 satellite is shown in **Table 4.4** below.

Transponder Number	Receive Beam			Transmit Beam				
	FNB (V)	FNANZ (H)	FNZB (V)	FNB (H)	FNZB (H)	FNA (V)	FNZA (V)	FNANZ (V)
1		x				s		s
2		x				s		s
3		x				s		s
4		x				s		s
5		x					s	s
6		x					s	s
7		x					s	s
8		x					s	s
9	x			x				
10	x			x				
11	x			x				
12	x			x				
13	x			x				
14	x			x				
15	x			x				
16	x			x				
Standard Mode Note 1								
NZ9			x		x			
NZ10			x		x			
NZ11			x		x			
NZ12			x		x			
NZ13			x		x			
NZ14			x		x			
NZ15			x		x			
NZ16			x		x			
Simulcast Mode Note 1								
9	9			9	NZ9			
10	10			10	NZ10			
11	11			11	NZ11			
12	12			12	NZ12			
13	13			13	NZ13			
14	14			14	NZ14			
15	15			15	NZ15			
16	16			16	NZ16			

TABLE 4.4 D1 AND D2 TRANSPONDER AND BEAM CONNECTIVITY

(Each transponder may be switched to one of the beams as shown).

Notes: 1. Transponders 9-16 and NZ9-NZ16 can operate in standard or simulcast modes.

Refer Section 4.3.3.1.

In standard mode these transponders operate as dedicated transponders.

In simulcast mode, the transponder numbers occupied by the simulcast mode uplink and downlink are separately listed. Each of the transponders NZ9-NZ16 is independently switchable between standard mode and simulcast mode.

D SERIES SATELLITE PAYLOAD INFORMATION

Legend of abbreviations:

FNA	FSS band National Beam A
FNB	FSS band National Beam B
FNZA	FSS band NZ beam A
FNZB	FSS band NZ beam B
FNANZ	FSS band National Australia Beam A plus New Zealand Beam A
(V)	Vertical polarisation
(H)	Horizontal polarisation
X	Dedicated beam
S	Switchable between beams marked with S for respective transponder

4.3.3.1 Simulcast Mode

Simulcast describes the configuration where uplinks from the FNB service area are downlinked simultaneously into the FNB service area and the FNZB service area via their own TWTAs. In this mode, there is no loss of total EIRP into each service area.

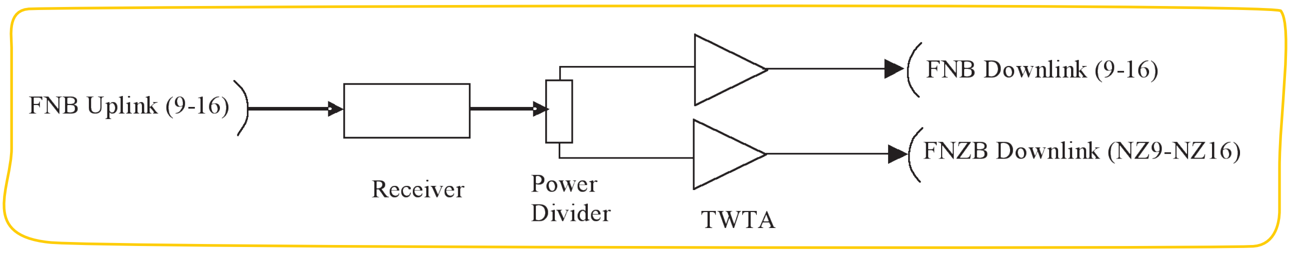


FIGURE 4.2 SIMULCAST CONFIGURATION

In Standard mode, FNB transponders 9 to 16 have uplinks and downlinks in the FNB service area only.

Similarly, FNZB transponders NZ9 to NZ16 have uplinks and downlinks in the FNZB service area only.

In Simulcast mode, the uplinks for up to 8 individual FNB transponders are simultaneously downlinked via the corresponding FNB TWTA and the FNZB TWTA whose bandwidth occupies the same spectrum.

Uplinks to each of the FNB transponders 9 to 16 can be simultaneously downlinked via both the corresponding FNB and FNZB transponders on an individual basis. There is no loss of power in the downlink beams because the TWTA output power is not shared between the beams.

Simulcast is available for uplinking from Australia and downlinking into Australia and NZ only.

4.4 D1 and D2 Satellite Beam Performance Levels

Contour maps of satellite beam performance, in terms of G/T and EIRP, are provided for the D1 satellite in **Attachment 1** and for the D2 satellite in **Attachment 2.**

For the D1 satellite, the FNA, FNB & FNANZ EIRP maps are based on 125W (linearised), i.e. 0.8dB output backoff from 150W saturated and the FNZA & FNZB EIRP maps are based on 44W (saturated). For the D2 satellite, the FNA, FNB & FNANZ EIRP maps are based on 125W (saturated) and the FNZA & FNZB EIRP maps are based on 44W (saturated).

Service designs based on satellite beam performances need to include allowances for the normal performance variations to be expected between different satellite transponders over the operating life of the satellites. To assist design engineers in taking these effects into account, Optus has established a number of “Beam Performance Levels” which include different assumptions about satellite performance. The most important of these is the “General Design Level” which is the only beam performance level for which information is provided in this guide.

4.5 D1 and D2 Transponder Gain Control

Each satellite transponder contains a Channel Control Unit (see section 3.1) which provides a means of controlling the transponder gain. This gives the transponder a range of operating C/T values to suit the characteristics of the systems operating on it at a given time. The C/T (called "C-to-T") is the uplink saturated carrier-to-noise-temperature ratio and is a fundamental design parameter of a satellite transponder. It is related to the SFD and G/T by the following equation:

$$C/T = SFD + G/T + 10\log10(\lambda^2/4\pi)$$

- where -

C/T = Saturated carrier-to-noise-temperature ratio (dBW/K)

SFD = Saturated flux density (dBW/m^2)

G/T = Satellite receive gain-to-noise-temperature ratio (dB/K)

$\lambda^2/4\pi$ = Isotropic area conversion factor (m^2)

Note that for a given transponder gain setting the C/T is fixed, meaning that the sum (SFD + G/T) is also fixed, i.e. the SFD and G/T vary in inverse proportion over the satellite receive beam pattern

On the D1 and D2 satellites two methods are used to provide transponder gain control for a range of C/Ts. Fixed Gain Mode (FGM) and Variable Gain Mode (VGM) are selectable by ground command in accordance with the following specifications.

4.5.1 Fixed Gain Mode (FGM)

FGM corresponds to traditional gain-step control in which a variable step-attenuator is switched under ground command to one of a number of settings or "gain steps".

Each of the D1 and D2 satellites has a gain step control range covering a nominal uplink saturated C/T range of -118 to -135 dBW/K in 1dB steps. At a point in the satellite uplink beam where the G/T is +2dB/K, the corresponding uplink SFD is as specified in **Table 4-5.** Note that the satellite is expected to operate over a C/T range substantially less than shown in this table. The correct selection of operating gain step is important in order to minimise uplink interference between transponders using polarisation or spatial re-use.

Nominal C/T (dBW/K)	SFD (at +2dB/K G/T Contour)
-118	-75.5
-135	-92.5

TABLE 4.5 D1 AND D2 FGM GAIN STEP RANGE

Each transponder is provided with independent ground commandable gain adjustment capability to facilitate selection on any transponder gain step as indicated in **Table 4.5.**

The C/T required for transponder saturation at any selected gain step does not vary by more than ±1dB over any 24 hour period, and ±2dB over the spacecraft service life.

4.5.2 Variable Gain Mode (VGM)

VGM provides a form of automatic gain control. Under VGM a feedback-loop maintains a constant input drive level to the transponder TWTA over an operating uplink C/T range. This compensates for uplink fading at the cost of gradually degrading the uplink C/N.

When the spacecraft is illuminated by a single carrier or multiple carriers within the transponder usable bandwidth, at a level required to produce a total receive carrier-to-noise temperature ratio (C/T) in the range

(i) -123 dBW/K to -143 dBW/K (except FNZB),

(ii) -118 dBW/K to -138 dBW/K (FNZB)

the transponder operating point is maintained at a total input backoff, selectable by ground command for each transponder, of between -1 and 10dB (in 0.5dB steps) relative to that required for single carrier saturation.

VGM operates on the total transponder power (signal plus noise) and has a time constant of between 10ms and 100ms. VGM is therefore intended for either single-carrier operation, or for multiple carriers where all carriers are uplinked from the same location and therefore undergo an uplink fade at the same time. VGM may be used with uplink power control if desired to extend the range of uplink fade compensation.

4.5.3 TDMA Operation

Up to any four (4) transponders may operate in synchronous TDMA mode with burst repetition rate or switching rate higher than 400 Hz simultaneously.

4.6 D1 and D2 Amplitude Transfer Characteristics

Representative AM/AM transfer characteristics for the TWTAs used in the D1 and D2 satellites is shown in **Figure 4.3.** This shows the transfer curves for single carrier. The X axis defines the Input Backoff (IBO) relative to TWTA saturation for the carrier whilst the Y axis defines the Output Backoff (OBO) for the carrier.

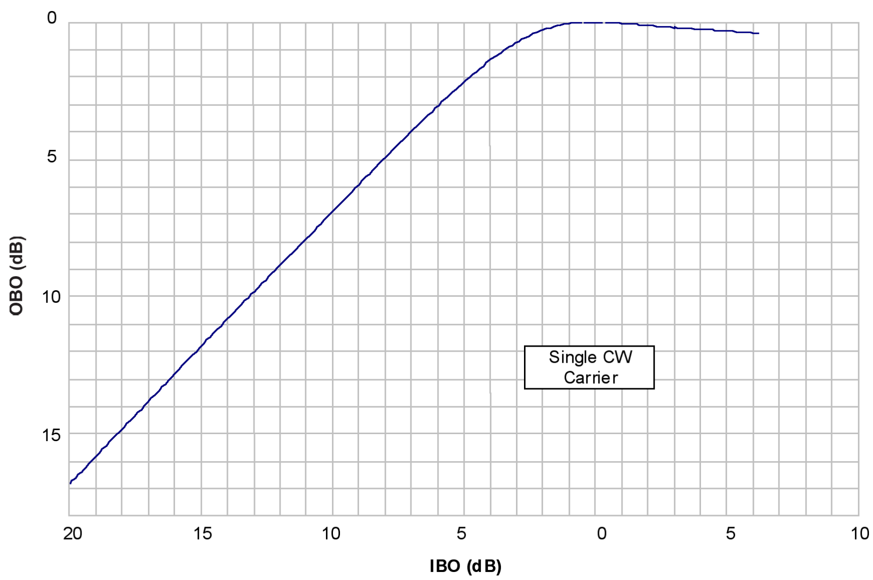


FIGURE 4.3 TYPICAL D1 AND D2 SATELLITE AMPLITUDE TRANSFER CHARACTERISTIC

Figure 4.4 shows the normalised TWTA gain of a typical D1 and D2 satellite transponder as a function of Input Backoff (IBO) for a single carrier. The X axis defines the Input Backoff (IBO) relative to TWTA saturation for the carrier whilst the Y axis defines the carrier gain of the transponder.

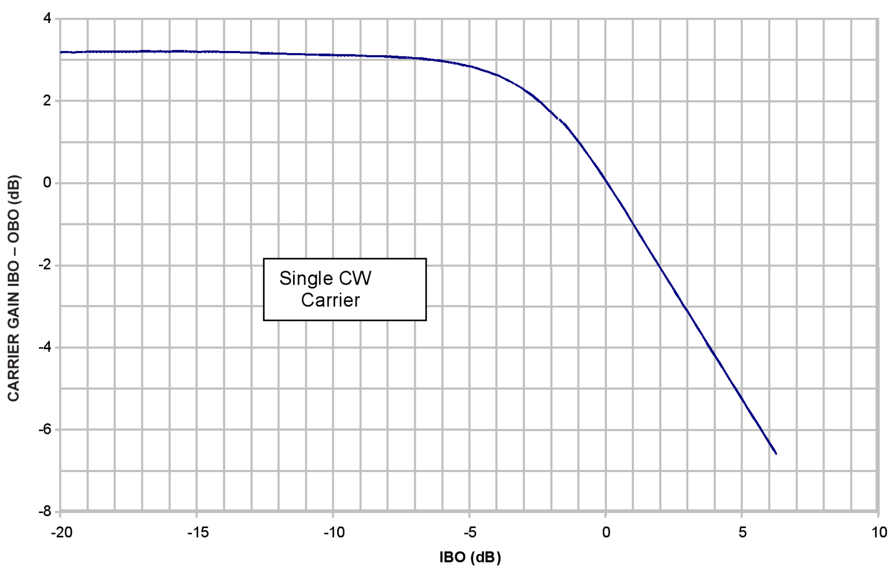


FIGURE 4.4 TYPICAL D1 AND D2 SATELLITE TRANSPONDER GAIN CHARACTERISTIC

D SERIES SATELLITE PAYLOAD INFORMATION

4.7 D1 and D2 Satellite Cross Polarisation Discrimination

Cross polarisation performance of the D1 and D2 orthogonally polarised repeaters A and B, and NZA and NZB for the satellite receive and transmit beams, will equal or exceed the following performance levels:

For the FNB, FNZB and FNANZ beams, the Satellite Receive Cross Polarisation Discrimination over 100% of the coverage area is at least 27dB

For the FNA, FNZA, FNB, FNZB and FNANZ beams, the Satellite Transmit Cross Polarisation Discrimination over 100% of the coverage area is at least 25dB

Cross-polarisation performance of the satellite link can be expected to degrade during rain storms and under other adverse weather conditions.

4.8 D1 and D2 Satellite Co Polarisation and Cross Polarisation Isolation

Co Polarisation isolation performance of the D1 and D2 satellites between the Australia and NZ beams is also important because of the frequency reuse on the B polarisation and the way the combined Australia and NZ beam is produced. The performance levels are indicated in **Tables 4.6 and 4.7.**

Desired Beam Co Pol	Interfering Beam Co Pol	Receive Co Pol Isolation over Coverage Area except McMurdo Sound, Lord Howe and Norfolk Islands	Receive Co Pol Isolation over Lord Howe Island	Receive Co Pol Isolation over Norfolk Island	Receive Co Pol Isolation over McMurdo Sound
FNB	FNZB	30 dB	min 25 dB	min 15 dB	min 18 dB
FNZB	FNB	30 dB	min 25 dB	min 15 dB	min 18 dB

TABLE 4.6 D1 AND D2 SATELLITE RECEIVE CO POLARISATION ISOLATION

Desired Beam Co Pol	Interfering beam Co Pol	Transmit Co Pol Isolation over Coverage Area except McMurdo Sound, Lord Howe and Norfolk Islands	Transmit Co Pol Isolation over Lord Howe Island	Transmit Co Pol Isolation over Norfolk Island	Transmit Co Pol Isolation over McMurdo Sound
FNB	FNZB	24 – 30 dB	min 19 dB	min 15 dB	min 22 dB
FNZB	FNB	27 – 30 dB	min 19 dB	min 15 dB	min 22 dB
FNA	FNZA	24 – 30 dB	min 19 dB	min 10 dB	n/a
FNZA	FNA	27 – 30 dB	min 19 dB	min 10 dB	n/a

TABLE 4.7 D1 AND D2 SATELLITE TRANSMIT CO POLARISATION ISOLATION

For the FNA, FNZA, FNANZ, FNB and FNZB beams, the Satellite Receive Cross Polarisation Isolation over 100% of the coverage area is at least 25dB.

For the FNA, FNZA, FNANZ, FNB and FNZB beams, the Satellite Transmit Cross Polarisation Isolation over 100% of the coverage area is at least 25dB.

4.9 D1 and D2 Satellite Beacons

All Optus satellites transmit beacon signals which are used by Optus to monitor the condition of the spacecraft and which may be used by customer earth stations for antenna tracking and uplink power control (UPC). The UPC beacon is appropriate for tracking by customer earth stations.

4.9.1 Telemetry Beacons

Each of the D1 and D2 satellite transmits three telemetry beacons. The third beacon is a standby beacon and is not activated if either of the first two beacons is functional. These beacons are transmitted in Right Hand Circular polarisation via the Omni antenna for transfer orbit activities. For on station service these beacons are transmitted in Horizontal polarisation over the D1 and D2 satellite FNB Beam service area. **Table 4.8** indicates specifications of the Telemetry beacons.

Telemetry Beacons	D1	D2
Frequency TM1	12243.25MHz	12243.75 MHz
Frequency TM2	12245.25MHz	12245.75 MHz
Frequency TM3 Note 1	12243.25MHz	12243.75 MHz
Frequency Stability	± 25KHz over any 24 hour period	
	± 130KHz over the spacecraft lifetime	
Polarisation	Horizontal – On Station	
EIRP at Perth	16.6 dBW min on station	
EIRP at Sydney	18.5 dBW min on station	
EIRP Zone 1 Note 2	17.0 dBW min on station	
EIRP Zone 2 Note 3	17.0 dBW min on station	
EIRP Zone 3 Note 4	17.0 dBW min on station	
EIRP Zone 4 Note 5	13.0 dBW min on station	
EIRP Zone 5 Note 6	8.0 dBW min on station	

TABLE 4.8 D1 AND D2 SATELLITE TELEMETRY BEACONS

Note 1: TM3 is turned off if either TM1 or TM2 is functional

Note 2: Zone 1 Brisbane to Melbourne Coastal

Note 3: Zone 2 Cairns to Adelaide Coastal and Perth and SW West Australia area

Note 4: Zone 3 Tasmania

Note 5: Zone 4 Remainder of mainland Australia

Note 6: Zone 5 McMurdo Sound. Edge of coverage estimated EIRP level

This estimate does not take into consideration the effects of multipath interference due to low elevation angles and ice depolarisation.

4.9.2 Uplink Power Control Beacon

Each of the D1 and D2 satellites carries an uplink power control beacon which is used for tracking and Uplink Power Control (UPC). This beacon is radiated in Left Hand Circular Polarisation over the D1 satellite service area. The UPC beacon characteristics are as specified in **Table 4.9.** Within the FSS service area, the received EIRP level of the UPC beacon is at least 10.0dBW measured within a 1KHz bandwidth centred on the beacon centre frequency. The level received will be 3dB lower when received with a linear feed on either polarisation.

D SERIES SATELLITE PAYLOAD INFORMATION

D1 and D2 UPC Beacon	
Frequency	D1 : 12749.5 MHz D2 : 12200.1 MHz
Frequency Stability	± 10KHz over any 24 hour period
	± 15KHz over any 1 month period
	± 100KHz over the spacecraft service life.
Polarisation	Left Hand Circular
EIRP across FSS Service Area	>10.0 dBW throughout FSS service area Aust and NZ
EIRP at McMurdo Sound	10.0 dBW Note 1
EIRP at Sydney	11.2 dBW

TABLE 4.9 D1 AND D2 SATELLITE UPC BEACONS

Note 1: Estimate only

This estimate does not take into consideration the effects of multipath interference due to low elevation angles and ice depolarisation.

4.10. D1 and D2 Uplink Power Control Operation

Customers may use uplink power control systems (UPC) to compensate for uplink rain attenuation. Since a malfunctioning UPC system can interfere with other services and even damage a satellite TWTA, UPC systems must be approved by Optus before use and are strictly limited in the amount of uplink compensation permitted. Details of the amount of UPC permitted under various operating conditions may be obtained from Optus.

UPC systems use the attenuation measured on a downlink beacon to compensate for attenuation on the uplink. However attenuation is frequency-dependent and a scaling factor needs to be applied to determine the correct uplink compensation. At 14/12GHz Optus recommends a scaling factor of 1.3.

D SERIES SATELLITE PAYLOAD INFORMATION

5.0 D3 SATELLITE

The main characteristics of the Optus D3 satellite are listed in **Table 5.1** below.

	D3 Satellite
Physical Structure	Rectangular Prism body with solar wings
Dimensions	22 metres across extended solar panels
Dry Mass	1188 kg
Antenna	Two 2.3m Dual Shell Gridded Shaped Reflectors
Stabilisation Method	Zero Momentum, 3 Axis Stabilised
Solar Power Capacity	6000 watts (at end of life)
Battery Capacity	Full operation during eclipse
Geostationary Life	15 years
Inclined Life Extension	5yrs (nominal)
Number of Transponders	32 Ku-Band
Transponder Power	125 watts saturated RF power per transponder Tpdrs 1-24 44 watts saturated RF power per transponder Tpdrs NZ9-NZ16
Transponder Bandwidth	12 Transponders 36MHz Aust or Aust plus NZ (A pol BSS) 12 Transponders 36 MHz Aust or Aust plus NZ (B pol BSS) 8 Transponders 54 MHz NZ only back up (B pol FSS)
Communications payloads	Ku-Band communications UPC Beacon (Ku-Band)

TABLE 5.1 D3 SATELLITE SUMMARY

5.1 D3 Commercial Communications Payload Overview

A simplified block diagram of the D3 communications payload is shown in **Figure 5.1.**

The Ku-band payload is divided into three repeaters called A, B and NZ. Repeaters A and B operate in the BSS band and the NZ repeater operates in the FSS band. The A repeater consists of twelve transponders which are switchable into the National Australia A or National A plus NZ beams. The B repeater consists of twelve transponders which are switchable into the National Australia B or National B plus NZ beams. The NZ repeater consists of eight transponders which are permanently connected into the NZ beam for back up of the D1 NZ payload. The transponders receive and transmit on orthogonal linear polarisations. Satellite transponders 1 to 12 are identified as repeater A and receive on horizontal polarisation and transmit on vertical polarisation. Transponders 13 to 24 are identified as repeater B and receive on vertical polarisation and transmit on horizontal polarisation. Transponders NZ9 to NZ16 are identified as repeater NZ and receive on vertical polarisation and transmit on horizontal polarisation.

The Ku-band payload can be conveniently divided into seven sections described below:

i) Receive and Transmit Antennas

The receive and transmit antennas consist of two 2.3 metre dual shell gridded shaped reflectors, illuminated with separate feed antennas and sub-reflectors mounted on the spacecraft body. These provide highly shaped uplink and downlink beams: 5 receive and 5 transmit beams.

ii) Receivers (RCVRS)

The receiver section contains four receivers in a 4-for-2 redundancy ring for the BSS services beams, and two receivers in a 2-for-1 redundant pair for the FSS New Zealand only beam. The BSS receivers amplify the entire 500MHz spectrum and translate it by 5600MHz from the 17GHz band to the 11-12GHz band. The FSS receivers amplify the entire 500MHz spectrum and translate it by 1748MHz from the 14GHz band to the 12GHz band.

iii) Input Multiplexers (IMUX)

The receivers are followed by the input multiplexers (IMUX). These are filter banks which divide or “channelise” the receive band into a number of Ku-band channels. In the each BSS band repeater twelve Ku-Band channels are derived. In the FSS band repeater eight channels are derived.

iv) Hybrid combiner and beam select switch network

For the A and B repeaters only, the imuxes are followed by a network of hybrid and beam select swtiches. One hybrid and one switch is provided for each receive channel. The hybrids combine the received signals from the Australia and New Zealand antennas. The switch is used to select either the Australia receive beam or the combined Australia and New Zealand receive beam.

v) Channel Amplifiers

Each channel amplifier section consists of a Channel Control Unit (CCU) followed by a Travelling Wave Tube Amplifier (TWTA). The CCU controls the transponder gain setting and is discussed in **Section 6.5.**

All transponders in repeaters A & B have the same saturated RF power output - 125W. All transponders in the NZ repeater have the same saturated RF power output - 44W.

The channel amplifiers are connected on the input and output via separate redundancy rings for each repeater. On the A and B repeaters a ring provide 28-for-24 redundancy. On the NZ repeater a separate ring provide 10-for-8 redundancy.

vi) Transmit beam switch matrices (TSM)

For the BSS repeaters only, following the channel amplifiers are the transmit beam switch matrices (TSM). These are configured under ground command to select either the transmit beam for Australia only or combined Australia and New Zealand on a particular transponder.

vii) Output Multiplexers (OMUX)

All transponders switched to a given transmit beam are recombined into a 500MHz spectrum in an output multiplexer (OMUX) bank before being fed to the transmit antenna. An OMUX bank is provided for each downlink beam. The OMUX banks provide channel filtering plus harmonic filters to absorb and reject TWTA harmonics.

D SERIES SATELLITE PAYLOAD INFORMATION

Communications Payload (Ku Band)

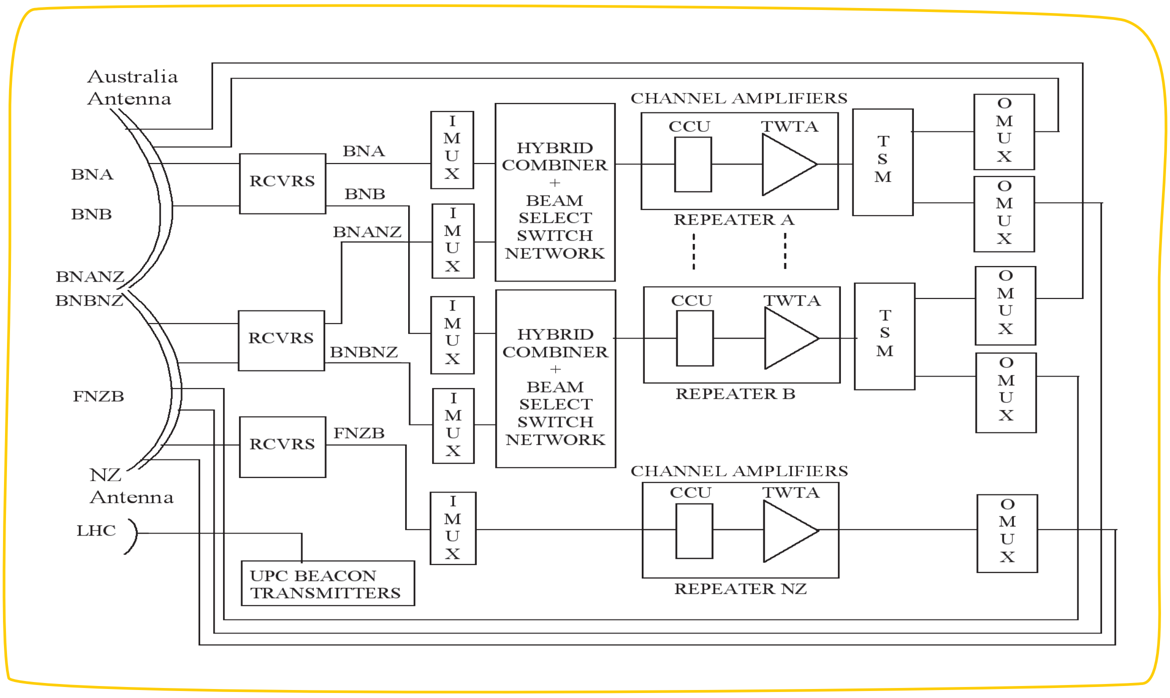


FIGURE 5.1 D3 SATELLITE COMMUNICATIONS PAYLOAD BLOCK DIAGRAM

6.0 D3 KU-BAND COMMUNICATIONS PAYLOAD

The Optus D3 satellite can provide twenty-four active 17/11 GHz transponders operating in a dual polarisation configuration with twelve transponders on each polarisation. In addition eight 14/12 GHz back up transponders are provided for the D1 NZ beam services.

6.1 D3 Frequency Plan

The D3 satellite will receive and transmit at the following Ku-Band frequencies:

BSS Band	**Receive**	17,300-17,800 MHz	(17.30-17.80 GHz)
	Transmit	11,700-12,200 MHz	(11.70-12.20 GHz)
FSS Band Back Up	**Receive**	14,000-14,500 MHz	(14.00-14.50 GHz)
	Transmit	12,250-12,750 MHz	(12.25-12.75 GHz)

The transponder channel plan is shown in **Figure 6.1.**

The frequency plan uses the following spacing of transponder centre frequencies.

BSS Band

Separation between transponder centre frequencies:

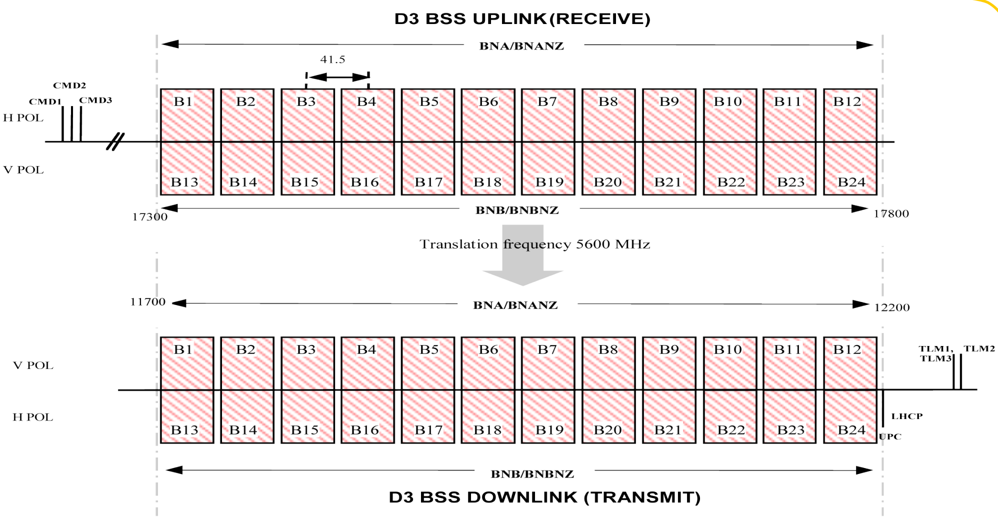
(adjacent 36 MHz transponders)	41.5 MHz
Frequency Offset (Repeater A to Repeater B)	Nil

FSS Band

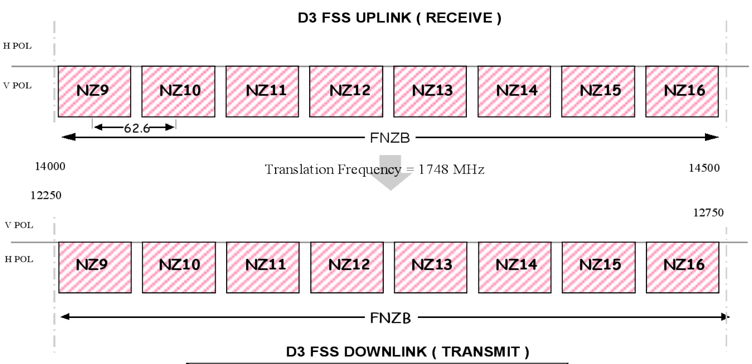
Separation between transponder centre frequencies:

(adjacent 54 MHz transponders)	62.6 MHz
Frequency Offset (Repeater A to Repeater B)	Not applicable

D SERIES SATELLITE PAYLOAD INFORMATION



BSS Centre Frequencies (MHz)		
Channel	Uplink	Downlink
B1	17320.50	11720.50
B2	17362.00	11762.00
B3	17403.50	11803.50
B4	17445.00	11845.00
B5	17486.50	11886.50
B6	17528.00	11928.00
B7	17569.50	11969.50
B8	17611.00	12011.00
B9	17652.50	12052.50
B10	17694.00	12094.00
B11	17735.50	12135.50
B12	17777.00	12177.00
B13	17320.50	11720.50
B14	17362.00	11762.00
B15	17403.50	11803.50
B16	17445.00	11845.00
B17	17486.50	11886.50
B18	17528.00	11928.00
B19	17569.50	11969.50
B20	17611.00	12011.00
B21	17652.50	12052.50
B22	17694.00	12094.00
B23	17735.50	12135.50
B24	17777.00	12177.00
TLM1		12239.25
TLM2		12241.25
TLM3		12239.25
UPC		12201.10



FSS NZ Centre Frequencies (MHz)		
Channel	Uplink	Downlink
NZ9	14029.90	12281.90
NZ10	14092.50	12344.50
NZ11	14155.10	12407.10
NZ12	14217.70	12469.70
NZ13	14280.30	12532.30
NZ14	14342.90	12594.90
NZ15	14405.50	12657.50
NZ16	14468.10	12720.10

FIGURE 6.1 D3 SATELLITE FREQUENCY, POLARISATION AND CONNECTIVITY

D SERIES SATELLITE PAYLOAD INFORMATION

6.2 D3 Frequency Translation Characteristics

The D3 Satellite frequency translation characteristics for the Ku band communications payload, including expected stability performance, are as follows:

D3 Satellite Parameter	Performance Measure
BSS Band Services	
Translation Frequency	5,600 MHz
Short-term Drift	±5.0 kHz/month
Long-Term Drift (over satellite life)	±50.0 kHz
FSS Band Services	
Translation Frequency	1,748 MHz
Short-term Drift	±1.75 kHz/month
Long-term Drift (over satellite life)	±15 kHz

TABLE 6.1 D3 KU-BAND TRANSLATION FREQUENCY CHARACTERISTICS

6.3 D3 Satellite Beam Information

The D3 Satellite has several receive and transmit beams on both horizontal and vertical polarisation.

Receive and transmit connectivity may be configured by ground command from the Optus Satellite Control Centre to match system operational requirements as they evolve throughout the life of each satellite.

6.3.1 Receive Beams

The receive beams for the D3 Satellite are as follows:

Transponders	D3 Satellite Receive Beams
Transponders 1-12	BNA or BNANZ
Transponders 13-24	BNB or BNBNZ
Transponders NZ9-NZ16	FNZB

TABLE 6.2 D3 SATELLITE RECEIVE BEAMS

6.3.2 Transmit Beams

The transmit beams for the D3 satellite are as follows:

Transponders	D3 Satellite Transmit Beams
Transponders 1-12	BNA or BNANZ
Transponders 13-24	BNB or BNBNZ
Transponders NZ9-NZ16	FNZB

TABLE 6.3 D3 SATELLITE TRANSMIT BEAMS

6.3.3 D3 Transponder and Beam Connectivity

Transponder connectivity may be configured by ground command from the Optus Satellite Control Centre to match system operational requirements as they evolve throughout the life of each satellite.

The connectivity available on the D3 Satellite is shown in **Table 6.4** below.

Transponder/ Channel No.	Receive Beam					Transmit Beam				
	BNA (H)	BNANZ (H)	BNB (V)	BNBNZ (V)	FNZB (V)	BNA (V)	BNANZ (V)	BNB (H)	BNBNZ (H)	FNZB (H)
B1	S	S				S	S			
B2	S	S				S	S			
B3	S	S				S	S			
B4	S	S				S	S			
B5	S	S				S	S			
B6	S	S				S	S			
B7	S	S				S	S			
B8	S	S				S	S			
B9	S	S				S	S			
B10	S	S				S	S			
B11	S	S				S	S			
B12	S	S				S	S			
B13			S	S				S	S	
B14			S	S				S	S	
B15			S	S				S	S	
B16			S	S				S	S	
B17			S	S				S	S	
B18			S	S				S	S	
B19			S	S				S	S	
B20			S	S				S	S	
B21			S	S				S	S	
B22			S	S				S	S	
B23			S	S				S	S	
B24			S	S				S	S	
FSS NZ backup										
NZ9					X					X
NZ10					X					X
NZ11					X					X
NZ12					X					X
NZ13					X					X
NZ14					X					X
NZ15					X					X
NZ16					X					X

TABLE 6.4 D3 TRANSPONDER AND BEAM CONNECTIVITY

(Each transponder may be switched to one of the beams as shown).

Legend of abbreviations:

BNA BSS band National Beam A

BNB BSS band National Beam B

BNANZ BSS band National Aust Beam A plus New Zealand Beam A

BNBNZ BSS band National Aust Beam B plus New Zealand Beam B

FNZB FSS band NZ Beam B

(V) Vertical polarisation

(H) Horizontal polarisation

X Dedicated beam

S Switchable between beams marked with S for respective transponder

6.4 D3 Satellite Beam Performance Levels

Contour maps of the D3 Satellite beam performance, in terms of G/T and EIRP, are provided in **Attachment 3.**

BSS EIRP maps are based on 125W (saturated). FSS EIRP maps are based on 44W (saturated).

Service designs based on satellite beam performances need to include allowances for the normal performance variations to be expected between different satellite transponders over the operating life of the satellites. To assist design engineers in taking these effects into account, Optus has established a number of "Beam Performance Levels" which include different assumptions about satellite performance. The most important of these is the "General Design Level" which is the only beam performance level for which information is provided in this guide.

6.5 D3 Transponder Gain Control

Each satellite transponder contains a Channel Control Unit (see **Section 5.1**) which provides a means of controlling the transponder gain. This gives the transponder a range of operating C/T values to suit the characteristics of the systems operating on it at a given time. The C/T (called "C-to-T") is the uplink saturated carrier-to-noise-temperature ratio and is a fundamental design parameter of a satellite transponder. It is related to the SFD and G/T by the following equation:

$$C/T = SFD + G/T + 10\log10(\lambda^2/4\pi)$$

- where -

C/T = Saturated carrier-to-noise-temperature ratio (dBW/K)

SFD = Saturated flux density (dBW/m^2)

G/T = Satellite receive gain-to-noise-temperature ratio (dB/K)

$\lambda^2/4\pi$ = Isotropic area conversion factor (m^2)

Note that for a given transponder gain setting the C/T is fixed, meaning that the sum (SFD + G/T) is also fixed, i.e. the SFD and G/T vary in inverse proportion over the satellite receive beam pattern.

On the D3 Satellite two methods are used to provide transponder gain control for a range of C/Ts. Fixed Gain Mode (FGM) and Variable Gain Mode (VGM) are selectable by ground command in accordance with the following specifications.

6.5.1 Fixed Gain Mode (FGM)

FGM corresponds to traditional gain-step control in which a variable step-attenuator is switched under ground command to one of a number of settings or "gain steps".

The D3 Satellite has a gain step control range covering a nominal uplink saturated C/T range of -116 to -135 dBW/K in 1dB steps. At a point in the satellite uplink beam where the G/T is +2dB/K, the corresponding uplink SFD is as specified in **Table 6.5.** Note that the satellite is expected to operate over a C/T range substantially less than shown in this table. The correct selection of operating gain step is important in order to minimise uplink interference between transponders using polarisation or spatial re-use.

Nominal C/T (dBW/K)	SFD (at +2dB/K G/T contour)
-116	-71.7
-135	-90.7

TABLE 6.5 D3 FGM GAIN STEP RANGE

Each transponder is provided with independent ground commandable gain adjustment capability to facilitate selection on any transponder gain step as indicated in **Table 6.5.**

The C/T required for transponder saturation at any selected gain step does not vary by more than ± 1dB over any 24 hour period, and ± 2dB over the spacecraft service life.

6.5.2 Variable Gain Mode (VGM)

VGM provides a form of automatic gain control. Under VGM a feedback-loop maintains a constant input drive level to the transponder TWTA over an operating uplink C/T range. This compensates for uplink fading at the cost of gradually degrading the uplink C/N.

When the spacecraft is illuminated by a single carrier or multiple carriers within the transponder usable bandwidth, at a level required to produce a total receive carrier-to-noise temperature ratio (C/T) in the range

(i) -123 dBW/K to -143 dBW/K (except FNZB),

(ii) -118 dBW/K to -138dBW/K (FNZB)

the transponder operating point is maintained at a total input back-off, selectable by ground command for each transponder, of between -1 and 10dB (in 0.5dB steps) relative to that required for single carrier saturation.

VGM operates on the total transponder power (signal plus noise) and has a time constant of greater than or equal to 10ms and less than 100ms. VGM is therefore intended for either single-carrier operation, or for multiple carriers where all carriers are uplinked from the same location and therefore undergo an uplink fade at the same time. VGM may be used with uplink power control if desired to extend the range of uplink fade compensation.

6.5.3 TDMA Operation

Up to any four (4) transponders may operate in synchronous TDMA mode with burst repetition rate or switching rate higher than 400 Hz simultaneously.

D SERIES SATELLITE PAYLOAD INFORMATION

6.6 D3 Amplitude Transfer Characteristics.

Representative AM/AM transfer characteristics for the TWTAs used in the D3 Satellite is shown in **Figure 6.2.** This shows the transfer curves for single carrier. The X axis defines the Input Backoff (IBO) relative to TWTA saturation for the carrier whilst the Y axis defines the Output Backoff (OBO) for the carrier.

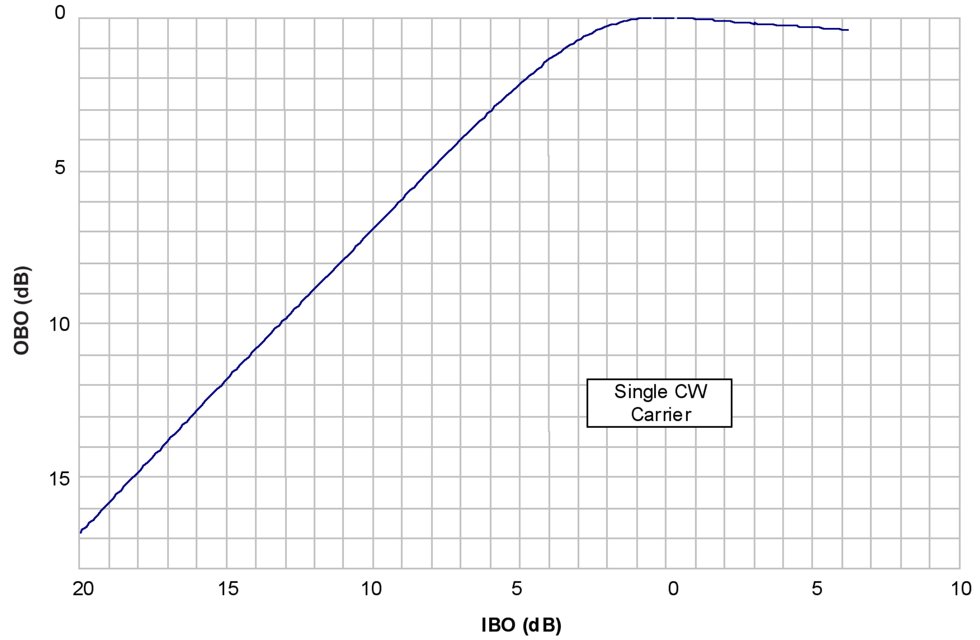


FIGURE 6.2 TYPICAL D3 SATELLITE AMPLITUDE TRANSFER CHARACTERISTIC

Figure 6.3 shows the normalised TWTA gain of a typical D3 Satellite transponder as a function of Input Backoff (IBO) for a single carrier. The X axis defines the Input Backoff (IBO) relative to TWTA saturation for the carrier whilst the Y axis defines the carrier gain of the transponder.

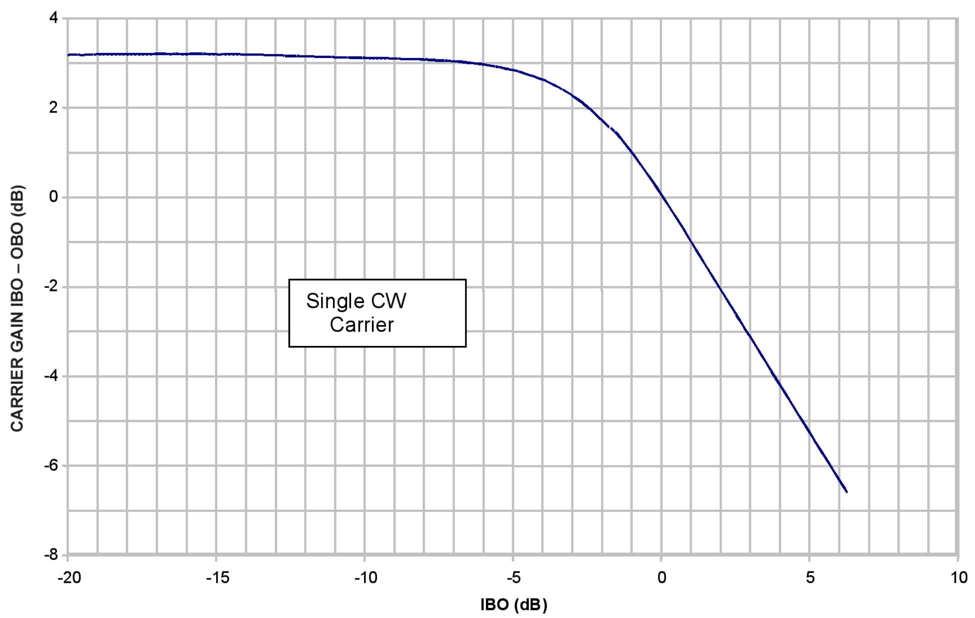


FIGURE 6.3 TYPICAL D3 SATELLITE TRANSPONDER GAIN CHARACTERISTIC

6.7 D3 Satellite Cross Polarisation Discrimination

Cross polarisation performance of the orthogonally polarised repeaters BNA and BNB, and FNZB for the D3 satellite receive and transmit beams, will equal or exceed the following performance levels:

For the BNA, BNB and FNZB beams, the Satellite Receive Cross Polarisation Discrimination over 100% of the coverage area is at least 30dB

For the BNA, BNB, and FNZB beams, the Satellite Transmit Cross Polarisation Discrimination over 100% of the coverage area is at least 30dB

Cross-polarisation performance of the satellite link can be expected to degrade during rain storms and under other adverse weather conditions.

6.8 D3 Satellite Co Polarisation and Cross Polarisation Isolation

When operating BNANZ and BNBNZ beams co polarisation isolation performance between the Australia and NZ uplink beams is also important because of the way the combined Australia and NZ beam is produced. The performance levels are indicated in **Tables 6.6 and 6.7.**

Desired Beam co pol	Interfering Beam co pol	Receive Co Pol Isolation between Aust and NZ uplink beams over Coverage Area except Lord Howe and Norfolk Islands	Receive Co Pol Isolation between Aust and NZ uplink beams over Lord Howe Island	Receive Co Pol Isolation between Aust and NZ uplink beams over Norfolk Island
BNANZ Aust U/L	BNANZ NZ U/L	30 dB	min 25 dB	min 15 dB
BNANZ NZ U/L	BNANZ Aust U/L	30 dB	min 25 dB	min 15 dB

TABLE 6.6 D3 SATELLITE RECEIVE CO POLARISATION ISOLATION

Desired Beam Co Pol	Interfering Beam Co Pol	Transmit Co Pol Isolation between Aust and NZ downlink beams over Coverage Area except Lord Howe and Norfolk Islands	Transmit Co Pol Isolation between Aust and NZ downlink beams over Lord Howe Island	Transmit Co Pol Isolation between Aust and NZ downlink beams over Norfolk Island
BNANZ Aust U/L	BNANZ NZ U/L	30 dB	min 25 dB	min 15 dB
BNANZ NZ U/L	BNANZ Aust U/L	30 dB	min 25 dB	min 15 dB

TABLE 6.7 D3 SATELLITE TRANSMIT CO POLARISATION ISOLATION

For the BNA, BNB, BNANZ, BNBNZ,FNZB beams, the Satellite Receive Cross Polarisation Isolation over 100% of the coverage area is at least 30dB.

For the BNA, BNB, BNANZ, BNBNZ,FNZB beams, the Satellite Transmit Cross Polarisation Isolation over 100% of the coverage area is at least 30dB.

6.9 D3 Satellite Beacons

All Optus satellites transmit beacon signals which are used by Optus to monitor the condition of the spacecraft and which may be used by customer earth stations for antenna tracking and uplink power control (UPC). The UPC beacon is appropriate for tracking by customer earth stations.

6.9.1 Telemetry Beacons

The D3 satellite transmits three telemetry beacons. The third beacon is a standby beacon and is not activated if either of the first two beacons is functional. These beacons are transmitted in Right Hand Circular polarisation via the Omni antenna for transfer orbit activities. For on station service these beacons are transmitted in Vertical polarisation over the D3 satellite BNA Beam service area. The Beacon frequencies are 12239.25MHz and 12241.25MHz. **Table 6.8** indicates specifications of the Telemetry beacons.

D3 Telemetry Beacons	
Frequency TM1	12239.25MHz
Frequency TM2	12241.25MHz
Frequency TM3 Note 1	12239.25MHz
Frequency Stability	± 25KHz over any 24 hour period
	± 130KHz over the spacecraft lifetime
Polarisation	Vertical – On Station
EIRP at Perth	18.5 dBW min on station
EIRP at Sydney	18.5 dBW min on station
EIRP Zone 1 Note 2	18.1 dBW min on station
EIRP Zone 2 Note 3	17.7 dBW min on station
EIRP Zone 3 Note 4	17.5 dBW min on station
EIRP Zone 4 Note 5	13.0 dBW min on station

TABLE 6.8 D3 SATELLITE TELEMETRY BEACONS

Note 1: TM3 is turned off if either TM1 or TM2 is functional

Note 2: Zone 1 Brisbane to Melbourne Coastal

Note 3: Zone 2 Cairns to Adelaide Coastal and Perth and SW West Australia area

Note 4: Zone 3 Tasmania

Note 5: Zone 4 Remainder of mainland Australia

Note 6: Zone 5 McMurdo Sound. Edge of coverage estimated EIRP level.This estimate does not take into consideration the effects of multipath interference due to low elevation angles and ice depolarisation.

6.9.2 Uplink Power Control Beacon

The D3 satellite carries an uplink power control beacon which is used for tracking and Uplink Power Control (UPC). This beacon is radiated in Left Hand Circular Polarisation over the D3 satellite service area. The beacon frequency is 12201.1 MHz. The frequency stability of the UPC beacon is as specified in **Table 6.9.** Within the BSS service area, the received EIRP level of the UPC beacon is at least 10.0dBW measured within a 1KHz bandwidth centred on the beacon centre frequency. The level received will be 3dB lower when received with a linear feed on either polarisation.

D3 UPC Beacon	
Frequency	12201.1 MHz
Frequency Stability	± 10KHz over any 24 hour period
	± 15KHz over any 1 month period
	± 100KHz over the spacecraft service life.
Polarisation	Left Hand Circular
EIRP across BSS Service Area	>10.0 dBW throughout BSS service area Aust and NZ
EIRP at Sydney	11.2 dBW

TABLE 6.9 D3 SATELLITE UPC BEACON

6.10 D3 Uplink Power Control Operation

Customers may use uplink power control systems (UPC) to compensate for uplink rain attenuation. Since a malfunctioning UPC system can interfere with other services and even damage a satellite TWTA, UPC systems must be approved by Optus before use and are strictly limited in the amount of uplink compensation permitted. Details of the amount of UPC permitted under various operating conditions may be obtained from Optus.

UPC systems use the attenuation measured on a downlink beacon to compensate for attenuation on the uplink. However attenuation is frequency-dependent and a scaling factor needs to be applied to determine the correct uplink compensation. At 17/11-12GHz Optus recommends a scaling factor of 1.9.

In the case of transferring services from the C1 satellite to the D3 satellite, both UPC beacons are Left Hand Circular polarisation but there is a minor level difference of about 0.5dB between the C1 and D3 satellites.

D SERIES SATELLITE PAYLOAD INFORMATION

ATTACHMENT 1

D1 Satellite Beam Contours for the Ku-Band Communications Payload

The contour diagrams in Attachment 1 show the General Design Levels for geostationary Optus satellites.

This information contains tested D1 Ku-band patterns. The patterns are composites of three frequencies and therefore represent the worst-case over frequency. They also include worst-case beam pointing errors.

Contour diagrams, Figures A1-1 to A1-10 are provided for satellite G/T for FNB, FNANZ and FNZB and for EIRP for FNA, FNB, FNANZ, FNZA and FNZB.

The satellite G/T indicates the satellite transponder receive performance level at the satellite as "seen" from the ground.

The contour diagrams of EIRP show the radiated satellite transponder power in the direction of the ground locations.

FNA, FNB & FNANZ EIRP maps are based on 125W (linearised), i.e. 0.8dB output backoff from 150W saturated.

FNZA & FNZB EIRP maps are based on 44W (saturated).

The contours for the D1 satellite apply to orbit location of 160° East.

All patterns contained within this document are based on the manufacturer's data .

Contracted performance will need to be marginally lower than that specified in this document to allow for individual transponder differences, TWT redundancy and different orbital locations.

General Design Level

The General Design Level (GDL) of beam performance represents the best estimate by Optus of the worst-case performance through to end-of-life for any satellite transponder switched to a particular beam. It allows for all possible cases of service restoration or transponder reallocation, and Optus recommends that it be used for the design of satellite systems to ensure that they will work on any satellite transponder through to end-of-life. In particular the General Design Level of beam performance is recommended for the sizing of earth station antennas and High Power Amplifiers (HPAs) on the uplink, and the calculation of earth station receive G/Ts on the downlink.

The contour maps show the General Design Level of beam performance at the time of publication of this guide for the D1 satellite operating in geostationary orbit.

Specific Performance Levels

Beam performance specific to a given transponder on a given satellite in a given orbit position at a given time will be provided by Optus to customers on request. Optus does not recommend that specific performance levels be used to design systems or size earth stations.

Optus will only contract to a Warranted Performance Level which makes allowances for all possible cases of service restoration or transponder reallocation.

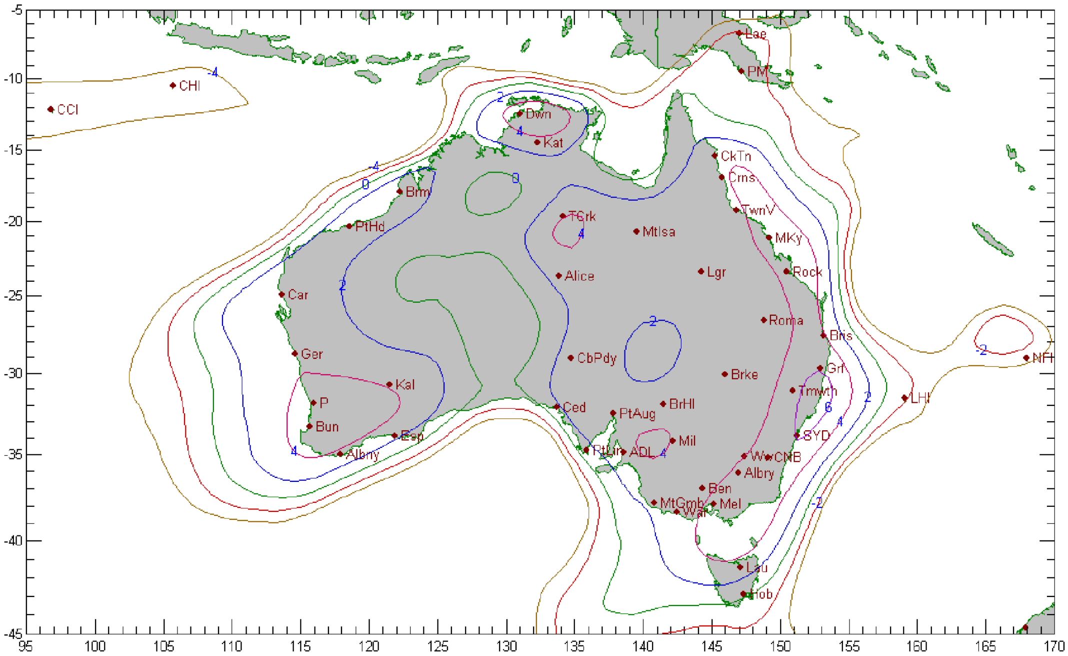


FIGURE A1-1 D1 FNB BEAM RECEIVE GAIN ON TEMPERATURE (G/T) AUSTRALIA

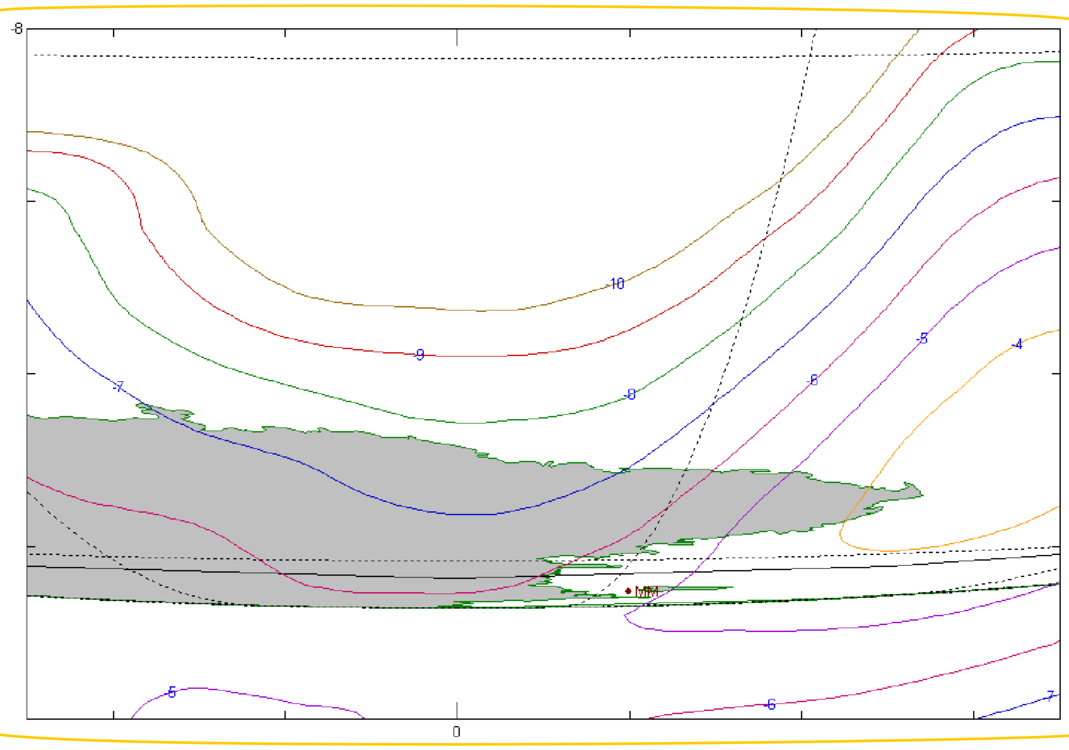


FIGURE A1-2 D1 FNB BEAM RECEIVE GAIN ON TEMPERATURE (G/T) MCMURDO SOUND

D SERIES SATELLITE PAYLOAD INFORMATION

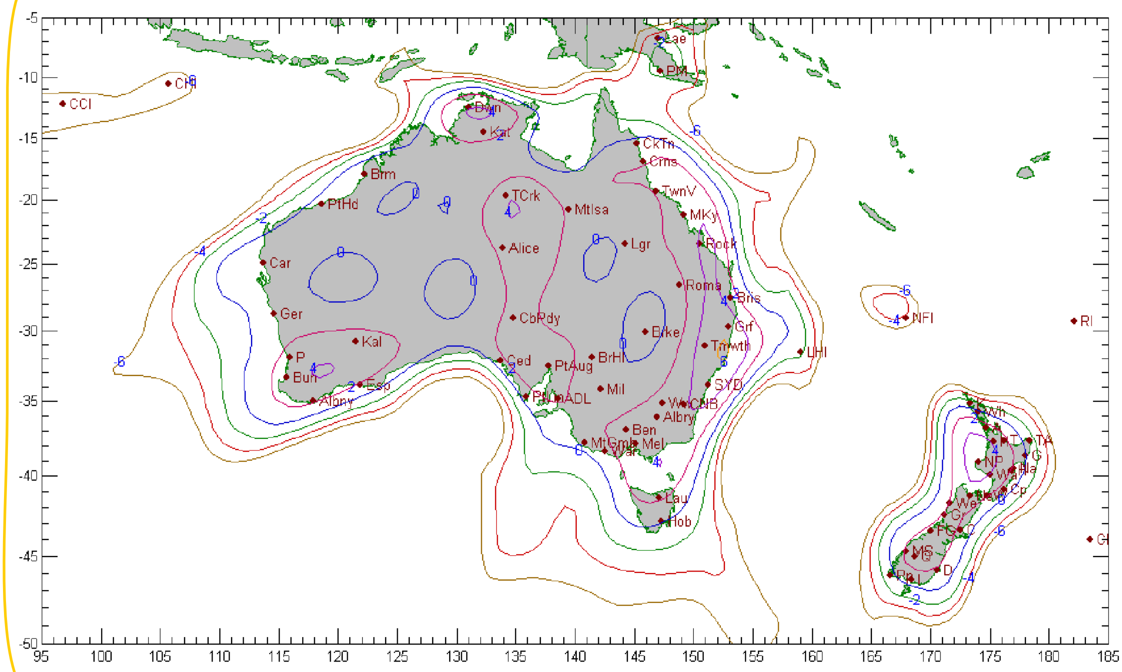


FIGURE A1-3 D1 FNANZ BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

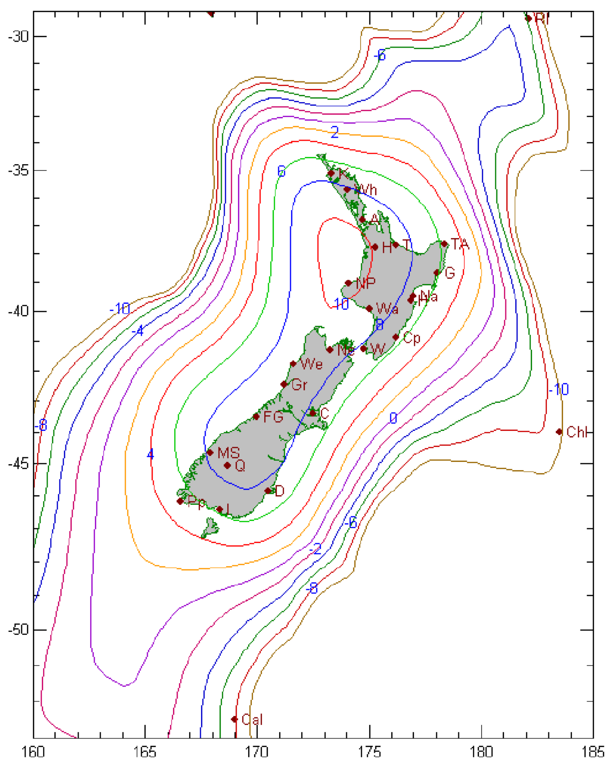


FIGURE A1-4 D1 FNZB BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

D SERIES SATELLITE PAYLOAD INFORMATION

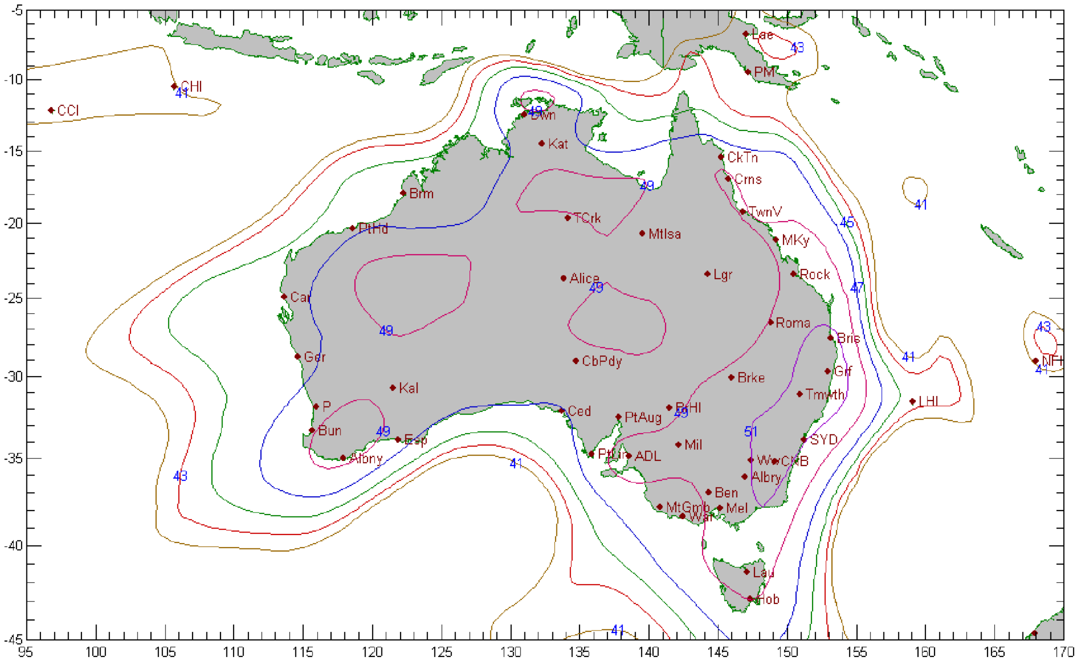


FIGURE A1-5 D1 FNB BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP) AUSTRALIA

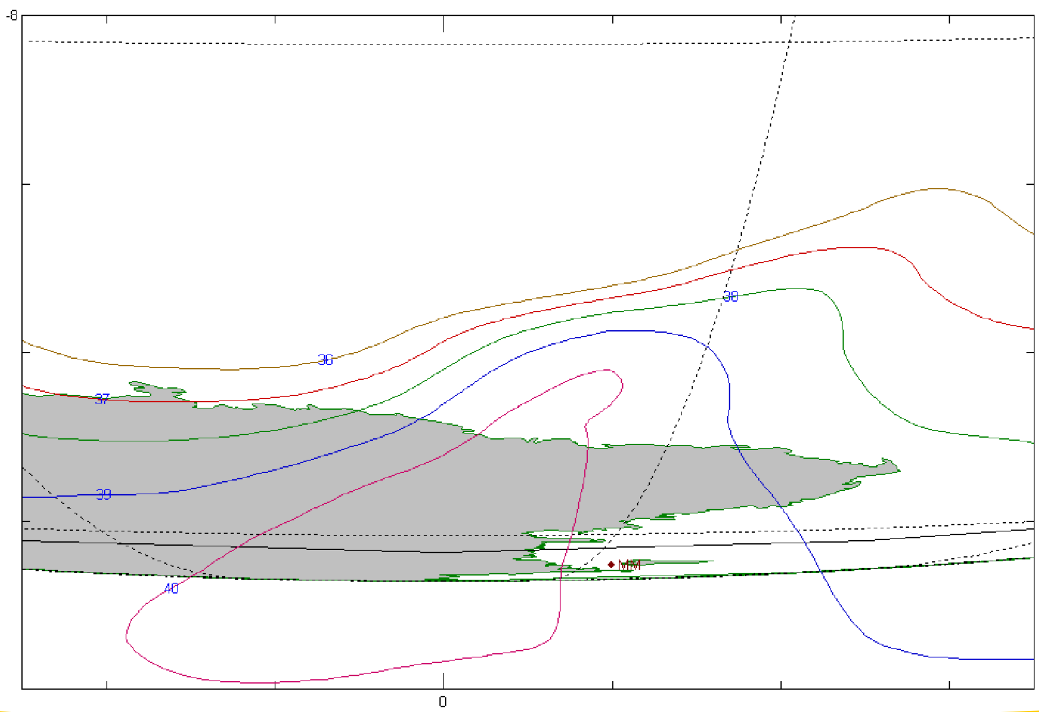


FIGURE A1-6 D1 FNB BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP) MCMURDO SOUND

D SERIES SATELLITE PAYLOAD INFORMATION

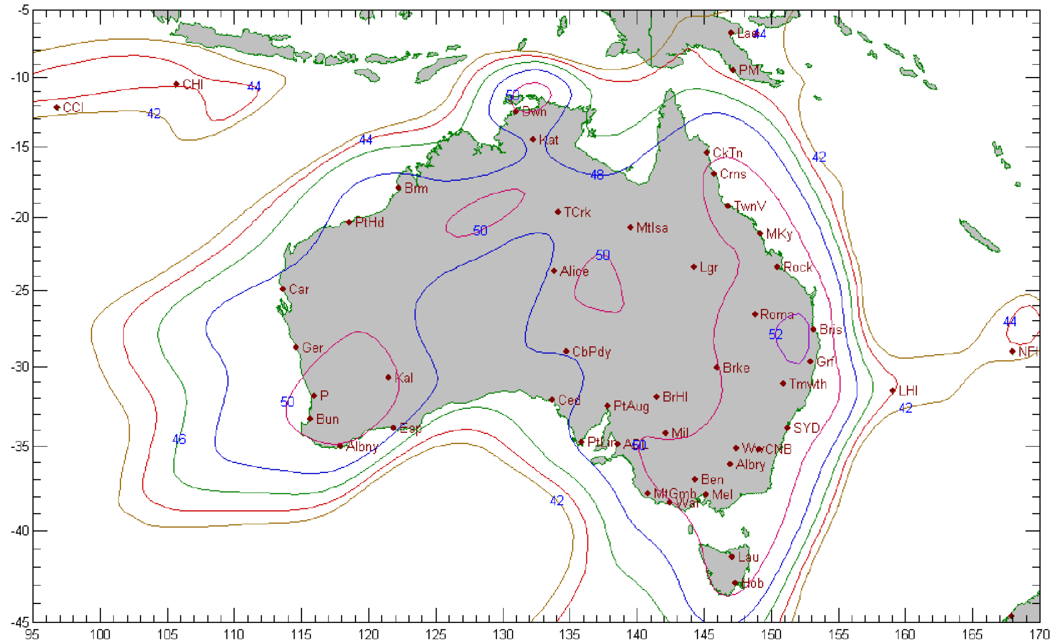


FIGURE A1-7 D1 FNA BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

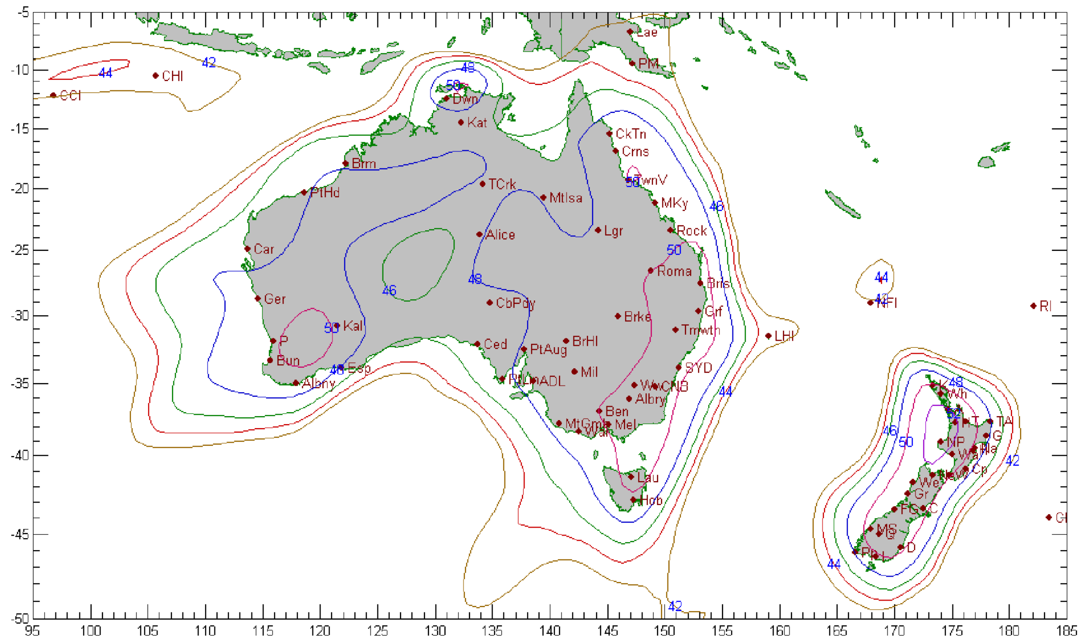


FIGURE A1-8 D1 FNANZ BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

D SERIES SATELLITE PAYLOAD INFORMATION

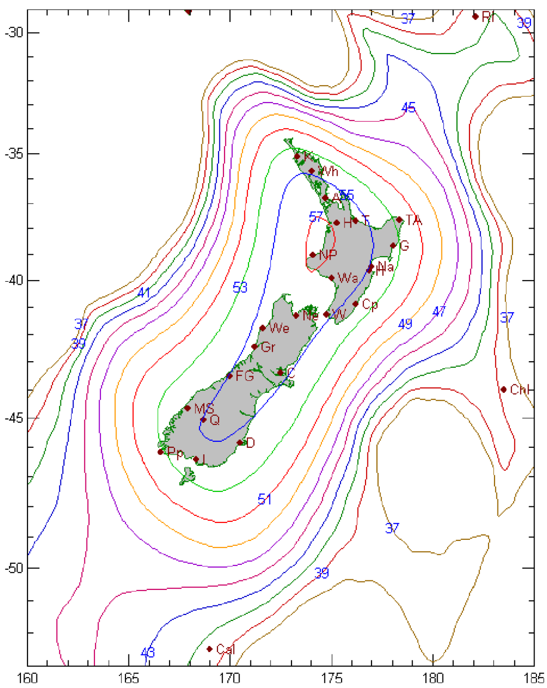


FIGURE A1-9 D1 FNZB BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

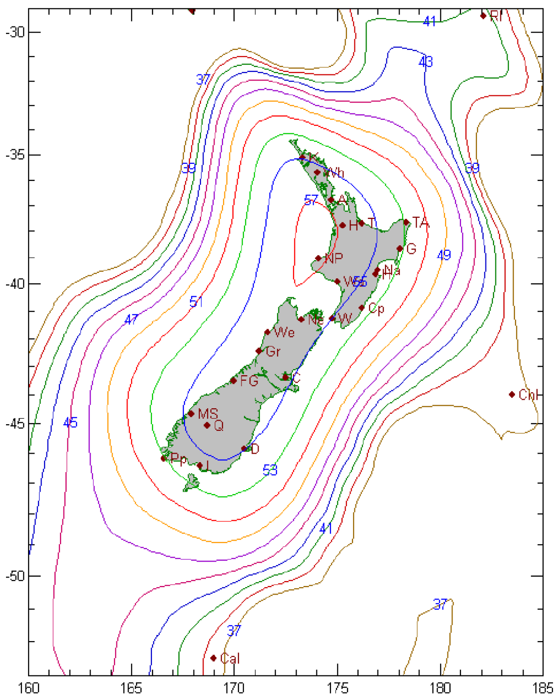


FIGURE A1-10 D1 FNZA BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

OPTUS yes

ATTACHMENT 2

D2 Satellite Beam Contours for the Ku-Band Communications Payload

The contour diagrams in Attachment 2 show the General Design Levels for geostationary Optus satellites.

This information contains tested D2 Ku-band patterns. The patterns are composites of three frequencies and therefore represent the worst-case over frequency. They also include worst-case beam pointing errors.

Contour diagrams, Figures A2-1 to A2-10 are provided for satellite G/T for FNB, FNANZ and FNZB and for EIRP for FNA, FNB, FNANZ, FNZA and FNZB.

The satellite G/T indicates the satellite transponder receive performance level at the satellite as "seen" from the ground.

The contour diagrams of EIRP show the radiated satellite transponder power in the direction of the ground locations.

FNA, FNB & FNANZ EIRP maps are based on 125W (saturated).

FNZA & FNZB EIRP maps are based on 44W (saturated).

The contours for the D2 satellite apply to orbit location of 152° East.

All patterns contained within this document are based on the manufacturer's data .

Contracted performance will need to be marginally lower than that specified in this document to allow for individual transponder differences, TWT redundancy and different orbital locations.

General Design Level

The General Design Level (GDL) of beam performance represents the best estimate by Optus of the worst-case performance through to end-of-life for any satellite transponder switched to a particular beam. It allows for all possible cases of service restoration or transponder reallocation, and Optus recommends that it be used for the design of satellite systems to ensure that they will work on any satellite transponder through to end-of-life. In particular the General Design Level of beam performance is recommended for the sizing of earth station antennas and High Power Amplifiers (HPAs) on the uplink, and the calculation of earth station receive G/Ts on the downlink.

The contour maps show the General Design Level of beam performance at the time of publication of this guide for the D2 satellite operating in geostationary orbit.

Specific Performance Levels

Beam performance specific to a given transponder on a given satellite in a given orbit position at a given time will be provided by Optus to customers on request. Optus does not recommend that specific performance levels be used to design systems or size earth stations.

Optus will only contract to a Warranted Performance Level which makes allowances for all possible cases of service restoration or transponder reallocation.

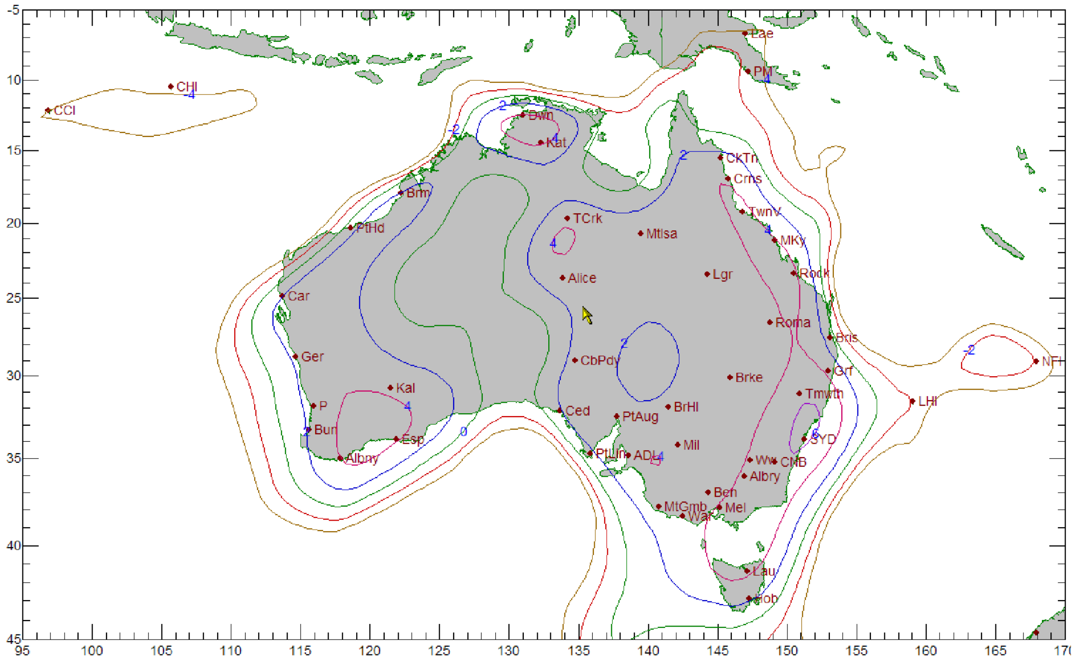


FIGURE A2-1 D2 FNB BEAM RECEIVE GAIN ON TEMPERATURE (G/T) AUSTRALIA

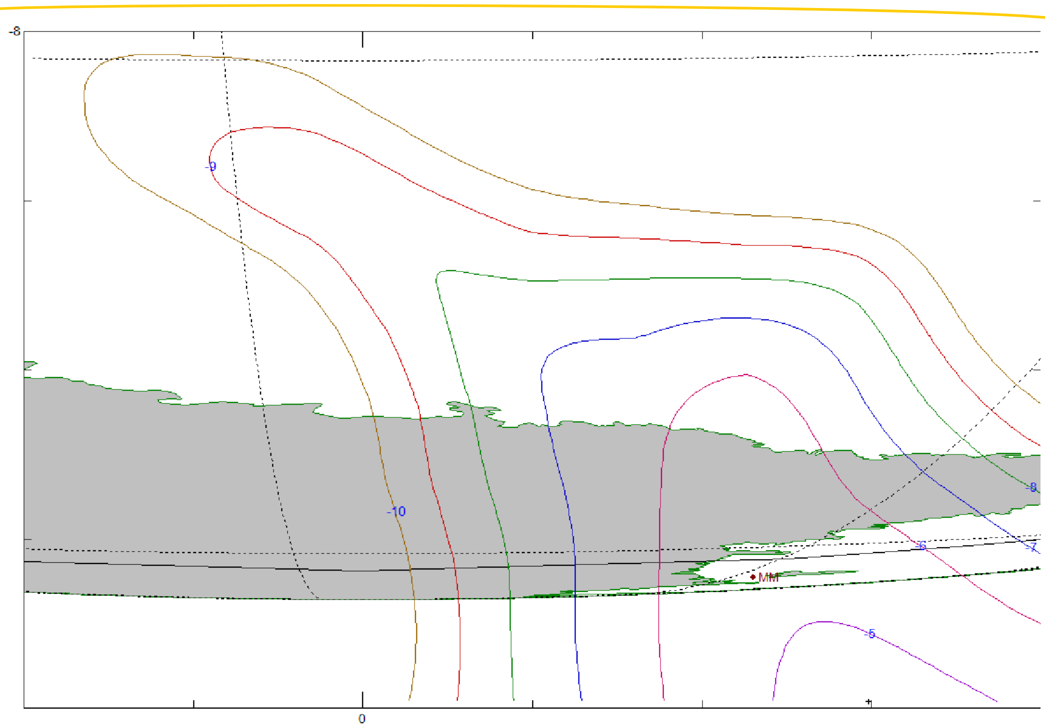


FIGURE A2-2 D2 FNB BEAM RECEIVE GAIN ON TEMPERATURE (G/T) MCMURDO SOUND

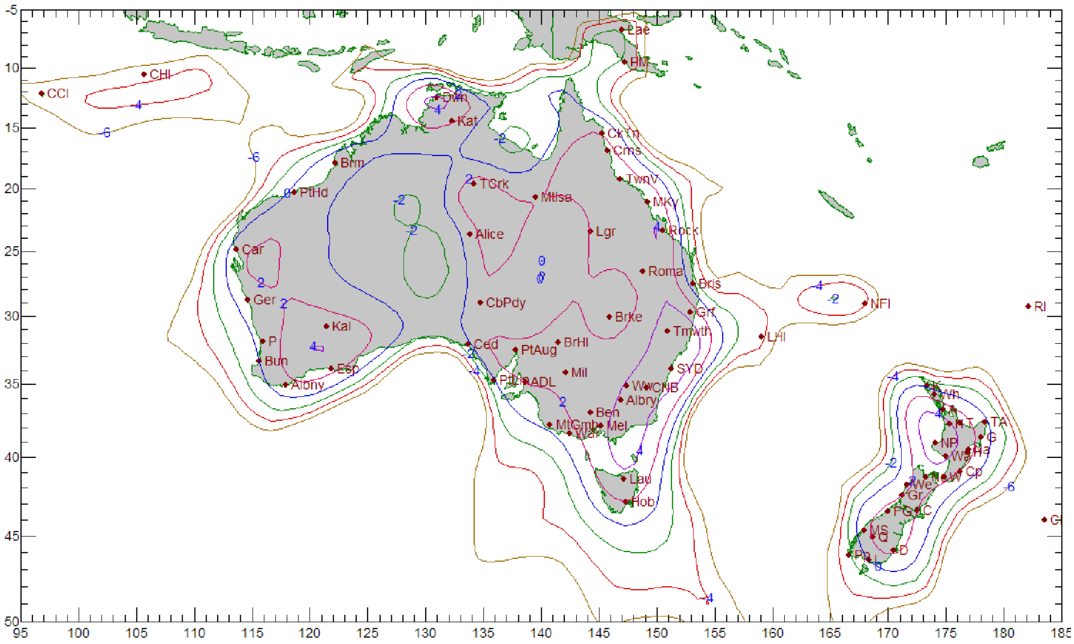


FIGURE A2-3 D2 FNANZ BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

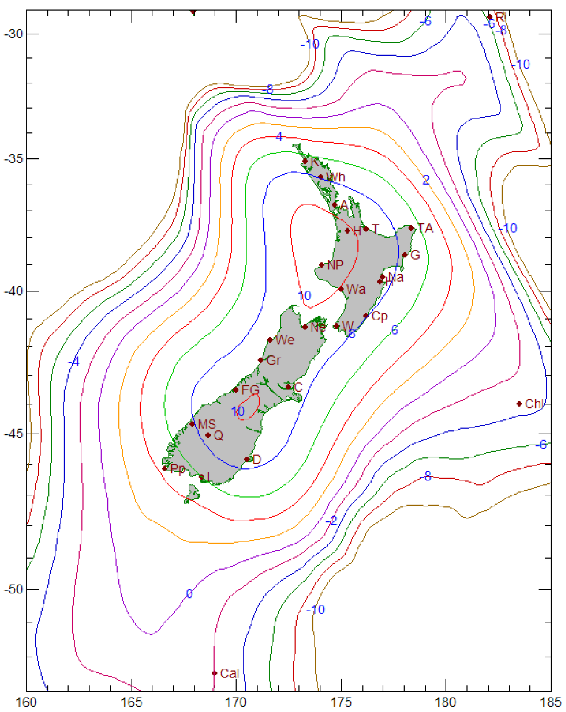


FIGURE A2-4 D2 FNZB BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

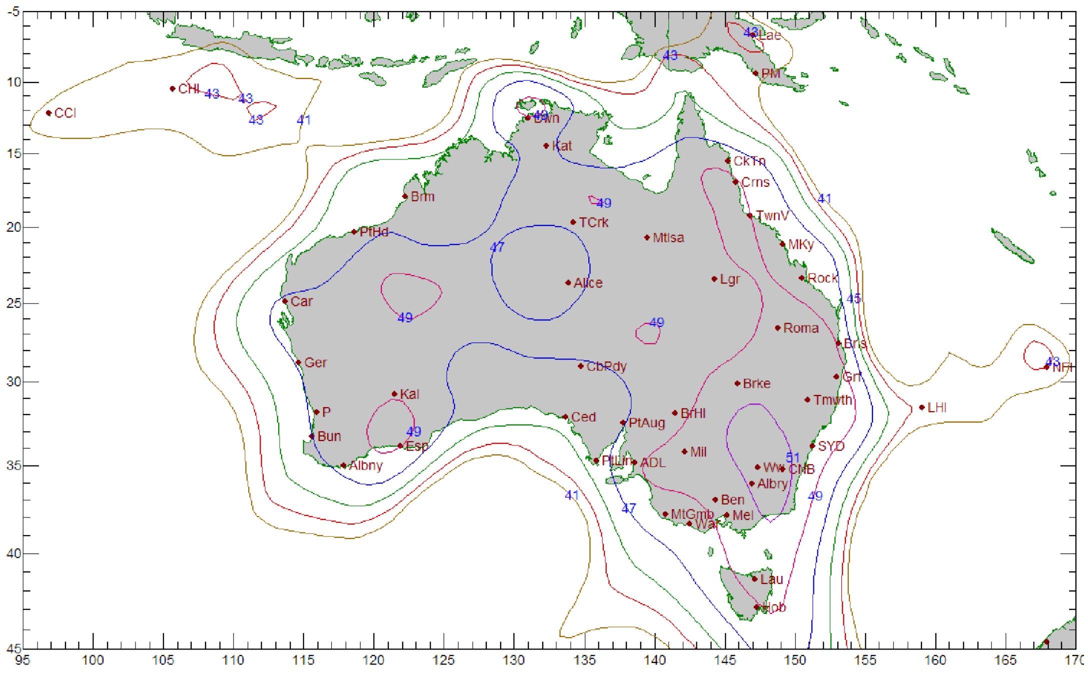


FIGURE A2-5 D2 FNB BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP) AUSTRALIA

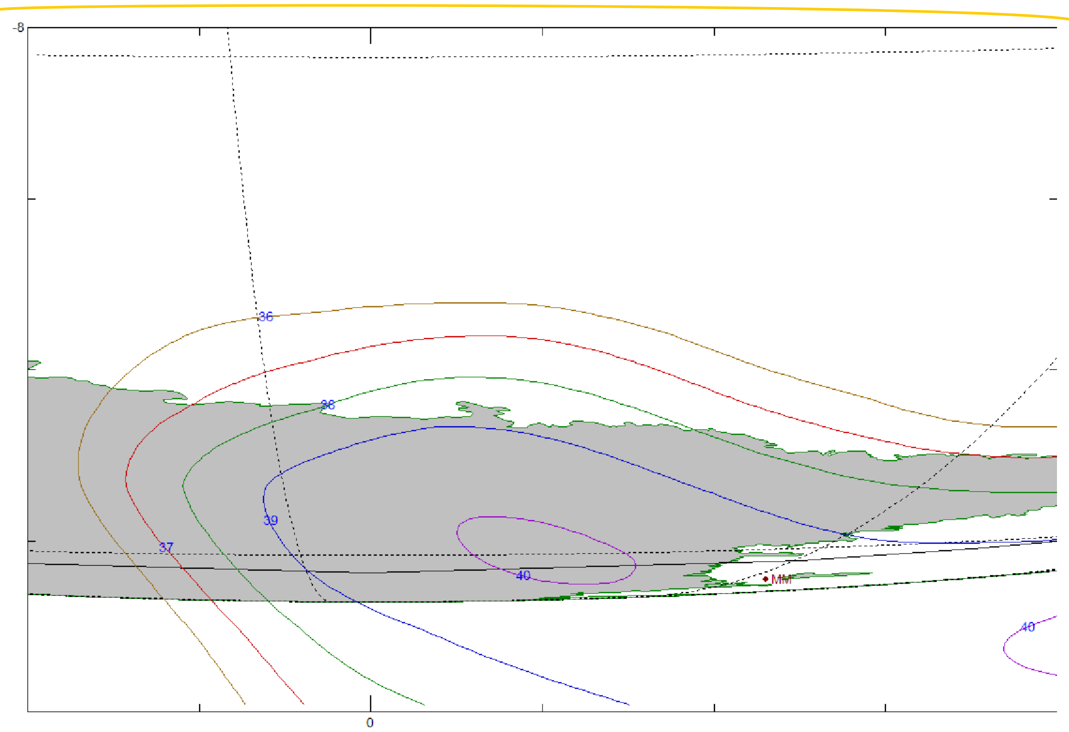


FIGURE A2-6 D2 FNB BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP) MCMURDO SOUND

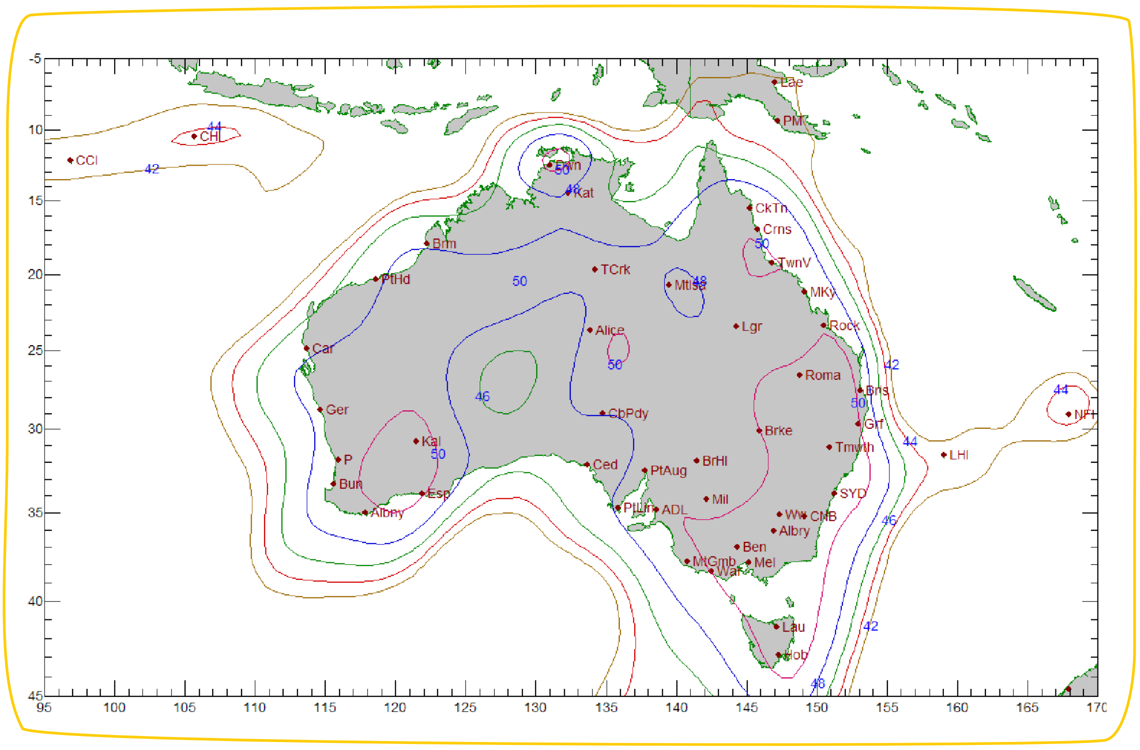


FIGURE A2-7 D2 FNA BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

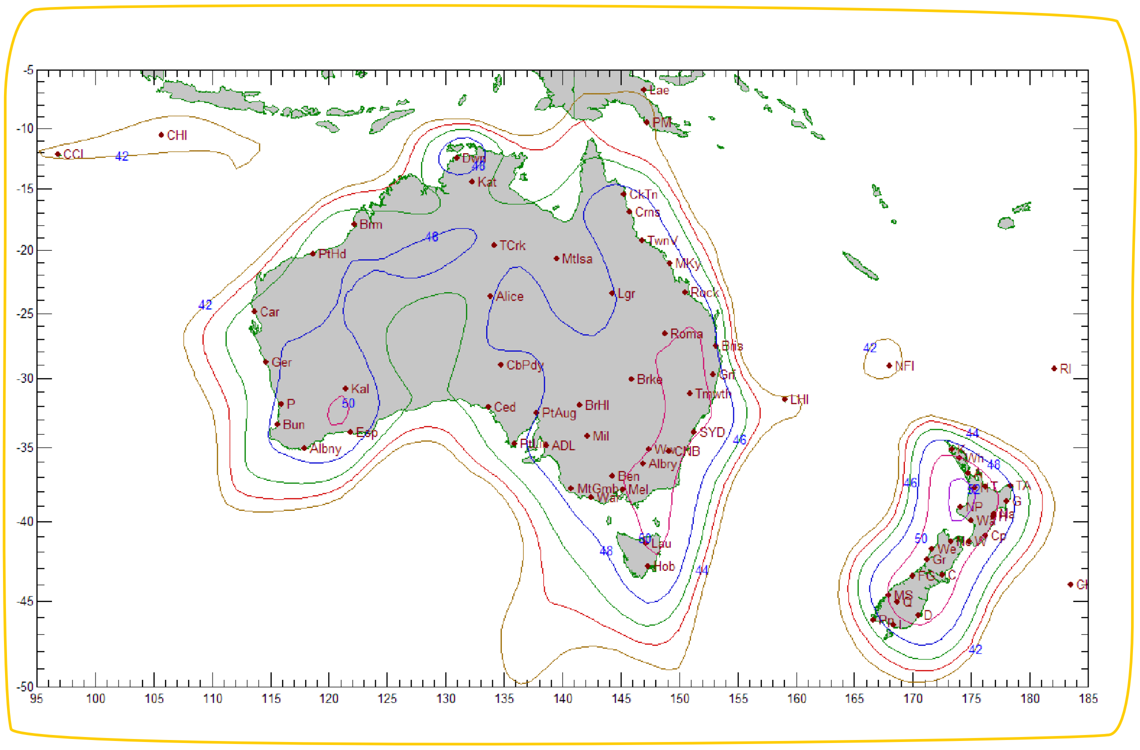


FIGURE A2-8 D2 FNANZ BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

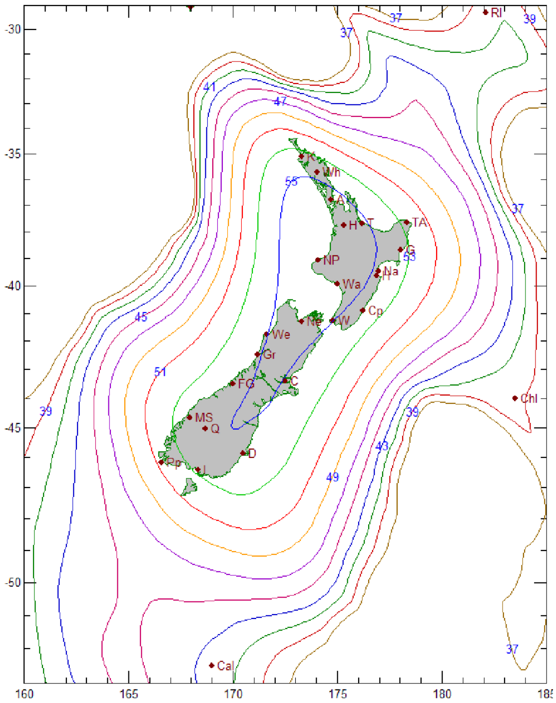


FIGURE A2-9 D2 FNZB BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

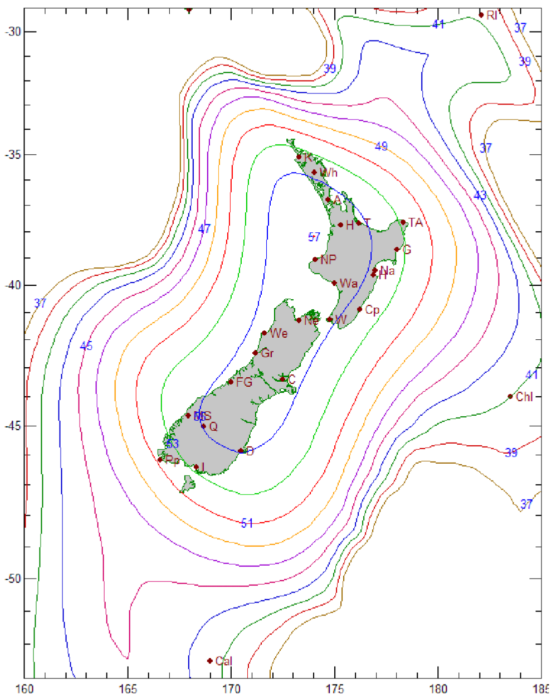


FIGURE A2-10 D2 FNZA BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

D SERIES SATELLITE PAYLOAD INFORMATION

ATTACHMENT 3

D3 Satellite Beam Contours for the Ku-Band Communications Payload

The contour diagrams in **Attachment 3** show the General Design Levels for geostationary Optus satellites.

This information contains tested D3 Ku-band patterns. The patterns are composites of three frequencies and therefore represent the worst-case over frequency. They also include worst-case beam pointing errors.

Contour diagrams, Figures A3-1 to A3-10 are provided for satellite G/T and EIRP for BNA, BNB, BNANZ, BNBNZ and FNZB (Back up coverage for NZ D1 capacity).

The satellite G/T indicates the satellite transponder receive performance level as “seen” from the ground.

The contour diagrams of EIRP show the radiated satellite transponder power as “seen” on the ground for a single saturating carrier.

BSS EIRP maps are based on 125W (saturated).

FSS EIRP maps are based on 44W (saturated).

The contours for the D3 satellite apply to orbit location of 156° East.

All patterns contained within this document are indicative based on the manufacturer’s measured data.

Contracted performance will need to be marginally lower than that specified in this document to allow for individual transponder differences, TWT redundancy and different orbital locations.

General Design Level

The General Design Level (GDL) of beam performance represents the best estimate by Optus of the worst-case performance through to end-of-life for any satellite transponder switched to a particular beam. It allows for all possible cases of service restoration or transponder reallocation, and Optus recommends that it be used for the design of satellite systems to ensure that they will work on any satellite transponder through to end-of-life. In particular the General Design Level of beam performance is recommended for the sizing of earth station antennas and High Power Amplifiers (HPAs) on the uplink, and the calculation of earth station receive G/Ts on the downlink.

The contour maps show the General Design Level of expected beam performance at the time of publication of this guide for the D3 satellite operating in geostationary orbit.

Specific Performance Levels

Beam performance specific to a given transponder on a given satellite in a given orbit position at a given time will be provided by Optus to customers on request. Optus does not recommend that specific performance levels be used to design systems or size earth stations.

Optus will only contract to a Warranted Performance Level which makes allowances for all possible cases of service restoration or transponder reallocation.

D SERIES SATELLITE PAYLOAD INFORMATION

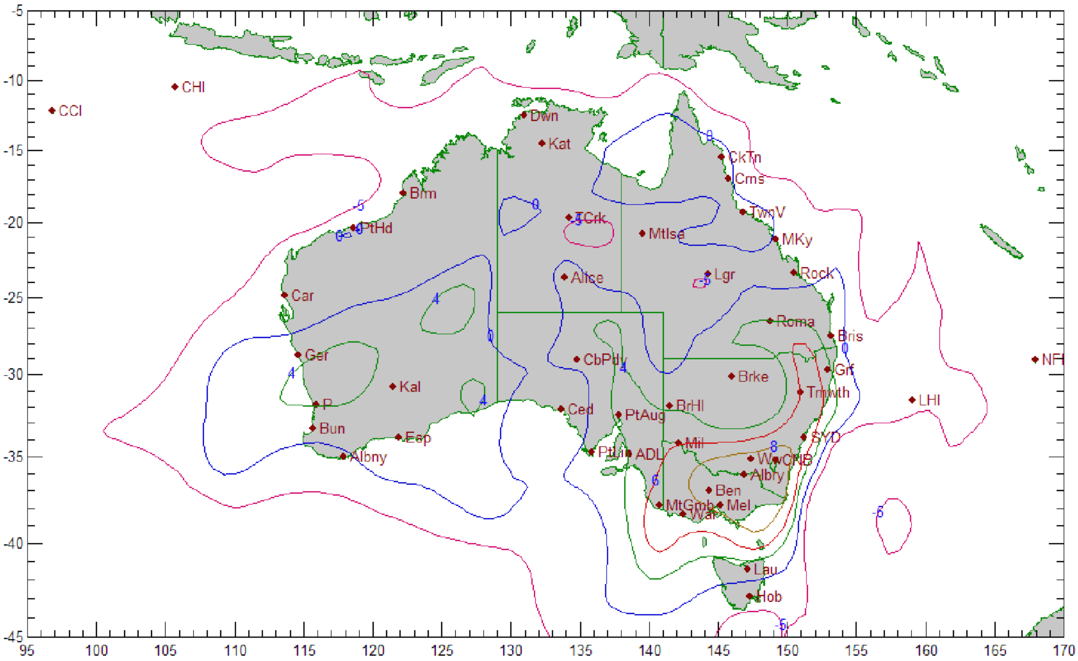


FIGURE A3-1 D3 BNA BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

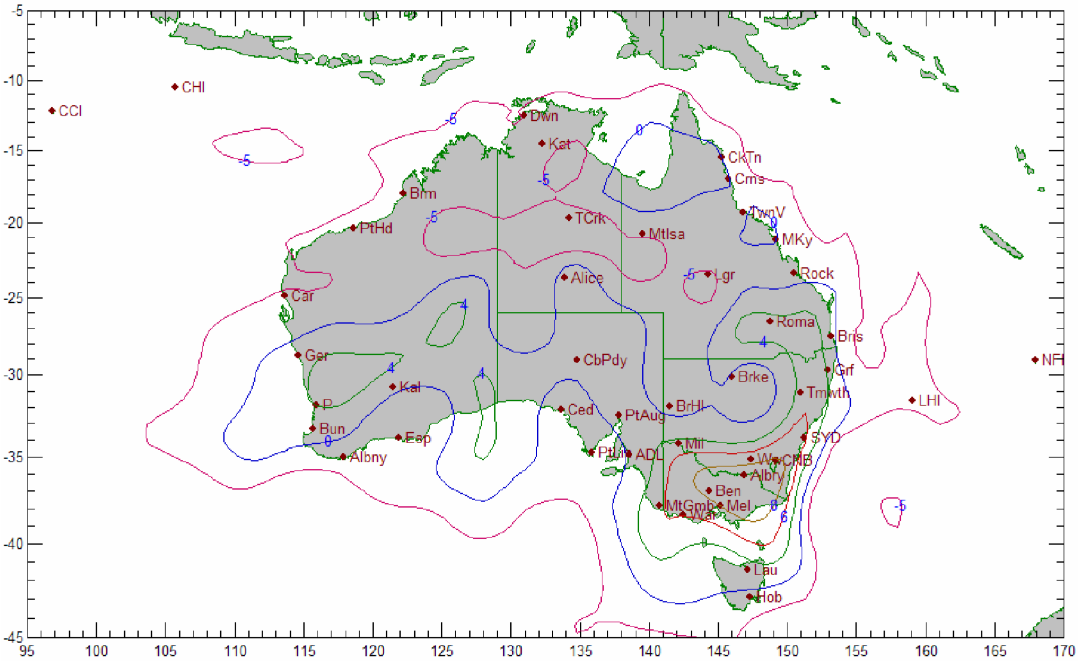


FIGURE A3-2 D3 BNB BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

D SERIES SATELLITE PAYLOAD INFORMATION

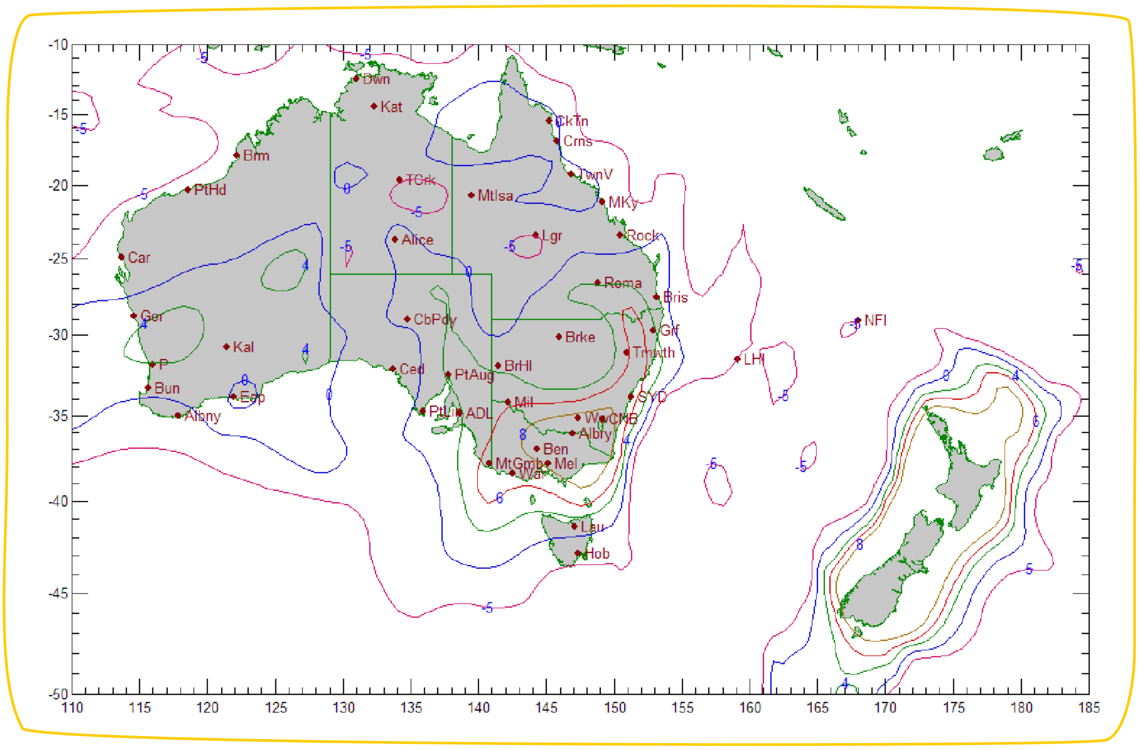


FIGURE A3-3 D3 BNANZ BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

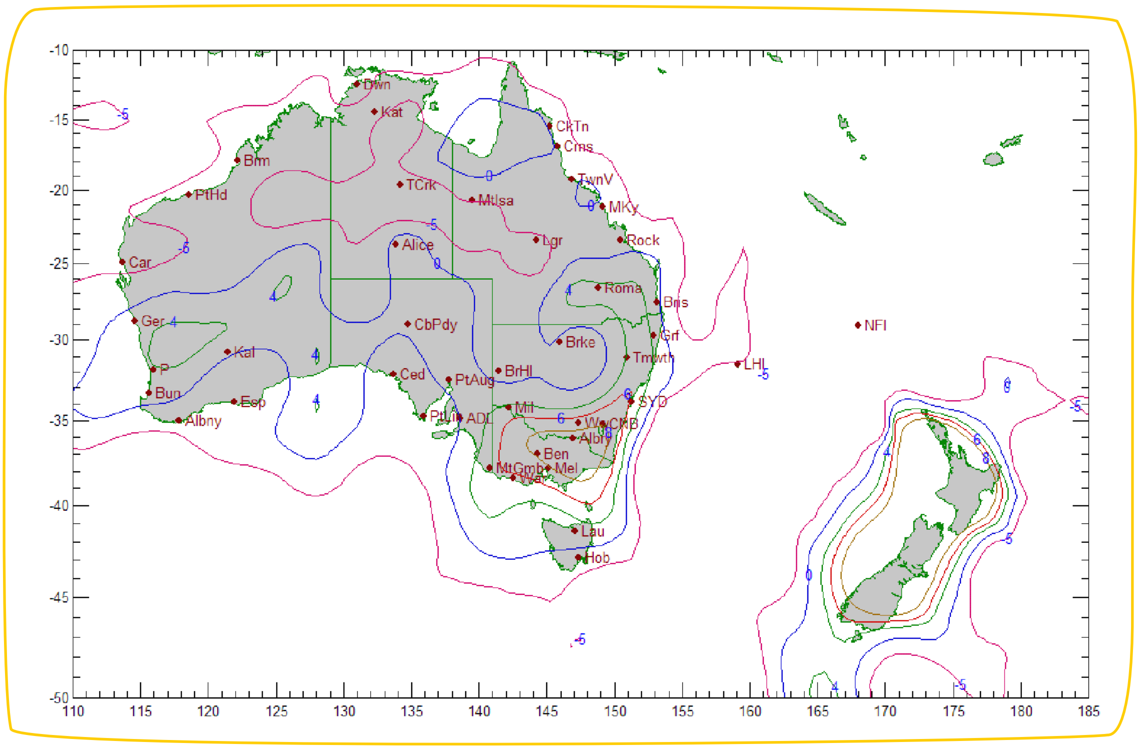


FIGURE A3-4 D3 BNBNZ BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

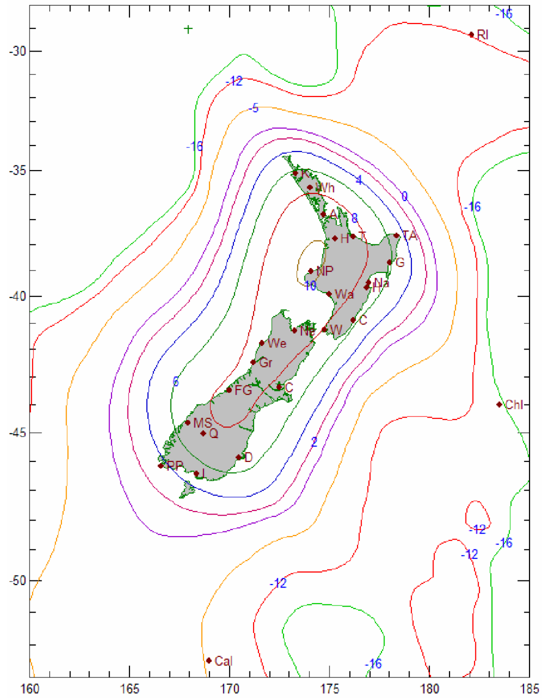


FIGURE A3-5 D3 FNZB BEAM RECEIVE GAIN ON TEMPERATURE (G/T)

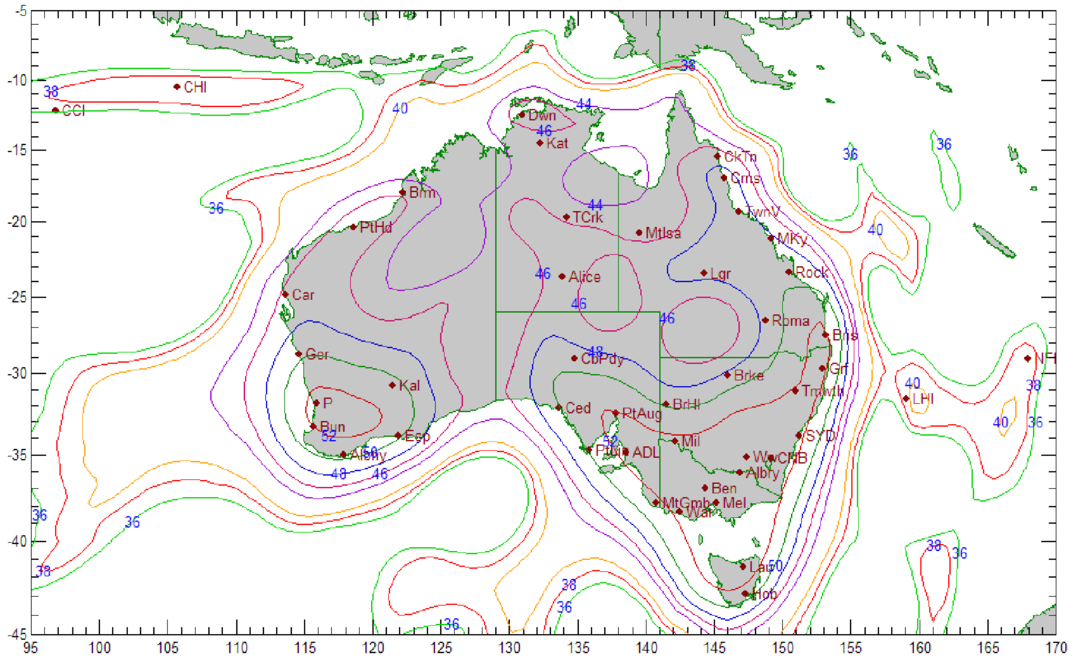


FIGURE A3-6 D3 BNA BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

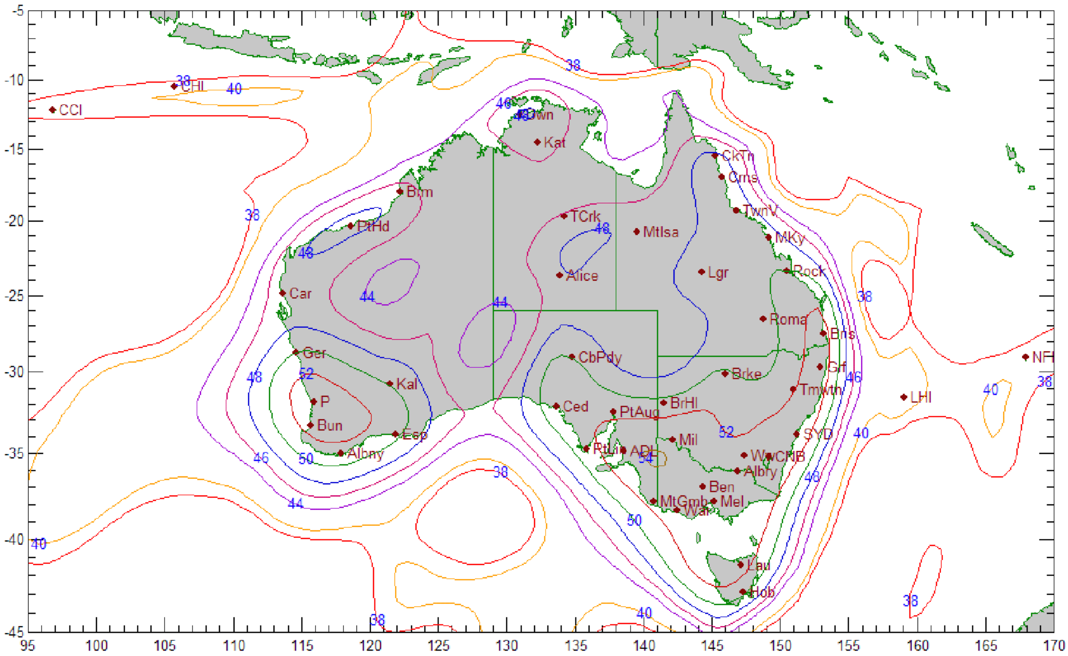


FIGURE A3-7 D3 BNB BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

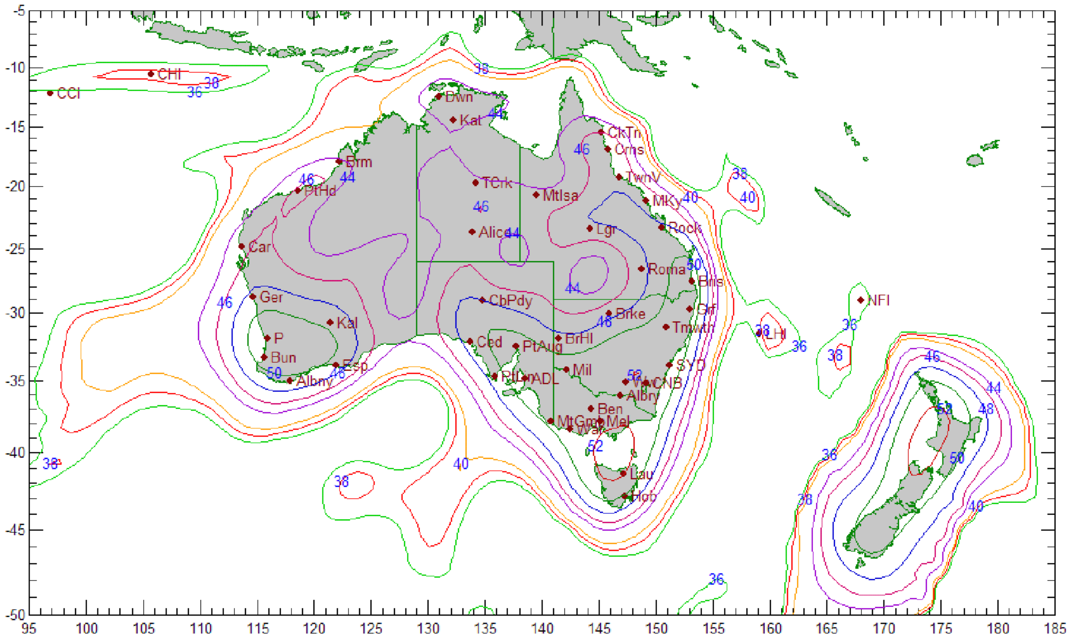


FIGURE A3-8 D3 BNANZ BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

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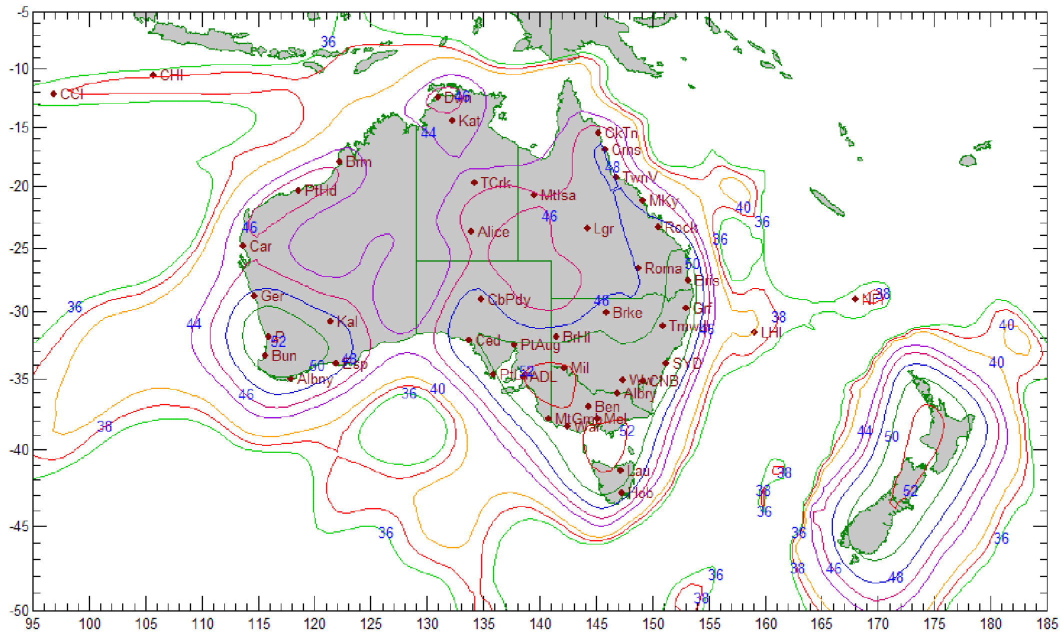

FIGURE A3-9 D3 BNBNZ BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

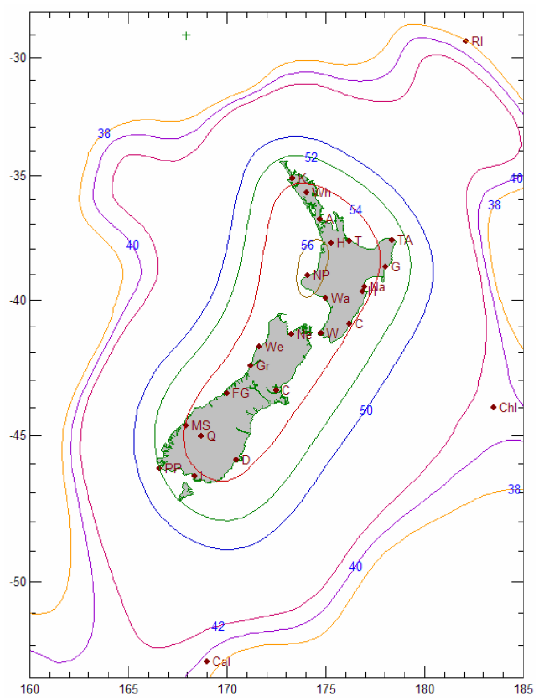

FIGURE A3-10 D3 FNZB BEAM EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)

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NETWORKS MADE EASY-PEASY

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