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PATH LOSS AND RISK ASSESSMENT REPORT FOR HARTEBEESLEEGTE BASED ON THE EMISSION CONTROL PLAN FOR THE ACCIONA AW125 TH100A WTG

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ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
AM	Amplitude Modulation
CAL	Calibration
CCW	Counter Clockwise
CM	Common Mode
E-Fields	Electric Fields
EM	Electro Magnetic
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
Eq	Equation
EUT	Equipment Under Test
Fr	Resonant frequency
H- Fields	Magnetic Fields
IEEE	Institute of Electrical and Electronic Engineers
MIL-STD	Military Standard
PSU	Power Supply Unit
R&S	Rohde and Schwarz
RF	Radio Frequency
SE	Shielding Effectiveness
SELDS	Shielded Enclosure Leak Detection System
SKA	Square Kilometer Array

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1. INTRODUCTION

An area 75km north of Loeriesfontein in the Northern Cape Province, has been identified for the Hartebeesleegte Windfarm Facility (Hartebeesleegte) development by South Africa Mainstream Renewable Power Developments (Pty) Ltd (Mainstream).

The SKA is a stakeholder listed in the Interested and Affected parties of the EIA phase of the proposed project. In order to determine whether the planned windfarm development could have any influence on the SKA, Mainstream requested a risk evaluation of the planned development to SKA activities.

The frequency band of concern for SKA mid-band is 200MHz to 20GHz.This assessment does not consider any potential telecommunication services or networks that are to be established as part of the operational plan.

This risk assessment assumes the use of 47 Acciona AW 125 TH100A turbines within the Hartebeesleegte development and will be compared to known radiated emission data from the AW125 TH100A Acciona WTG as presented in the Acciona Control Plan [5].

2. SCOPE

The Acciona AW 125 TH 100A is the model within the AW 3000 platform that will be evaluated for this project. This assessment will be updated based on additional measurement results and design information as it becomes available.

2.1 INTENT

The intent of this evaluation is to ensure that the Hartebeesleegte facility poses a low risk of detrimental impact on the SKA by using known radiated emission amplitudes of the Acciona AW3000/125 TH100 50Hz wind turbine. Specific mitigation measures to be implemented on the AW3000/125 TH100 50Hz wind turbine in order to achieve 40 dB of attenuation has been reviewed and agreed by SKA South Africa as described in [5].

3. ASSESSMENT METHODOLOGY

i. Confirm windfarm location with Mainstream.
ii. Confirm nearest SKA dish installation area with SKA.
iii. Confirm system architecture with Mainstream or turbine supplier.
iv. Plot line of sight graphs using the hub height and 15m for the SKA dish between the SKA dish and nearest wind turbine generator (WTG).
v. Perform path loss calculations using the Irregular Terrain Model between the WTG and SKA dish.
vi. Use the Acciona AW3000/125 TH100 radiated emission data and subtract the total path loss to confirm the result is less than the specified level at the SKA dish installation location.
vii. If the result from point vi above exceeds the specified level, additional mitigation is required.

4. REFERENCES

4.1 REFERENCED DOCUMENTS

[1]	No.R 90. Government Gazette 10 February 2012 (35007).	Regulations on Radio Astronomy Protection Levels in Astronomy Advantage Areas Declared for the Purposes of Radio Astronomy
[2]	NIE 49577REM.001	Measurements according to client protocol " Emission Test Procedure for the AW TH100A WTG"
[3]	DG200233 Rev G	AW3000 Earthing and Lightning protection Systems; Acciona Windpower
[4]	INP125 Rev A	Windfarm Communications – Garob / Copperton: Acciona Windpower
[5]	CP 6902/16 Rev 2.0	Emission Control Plan for the AW125 TH100A WTG
[6]	CP 7099/16 Rev 1.0	Path Loss and Risk Assessment Report for Teekloof based on the Emission Control Plan for the Acciona AW125 TH100A WTG

4.2 GENERAL REFERENCE MATERIAL

a. EMC Analysis Methods and Computational Models, Frederick M. Tesche, Michel V. Ianoz, Torbjörn Karlson, Wiley Interscience, 1997

b. Noise reduction techniques in electronic systems, Second edition, Henry W. Ott, Wiley Interscience Publications, 1998

c. Electromagnetic Compatibility - Principles and Applications, Second Edition, David A. Weston, Marcel Dekker Inc, 2000

5. SYSTEM ARCHITECTURE

5.1 BASIC INFORMATION

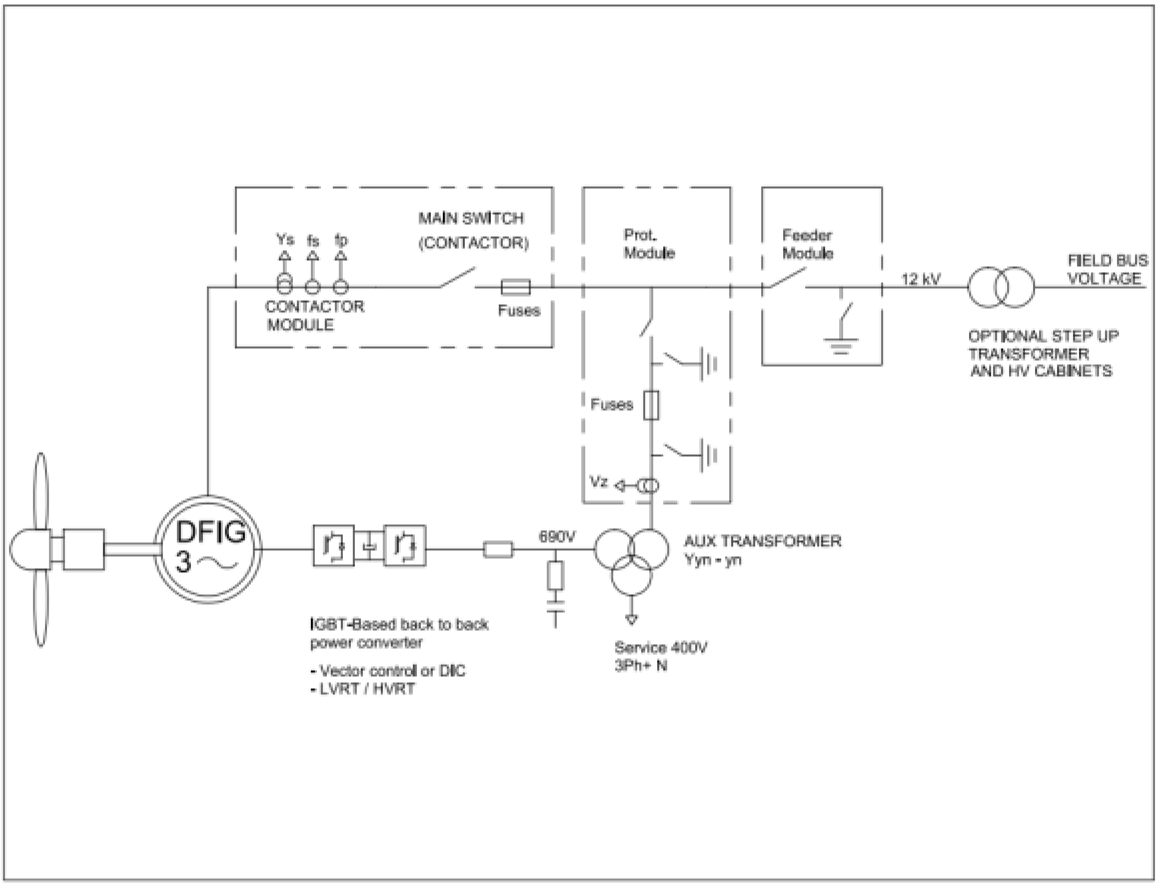


Figure 1: High level block diagram

5.2 TURBINE STRUCTURE & LAYOUT

The turbine configuration evaluated as part of this document consists of a base, a 100m concrete tower and a nacelle on top as shown in Figure 2. A hub height of 150m was used during the calculations as requested by Mainstream.

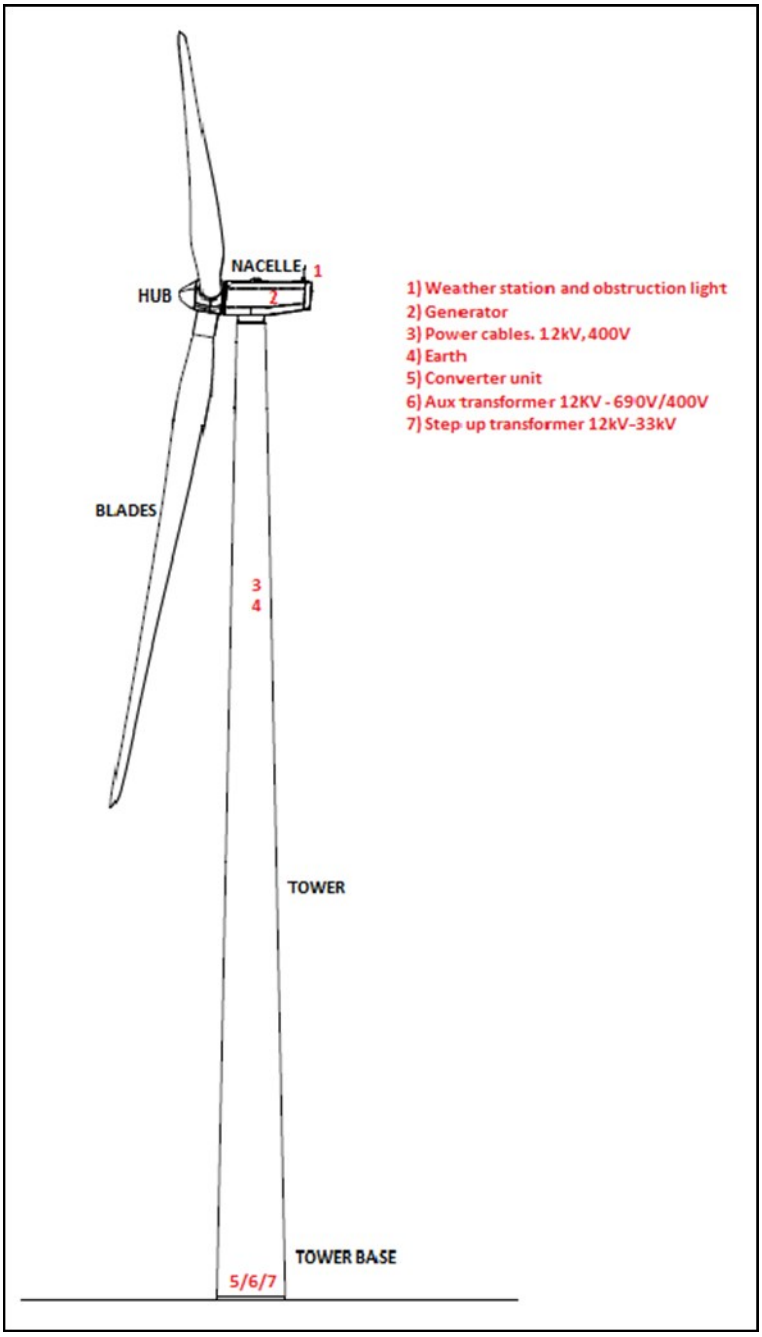


Figure 2: Turbine components

5.3 SITE WIDE COMMUNICATIONS

The communication among the wind turbines, the met masts and windturbines and the substation will always be through an Ethernet optical fiber network as described in INP125-A.

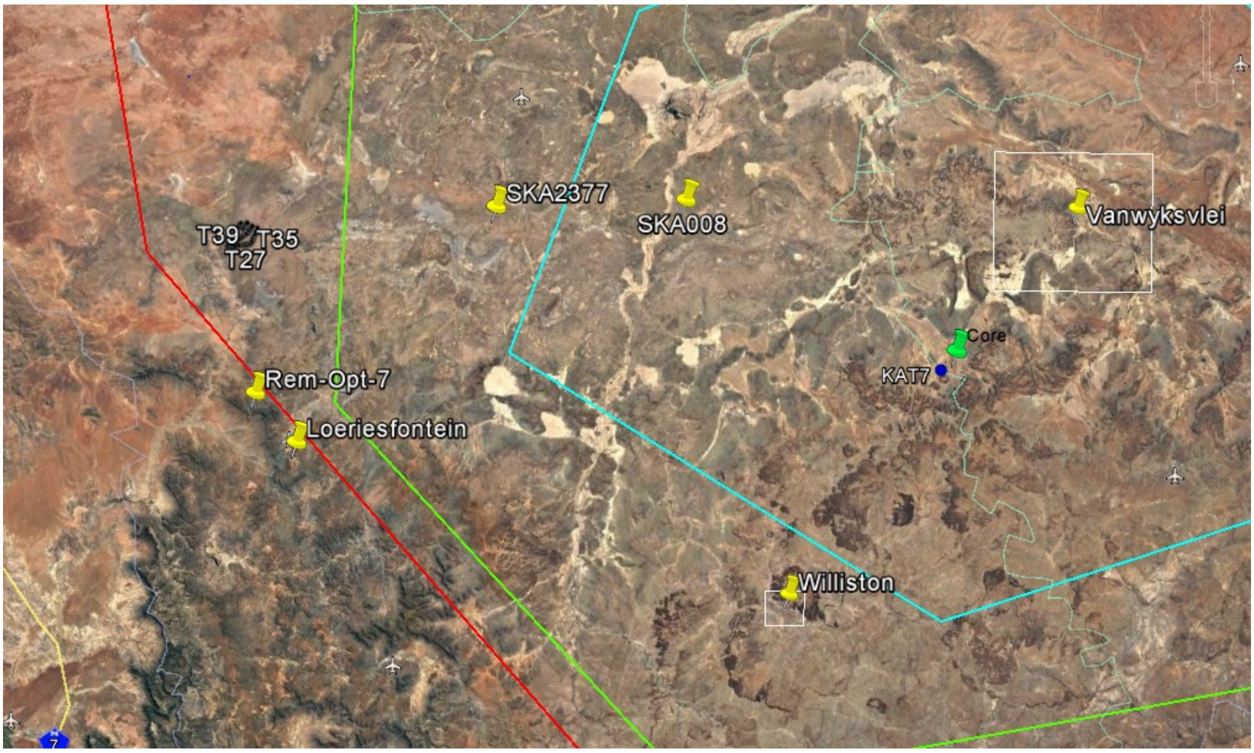
6. EMC REQUIREMENTS

The current Emission Control Plan for the AW125 TH100A WTG [5] provides for a 40dB reduction in radiated emissions to ensure the cumulative emission level of previously assessed wind farms where the Acciona AW 125 TH100A WTG will be used is within the requirements of SKA. This requirement is based on measurements on the Acciona AW 125 TH100A WTG at the Gouda facility in South Africa and Barosoain windfarm, Navarra, Spain.

7. EMC ANALYSIS

7.1 SITE LOCATION

7.1.1 Area Map



Picture 1: Area map showing Hartebeesleegte locations relative to SKA

Two WTG locations (WTG 1 and WTG 39) and two SKA installations (Rem Opt 7 and SKA 2377) were used for the evaluation.

7.1.2 Local Map

Picture 2: Local map showing nearest two SKA Locations

7.1.3 Distance Table

	Hartebeesleegte WTG 1	Hartebeesleegte WTG 39
SKA Rem Opt 7	47.2km	52.4km
SKA ID 2377	76.0km	68.1km
MeerKAT (Core)	212.4km	206km

Table 1: Hartebeesleegte layout distance from SKA infrastructure

7.1.4 Elevation Maps

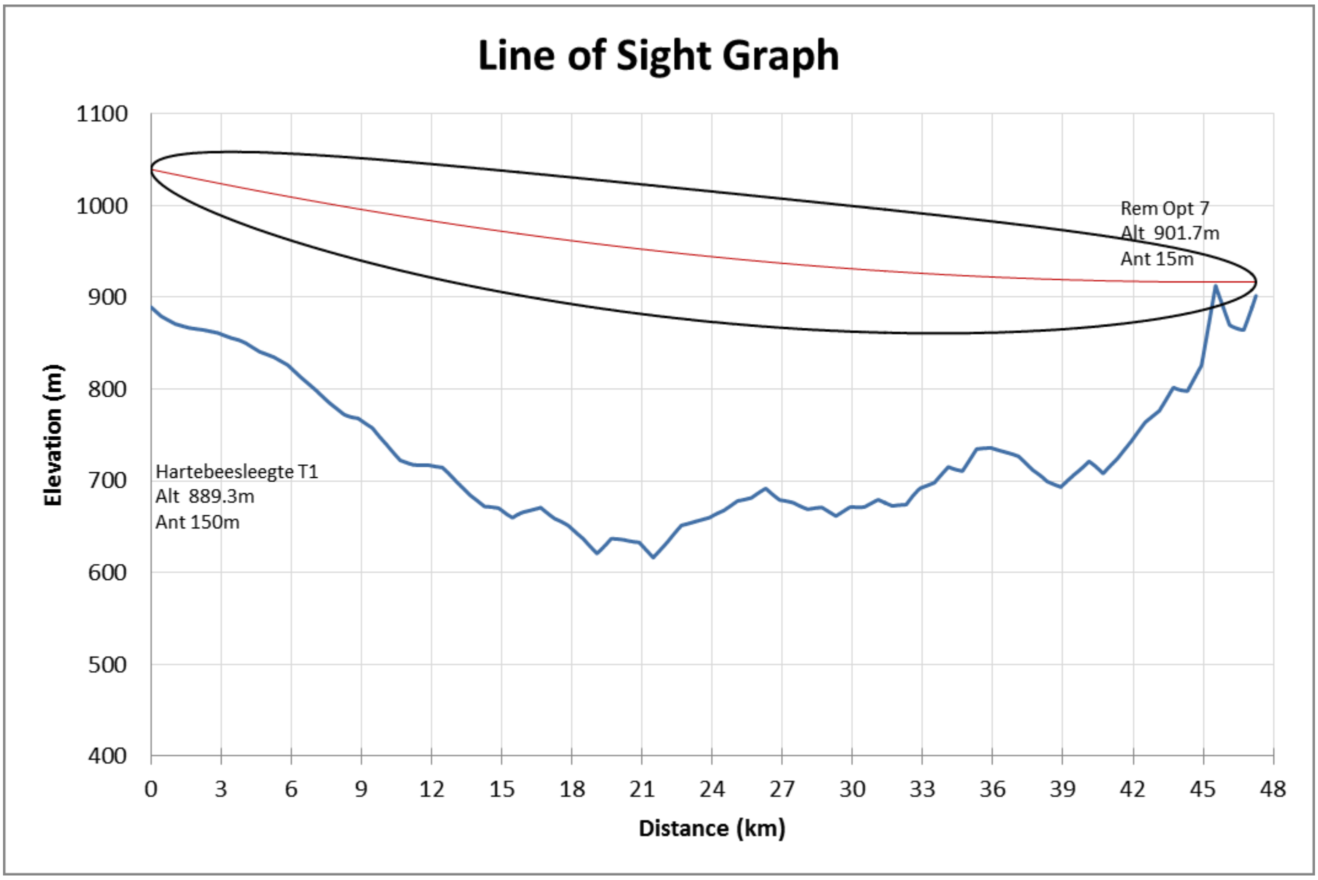


Figure 3: WTG 1 to Rem Opt 7

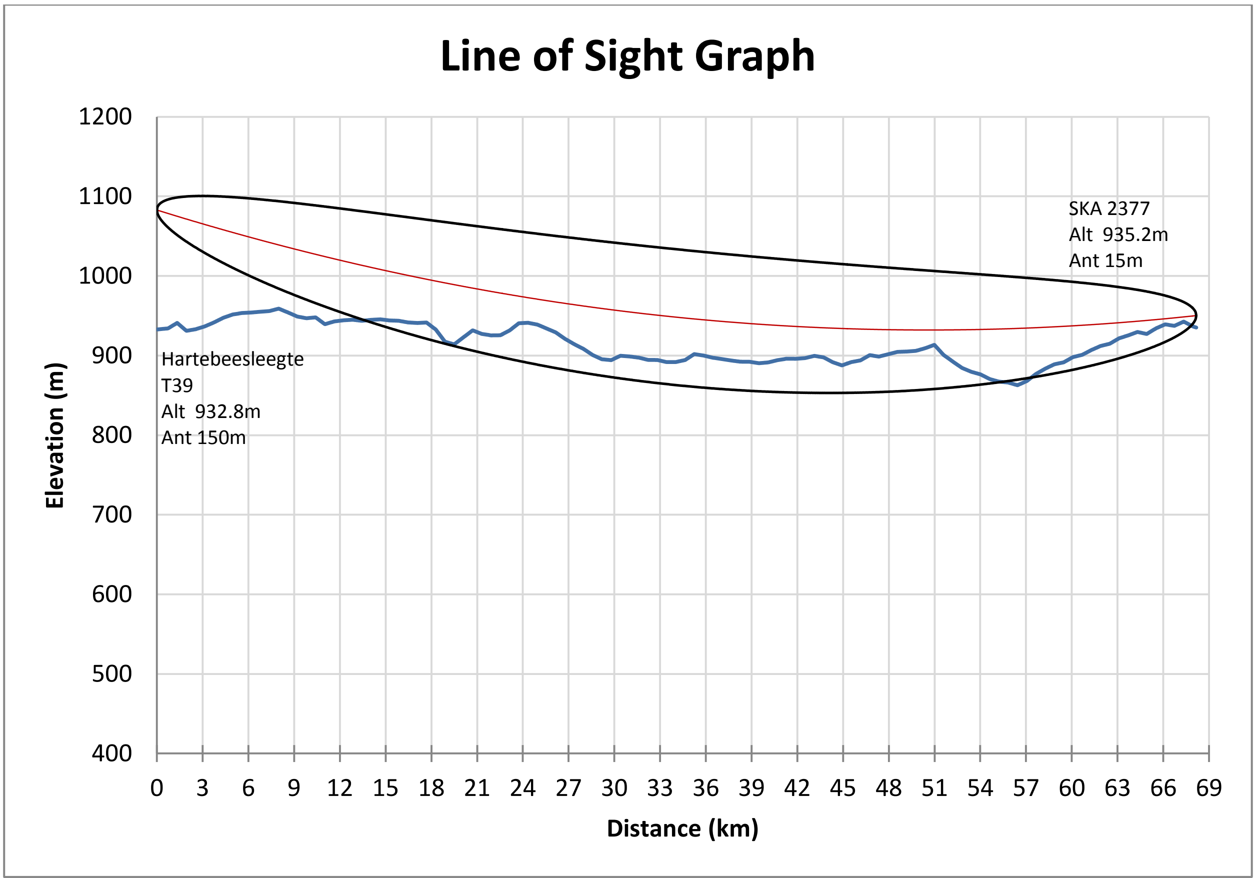


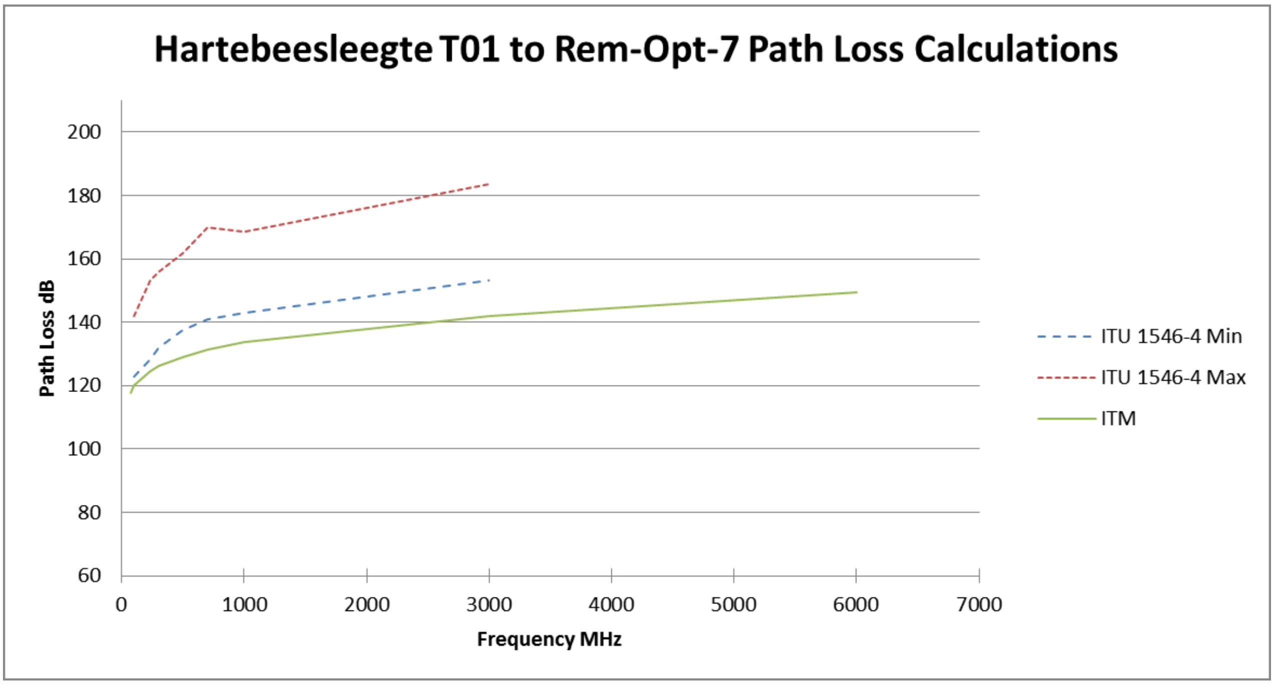
Figure 4: WTG 39 to SKA 2377

7.2 PATH LOSS CALCULATIONS

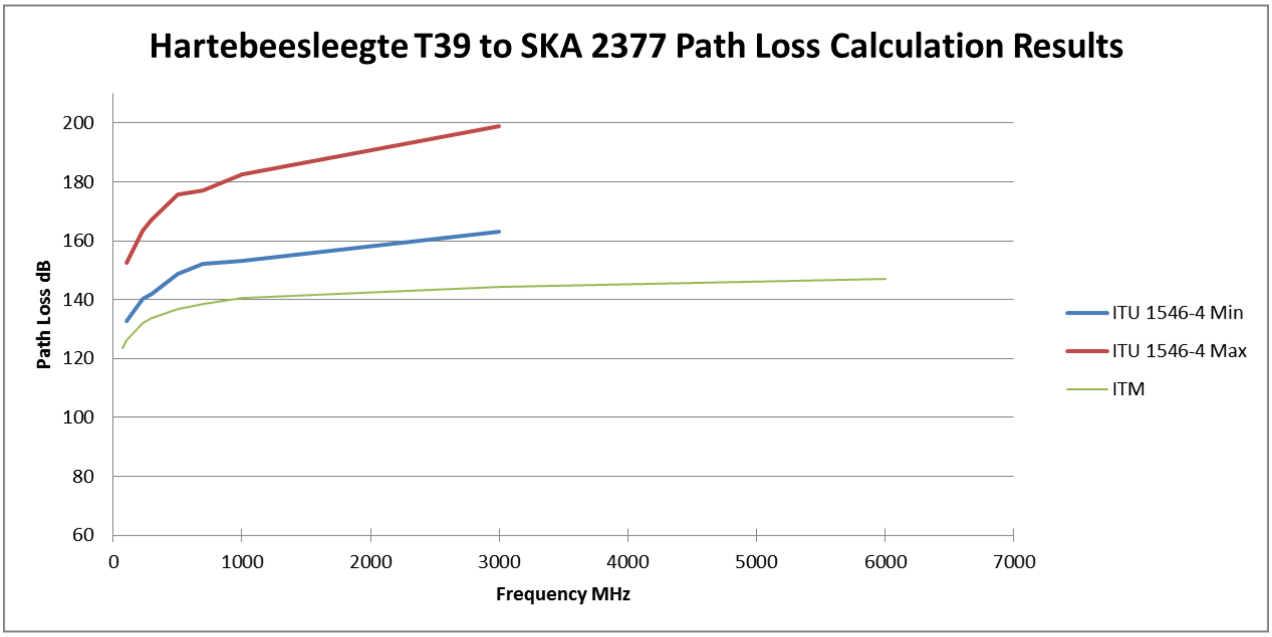
The path loss was calculated using the parameters as specified in Table 2: Path loss input data.

Parameter	Description	Quantity	Comment
Source/ Victim separation distance	SKA 2377 to WTG 41	47.2km	Line of sight
Source/ Victim separation distance	Rem Opt 7 to WTG 1	68.1km	Line of sight
Frequency	Frequencies assessed	100MHz, 300MHz, 500MHz, 1000MHz, 3000MHz, 6000MHz	Free space loss increases with frequency.
SARAS	Protection level	dBm/Hz = -17.2708 log 10 (f) -192.0714 for f<2GHz	Government Gazette 10 February 2012
Location	WTG 1	Lat: -30.3997323475778° Lon: 19.2590607795864°	Waypoint received from Mainstream
Location	WTG 39	Lat: -30.350026236847° Lon: 19.3376920837908°	Waypoint received from Mainstream
Location	SKA 2377	Lat: -30.340201° Lon: 20.047739°	Waypoint received from SKA SA (Pty) Ltd
Location	Rem Opt 7	Lat: -30.822164° Lon: 19.311400°	Waypoint received from SKA SA (Pty) Ltd
TX height	Nacelle Base	150m 2m	Height of nacelle eqp Height of base eqp
RX height	All SKA receivers	15m	Height used for SKA receive horn

Table 2: Path loss input data



Graph 1: WTG 1 (150m height) to SKA Rem Opt 7 Path Loss Calculation result



Graph 2: WTG 39 (150m) to SKA 2377 Path Loss Calculation result

Graph 1 and Graph 2 show path loss calculations for the nacelle equipment emissions at 150m hub height.

SPLAT! (Signal Propagation, Loss And Terrain) analysis and Radio Mobile Deluxe was used to calculate the ITM path loss values. Both are based on the Longley –Rice Irregular Terrain Model and Irregular Terrain With Obstruction Model. The digital elevation model resolution data used was 3-arc –seconds.

The ITU 1546-4 was calculated with Monte Carlo based ITU 1546-4 path loss software to obtain a minimum and maximum path loss values.

A standard factor of 10 $\log_{10}$ N where N = the number of turbines (16.7dB for 47 turbines) to account for cumulative emissions should also be applied.

7.3 MITIGATION REQUIRED

7.3.1 Path Loss comparison

The ITM path loss calculation results of the four sites where the AW 125 TH100A Acciona turbines with modifications as described in the Garob EMC Control Plan [5] to mitigate radiated emissions is shown below:

Frequency [MHz]	Garob (19.65km) [dB]	Copperton (38.18km) [dB]	Aletta (46.25km) [dB]	Hartebeesleegte (47.2km) [dB]
100	109.85	120.7	119.7	120.0
300	Not available	127.7	121.0	126.1
500	113.08	130.5	124.1	129.1
700	Not available	132.2	130.1	131.2
1000	124.65	133.8	141.7	133.6

Table 3: Path loss comparison between sites

7.3.2 Conclusion

Due to natural terrain barriers and the 47.2km distance between Hartebeesleegte and Rem-opt 7, the closest SKA unit, no degradation of performance is expected when the mitigated AW 125 TH100A Acciona turbines are installed. This shown by the 10dB higher path loss for Hartebeesleegte compared to Garob in Table 3

7.4 TESTS AT THE NEW SITE

To verify overall windfarm emissions, ambient measurements should be done at the new site before construction starts. Tests points should be carefully selected based on test equipment sensitivity with the objective to observe the increase in ambient emissions as construction progresses.

7.5 FINAL SITE TESTS

Final site tests will be done on completion of the project to confirm the radiated emission levels.
Although not anticipated, proper mitigation measures on identified emitters will be studied and implemented if final test shows emissions exceeding the SKA threshold.