Stáisiún Uí Chonghaile, Baile Átha Cliath 1, D01 V6V6
Connolly Station, Dublin 1, D01 V6V6
T 01 703 4293 E foi@irishrail.ie W www.irishrail.ie

18th September 2020

[redacted]

Email: [redacted]

Re: FOI request IE_FOI_390

Dear [redacted],

I refer to your request dated 11th August 2020 made under the Freedom of Information Act 2014, which was received on that date, for records held by Iarnród Éireann.

Request:

- *The cell-map study whose findings indicated where telecoms masts being built in support of the new GSM-R network for the Cork-Cobh-Midleton commuter rail line (e.g. masts at Carrigaloe, Carrigtwohill, and Cobh) should be constructed.*

Response:

I [redacted], Decision Maker have now made a final decision to grant your request on 18th September 2020.

You have sought access to the records outlined above and I consider this an appropriate form of access in this case. Accordingly a copy of the records is now enclosed including a copy of the schedule to these records.

Rights of appeal

In the event that you are not happy with this decision you can make an appeal in relation to this matter, you can do so by writing to the FOI Unit, Corporate Communications, Iarnród Éireann Irish Rail, Connolly Station, Amiens St, Dublin 1 or by e-mail to foi@irishrail.ie. You should make your appeal within 4 weeks (20 working days) from the date of this notification, where a day is defined as a working day excluding, the weekend and public holidays, however, the making of a late appeal may be permitted in appropriate circumstances.
The appeal will involve a complete reconsideration of the matter by a more senior member of the staff of this body.

Should you have any questions or concerns regarding the above, please contact the FOI Officer on [redacted] or by email at foi@irishrail.ie

Yours sincerely,

[redacted]

Decision Maker, Infrastructure Management,

Iarnród Éireann

Freedom of Information Request:
Schedule of Records for IE_FOI_396 : Summary for Decision Making

Record No.	Date of Record	Brief Description	No. of Pages	Decision: Grant/Part Grant/Refuse	Section of Act if applicable	Record Edited/Identify Deletions
1	18.09.2020	IE_FOI_390 Response Document	47	Grant	~	~

Signed

Freedom of Information / Data Protection Executive

IE FOI 390 Response Document

Request:

The cell-map study whose findings indicated where telecoms masts being built in support of the new GSM-R network for the Cork-Cobh-Midleton commuter rail line (e.g. masts at Carrigaloe, Carrigtwohill, and Cobh) should be constructed.

Response:

The radio planning for the GSM-R network is being carried out by Iarnród Éireann's contractor Kontron. A radio network planning software tool 'Atoll' with a radio frequency outdoor propagation model based on the Hata model is used. I attach a data sheet on the Atoll tool and the cell planning study titled 'Ireland: Cork-Cobh Radio Cell Planning.

Ireland: Cork-Cobh / Radio Cell Planning

Document number:	IE/OPS/DD/034216 V01/EN
Document issue:	01.03 / EN
Document status:	Initial
Date:	12/May/2020

Release Management

Author	Version	Release Date	Changes
Laroussi GATTOUFI, Radio, GSM-R Network Engineering	01.01 EN	6 Novtember 2019	Document Creation

Review & Approval

Name	Company	Date	Signature

CONTENTS

1. INTRODUCTION

1.1. OBJECT

This document presents radio design outputs for GSM-R coverage of the Cork-Cobh line (Ireland) design with 9 transmitters where

- 7 BTS are BTS-R KONTRON O1+1 BTS type.
- 1 Repeater (BTS-R as a repeater of the Cork station site)

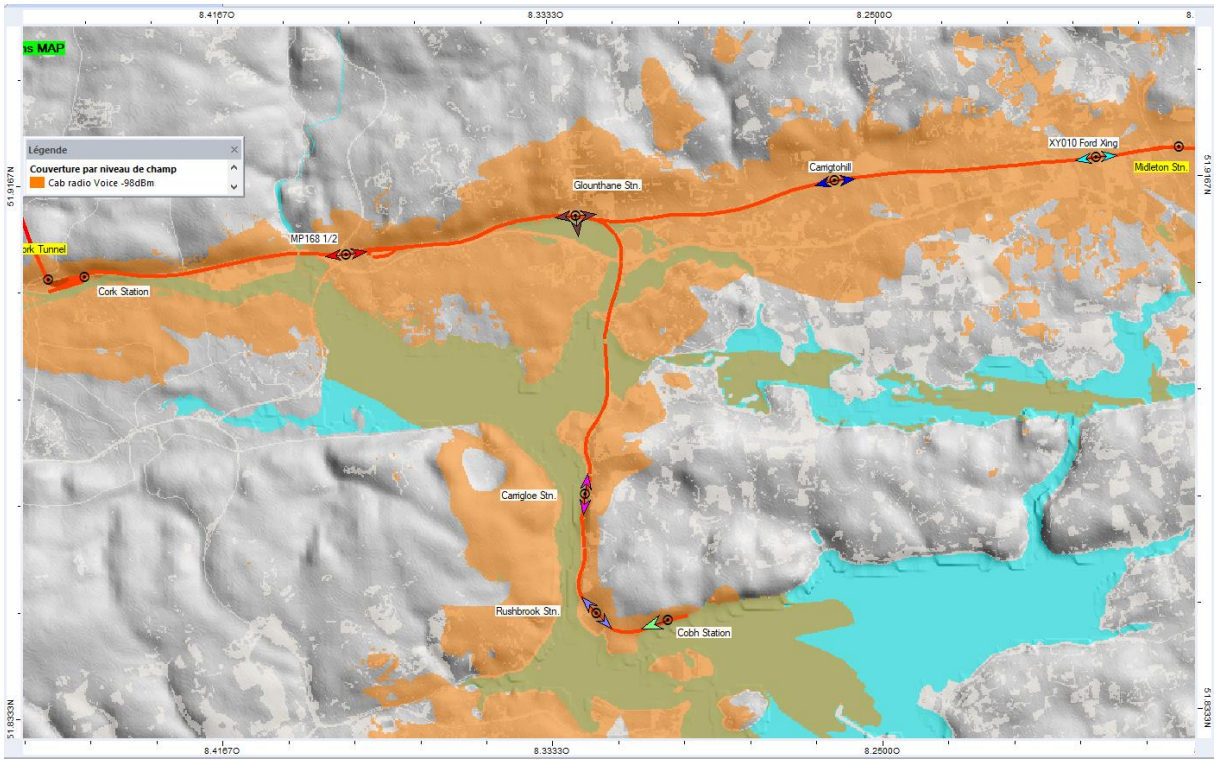
A general view of Cork-Cobh line is shown below (The Cork-Cobh line will be called in this document the Cobh Line).

Note: the Cobh lines is considered from:

- the site location called "Cork station" on the west part including the Cork tunnel

- the site of Cobh station at the south part

- the Middleton station on east part.



1.2. APPLICATION DOMAIN

This document presents cell planning done using Atoll Radio Planning Tool.

Its goal is to provide inputs for GSM-R Cobh line deployment to IE.

Assumptions have been taken that may need to be revised in future versions.

1.3. DOCUMENT AUDIENCE

Audience of this document is IE project designated people, KONTRON side project members.

2. ANNEX DOCUMENTS

2.1. APPLICABLE DOCUMENTS

[A01] IE/ IE National Coverage GSM-R Tender

2.2. REFERENCE DOCUMENTS

[R01] **O-2475 v3.0** ERTMS/GSM-R Quality of Service Test Specification

[R02] **Subset - 093 v2.3.0** GSM-R Interfaces Class 1 Requirement

[R03] **UIC Code 951 Version 16.0** EIRENE System Requirements Specification

[R04] **UIC Code 950 Version 8.0** EIRENE: Functional Requirements Specification

3. ABBREVIATIONS & DEFINITIONS

3.1. ABBREVIATIONS

BCCH	Broadcast Control Channel
BER	Bit Error Rate
BTS	Base Transceiver Station
C/I	Carrier power / Interferer power
CW	Constant wave
dB	Decibel
dBi	Antenna gain in decibels with respect to the isotropic radiation
dBm	Logarithmic dimensionless unit for power values based on 1 mW
DDM	Dual Duplexer Module
DL	Downlink
DM	Design Margin
DMF	Design Minimum Field
DRX	Driver+Receiver+Frame Processor
DTM	Digital Terrain Map
EIRP	Equivalent Isotropic Radiated Power
ETCS	European Train Control System
ETSI	European Telecommunication Standards Institute
FER	Frame Erasure Rate
GSM	Global System for Mobile communications
GSM-P	GSM-Public
GSM-R	GSM-Railway
MRP	Multiple Reuse Pattern
MS	Mobile Station
TX	Transmitter
OMF	Outdoor Minimum Field
RM	Radio Module
RF	Radio Frequency
RX	Receiver
RX-Level	Received RF level measured by the BTS or MS.
PA	Power Amplifier
QoS	Quality of Service
SPM	Standard radio Propagation model
TCH	Traffic Channel
TRX	BTS Transceiver entity
UIC	International Railways Organization
UL	Uplink
WLB	Worst Link Budget

3.2. DEFINITIONS

Antenna gain: Maximum isotropic gain in all directions for omni directive antenna and in the most favorable direction for sectorial antenna.

Design minimum field: The minimum field strength to take into account for cell planning.

Outdoor minimum field: Minimum outdoor field strength, from the serving cell, that will be experienced by the mobile in order to ensure the communication.

4. ASSUMPTIONS

4.1. GUARANTEED SERVICES

As per IE contractual requirements cellular coverage is required to support trains up to a speed of 160 Km/h for conventional tracks. The radio system is a GSM-R network, based on EIRENE recommendations and has been designed to support ETCS level 2 applications. Services provided by the network are voice and data over circuit switching (CSD 2.4; 4.8 and 9.6) at a speed of up to 160 Km/h.

According to the initial IE GSM-R project (Phase1 requirements), contractual requirements of the project, the following EIRENE minimum values will be applied:
The following minimum values are mandatory by EIRENE specifications:

- Coverage probability of 95% based on a coverage level of 44.5 dBµV/m (-98 dBm) for voice and non-safety critical data;
- Coverage probability of 95% based on a coverage level of 41.5 dBµV/m (-95 dBm) on lines with ETCS level 2/3 for speeds above 220 km/h;

Based on different workshops and different discussions between IE and Kontron Transportation during Phase2 and phase3 project elaboration, the initial requirements (phase1 requirements) were reviewed and changed.
Indeed, For phase3 of the IE GSM-R project, the following minimum values are guaranteed:

- Coverage probability of 95% based on a coverage level of 44.5 dBµV/m (-98 dBm) for voice and non-safety critical data;
- Coverage probability of 95% based on a coverage level of 41.5 dBµV/m (-95 dBm) on lines with ETCS level 2/3 for speeds above 160 km/h as best effort

However, only coverage level of -98dBm is guaranteed on whole the line, by consequent EIRENE KPI will not be guaranteed on whole line.
The specified coverage probability means that with a probability value of at least 95% in each location interval (length 100m) the measured coverage level shall be greater than or equal to the figures stated above.

The RF planning is based on a single layer.

4.2. EQUIPMENTS

4.2.1 MOBILE

The GSM-R network will be dimensioned for Cab Radio and General Purpose Radio mobiles with the following characteristics

Product list	MS Tx PA output power	MS Sensitivity
Cab Radio	8 W / 39 dBm	-104 dBm
General Purpose Radio	2 W / 33 dBm	-102 dBm
Operational Radio	2 W / 33 dBm	-102 dBm

To comply with the specifications using 8W cab radio we need :

- External antenna installed on top of the train
- Antenna height 4,5 meters above ground
- Antenna gain 2dBi
- Cable loss 2dB max

4.2.2 BTS EQUIPMENT

The Kontron family of Base Transceiver Station (BTS) products offers the flexibility of high performance and dense packaging needed to provide the operator with optimum network solutions. This BTS portfolio benefits from Kontron vast experience in spectrum management and network engineering.

On Cork Line, the Kontron family Base Transceiver Station (BTS) products that will be used is the BTS-R: This is newest KONTRON product which was already deployed successfully on the Sligo line and in many others countries

4.2.3 BTS MAIN CHARACTERISTICS

The following table states the parameters of the KONTRON BTS-R used:

Product list	Sensitivity No Diversity	Sensitivity with Diversity	BTS Power	DPX loss
BTS R	-114 dBm	-118 dBm	2 x 60W (2 x 47.8 dBm)	1.4 dB

4.2.4 SITE BTS LIST

New Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
Cork Tunnel	8°27'35,81"O	51°54'7,85"N	8	No pylon.	BTS-R/RRH as rep	Repeater		
Cork Station	8°27'2,92"O	51°54'8,86"N	4	15	BTS-R	O1+1	965	
MP168 1/2	8°23'5"O	51°54'20,28"N	4	30-->20	BTS-R	O1+1	970	
Glounthane station	8°19'35,3"O	51°54'41,1"N	4	30	BTS-R	O1+1	960	
Carrigtohill station	8°15'47,76"O	51°54'58,63"N	12	15	BTS-R	O1+1	955	
XY010 Ford Xing	8°11'40,35"O	51°55'11,18"N	11	15	BTS-R	O1+1	964	
Carrigloe station	8°19'29,25"O	51°52'4,81"N	13	20-->30	BTS-R	O1+1	968	
Rushbrook station	8°19'19,88"O	51°50'57,66"N	13	10	BTS-R	O1+1	957	
Cobh relay room	8°18'14,91"O	51°50'52,8"N	5	15	BTS-R	O1+1	971	

4.2.5 BTS MAIN CHARACTERISTICS

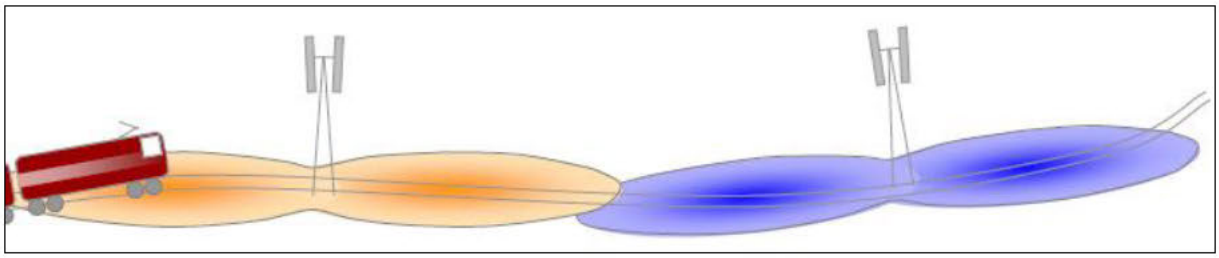
The following table states the parameters of the KONTRON BTS-R used:

Product list	Sensitivity No Diversity	Sensitivity with Diversity	BTS Power	DPX loss
BTS R	-114 dBm	-118 dBm	2 x 60W (2 x 47.8 dBm)	1.4 dB

4.2.6 COUPLING SYSTEM FOR THE BTS

The BTS is connected to 2 set of sectorial antennas to provide a single cell within a BTS omni configuration.

Mono-cellular configuration (composite) using sectorial antennas:



The resulting mono-cellular configuration (or composite) with sectorized antennas avoids a handover beneath the site and improves the overall quality of service.

Generally, railways operator requests to place BTSs at the positions where technical buildings (TBs) are located. In a few cases we the need to install higher towers and use more powerful antennas.

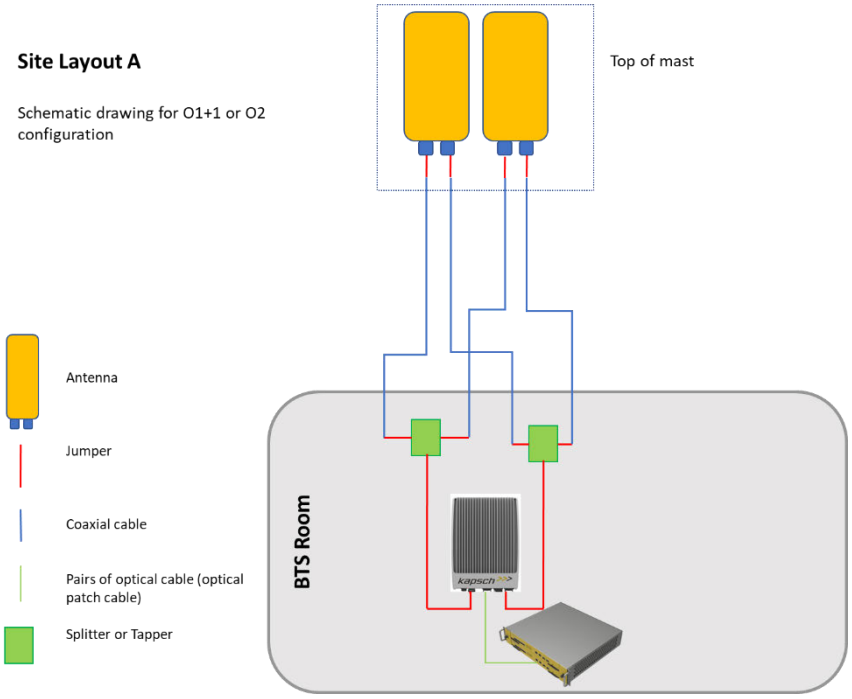
The height of the pylons has been set generally between 15 and 30 meters. All BTS are indoor set in shelters or in dedicated rooms in the buildings.

Space diversity antenna configuration is generally preferred in GSM-R as it offers maximum diversity gain and introduces no polarization losses. The drawback of this configuration is that it requires a strong pylon to support 4 antennas with vertical polarization per mast. Therefore KONTRON recommends deploying mast with Cross polar antennas.

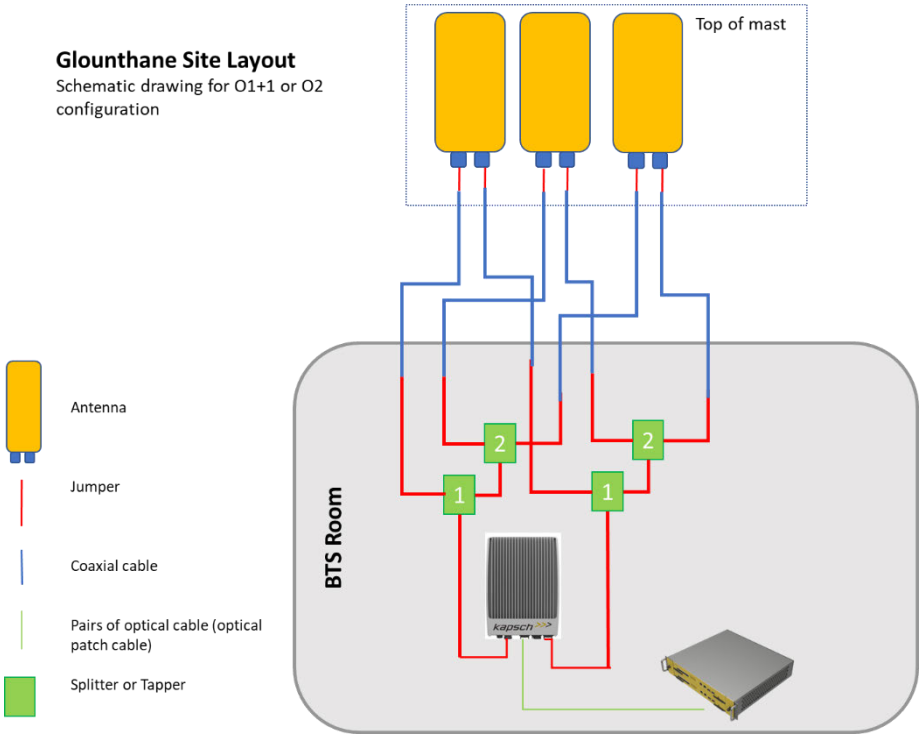
Receiving polarization diversity is employed on each site. The cross polarized antennas on each side of the pylon are connected to the 2 receiver ways of the BTS (Rx main and Rx Diversity) as illustrated below.

4.2.7 SITE CONFIGURATION

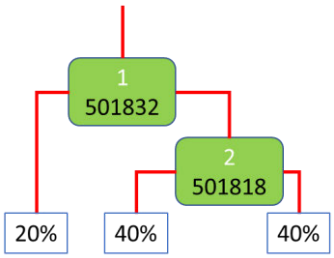
4.2.7.1 BTS-R SITES



4.2.7.2 GLOUNTHANE BTS-R SITE



Splitter 1 and 2 with reference



4.2.8 CHARACTERISTICS OF THE RF AERIAL EQUIPMENT

RF AERIAL EQUIPMENT			
Type	**Reference**	**Manufacturer**	
Antenna			
Panel Antenna	K80010456V02	KATHREIN	Gain 20.5dBi
Yagi Antenna	AR 1021	PROTEL	Gain 16.5 dBi
External combiner			
Splitter 1/2 1/2	501 818	SELECOM	7/16"
Coupleur antenne 3dB	501 626	SELECOM	7/16"
Coupleur antenne 5dB	501 811	SELECOM	7/16"
Coupleur antenne 7dB	501 832	SELECOM	7/16"
Coupleur antenne 6dB	501 831	SELECOM	7/16"
Jumpers			
head of mast L=3m	545 030	SELECOM	7/16"
Shelter L=2m	545 020	SELECOM	7/16"
L=1m	545 010	SELECOM	7/16"
Adaptors			
7-16"	M-M	SELECOM	
Load 7-16"	25W	SELECOM	

4.2.8.1 PANEL ANTENNA

- Antenna type that has been chosen by KONTRON according to the contractual radio planning constraints.
- It is assumed that antennas can be electrically & mechanically tilted with minimum range of 0° to 10°.
- The model used is provided by Kathrein and has the following reference K80010456V02 .
- The data sheet is presented below.

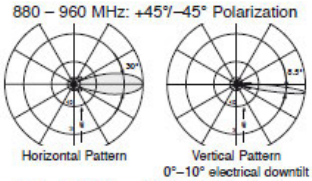
Panel 790–960
Dual Polarization X
Half-power Beam Width 30°
Adjust. Electrical Downtilt 0°–10°
set by hand or by optional RCU (Remote Control Unit)

KATHREIN
Antennen · Electronic

XPol Panel 790–960 30° 20.5dBi 0°–10°T

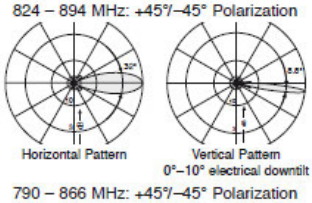
Type No.	80010456V02		
Frequency range	790 – 862 MHz	790–960 824 – 894 MHz	880 – 960 MHz
Polarization	+45°, –45°	+45°, –45°	+45°, –45°
Gain at 0° T	2 x 20.0 dBi	2 x 20.2 dBi	2 x 20.5 dBi
Horizontal Pattern:			
Half-power beam width	33°	32°	30°
Front-to-back ratio, copolar	> 28 dB	> 29 dB	> 30 dB
Cross polar ratio Maindirection 0°	Typically: 25 dB	Typically: 23 dB	Typically: 20 dB
Tracking, Avg.	2.5 dB		
Squint	±2.0°		
Vertical Pattern:			
Half-power beam width	9.1°	8.8°	8.5°
Electrical tilt	0.5°–10°, continuously adjustable		
Sidelobe suppression for first sidelobe above main beam	0° ... 5° ... 10° T > 16 ... 13 ... 13 dB	0° ... 5° ... 10° T > 18 ... 18 ... 17 dB	0° ... 5° ... 10° T > 18 ... 16 ... 15 dB
Impedance	50 Ω		
VSWR	< 1.5		
Isolation, between ports	> 30 dB		
Intermodulation IM3	< –150 dBc (2 x 43 dBm carrier)		
Max. power per input	500 W (at 50 °C ambient temperature)		

880 – 960 MHz: +45°/–45° Polarization



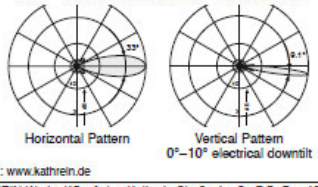
Horizontal Pattern — Vertical Pattern 0°–10° electrical downtilt

824 – 894 MHz: +45°/–45° Polarization



Horizontal Pattern — Vertical Pattern 0°–10° electrical downtilt

790 – 866 MHz: +45°/–45° Polarization



Horizontal Pattern — Vertical Pattern 0°–10° electrical downtilt

Mechanical specifications	
Input	2x 7-16 female
Connector position	Rearside
Adjustment mechanism	1x, Position bottom continuously adjustable
Wind load	Frontal: 1760 N (at 150 km/h) Lateral: 330 N (at 150 km/h) Rearside: 2040 N (at 150 km/h)
Max. wind velocity	200 km/h
Height/width/depth	2254 / 576 / 99 mm
Category of mounting hardware	H (Heavy)
Weight	22 kg / 24 kg (clamps incl.)
Packing size	2500 x 600 x 150 mm
Scope of supply	Panel and 2 units of clamps for 50 – 115 mm diameter

Subject to alteration.
936 390776

Internet: www.kathrein.de
80010456V02 Page 1 of 2
KATHREIN-Werke KG · Anton-Kathrein-Straße 1 – 3 · P.O. Box 10 04 44 · 83004 Rosenheim · Germany · Phone +49 8031 184-0 · Fax +49 8031 184-973

4.2.8.2 YAGI ANTENNA

- This antenna is planned to be used for the coverage of the Cork tunnel and is connected to the BTS-R as repeater located at the south entrance of the Cork tunnel
- The model used is provided by Protel and has the following reference AR1021 .
- The data sheet is presented below.

PROTEL ANTENNE

MOD. AR1021.1 – COD. ARYL62117.1 Z

Directional antenna for mobile band. Especially suitable for tunnels coverage. LTE-GSM-R-LTE READY-READY

ELECTRICAL DATA		
Frequency range	MHz	760÷960
Bandwidth	MHz	180
Gain	dBi	16
VSWR		≤1.5
Nominal impedance	Ω	50
Polarization		V
V beamwidth	-3 dB	28°
H beamwidth	-3 dB	30°
Max Power	W	≥25
Connector for AR1022.1		N=100 7/16=200
Connector for AR1022.C		N or 7/16 female
Lightning protection		All metal parts are DC grounded

MECHANICAL DATA		
Dimension length	mm	Ø 330 x 1330
Weight	Kg	8
Ice protection		No full radome

MATERIALS
Aluminium – Teflon – Brass – Stainless steel

ACCESSORIES			
CODE	TYPE	DIMEN.	WEIGHT
AR1021F	1 clamp	Ø 40-75	2.7 Kg.
AR1021T	2 tilt clamps	Ø 40-114	4.2 Kg.

MOD. AR1020.1 – COD. ARYL62418. 1Z

Directional antenna for GSM band. Especially suitable for tunnels coverage and mountain valleys. LTE-GSM-R-LTE READY- READY

ELECTRICAL DATA		
Frequency range	MHz	790÷960
Bandwidth	MHz	180
Gain	dBi	16.5
VSWR		≤1.5
Nominal impedance	Ω	50
Polarization		V
V beamwidth	-3 dB	27°
H beamwidth	-3 dB	28°
Front back ratio	dB	≥25
Max Power	W	N=100 7/16=200
Connector		N or 7/16 female
Lightning protection		All metal parts are DC grounded

MECHANICAL DATA		
Dimension length	mm	Ø 330 x 1557
Weight	Kg	6.5
Ice protection		No full radome

MATERIALS
Aluminium – Teflon – Brass – Stainless steel

ACCESSORIES			
CODE	TYPE	DIMEN.	WEIGHT
AR1020F	1 clamp	Ø 40-75	2.7 Kg.
AR1020T	2 tilt clamps	Ø 40-114	4.2 Kg.

4.2.8.3 COUPLERS / SPLITTERS

Selecom

Coupleur d'antennes Outdoor 330-2700 MHz

330-2700MHz Antenna Coupler outdoor

Compact, faible coût, très facile d'installation sur tous types de supports (*chemin de câble, shelter, mur…*), ces coupleurs sont parfaitement adaptés pour répartir une puissance vers plusieurs systèmes d'antenne. Les coupleurs à sorties déséquilibrées permettent notamment de s'adapter à différentes configurations nécessitant une répartition inégale de la puissance.

Compact, low cost and easy to install on each supports (cable trays, shelters, walls…), these couplers are perfectly adapted to divide powers in several antennas.

These couplers are available with balanced or unbalanced outputs, those solutions offer a perfect distribution of the power.

Caractéristiques / **Characteristics**							
7/16 femelle *7/16 Female*	**Réf.**	**501 818**	**501 811**	**501 820**	**501 831**	**501 832**	**501 825**
Nombre de sorties *Outputs*		2	3	4	2	2	2
Répartition *Distribution*		1/2 1/2	1/3-1/3 1/3	1/4-1/4 1/4-1/4	1/4 3/4	1/5 4/5	1/10 9/10
Pertes d'insertion *Insertion loss*		= 3,2 dB	= 5,0 dB	= 6,2 dB	6dB ± 1dB 1,25dB	7dB ± 1dB 1,0 dB	10dB ± 1dB 0,5 dB
Ondulation *Band Ripple*		= ± 0,5 dB					
Bande de fréquence *Frequency range*		330 - 2700 MHz			380 -1500 MHz 1710 - 2700 MHz		
Adaptation *Return loss*		= 20 dB			= 18 dB		
Puissance entrée *Input power*		200 W					
Intermodulation *PIM*		- 155 dBc @ 2 x 20 W					
Température de fonctionnement *Functionning temperature range*		- 40° + 70° C					
Indice de protection *Protection level*		IP 65					
Poids *Weight*		1 kg	1,1 kg	1,2 kg	0,5 kg		

4.3. DIGITAL TERRAIN MAP

4.3.1 DESCRIPTION

The DTM module used for the radio design has a 20-m resolution.

The projection used is UTM / WGS 84 .

4.3.2 CLUTTERS

Maps have different clutter classes, i.e. open, inland water, forest, urban, dense urban, suburban, etc.

One specific clutter, i.e. cutting, has been added after RF environment survey done in order to represent radio environment along the track. There were numerous cuttings recognized along the track. The cutting was considered as do if its' height is expected to be higher than cab radio antenna, i.e. 4 meters.

The clutter database has been corrected accordingly to all the available sources: GPS samples recorded during CW measurements, pictures and videos taken during environmental surveys, Google Earth correlation.

4.3.3 VECTORS

The railway vectors have been edited accordingly to all the available information: GPS samples taken during CW measurements, pictures and videos taken during environmental surveys, Google Earth inspection.

4.4. PROPAGATION MODEL

The RF outdoor propagation models used in the system design are essentially based on the Hata model that utilizes clutter attenuation factors based on typical values for morphologies such as dense urban, urban and suburban. These factors can either add or subtract additional losses to the values predicted by the Hata model.

5. ENVIRONMENTAL SURVEY

RF environmental survey has been done along the track for:

- Checking DTM (GeoDatabase) information (clutters mainly);
- Assimilating propagation conditions for each environment:
    - Type of foliage and its density
    - Type of buildings, constructions and its density
    - Presence of special structures (cuttings, viaducts, ...), obstacles to radio propagation ;
- Adding complementary information into the map: Cuttings, Embankments, and Viaducts…

Environmental survey was performed by KONTRON RF Team in order to have detailed photo survey of all project's sites and areas that are likely to be problematic in terms of coverage;

The aim pursued was to ensure the absence of any inconsistency or mistake in an available DTM .

The results obtained from the environmental survey allowed RF Team to:

- Clearly identify the environments present along the railway tracks;
- Identify DTM potential gaps;

As a result of environmental survey numerous cuttings that could have an impact on radio design were identified along the track.

During the optimization phase of the Cobh Line, it will be required to perform previously a scanning of the GSM-R band without any GSM-R BTS on-air, in order to ensure that GSM-R spectrum is clean in terms of external transmission.

6. LINK BUDGET

6.1. LINK BUDGET DETAILS

The link budget is used to compute the maximum path loss corresponding to a specific equipment configuration and application. It is based on a path loss calculation between the BTS (transmitter) and the mobile (receiver).

Two path losses are calculated: the uplink path (Mobile to BTS) and the downlink path (BTS to Mobile).

The inputs needed to perform this calculation are organized in three categories:

1) The general parameters (BTS related, antenna heights etc.) that will be independent of the service type

2) The parameters that will depend on the service type (e.g. mobile type)

3) The engineering margins that will depend on the service type and the speed of the train and which ensure that the required QoS is met.

Useful and main outputs of the link budgets are the balanced EIRP, the outdoor minimum field and the design minimum field.

Typically it is necessary to provide coverage to different types of mobile equipment configurations. In accordance with the equipment types defined and the service to be provided, the worst link budget is calculated and the worst case is considered.

This means that if we dimension the link budget on the worst case, the requisites of the best case will be, obviously, satisfied.

The relationships between the more important link budget parameters are as below:

EIRP= [BS Power] + [BS Antenna Gain] – [Duplexer (Combiner Losses)] – [Common Cable Losses] – [Splitter Loss]

The equivalent EIRP calculated in the final link budget includes as well the Slant Polarization loss.

WLB = [EIRP] – [OMF]

DMF = [OMF]- [Design Margins]-[Shadow Margin]+ [Antenna Height Gain]

The key engineering margins are discussed next:

Overlapping Margin: The overlapping margin is a design margin. The aim of this margin is to provide at the border of a cell an extra coverage to allow the fast mobile to perform a handover and a cell reselection.

The overlapping margin is added to the OMF to ensure that the overlapping between two neighboring cells is sufficient to perform the handover and cell reselection procedures in good condition. It depends on the duration of the process, the cell parameters setting and on the speed of the train. Only moving mobiles (including the Class 2 Cab Radio mobiles) are affected by this margin.

Quality Margin: This is a margin which ensures that the receiver provides the BER specified at the requested train speed for the specified service (voice, circuit switched data or packet switched data.) The high speed GSM-R environment introduces Doppler shifts which results in a non-stationary channel response. The quality margin is added to account for this.

Train Clutter Margin: This margin accounts for the antenna placement for the cab radio antenna in the midst of the power catenaries, air-conditioning etc. The placement of the antenna amidst such “clutter” results in significant antenna nulls which must be accounted for by this engineering margin. Handheld mobile will not be affected by “antenna clutter”.

Shadow Margin: The impact of obstacles on RF propagation results in a log-normal field strength distribution centered on the mean value. This phenomenon is known as slow fading or shadowing. The shadow margin is the margin applied to the OMF (in addition to the design margins) to achieve the required outdoor quality inside the coverage area.

Note that Reception sensitivity differs from one environment to another:

BTS Rx Sensitivity without diversity is -110 dBm. When adding diversity with Cross Polarization, sensitivity is improved. This gain comes from the better multi-path signal reassembling and better resistance to signal polarization evolution when colliding obstacles. It is usually considered that Cross Polarization gain is 4dB, however is rural/open environment Cross Polarization gain is not maximized as multipath and signal distortion are sporadic. Studies performed by KONTRON have shown validated this consideration. For rural environment, diversity gain is 3dB.

Outdoor Minimum Field plus the design margins, when needed for the requested services, provide the Design Minimum Field.

Note: Design Minimum Field strength DOES NOT correspond to the field strength value that will be experienced by the terminal. Thus we can consider Quality of Coverage is given at 95% on Design Minimum Field

6.2. CAB RADIO IN RURAL / HILLY ENVIRONMENT

Customer Information		
Contract	Irland/Cork line	
Mobile Type	8W Cab radio	
Service Type	Data Safety critical CSD4.8	
Train Speed	160 km/h	
Frequency Band	GSM900 R	
Customer Requirement	-98dBm @ QoC 95%	GSM-R Link Budget Tool BTS-R v01.01

Equipment Performances		
	BTS (Base Station)	MS (Mobile Station)
	Transmitter (Downlink)	Transmitter (Uplink)
TX Output Power at antenna connector	46,8 dBm	39,0 dBm
	Receiver (Uplink)	Receiver (Downlink)
RX Sensitivity (Static)	-112,0 dBm	-104,0 dBm
Antenna Gain	20,5 dBi	2,0 dBi
BTS Rx Diversity Dynamic gain	4,0 dB	

Site Characteristics		
	BTS (Base Station)	MS (Mobile Station)
Antenna Height	30,0 m	4,5 m
BTS Antenna Type	Cross Polar Panel	
BTS Feeder Type	7/8'	
External Combiner Losses	3,2 dB	0,0 dB
External Cables Losses	2,2 dB	2,0 dB

Engineering margins		
	Uplink margins	Downlink margins
Quality Margin	7,2 dB	3,7 dB
Body Losses	0,0 dB	0,0 dB
Train Rooftop Margin	0,0 dB	0,0 dB
Customer Margin	0,0 dB	0,0 dB
Other Additional Margins	0,0 dB	0,0 dB

Link Budget	
Total UpLink Budget	162,9 dB
Total DownLink Budget	162,2 dB
Worst Link Budget	**162,2 dB**

Coverage Compliancy	
Equivalent EIRP	61,9 dBm
Outdoor Minimum Field	**-98,0 dBm**
Quality of coverage (at Cell Edge)	95%

6.3. HANDHELD IN RURAL / HILLY ENVIRONMENT

Customer Information		
Contract	Irland/Cork line	
Mobile Type	2W Handheld	
Service Type	Data Safety critical CSD4.8	
Train Speed	160 km/h	
Frequency Band	GSM900 R	
Customer Requirement	-98dBm @ QoC 95%	GSM-R Link Budget Tool BTS-R v01.01

Equipment Performances		
	BTS (Base Station)	MS (Mobile Station)
	Transmitter (Downlink)	Transmitter (Uplink)
TX Output Power at antenna connector	46,8 dBm	33,0 dBm
	Receiver (Uplink)	Receiver (Downlink)
RX Sensitivity (Static)	-112,0 dBm	-102,0 dBm
Antenna Gain	21,0 dBi	-2,0 dBi
BTS Rx Diversity Dynamic gain	4,0 dB	

Site Characteristics		
	BTS (Base Station)	MS (Mobile Station)
Antenna Height	30,0 m	1,5 m
BTS Antenna Type	Cross Polar Panel	
BTS Feeder Type	7/8'	
External Combiner Losses	3,2 dB	0,0 dB
External Cables Losses	2,2 dB	0,0 dB

Engineering margins		
	Uplink margins	Downlink margins
Quality Margin	0,0 dB	0,0 dB
Body Losses	3,0 dB	3,0 dB
Train Rooftop Margin	0,0 dB	0,0 dB
Customer Margin	0,0 dB	0,0 dB
Other Additional Margins	0,0 dB	0,0 dB

Link Budget	
Total UpLink Budget	159,6 dB
Total DownLink Budget	159,4 dB
Worst Link Budget	**159,4 dB**

Coverage Compliancy	
Equivalent EIRP	62,4 dBm
Outdoor Minimum Field	**-97,0 dBm**
Quality of coverage (at Cell Edge)	95%

Other Important Factors	
In Train Penetration Factor	0,0 dB
Slant Polar Loss	2,0 dB
Overlapping Margin	2,4 dB

6.4. LINK BUDGET CONCLUSION

The Outdoor Minimum Field for the radio design is as follow:

	Outdoor minimum field (dBm)	Design minimum field (dBm)
Cab radio	-98	-81,3

Design Minimum Field is a target level for RF design. Wherever this level is achieved in simulation process it is assumed that all required services are guaranteed. Therefore, the most constraining link budget of Cab Radio is taken as an ultimate target level for radio design.

The exact values of Design Minimum Field are acquired along the complete environmental analysis, model calibration process and margins application.

7. RADIO CELL PLANNING RESULTS

The Radio Planning tool that has been used for the design of this pilot line is Forsk Atoll v3.3.2

- ➔ Considering that the Cobh line is:
  - Starting with the site of Cork station
  - Finishing with the site of Cobh station and the XY010 Ford Xing site
  - Cork site and Cork tunnel is considered as a part of the Cobh line
- ➔ the number of sites to cover the Cork line is:
  - 8 BTS are BTS-R type
  - 1 BTS-R as a repeater
- ➔ All the BTS sites will be within IE property, as requested by IE.
- ➔ Sites list details can be found in the next chapter.

7.1. RADIO CELL PLANNING SUMMARY TABLE

The sites list details contains the following design information about the site

- site position, both in Latitude/Longitude format and in meters (datum: WGS84, UTM zone: 36N).
- height of the mast/tower
- number of BTS and number of pseudo-sectors

and about each sector

- antenna type, with main characteristics (gain, H/V half-power beam width, polarization)
- azimuth
- mechanical downtilt (electrical tilt is considered at 0)
- antenna height

id	Old Site Name	New Site Name	Longitude	Latitude	Pylon Height (m)	Type	Config	BCCH	Antenna	Height (m)	Azimuth (°)	Mechanical Downtilt (°)	Secondary Antenna	Azimuth (°)	Mechanical Downtilt (°)	% Power	Height (m)	Third Sector Antenna	Azimuth (°)	Mechanical Downtilt (°)	% Power	Height (m)
0		Cork Tunnel	8°27'35,81"O	51°54'7,85"N	No pylon. See current Analog ant	BTS-R/RRH as rep	Repeater		Protel AR1021	6	337	0										
1	Cork Station	Cork Station	8°27'2,92"O	51°54'8,86"N	15	BTS-R	O1+1	965	Kathrein 80010456v02 T0	13,75	83	0	Kathrein 80010456v02 T0	260	0	50	13,75					
2	North Esk Freight Depot	MP168 1/2	8°23'5"O	51°54'20,28"N	30-->20	BTS-R	O1+1	970	Kathrein 80010456v02 T0	18,75	82	0	Kathrein 80010456v02 T0	266	0	50	18,75					
3	Glounthane Stn.	Glounthane Stn.	8°19'35,3"O	51°54'41,1"N	30	BTS-R	O1+1	960	Kathrein 80010456v02 T0	28,75	85	0	Kathrein 80010456v02 T0	266	0	40	28,75	Kathrein 80010456v02 T0	174	4	20	28,75
4	Carrigtohill	Carrigtohill new	8°15'47,92"O	51°54'59,22"N	15	BTS-R	O1+1	955	Kathrein 80010456v02 T0	13,75	86	0	Kathrein 80010456v02 T0	257	0	25	13,75					
5	XY010 Ford Xing	XY010 Ford Xing	8°11'40,35"O	51°55'11,18"N	15	BTS-R	O1+1	964	Kathrein 80010456v02 T0	13,75	87	0	Kathrein 80010456v02 T0	263	0	50	13,75					
6	Carrigloe Stn.	Carrigloe Stn.	8°19'29,25"O	51°52'4,81"N	20-->30	BTS-R	O1+1	968	Kathrein 80010456v02 T0	28,75	184	0	Kathrein 80010456v02 T0	5	4	50	28,75					
7	Rushbrook Stn.	Rushbrook Stn.	8°19'19,88"O	51°50'57,66"N	10	BTS-R	O1+1	957	Kathrein 80010456v02 T0	8,75	134	0	Kathrein 80010456v02 T0	318	0	50	8,75					
8	Cobh Station	Cobh Station	8°18'14,91"O	51°50'52,8"N	15	BTS-R	O1+1	971	Kathrein 80010456v02 T0	13,75	254	0										

7.2. SITES POSITION DETAILS

This section describes in more detail each site position.

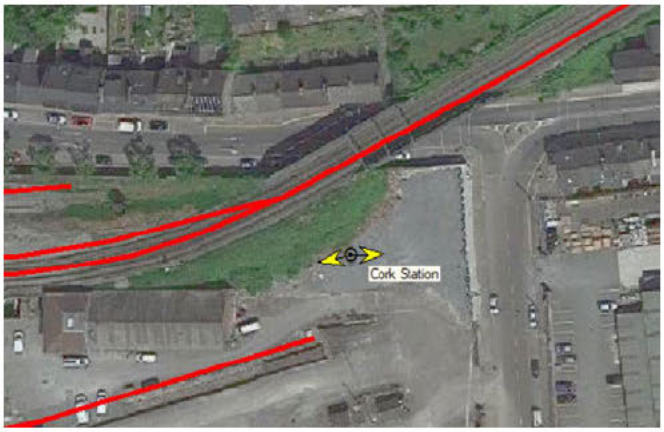
Useful information:

- Google earth image is oriented to the North
- First photo of the estimated position (yellow circle) is in direction to Cork (left or top photo)
- Second photo of the estimated position (yellow circle) is in direction to Cobh (right or bottom photo)

7.2.1 CORK STATION

Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
Cork Station	8°27'2,92"O	51°54'8,86"N	4	15	BTS-R	O1+1	965	

Site Location



Estimated site position

7.2.2 CORK TUNNEL REPEATER

Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
Cork Tunnel	8°27'35,81"O	51°54'7,85"N	8	No pylon. See current Analog ant	BTS-R/RRH as rep	Repeater	Cork site BCCH	

Site Location

Estimated site position

7.2.3 MP168 1/2

Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
MP168 1/2	8°23'5"O	51°54'20,28"N	4	30-->15	BTS-R	O1+1	970	

Site Location

Estimated site position

7.2.4 GLOUNTHANE STATION

Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
Glounthane station	8°19'35,3"O	51°54'41,1"N	4	30	BTS-R	O1+1	960	

➔ **Existing site**

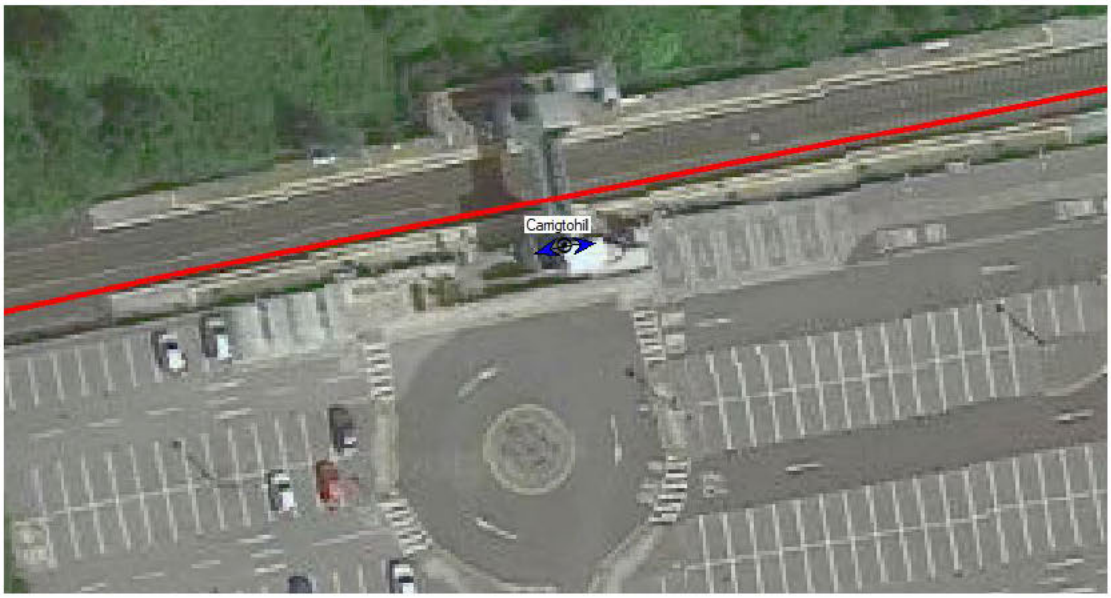
Site Location

Site position

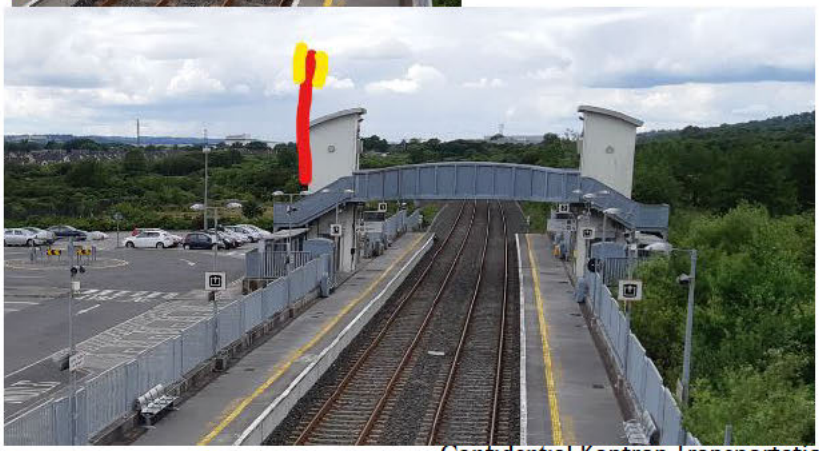
7.2.5 CARRIGTOHILL STATION

Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
Carrigtohill station	8°15'47,76"O	51°54'58,63"N	12	15	BTS-R	O1+1	955	

Site Location



Estimated site position



7.2.6 XY010 FORD XING (MIDLETON STATION)

Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
XY010 Ford Xing	8°11'40,35"O	51°55'11,18"N	11	15	BTS-R	O1+1	964	

Site Location

Estimated site position

7.2.7 CARRIGLOE STATION

Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
Carrigloe station	8°19'29,25"O	51°52'4,81"N	13	20-->30	BTS-R	O1+1	968	

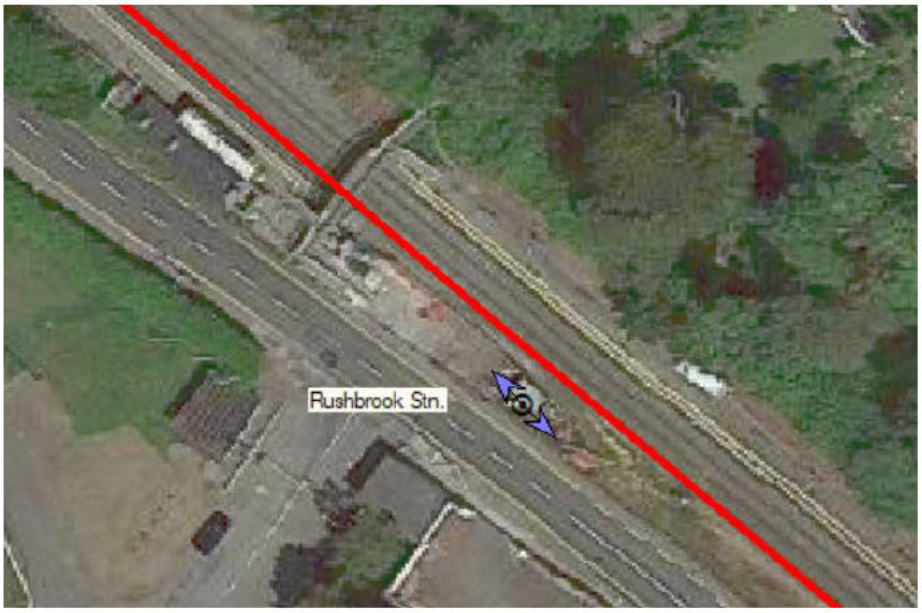
Site Location

Estimated site position

7.2.8 RUSHBROOK STATION

Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
Rushbrook station	8°19'19,88"O	51°50'57,66"N	13	10	BTS-R	O1+1	957	

Site Location



Estimated site position

7.2.9 COBH RELAY ROOM

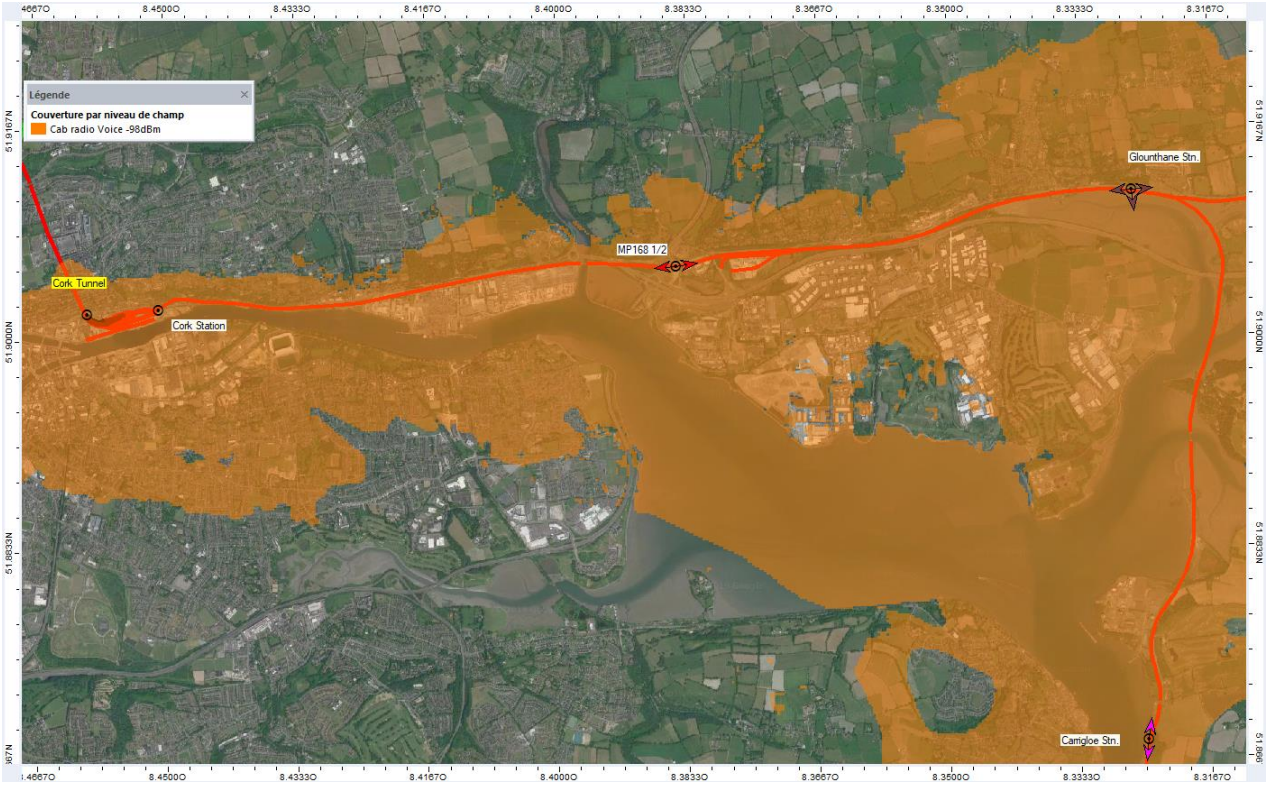
Site Name	Longitude	Latitude	Altitude	Pylon Height (m)	Type	Config	BCCH	DM Location
Cobh relay room	8°18'14,91"O	51°50'52,8"N	5	15	BTS-R	O1+1	971	

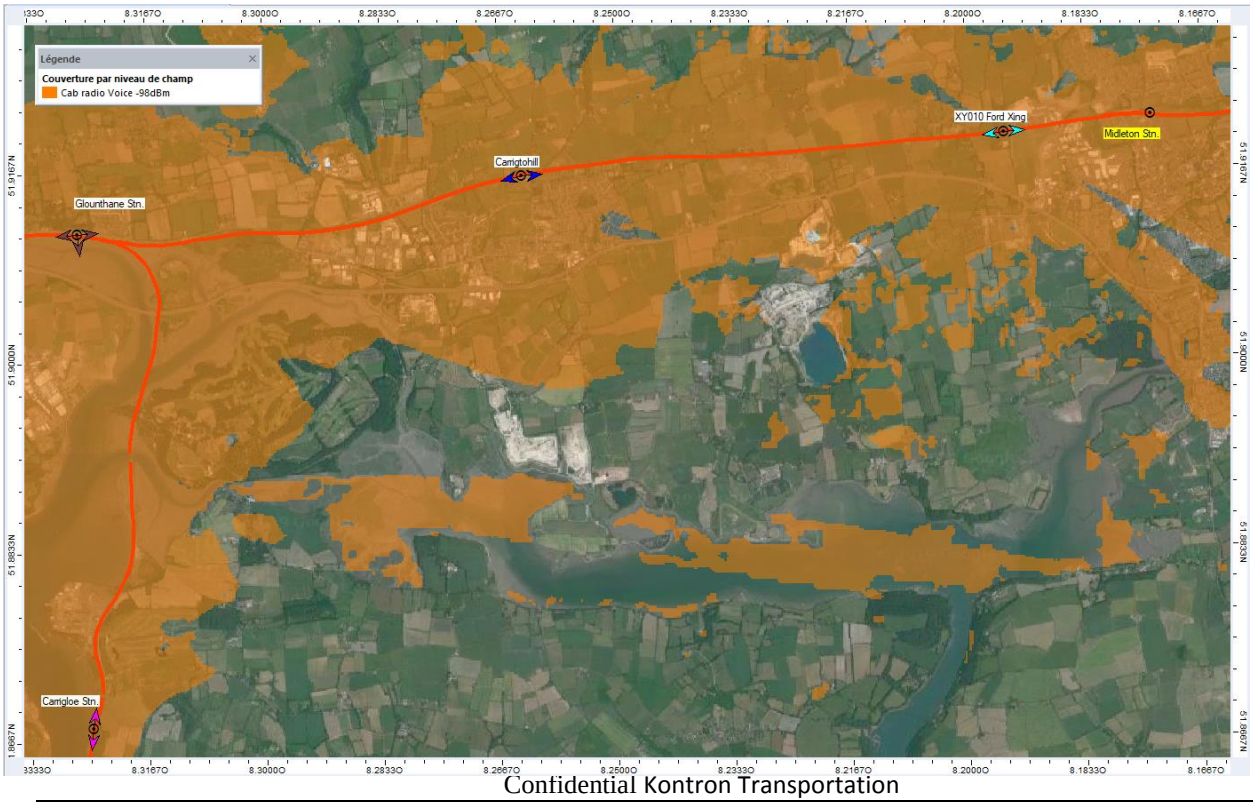
Site Location

Estimated site position

8. COVERAGE MAPS

8.1. SIGNAL LEVEL COVERAGE

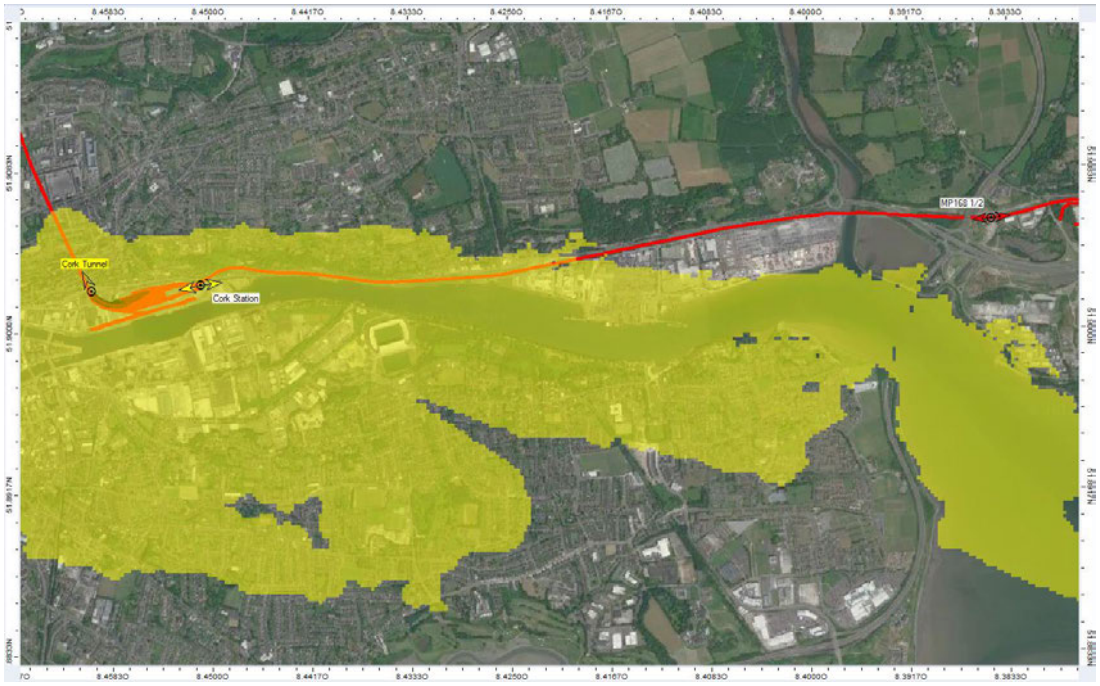





Légende
Couverture par niveau de champ
Cab radio Voice -98dBm
Carrigloe Stn.
Rushbrook Stn.
Cobh Station

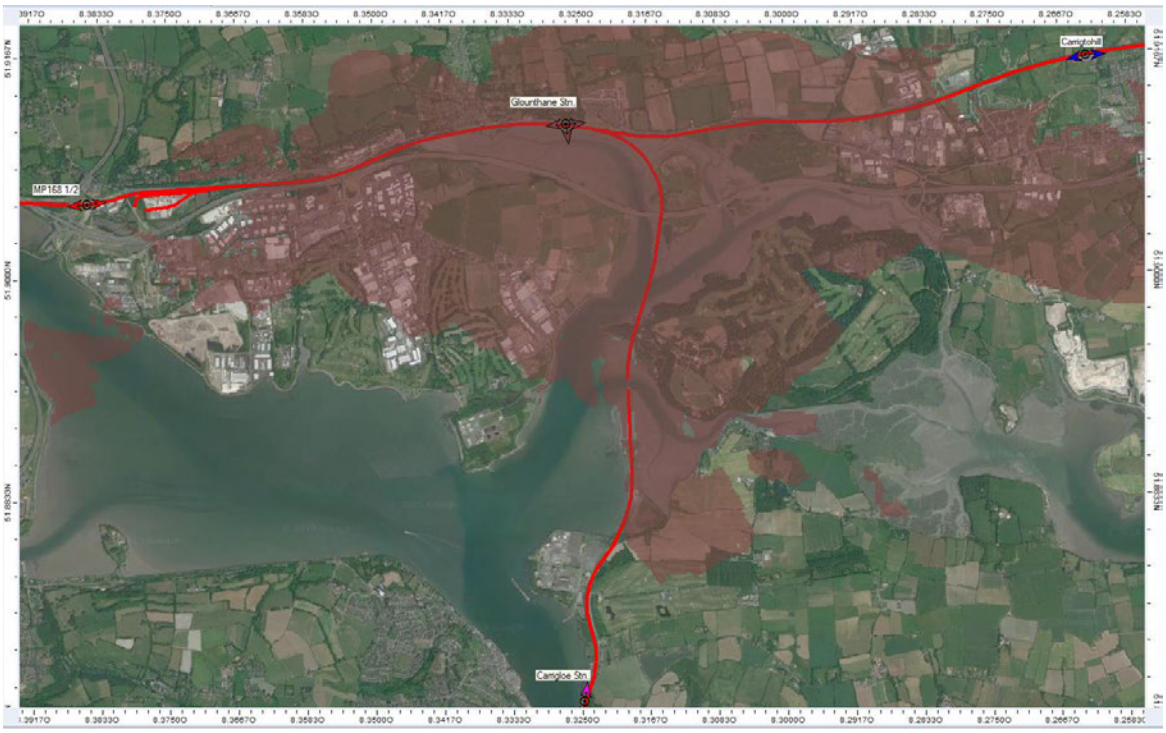
8.2. COVERAGE PER SITE

8.2.1 CORK STATION

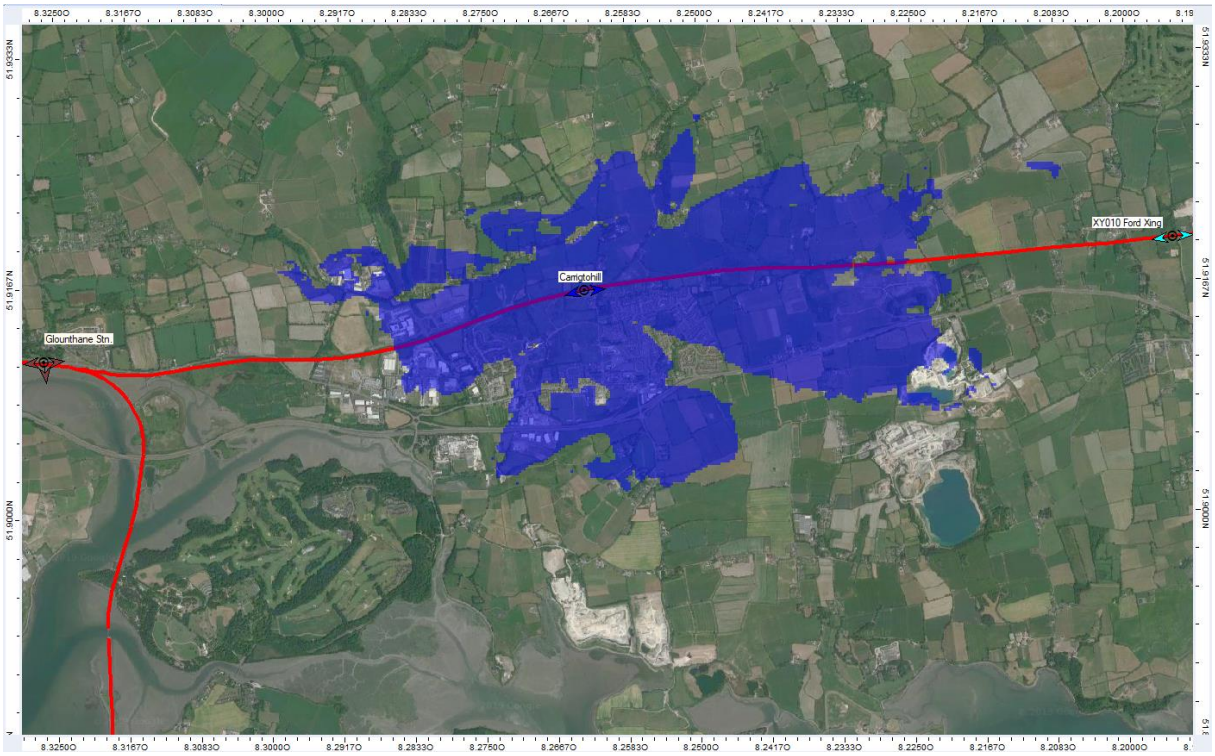


8.2.2 MP168 1/2

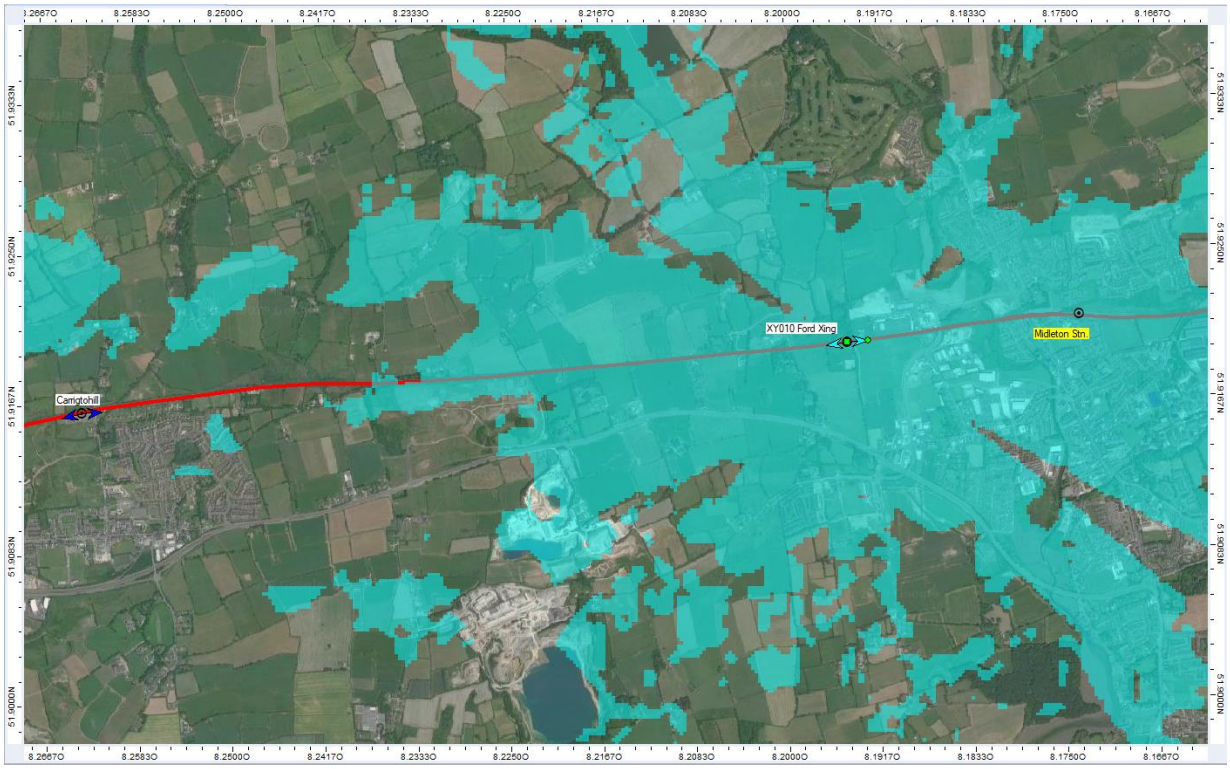
8.2.3 GLOUNTHANE STATION



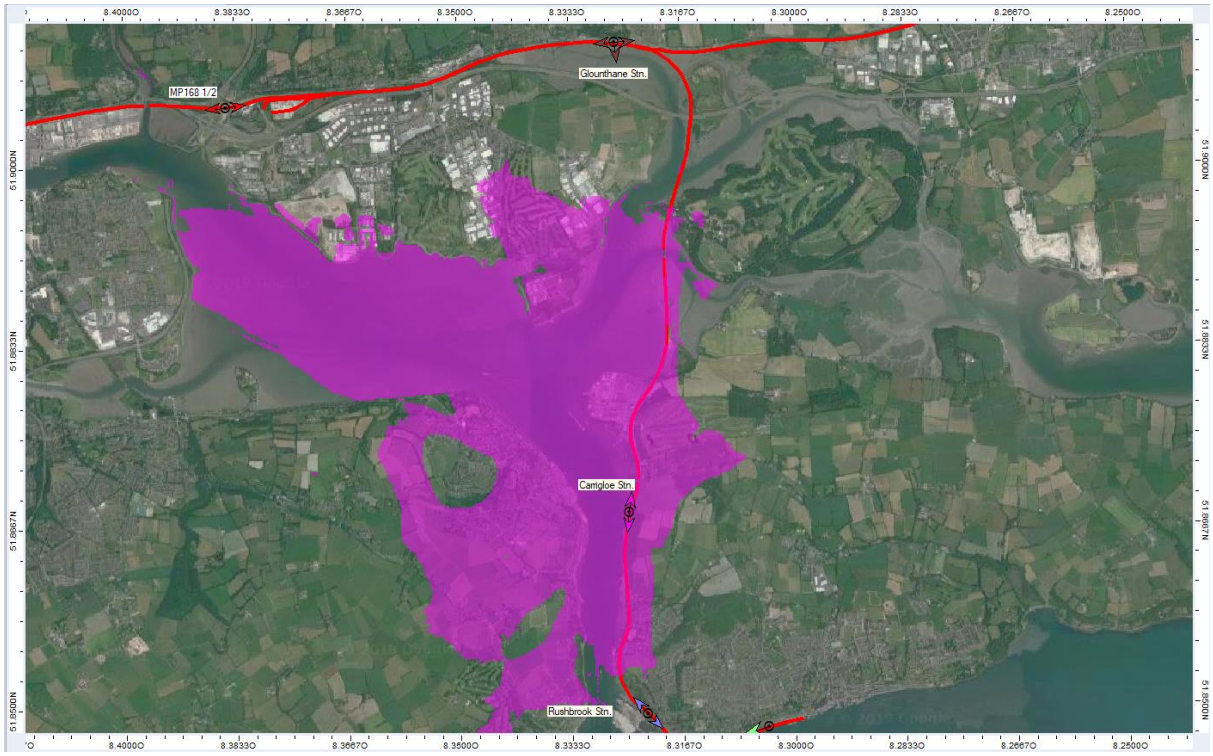
8.2.4 CARRIGTOHILL STATION



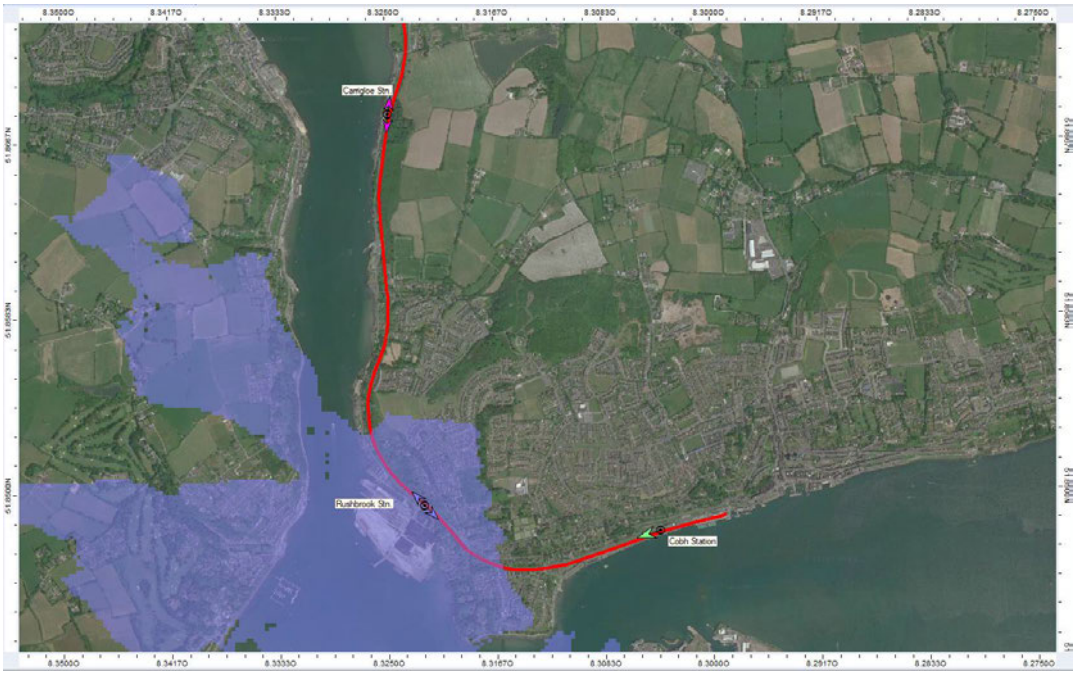
8.2.5 XY010 FORD XING (MIDLETON STATION)



8.2.6 CARRIGLOE STATION



8.2.7 RUSHBROOK STATION



8.2.8 COBH RELAY ROOM

9. FREQUENCY PLANNING

9.1. Frequency Band Overview

The frequency band allocated by the standardization body ETSI to GSM-R is [876 MHz – 880 MHz] in uplink and [921 MHz -925 MHz] in downlink. The spacing between two consecutive channels is 200 KHz. Therefore 19 channels are dedicated to GSM-R service.

Each frequency channel is uniquely defined by its Absolute Radio Frequency Channel Number (ARFCN) as illustrated below.

ARFCN Number	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973
F UPLINK MHz	876,2	876,4	876,6	876,8	877	877,2	877,4	877,6	877,8	878	878,2	878,4	878,6	878,8	879	879,2	879,4	879,6	879,8
F DOWNLINK MHz	921,2	921,4	921,6	921,8	922	922,2	922,4	922,6	922,8	923	923,2	923,4	923,6	923,8	924	924,2	924,4	924,6	924,8

To reduce the interference level a good isolation between frequency channels is required, Kontron recommends a minimum of 600 kHz spacing between frequencies on the same site and a minimum of 400 kHz spacing between two neighboring sites.

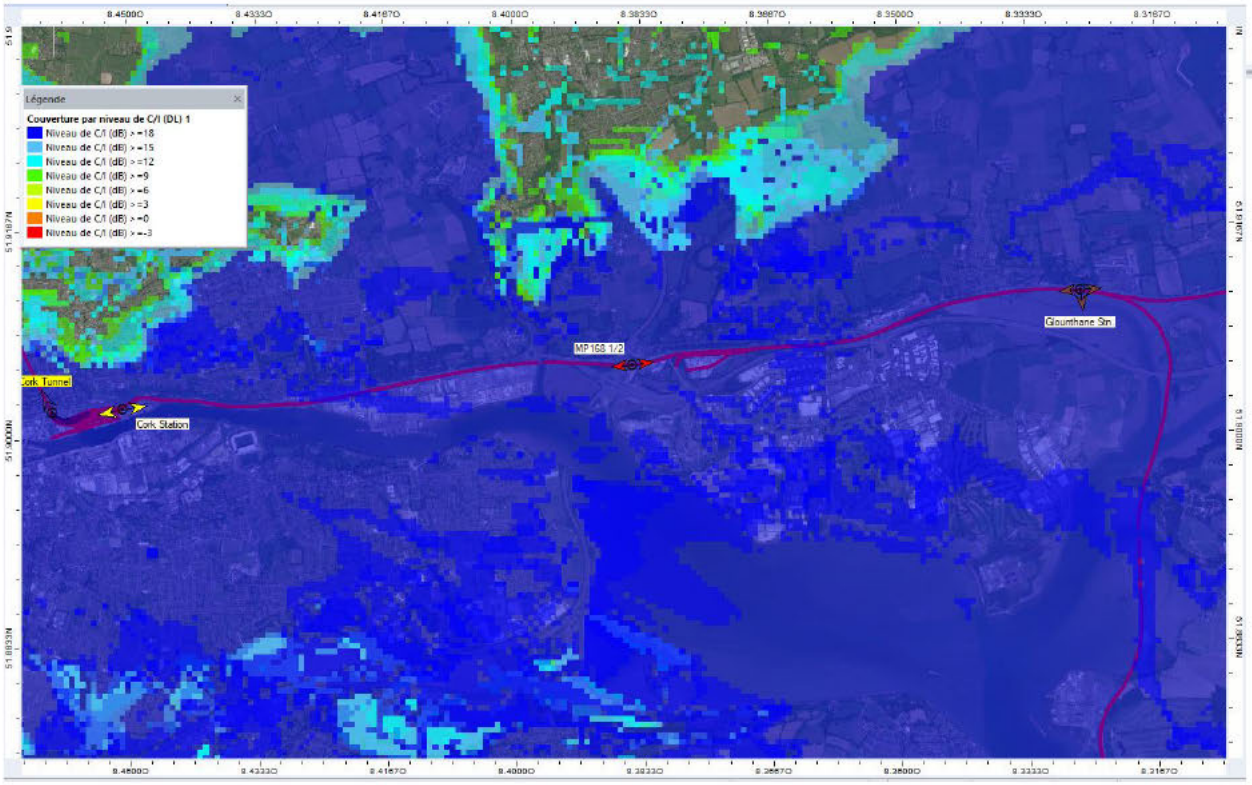
9.2. Frequency Strategy

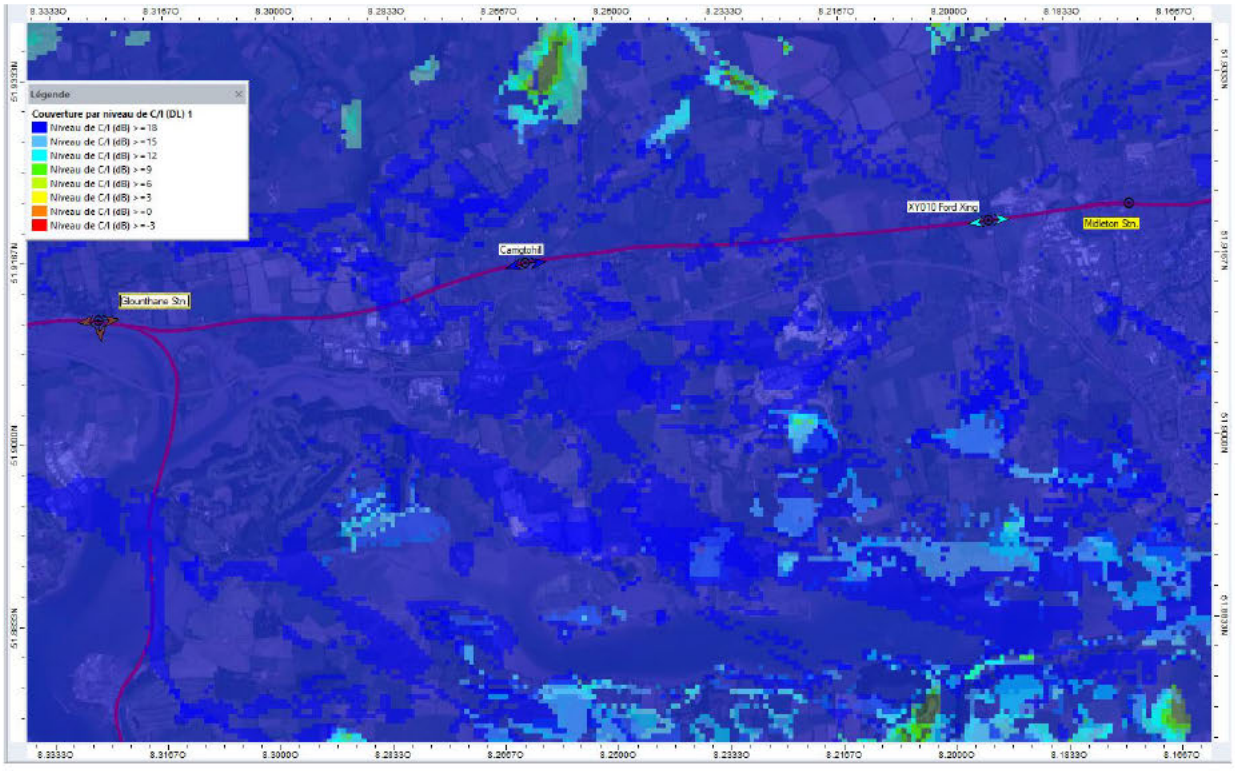
The frequency planning strategy for this line as been done site by site due to the environment configuration. The line is surrounded by sea, which lead to have a huge risk of resurgence even far away from transmitters. The frequency planning has been done in order to use the overall spectrum resources and considering this water effect.

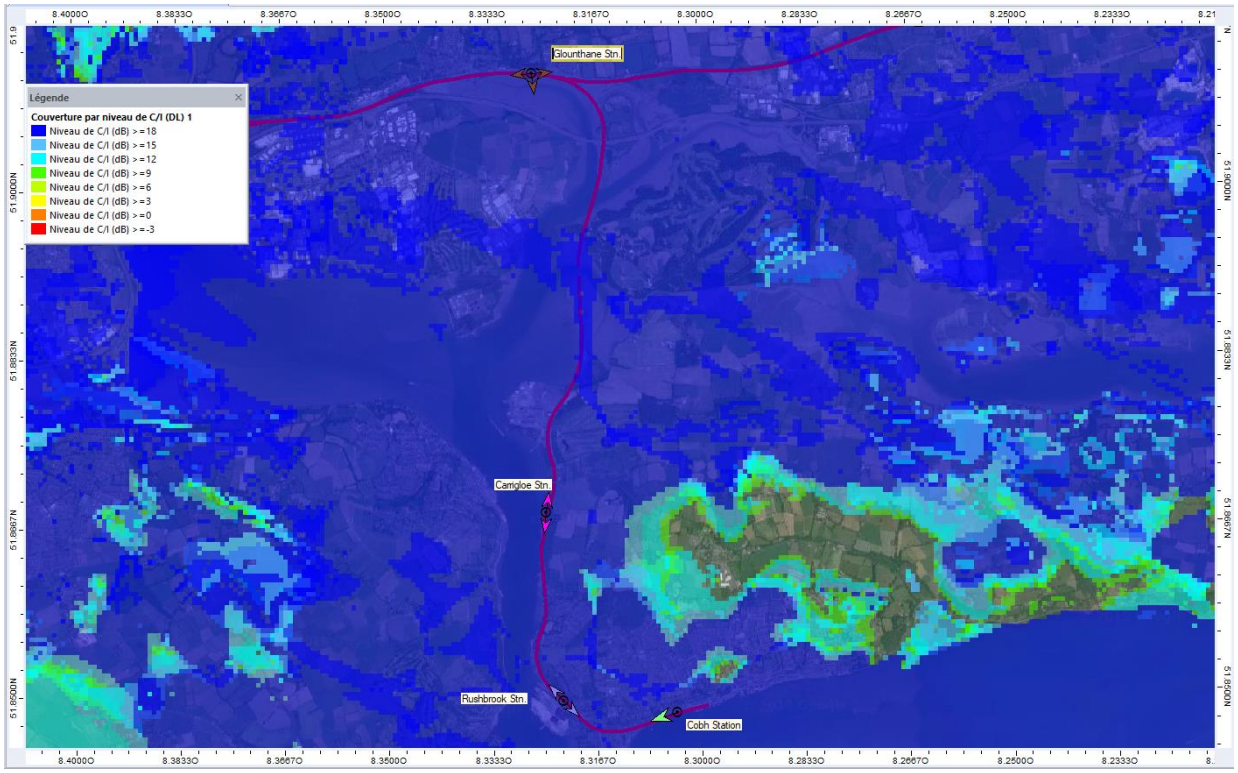
9.3. Frequency Planning

Site Name	Longitude	Latitude	Config	BCCH
Cork Tunnel	8°27'35,81"O	51°54'7,85"N	Repeater	965
Cork Station	8°27'2,92"O	51°54'8,86"N	O1+1	
MP168 1/2	8°23'5"O	51°54'20,28"N	O1+1	970
Glounthane Stn.	8°19'35,3"O	51°54'41,1"N	O1+1	960
Carrigtohill new	8°15'47,92"O	51°54'59,22"N	O1+1	955
XY010 Ford Xing	8°11'40,35"O	51°55'11,18"N	O1+1	964
Carrigloe Stn.	8°19'29,25"O	51°52'4,81"N	O1+1	968
Rushbrook Stn.	8°19'19,88"O	51°50'57,66"N	O1+1	957
Cobh relay room	8°18'14,91"O	51°50'52,8"N	O1+1	971

9.4. Interference Maps






Glounthane Stn
Carrigloe Stn
Rushbrook Stn
Cobh Station
Légende
Couverture par niveau de C/I (DL) 1
Niveau de C/I (dB) >=18
Niveau de C/I (dB) >=15
Niveau de C/I (dB) >=12
Niveau de C/I (dB) >=9
Niveau de C/I (dB) >=6
Niveau de C/I (dB) >=3
Niveau de C/I (dB) >=0
Niveau de C/I (dB) >=-3

10. CONCLUSION

➔ Cell planning along the Cobh line tracks between the site of Cork station, Cobh relay room and the site covering Midleton station requires 8 **O1+1 BTS-R and 1 BTS-R as a repeater**

➔ All the BTS sites will be within IE property, as requested by IE.

➔ This document cannot be used for deployment activity and may be iterated all along project integration and optimization.

END OF DOCUMENT