

Atelier : Industrie du futur et 5G

Comment anticiper les problèmes de propagation dans un bâtiment

C.Alayrac & H. Raki – 2 Juin 2022 – version 1.0

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Le CRT CRESITT est soutenu par :



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L'Europe s'engage en région Centre-Val de Loire avec le Fonds européen de développement régional.



1G

Appel téléphonique
Envoie message texte

Analogique
AMPS



2G

Transmission numérique
Amélioration qualité
Communication internationale

Numérique
GSM



3G

Accès à internet depuis
smartphone

CDMA2000
UMTS
EDGE



4G

Amélioration du débit
→ Streaming HD

LTE
Wi-Max
MIMO

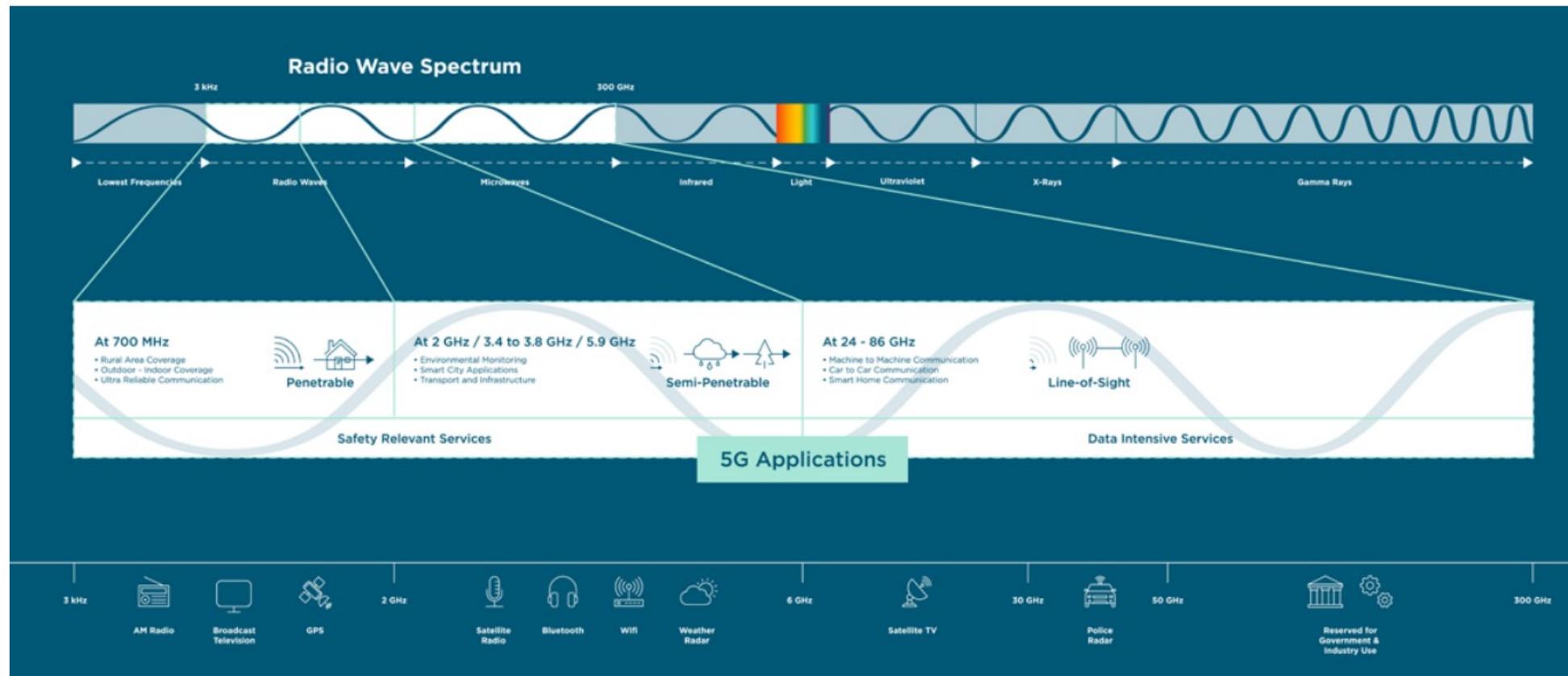


5G

Amélioration 4G x10

5G-NR
Massive
MIMO

La principale distinction 4G et 5G → réduction du temps de latence, 1 ms max.
→ connexion appareils dans les secteurs critiques



Prise en compte de nombreux paramètres pour atteindre les performances

Couverture

analyses fines de différentes bandes de fréquences, déploiement de station de base, environnements...

Performance du réseau

choix du canal radio est impacté par l'environnement urbain et « indoor »

Arbitrage tests versus délais de mise en place

La spécificité des essais engendre des surcoût et des délais

Mais des essais mal réalisés peuvent engendrer de coûts de non qualité plus important

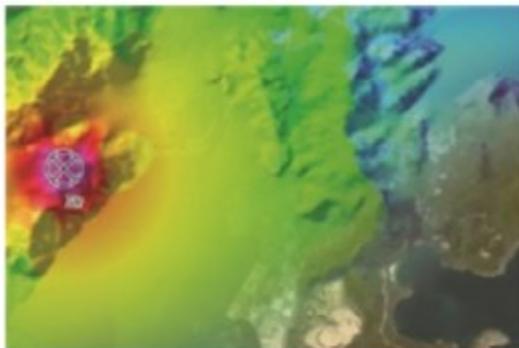


Source : <https://itemm.fr/itemm/reze-hangar-pendule-clovis-guitares/>

- Portée radio
- Débit utile
- Nombre de répéteurs à mettre en place
→ impact coût infrastructure



Source : <https://www.eggerpumps.com/fr-fr/branches/industrie-chimique>



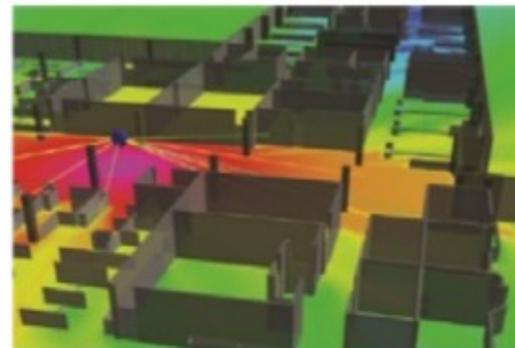
Rural Propagation

Large rural scenarios are based on the processing of topography and clutter maps in pixel formats.



Urban Propagation

WinProp offers sophisticated propagation models based on ray-optical techniques such as like ray tracing.

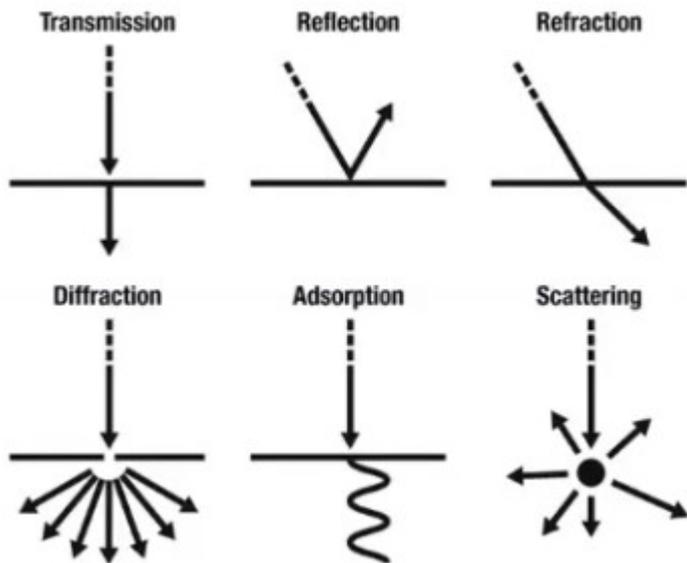


Indoor Propagation

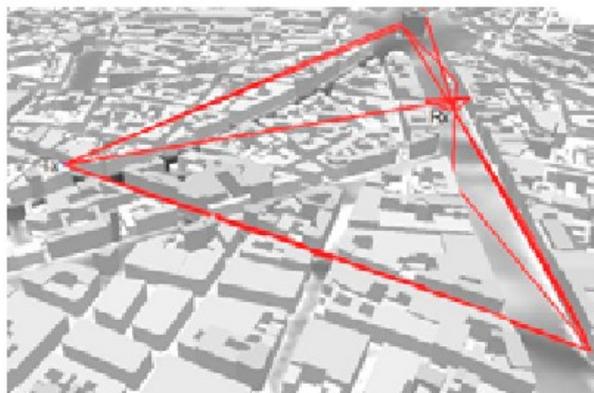
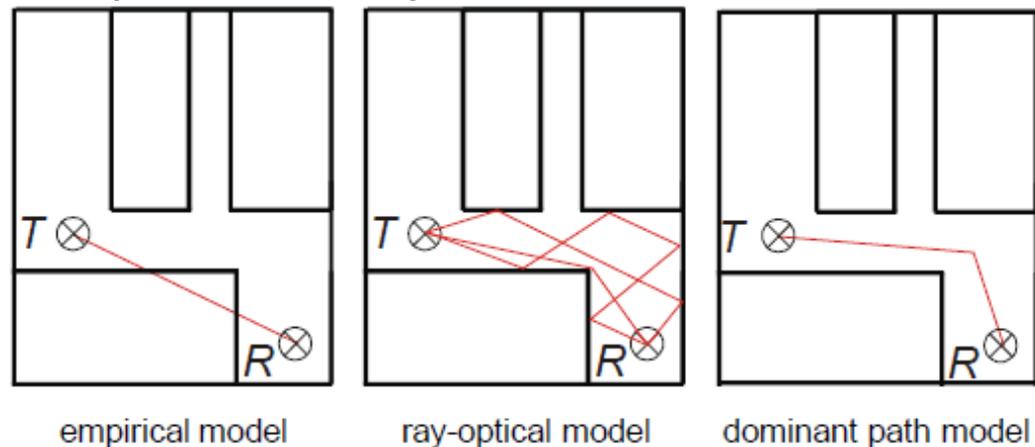
Indoor scenarios include 3D vectors with individual material properties to describe more complex objects like office floors.



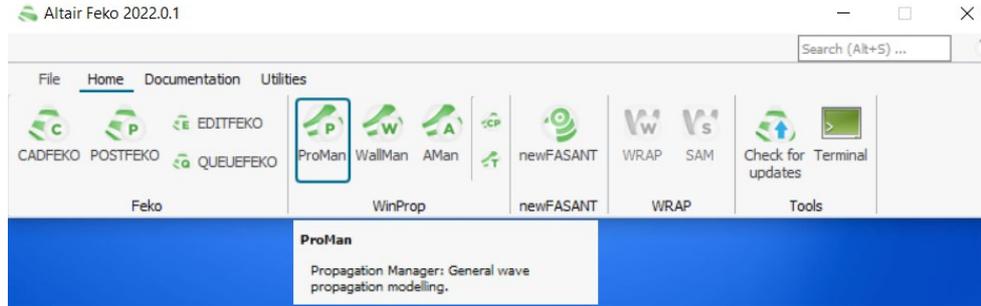
La physique



Principe du tir de rayon

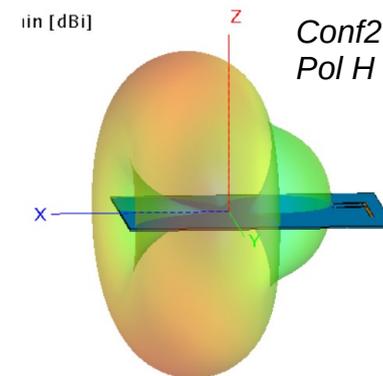
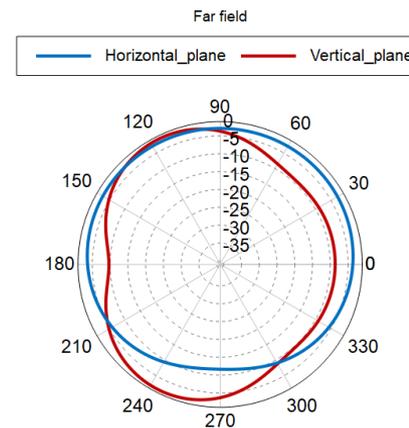
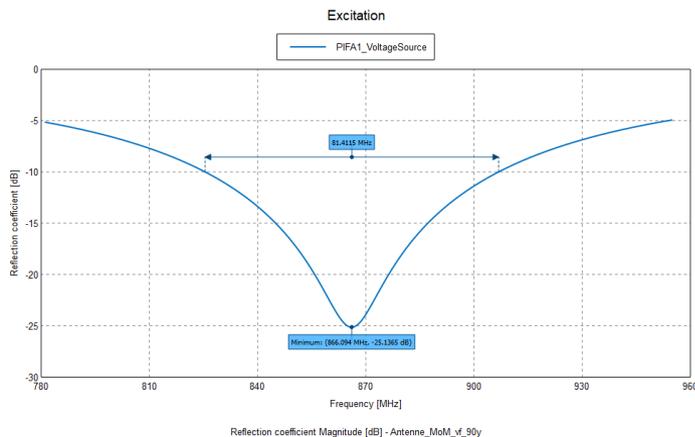
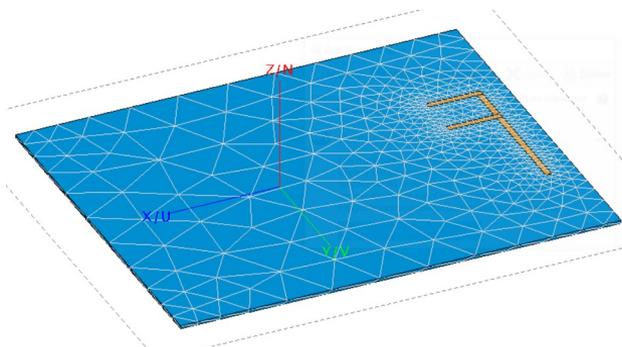


Exemple mise en œuvre Module LORA au LAB'O



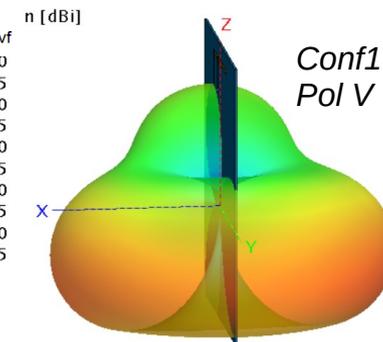
- Design d'une antenne PIFA 868Mhz
Simulation gain, directivité, impédance...
- Génération du modèle du bâtiment
- Import de l'antenne simulée
- Simulation de la puissance reçue à chaque étage
- Simulation des débits utilisables sur chaque étage

- FEKO : Antenne PIFA**



Total Gain (Frequency = 868 MHz; Theta = 90 deg; Phi = 0 deg) - Antenne_MoM_vf

Antenne à polarisation linéaire

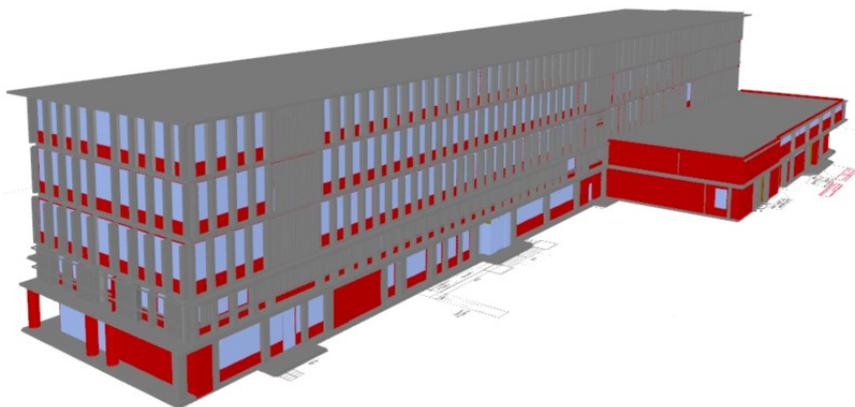


Formation : Intégration d'antennes dans le monde de l'IoT (2j)

Formation portée par Captronic

Date
06 - 07 Juil 2022

- WallMan : Bâtiment LAB'O



• WallMan : Bâtiment LAB'O

Default Values for New Objects

Geometrical Parameters for Orthogonal Drawing Mode

Object relative to current plane (current 3rd coordinate)

Height of walls relative to current plane: m

Upper and lower coordinate defined individually (end absolute)

Min. Coord: m Max. Coord: m

Automatic mode

If floor levels are defined, height of walls is adapted according to the active floor level. Otherwise height of walls is relative to current plane.

Material Properties

Material Properties of new Walls

Material Properties of new Subdivisions

Material Properties of new Furniture

Materials used in Database

Clutter Properties

Clutter Class of Prediction Planes



Material Catalogue

Materials (currently 70)

The following table contains all materials and vegetations of this database. You can click on the column headers to sort the materials/vegetations with respect to the values in this column.

Show color of materials in table

ID	Description	Type	Objects
9	Concrete; thickness: 10 cm.	Material	622
3	Brick; thickness: 10 cm.	Material	523
72	Default Furniture	Furniture	495
4	Brick; thickness: 20 cm.	Material	400
25	Metal; thickness: 5 mm.	Material	196
17	Glass; thickness: 2 mm.	Material	114
66	Wood heavy; thickness: 5 cm.	Material	105
11	Concrete; thickness: 30 cm.	Material	57
69	Wood; thickness: 5 cm.	Material	52
24	Metal; thickness: 1 mm.	Material	5
5	Brick; thickness: 30 cm.	Material	3
10	Concrete; thickness: 20 cm.	Material	1
18	Glass; thickness: 5 mm.	Material	1

Scale Objects

Selection of scaling method

By drawing a line

With known scaling factor

Factor:

Fixpoint

Database origin

Lower left of all objects

Center of all Objects

Scale walls

on X axis on Y axis on Z axis

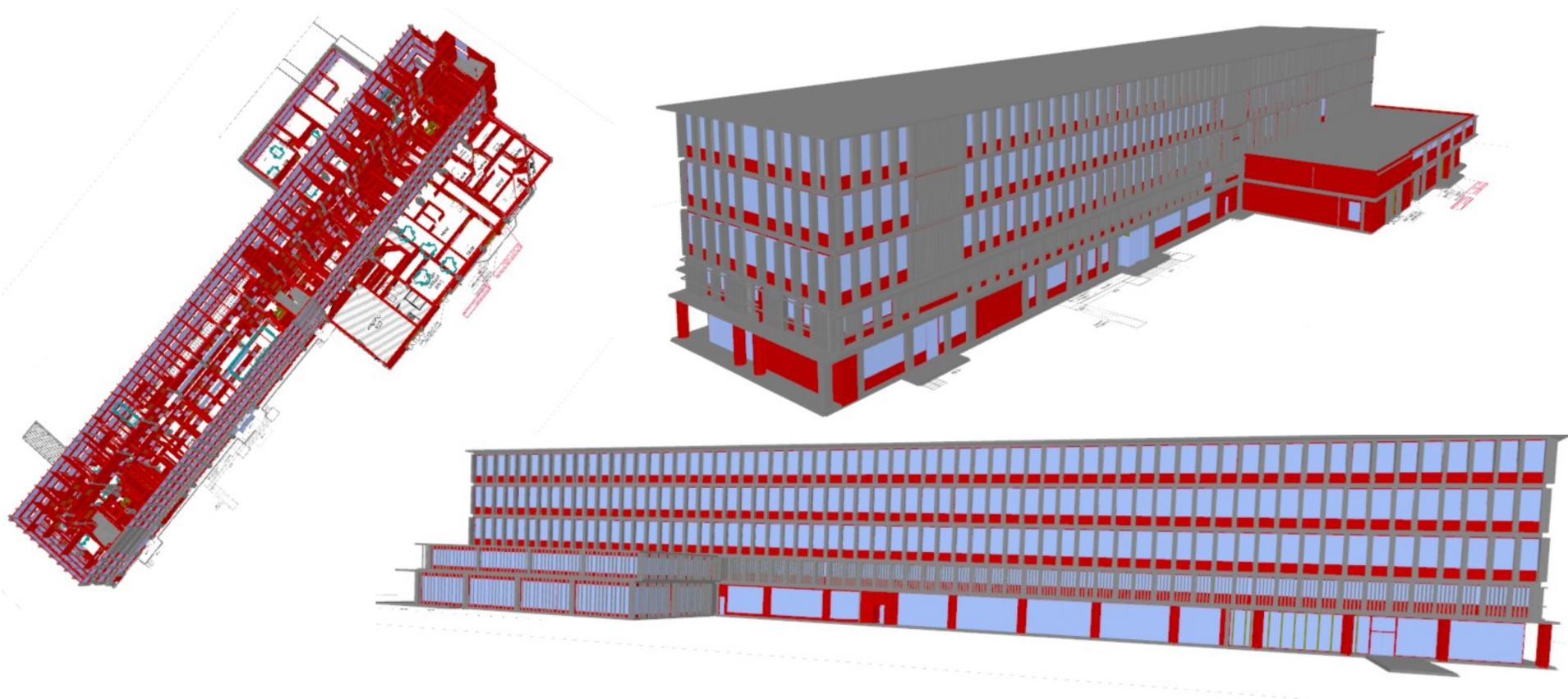
Scale other objects

Images Pixel Maps

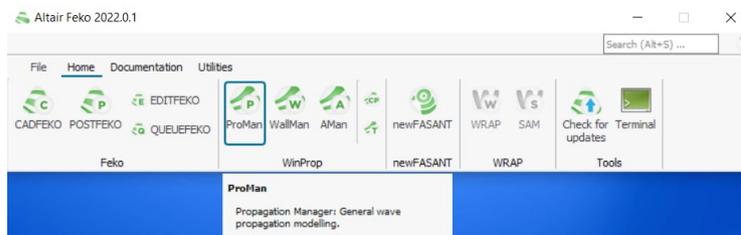
Scale

Enter length of the specified line: m

- **WallMan : Bâtiment LAB'O**



- ProMan



New Project

Wireless Technology (Air Interface)

Please define the air interface (technology) of the wireless network you want to plan/simulate.

You can either select a pre-defined air interface or you can define all settings of your air interface individually. If you want to use this tool only for propagation analysis, you should disable the air interface.

Network Planning based on description file for air interface

Name of the file with the settings of the air interface
LoRa EU

Scenario
Indoor Scenarios (3D vector databases for arbitrary 3D scenarios)

Databases

Use only preprocessed vector databases
3D indoor building data (Vector database)
C:\Users\cresitt\Desktop\Hamza_Cresitt_Windows\202205_Wv

Components Catalogue (optional)

Polarimetric Analysis

Standard (suitable for all scenarios and propagation models)
 Full (limited selection of scenarios and propagation models)

OK Cancel

Define Display Height

Display height (z coordinate)

Height: 1.5 (m)

Height can always be modified via display menu

OK Cancel

- Protocole LORA choisi

Edit Project Parameter - LoRa_RDC

Air Interface | Simulation | Traffic | Network | Propagation | Sites | Components | Database | Computation

Multiple Access

Duplex Separation

MIMO Technology

Bandwidth
 Channel Bandwidth kHz

Carriers

T	ID	Frequency...
S	1	868.10 MHz
S	2	868.30 MHz
S	3	868.50 MHz
S	4	868.70 MHz
S	5	868.90 MHz
S	6	869.10 MHz
S	7	869.30 MHz
S	8	869.50 MHz

Transmission Modes (MCS)

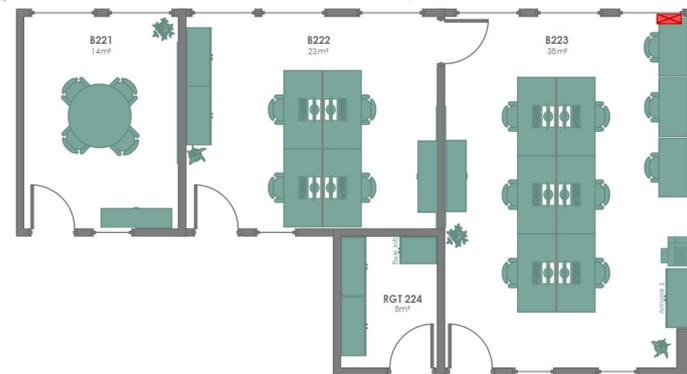
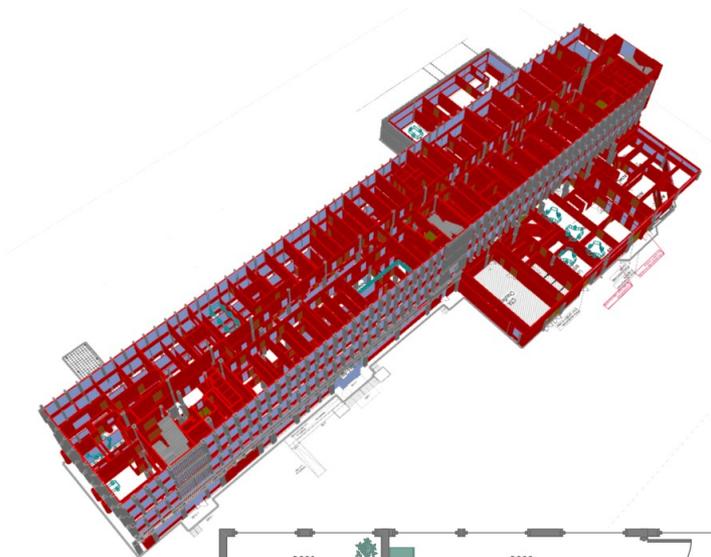
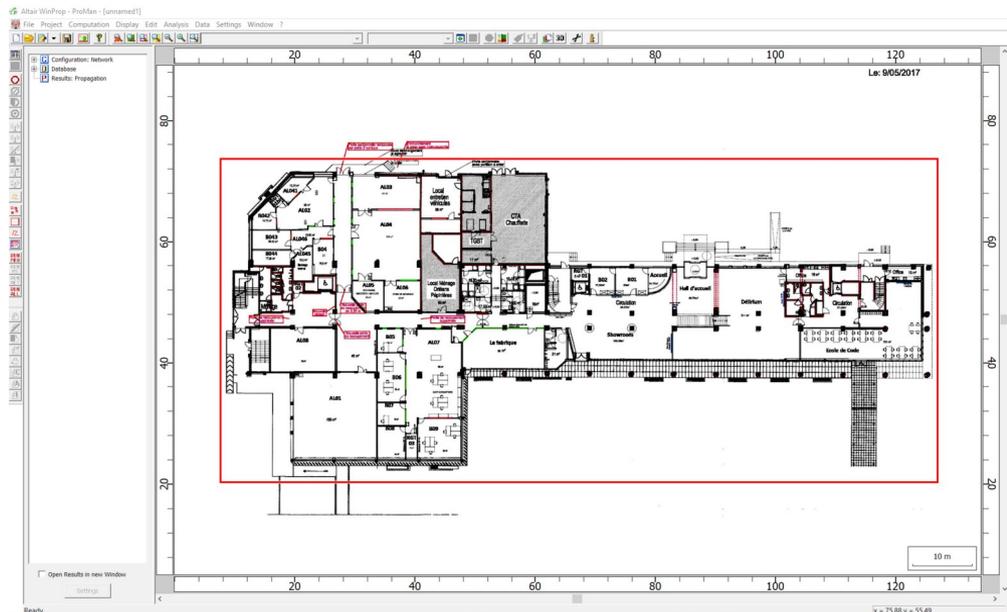
Name	P...	Data Rat...	Data Rat...
LoRa SF 6	3	470.84 B/s	-
LoRa SF 7	4	276.23 B/s	-
LoRa SF 8	5	156.95 B/s	-
LoRa SF 9	6	87.89 B/s	-
LoRa SF 10	7	50.22 B/s	-
LoRa SF 11	8	25.11 B/s	-
LoRa SF 12	1	15.69 B/s	-

Cell Assignment

 Min. required SNIR dB

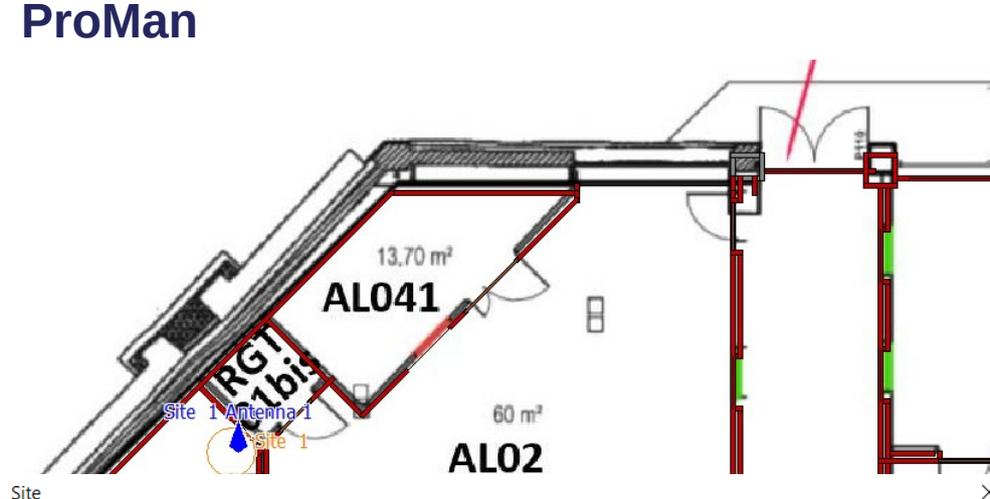
Mobile Station / Subscriber Station

- ProMan



Module émetteur dans B042 (RdC) à 2,50m de hauteur
Récepteur dans B223 (2ème Étage) B223 à 1,20m du sol

- ProMan



Site

Site ID: Site 1

Comment:

Type of Site: Site for antenna

Location:

x / Longitude: 16.23 y / Latitude: 65.27 z / Height: 0.00 m

Antennas:

Name	Antenna	Azimuth	Downtilt	Longitude	Latitude	Height	Carrier	Power	Mod
Site 1 Antenna 1	Antenne...	0.00	0.00	16.39 m	65.27 m	2.50 m	S-1	15.00 dBm	Outp

Cell

Number and Name of Cell in Project

Nr: 1 Name: Site 1 Antenna 1

Status of Cell in Project

Enabled (Prediction computed)

Disabled (Prediction not computed)

Location of Antenna

x / Longitude: 16.3900 m

y / Latitude: 65.2700 m

z / Height: 2.5000 m

Height relative (to ground)

Height absolute (to sea level)

Antenna Pattern

Omnidirectional (isotropic) antenna

Directional / Sector antenna

Orientation

Azimuth: 0 ° Downtilt: 0 °

Antenna Pattern

C:\Users\cresitt\Desktop\Hamza_Cresitt_M

Select Show

Gain of antenna: 3.40277 dBi

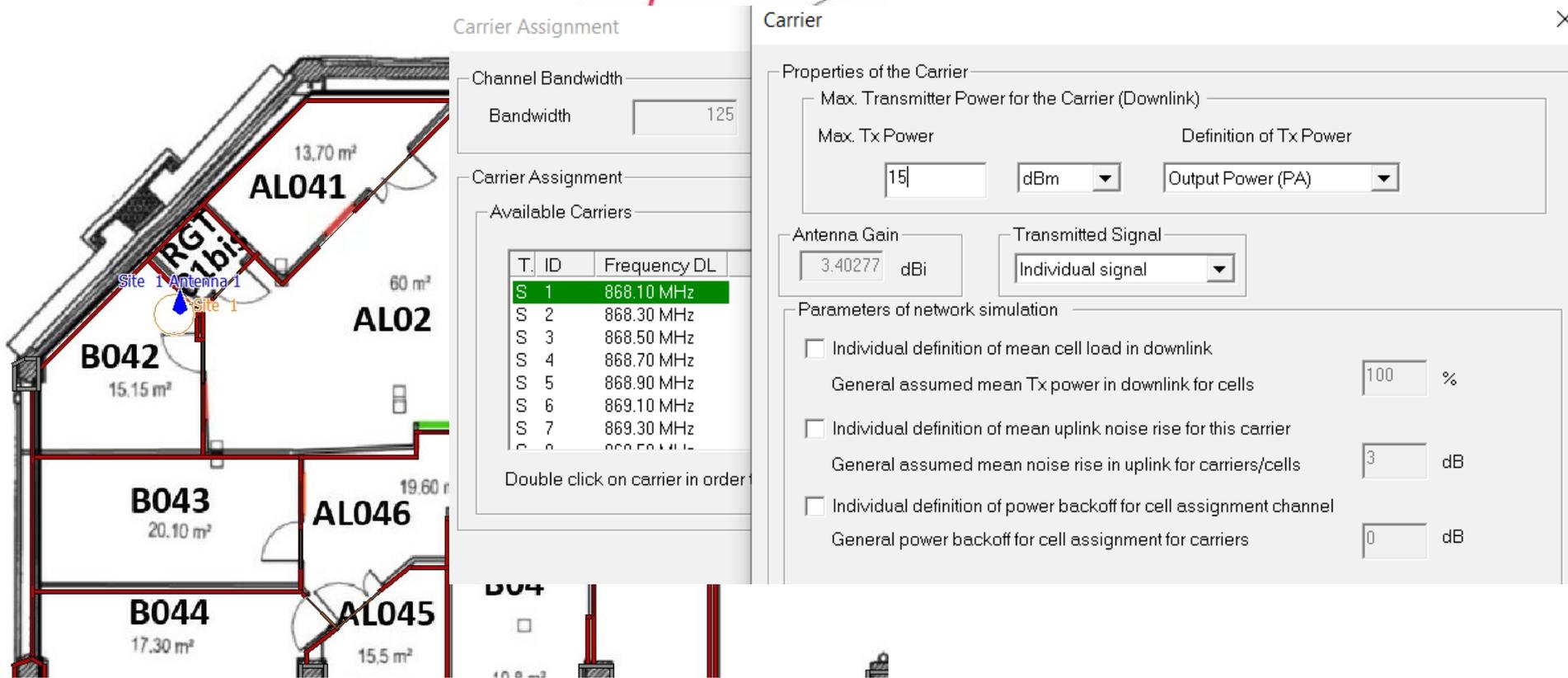
Prediction Area (Cell)

Prediction area is identical for all cells/transmitters and defined on the simulation tab.

Measurements Polarization

OK Cancel

- ProMan



Carrier Assignment

Channel Bandwidth
Bandwidth: 125

Carrier Assignment
Available Carriers

T.	ID	Frequency DL
S	1	868.10 MHz
S	2	868.30 MHz
S	3	868.50 MHz
S	4	868.70 MHz
S	5	868.90 MHz
S	6	869.10 MHz
S	7	869.30 MHz
S	8	869.50 MHz

Double click on carrier in order

Carrier

Properties of the Carrier

Max. Transmitter Power for the Carrier (Downlink)

Max. Tx Power: 15 dBm
Definition of Tx Power: Output Power (PA)

Antenna Gain: 3.40277 dBi
Transmitted Signal: Individual signal

Parameters of network simulation

- Individual definition of mean cell load in downlink
General assumed mean Tx power in downlink for cells: 100 %
- Individual definition of mean uplink noise rise for this carrier
General assumed mean noise rise in uplink for carriers/cells: 3 dB
- Individual definition of power backoff for cell assignment channel
General power backoff for cell assignment for carriers: 0 dB

• ProMan

Edit Project Parameter - TEST_05_LABO_grp_rev02_

Simulation | Propagation | Sites | Database | Computation

Output Directory / Basic Filename for Propagation Results

Directory: Test_7_re_EI2_8m Change

Additional Output of Results in ASCII files

Computed Prediction Results

Received Power

Field Strength Delay Spread, Angular Spread and Angular Mean can only be predicted with ray-optical propagation models.

Path Loss Angular Means (BS+MS, Azimuth+Elevation)

LOS Analysis Min. Path Delay

Additional Prediction Data (exported into ASCII file during computation - required to show CIR and Paths)

Channel Impulse Response (CIR) Propagation Paths

Transmission Matrix Write data also into binary .ray file

Consideration of Antenna Properties at Mobile Station

Consider Antenna of MS Propagation Simulation
=> Assumes isotropical antenna at MS
Postprocessing (i.e. RUN MS)
=> Consideration of MS Antenna Properties

OK Annuler

Edit Project Parameter - LoRa_RDC

Air Interface | Simulation | Traffic | Network | Propagation | Sites | Components | Database | Computation

Output Directory for Network Results

Directory: NetName_LoRa_RDC Change

Additional Output of Results in ASCII files Received Power in Tabular Format

Network Simulation Mode

Apply Antenna Masking for Network Planning (Propagation Results with Omni Pattern)

General results

Best Server (Cell Assignment) Settings

Max. achievable Throughput Settings

EMC Analysis Settings

Results related to the cell assignment

Serving Carrier: Received Power (Cell Assign.)

Serving Carrier: SNIR (Cell Assignment)

No. of Carriers received Settings

No. of TRX received Settings

No. of Sites received Settings

Neighbor Cell List Settings

Analysis of the serving carrier

Pilot: Total received (signal + noise + interfer.)

Pilot Interference level (noise + interference)

Traffic Analysis

Traffic State

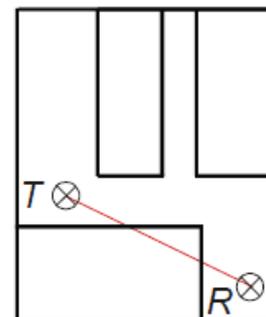
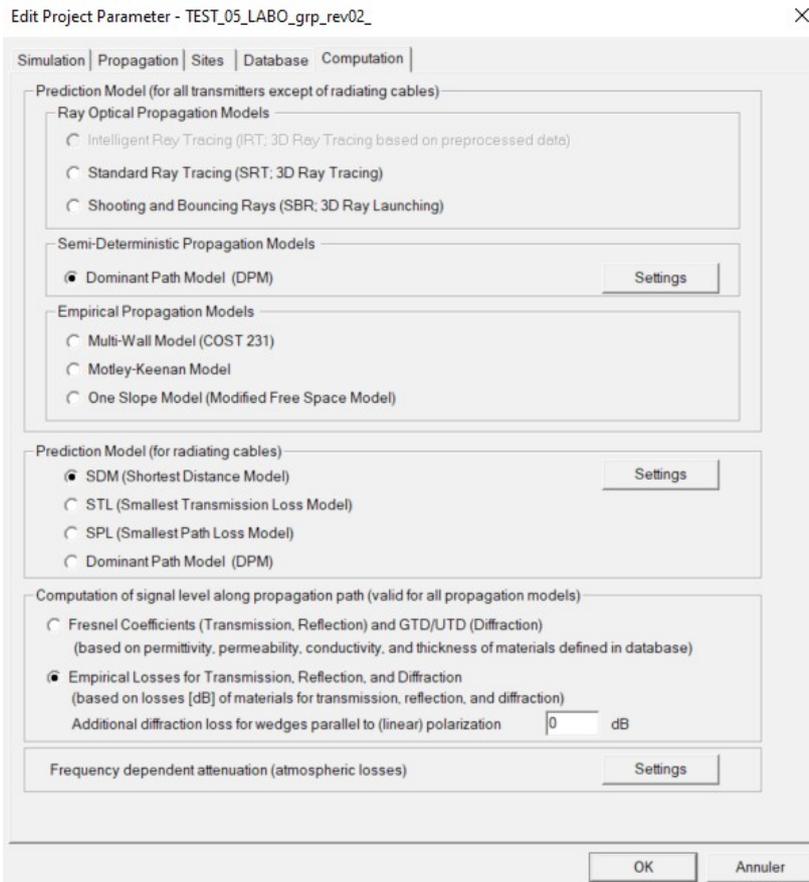
Offered Traffic

Served Users

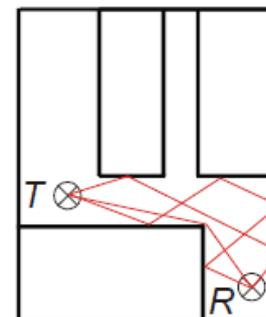
Blocked Users (due to traffic, quality, unassigned)

Nr of subscribers for application

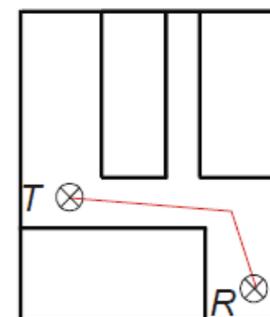
- ProMan



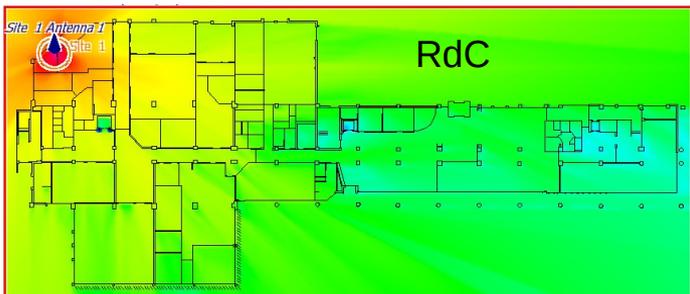
empirical model



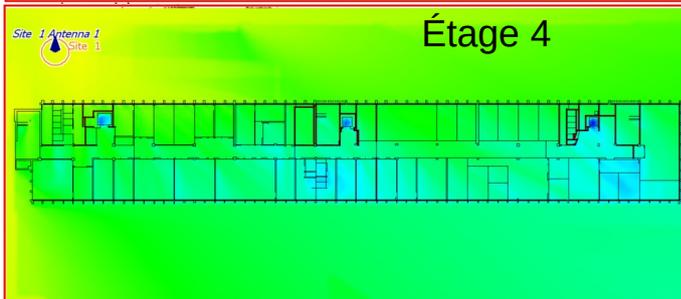
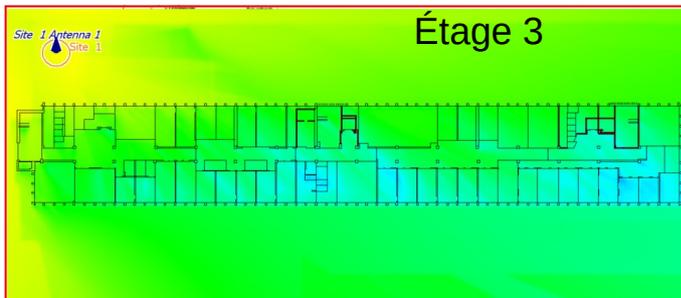
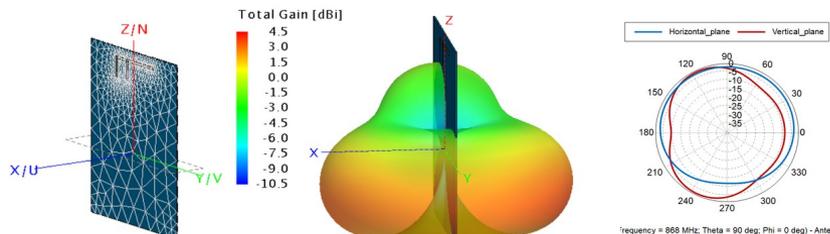
ray-optical model



dominant path model

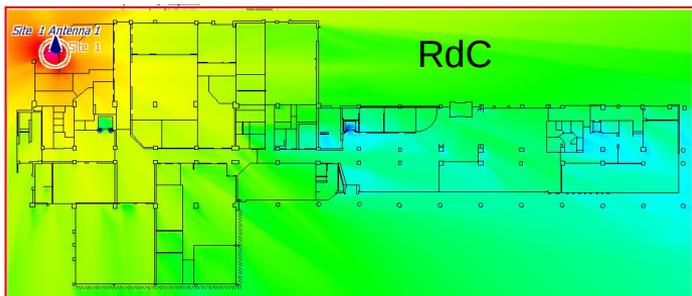


Empirical Loss : Config1

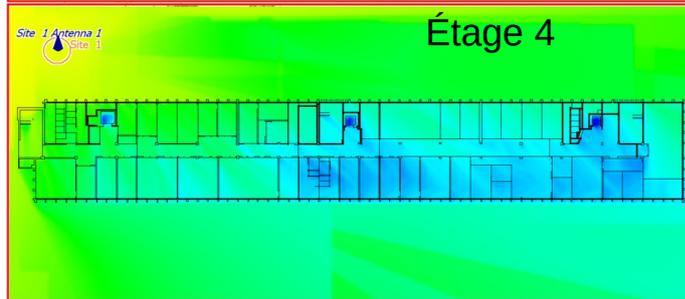
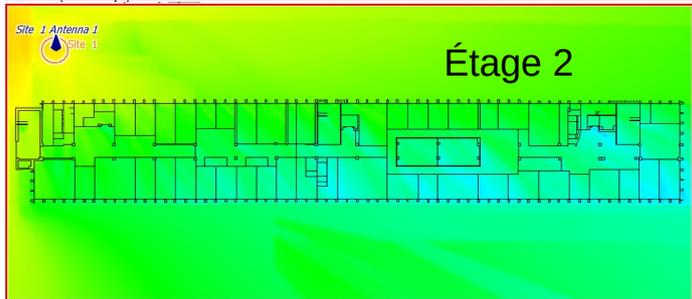
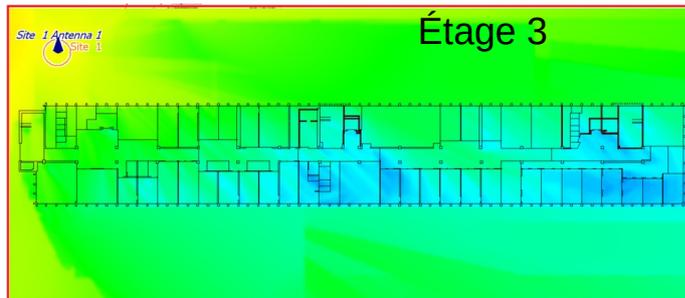
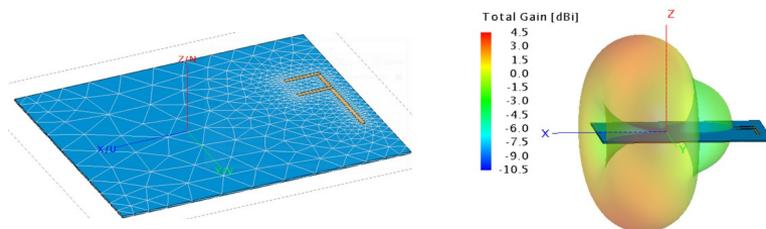


POWER



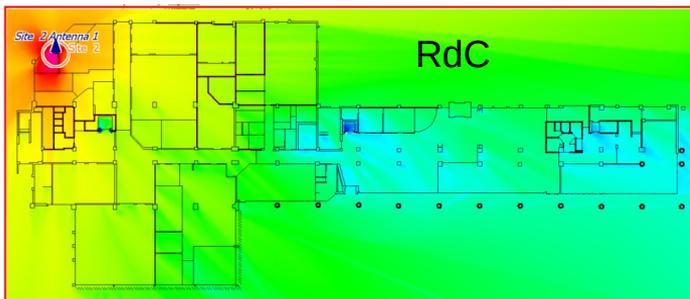


Empirical Loss : Config2

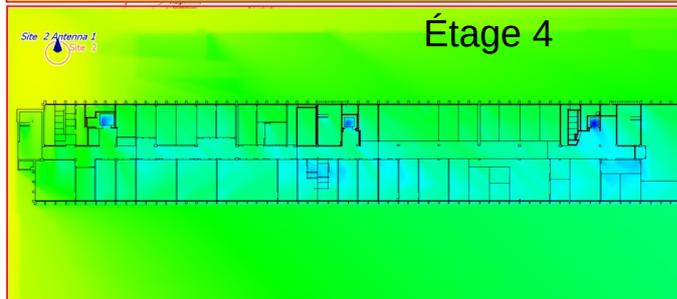
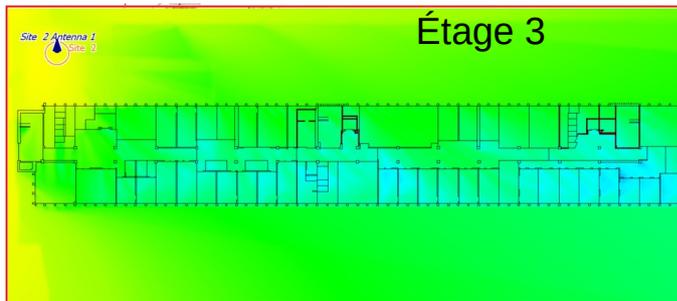
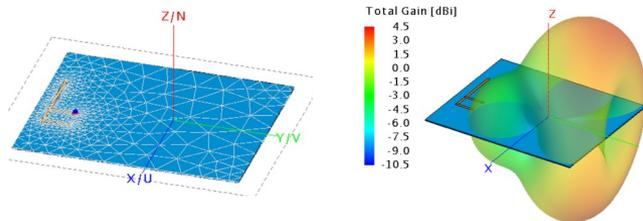


POWER

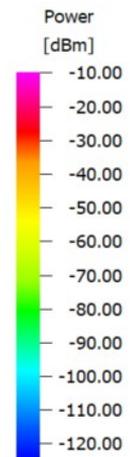


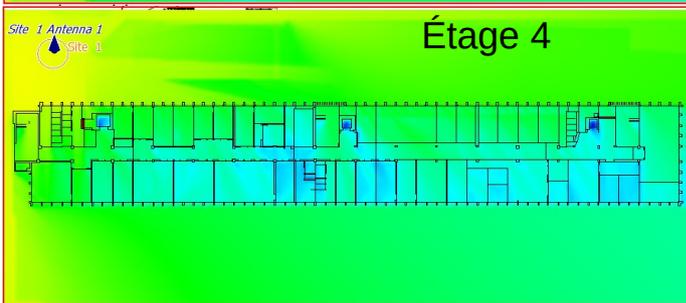
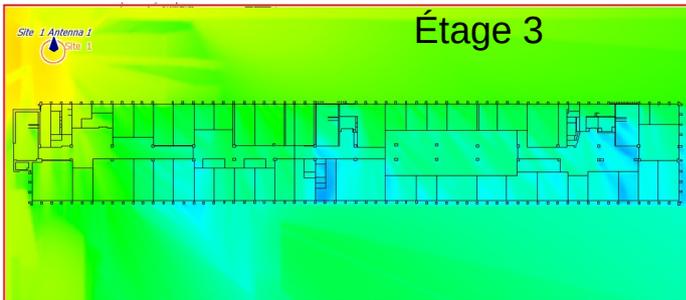
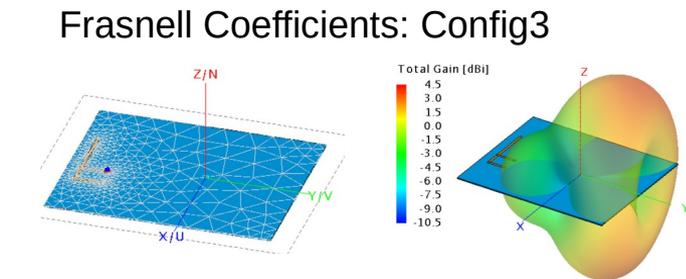
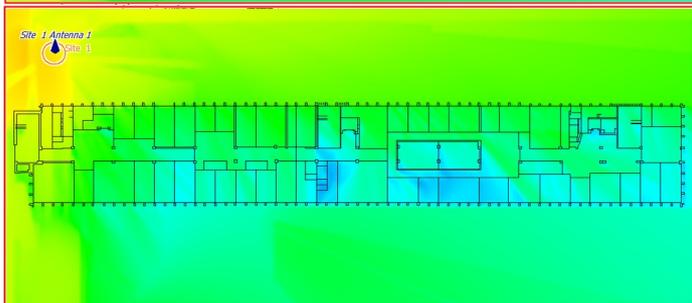
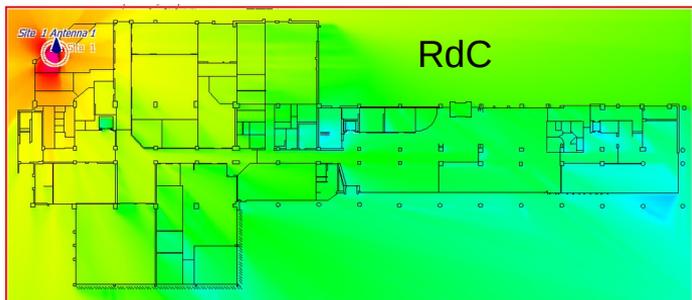


Empirical Loss : Config3



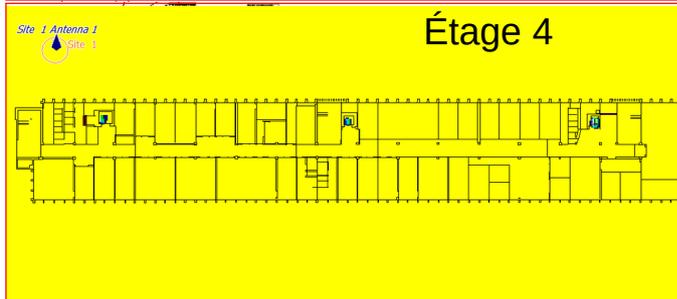
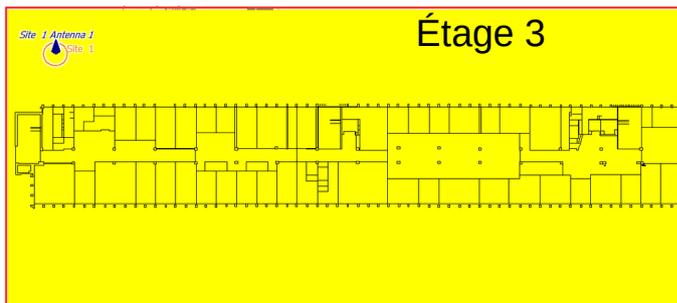
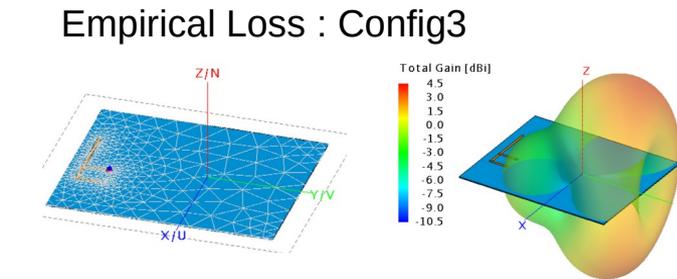
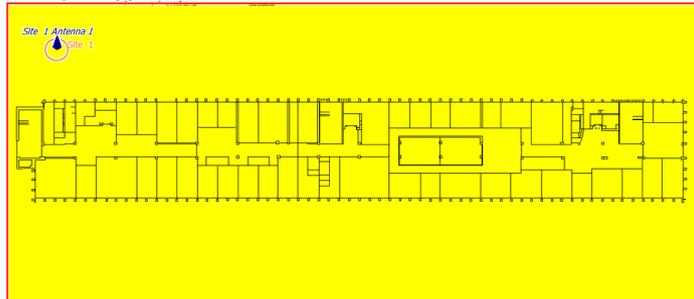
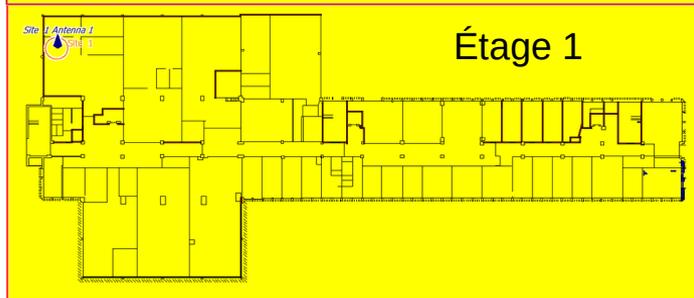
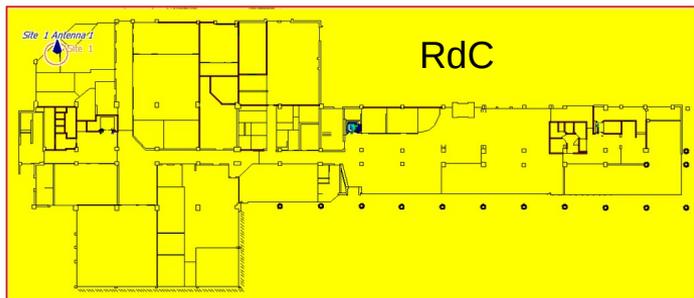
POWER





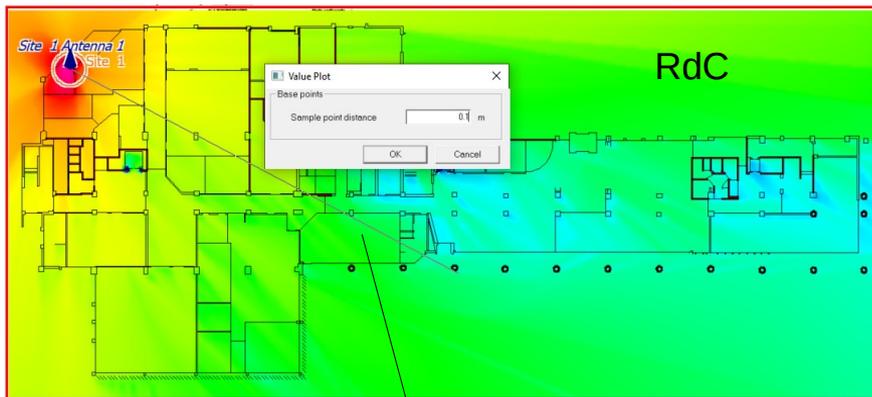
POWER



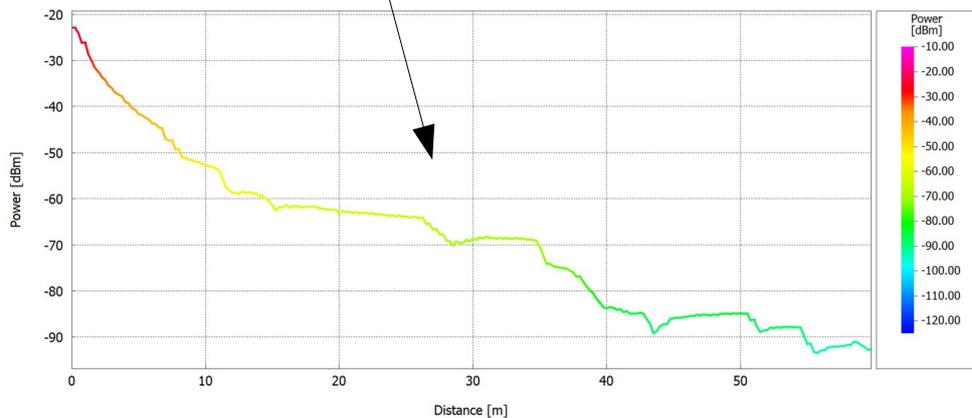
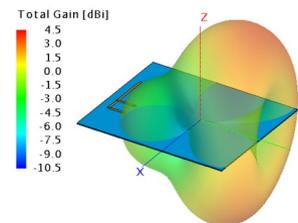
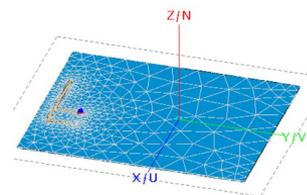


Data Rate (Byte/s)

- = 470.8
- = 276.2
- = 15.69
- = 156.9
- = 87.89
- = 50.22
- = 25.11



Empirical Loss : Config3



RDC Empirical Loss : Config3

Path Loss



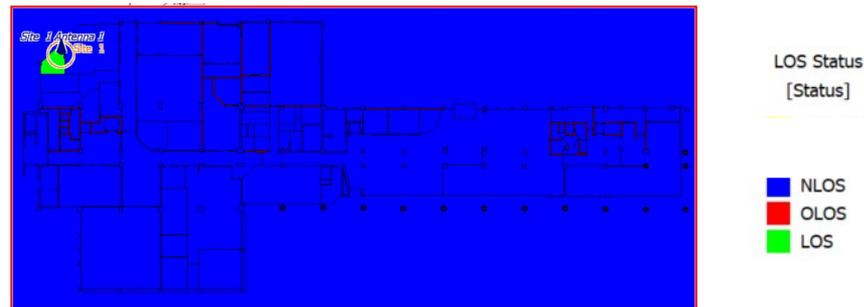
Field Strength



Delay Time



LOS



LOS : En vision directe

NOS : Non visible mais transmission à travers mur

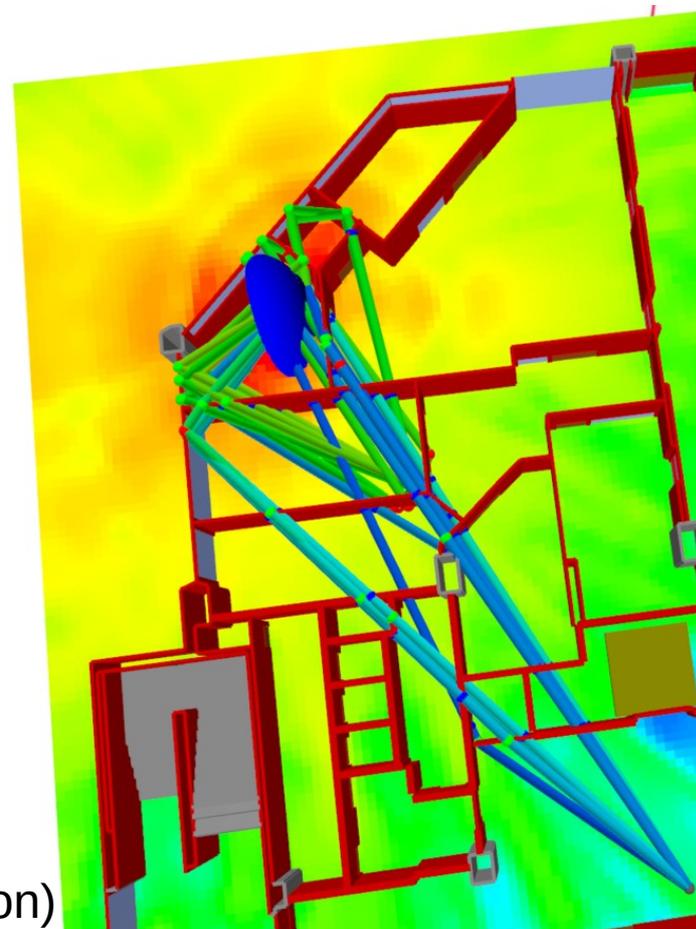
OLOS : Non visible, pas de transmission à travers mur

Config3

Propagation Paths

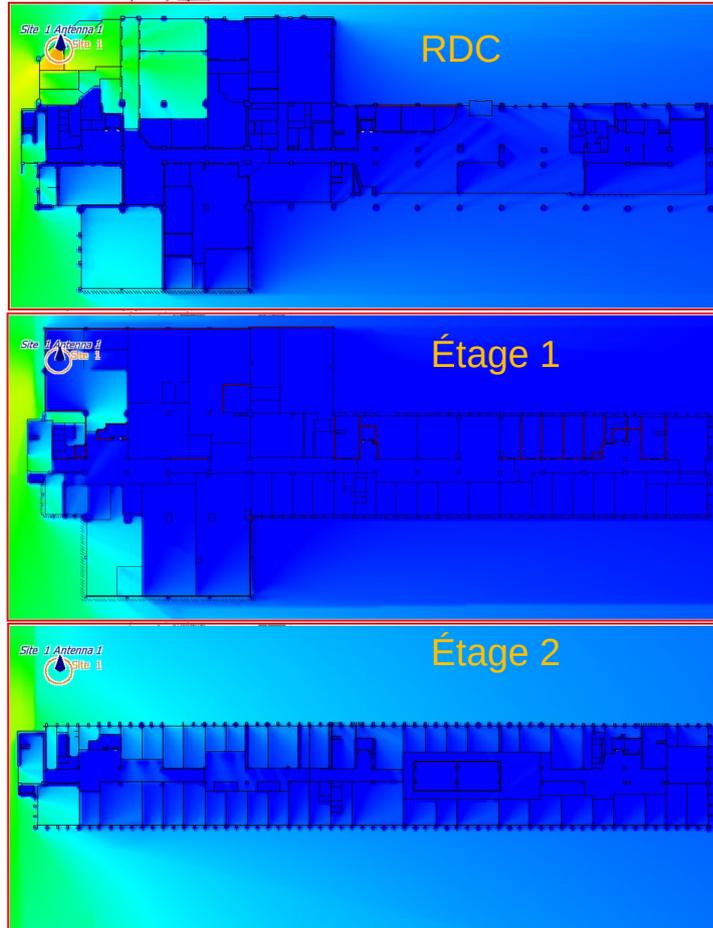
The following table shows all propagation paths to the selected receiver pixel. The sorting sequence can be changed by clicking on the column headers.

Index	Type	Interactions	Delay	Phase	Signal Level	DoD Azi...	DoD El ^
<input checked="" type="checkbox"/> 1	Ray Opti...	7 (1 R, 1 D, 5 T, 0 S)	83.41 ns	136.89 deg	-94.45 dBm	229.27 deg	83.61
<input checked="" type="checkbox"/> 2	Ray Opti...	7 (0 R, 0 D, 7 T, 0 S)	69.40 ns	125.63 deg	-95.30 dBm	295.49 deg	93.58
<input checked="" type="checkbox"/> 3	Ray Opti...	7 (1 R, 1 D, 5 T, 0 S)	83.52 ns	170.16 deg	-97.08 dBm	229.48 deg	85.41
<input checked="" type="checkbox"/> 4	Ray Opti...	7 (1 R, 1 D, 5 T, 0 S)	83.57 ns	185.50 deg	-97.83 dBm	228.61 deg	85.75
<input checked="" type="checkbox"/> 5	Ray Opti...	6 (0 R, 1 D, 5 T, 0 S)	70.60 ns	310.93 deg	-102.02 dBm	284.37 deg	66.09
<input checked="" type="checkbox"/> 6	Ray Opti...	7 (1 R, 1 D, 5 T, 0 S)	84.06 ns	340.90 deg	-102.39 dBm	229.88 deg	86.83
<input checked="" type="checkbox"/> 7	Ray Opti...	7 (1 R, 1 D, 5 T, 0 S)	84.59 ns	133.99 deg	-107.11 dBm	218.33 deg	92.94
<input checked="" type="checkbox"/> 8	Ray Opti...	7 (1 R, 1 D, 5 T, 0 S)	79.63 ns	221.52 deg	-108.37 dBm	152.01 deg	85.07
<input checked="" type="checkbox"/> 9	Ray Opti...	6 (1 R, 1 D, 4 T, 0 S)	70.69 ns	157.66 deg	-109.40 dBm	284.45 deg	65.98
<input checked="" type="checkbox"/> 10	Ray Opti...	6 (1 R, 1 D, 4 T, 0 S)	81.08 ns	316.02 deg	-113.55 dBm	160.87 deg	93.07
<input checked="" type="checkbox"/> 11	Ray Opti...	7 (1 R, 1 D, 5 T, 0 S)	72.08 ns	230.98 deg	-113.67 dBm	285.65 deg	64.27



Notes

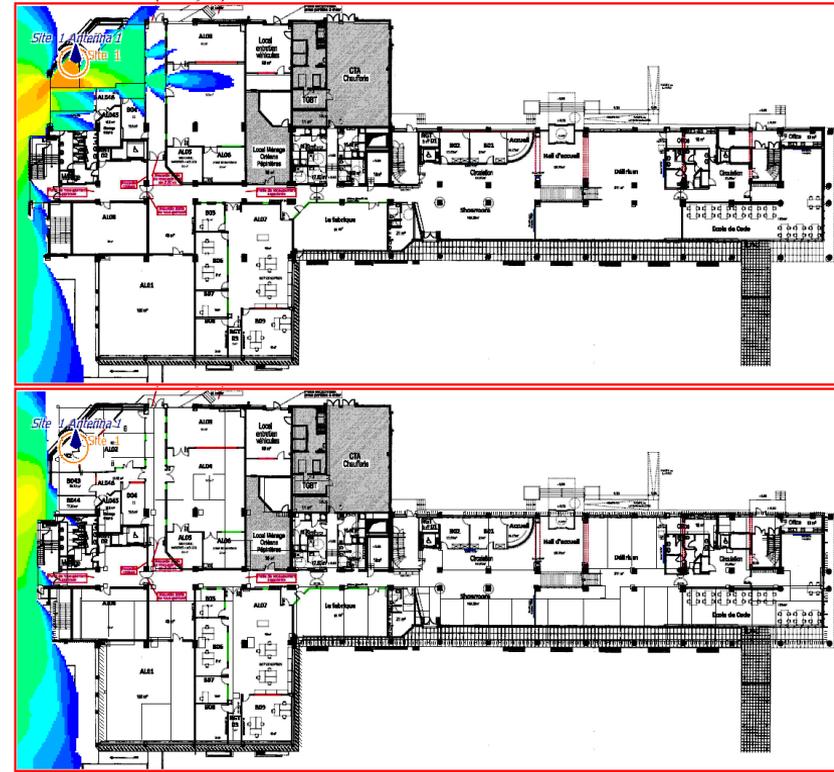
- SRT : High accuracy in region of Tx and limited accuracy far away (8 hours simulation)
- DPM : - High accuracy far away from Tx (1mn simulation)



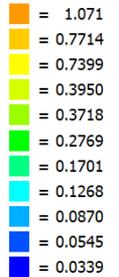
Power

5G Config3

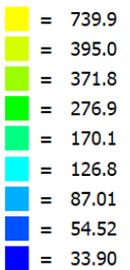
Data Rate



DL: Max. Data Rate [MBit/s]



DL: Max. Data Rate [kBit/s]





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