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PROYECTO MONOGRÁFICO

Diseño de una Red UMTS en el Municipio de Diriamba, Departamento de Carazo

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INTRODUCCIÓN

El objetivo de este documento es planificar y diseñar una red de comunicaciones móviles UMTS que dé cobertura al núcleo urbano en el municipio de Diriamba.

Para ello se empleará la herramienta software de planificación y simulación radioeléctrica Atoll, desarrollada por la empresa FORSK. Con la ayuda de esta herramienta se determinarán los parámetros de diseño de la red y se realizarán las simulaciones pertinentes para verificar que se han alcanzado los objetivos de calidad.

ATOLL es un entorno de planificación radio basado en ventanas, fácil de usar, que da soporte a operadores de telecomunicaciones inalámbricas durante todo el tiempo de vida de la red. Desde el diseño inicial, hasta la fase de optimización y durante las distintas ampliaciones.

Más que una herramienta de ingeniería, ATOLL es un sistema de información técnico abierto, escalable y flexible que puede integrarse fácilmente en otros sistemas de telecomunicaciones, aumentando la productividad y reduciendo los tiempos de desarrollo.

La evolución de los sistemas de móviles de comunicaciones ha sido un proceso que ha visto en pocos años la introducción de múltiples tecnologías que han permitido que sea cada vez mayor la cantidad de personas que hacen uso del teléfono celular como dispositivo indispensable en sus vidas cotidianas.

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Por la gran cantidad de variables inherentemente en el diseño y planificación de una red de comunicaciones móviles, como lo son las interferencias, movilidades de los usuarios, servicios demandados, condiciones de propagación, entre otras, es indispensable un proceso de planificación y optimización en el diseño de la red y disponer de un mecanismo que permita compartir de forma organizada los recursos radio entre los usuarios.

Por ello, con el incremento de la población se tiene como resultado mayor cobertura y comunicaciones de calidad, en este proyecto de monografía hemos elegido realizar un estudio de planificación y optimización de servicios de cobertura en el municipio de Diriamba, Departamento de Carazo, con el propósito de evaluar las posibilidades de esa zona geográfica del país para la implantación de tecnologías 3G, y así lograr comunicación fluida, práctica y al alcance de la población en general, para ello se propone la planificación una red UMTS utilizando la herramienta de planificación ATOLL.

ANTECEDENTES

En Nicaragua la apertura de la Telefonía móvil inició en 1992, cuando TELCOR otorgó un contrato de concesión a la empresa Telefonía Celular de Nicaragua S.A (NICACEL, S. A) para ofrecer el servicio de telefonía celular en todo el Pacífico de Nicaragua. Posteriormente, en 1997 BellSouth entro a este segmento de telefonía inalámbrica cuando compro parte de las acciones de NICACEL.

En 2001, TELCOR decidió abrir el segmento a la participación de otros operadores, iniciando el proceso de licitación de la segunda licencia para telefonía móvil. Se presentaron 13 empresas; una licencia de operación fue otorgada a ENITEL que entro al mercado en diciembre 2002.

ENITEL Móvil operaba con tecnología GSM y Telefónica Movistar (antes BellSouth) con tecnología TDMA y CDMA, ambas tecnologías no eran compatibles entre sí. Desde 2003 ENITEL y PCS han implantado esta tecnología mientras que el operador Telefónica Movistar cambio su infraestructura hacia la tecnología GSM. De 2006 a la fecha el servicio GSM de telefonía celular ha dominado el mercado nacional de telefonía móvil.

Esta etapa ha sido crucial para concretar este proyecto monográfico, y así valorar cuál será su impacto, utilidad y pertinencia, en este sentido hemos podido concluir el no hallazgo de trabajos similares orientados a presentar un manual en el que se pueda encontrar información sobre la planificación y optimización de redes celulares móviles, por tal razón nuestra investigación por la naturaleza de sus antecedentes adopta un carácter totalmente exploratorio al no existir trabajos precedentes que lo enriquezcan y le den fuentes informativas para su inicio, más que la disponible en la literatura científica que gira entorno a esta temática y las especificaciones técnicas de los estándares que sustentan esta tecnología.

Por tales razones, este trabajo dentro de la carrera, la universidad y el sector educativo superior lo hacen novedoso, por cuanto más que llegar ha convertirse en un texto oficial dentro de alguna disciplina de la carrera de electrónica o de telecomunicaciones, tiene las intenciones de hacer una descripción simple y detallada de cómo se debe de realizar este tipo de procesos.

JUSTIFICACIÓN

La aplicación de las tecnologías para las comunicaciones en general y su acceso universal a los servicios que de ellas se derivan, según el FMI, el Banco Mundial y el Foro Económico Mundial, hoy en día se considerado un indicador de crecimiento y desarrollo económico de cualquier nación, por lo que este fenómeno ha contribuido significativamente al progreso y desarrollo, tanto económico, cultural y social de cualquier comunidad, municipio o nación.

En Nicaragua existen dos operadoras, las cuales son Movistar y Claro. Ambas compañías ofrecen servicios de GMS y 3G; sin embargo, no tienen cobertura total en todo el país.

En Diriamba, Claro ofrece mejor señal GSM que Movistar en municipios retirados como La Paz, El Rosario, La Conquista y Santa Teresa.

Sin embargo, el servicio de 3G no es ofrecido por todas las antenas que Claro y Movistar tienen posicionadas en el departamento de Carazo. Y al igual que el servicio de GSM, el servicio de 3G tiene su mayor cobertura en la zona central de

Por estos problemas de alcance, en este trabajo se investigación se propone un despliegue de antenas para una mayor cobertura 3G en el municipio de Diriamba, departamento de Carazo.

OBJETIVOS

Objetivo General:

Presentar una propuesta de diseño de una red de telefonía celular basado en tecnología UMTS (3G) en el municipio de Diriamba, departamento de Carazo, que sirva como referencia para estudios en planeación por cobertura en redes de esta naturaleza.

Objetivos Específicos:

1. Analizar los requerimientos que intervienen en el proceso de planificación de una red UMTS con la herramienta ATOLL.

2. Determinar los objetivos de cobertura, datos del terreno, modelos de propagación, cargas de mapas digitales, y otros parámetros que se requieren evaluar.

3. Realizar la planeación de la red UMTS por coverage, en el municipio de Diriamba, departamento de Carazo que defina las diferentes ubicaciones y parámetros de los equipos que estarán ubicados en las estaciones bases para satisfacer el área de cobertura.

CAPITULO I: PLANEACIÓN DE REDES CELULARES BASADAS EN TECNOLOGÍA UMTS

El proceso de migración y planeación de la red está dividido en cinco fases principales; de las cuales, cuatro se encuentran antes del despliegue comercial y la última fase se realiza una vez que la red ha sido desplegada.[1]

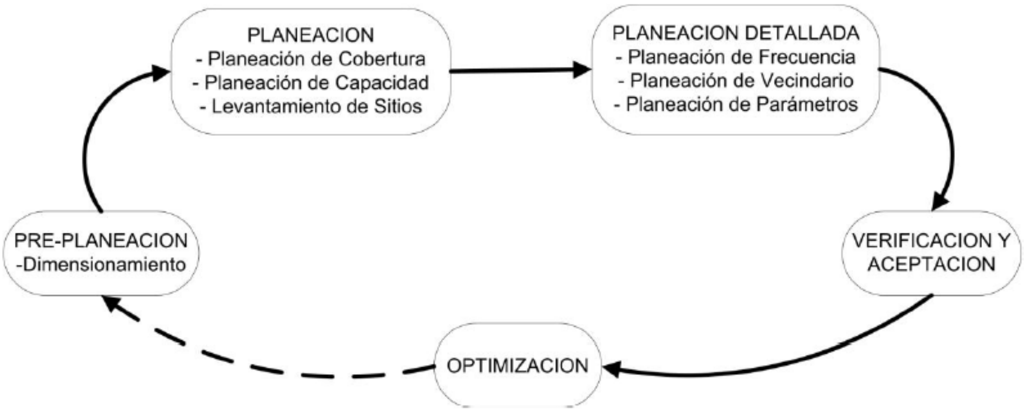

Fig. 1. Fases y Procedimiento para la Planeación de una Red[2]

Las cinco fases principales en el proceso son : preplaneación, planeación, planeación detallada, aceptación y optimización. La actividad principal de la pre-planeación es el dimensionamiento, el cual proporciona como resultado la configuración inicial de la red. El primer paso en la fase de planeación es la planeación nominal; esta proporciona la localización del primer sitio en un mapa basado en la variable de entrada de la fase de pre-planeación. El procedimiento continúa con la planeación de cobertura después de la ubicación de los sitios y la planeación de transmisión.[3]

[1] http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf. "PROCESO DE MIGRACIÓN Y PLANEACIÓN HACIA LA RED DE RADIO DEL SISTEMA DE TELEFONÍA MOVIL UMTS" .Pag. 231
[2] Ibid. Pag. 232
[3] Ibid

La planeación de capacidad también se incluye en la fase de planeación. Después de la fase de planeación detallada, la red estará lista para su verificación y aceptación, la cual continúa con actividades antes de despliegue para finalizar con el proceso de optimización una vez que la red ha entrado en operación.[4]

Fase de Pre-Planeación

La fase cubre todas las tareas de preparación para la configuración inicial antes de que se inicie la planeación actual de la red. Como en cualquier otro negocio, esta es una ventaja de la que hay que tener cuidado debido a la situación actual del mercado y de los competidores. El criterio de planeación de la red está basado en los clientes y los requerimientos dependen de muchos factores, los criterios principales deberán ser los objetivos de cobertura y calidad. También existen muchas limitaciones, tales como: la limitación de la banda de frecuencia y el presupuesto disponible para la inversión.[5]

La prioridad de los parámetros para la planeación son proporcionados por los clientes, debido a que el plan de red no puede ser optimizado sin exigir que todos los parámetros y las necesidades prioritarias estén de acuerdo con el cliente durante el proceso.[6]

El criterio de planeación de red es utilizado como una variable de entrada para el dimensionamiento de la red. A continuación se listan las diferentes variables de entrada para el dimensionamiento:

- Requerimientos de Cobertura: El nivel de señal para exteriores, dentro del vehículo y en interiores con las probabilidades de cobertura.
- Requerimientos de Calidad: Rango de caída de llamadas y bloqueo de llamadas.

[4] Ibid
[5] Ibid. Pag. 233.
[6] Ibid

- Banda de Frecuencias del Espectro: Modo de operación.
- Información de Suscriptor: Número de usuario y figuras de crecimiento.
- Tráfico por Usuario: Valores de horas pico.
- Tipos de Servicios.[7]

El dimensionamiento proporciona un plan preliminar de red con una variable de salida, la cual se complementa con la cobertura y la capacidad de las fases de planeación para crear un plan más detallado. El plan preliminar incluye el número de elementos de red que se necesitan para alcanzar los requerimientos de calidad de servicio establecidos por el operador, por ejemplo en UMTS: el número de Nodos B y de TRX (transceptores). También es necesario saber que el dimensionamiento se repite en caso de una extensión de la red.[8]

El resultado del dimensionamiento es un promedio de los requerimientos por tipo de área: urbano, suburbano, rural, etc. Un mejor detalle en la planeación de capacidad y localización para las células individuales se pueden alcanzar a través de una herramienta de planeación que posea mapas digitales e información de tráfico. Los resultados del dimensionamiento son una variable de entrada para el plan de cobertura, el cual es el siguiente paso en el proceso de planeación de una red.[9]

Las Macro Celdas son utilizadas en áreas rurales y suburbanas para cubrir grandes extensiones porque poseen un rango de cobertura de 1km a 35km, las antenas se encuentran en la posición más alta.[10]

Las Micro Celdas poseen un rango menor de 1km y se utilizan para cubrir exteriores, las antenas se colocan típicamente en las paredes y por debajo del nivel promedio de los techos.[11]

[7] http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf. Pag. 233.
[8] Ibid.
[9] Ibid.
[10] Ibid
[11] Ibid.Pag 235

Las Pico Celdas poseen un rango de cobertura menor de 500mts y están caracterizadas por antenas colocadas muy bajo en las paredes, es decir, por debajo del nivel de los techos. Estas últimas se utilizan tanto para cobertura interior y exterior.[12]

Cálculos de Evaluación del Enlace

La evaluación del enlace es parte del proceso de pre-planeación de la red, la cual ayuda a dimensionar la cobertura, capacidad y calidad de servicio requeridas por la red. Las variables de salida de la evaluación son normalmente el máximo de pérdida por trayectoria permitida por cada servicio. Esta se utiliza después con los modelos de propagación adecuados al área para estimar el máximo rango de cobertura de la célula y posteriormente, para estimar la densidad por sitio requerida. Debido a que los perfiles de servicio y la densidad de tráfico impactarán sobre el factor de carga y por tanto en el rango de cobertura para cada servicio, el dimensionamiento basado en la evaluación del enlace se convierte en un proceso iterativo. Esto se refiere a que después de terminar un radio de cobertura nominal de una célula para un factor de carga específico, los perfiles de servicio y densidades de tráfico junto con el rango de cobertura de la célula encontrados deberían de ser utilizados para calcular el factor de carga recalculado. Si el valor de carga aún excede el valor del diseño, entonces se debe repetir el proceso iterativo para el rango de cobertura de la célula, hasta que el cálculo del factor de carga no exceda el valor del diseño.[13]

Existen dos factores principales que limitan la evaluación del enlace en UMTS: la potencia del equipo de usuario uplink y la potencia de transmisión del Nodo B en el dowlink. Una evaluación del enlace simple se puede realizar para estimaciones de dimensionamiento rápido bajo criterios especificados y asunciones como:

[12] Ibid. Pag. 235
[13] Ibid

- Tipo de servicio: especificado con la velocidad del bit, el requerimiento Eb/No, la velocidad de movilidad esperada bajo cierta condición de carga (interferencia del piso de ruido).
- Tipo de ambiente para la propagación de la onda de radio (terreno, penetración en carros y edificios).
- Comportamiento y tipo de equipo de usuario (velocidad, máximo nivel de potencia entre otros).
- Localización de sitios y configuración del hardware (antenas, potencia de Nodo B, pérdidas por cables, sensibilidad de referencia de los equipos).
- Área requerida para la probabilidad de cobertura.[14]

En la Fig. 2 se ilustran algunos parámetros utilizados para la evaluación del enlace.

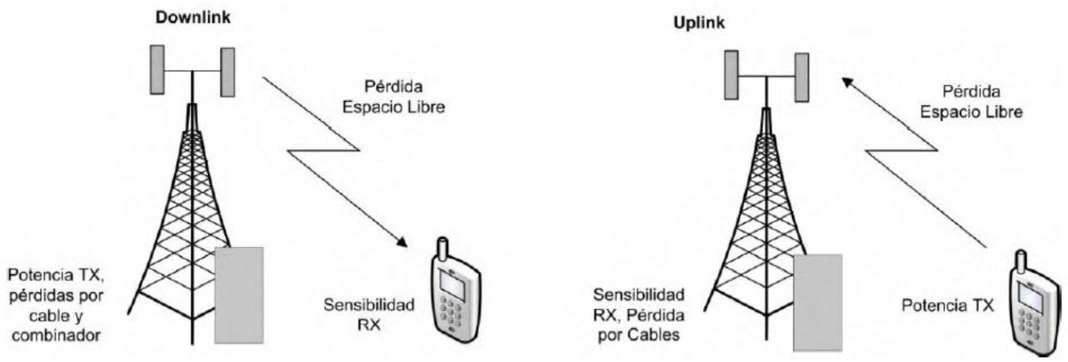

Fig. 2. Parámetros de Evaluación del Enlace[15]

La evaluación del enlace en WCDMA es complicado debido a que la potencia transmitida por cada usuario impacta los parámetros de evaluación de los otros usuarios. Por ejemplo, la potencia transmitida designada para cada usuario en el dowlink o utilizada por cada usuario en el uplink se convierte en un grado de interferencia para otros usuarios en la célula. Debido a que cada usuario influencia los requerimientos de transmisión de potencia para otros usuarios, esto resulta en un efecto de retroalimentación positiva en el lazo de potencia requerida para cada

[14] http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf. Pag. 236.
[15] Ibid. Pag. 237

usuario. Esto significa que la predicción de cobertura y capacidad debe realizarse iterativamente hasta que los requerimientos de potencia de varios usuarios en la célula se estabilicen. Este impacto entre usuario es más complicado modelarlo sobre el dowlink por dos razones: éste depende de los parámetros dependientes de la localización del móvil y debido a que la potencia de la estación base se comparte entre usuarios.[16]

Evaluación del Enlace Uplink y Análisis Estático

La evaluación del enlace Uplink se simplifica modelando el efecto multiusuario a través de una sola agrupación de parámetros denominada el factor de carga del Uplink. El factor de carga es utilizado para modelar la interferencia multiusuario acumulada en la estación base. El factor de carga es una medida de la capacidad diseñada para la célula y es utilizada en el cálculo de la sensibilidad de la estación base para cada servicio. El rango de cobertura nominal de la célula se decide en base a una probabilidad de cobertura para un servicio dado, así como lo decida el operador. [17]

Si al evaluar el factor de carga Uplink, éste excede el valor del diseño, entonces el rango de la cobertura nominal de la célula calculada debe ser reducido y la iteraciones repetidas hasta que el factor de carga resultante no exceda más el valor de diseño. [18]

El factor de carga agrupa todas las contribuciones de interferencia provenientes de los usuarios que poseen un servicio distinto en un solo factor. Este es utilizado como un parámetro en la evaluación del enlace para calcular el ruido acumulado del piso de ruido en el receptor para todos los servicios. [19]

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[16] http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf. Pag. 237.
[17] Ibid
[18] Ibid
[19] Ibid. Pag 238

Para una carga de célula dada (capacidad) como se determinó a través del factor de carga, el rango de cobertura de cada servicio se estima a través de su requerimiento Eb/No y su velocidad de transferencia de bit.[20]

El factor de carga para el Uplink define la relación de la interferencia multiusuario más el ruido termal efectivo en la estación base. Matemáticamente:

$$\eta = \frac{Ihc + Ioc}{Nt}$$

Donde:

Ƞ = factor de carga uplink

Ihc: interferencia de la propia célula (causada por los transmisores cercanos dentro de la celda).

Ioc: interferencia de las otras células.

Nt: ruido termal efectivo más la interferencia de potencia multiusuario en la estación base.

La ecuación se puede aproximar sí se expresa la interferencias de las otras celdas, "Ioc", como una fracción de la interferencia en la propia celda, "Ihc", a través del factor f, entonces:

Ioc = f . Ihc

En donde, la interferencia de la propia celda en la estación base puede ser calculada a través de la suma de la potencia de las señales recibidas de cada conexión j, la cual es Ej . Rj . vj, asumiendo un control de potencia perfecto compensado en todas las conexiones para las pérdidas por trayectorias en donde Ej y Rj representa la energía por bit y la velocidad de conexión por bit, respectivamente y "vj" es el factor de actividad para la conexión, se obtiene :

[20] Ibid

$$Ihc = \sum_{j=1}^{M} Ej \cdot Rj \cdot vj$$

En donde M denota el número de conexiones Uplink en la celda.
Sin combinamos las últimas 3 ecuaciones tendremos:

$$\eta = (1 + f) \frac{\sum_{j=1}^{M} Ej \cdot Rj \cdot vj}{Nt}$$

Estimación de la Sensibilidad de la Estación Base

La sensibilidad se define generalmente como la potencia mínima de la señal requerida en la entrada del receptor para obtener el requerimiento de calidad del servicio. Ya que la estructura y el diseño de la calidad de servicio para un receptor dado está determinada por la relación señal ruido (S/N), la sensibilidad dependerá del piso de ruido presente a la entrada del receptor.[21]

En WCDMA, la sensibilidad de la estación base varía de celda a celda, con la distribución del servicio y las velocidades de bit utilizadas, es decir, que dependiendo del número de usuarios y de las velocidad de bit así será el impacto en el piso de ruido de la estación base.[22]

En las consideraciones para la evaluación del enlace, el nivel del ruido de la estación base sobre una portadora WCDMA se ve influenciado por la interferencia multiusuario. La interferencia multiusuario eleva el piso de ruido en el receptor y este incremento es calculado a través del el factor 1/ (1-η), de donde η es el factor de carga.[23]

Entonces:

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[21] http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf. Pag. 239.
[22] Ibid
[23] Ibid

$$\rho = Eb / No = \frac{\frac{S / Rb}{Pn}}{(1-\eta) \cdot W}$$

Rb: Velocidad de bit del servicio.

Pn: Potencia total del ruido termal efectivo junto a la banda portadora en el receptor.

S: Potencia de la señal en la entrada del receptor.

Ƞ: Factor de carga del uplink.

W: Banda del canal efectivo

Resolviendo para S, se puede encontrar la fórmula de la sensibilidad del receptor como :

$$\frac{1}{1-\eta} \rho \cdot Pn / \left(\frac{W}{Rb} \right) (\text{En escala Lineal})$$

En donde, el requerimiento de la relación señal a ruido ρ, dependerá de la estructura del receptor el requerimiento de la calidad de servicio la velocidad de bit y la velocidad de movimiento. [24]

Estimación de la Ganancia por Soft Handover

El Soft Handover contribuye a la ganancia en la evaluación del enlace en dos formas. La más común es la ganancia que provee contra el desvanecimiento rápido que resulta del efecto multitrayectoria. Ésta se alcanza debido a la ganancia combinada de macro diversidad, la cual reduce la Eb/No requerida en un solo enlace. El segundo beneficio del Soft Handover es que contribuye al margen contra los efectos del ensombrecimiento lognormal. Esto sucede debido a que el desvanecimiento lognormal está parcialmente sin correlación entre las diferentes células (o sectores) y el proceso de handover también resulta en la selección del

[24] http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf. Pag. 240.

mejor servidor. A continuación se proporciona una manera de estimar esta ganancia a través de la influencia que ocurre sobre el área de probabilidad de cobertura. El área de probabilidad de cobertura se define como la probabilidad de que el nivel de señal sobre toda el área de la célula está alrededor de un umbral determinado.[25]

Ya que el soft handover requiere un cierto grado de traslape entre las células adyacentes, más de una célula puede proveer cobertura en las áreas de traslape. Esto significa que en promedio el área de probabilidad de cobertura de la célula incrementará relativamente para una célula aislada. Esto se transforma en un pequeño número de estaciones bases requeridas para encontrar la misma probabilidad de cobertura en conjunto. De allí, la probabilidad de localización de cobertura debe ser modificada para tomar en cuenta el estado del efecto multiservidor debido a los proceso de handover. La probabilidad de cobertura en el borde de la célula, la cual se puede trasladar dentro de la probabilidad de cobertura, se analizará con la siguiente fórmula:[26]

$$\text{Pout} = \frac{1}{\sqrt{2\Pi}} \int_{-\infty}^{\infty} e^{\frac{-x^2}{x}} \left[Q\left(\frac{\gamma\text{SHO} - c \cdot \sigma \cdot x}{d \cdot \sigma} \right) \right]^2 dx$$

Donde:

Pout: es el corte de cobertura en el borde de la célula.

ySHO: margen de desvanecimiento requerido cuando se incluye la ganancia del softhandover.

σ: desviación estándar del desvanecimiento lognormal y para un 50% de correlación del desvanecimiento lognormal entre dos enlaces para dos estaciones base, $c = d = 1/\sqrt{2}$

[25] http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf. Pag. 241

[26] Ibid

Esta probabilidad en el borde de la célula se puede convertir en la probabilidad del área de cobertura. Entonces, la ganancia soft handover en contra del desvanecimiento lento lognormal es calculada como :

$$GSHO = \gamma Single - \gamma SHO$$

Donde ySingle es el margen de desvanecimiento lognormal para un solo enlace y es dependiente de la probabilidad de cobertura del área deseada , del exponente de pérdida por trayectoria y de la desviación estándar del desvanecimiento lognormal para el ambiente seleccionado.[27]

Carga en el Dowlink y Chequeo de la Potencia Transmitida

En el lado del downlink, no es posible realizar un cálculo de evaluación de enlace simple debido a la compartición de potencia en la estación base y la ubicación dependiente de los parámetros de la interferencia.[28]

La potencia de la estación base requerida por conexión también dependerá de los requerimientos de los otros usuarios así como ellos puedan influenciar el piso de ruido de la célula. Por otro lado, se espera que el rango de cobertura de servicio este dominado por el uplink en las tecnologías 3G, en donde el downlink maneja la capacidad debido a la potencia de la estación base compartida entre las conexiones. De allí que la evaluación del enlace para el downlink sea una suma de la determinación de la potencia total transmitida por la estación base requerida para soportar un número de conexiones con un número de diferentes servicios, junto con los rangos de cobertura de servicios determinados para el enlace uplink y el modelo de tráfico. La fórmula para calcular la potencia de transmisión de la estación base es : [29]

[27] http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf. Pag. 242.
[28] Ibid
[29] Ibid.

$$Pt^{m} = \frac{Pn \cdot \sum_{k=1}^{M} \frac{\rho_k R_k v_k}{W \cdot g_{mk}}}{1 - \left\{ \gamma_{cmm} + \sum_{k=1}^{M} \frac{\rho_k R_k v_k}{W} \left[(1 - \alpha_k) + f_k \right] \right\}}$$

En la cual, Pn es la potencia de ruido en la banda y la expresión entre llaves del denominador se refiere al factor de carga efectivo en el downlink, ηDL para la célula, que se representa como:

$$\eta_{DL} = \gamma_{cmm} + \sum_{k=1}^{M} \frac{\rho_k R_k v_k}{W} \left[(1 - \alpha_k) + f_k \right]$$

En donde:

γ_{cmm}, es el porcentaje de la potencia del Nodo B asignada al piloto y a los canales comunes de control, “M” es el número de conexiones en la célula, ρ_k es la potencia transmitida sobre la conexión del móvil «k», R_k es la velocidad de bit servida, v_k es el rango de actividad del servicio, “W” es el ruido efectivo equivalente del ancho de banda del canal, α_k es el factor de ortogonalidad y f_k es la relación de interferencia intercelular.

CAPITULO II: IMPORTANCIA DE SIMULADORES PARA PLANEACIÓN DE REDES UMTS

La importancia de los softwares para el planeamiento de redes móviles es muy significativo, ya que ofrecen muchas ventajas en lo que respecta al aumento de productividad, mejorar la calidad de servicio, reducir el time to market y permiten estudiar sistemas complejos.[30]

Los objetivos de los simuladores son los siguientes:

- Simplifica el proceso de desarrollo.
- Modelado conforme a los parámetros a medir.
- Escalable y configurable.
- Poder diferenciar cuales son las simplificaciones del modelo y su alcance.
- Posibilidad de definir distintos escenarios.
- Arquitectura abierta.
- Velocidad de simulación. Rendimiento.[31]

En la actualidad, un gran número de grupos de investigación europeos se encuentran sumidos en el desarrollo y evaluación de algoritmos avanzados de gestión de recursos dentro del sistema UMTS. Dada la gran complejidad de los sistemas evaluados y gracias a la creciente capacidad de computación de los ordenadores personales, los métodos de simulación se están estableciendo como una herramienta de uso generalizado. Estos simuladores pueden hacer uso, bien de modelos matemáticos que sintetizan de forma precisa entornos reales, creando un escenario sintético, o pueden utilizar datos reales recogidos de entornos y redes operativas. Desgraciadamente, por norma general los diferentes grupos hacen uso de herramientas desarrolladas de forma individual, agravándose aún más esta

[30] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 3
[31] Ibid.

situación ante la falta de un escenario de referencia que posibilite la comparación de forma directa de los diferentes estudios realizados.[32]

Dentro de este marco surge una iniciativa, englobada dentro de la acción europea COST273, conocida como MORANS (Mobile Radio Access Network Reference Scenarios). Esta iniciativa acomete la definición de varios escenarios de referencia comunes de forma que los distintos resultados obtenidos sean comparables.[33]

Tipos de Simuladores

Existen diversos tipos de simuladores, según de los parámetros que deseemos modelar y analizar. A veces no es fácil establecer la separación entre ellos, de hecho normalmente existen combinaciones de estos tipos.

- Simulador de red (system level).
- Simulador nivel de enlace.
- Simulador capa física.
- Simulador protocolos.
- Simulador de terminal.
- Específicos.
- Generadores de escenarios.
- Simuladores integrados.
- Simuladores/emuladores hardware.[34]

División entre nivel de enlace y sistema (red)

Los ordenadores posibilitan el modelado de algoritmos y características de red y movilidad con un alto nivel de detalle, ajustándose a los estándares. Una aproximación combinando el nivel de enlace y de red en un único modelo podría

[32] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 4
[33] Ibid
[34] Ibid. Pag. 5

estar cerca de la realidad. Sin embargo, normalmente se prefiere una separación de los niveles de red y de enlace. Esta aproximación reduce la complejidad del modelo, permitiendo trabajar con el de una forma más cómoda, además de reducir los tiempos de simulación.[35]

En el nivel de enlace se modela una única comunicación. Esto permite un buen análisis del flujo de datos transmitido entre una estación móvil y una estación base. El nivel de enlace en este caso incluye un modelado de la capa física o resultados de una simulación de ese nivel.[36]

En el nivel de sistema, hay muchas estaciones base y el tráfico presente en la zona interactúa según las condiciones de propagación. Los aspectos del nivel de enlace son modelados y simplificados tanto como sea posible. Desafortunadamente, no es posible ignorar totalmente algunos aspectos del nivel de enlace en el nivel de red sin perder fenómenos de interferencia de células y su correspondiente impacto en la calidad.[37]

Evaluación de QoS

Cualquier acontecimiento que afecta QoS debe poder ser identificado y si es posible modelado en un simulador para proporcionar un patrón del error tan realista como sea posible. La simulación y evaluación de la QoS es un tema muy complejo a la vez que importante es UMTS, por esta razón existen numerosos estudios referentes a este aspecto.[38]

Los eventos que afectan QoS se dividen generalmente en dos grupos: los que se modelan en el nivel de enlace y los que se modelan en el nivel de sistema o de red.[39]

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[35] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 5
[36] Ibid.
[37] Ibid
[38] Ibid. Pag 6
[39] Ibid.

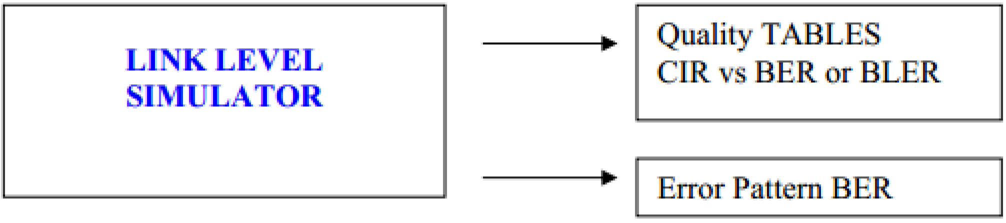

Fig. 3. Link Level Simulator[40]

Estos resultados se utilizan como entradas en simulaciones a nivel de sistema. Como en las redes reales, la QoS se puede evaluar con un solo móvil en una red descargada o en cargada. La QoS de una sola comunicación en una red descargada puede ser evaluada a nivel de enlace. Sin embargo, QoS de una comunicación entre otras necesita modelar las interacciones entre las comunicaciones y los algoritmos del nivel de sistema.[41]

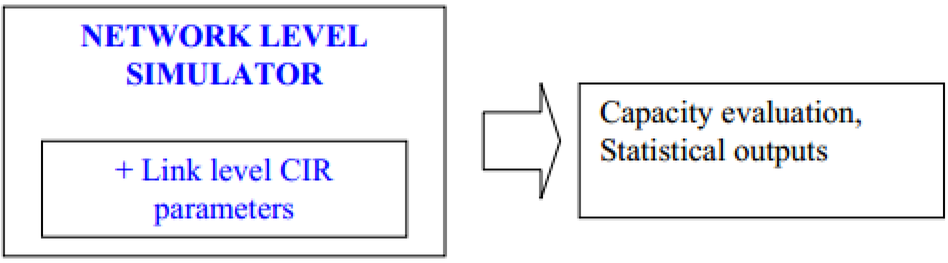

Fig. 4. Network Level Simulator[42]

Esta simulación es compleja y se suele plantear en función del tipo de comunicación. Por otro lado podemos retroalimentar el análisis a nivel de enlace con los resultados del nivel del sistema para obtener unos patrones de BER mas realistas.

[40] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 6
[41] Ibid.
[42] Ibid.

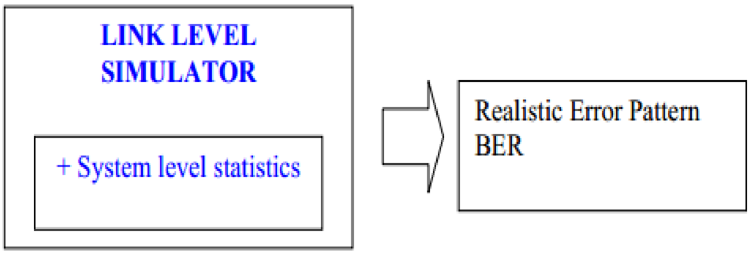

Fig. 5. Link Level Simulator + System Level Statics[43]

Aproximaciones Dinámicas (time based) y Estáticas (snapshot)

Las aproximaciones basadas en el tiempo proporcionan modelos dinámicos, que permiten analizar en detalle el cambio de la estación base activa del dispositivo. Sin embargo, siempre hay un compromiso ante la frecuencia de las muestras y la duración de la simulación.[44]

Una aproximación más práctica es una simulación puramente estática, que requiere una menor carga computacional. La aproximación de Monte Carlo se basa en el posicionamiento en posiciones discretas aleatorias de la estación móvil en la red, seguido de la determinación de un estado estable. Un análisis estadístico requeriría varios posicionamientos distintos para obtener resultados significativos. Este sistema estático no es apropiado para simular algunos efectos de propagación y algunos análisis de QoS.[45]

Por otro lado, existen distintas soluciones intermedias entre estas dos posturas extremas comentadas.[46]

[43] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 6.
[44] Ibid. Pag. 7
[45] Ibid.
[46] Ibid.

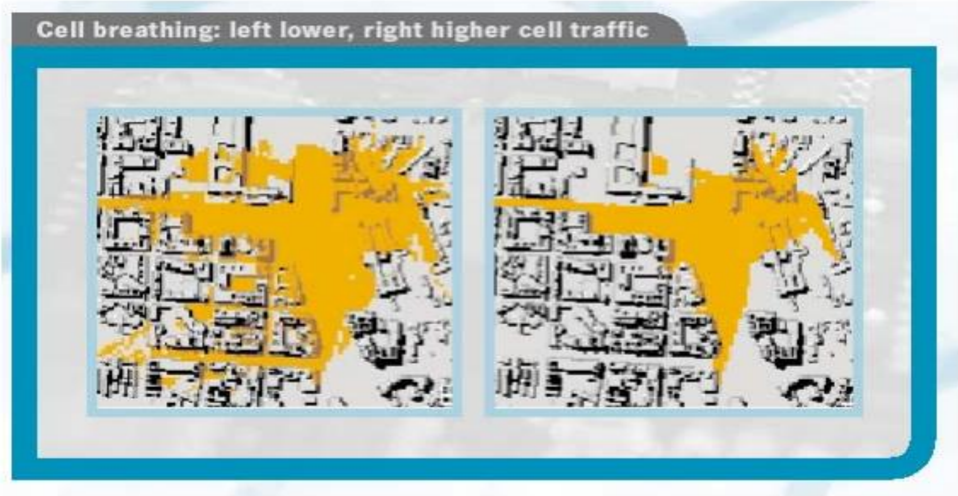

Fig. 6. Efecto Cell Breathing[47]

Una de las características fundamentales de los sistemas CDMA implementados en UMTS es que el rango de cobertura está estrechamente relacionado con la capacidad del sistema: cuanto más tráfico es soportado por una célula, más se reduce su cobertura. Este fenómenos se como “Cell Breathing” (respiración de la célula). Este comportamiento dinámico hace que la planificación de las células y el dimensionado de la red sea una tarea muy compleja.[48]

Simuladores/emuladores Hardware

La evolución de GSM a UMTS supone cambios importantes en la infraestructura de la red. Principalmente todos los elementos de la nueva interfaz de radio de acceso a la red.[49]

Hasta que la redes UMTS estén perfectamente establecidas y comprendidas, la validación y aceptación de los elementos de red no será una tarea fácil. Y para complicar más aun las cosas, muchas redes UMTS incorporan o incorporarán

[47] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 7
[48]Ibid.
[49] Ibid. Pag. 8

elementos de distintos fabricantes. Los interfaces estandarizados y abiertos permiten a los operadores utilizar estos elementos de distintos fabricantes.[50]

A pesar de que los diseñadores de equipos interpretaran las especificaciones 3G de buena fe siguiendo el estándar, inevitablemente llegarán a conclusiones que pueden ser distintas de unos a otros e incluso los fabricantes podrán decidir incorporar o no ciertas características en sus equipos. Estos puede llevar a problemas de interfuncionamiento cuando se conecten elementos de distintos fabricantes[51].

Esto plantea un dilema a los operadores de red, ¿Cómo pueden verificar el cumplimientos de los estándares y la interoperabilidad de estos elementos produciendo los menores problemas en la red? La solución es el uso de simuladores/emuladores de elementos de red ya que:[52]

- Garantizan un completo cumplimiento de los estándares e interactuarán con los demás elementos de red para comprobar su funcionamiento.
- Recogen estadísticas y analizan los resultados.
- Pueden simular comportamientos erróneos.
- Pueden generar tráfico con distintas características.[53]

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[50] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 8
[51] Ibid.
[52] Ibid.
[53] Ibid

CAPITULO III: HERRAMIENTA DE SIMULACIÓN PARA LA PLANEACIÓN DE REDES UMTS (ATOLL)

Atoll es una aplicación con un entorno gráfico para la planificación de entornos de radiotelecomunicaciones. Es especialmente útil para compañías de telecomunicaciones que deben diseñar entornos wireless incluyendo su ciclo de vida completo, esto es, partiendo de un diseño inicial, ampliándolo y optimizando el mismo.[54]

Partiendo de las capacidades en ingeniería que este software ofrece, Atoll es un sistema abierto, escalable y con un sistema de información técnica para poder ser utilizado con otros sistemas de análisis.[55]

Además, provee una base de datos de redes UMTS. Permite el modelado de tráfico, simulaciones y análisis de datos de forma gráfica y un planeador de códigos por zonas para redes de células.[56]

Algunas Características Generales

Características GIS:

- Base de datos cartográfica.
- Editor cartográfico integrado.
- Interfaz con herramientas GIS.

Modelado de propagación y enlace:

- Cálculo de predicciones.
- Modelos de propagación de micro y macro células.

[54] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 15
[55] Ibid.
[56] Ibid

- Soporta modelos externos a través de su API.
- Análisis de interferencias.
- Análisis de fiabilidad del enlace.

Módulo de medidas:

- Toma de medidas.
- Reproducción de las medidas en mapas.
- Modelos de propagación automáticos a partir de medidas.
- Permite establecer eventos de llamada.

Informes:

- Generador de informes flexible.
- Importación / exportación de datos.

UMTS

Base de datos de red UMTS

- Múltiples portadoras.
- Equipos UMTS.
- Modelado de repetidores y transmisores.

Modelado de tráfico

- Múltiples servicios de conmutación de circuitos y paquetes.
- Múltiples fuentes de tráfico.
- Mapas de distribución de usuarios.
- Modelado de perfiles de usuario.

Simulación y análisis

- Simulador Monte Carlo de W-CDMA.
- Estudios de predicción.
- Áreas de handover.
- Análisis de estadísticas.

Co Planificación GSM/UMTS

- Planificación simultanea de redes UMTS y GSM.
- Handover entre ambas tecnologías.[57]

[57] Carlos Andrés Alonso. Carlos Bueno López. Simuladores UMTS. Redes y Servicios de Radio. Curso 2004/2005. Pag. 16

CAPITULO IV: DISEÑO DE LA RED CELULAR UMTS EN EL MUNICIPIO DE DIARIAMBA, DEPARTAMENTO DE CARAZO. NICARAGUA.

En el diseño se utilizarán las herramientas de software Google Earth y Atoll para la realización de la planeación de la red UMTS.

A continuación se presenta una imagen tomada de Google Earth donde se muestra el municipio de Diriamba.

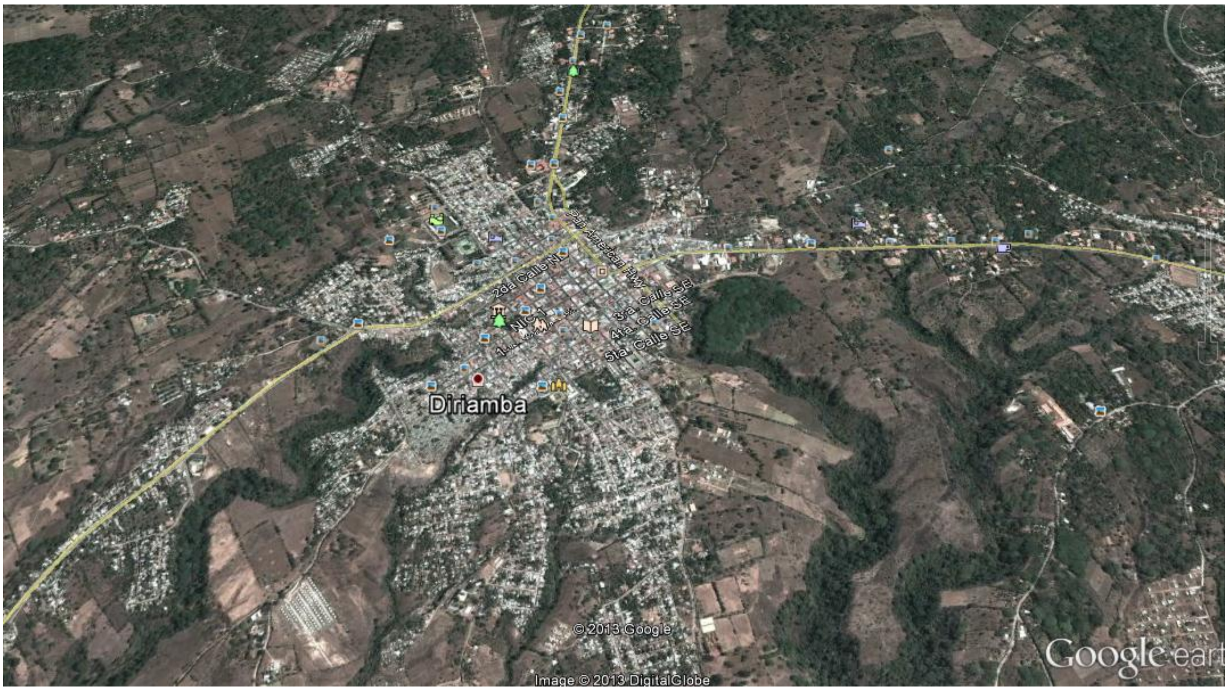


Fig. 7. Imagen aérea de Diriamba

Se requerirá configurar el proyecto para realizar el diseño de la red UMTS en el municipio de Diriamba. A continuación se presenta la imagen donde se determina la tecnología requerida para dicho diseño:

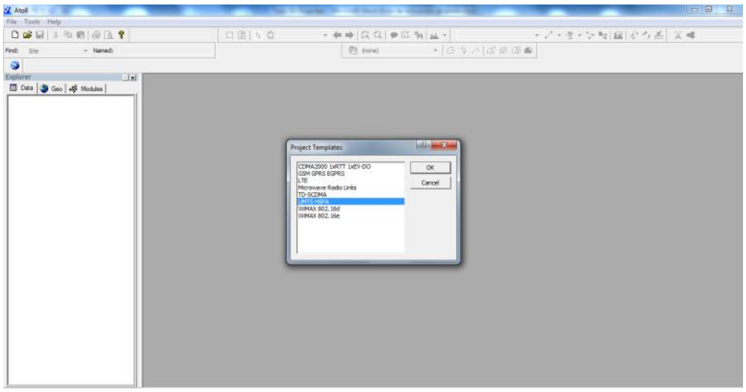


Fig. 8 Asignación de UMTS

Para el diseño que se pretende desarrollar se escogió la opción UMTS HSPA.

Después se determinan las coordenadas en el software para determinar la posición en función de latitud y longitud donde se realizará la simulación.

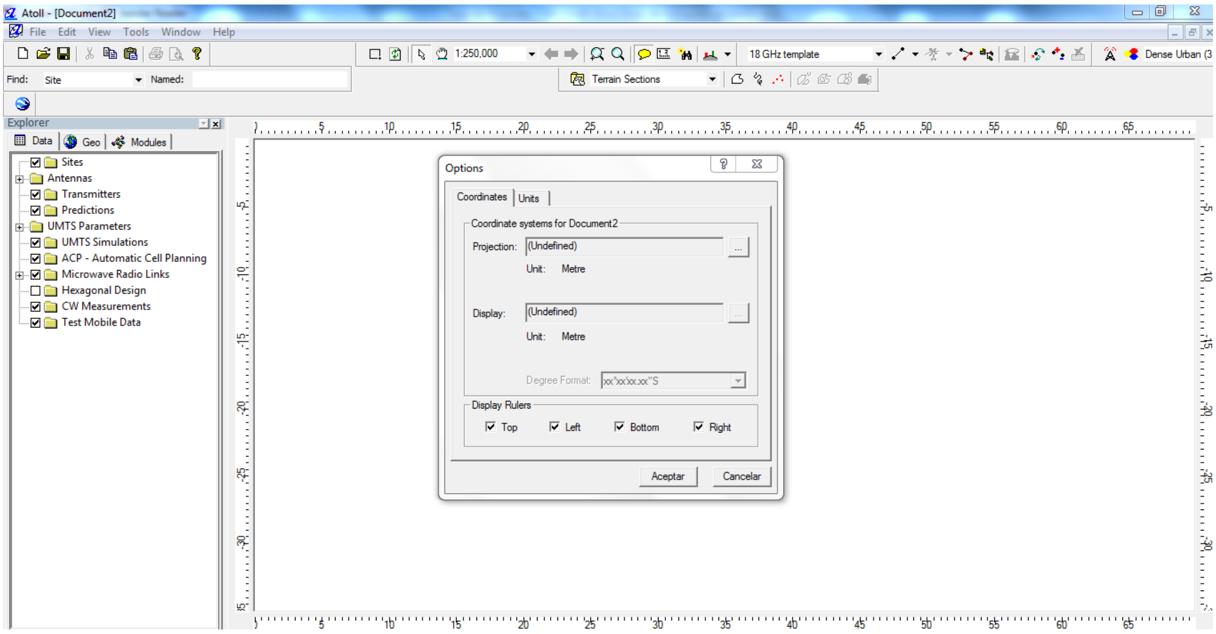


Fig. 9 Opción para coordenadas

Se elige la opción WGS84 UTM Zones /16 N.

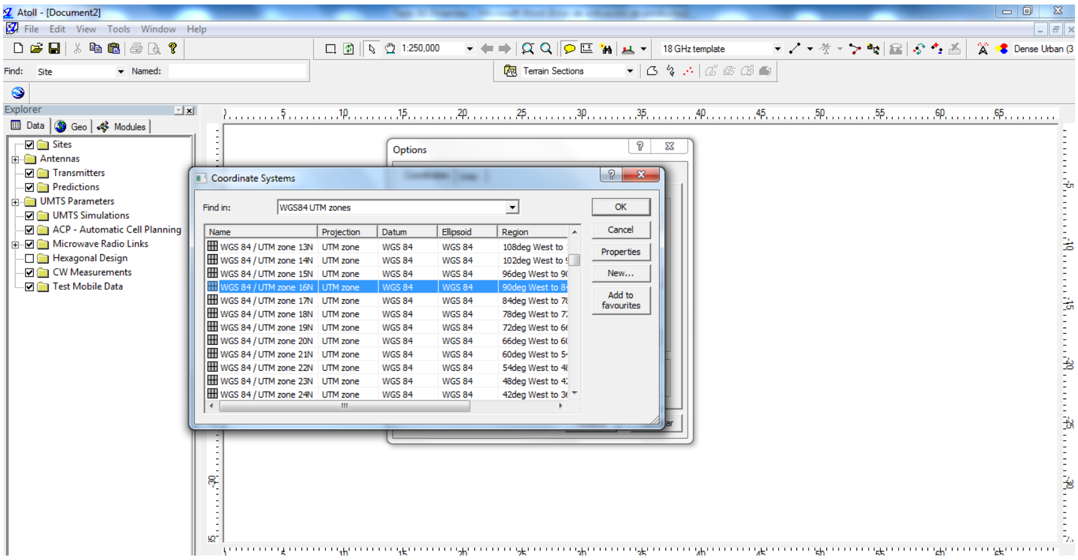


Fig. 10 WGS84 UTM /Zones 16N

Posteriormente en la ventana, en la opción Display se elige WGS 84, así:

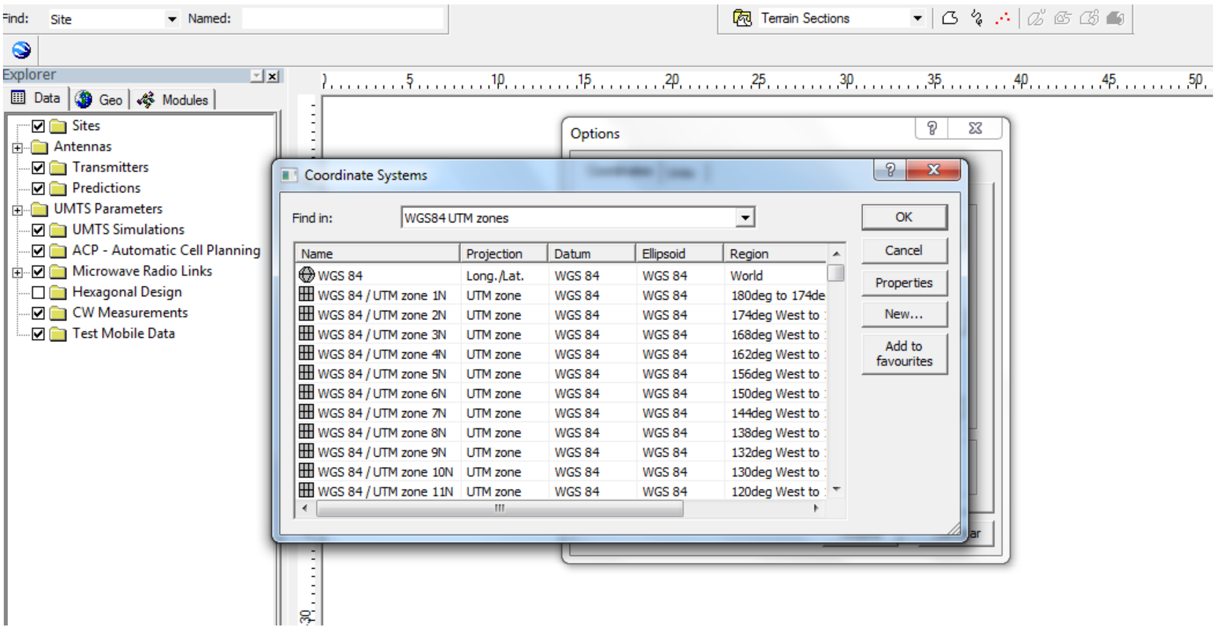


Fig. 10. WGS 84

Cuando se elige la opción anterior se tendrá la siguiente ventana:

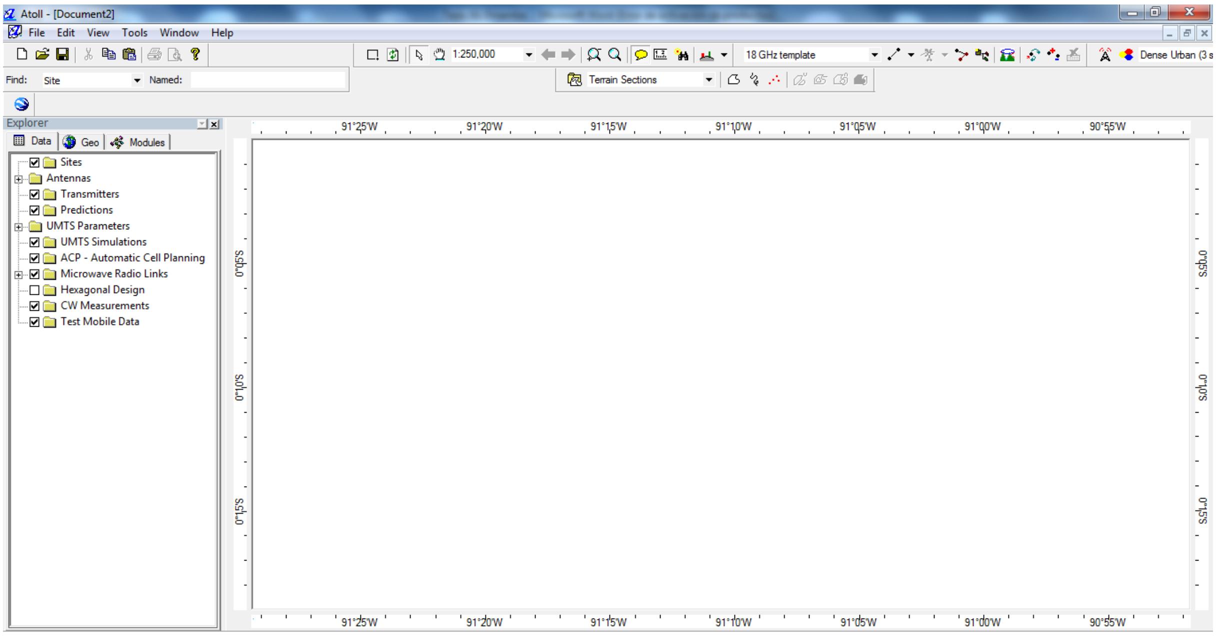


Fig. 11. Ambiente para iniciar a cargar los mapas

A partir de ahora se pueden cargar los mapas de interés para realizar el estudio de cobertura por transmisor y nivel de señal.

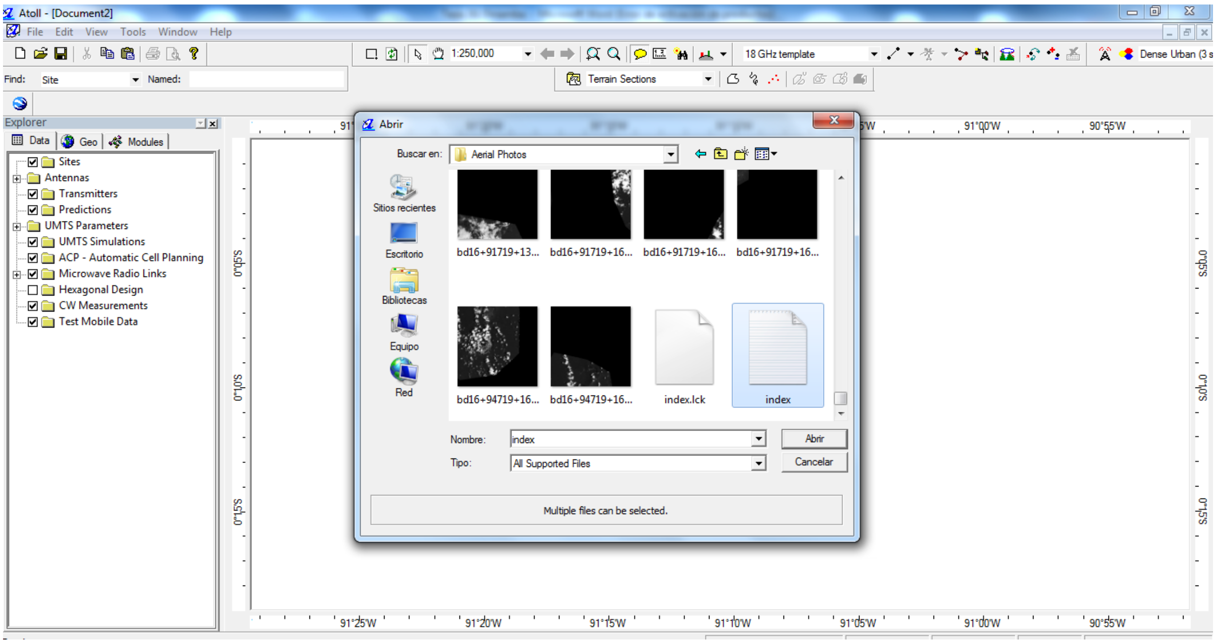


Fig. 12. Importar el mapa de Imagen

Se tendrá el siguiente resultado:

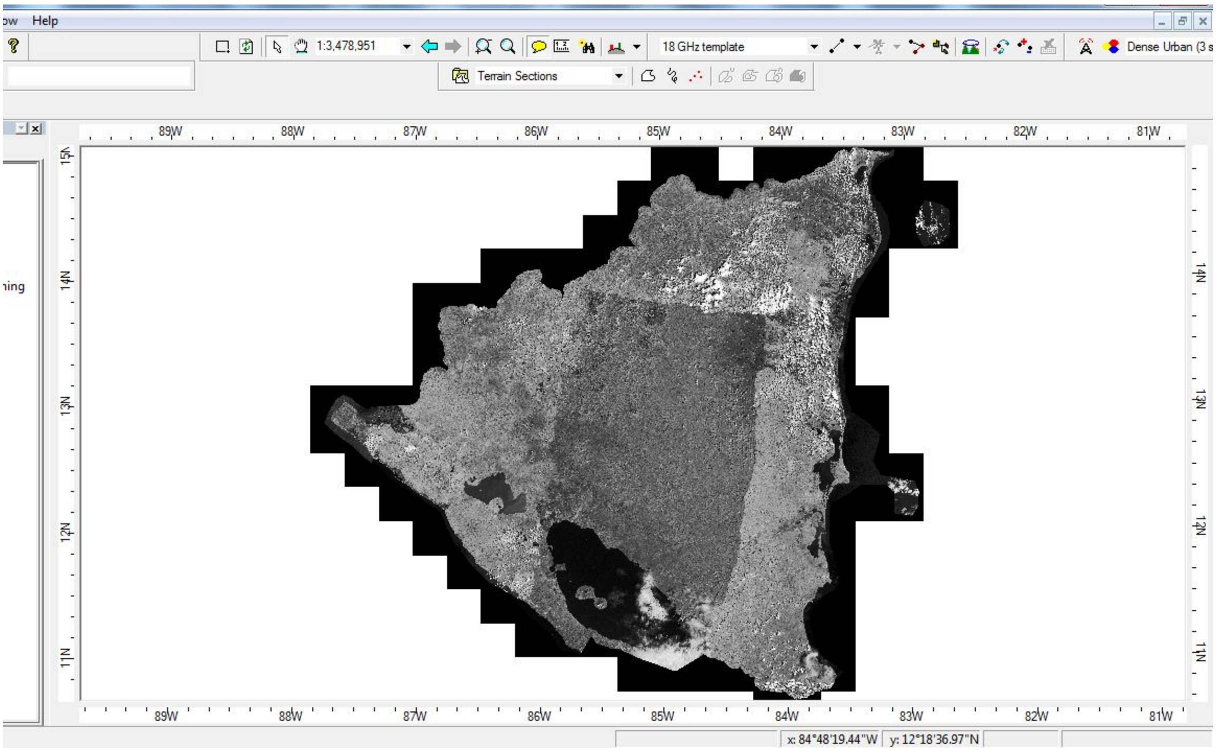


Fig. 13. Mapa de Nicaragua

Después es necesario cargar el Mapa Clutter Clases

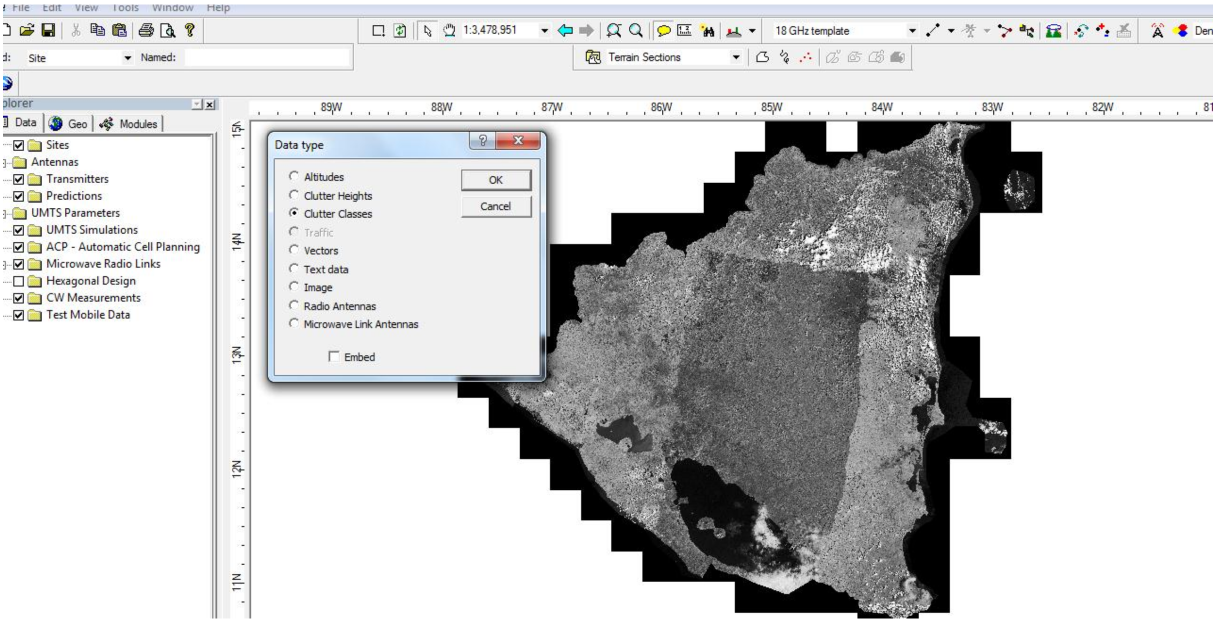


Fig. 14 Data Type / Clutter Clases

La imagen que resulta al cargar el Clutter Clases es la siguiente:

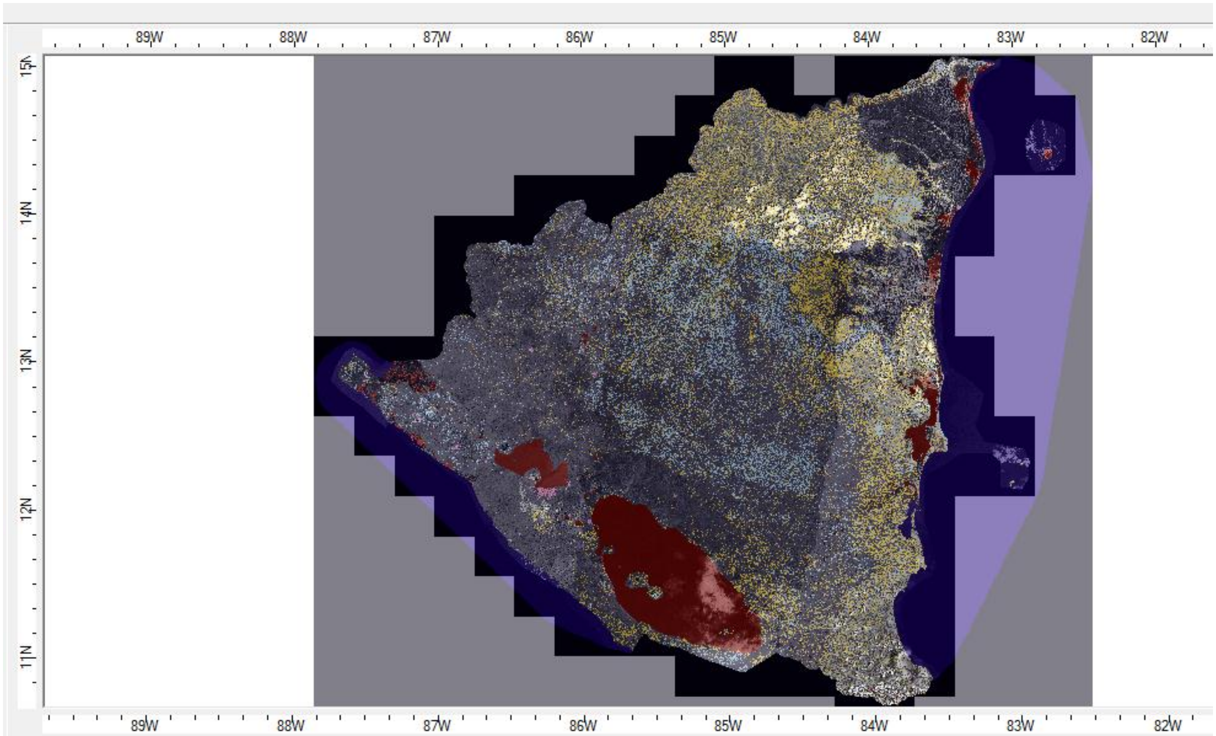


Fig. 15 Mapa cargado con el Clutter Clases

Se procede a cargar el Clutter Heights:

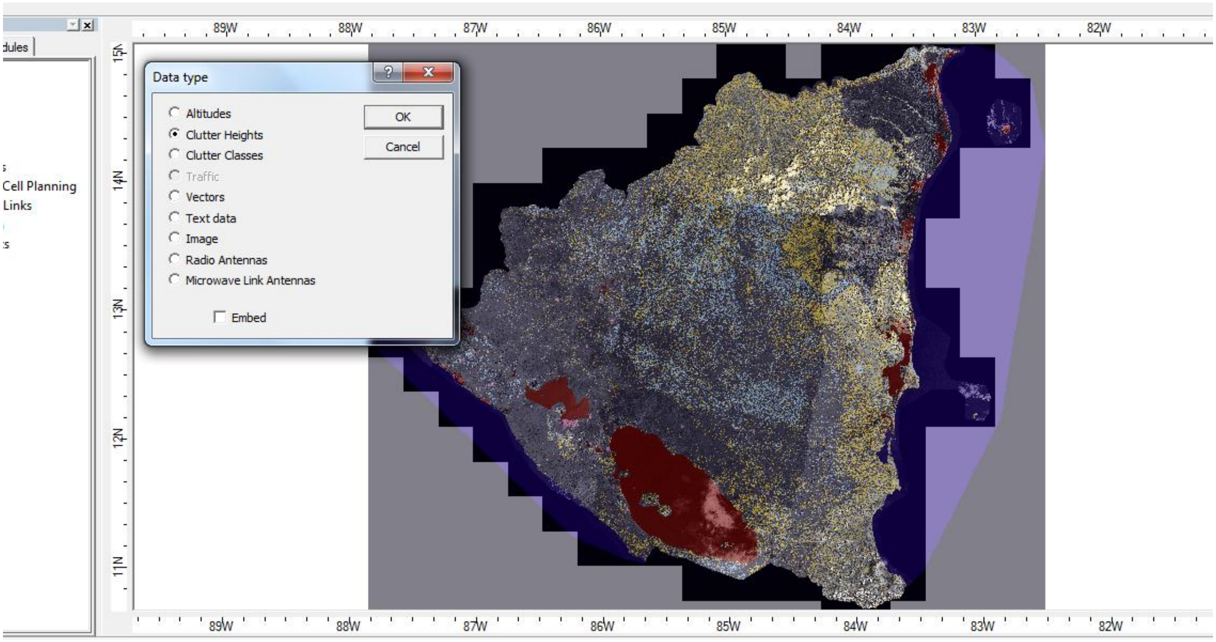


Fig. 16. Data Type / Clutter Heights

El mapa de Nicaragua queda de la siguiente manera cuando se carga el Clutter Height:

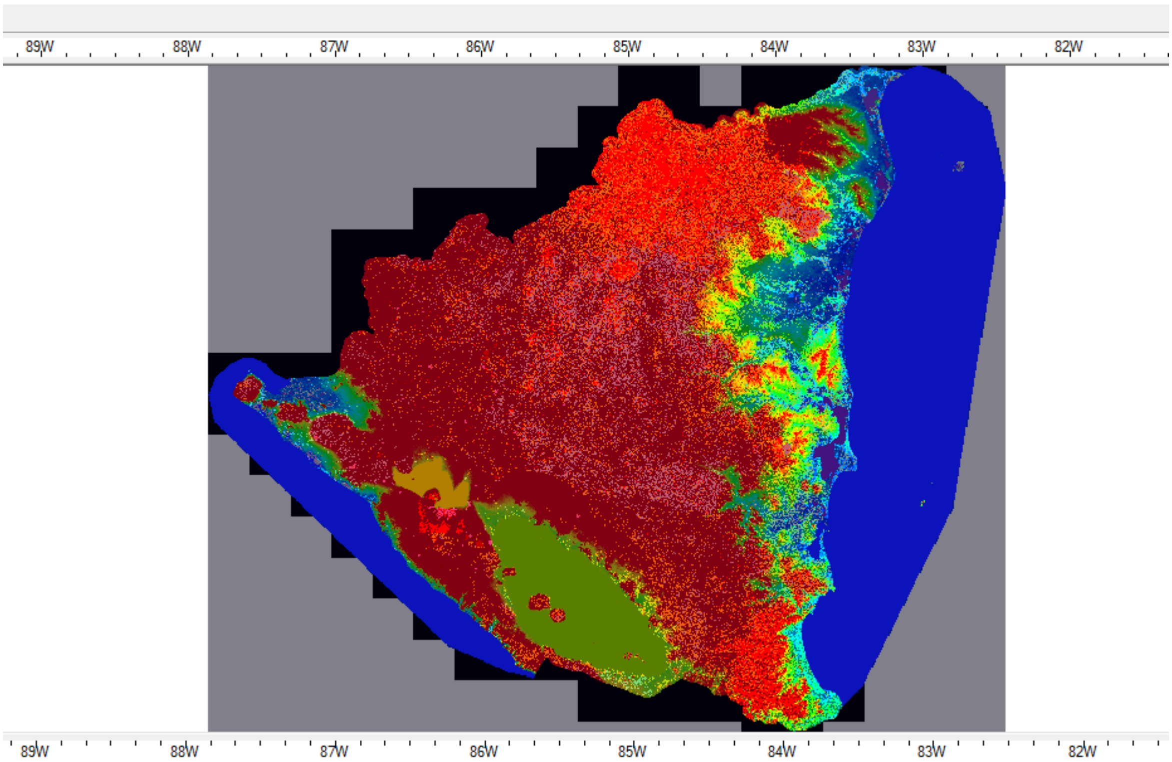


Fig. 17. Mapa de Nicaragua cargado con el Clutter Heights

Posteriormente se carga el Mapa Vectors, quedando la siguiente imagen:

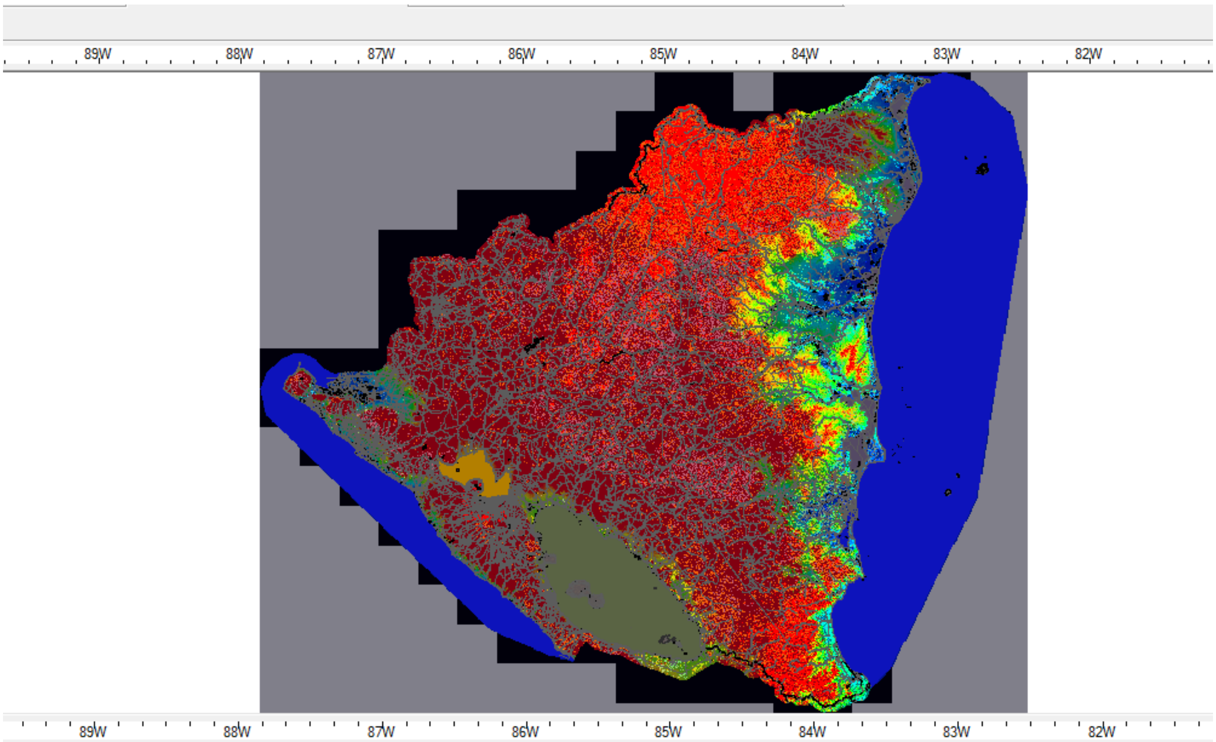


Fig. 18. Mapa Nicaragua cargado con el Mapa Vectors

Hay que determinar la Hot Spot Zone en el mapa de Nicaragua que está cargado en el software Atoll. Si hacemos un acercamiento nos permitirá delimitar mejor el área donde se realizará el estudio de coverage:

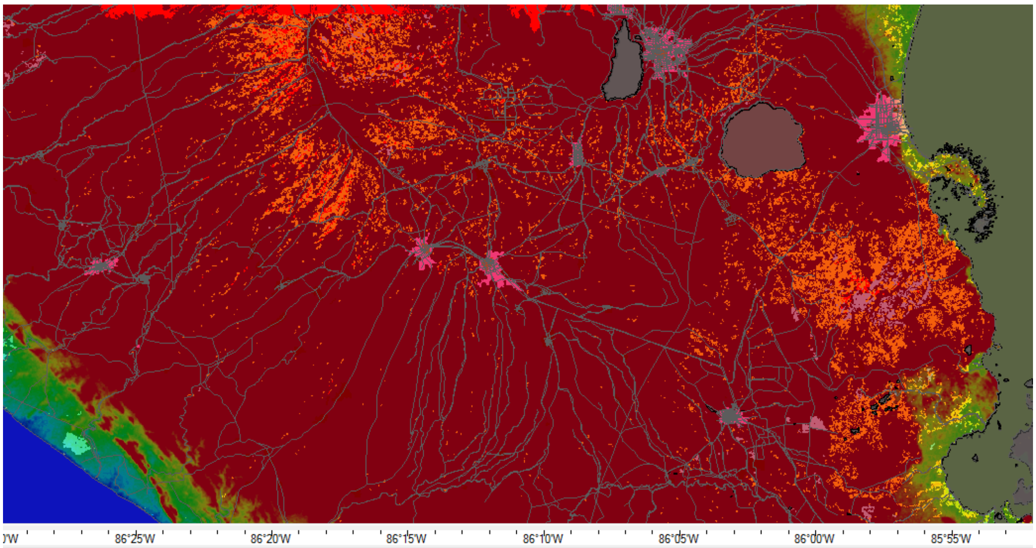


Fig. 19 Acercamiento en la zona de interés

A continuación se dibuja un polígono que determine la Hot Spot Zones:

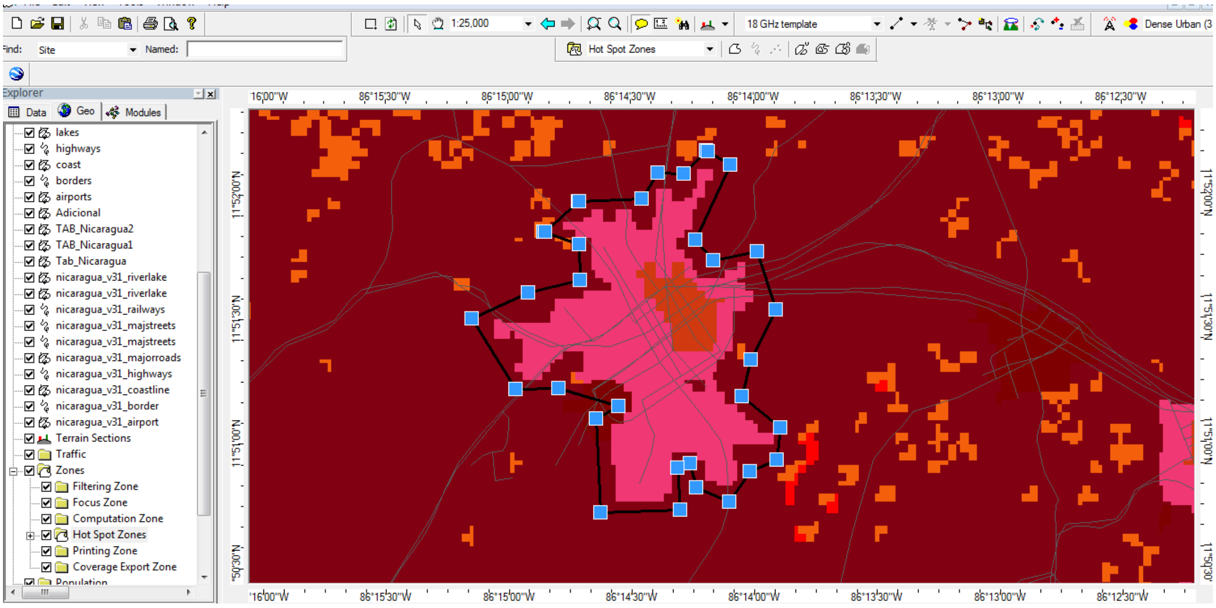
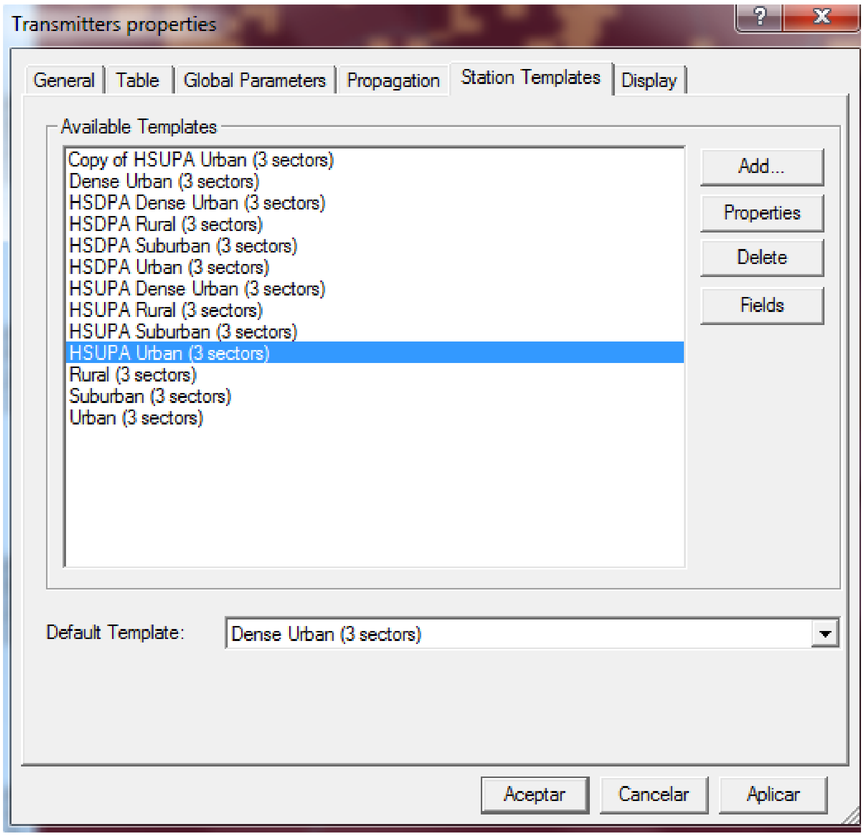


Fig. 20 Delimitación de la Hot Spot Zone

En la Fig. 17 se muestra la Hot Spot Zone para el municipio de Diriamba. Después que se determina la zona se deberán configurar los sitios. La cpmración en Atoll se realiza de la siguiente manera. Ver Fig. 18.



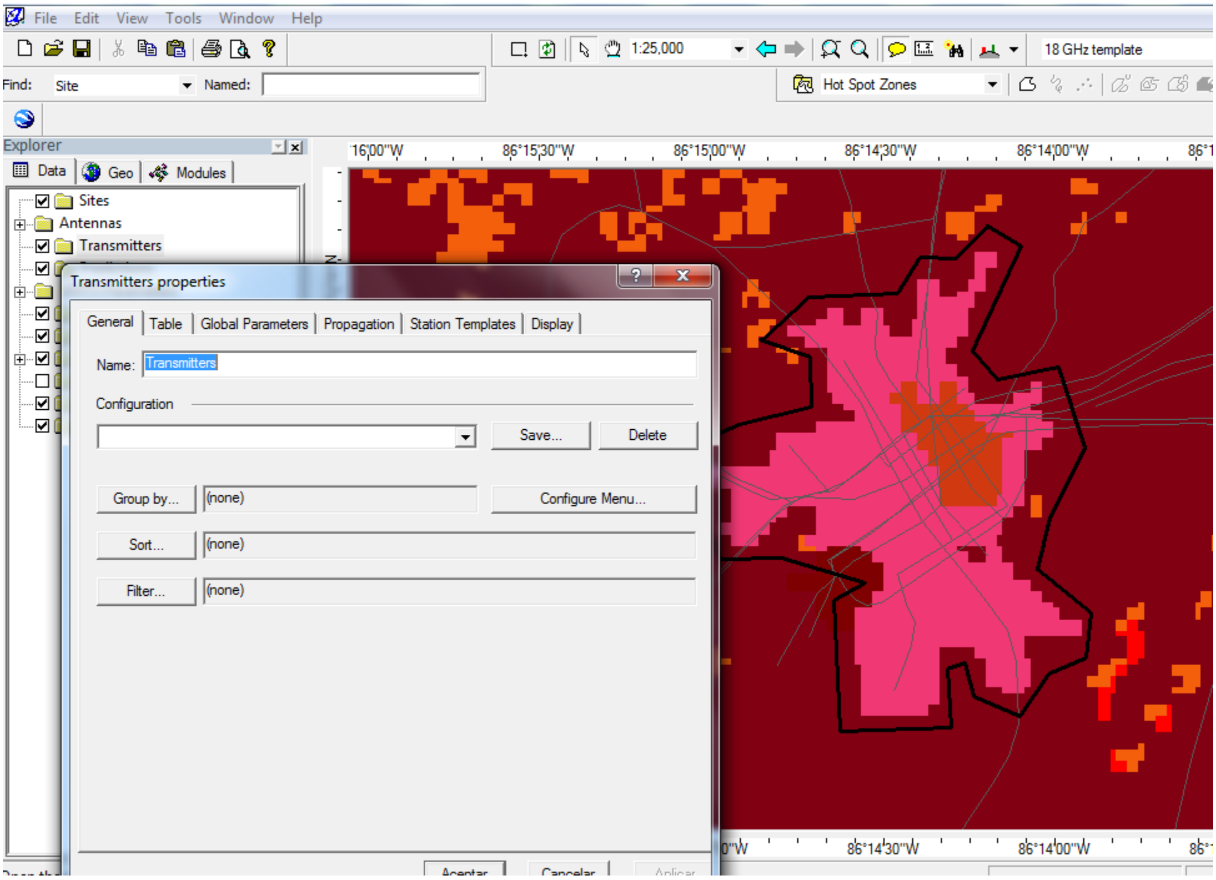


Fig. 21. Transmiters properties

Se utilizarán 3 sectores, para zona urbana.

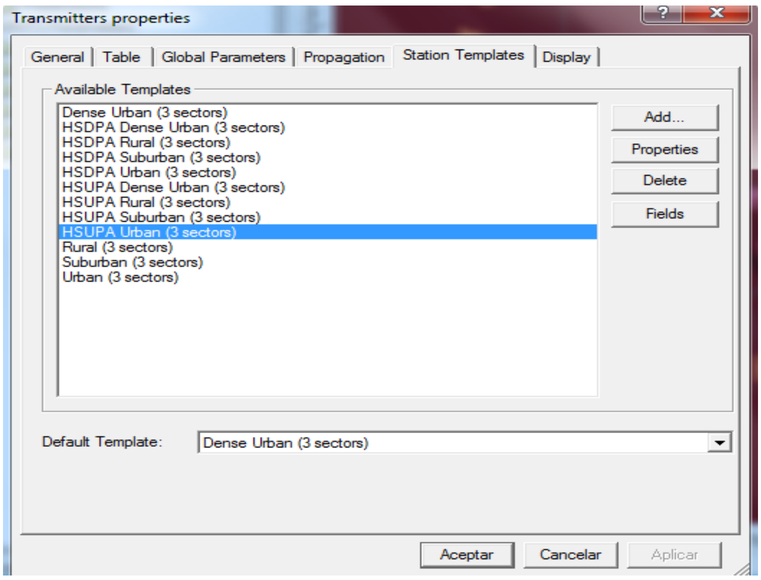


Fig. 12 HSUPA Urban (3 sectors)

También se realiza la siguiente configuración:

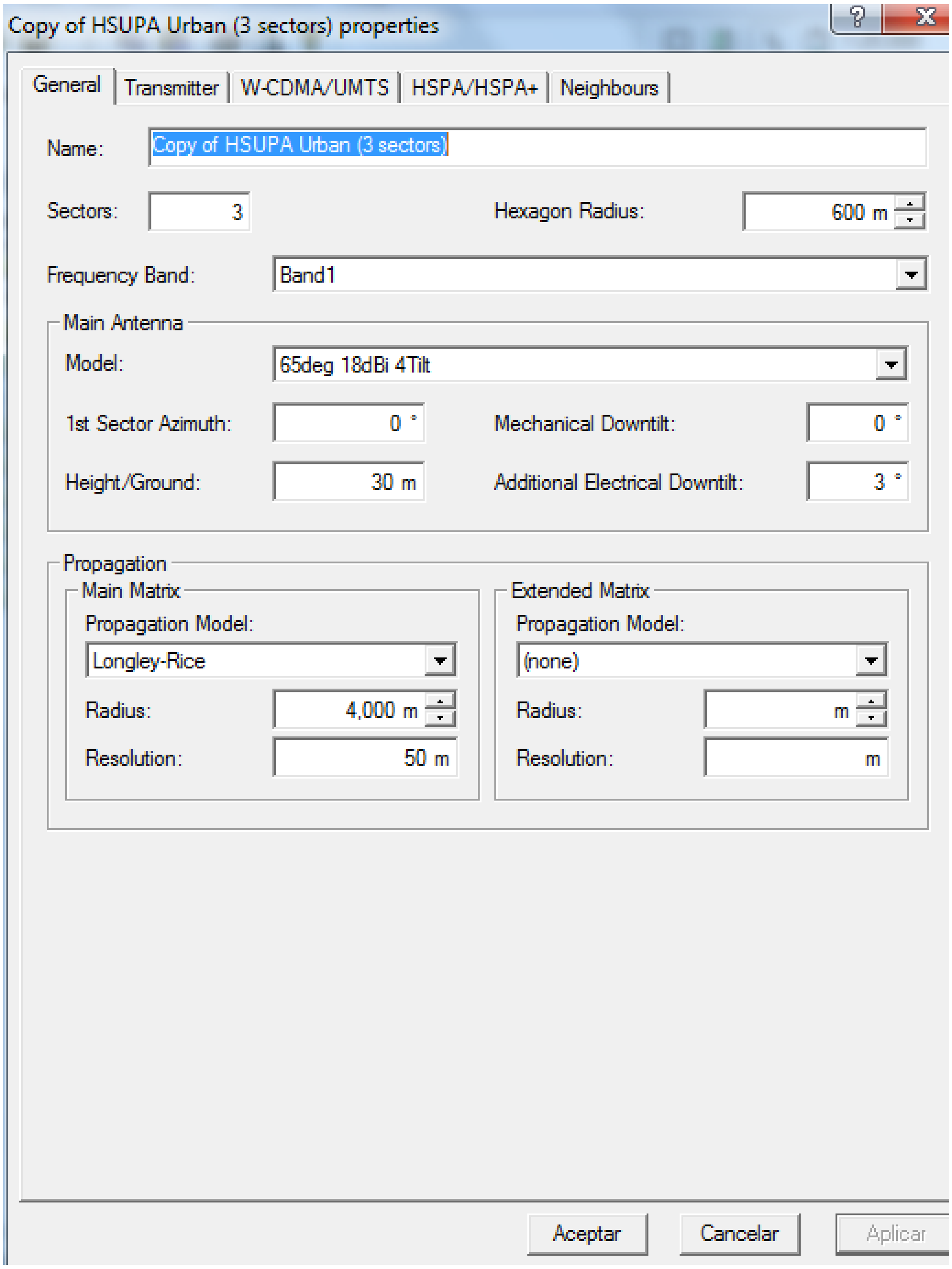


Fig. 23 HSUPA Properties

Vamos a configurar el “Equipment” de la siguiente manera:

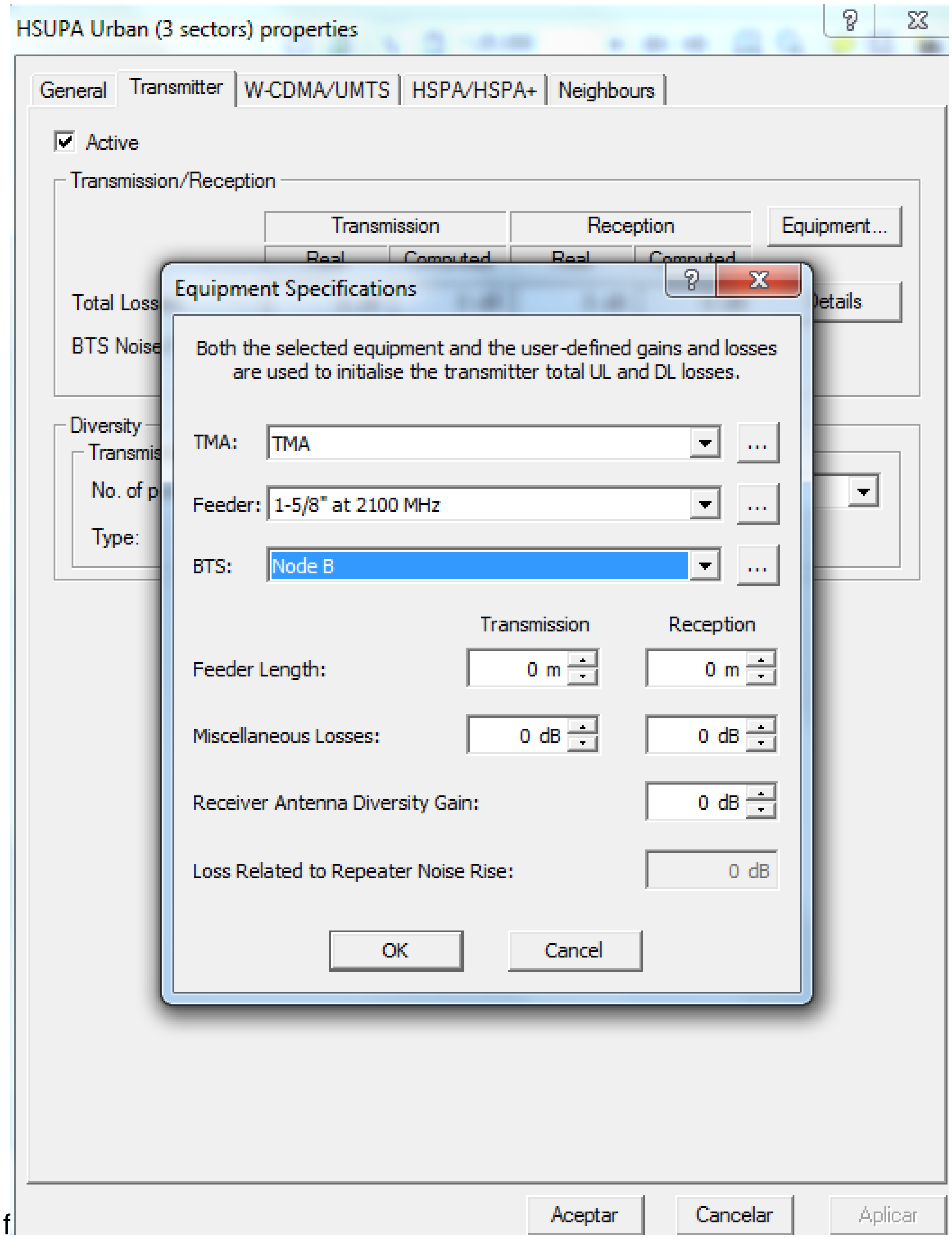


Fig. 24. Equipment Specifications

Se procede a ubicar los sitios, se tiene que determinar la computation zone, los sitios estarán ubicados así:

Fig. 25. Vista de la ubicación de los sitios

Las coordenadas para los sitios son:

- Diriamba1: 11°51'29.50"N; 86°14'21.36"O
- Diriamba2: 11°51'13.49"N; 86°14'13.87"O
- Diriamba3: 11°51'22.03"N; 86°14'45.21"O
- Diriamba4: 11°51'45.01"N; 86°14'22.26"O
- Diriamba5: 11°51'34.49"N; 86°14'4.73"O

Se procede a cargar las 5 coordenadas en Atoll en la Computation Zone, se tiene el siguiente resultado:

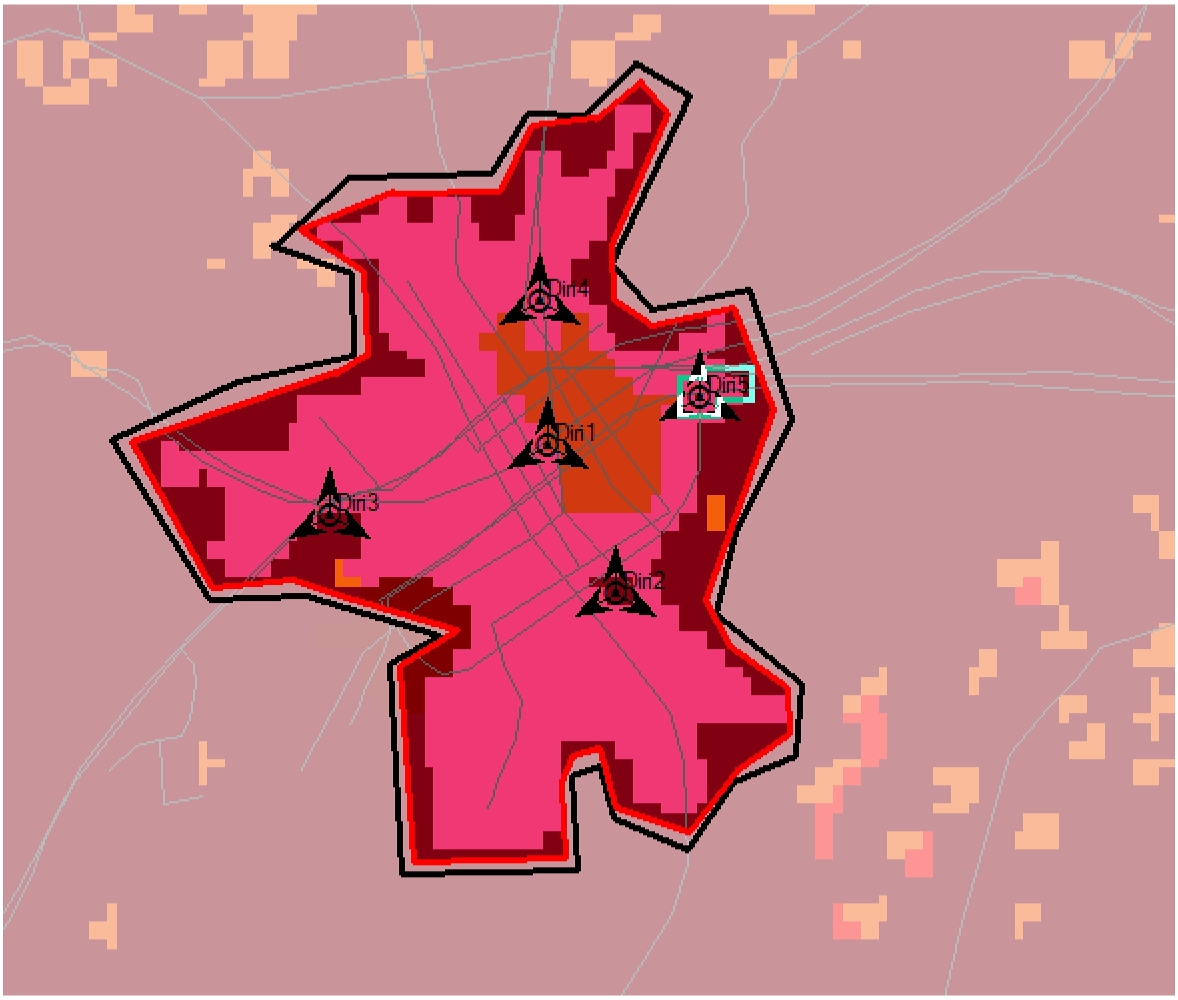


Fig. 26. Sitios Cargados en la Computation Zone

Ahora se procederá a ir a predicciones para determinar la cobertura por transmisor. Ver Fig. 27.

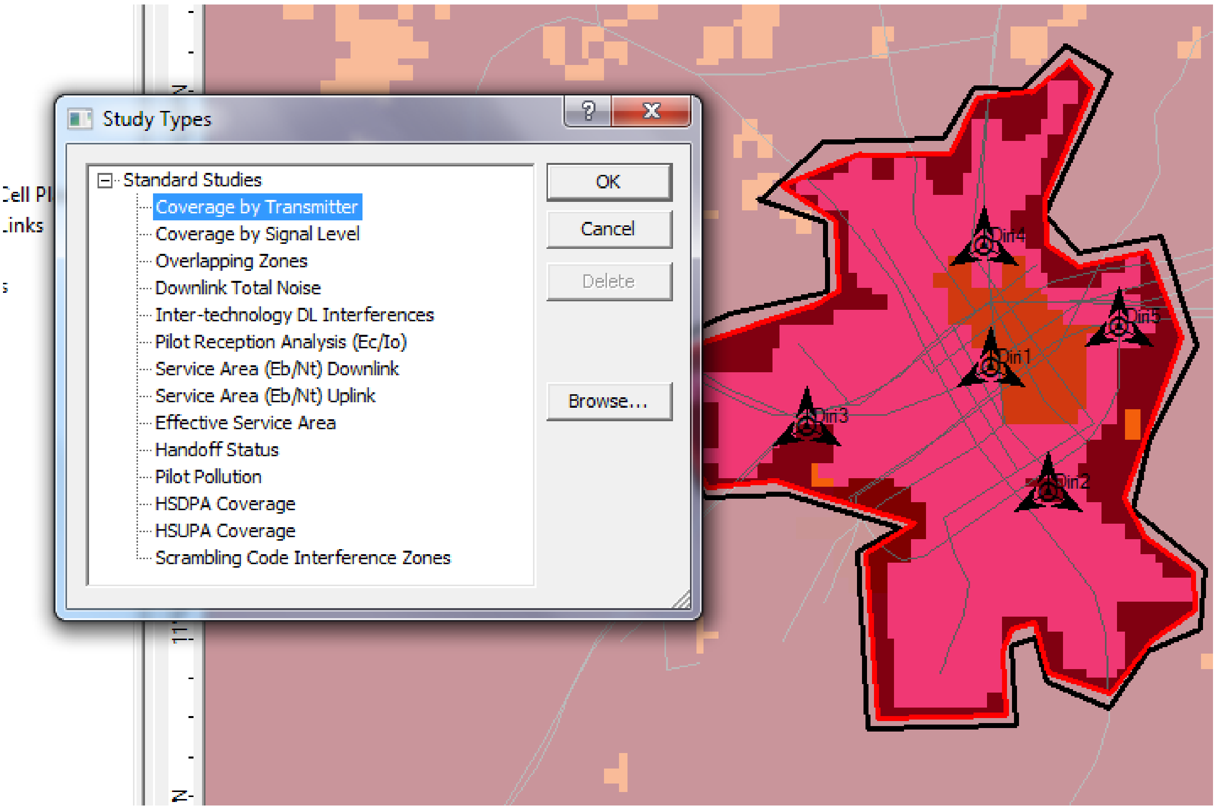


Fig. 27. Study Types. Coverage by Transmitter

Después se ejecuta el cálculo del Coverage by Transmiter. Ver Fig. 28

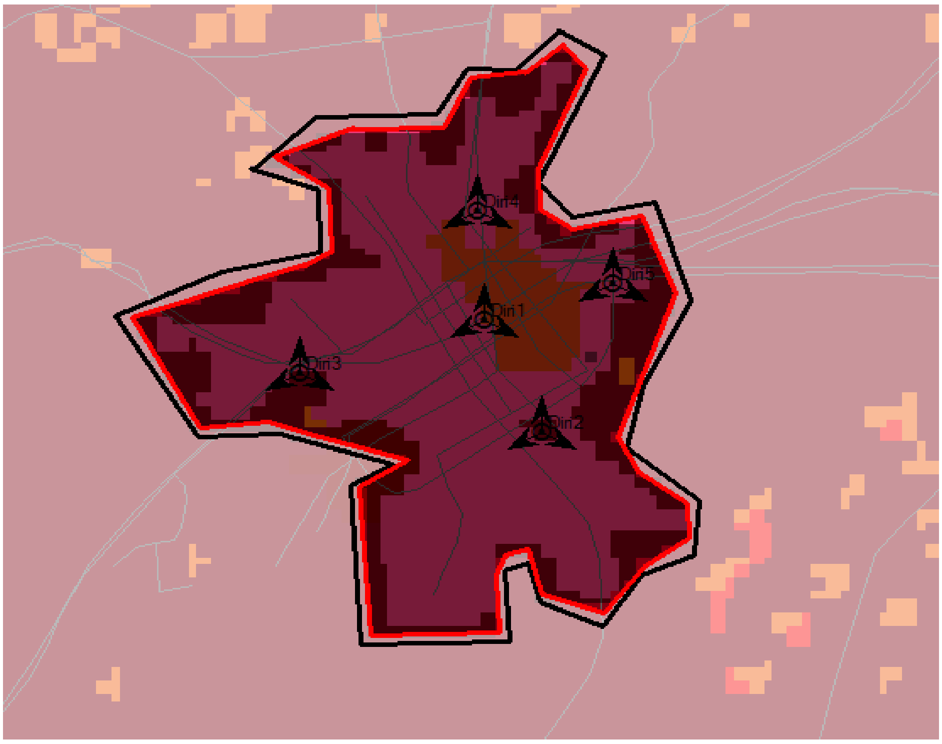


Fig. 28 Resultado del Coverage by Transmitter

Ahora se procederá a hacer la simulación "Coverage by Signal" para la misma zona de computo. Ver Fig. 29

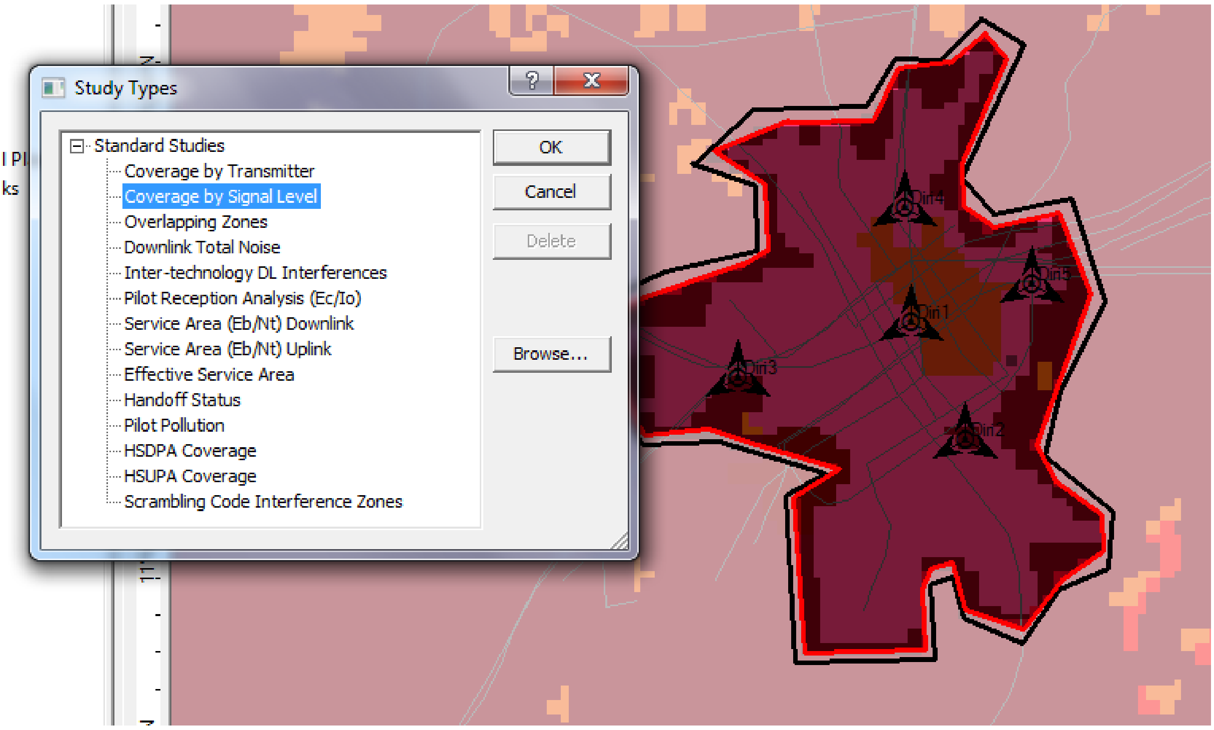


Fig. 29 Study Types. Coverage by Signal Level

Después se realiza la asignación de colores por valor de potencia. Ver Fig. 30

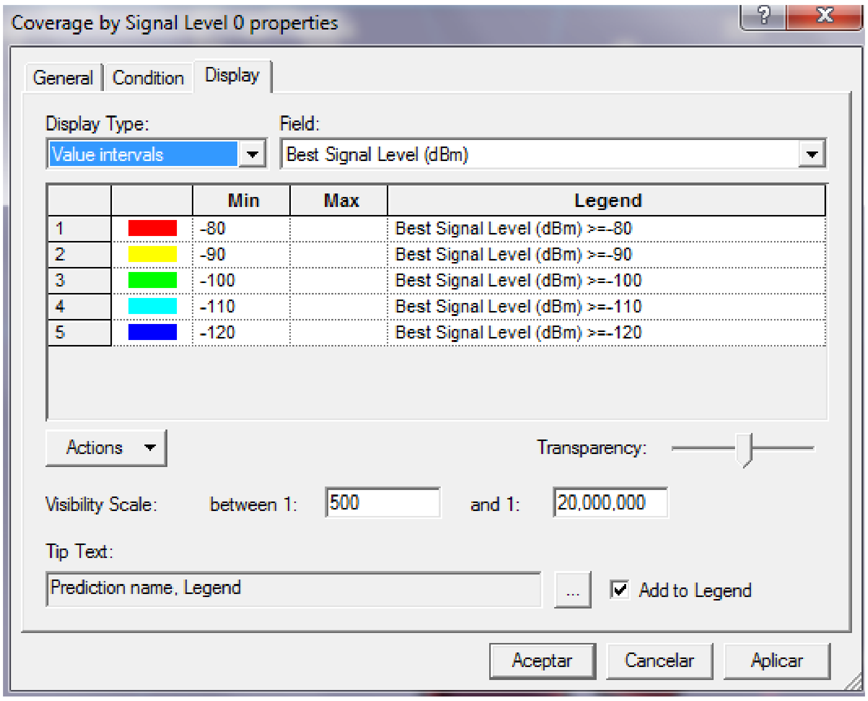


Fig. 30 Asignación de Colores en Términos de Potencia

Posteriormente se procede a calcular la predicción en Coverage by Signal, teniendo como resultado la siguiente imagen. Ver Fig. 31

.

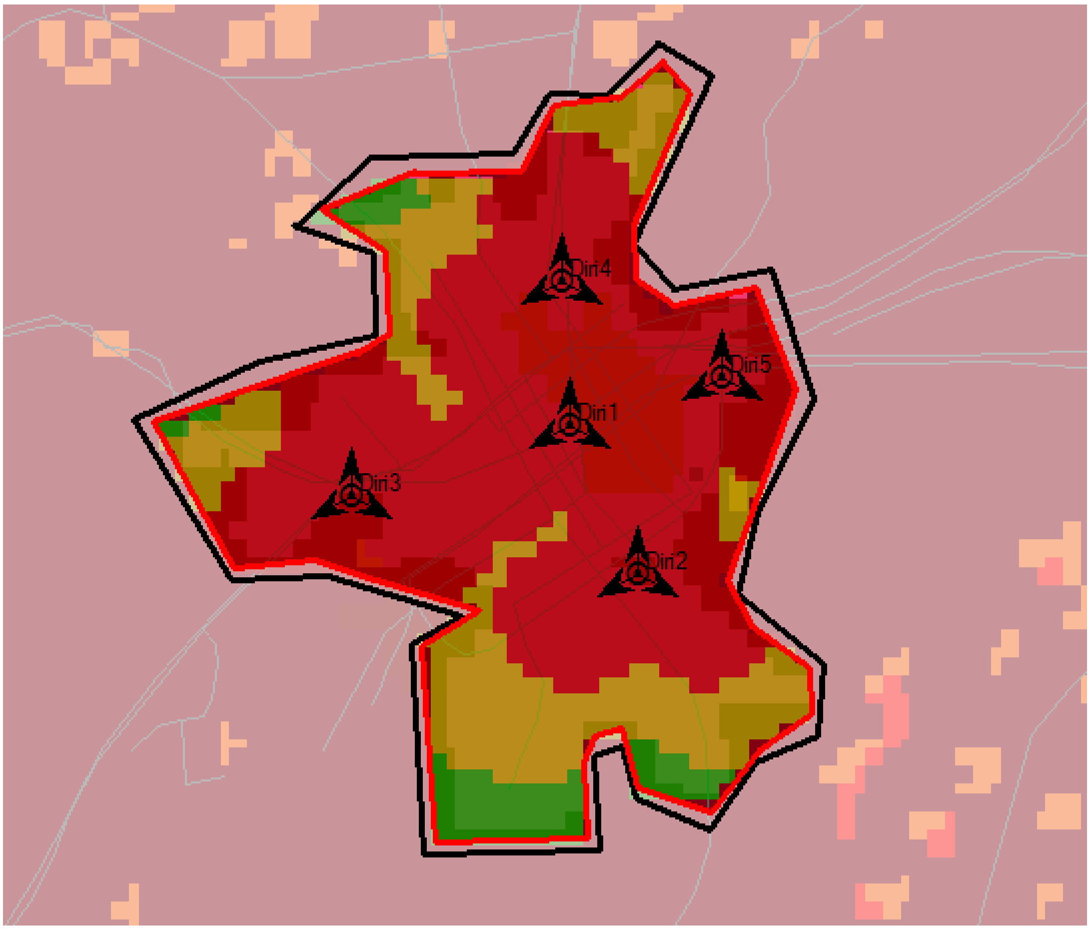


Fig. 31 Coverage by Signal

Cuando se tiene tiene generadas las simulaciones Coverage por Transmitter y by Signal se procede a generar los datos estadísticos, se mostrará mediante un histograma donde se muestra los niveles de potencia de la señal. Ver. Fig. 32

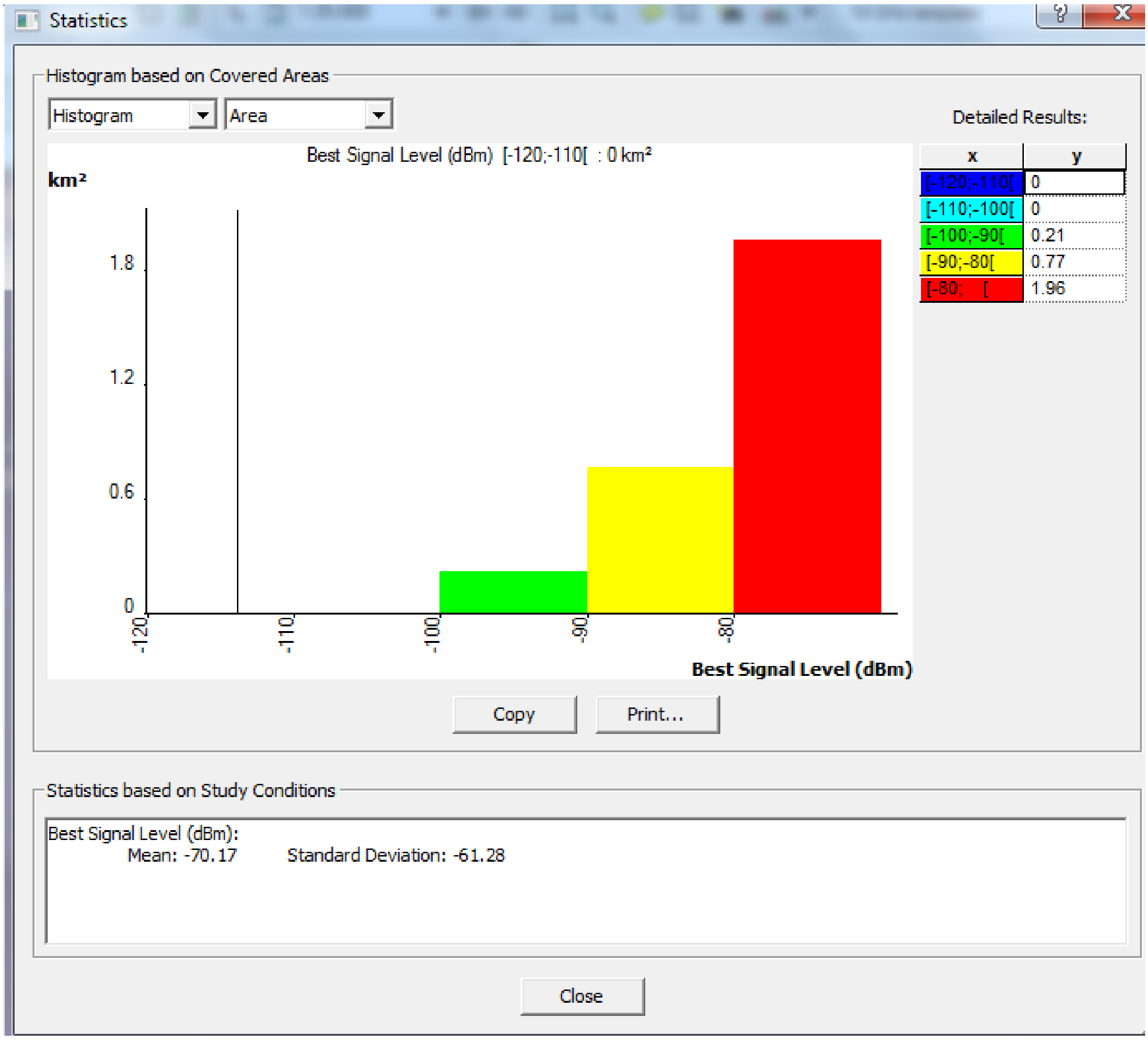


Fig. 32. Histograma

Posteriormente generaremos el informe en función del porcentaje de la Computation Zone. Ver Fig. 33.

Kevin: Coverage by Signal Level 0

Name	% Computation Zone
Coverage by Signal Level 0	100
Best Signal Level (dBm) >=-80	67
Best Signal Level (dBm) >=-90	93.3
Best Signal Level (dBm) >=-100	100
Best Signal Level (dBm) >=-110	100
Best Signal Level (dBm) >=-120	100
Hot-Spot : Hot Spot Zones 1	
Coverage by Signal Level 0	100
Best Signal Level (dBm) >=-80	67
Best Signal Level (dBm) >=-90	93.3
Best Signal Level (dBm) >=-100	100
Best Signal Level (dBm) >=-110	100
Best Signal Level (dBm) >=-120	100

Fig. 33. Reporte del Coverage by Signal Level

Podemos exporter al Google Earth las simulaciones anteriores para tener una mejor comprensión de los niveles de potencia en términos de distancia. Ver Fig. 34.

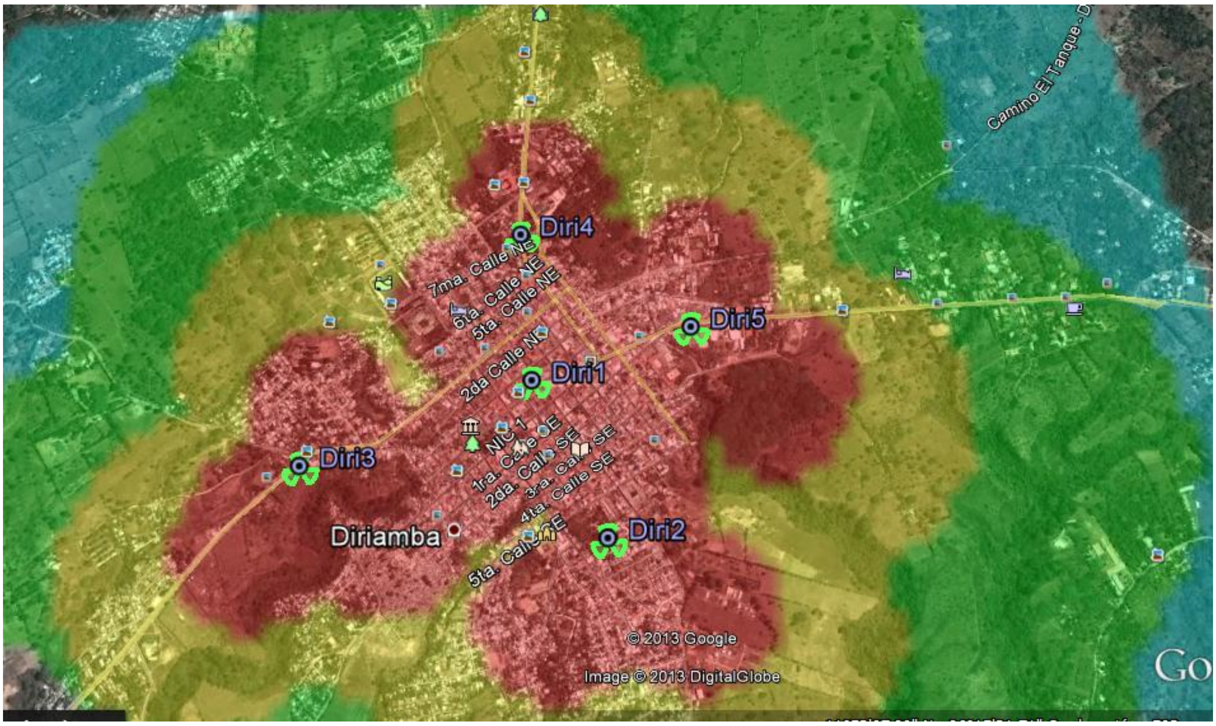


Fig. 34. Imagen en Google de la Cobertura en el Municipio de Diriamba

CONCLUSIONES

En este trabajo de investigación realizó un análisis de la tecnología 3G para la comprensión en lo que respecta a la propuesta de planeación por cobertura en el municipio de Diriamba.

Se realizó un estudio de los simuladores que se utilizan para la planeación de redes UMTS, dichos simuladores consisten en un conjunto de clases y funciones de programación.

La evolución de los sistemas de telecomunicaciones móviles es muy vertiginoso, por tal razón se requiere de herramientas que permitan bajar los costos de diseño y mejorar la calidad de los servicios que brindan las operadoras de telefonía celular.

Se determinó que los principales objetivos que se plantean cuando se planifica una red UMTS son: máxima cobertura, máxima capacidad, máxima capacidad de servicio (QoS), mínima interferencia y aminorar los costos. En este trabajo se planificó únicamente en términos de cobertura tanto por Transmitter como por Coverage by Signal con la utilización de la herramienta de planeación Atoll.

Se logró presentar una propuesta de configuración que podrá servir como referencia para estudios en términos de cobertura para la implementación de una red UMTS en otros objetivos comerciales. Se recomienda que se utilicen herramientas para la optimización de la red y realizar análisis de interferencia maximizar la capacidad de los Nodos B y mejorar el QoS.

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- http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/621.382-D542e/621.382-D542e-Capitulo%20III.pdf.

9 UMTS HSPA Networks

Atoll enables you to create and modify all aspects of a UMTS HSPA (HSDPA and HSUPA) network. Once you have created the network, **Atoll** offers many tools to let you verify the network. Based on the results of your tests, you can modify any of the parameters defining the network.

The process of planning and creating a UMTS HSPA network is outlined in "Designing a UMTS Network" on page 431. Creating the network of base stations is explained in "Planning and Optimising UMTS Base Stations" on page 432. Allocating neighbours and scrambling codes is also explained. In this section, you will also find information on how you can display information on base stations on the map and how you can use the tools in **Atoll** study base stations.

In "Studying Network Capacity" on page 511, using traffic maps to study network capacity is explained. Creating simulations using the traffic map information and analysing the results of simulations is also explained.

Using test mobile data paths to verify the network is explained in "Optimising and Verifying Network Capacity" on page 539. How to filter imported test mobile data paths, and how to use the data in coverage predictions is also explained.

9.1 Designing a UMTS Network

Figure 9.1 depicts the process of planning and creating a UMTS HSPA network.

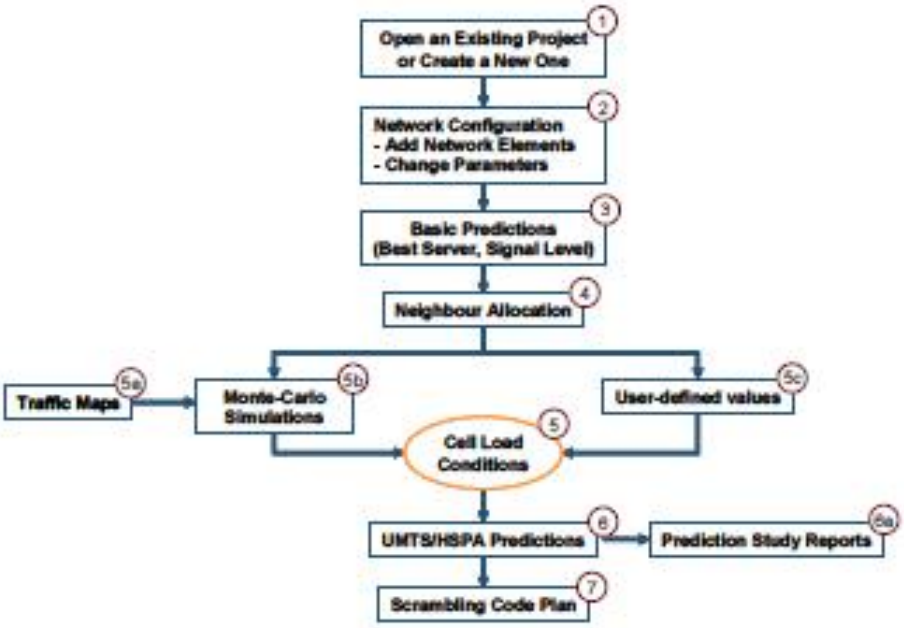

Figure 9.1: Planning a UMTS network - workflow

The steps involved in planning a UMTS HSPA network are described below. The numbers refer to Figure 9.1.

1. Open an existing radio-planning document or create a new one (1).
   - You can open an existing **Atoll** document by selecting **File > Open**.
   - Creating a new a new **Atoll** document is explained in Chapter 2: Starting an Atoll Project.
2. Configure the network by adding network elements and changing parameters (2).

   You can add and modify the following elements of base stations:

   - "Creating or Modifying a Site" on page 439
   - "Creating or Modifying a Transmitter" on page 439
   - "Creating or Modifying a Cell" on page 440

   You can also add base stations using a base station template (see "Placing a New Station Using a Station Template" on page 440).
3. Carry out basic coverage predictions (3)
   - "Making a Point Analysis to Study the Profile" on page 454
   - "Studying Signal Level Coverage" on page 455 and "Signal Level Coverage Predictions" on page 463

4. Allocate neighbours, automatically or individually (4).
   - "Planning Neighbours" on page 492.
5. Before making more advanced coverage predictions, you need to define cell load conditions (5).

   You can define cell load conditions in the following ways:

   - You can generate realistic cell load conditions by creating a simulation based on a traffic map (5a and 5b) (see "Studying Network Capacity" on page 511).
   - You can define them manually either on the Cells tab of each transmitter's **Properties** dialogue or in the Cells table (see "Creating or Modifying a Cell" on page 440) (5c).
6. Make UMTS-specific coverage predictions using the defined cell load conditions (6).
   - "UMTS-Specific Studies" on page 474
   - "HSDPA Coverage Prediction" on page 489
   - "HSUPA Coverage Prediction" on page 491.
7. Allocate scrambling codes (7).
   - "Planning Scrambling Codes" on page 503.

9.2 Planning and Optimising UMTS Base Stations

As described in Chapter 2: Starting an Atoll Project, you can start an **Atoll** document from a template, with no sites, or from a database with a set of sites. As you work on your **Atoll** document, you will still need to create sites and modify existing ones.

In **Atoll**, a site is defined as a geographical point where one or more transmitters are located. Once you have created a site, you can add transmitters. In **Atoll**, a transmitter is defined as the antenna and any other additional equipment, such as the TMA, feeder cables, etc. In a UMTS project, you must also add cells to each transmitter. A cell refers to the characteristics of a carrier on a transmitter.

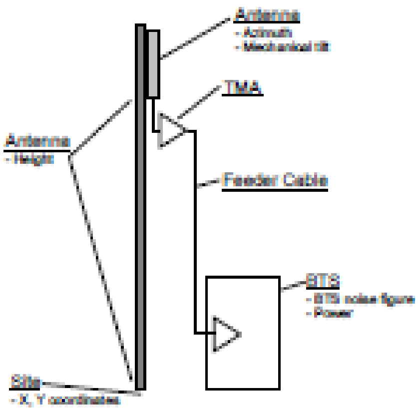

Figure 9.2: A transmitter

Atoll lets you create one site, transmitter, or cell at a time, or create several at once by creating a station template. Using a station template, you can create one or more base stations at the same time. In **Atoll**, a *base station* refers to a site with its transmitters, antennas, equipment, and cells.

Atoll allows you to make a variety of coverage predictions, such as signal level or transmitter coverage predictions. The results of calculated coverage predictions can be displayed on the map, compared, or studied.

Atoll enables you to model network traffic by allowing you to create services, users, user profiles, environments, and terminals. This data can be then used to make quality studies, such as effective service area, noise, or handover status predictions, on the network.

In this section, the following are explained:

- "Creating a UMTS Base Station" on page 433
- "Creating a Group of Base Stations" on page 447
- "Modifying Sites and Transmitters Directly on the Map" on page 447
- "Display Tips for Base Stations" on page 447
- "Creating a Dual-Band UMTS Network" on page 448
- "Creating a Repeater" on page 448
- "Creating a Remote Antenna" on page 451

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- "Setting the Working Area of an Atoll Document" on page 453
- "Studying a Single Base Station" on page 453
- "Studying Base Stations" on page 457
- "Planning Neighbours" on page 492
- "Planning Scrambling Codes" on page 503.

9.2.1 Creating a UMTS Base Station

When you create a UMTS site, you create only the geographical point; you must add the transmitters and cells afterwards. The site, with the transmitters, antennas, equipment, and cells is called a *base station*.

In this section, each element of a base station is described. If you want to add a new base station, see "Placing a New Station Using a Station Template" on page 440. If you want to create or modify one of the elements of a base station, see "Creating or Modifying a Base Station Element" on page 439. If you need to create a large number of base stations, **Atoll** allows you to import them from another **Atoll** document or from an external source. For information, see "Creating a Group of Base Stations" on page 447.

This section explains the various parts of the base station process:

- "Definition of a Base Station" on page 433
- "Creating or Modifying a Base Station Element" on page 439
- "Placing a New Station Using a Station Template" on page 440
- "Managing Station Templates" on page 442
- "Duplicating an Existing Base Station" on page 446.

9.2.1.1 Definition of a Base Station

A base station consists of the site, one or more transmitters, various pieces of equipment, and radio settings such as, for example, cells. You will usually create a new base station using a station template, as described in "Placing a New Station Using a Station Template" on page 440. This section describes the following elements of a base station and their parameters:

- "Site Description" on page 433
- "Transmitter Description" on page 434
- "Cell Definition" on page 436.

9.2.1.1.1 Site Description

The parameters of a site can be found in the site's **Properties** dialogue. The **Properties** dialogue has two tabs:

- The General tab (see Figure 9.3):

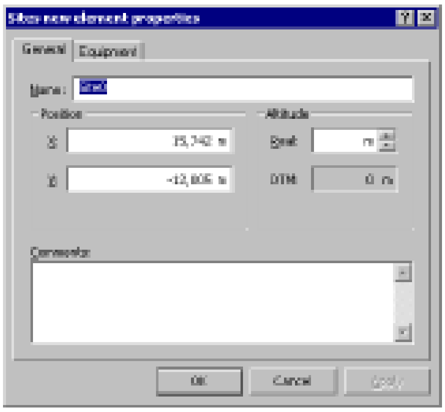


Figure 9.3: New Site dialogue

- **Name: Atoll** automatically enters a default name for each new site. You can modify the default name here. If you want to change the default name that **Atoll** gives to new sites, see the *Administrator Manual*.
- **Position:** By default, **Atoll** places the new site at the centre of the map window. You can modify the location of the site here.

> **Tip:** *While this method allows you to place a site with precision, you can also place sites using the mouse and then position them precisely with this dialogue afterwards. For information on placing sites using the mouse, see "Moving a Site Using the Mouse" on page 31.*

- **Altitude:** The altitude, as defined by the DTM for the location specified under **Position**, is given here. You can specify the actual altitude under **Real**, if you wish. If an altitude is specified here, **Atoll** will use this value for calculations.

- The Transmitter tab (see Figure 9.4):

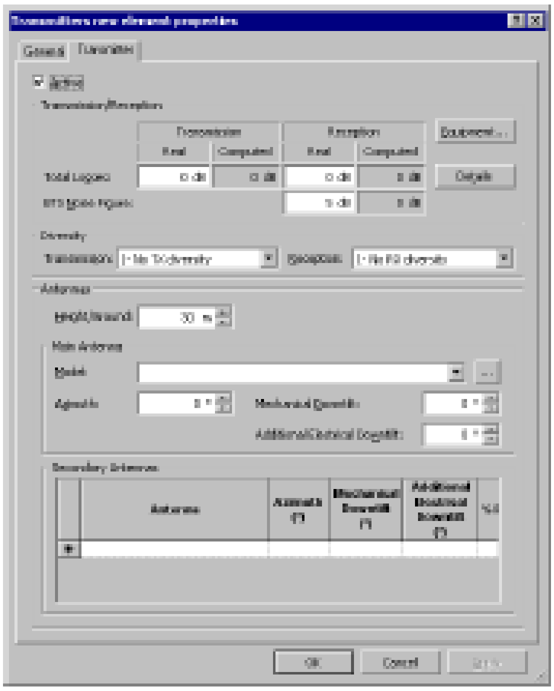


Figure 9.4: Transmitter dialogue - Transmitter tab

- **Active:** If this transmitter is to be active, you must select the **Active** check box. Active transmitters are displayed in red in the **Transmitters** folder of the Data tab.

Note:	Only active transmitters are taken into consideration during calculations.

- **Transmission/Reception:** Under **Transmission/Reception**, you can see the total losses and the noise figure of the transmitter. **Atoll** calculates losses and noise according to the characteristics of the equipment assigned to the transmitter. Equipment can be assigned by using the **Equipment Specifications** dialogue which appears when you click the **Equipment** button.
- On the **Equipment Specifications** dialogue (see Figure 9.5), the equipment you select and the gains and losses you define are used to initialise total transmitter UL and DL losses:
  - **TMA:** You can select a tower-mounted amplifier (TMA) from the list. You can click the **Browse** button (...) to access the properties of the TMA. For information on creating a TMA, see "Defining TMA Equipment" on page 147.
  - **Feeder:** You can select a feeder cable from the list. You can click the **Browse** button (...) to access the properties of the feeder. For information on creating a feeder cable, see "Defining Feeder Cables" on page 147.
  - **BTS:** You can select a base transceiver station (BTS) equipment from the **BTS** list. You can click the **Browse** button (...) to access the properties of the BTS. For information on creating a BTS, see "Defining BTS Equipment" on page 148.
  - **Feeder Length:** You can enter the feeder length at transmission and reception.
  - **Miscellaneous Losses:** You can enter miscellaneous losses at transmission and reception. The value you enter must be positive.
  - **Receiver Antenna Diversity Gain:** You can enter a receiver antenna diversity gain. The value you enter must be positive.

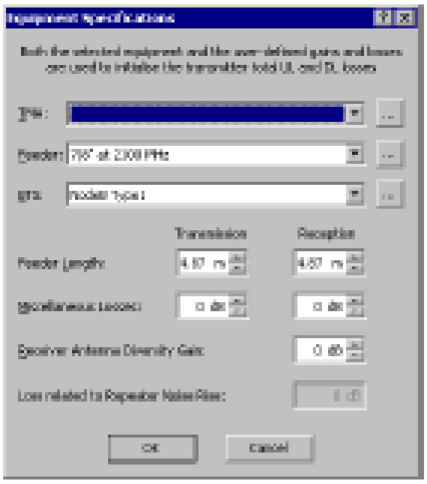


Figure 9.5: The Equipment Specifications dialogue

Note:	Any loss related to the noise due to a transmitter's repeater is included in the calculated losses. **Atoll** always considers the values in the **Real** boxes in prediction studies even if they are different from the values in the **Computed** boxes. The information in the real **BTS Noise Figure** reception box is calculated from the information you entered in the **Equipment Specifications** dialogue. You can modify the real **Total Losses** at transmission and reception and the real **BTS Noise Figure** at reception if you wish. Any value you enter must be positive.

- **Antennas:**
  - **Height/Ground:** The **Height/Ground** box gives the height of the antenna above the ground. This is added to the altitude of the site as given by the DTM. If the transmitter is situated on a building, the height entered must include the height of building.
  - **Main Antenna:** Under **Main Antenna**, the type of antenna is visible in the **Model** list. You can click the **Browse** button ( ) to access the properties of the antenna. The other fields, **Azimuth**, **Mechanical Downtilt**, and **Additional Electrical Downtilt**, display additional antenna parameters.
  - Under **Diversity**, you can select the number of transmission and reception antenna ports used for MIMO (**No. of ports**). MIMO systems are supported by some HSDPA bearers (improvements introduced by the release 7 of the 3GPP UTRA specifications, referred to as HSPA+). For more information on how the number of antenna ports are used, see "Multiple Input Multiple Output Systems" on page 556.

    R99 bearers only support transmit and receive diversities. You can define the transmit diversity method from the **Transmission** list when more than one transmission antenna port are available. The receive diversity method depends on the number of reception antenna ports selected (2RX for two reception antenna ports and 4RX for four reception antenna ports).
  - Under **Secondary Antennas**, you can select one or more secondary antennas in the **Antenna** column and enter their **Azimuth**, **Mechanical Downtilt**, **Additional Electrical Downtilt**, and **% Power**, which is the percentage of power reserved for this particular antenna. For example, for a transmitter with one secondary antenna, if you reserve 40% of the total power for the secondary antenna, 60% is available for the main antenna.

    For information on working with data tables, see "Working with Data Tables" on page 50.

9.2.1.1.3 Cell Definition

In **Atoll**, a cell is defined as a carrier, with all its characteristics, on a transmitter; the cell is the mechanism by which you can configure a UMTS multi-carrier network. In other words, a transmitter has one cell for every carrier.

When you create a transmitter, **Atoll** reminds you to create at least one cell for the transmitter. The following explains the parameters of a UMTS cell, including the parameters for HSDPA and HSUPA functionality. As you create a cell, **Atoll** calculates appropriate values for some fields based on the information you have entered. You can, if you wish, modify these values.

The properties of a UMTS cell are found on Cells tab of the **Properties** dialogue of the transmitter to which it is assigned.

The Cells tab has the following options:

- **Inter-Carrier Power Sharing:** You can enable power sharing between cells by selecting the **Inter-Carrier Power Sharing** check box under **HSDPA** and entering a value in the **Maximum Shared Power** box. In order for **Inter-Carrier Power Sharing** to be available, you must have at least one HSDPA carrier with dynamic power allocation.

  Inter-Carrier Power Sharing enables the network to dynamically allocate available power from R99-only and HSDPA carriers among HSDPA carriers.

When you select **Inter-Carrier Power Sharing** and you define a maximum shared power, the **Max Power** of each cell is used to determine the percentage of the transmitter power that the cell cannot exceed.

The most common scenario is where you have R99-only cells that are not using 100% of their power and can share it with an HSDPA carrier. To use power sharing efficiently, you should set the **Max Power** of the HSDPA cells to the same value as the **Maximum Shared Power**. For example, if the **Maximum Shared Power** is defined as 43 dBm, the **Max Power** of all HSDPA cells should be set to 43 dBm in order to be able to use 100% of the available power. In this case, all of an R99 cell's unused power can be allocated to the HSDPA cell.

- **Name:** By default, **Atoll** names the cell after its transmitter, adding the carrier number in parentheses. If you change transmitter name or carrier, **Atoll** does not update the cell name. You can enter a name for the cell, but for the sake of consistency, it is better to let **Atoll** assign a name. If you want to change the way **Atoll** names cells, see the *Administrators Manual*.
- **ID:** You can enter an ID for the cell. This is a user-definable network-level parameter for cell identification.
- **Carrier:** The number of the carrier.
- **Active:** If this cell is to be active, you must select the **Active** check box.
- **Max Power (dBm):** The maximum available downlink power for the cell.
- **Pilot Power (dBm):** The pilot power.
- **SCH power (dBm):** The average power of both the synchronisation channels (P-SCH and S-SCH).

Note:	The SCH power is only transmitted 1/10 of the time. Consequently, the value entered for the SCH power should only be 1/10 of its value when transmitted, in order to respect its actual interference on other channels.

- **Other CCH power (dBm):** The power of other common channels (P-CCPCH, S-CCPCH, AICH).
- **AS Threshold (dB):** The active set threshold. It is the Ec/I0 margin in comparison with the Ec/I0 of the best server. It is used to determine which cells, apart from the best server, will be part of the active set.
- **DL Peak Rate per User (kbps):** The downlink peak rate per user in kbps. The DL peak rate per user is the maximum connection rate in the downlink for a user. The DL and UL peak rates are taken into account during power control simulation.
- **UL Peak Rate per User (kbps):** The uplink peak rate per user in kbps. The UL peak rate per user is the maximum connection rate in the uplink for a user. The DL and UL peak rates are taken into account during power control simulation.
- **Max DL Load (% Pmax):** The percentage of the maximum downlink power (set in **Max Power**) not to be exceeded. This limit will be taken into account during the simulation if the option **DL Load** is selected. If the **DL load** option is not selected during a simulation, this value is not taken into consideration.
- **Max UL Load Factor (%):** The maximum uplink load factor not to be exceeded. This limit can be taken into account during the simulation.
- **Total Power (dBm or %):** The total transmitted power on downlink is the total power necessary to serve R99 and HSDPA users. This value can be a simulation result or can be entered by the user.

Note:	By default, the total power is set as absolute value. You can set this value as a percentage of the maximum power of the cell by right-clicking the **Transmitters** folder on the Data tab of the **Explorer** window and selecting **Properties** from the context menu. Then, on the Global Parameters tab of the **Properties** dialogue, under **DL Load**, you can select **% Pmax**. The total power value is automatically converted and set as a percentage of the maximum power.

- **UL Load Factor (%):** The uplink cell load factor. This factor corresponds to the ratio between the uplink total interference and the uplink total noise. This value can be a simulation result or can be entered by the user.
- **UL Reuse Factor:** The uplink reuse factor is determined from uplink intra and extra-cell interference (signals received by the transmitter respectively from intra and extra-cell terminals). This is the ratio between the total uplink interference and the intra-cell interference. This value can be a simulation result or can be entered by the user.
- **Scrambling Code Domain:** The scrambling code domain to which the allocated scrambling code belongs. This and the scrambling code reuse distance are used by the scrambling code planning algorithm.
- **SC Reuse Distance:** The scrambling code reuse distance. This and the scrambling code domain are used by the scrambling code planning algorithm.
- **Primary Scrambling Code:** The primary scrambling code.
- **Comments:** If desired, you can enter any comments in this field.
- **Max Number of Intra-carrier Neighbours:** The maximum number of intra-carrier neighbours for this cell. This value is used by the intra-carrier neighbour allocation algorithm.
- **Max Number of Inter-carrier Neighbours:** The maximum number of inter-carrier neighbours for this cell. This value is used by the inter-carrier neighbour allocation algorithm.
- **Max Number of Inter-technology Neighbours:** The maximum number of inter-technology neighbours for this cell. This value is used by the inter-technology neighbour allocation algorithm.
- **Neighbours:** You can access a dialogue in which you can set both intra-technology (intra-carrier and inter-carrier) and inter-technology neighbours by clicking the **Browse** button ( ). For information on defining neighbours, see "Planning Neighbours" on page 492.

> **Tip:** *The* ***Browse*** *button ( ) might not be visible in the* ***Neighbours*** *box if this is a new cell. You can make the* ***Browse*** *button appear by clicking* ***Apply****.*

- **HSPA Support**: The HSPA functionality supported by the cell. You can choose between **None** (i.e. R99 only), **HSDPA**, **HSPA** (i.e HSDPA and HSUPA), **HSPA+ with transmit diversity** or **HSPA+ with spatial multiplexing**.

  When HSDPA functionality is supported, the following fields are available:

  - **HSDPA Dynamic Power Allocation:** If you are modelling dynamic power allocation, the **HSDPA Dynamic Power Allocation** should be checked. During a simulation, **Atoll** first allocates power to R99 users and then dynamically allocates the remaining power of the cell to the HS-PDSCH and HS-SCCH of HSDPA users. At the end of the simulation, you can commit the calculated HSDPA power and total power values to each cell.

> **Note:** In the context of dynamic power allocation, the total power equals the maximum power minus the power headroom.

  - **Available HSDPA Power (dBm):** When you are modelling static power allocation, the **HSDPA Dynamic Power Allocation** check box is cleared and the available HSDPA power is entered in this box. This is the power available for the HS-PDSCH and HS-SCCH of HSDPA users.
  - **Power Headroom (dB):** The power headroom is a reserve of power that **Atoll** keeps for Dedicated Physical Channels (DPCH) in case of fast fading. During simulation, HSDPA users will not be connected if the cell power remaining after serving R99 users is less than the power headroom value.
  - **HS-SCCH Dynamic Power Allocation**: If you are modelling dynamic power allocation the **HS-SCCH Dynamic Power Allocation** check box should be checked and a value should be entered in **HS-SCCH Power (dBm)**. During power control, **Atoll** will control HS-SCCH power in order to meet the minimum quality threshold (as defined for each mobility type). The value entered in **HS-SCCH Power (dBm)** is the maximum power available for each HS-SCCH channel. The calculated power for each HSDPA user during the simulation cannot exceed this maximum value.
  - **HS-SCCH Power (dBm)**: The value for each HS-SCCH channel will be used if you are modelling dynamic power allocation. If you have selected the **HS-SCCH Dynamic Power Allocation** check box and modelling dynamic power allocation, the value entered here represents a maximum for each HSDPA user. If you have not selected the **HS-SCCH Dynamic Power Allocation** check box and are modelling static power allocation, the value entered here represents the actual HS-SCCH power per HS-SCCH channel.
  - **Number of HS-SCCH Channels:** The maximum number of HS-SCCH channels for this cell. Each HSDPA user consumes one HS-SCCH channel. Therefore, at any given time (over a time transmission interval), the number of HSDPA users cannot exceed the number of HS-SCCH channels per cell.
  - **Min. Number of HS-PDSCH Codes:** The minimum number of OVSF codes available for HS-PDSCH channels. This value will be taken into account during simulations in order to find a suitable bearer.
  - **Max Number of HS-PDSCH codes:** The maximum number of OVSF codes available for HS-PDSCH channels. This value will be taken into account during simulations and coverage predictions in order to find a suitable bearer.
  - **Max Number of HSDPA Users:** The maximum number of HSDPA bearer users (HSDPA and HSUPA users) that this cell can support at any given time.
  - **Number of HSDPA Users:** The number of HSDPA bearer users (HSDPA and HSUPA users) is an average and can be used for certain coverage predictions. You can enter this value yourself, or have the value calculated by **Atoll** using a simulation.
  - **HSDPA Scheduler Algorithm:** The scheduling technique that will be used to rank the HSDPA users to be served:
    - **Max C/I:** "n" HSDPA users (where "n" corresponds to the maximum number of HSDPA users defined) are scheduled in the same order as in the simulation (i.e., in random order). Then, they are sorted in descending order by the channel quality indicator (CQI).
    - **Round Robin:** HSDPA users are scheduled in the same order as in the simulation (i.e., in random order).
    - **Proportional Fair:** "n" HSDPA users (where "n" corresponds to the maximum number of HSDPA users defined) are scheduled in the same order as in the simulation (i.e., in random order). Then, they are sorted in descending order according to a random parameter which corresponds to a combination of the user rank in the simulation and the channel quality indicator (CQI).

> **Note:** The random parameter is calculated by giving both the user simulation rank and the CQI a weight of 50%. You can change the default weights by setting the appropriate options in the atoll.ini file. For more information, see the *Administrator Manual*.

  When HSUPA functionality is supported, the following fields are also available:

  - **DL HSUPA Power:** The power (in dBm) allocated to HSUPA DL channels (E-AGCH, E-RGCH, and E-HICH). This value must be entered by the user.
  - **Max Number of HSUPA Users:** The maximum number of HSUPA users that this cell can support at any given time.
  - **UL Load Factor Due to HSUPA (%):** The uplink cell load contribution due to HSUPA. This value can be a simulation result or can be entered by the user.
  - **Number of HSUPA Users:** The number of HSUPA users is an average and can be used for certain coverage predictions. This value can be a simulation result or can be entered by the user.

- **Comments:** You can enter comments in this field if you wish.

- The Equipment tab:
  - **Max Number of Uplink Channel Elements:** The maximum number of physical radio resources for the current site in the uplink. By default **Atoll** enters the maximum possible (256).
  - **Max Number of Downlink Channel Elements:** The maximum number of physical radio resources for the current site in the downlink. By default **Atoll** enters the maximum possible (256).
  - **Max Iub Uplink Backhaul Throughput:** The maximum Iub backhaul throughput for the current site in the uplink.
  - **Max Iub Downlink Backhaul Throughput:** The maximum Iub backhaul throughput for the current site in the downlink.
  - **Equipment:** You can select equipment from the list. To create new site equipment, see "Creating Site Equipment" on page 552.

    If no equipment is assigned to the site, **Atoll** considers the following default values:

    - Rake efficiency factor = 1
    - MUD factor = 0
    - Carrier selection = UL minimum noise
    - Overhead CEs downlink and uplink = 0
    - The option **AS Restricted to Neighbours** is not selected, and **Atoll** uses one channel element on the uplink or downlink for any service during power control simulation.

9.2.1.1.2 Transmitter Description

The parameters of a transmitter can be found in the transmitter's **Properties** dialogue. When you create a transmitter, the **Properties** dialogue has two tabs: the General tab and the Transmitter tab. Once you have created a transmitter, its **Properties** dialogue has three additional tabs: the Cells tab (see "Cell Definition" on page 436), the Propagation tab (see Chapter 5: Managing Calculations in Atoll), and the Display tab (see "Display Properties of Objects" on page 33).

- The General tab:
  - **Name:** By default, **Atoll** names the transmitter after the site it is on, adding an underscore and a number. You can enter a name for the transmitter, but for the sake of consistency, it is better to let **Atoll** assign a name. If you want to change the way **Atoll** names transmitters, see the *Administrators Manual*.
  - **Site:** You can select the **Site** on which the transmitter will be located. Once you have selected the site, you can click the **Browse** button (...) to access the properties of the site on which the transmitter will be located. For information on the site **Properties** dialogue, see "Site Description" on page 433. You can click the **New** button to create a new site on which the transmitter will be located.
  - **Frequency Band:** You can select a **Frequency Band** for the transmitter. Once you have selected the frequency band, you can click the **Browse** button (...) to access the properties of the band. For information on the frequency band **Properties** dialogue, see "Defining Frequency Bands" on page 549.
  - **Position relative to the site:** You can modify the **Position relative to the site**, if you wish.

Note:	By default, the SCH power, the CCH power, the HS-SCCH power and the HSUPA power are set as absolute values. You can set these values as relative to the pilot power by right-clicking the **Transmitters** folder on the Data tab of the **Explorer** window and selecting **Properties** from the context menu. Then, on the Global Parameters tab of the **Properties** dialogue, under **DL Powers**, you can select **Relative to Pilot**. The SCH power, the CCH power, the HS-SCCH power and the HSUPA power values are automatically converted and set as relative to the pilot power.

- **MBMS:** You can access a dialogue in which you can set MBMS channel powers and channel data rates by clicking the **Browse** button ( ). This option is only available if the optional MBMS feature has been activated. Activating this optional feature requires data structure modifications (for more information, see the *Administrator Manual*).

  If an MBMS SCCPCH is not used, you should leave the field corresponding to it's transmission power empty. The MBMS channel powers are used to calculate the optional MBMS service area Eb/Nt coverage prediction, and are taken into account in other calculations in the same way as the other common control channel power, i.e., for the calculation of interference.

Tip:	*The **Browse** button ( ) might not be visible in the **MBMS** box if this is a new cell. You can make the **Browse** button appear by clicking **Apply**.*

9.2.1.2 Creating or Modifying a Base Station Element

A base station consists of the site, one or more transmitters, various pieces of equipment, and radio settings such as, for example, cells.

This section describes how to create or modify the following elements of a base station:

- "Creating or Modifying a Site" on page 439
- "Creating or Modifying a Transmitter" on page 439
- "Creating or Modifying a Cell" on page 440.

9.2.1.2.1 Creating or Modifying a Site

You can modify an existing site or you can create a new site. You can access the properties of a site, described in "Site Description" on page 433, through the site's **Properties** dialogue. How you access the **Properties** dialogue depends on whether you are creating a new site or modifying an existing site.

To create or modify a site:

1. If you are creating a new site:
   a. Click the Data tab in the **Explorer** window.
   b. Right-click the **Sites** folder. The context menu appears.
   c. Select **New** from the context menu. The **Sites New Element Properties** dialogue appears (see Figure 9.3 on page 433).
2. If you are modifying the properties of an existing site:
   a. Click the Data tab in the **Explorer** window.
   b. Click the **Expand** button (⊞) to expand the **Sites** folder.
   c. Right-click the site you want to modify. The context menu appears.
   d. Select **Properties** from the context menu. The site's **Properties** dialogue appears.
3. Modify the parameters described in "Site Description" on page 433.
4. Click **OK**.

Tip:	*If you are creating several sites at the same time, or modifying several existing sites, you can do it quickly by editing or pasting the data directly in the **Sites** table. You can open the **Sites** table by right-clicking the **Sites** folder on the Data tab of the **Explorer** window and selecting **Open Table** from the context menu. For information on copying and pasting data, see "Copying and Pasting in Tables" on page 56.*

9.2.1.2.2 Creating or Modifying a Transmitter

You can modify an existing transmitter or you can create a new transmitter. You can access the properties of a transmitter, described in "Transmitter Description" on page 434, through the transmitter's **Properties** dialogue. How you access the **Properties** dialogue depends on whether you are creating a new transmitter or modifying an existing transmitter.

To create or modify a transmitter:

1. If you are creating a new transmitter:
   a. Click the Data tab in the **Explorer** window.
   b. Right-click the **Transmitters** folder. The context menu appears.
   c. Select **New** from the context menu. The **Transmitters New Element Properties** dialogue appears (see Figure 9.4).
2. If you are modifying the properties of an existing transmitter:
   a. Click the Data tab in the **Explorer** window.
   b. Click the **Expand** button (⊞) to expand the **Transmitters** folder.
   c. Right-click the transmitter you want to modify. The context menu appears.
   d. Select **Properties** from the context menu. The transmitter's **Properties** dialogue appears.
3. Modify the parameters described in "Transmitter Description" on page 434.
4. Click **OK**. If you are creating a new transmitter, **Atoll** reminds you to create a cell. For information on creating a cell, see "Creating or Modifying a Cell" on page 440.

> ***Tips:***
> - *If you are creating several transmitters at the same time, or modifying several existing transmitters, you can do it more quickly by editing or pasting the data directly in the **Transmitters** table. You can open the **Transmitters** table by right-clicking the **Transmitters** folder on the Data tab of the **Explorer** window and selecting **Open Table** from the context menu. For information on copying and pasting data, see "Copying and Pasting in Tables" on page 56.*
> - *If you want to add a transmitter to an existing site on the map, you can add the transmitter by right-clicking the site and selecting **New Transmitter** from the context menu.*

9.2.1.2.3 Creating or Modifying a Cell

You can modify an existing cell or you can create a new cell. You can access the properties of a cell, described in "Cell Definition" on page 436, through the **Properties** dialogue of the transmitter where the cell is located.

To create or modify a cell:

1. Click the Data tab of the **Explorer** window.
2. Click the **Expand** button (⊞) to expand the **Transmitters** folder.
3. Right-click the transmitter on which you want to create a cell or whose cell you want to modify. The context menu appears.
4. Select **Properties** from the context menu. The transmitter's **Properties** dialogue appears.
5. Select the Cells tab.
6. Modify the parameters described in "Cell Definition" on page 436.
7. Click **OK**.

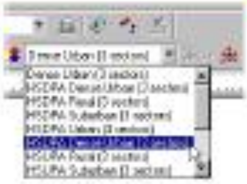
> ***Tips:***
> - *If you are creating or modifying several cells at the same time, you can do it more quickly by editing the data directly in the **Cells** table. You can open the **Cells** table by right-clicking the **Transmitters** folder on the Data tab of the **Explorer** window and selecting **Cells > Open Table** from the context menu. You can either edit the data in the table, paste data into the table (see "Copying and Pasting in Tables" on page 56), or import data into the table (see "Importing Tables from Text Files" on page 59).*
> - *If you want to add a cell to an existing transmitter on the map, you can add the cell by right-clicking the transmitter and selecting **New Cell** from the context menu.*

9.2.1.3 Placing a New Station Using a Station Template

In **Atoll**, a station is defined as a site with one or more transmitters sharing the same properties. With **Atoll**, you can create a network by placing stations based on station templates. This allows you to build your network quickly with consistent parameters, instead of building the network by first creating the site, then the transmitters, and finally by adding the cells.

To place a new station using a station template:

1. In the **Radio** toolbar, select a template from the list.



2. Click the **New Transmitter or Station** button ( ) in the **Radio** toolbar.

3. In the map window, move the pointer over the map to where you would like to place the new station. The exact coordinates of the pointer's current location are visible in the **Status** bar.

4. Click to place the station.

> ***Tips:***
> - *To place the station more accurately, you can zoom in on the map before you click the New Station button. For information on using the zooming tools, see "Changing the Map Scale" on page 38.*
> - *If you let the pointer rest over the station you have placed, **Atoll** displays its tip text with its exact coordinates, allowing you to verify that the location is correct.*

You can also place a series of stations using a **Atoll** template. You do this by defining an area on the map where you want to place the stations. **Atoll** calculates the placement of each station according to the defined hexagonal cell radius in the station template. For information on defining the cell radius, see "Creating or Modifying a Station Template" on page 442.

To place a series of stations within a defined area:

1. In the **Radio** toolbar, select a template from the list.
2. Click the **Hexagonal Design** button ( ), to the left of the template list. A hexagonal design is a group of stations created from the same station template.

> **Note:** If the **Hexagonal Design** button is not available ( ), the hexagonal cell radius for this template is not defined. For information on defining the cell radius, see "Creating or Modifying a Station Template" on page 442.

3. Draw a zone delimiting the area where you want to place the series of stations:
   a. Click once on the map to start drawing the zone.
   b. Click once on the map to define each point on the map where the border of the zone changes direction.
   c. Click twice to finish drawing and close the zone.

   Atoll fills the delimited zone with new stations and their hexagonal shapes. Station objects such as sites and transmitters are also created and placed into their respective folders.

You can work with the sites and transmitters in these stations as you work with any station object, adding, for example, another antenna to a transmitter.

Placing a Station on an Existing Site

When you place a new station using a station template as explained in "Placing a New Station Using a Station Template" on page 440, the site is created at the same time as the station. However, you can also place a new station on an existing site.

To place a station on an existing site:

1. On the Data tab, clear the display check box beside the **Hexagonal Design** folder.
2. In the **Radio** toolbar, select a template from the list.
3. Click the **New Station** button ( ) in the **Radio** toolbar.
4. Move the pointer to the site on the map. When the frame appears around the site, indicating it is selected, click to place the station.

9.2.1.4 Managing Station Templates

Atoll comes with UMTS station templates, but you can also create and modify station templates. The tools for working with station templates can be found on the **Radio** toolbar (see Figure 9.6).

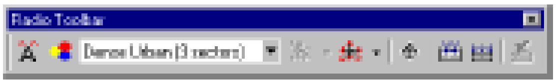


Figure 9.6: The Radio toolbar

9.2.1.4.1 Creating or Modifying a Station Template

When you create a station template, **Atoll** bases it on the station template selected in the **Station Template Properties** dialogue. The new station template has the same parameters as the one it is based on. Therefore, by selecting the existing station template that most closely resembles the station template you want to create, you can create a new template by only modifying the parameters that differ.

As well, you can modify the properties of any station template.

To create or modify a station template:

1. In the **Radio** toolbar, click the arrow to the right of the list.
2. Select **Manage Templates** from the list. The **Station Template Properties** dialogue appears.
3. You can now create a new station template or modify an existing one:
   - **To create a new station template:** Under **Station Templates**, select the station template that most closely resembles the station template you want to create and click **Add**. The **Properties** dialogue appears.
   - **To modify an existing station template:** Under **Station Templates**, select the station template whose properties you want to modify and click **Properties**. The **Properties** dialogue appears.
4. Click the General tab of the **Properties** dialogue. On this tab (see Figure 9.7), you can modify the following: the **Name** of the station template, the number of **Sectors**, each with a transmitter, and the **Hexagon Radius**, i.e., the theoretical radius of the hexagonal area covered by each sector.

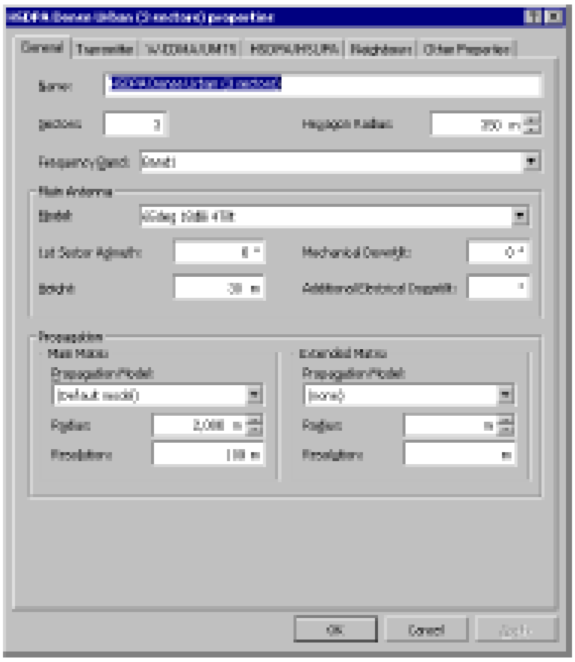


Figure 9.7: Station Template Properties dialogue – General tab

   - Under **Main Antenna**, you can modify the following: the antenna **Model**, **1st Sector Azimuth**, from which the azimuth of the other sectors are offset to offer complete coverage of the area, the **Height** of the antenna from the ground (i.e., the height over the DTM; if the transmitter is situated on a building, the height entered must include the height of building), the **Mechanical Downtilt**, and the **Additional Electrical Downtilt**.
   - Under **Propagation**, you can modify the following: the **Propagation Model**, **Radius**, and **Resolution** for both the **Main Matrix** and the **Extended Matrix**. For information on propagation models, see Chapter 5: Managing Calculations in Atoll.

5. Click the Transmitter tab. On this tab (see Figure 9.8), if the **Active** check box is selected, you can modify the following:

- Under **Transmission/Reception**, you can click the **Equipment** button to open the **Equipment Specifications** dialogue and modify the tower-mounted amplifier (TMA), feeder cables, or base transceiver station (BTS). For information on the **Equipment Specifications** dialogue, see "Transmitter Description" on page 434.
- The information in the real **Total Losses** in transmission and reception boxes is calculated from the information you entered in the **Equipment Specifications** dialogue (see Figure 9.5 on page 436). Any loss related to the noise due to a transmitter's repeater is included in the calculated losses. **Atoll** always considers the values in the **Real** boxes in prediction studies even if they are different from the values in the **Computed** boxes. You can modify the real **Total Losses** at transmission and reception if you wish. Any value you enter must be positive.
- The information in the real **BTS Noise Figure** reception box is calculated from the information you entered in the **Equipment Specifications** dialogue. You can modify the real **BTS Noise Figure** at reception if you wish. Any value you enter must be positive.
- Under **Diversity**, you can select the number of transmission and reception antenna ports used for MIMO (**No. of ports**). MIMO systems are supported by some HSDPA bearers (improvements introduced by the release 7 of the 3GPP UTRA specifications, referred to as HSPA+). For more information on how the number of antenna ports are used, see "Multiple Input Multiple Output Systems" on page 556.

  R99 bearers only support transmit and receive diversities. You can define the transmit diversity method from the **Transmission** list when more than one transmission antenna port are available. The receive diversity method depends on the number of reception antenna ports selected (2RX for two reception antenna ports and 4RX for four reception antenna ports).

Figure 9.8: Station Template Properties dialogue – Transmitter tab

6. Click the W-CDMA/UMTS tab. In this tab (see Figure 9.9), you modify the **Carriers** (each corresponding to a cell) that this station supports. For information on carriers and cells, see "Cell Definition" on page 436.
   - You can select the **Carriers** for this template.
   - Under **Power**, you can select the **Power Shared Between Cells** check box. As well, you can modify the **Pilot**, the **SCH**, the **Other CCH** powers, and the **AS Threshold**.
   - Under **Simulation Constraints**, you can modify the **Max Power**, the **Max DL Load** (defined as a percentage of the maximum power), the **DL Peak Rate/User**, the **Max UL Load Factor**, and the **UL Peak Rate/User**.
   - Under **Load Conditions**, you can modify the **Total Transmitted Power**, the **UL Load Factor**, and the **UL Reuse Factor**.
   - You can also modify the **Number of Uplink** and **Downlink Channel Elements**, the **Max Iub Uplink** and **Downlink Backhaul Throughputs** and select the **Equipment**.

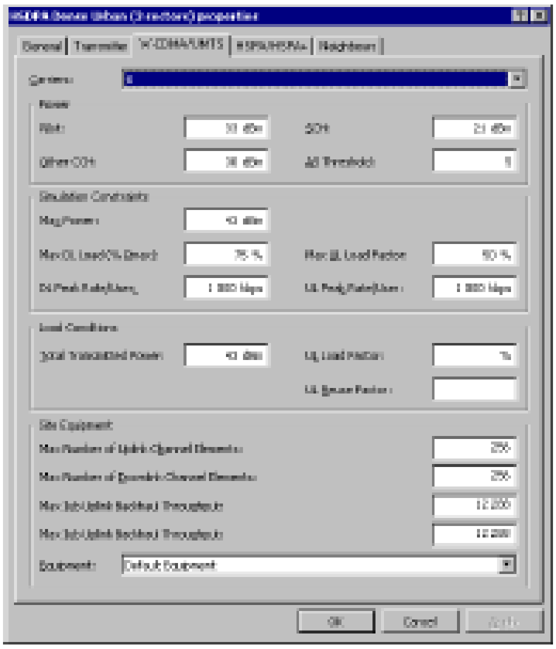


Figure 9.9: Station Template Properties dialogue – W-CDMA/UMTS tab

7. Click the HSPA/HSPA+ tab.

   On this tab (see Figure 9.10), you can define the HSPA functionality supported by the cells. You can choose between **None** (i.e. R99 only), **HSDPA**, **HSPA** (i.e HSDPA and HSUPA), **HSPA+** with **transmit diversity** or **HSPA+** with **spatial multiplexing**. When HSDPA functionality is supported, you can modify the following under **HSDPA** (for more information on the fields, see "Cell Definition" on page 436):

   - You can select the **Allocation Strategy** (**Static** or **Dynamic**). If you select **Static** as the **Allocation Strategy**, you can enter the **HSDPA Power**. If you select **Dynamic** as the **Allocation Strategy**, you select the **Inter-Carrier Power Sharing** option and enter the **Max. Shared Power**.
   - Under **HS-PDSCH**, you can modify the **Min.** and **Max Number of Codes** and the **Power Headroom**.
   - Under **HS-SCCH**, you can select the **Allocation Strategy** (**Static** or **Dynamic**) and the **Number of Channels**. If you select **Static** as the **Allocation Strategy**, you must enter the value of the **HS-SCCH/Pilot Offset**.
   - Under **Scheduler**, you can modify the **Algorithm**, the **Max Number of Users**, and the **Number of Users**.

   Under **HSUPA**, if HSUPA functionality is supported, you can modify the following (for more information on the fields, see "Cell Definition" on page 436):

   - You can modify the **DL Power**, the **UL Load**, the **Max Number of Users**, and the **Number of Users**.

Figure 9.10: Station Template Properties dialogue – HSDPA tab

8. Click the Neighbours tab. In this tab (see Figure 9.11), you can modify the **Max Number of Intra-** and **Inter-Carrier Neighbours** and the **Max Number of Inter-Technology Neighbours**. For information on defining neighbours, see "Planning Neighbours" on page 492.

Figure 9.11: Station Template Properties dialogue – Neighbours tab

9. Click the Other Properties tab. The Other Properties tab will only appear if you have defined additional fields in the **Sites** table, or if you have defined an additional field in the **Station Template Properties** dialogue.
10. When you have finished setting the parameters for the station template, click **OK** to close the dialogue and save your changes.

9.2.1.4.2 Modifying a Field in a Station Template

To modify a field in a station template:

1. In the **Radio** toolbar, click the arrow to the right of the list.
2. Select **Manage Templates** from the list. The **Station Template Properties** dialogue appears.
3. Select the template in the **Available Templates** list.
4. Click the **Fields** button.
5. In the dialogue that appears, you have the following options:
   - **Add:** If you want to add a user-defined field to the station templates, you must have already added it to the **Sites** table (for information on adding a user-defined field to a table, see "Adding a Field to an Object Type's Data Table" on page 51) for it to appear as an option in the station template properties. To add a new field:
     i. Click the **Add** button. The **Field Definition** dialogue appears.
     ii. Enter a **Name** for the new field. This is the name that will be used in database.
     iii. If desired, you can define a **Group** that this custom field will belong to. When you open an **Atoll** document from a database, you can then select a specific group of custom fields to be loaded from the database, instead of loading all custom fields.
     iv. In **Legend**, enter the name for the field that will appear in the **Atoll** document.
     v. For **Type**, you can select from **Text**, **Short Integer**, **Long Integer**, **Single**, **Double**, **True/False**, **Date/Time**, and **Currency**. If you choose text, you can also set the field **Size** (in characters), and create a

Choice list, by entering the possible selections directly in the **Choice list** window and pressing ENTER after each one.

vi. Enter, if desired, a **Default value** for the new field.

vii. Click **OK** to close the **Field Definition** dialogue and save your changes.

- **Delete:** To delete a user-defined field:

i. Select the user-defined field you want to delete.

ii. Click the **Delete** button. The user-defined field appears in strikeout. It will be definitively deleted when you close the dialogue.

- **Properties:** To modify the properties of a user-defined field:

i. Select the user-defined field you want to modify.

ii. Click the **Properties** button. The **Field Definition** dialogue appears.

iii. Modify any of the properties as desired.

iv. Click **OK** to close the **Field Definition** dialogue and save your changes.

6. Click **OK**.

9.2.1.4.3 Deleting a Station Template

To delete a station template:

1. In the **Radio** toolbar, click the arrow to the right of the list.
2. Select **Manage Templates** from the list. The **Station Template Properties** dialogue appears.
3. Under **Station Templates**, select the station template you want to delete and click **Delete**. The template is deleted.
4. Click **OK**.

9.2.1.5 Duplicating an Existing Base Station

You can create new base stations by duplicating an existing base station. When you duplicate an existing base station, the base station you create will have the same site, transmitter, and cell parameter values as the original one. Duplicating a base station allows you to:

- Quickly create a new base station with the same settings as the original base station in order to study the effect of a new base station on the coverage and capacity of the network, and
- Quickly create a homogeneous network with stations that have the same characteristics.

To duplicate an existing base station:

1. Click the Data tab in the **Explorer** window.
2. Click the **Expand** button (⊞) to expand the **Sites** folder.
3. Right-click the site you want to duplicate. The context menu appears.
4. From the context menu, select one of the following:
   - Select **Duplicate > With Neighbours** from the context menu, if you want to duplicate the base station along with the lists of intra- and inter-technology neighbours of its transmitters.
   - Select **Duplicate > Without Neighbours** from the context menu, if you want to duplicate the base station without the intra- and inter-technology neighbours of its transmitters.

   You can now place the new base station on the map using the mouse.

5. In the map window, move the pointer over the map to where you would like to place the new base station. The exact coordinates of the pointer's current location are visible in the **Status** bar.

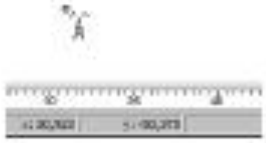


Figure 9.12: Placing a new base station

> ***Tips:***
> - *To place the station more accurately, you can zoom in on the map before you select **Duplicate** from the context menu. For information on using the zooming tools, see* "Changing the Map Scale" on page 38.
> - *If you let the pointer rest over the station you have placed, **Atoll** displays tip text with its exact coordinates, allowing you to verify that the location is correct.*

6. Click to place the duplicate base station.

A new base station is placed on the map. The site, transmitters, and cells of the new base station have the same names as the site, transmitters, and cells of the original base station with each name marked as "Copy of." The site, transmitters, and cells of the duplicate base station have the same settings as those of the original base station. All the remote antennas and repeaters of any transmitter on the original site are also duplicated.

You can also place a series of duplicate base stations by pressing and holding CTRL in step 6. and clicking to place each duplicate station.

For more information on the site, transmitter, subcell, and TRX properties, see "Definition of a Base Station" on page 433.

9.2.2 Creating a Group of Base Stations

You can create base stations individually as explained in "Creating a UMTS Base Station" on page 433, or you can create one or several base stations by using station templates as explained in "Placing a New Station Using a Station Template" on page 440. However, if you have a large data-planning project and you already have existing data, you can import this data into your current **Atoll** document and create a group of base stations.

> **Note:** When you import data into your current **Atoll** document, the coordinate system of the imported data must be the same as the display coordinate system used in the document. If you cannot change the coordinate system of your source data, you can temporarily change the display coordinate system of the **Atoll** document to match the source data. For information on changing the coordinate system, see "Setting a Coordinate System" on page 92.

You can import base station data in the following ways:

- **Copying and pasting data:** If you have data in table form, either in another **Atoll** document or in a spreadsheet, you can copy this data and paste it into the tables in your current **Atoll** document. When you create a group of base stations by copying and pasting data, you must copy and paste site data in the **Sites** table, transmitter data in the **Transmitters** table, and cell data in the **Cells** table, in that order.

  > **Important:** The table you copy data from must have the same column layout as the table you are pasting data into.

  For information on copying and pasting data, see "Copying and Pasting in Tables" on page 56.

- **Importing data:** If you have data in text or comma-seperated value (CSV) format, you can import it into the tables in the current document. If the data is in another **Atoll** document, you can first export it in text or CSV format and then import it into the tables of your current **Atoll** document. When you are importing, **Atoll** allows you to select what values you import into which columns of the table.

  When you create a group of base stations by importing data, you must import site data in the **Sites** table, transmitter data in the **Transmitters** table, and cell data in the **Cells** table, in that order.

  For information on exporting table data, see "Exporting Tables to Text Files" on page 58. For information on importing table data, see "Importing Tables from Text Files" on page 59.

> **Note:** You can quickly create a series of base stations for study purposes using the **Hexagonal Design** tool on the **Radio** toolbar. For information, see "Placing a New Station Using a Station Template" on page 440.

9.2.3 Modifying Sites and Transmitters Directly on the Map

In **Atoll**, you can access the **Properties** dialogue of a site or transmitter using the context menu on the Data tab of the **Explorer** window. However, in a complex radio-planning project, it can be difficult to find the data object in the Data tab, although it might be visible in the map window. **Atoll** lets you access the **Properties** dialogue of sites and transmitters directly from the map. If there is more than one transmitter with the same azimuth, clicking the transmitters in the map window opens a context menu allowing you to select the transmitter. You can also change the position of the station by dragging it, or by letting **Atoll** find a higher location for it.

Modifying sites and transmitters directly on the map is explained in detail in Chapter 1: The Working Environment:

- "Selecting One of Several Transmitters or Microwave Links" on page 30
- "Moving a Site Using the Mouse" on page 31
- "Moving a Site to a Higher Location" on page 31
- "Changing the Azimuth of the Antenna Using the Mouse" on page 32
- "Changing the Position of the Transmitter Relative to the Site" on page 32.

9.2.4 Display Tips for Base Stations

Atoll allows to you to display information about base stations in a number of different ways. This enables you not only to display selected information, but also to distinguish base stations at a glance.

The following tools can be used to display information about base stations:

- **Label:** You can display information about each object, such as each site or transmitter, in the form of a label that is displayed with the object. You can display information from every field in that object type's data table, including from fields that you add. The label is always displayed, so you should choose information that you would want to always be visible; too much information will lead to a cluttered display. For information on defining the label, see "Defining the Object Type Label" on page 35.
- **Tooltips:** You can display information about each object, such as each site or transmitter, in the form of a tooltip that is only visible when you move the pointer over the object. You can choose to display more information than in the label, because the information is only displayed when you move the pointer over the object. You can display information from every field in that object type's data table, including from fields that you add. For information on defining the tooltips, see "Defining the Object Type Tip Text" on page 36.
- **Transmitter colour:** You can set the transmitter colour to display information about the transmitter. For example, you can select "Discrete Values" to distinguish transmitters by antenna type, or to distinguish inactive from active sites. You can also define the display type for transmitters as "Automatic." **Atoll** then automatically assigns a colour to each transmitter, ensuring that each transmitter has a different colour than the transmitters surrounding it. For information on defining the transmitter colour, see "Defining the Display Type" on page 34.
- **Transmitter symbol:** You can select one of several symbols to represent transmitters. For example, you can select a symbol that graphically represents the antenna half-power beamwidth ( ). If you have two transmitters on the same site with the same azimuth, you can differentiate them by selecting different symbols for each (and). For information on defining the transmitter symbol, see "Defining the Display Type" on page 34.

9.2.5 Creating a Dual-Band UMTS Network

In **Atoll**, you can model a dual-band UMTS network, i.e., a network consisting of 2100 MHz and 900 MHz transmitters, in one document. Creating a dual-band UMTS network consists of the following steps:

1. Defining the two frequency bands in the document (see "Defining Frequency Bands" on page 549).
2. Selecting and calibrating a propagation model for each frequency band (see Chapter 5: Managing Calculations in Atoll).
3. Assigning a frequency band, with its propagation model, to each transmitter (see "Transmitter Description" on page 434).
4. Defining the frequency bands with which terminals are compatible (see "Modelling Terminals" on page 478).

9.2.6 Creating a Repeater

A repeater receives, amplifies, and re-transmits the radiated or conducted RF carrier both in downlink and uplink. It has a donor side and a server side. The donor side receives the signal from a donor transmitter or repeater. This signal may be carried by different types of links such as radio link or microwave link. The server side re-transmits the received signal.

Atoll models RF repeaters and microwave repeaters. The modelling focuses on:

- The additional coverage these systems provide to transmitters in the downlink.
- The UL total gain value in service areas studies (effective service area and UL Eb/Nt service area) and the noise rise generated at the donor transmitter by the repeater.

In this section, the following are explained:

Note:	Broad-band repeaters are not modelled. **Atoll** assumes that all carriers from the 3G donor transmitter are amplified.

9.2.6.1 Creating and Modifying Repeater Equipment

You can define repeater equipment to be assigned to each repeater in the network.

To create or modify repeater equipment:

1. Click the Data tab in the **Explorer** window.
2. Right-click the **Transmitters** folder. The context menu appears.
3. Select **Repeaters > Equipment** from the context menu. The **Repeater Equipment** table appears.
4. To create repeater equipment, enter the following in the row marked with the **New Row** icon ( ):
   a. Enter a **Name** and **Manufacturer** for the new equipment.
   b. Enter a **Noise Figure**. The repeater causes a rise in noise at the donor transmitter, so the noise figure is used to calculate the UL loss to be added to the donor transmitter UL losses. The noise figure must be a positive value.

parameters enable **Atoll** to ensure that the user-defined amplifier gain is consistent with the limits of the equipment if there are any.

d. Enter a **Gain Increment**. **Atoll** uses the increment value when you increase or decrease the repeater amplifier gain using the buttons to the right of the **Amplification** box ( ) on the General tab of the repeater **Properties** dialogue.

e. Enter the maximum power that the equipment can transmit on the downlink in the **Maximum Downlink Power** column. This parameter enables **Atoll** to ensure that the downlink power after amplification does not exceed the limit of the equipment.

f. If desired, enter a **Maximum Uplink Power**, an **Internal Delay** and **Comments**. These fields are for information only and are not used in calculations.

5. To modify repeater equipment, change the parameters in the row containing the repeater equipment you wish to modify.

9.2.6.2 Placing a Repeater on the Map Using the Mouse

In **Atoll**, you can create a repeater and place it using the mouse. When you create a repeater, you can add it to an existing site, or have **Atoll** automatically create a new site. **Atoll** supports cascading repeaters, in other words, repeaters that extend the coverage of another repeater.

To create a repeater and place it using the mouse:

1. Select the donor transmitter or repeater. You can select it from the **Transmitters** folder of the **Explorer** window's Data tab, or directly on the map.
2. Click the arrow next to **New Repeater or Remote Antenna** button ( ) on the **Radio** toolbar.
3. Select **Repeater** from the menu.
4. Click the map to place the repeater. The repeater is placed on the map, represented by a symbol ( ) in the same colour as the donor transmitter or repeater. By default, the repeater has the same azimuth as the donor transmitter or repeater. Its tooltip and label display the same information as displayed for the donor transmitter or repeater. As well, its tooltip and label identify the repeater and the donor transmitter or repeater.

   For information on defining the properties of the new repeater, see "Defining the Properties of a Repeater" on page 449.

> **Note:** You can see to which base station the repeater is connected by clicking it; **Atoll** displays a link to the donor transmitter or repeater.

9.2.6.3 Creating Several Repeaters

In **Atoll**, the characteristics of each repeater are stored in the **Repeaters** table. You can create several repeaters at the same time by pasting the information into the **Repeaters** table:

- If you have data in table form, either in another **Atoll** document or in a spreadsheet, you can copy this data and paste it into the **Repeaters** table in your current **Atoll** document.

> **Important:** The table you copy data from must have the same column layout as the table you are pasting data into.

For information on copying and pasting data, see "Copying and Pasting in Tables" on page 56.

9.2.6.4 Defining the Properties of a Repeater

To define the properties of a repeater:

1. Right-click the repeater either directly on the map, or from the **Transmitters** folder of the **Explorer** window's Data tab. The context menu appears.
2. Select **Properties** from the context menu. The **Properties** dialogue appears.
3. Click the General tab. You can modify the following parameters:
   - You can change the **Name** of the repeater. By default, repeaters are named "RepeaterN" where "N" is a number assigned as the repeater is created.
   - You can change the **Donor** transmitter by selecting it from the **Donor** list. Clicking the **Browse** button ( ) opens the **Properties** dialogue of the donor transmitter.
   - You can change the **Site** on which the repeater is located. Clicking the **Browse** button ( ) opens the **Properties** dialogue of the site.
   - You can enter a **Position relative to site location**, if the repeater is not located on the site itself.
   - You can select equipment from the **Equipment** list. Clicking the **Browse** button ( ) opens the **Properties** dialogue of the equipment.

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- You can change the **Amplification** gain. The amplification gain is used in the link budget to evaluate the repeater total gain.

4. Click the Donor Side tab. You can modify the following parameters:
   - Under **Donor-Repeater Link**, select a **Link Type**.
     - If you select **Microwave Link**, enter the **Propagation Losses** and continue with step 5.
     - If you select **Air Link**, select a **Propagation Model** and enter the **Propagation Losses** or click **Calculate** to determine the actual propagation losses between the donor and the repeater. If you do not select a propagation model, the propagation losses between the donor transmitter and the repeater are calculated using the ITU 526-5 propagation model.

       When you create an off-air repeater, it is assumed that the link between the donor transmitter and the repeater has the same frequency as the network.

> **Important:** If you want to create a remote antenna, you must select **Optical Fibre Link**.

   - If you selected **Air Link** under **Donor-Repeater Link**, enter the following information under **Antenna**:
     i. Select a **Model** from the list. You can click the **Browse** button (...) to access the properties of the antenna.
     ii. Enter the height off the ground of the antenna in the **Height/Ground** box. This will be added to the altitude of the transmitter as given by the DTM.
     iii. Enter the **Azimuth** and the **Mechanical Downtilt**.

> **Note:** You can click the **Calculate** button to update azimuth and downtilt values after changing the repeater donor side antenna height or the repeater location. If you choose another site or change site coordinates in the General tab, click **Apply** before clicking the **Calculate** button.

   - If you selected **Air Link** under **Donor-Repeater Link**, enter the following information under **Feeders**:
     i. Select a **Type** of feeder from the list. You can click the **Browse** button (...) to access the properties of the feeder.
     ii. Enter the **Length** of the feeder cable at **Transmission** and at **Reception**.

5. Click the Coverage Side tab. You can modify the following parameters:
   - Select the **Active** check box. Only active repeaters (displayed in red in the **Transmitters** folder in the Data tab of the **Explorer** window) are calculated.
   - Under **Total Gains**, enter the gains in the **Downlink** and **Uplink** or click **Calculate** to determine the actual gains. If you have modified any parameter in the General, Donor Side, or Coverage Side tabs, click **Apply** before clicking the **Calculate** button. **Atoll** uses the DL total gain values to calculate the signal level received from the repeater. The UL total gain value is considered in UL Eb/Nt service area studies.

     The DL total gain is applied to each power (pilot power, SCH power, etc.). It takes into account losses between the donor transmitter and the repeater, donor characteristics (donor antenna gain, reception feeder losses), amplification gain, and coverage characteristics (coverage antenna gain and transmission feeder losses).

     The UL total gain is applied to each terminal power. It takes into account losses between the donor transmitter and the repeater, donor part characteristics (donor antenna gain, transmission feeder losses), amplification gain and coverage part characteristics (coverage antenna gain and reception feeder losses).
   - Under **Antennas**, you can modify the following parameters:
     i. Enter the height off the ground of the antenna in the **Height/Ground** box. This will be added to the altitude of the site as given by the DTM.
     ii. Under **Main Antenna**, select a **Model** from the list. You can click the **Browse** button (...) to access the properties of the antenna. Then, enter the **Azimuth**, the **Mechanical Downtilt**, and, if applicable, the **Additional Electrical Downtilt**. By default, the characteristics (antenna, azimuth, height, etc.) of the repeater coverage side correspond to the characteristics of the donor transmitter.
     iii. Under **Secondary Antennas**, you can select one or more secondary antennas in the **Antenna** column and enter their **Azimuth**, **Mechanical Downtilt**, **Additional Electrical Downtilt**, and **% Power**. For information on working with data tables, see "Working with Data Tables" on page 50.
   - Under **Feeders**, you can modify the following information:
     i. Select a **Type** of feeder from the list. You can click the **Browse** button (...) to access the properties of the feeder.
     ii. Enter the **Length** of the feeder cable at **Transmission** and at **Reception**.
   - Under **Losses**, **Atoll** displays the **Loss Related to Repeater Noise Rise**.

6. Click the Propagation tab. Since repeaters are taken into account during calculations, you must set the propagation parameters. On the Propagation tab, you can modify the following: the **Propagation Model**, **Radius**, and **Res-**

olution for both the **Main Matrix** and the **Extended Matrix**. By default, the propagation characteristics of the repeater (model, calculation radius, and grid resolution) are the same as those of the donor transmitter. For information on propagation models, see Chapter 5: Managing Calculations in Atoll.

9.2.6.5 Tips for Updating Repeater Parameters

Atoll provides you with a few shortcuts that you can use to change certain repeater parameters:

- You can update the calculated azimuth and downtilt of the donor-side antennas of all repeaters by selecting **Repeaters > Calculate Donor Side Azimuths and Tilts** from the **Transmitters** context menu.
- You can update the UL and DL total gains of all repeaters by selecting **Repeaters > Calculate Gains** from the **Transmitters** context menu.

> **Note:** You can prevent **Atoll** from updating the UL and DL total gains of selected repeaters by creating a custom field called "FreezeTotalGain" in the **Repeaters** table and setting the value of the field to "True." Afterwards, when you select **Repeaters > Calculate Gains** from the **Transmitters** context menu, **Atoll** will only update the UL and DL total gains for repeaters with the custom field "FreezeTotalGain" set to "False."

- You can update the propagation losses of all off-air repeaters by selecting **Repeaters > Calculate Donor Side Propagation Losses** from the **Transmitters** context menu.
- You can select a repeater on the map and change its azimuth (see "Changing the Azimuth of the Antenna Using the Mouse" on page 32) or its position relative to the site (see "Changing the Position of the Transmitter Relative to the Site" on page 32).

9.2.7 Creating a Remote Antenna

Atoll allows you to create remote antennas to position antennas at locations that would normally require long runs of feeder cable. A remote antenna is connected to the base station with an optic fibre. Remote antennas allow you to ensure radio coverage in an area without a new base station.

In **Atoll**, the remote antenna should be connected to a base station that does not have any antennas. It is assumed that a remote antenna, as opposed to a repeater, does not have any equipment and generates no amplification gain nor noise. In certain cases, you may want to model a remote antenna with equipment or a remote antenna connected to a base station that has antennas. This can be done by modelling a repeater. For information on creating a repeater, see "Creating a Repeater" on page 448.

In this section, the following are explained:

- "Placing a Remote Antenna on the Map Using the Mouse" on page 451
- "Creating Several Remote Antennas" on page 452
- "Defining the Properties of a Remote Antenna" on page 452
- "Tips for Updating Remote Antenna Parameters" on page 453.

9.2.7.1 Placing a Remote Antenna on the Map Using the Mouse

In **Atoll**, you can create a remote antenna and place it using the mouse. When you create a remote antenna, you can add it to an existing base station without antennas, or have **Atoll** automatically create a new site.

To create a remote antenna and place it using the mouse:

1. Select the donor transmitter. You can select it from the **Transmitters** folder of the **Explorer** window's Data tab, or directly on the map.

> **Note:** Ensure that the remote antenna's donor transmitter does not have any antennas.

2. Click the arrow next to **New Repeater or Remote Antenna** button ( ) on the **Radio** toolbar.
3. Select **Remote Antenna** from the menu.
4. Click the map to place the remote antenna. The remote antenna is placed on the map, represented by a symbol ( ) in the same colour as the donor transmitter. By default, the remote antenna has the same azimuth as the donor transmitter. Its tooltip and label display the same information as displayed for the donor transmitter. As well, its tooltip and label identify the remote antenna and the donor transmitter.

   For information on defining the properties of the new remote antenna, see "Defining the Properties of a Remote Antenna" on page 452.

> **Note:** You can see to which base station the remote antenna is connected by clicking it; **Atoll** displays a link to the donor transmitter.

9.2.7.2 Creating Several Remote Antennas

In **Atoll**, the characteristics of each remote antenna are stored in the **Remote Antennas** table. You can create several remote antennas at the same time by pasting the information into the **Remote Antennas** table.

- If you have data in table form, either in another **Atoll** document or in a spreadsheet, you can copy this data and paste it into the **Remote Antennas** table in your current **Atoll** document.

> **Important:** The table you copy data from must have the same column layout as the table you are pasting data into.

For information on copying and pasting data, see "Copying and Pasting in Tables" on page 56.

9.2.7.3 Defining the Properties of a Remote Antenna

To define the properties of a remote antenna:

1. Right-click the remote antenna either directly on the map, or from the **Transmitters** folder of the **Explorer** window's Data tab. The context menu appears.
2. Select **Properties** from the context menu. The **Properties** dialogue appears.
3. Click the General tab. You can modify the following parameters:
   - You can change the **Name** of the remote antenna. By default, remote antennas are named "RemoteAntennaN" where "N" is a number assigned as the remote antenna is created.
   - You can change the **Donor** transmitter by selecting it from the **Donor** list. Clicking the **Browse** button (...) opens the **Properties** dialogue of the donor transmitter.
   - You can change the **Site** on which the remote antenna is located. Clicking the **Browse** button (...) opens the **Properties** dialogue of the site.
   - You can enter a **Position relative to site location**, if the remote antenna is not located on the site itself.

> **Note:** A remote antenna does not have equipment.

4. Click the Donor Side tab. You can modify the following parameters:
   - Under **Donor-Repeater Link**, select **Optical Fibre Link** and enter the **Fibre Losses**.
5. Click the Coverage Side tab. You can modify the following parameters:
   - Select the **Active** check box. Only active remote antennas (displayed in red in the **Transmitters** folder in the Data tab of the **Explorer** window) are calculated.
   - Under **Total Gains**, enter the gains in the **Downlink** and **Uplink** or click **Calculate** to determine the actual gains. If you have modified any parameter in the General, Donor Side, or Coverage Side tabs, click **Apply** before clicking the **Calculate** button. **Atoll** uses the DL total gain values to calculate the signal level received from the remote antenna. The UL total gain value is considered in UL Eb/Nt service area studies.

     The DL total gain is applied to each power (pilot power, SCH power, etc.). It takes into account losses between the donor transmitter and the remote antenna.

     The UL total gain is applied to each terminal power. It takes into account losses between the donor transmitter and the remote antenna.
   - Under **Antennas**, you can modify the following parameters:
     i. Enter the height off the ground of the antenna in the **Height/Ground** box. This will be added to the altitude of the transmitter as given by the DTM.
     ii. Under **Main Antenna**, select a **Model** from the list. You can click the **Browse** button (...) to access the properties of the antenna. Then, enter the **Azimuth** and the **Mechanical Downtilt**.
     iii. Under **Secondary Antennas**, you can select one or more secondary antennas in the **Antenna** column and enter their **Azimuth**, **Mechanical Downtilt**, **Additional Electrical Downtilt**, and **% Power**. For information on working with data tables, see "Working with Data Tables" on page 50.
   - Under **Feeders**, you can modify the following information:
     i. Select a **Type** of feeder from the list. You can click the **Browse** button (...) to access the properties of the feeder.
     ii. Enter the **Length** of the feeder cable at **Transmission** and at **Reception**.
6. Click the Propagation tab. Since remote antennas are taken into account during calculations, you must set propagation parameters, as with transmitters. On the Propagation tab, you can modify the following: the **Propagation Model**, **Radius**, and **Resolution** for both the **Main Matrix** and the **Extended Matrix**. By default, the propagation characteristics of the remote antenna (model, calculation radius, and grid resolution) are the same as those of the donor transmitter. For information on propagation models, see Chapter 5: Managing Calculations in Atoll.

9.2.7.4 Tips for Updating Remote Antenna Parameters

Atoll provides you with a few shortcuts that you can use to change certain remote antenna parameters:

- You can update the UL and DL total gains of all remote antennas by selecting **Remote Antennas > Calculate Gains** from the **Transmitters** context menu.

> **Note:** You can prevent **Atoll** from updating the UL and DL total gains of selected remote antennas by creating a custom field called "FreezeTotalGain" in the **Remote Antennas** table and setting the value of the field to "True." Afterwards, when you select **Remote Antennas > Calculate Gains** from the **Transmitters** context menu, **Atoll** will only update the UL and DL total gains for remote antennas with the custom field "FreezeTotalGain" set to "False."

- You can select a remote antenna on the map and change its azimuth (see "Changing the Azimuth of the Antenna Using the Mouse" on page 32) or its position relative to the site (see "Changing the Position of the Transmitter Relative to the Site" on page 32).

9.2.8 Setting the Working Area of an Atoll Document

When you load project data from a database, you will probably only modify the data in the region for which you are responsible. For example, a complex radio-planning project may cover an entire region or even an entire country. You, however, might be responsible for the radio planning for only one city. In such a situation, doing a coverage prediction that calculates the entire network would not only take a lot of time, it is not necessary. Consequently, you can restrict a coverage prediction to the sites that you are interested in and generate only the results you need.

In **Atoll**, there are two ways of restricting the number of sites covered by a coverage prediction, each with its own advantages:

- **Filtering the desired sites**

  You can simplify the selection of sites to be studied by using a filter. You can filter sites according to one or more fields, or you can create an advanced filter by combining several criteria in several fields. You can create a graphic filter by either using an existing vector polygon or creating a new vector polygon. For information on graphic filters, see "Filtering Data Using a Filtering Zone" on page 80. This enables you to keep only the base stations with the characteristics you want to study. The filtering zone is taken into account whether or not it is visible.

  For information on filtering, see "Filtering Data" on page 70.

- **Setting a computation zone**

  Drawing a computation zone to encompass the sites to be studied limits the number of sites to be calculated, which in turn reduces the time necessary for calculations. In a smaller project, the time savings may not be significant. In a larger project, especially when you are making repeated studies in order to see the effects of small changes in site configuration, the savings in time is considerable. Limiting the number of sites by drawing a computation zone also limits the resulting calculated coverage. The computation zone is taken into account whether or not it is visible.

  It is important not to confuse the computation zone and the focus zone or hot spot zone. The computation zone defines the area where **Atoll** computes path loss matrices, coverage studies, Monte Carlo, power control simulations, etc., while the focus zone or hot spot zone is the area taken into consideration when generating reports and results.

  For information on the computation zone, see "Creating a Computation Zone" on page 461.

You can combine a computation zone and a filter, in order to create a very precise selection of the base stations to be studied.

9.2.9 Studying a Single Base Station

As you create a site, you can study it to test the effectiveness of the set parameters. Coverage predictions on groups of sites can take a large amount of time and consume a lot of computer resources. Restricting your coverage prediction to the site you are currently working on allows you get the results quickly. You can expand your coverage prediction to a number of sites once you have optimised the settings for each individual site.

Before studying a site, you must assign a propagation model. The propagation model takes the radio and geographic data into account and computes losses along the transmitter-receiver path. This allows you to predict the received signal level at any given point. **Atoll** enables you to assign both a main propagation model, with a shorter radius and a higher resolution, and an extended propagation model, with a longer radius and a lower resolution. By using a calculation radius, **Atoll** limits the scope of calculations to a defined area. By using two matrices, **Atoll** allows you to calculate high resolution path loss matrices closer to the transmitter, while reducing calculation time by using an extended matrix with a lower resolution.

You can assign a propagation model to all transmitters at once, to a group of transmitters, or to a single transmitter. Assigning a propagation model is explained in "Assigning a Propagation Model" on page 459.

In this section, the following are explained:

- "Making a Point Analysis to Study the Profile" on page 454

- "Studying Signal Level Coverage" on page 455.

9.2.9.1 Making a Point Analysis to Study the Profile

In **Atoll**, you can make a point analysis to study reception along a profile between a reference transmitter and a UMTS user. Before studying a site, you must assign a propagation model. The propagation model takes the radio and geographic data into account and computes losses along the transmitter-receiver path. The profile is calculated in real time, using the propagation model, allowing you to study the profile and get a prediction on each selected point.

For information on assigning a propagation model, see "Assigning a Propagation Model" on page 459.

To make a point analysis:

1. In the map window, select the transmitter from which you want to make a point analysis.
2. Click the **Point Analysis Tool** ( ) in the **Radio** toolbar. The **Point Analysis Tool** window appears and the pointer changes ( ) to represent the receiver.
3. A line appears on the map connecting the selected transmitter and the current position. You can now do the following:
   - Move the receiver to change the current position.
   - Click to place the receiver at the current position. You can move the receiver again by clicking it a second time.
   - Right-click the receiver to choose one of the following commands from the context menu:
     - **Coordinates:** Select **Coordinates** to change the receiver position by entering new XY coordinates.
     - **Target Site:** Select a site from the list to place the receiver directly on a site.
4. Click the Profile tab.
5. The profile analysis appears in the Profile tab of the **Point Analysis Tool** window. The **altitude** (in metres) is reported on the vertical axis and the receiver-transmitter distance on the horizontal axis. A blue ellipsoid indicates the Fresnel zone between the transmitter and the receiver, with a green line indicating the line of sight (LOS). **Atoll** displays the angle of the LOS read from the vertical antenna pattern. Along the profile, if the signal meets an obstacle, this causes attenuation with diffraction displayed by a red vertical line (if the propagation model used takes diffraction mechanisms into account). The main peak is the one that intersects the most with the Fresnel ellipsoid. With some propagation models using a 3 knife-edge Deygout diffraction method, the results may display two additional attenuations peaks. The total attenuation is displayed above the main peak.

   The results of the analysis are displayed at the top of the Profile tab:

   - The received signal strength of the selected transmitter
   - The propagation model used
   - The shadowing margin and the cell edge coverage probability used for calculating it
   - The distance between the transmitter and the receiver.

   You can change the following options at the top of the Profile tab:

   - **Transmitter:** Select the transmitter from the list.
   - **Carriers:** Select the carrier to be analysed.
   - **Display Geo Data Only:** Select the **Display Geo Data Only** check box if you want to view the geographic profile between the transmitter and the receiver. **Atoll** displays the profile between the transmitter and the receiver with clutter heights. An ellipsoid indicating the Fresnel zone is also displayed. **Atoll does** not calculate nor display signal levels and losses.
6. Right-click the Profile tab to choose one of the following commands from the context menu:
   - **Properties:** Select **Properties** to display the **Analysis Properties** dialogue. This dialogue is available from the context menu on all tabs of the **Point Analysis Tool** window. You can change the following:
     - Change the **X** and **Y** coordinates to change the present position of the receiver.
     - Select the **Shadowing taken into account** check box and enter a **Cell Edge Coverage Probability**, and select "From Model" from the **Shadowing Margin** list.
     - Select **Signal Level**, **Path loss**, and **Total losses** from the **Result Type** list.
     - You can select the **Indoor Coverage** check box to add indoor losses. Indoor losses are defined per clutter class.
   - **Link Budget:** Select **Link Budget** to display a dialogue with the link budget.
   - **Model Details:** Select **Model Details** to display a text document with details on the displayed profile analysis. Model details are only available for the standard propagation model.

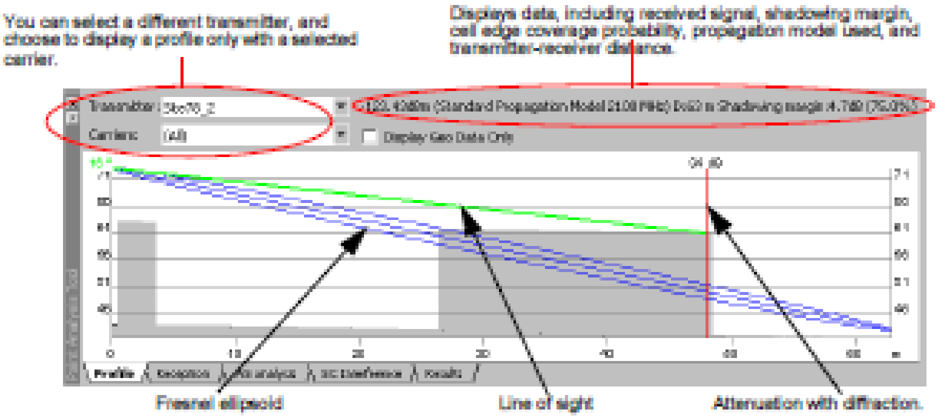

Figure 9.13: Point Analysis Tool - Profile tab

9.2.9.2 Studying Signal Level Coverage

As you are building your radio-planning project, you may want to check the coverage of a new base station without having to calculate the entire project. You can do this by selecting the site with its transmitters and then creating a new coverage prediction.

This section explains how to calculate the signal level coverage of a single site. A signal level coverage prediction displays the signal of the best server for each pixel of the area studied.

> **Note:** You can use the same procedure to study the signal level coverage of several sites by grouping the transmitters. For information on grouping transmitters, see "Grouping Data Objects by a Selected Property" on page 65.

To study the signal level coverage of a single base station:

1. Click the Data tab of the **Explorer** window.
2. Right-click the **Transmitters** folder and select **Group by > Sites** from the context menu. The transmitters are now displayed in the Transmitters folder by the site on which they are situated.

> *Tip: If you wish to study only sites by their status, at this step you could group them by status.*

3. Select the propagation parameters to be used in the coverage prediction:
   a. Click the **Expand** button (⊞) to expand the **Transmitters** folder.
   b. Right-click the group of transmitters you want to study. The context menu appears.
   c. Select **Open Table** from the context menu. A table appears with the properties of the selected group of transmitters.
   d. In the table, you can configure two propagation models: one for the main matrix, with a shorter radius and a higher resolution, and another for the extended matrix, with a longer radius and a lower resolution. By calculating two matrices you can reduce the time of calculation by using a lower resolution for the extended matrix and you can obtain more accurate results by using for the main and extended matrices propagation models best suited for each distance.
   e. In the **Main Matrix** column:
      - Select a **Propagation Model**
      - Enter a **Radius** and **Resolution**.
   f. If desired, in the **Extended Matrix** column:
      - Select a **Propagation Model**
      - Enter a **Radius** and **Resolution**.
   g. Close the table.
4. In the **Transmitters** folder, right-click the group of transmitters you want to study and select **Calculations > Create a New Study** from the context menu. The **Study Types** dialogue appears.

   The **Study Types** dialogue lists the studies available. They are divided into **Standard Studies**, supplied with **Atoll**, and **Customized Studies**. Unless you have already created some customized studies, the **Customized Studies** list will be empty.
5. Select **Coverage by Signal Level** and click **OK**. A study properties dialogue appears.

6. You can configure the following parameters in the **Properties** dialogue:

- **General tab:** You can change the assigned **Name** of the coverage prediction, the **Resolution**, and you can add a **Comment**. The resolution you set is the display resolution, not the calculation resolution.

  To improve memory consumption and optimise the calculation times, you should set the display resolutions of coverage predictions according to the precision required. The following table lists the levels of precision that are usually sufficient:

Size of the Coverage Prediction	Display Resolution
City Centre	5 m
City	20 m
County	50 m
State	100 m
Country	According to the size of the country

> **Note:** If you create a new coverage prediction from the context menu of either the **Transmitters** or **Predictions** folder, you can select the **sites** using the **Group By**, **Sort**, and **Filter** buttons under **Configuration**. Because you already selected the target sites, however, only the **Filter** button is available.

- **Condition tab:** The coverage prediction parameters on the Conditions tab allow you to define the signals that will be considered for each pixel (see Figure 9.14).
  - At the top of the Condition tab, you can set the signal level range to be considered. In Figure 9.14, a signal level **less** than or equal to -120 dBm will be considered.
  - Under **Server**, select "All" to consider signal levels from all servers.
  - If you select the **Shadowing taken into account** check box, you can change the **Cell Edge Coverage Probability**.
  - You can select the **Indoor Coverage** check box to add indoor losses. Indoor losses are defined per clutter class.
  - You can select the **Carrier** to be studied, or select "All" to have all carriers taken into account. The coverage prediction displays the strength of the received pilot signal.

Figure 9.14: Condition settings for a signal level coverage prediction

- **Display tab:** You can modify how the results of the coverage prediction will be displayed.
  - Under **Display Type**, select "Value Intervals."
  - Under **Field**, select "Best Signal Level." Selecting "All" or "Best Signal Level" on the Conditions tab will give you the same results because **Atoll** displays the results of the best server in either case. Selecting "Best Signal Level" necessitates, however, the longest time for calculation.
  - You can change the value intervals and their displayed colour. For information on changing display properties, see "Display Properties of Objects" on page 33.
  - You can create a tooltip with information about the coverage prediction by clicking the **Browse** button (...) next to the **Tip Text** box and selecting the fields you want to display in the tooltip.

Note:	If you change the display properties of a coverage prediction after you have calculated it, you may make the coverage prediction invalid. You will then have to recalculate the coverage prediction to obtain valid results.

7. Click the **Calculate** button ( ) in the **Radio** toolbar to calculate the signal level coverage prediction. The progress of the calculation, as well as any error messages, is displayed in the **Event Viewer**.

Once **Atoll** has finished calculating the coverage prediction, the results are displayed in the map window. The signal level coverage prediction can be found in the **Predictions** folder on the Data tab. **Atoll** automatically locks the results of a coverage prediction as soon as it is calculated, as indicated by the icon ( ) beside the coverage prediction in the **Predictions** folder. When you click the **Calculate** button ( ), **Atoll** only calculates unlocked coverage predictions ( ).

9.2.10 Studying Base Stations

When you make a coverage prediction, **Atoll** calculates all base stations that are active, filtered (i.e., that are selected by the current filter parameters), and whose propagation zone intersects a rectangle containing the computation zone.

Figure 9.15 gives an example of a computation zone. In Figure 9.15, the computation zone is displayed in red, as it is in the **Atoll** map window. The propagation zone of each active site is indicated by a blue square. Each propagation zone that intersects the rectangle (indicated by the green dashed line) containing the computation zone will be taken into consideration when **Atoll** calculates the coverage prediction. Sites 78 and 95, for example, are not in the computation zone. However, their propagation zones intersect the rectangle containing the computation zone and, therefore, they will be taken into consideration in the coverage prediction. On the other hand, the coverage zones of three other sites do not intersect the green rectangle. Therefore, they will not be taken into account in the coverage prediction.

Figure 9.15: An example of a computation zone

Before calculating a coverage prediction, **Atoll** must have valid path loss matrices. **Atoll** calculates the path loss matrices using the assigned propagation model. **Atoll** can use two different propagation models for each transmitter: a main propagation model with a shorter radius (displayed with a blue square in Figure 9.15) and a higher resolution and an extended propagation model with a longer radius and a lower resolution. **Atoll** will use the main propagation model to calculate higher resolution path loss matrices close to the transmitter and the extended propagation model to calculate lower resolution path loss matrices outside the area covered by the main propagation model.

In this section, the following are explained:

- "Path Loss Matrices" on page 458
- "Assigning a Propagation Model" on page 459

- "The Calculation Process" on page 461
- "Creating a Computation Zone" on page 461
- "Setting Transmitters or Cells as Active" on page 462
- "Signal Level Coverage Predictions" on page 463
- "Analysing a Coverage Prediction" on page 467
- "UMTS-Specific Studies" on page 474
- "HSDPA Coverage Prediction" on page 489
- "HSUPA Coverage Prediction" on page 491
- "Printing and Exporting Coverage Prediction Results" on page 492.

9.2.10.1 Path Loss Matrices

Path loss is caused by objects in the transmitter-receiver path and is calculated by the propagation model. In **Atoll**, the path loss matrices are needed for all base stations that are active, filtered and whose propagation zone intersects a rectangle containing the computation zone (for an explanation of the computation zone, see "Studying Signal Level Coverage" on page 455) and must be calculated before predictions and simulations can be made.

Storing Path Loss Matrices

Path loss matrices can be stored internally, in the **Atoll** document, or they can be stored externally. Storing path loss matrices in the **Atoll** document results in a more portable but significantly larger document. In the case of large radio-planning projects, embedding the matrices can lead to large documents which use a great deal of memory. Therefore, in the case of large radio-planning projects, saving your path loss matrices externally will help reduce the size of the file and the use of computer resources.

The path loss matrices are also stored externally in a multi-user environment, when several users are working on the same radio-planning document and share the path loss matrices. In this case, the radio data is stored in a database and the path loss matrices are read-only and are stored in a location accessible to all users. When the user changes his radio data and recalculates the path loss matrices, the calculated changes to the path loss matrices are stored locally; the common path loss matrices are not modified. These will be recalculated by the administrator taking into consideration the changes to radio data made by all users. For more information on working in a multi-user environment, see the *Administrator Manual*.

When you save the path loss matrices to an external directory, **Atoll** creates:

- One file per transmitter with the extension LOS for its main path loss matrix.
- A DBF file with validity information for all the main matrices.
- A folder called "LowRes" with LOS files and a DBF file for the extended path loss matrices.

To set the storage location of the path loss matrices:

1. Click the Data tab in the **Explorer** window.
2. Right-click the **Predictions** folder. The context menu appears.
3. Select **Properties** from the context menu. The **Properties** dialogue appears.
4. On the Predictions tab, under **Path Loss Matrix Storage**, you can set the location for your private path loss matrices and the location for the shared path loss matrices.
   - **Private Directory:** The **Private Directory** is where you store path loss matrices you generate or, if you are loading path loss matrices from a shared location, where you store your changes to shared path loss matrices.

     Click the button beside the **Private Directory** (▸) and select **Embedded** to save the path loss matrices in the **Atoll** document, or **Share** to select a directory where **Atoll** can save the path loss matrices externally.

Note:	Path loss matrices you calculate locally are not stored in the same directory as shared path loss matrices. Shared path loss matrices are stored in a read-only directory. In other words, you can read the information from the shared path loss matrices but any changes you make will be stored locally, either embedded in the ATL file or in a private external folder, depending on what you have selected in **Private Directory**.

Caution:	When you save the path loss files externally, the external files are updated as soon as calculations are performed and not only when you save the **Atoll** document. In order to keep consistency between the **Atoll** document and the stored calculations, you should save the **Atoll** document before closing it, if you have updated the path loss matrices.

   - **Shared Directory:** When you are working in a multi-user **Atoll** environment, the project data is stored in a database and the common path loss matrices are stored in a directory that is accessible to all users. Any changes you make will not be saved to this directory; they will be saved in the location indicated in **Private Directory**. The path loss matrices in the shared directory are updated by a user with administrator rights based on the updated information in the database. For more information on shared directories, see *The Administrator Manual*.
5. Click **OK**.

Checking the Validity of Path Loss Matrices

Atoll automatically checks the validity of the path loss matrices before calculating any coverage prediction. If you want, you can check whether the path loss matrices are valid without creating a coverage prediction.

To check whether the path loss matrices are valid:

1. Click the Data tab in the **Explorer** window.
2. Right-click the **Transmitters** folder. The context menu appears.
3. Select **Properties** from the context menu. The **Properties** dialogue appears.
4. Click the Propagation tab. The path loss matrix information is listed in the **Available Results** table.
5. Select one of the following display options:
   - **Display all the matrices:** All path loss matrices are displayed.
   - **Display only invalid matrices:** Only invalid path loss matrices are displayed.

   The **Available Results** table lists the following information for each displayed path loss matrix:

   - **Transmitter:** The name of the transmitter.
   - **Locked:** If the check box is selected, the path loss matrix will not be updated even if the path loss matrices are recalculated.
   - **Valid:** This is a boolean field indicating whether or not the path loss matrix is valid.
   - **Origin of Invalidity:** If the path loss matrix is indicated as being invalid, the reason is given here.
   - **Size:** The size of the path loss matrix for the transmitter.
   - **File:** If the path loss matrix is not embedded, the location of the file is listed.
6. Click the **Statistics** button to display the number of path loss matrices to be recalculated. The **Statistics** dialogue appears (see Figure 9.16) with the total number of invalid path loss matrices and the reasons for invalidity, as well as a summary of the reasons for invalidity.

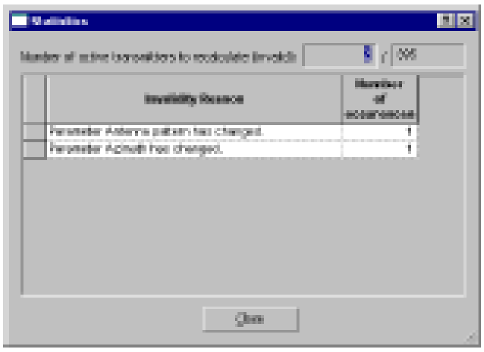

Figure 9.16: Path loss matrix statistics

9.2.10.2 Assigning a Propagation Model

In **Atoll**, you can assign a propagation model globally to all transmitters, to a defined group of transmitters, or a single transmitter. As well, you can assign a default propagation model for coverage predictions. This propagation model is used as for all transmitters where the main propagation model selected is "(Default model)."

Because you can assign a propagation model in several different ways, it is important to understand which propagation model **Atoll** will use:

1. If you have assigned a propagation model to a single transmitter, as explained in "Assigning a Propagation Model to One Transmitter" on page 461, or to a group of transmitters, as explained in "Assigning a Propagation Model to a Group of Transmitters" on page 460, this is the propagation model that will be used.

   The propagation model assigned to an individual transmitter or to a group of transmitters will always have precedence over any other assigned propagation model.

2. If you have assigned a propagation model globally to all transmitters, as explained in "Assigning a Propagation Model to All Transmitters" on page 460, this is the propagation model that will be used for all transmitters, except for those to which you have assigned a propagation model either individually or as part of a group.

> **Important:** When you assign a propagation model globally, you override any selection you might have made to an individual transmitter or to a group of transmitters.

3. If you have assigned a default propagation model for coverage predictions, as described in "Defining a Default Propagation Model" on page 187, this is the propagation model that will be used for all transmitters whose main propagation model is "(Default model)." If a transmitter has any other propagation model chosen as the main propagation model, that is the propagation model that will be used.

In this section, the following are explained:

- "Assigning a Propagation Model to All Transmitters" on page 460
- "Assigning a Propagation Model to a Group of Transmitters" on page 460
- "Assigning a Propagation Model to One Transmitter" on page 461.

Assigning a Propagation Model to All Transmitters

In **Atoll**, you can choose a propagation model per transmitter or globally.

To define a main and extended propagation model for all transmitters:

1. Click the Data tab in the **Explorer** window.
2. Right-click the **Transmitters** folder. The context menu appears.
3. Select **Properties** from the context menu. The **Properties** dialogue appears.
4. Click the Propagation tab.
5. Under **Main Matrix**:
   - Select a **Propagation Model**
   - Enter a **Radius** and **Resolution**.
6. If desired, under **Extended Matrix**:
   - Select a **Propagation Model**
   - Enter a **Radius** and **Resolution**.
7. Click **OK**. The selected propagation models will be used for all transmitters.

> **Note:** Setting a different main or extended matrix on an individual transmitter as explained in "Assigning a Propagation Model to One Transmitter" on page 461 will override this entry.

Assigning a Propagation Model to a Group of Transmitters

Transmitters that share the same parameters and environment will usually use the same propagation model and settings. In **Atoll**, you can assign the same propagation model to several transmitters by first grouping them by their common parameters and then assigning the propagation model.

To define a main and extended propagation model for a defined group of transmitters:

1. Click the Data tab in the **Explorer** window.
2. Right-click the **Transmitters** folder. The context menu appears.
3. Select from the **Group by** submenu of the context menu the property by which you want to group the transmitters. The objects in the folder are grouped by that property.

> **Note:** You can group transmitters by several properties by using the **Group By** button on the Properties dialogue. For more information, see "Advanced Grouping" on page 66.

4. Click the **Expand** button (⊞) to expand the **Transmitters** folder.
5. Right-click the group of transmitters to which you want to assign a main and extended propagation model. The context menu appears.
6. Select **Open Table** from the context menu. The **Transmitters** table appears with the transmitters from the selected group.

   For each transmitter, you can set the propagation model parameters in the following columns:
   - **Main Propagation Model**
   - **Main Calculation Radius**
   - **Main Resolution**
   - **Extended Propagation Model**
   - **Extended Calculation Radius**
   - **Extended Resolution**
7. To enter the same values in one column for all transmitters in the table:
   a. Enter the value in the first row in the column.
   b. Select the entire column.
   c. Select **Edit > Fill > Down** to copy the contents of the top cell of the selection into the other cells.

> **Note:** If you want to copy the contents of the last cell in the selection into all other cells, you can select **Edit > Fill > Up**. For more information on working with tables in **Atoll**, see "Working with Data Tables" on page 50.