CelPlan
Wireless Global Solutions

Better design for a new wireless world

CelPlanner and CelPerformance series 12

For nearly a hundred years telecommunications mainly consisted of voice services and very low speed data (telegraph and telex). With the advent of the Internet, several data services became mainstream in telecommunications, to the point that voice is becoming an accessory to IP-centric data networks.

Today, high-speed data services are already part of our daily lives at work and at home (web surfing, e-mail, virtual private networks, VoIP, virtual meetings, chats...). And the demand for high-speed data services should grow even more with the increasing number of people telecommuting.

Today's engineers have to be masters of multiple trades, as the different specialties converge. The design of a wireless network requires knowledge of business plans, networking, data applications, data protocols, data traffic, RF propagation, multiple wireless technologies, measurement techniques, optimization methodologies amongst many other topics.

CelPlan understands these needs and strives to provide a complete solution to target each of the tasks required to design, optimize, and maintain a wireless network.

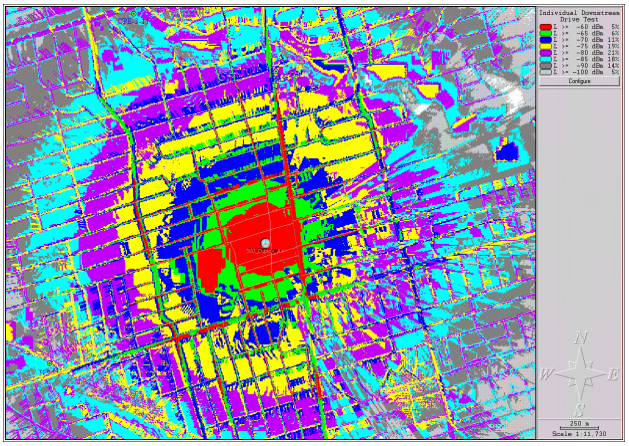
Because operators need to keep up with the increasing demand, legacy networks must be reviewed and optimized to open up spectrum for new technologies.

For this reason, a planning tool needs to support legacy technologies as well as the latest ones.

CelPlanner is a powerful network design tool that allows users to plan and validate most types of wireless networks. Some of the technologies supported by the tool include:

- GSM, GPRS, EDGE
- WCDMA, HSPA, HSPA+
- CDMA, cdma2000, EVDO
- WiFi, WiMAX, LTE (FDD/TDD)
- DVB-H/SH
- LMR/PMR, TETRA, P25
- AMPS, TDMA
- Simulcast/Paging

CelPlanner is the best tool to help operators with the multiple systems existent in a wireless world; including feasibility studies, greenfield network deployment, network expansions, technology overlay, and even traffic offload to smaller cells or alternate networks.

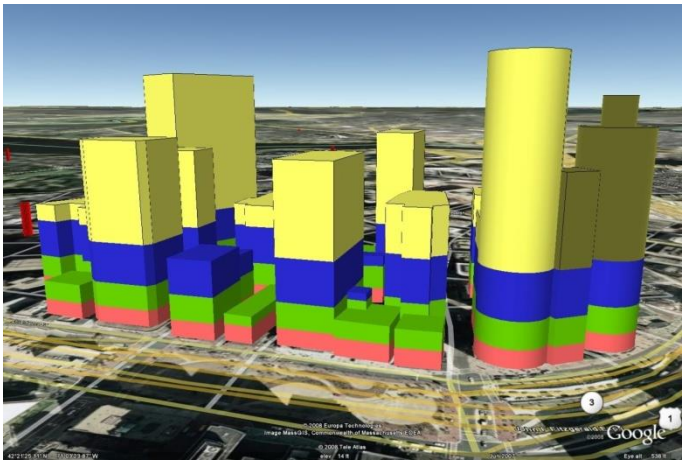


Signal Level Preddiction for Single Site

Many times operators are confronted with issues that can be tackled in different ways and they need to make sure they are choosing a cost-effective approach. CelPlanner capability of analyzing multiple what-if scenarios and comparing them offers users the chance to test solutions before making an actual investment.

Considering that the ultimate assessment of network performance belongs to the end user, CelPlanner executes all analyses through different users perspectives. Operators can assess the network through the eyes of the different types of subscribers they expect to have, be it a fixed rooftop installation or a mobile user.

For urban and dense urban areas where users can be located in different floors of buildings, designers can create analyses layers to see how different coverage and interference will be when compared to ground level users. Not only that but network optimization can be done considering the existence of such different users allowing operators to optimize the system as a whole and not only focus on ground level coverage.



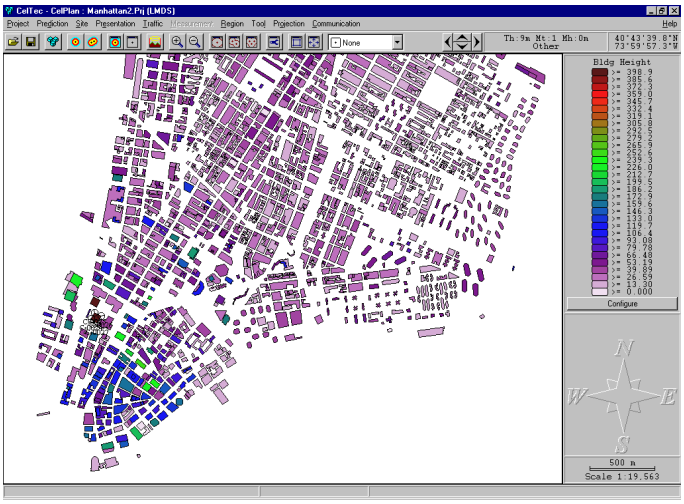
Urban area divided in layers for detailed coverage and interference analysis

BUILT-IN GIS PLATFORM

The fact that our tools have their own integrated GIS platform allows users to combine resolutions, quickly load information and even make adjustments to the database using CelPlan's GIS edition features. CelPlan's specialized GIS platform provides unique features such as:

- Up to 4 topography layers and 4 morphology layers simultaneously supported. This allows users to use multiple resolution files in the same design, with the tool automatically choosing the information with the best available resolution at each location.
- Up to 16 layers of vector files
- Up to 4 layers of images supporting different scales
- Use of Google Maps as background imagery
- Full integration with Google Earth within its multiple visualization windows
- Optional dynamic interpolation of terrain data to provide higher quality and increased resolution
- Height per pixel, i.e. the tool does not use clutter height tables which limit each morphological type to a single height in the whole area; instead, the database stores the height of each pixel, allowing, for example, buildings with their own individual height.

Even though **CelPlan**'s GIS format is proprietary, it is documented and open, thus it can be distributed to any GIS database provider as well as converted to and from other industry formats.



High resolution building database displayed using traffic density as attribute

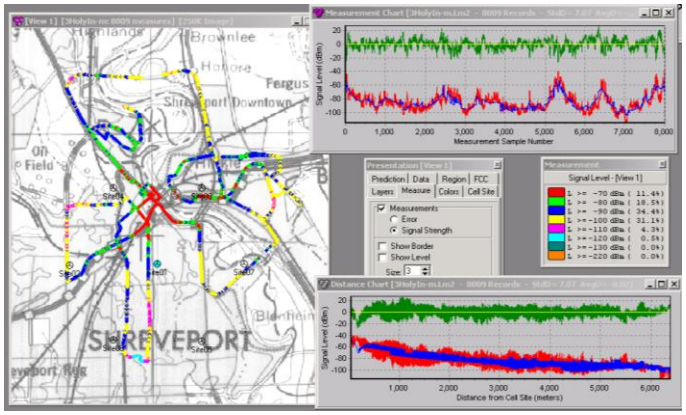
MODEL TUNING

CelPlan provides a unique capability to automatically tune all of its models based on field measurements. The tool uses a properietary algorithm to calculate the optimal propagation parameters for each market.

CelPlan allows users to compare measurements and predictions graphically and statistically, providing many different statistical parameters. This statistical analysis is applied to measurements, predictions, and errors and the difference between measurements and predictions.

The tool also displays measurements, predictions, and errors in sequence of distance and measurement. The geographical display of measurements is synchronized to these graphs thus allowing users to analyze errors and locate them geographically.

The tool also provides several ways to filter collected measurement samples: by distance, by morphology, by power, by noise floor, by error or simply by selecting a certain measurement area with the mouse.



Measurement data loaded on visualization window and collection graphs

ADVANCED PROPAGATION MODELS

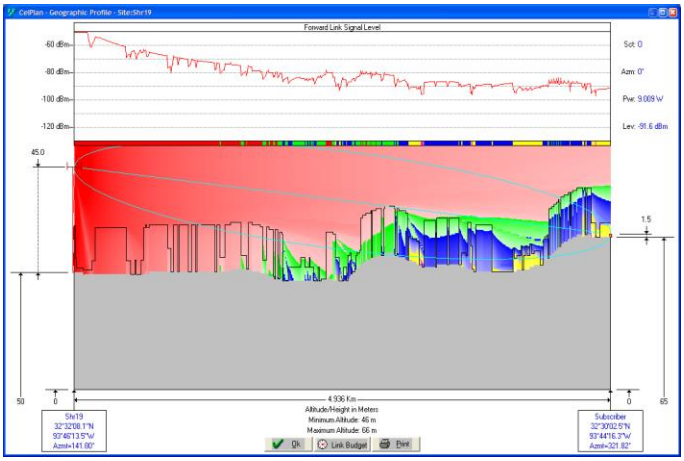
Classical propagation models consider the role that morphology plays in RF propagation by changing some of the model parameters, but a single category is used for the whole area. Extensions of these models, such as the general model, consider a single morphology type per path or, in more recent implementations, a single morphology per receiver location.

This implies that a parameter used to characterize a propagation path applies to a mix of morphologies and, because this mix varies significantly between paths, it cannot properly represent all mixes. Only single morphology sites can be properly represented by these traditional methods. Every site has to be measured to adjust the predictions and, even so, only average values can be adjusted, presenting large variations for individual points.

Aware of this issue CelPlan Technologies developed a fractional morphology method that considers the effect of different morphologies in the propagation path. In this method, propagation parameters are assigned to morphologies (instead of cells/sectors) and can be reused for new sites and new areas. This method can be applied to any of the classical propagation models using single or multiple slopes.

Traditional propagation models also fail to address many situations encountered in a wireless network, such as: antenna heights much higher or smaller than the surrounding morphology, effect of canyons (streets), the dual slope dichotomy caused situations in which the loss is not the same when the transmitter and receiver were reversed, small cells, indoor and multi-floor signals.

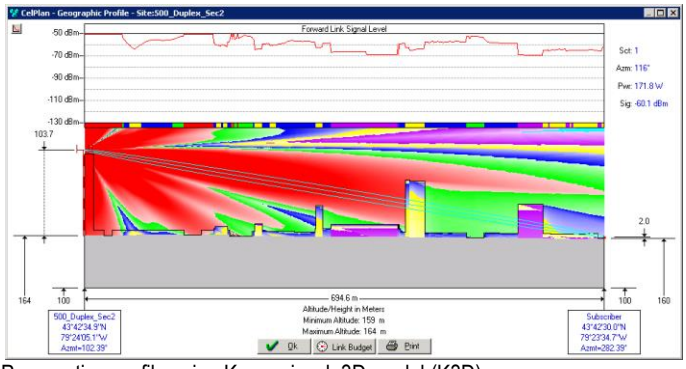
CelPlan's approach copes with all these issues with our K2D and K3D models.



Propagation profile using Korowajczuk 2D model (K2D)

The K2D model considers the signal progating directly from transmitter to receiver but also over obstructions, i.e. the height of the multiple clutter types is considered during path loss analysis. With this, users can then predict behind buildings, see the signal propagation on streets and avenues, and analyze multiple heights of users.

The Korowajczuk 2D model requires the availability of good terrain data bases with at least carved streets and average morphology heights.



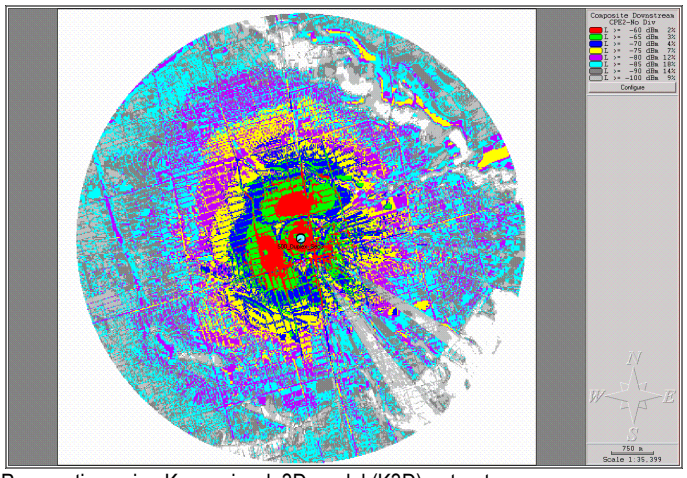
Propagation profile using Korowajczuk 3D model (K3D)

Building on top of this model, CelPlan published the K3D model which performs a true three dimentional analysis of the path loss by considering the inclined horizontal plane between transmitter and receiver. That is, three possible propagation paths are considered and the sum of them is used as the result. This model allows

detailed predictions that account for the presence of high, isolated buildings.

Additionally, certain morphologies, such as residential areas and single tree lines, do not add diffraction losses and should not be considered in diffraction calculations. The morphology based diffraction is applied only to morphologies specified by the designer and each of these morphologies has its own diffraction factor multiplier.

The model also supports up to three breakpoints, which allows for a better adjustment to changing environments. These break points are defined by the user based on measurement slopes in the area or in similar areas.

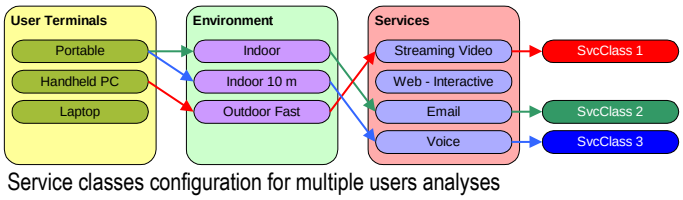


Propagation using Korowajczuk 3D model (K3D) - street canyons

ANALYSES FOR MULTIPLE TYPES OF USERS

CelPlanner supports up to 32 user-defined Service Classes that can be used for coverage and capacity analyses. The tool allows users to create Service Classes by selecting from libraries of Terminal Types, Environment Definitions, and Service Configurations. All libraries come with initial configurations. Users may edit them or add their own configurations.

Once the libraries are created users can then create Service Classes by assigning each component to the specified Service Class as illustrated on the diagram below:



Service classes configuration for multiple users analyses

Predictions for multiple Service Classes containing different user terminals, environments, and service configurations are executed simultaneously, which improves productivity when users are attempting to model the effects of multiple floors or multiple service thresholds.

The system generates predictions for all Service Classes, allowing users to visualize eac h of them by selecting the prediction type and Service Class to be presented. Users can choose whether resources optimization and cell footprint enhancement should consider a single class or mutliple classes.

DETAILED TRAFFIC AND KPI ANALYSIS

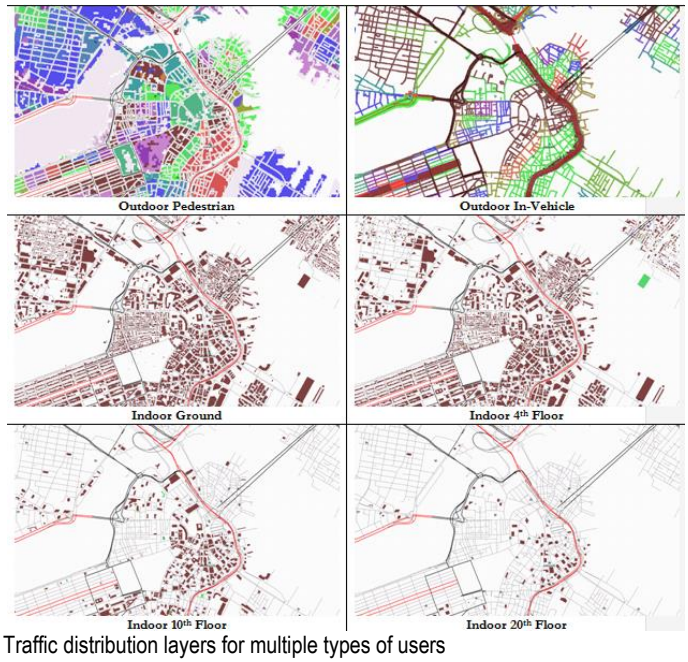
CelPlan provides complete support to perform the most complex traffic analysis in wireless networks. These analyses are essential for dimensioning, planning and performance evaluation of wireless networks.

Users can generate traffic layers from a pre defined traffic value, based on region attributes (e.g. households, population) or, for existing networks, based on best server sector traffic.

Furthermore, traffic can be uniformly or not uniformly distributed, i.e. using factors to specify how traffic is distributed between morphologies.

The traffic information can be used for capacity requirement calculations using a Bin-by-Bin method or a Monte Carlo Call Placement Simulation. Traffic can be calculated in Erlang for voice or in Mbps for data.

Traffic is associated with each service class, thus different types of users can have different demand, with different patterns, and in different locations.



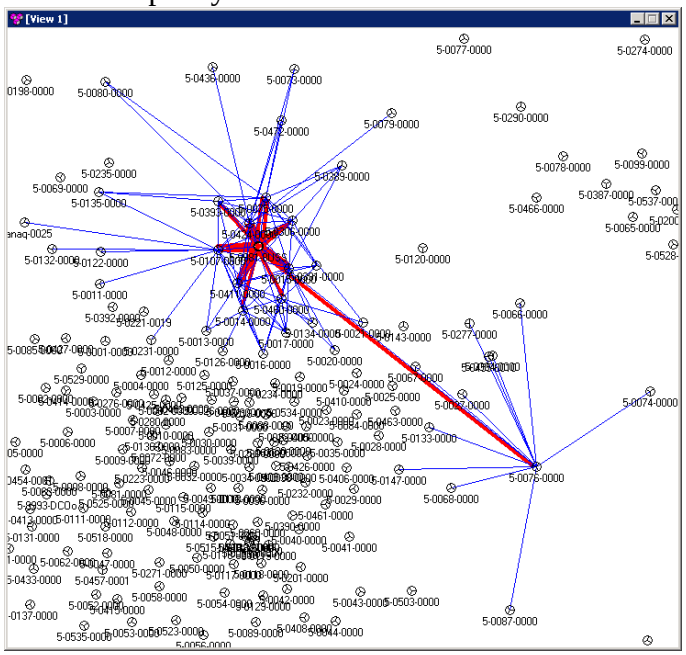
Traffic distribution layers for multiple types of users

RESOURCE PLANNING AND FOOTPRINT ENHANCEMENT

CelPlanner also provides outstanding interference analysis by calculating the outage for a certain C/I. The calculation of this outage is done by weighting the interference with traffic to express real life situations. Neighborhood and handoff thresholds are automatically calculated.

The tool allows planing of frequencies, analyses of fractional frequency reuse, as well as the multiple codes and resources required in the different wireless technologies (e.g. BSIC, PermBase, CellID, PN offset).

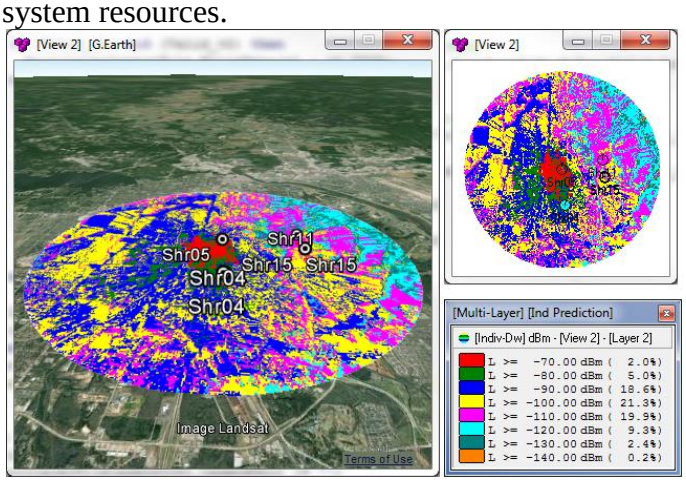
Wireless systems are always implemented with some overlap between cells to allow spectrum reuse. The overlap aids call-handoff from one cell to another. Certain technologies may benefit from this overlap through diversity. However, overlapping also increases interference and, consequently, may diminish capacity.



Network neighborhood analyses - first and second tier neighborhood

Achieving the proper amount of overlap while simultaneously minimizing interference is a very daunting task. Maintaining coverage while minimizing interference is an important step to significantly increase capacity. The tool automatically shapes cell footprints to simultaneously minimize interference (considering diversity effects), maintain the same coverage, and balance traffic.

Designers can shape cell footprints by adjusting one or more parameters. Our software analyzes all selected parameters on a sector-by-sector basis and chooses the footprint that minimizes the use of system resources.



Prediction displayed in synchronized MultiWindow environment

The tool analyzes the following parameters:

- Antenna Type
- Antenna Tilt
- Antenna Azimuth
- Antenna Height
- Radiated Power

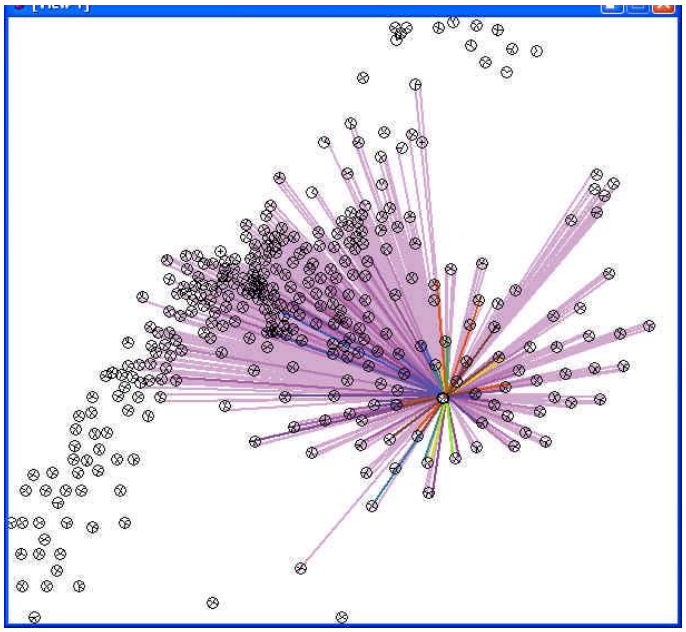
The tool allows users to prioritize or prohibit changes to these parameters on a sector-by-sector basis. Users can specify the parameters changes for each sector, their relative priority, and the acceptable value range for each modification. The software will analyze the network and adjust each sector to minimize its overlap without compromising traffic coverage beyond the user-specified percentage. Finally, the tool lists the proposed changes and reports the gains achieved. The project is then ready for optimization of frequencies and resources.

Additional constraints are defined when determining the range of valid values for each parameter. This limits the calculations made by the tool to a range of values that are acceptable to the carrier standards.

For greenfield systems, the tool offers a cell selection analysis, which uses a collection of candidate sites and considers several criteria to determine the most cost effective layout for the network.

The selection process:

- Allows cost assignment on a per candidate basis.
- Prioritizes for best coverage at lowest cost.
- Considers traffic layer.
- Considers backhaul connections (unique), checks line-of-sight among sites.
- Considers maximum capacity limit per site and inter-cell overlap.



Interference relationship matrix weighted by neighborhood and traffic

The tool expressly supports backhaul feasibility analysis as part of the site selection algorithm.

After cell footprint is optimized and the best layout of sites is selected, designers can use CelPlan's unique approach for resource planning, addressing the following areas:

- Automatic neighbor determination for different types of neighborhood (RF, topological, and handoff)
- Automatic Interference Relationship Matrix generation with traffic weighted relations for best servers and handoff servers. The matrix can be generated based on predictions, measurements, switch data or a combination of them.
- Automatic Resource Assignment, which provides the best assignments according to network requirements and user pre-set conditions
- Automatic handoff/handover thresholds calculation

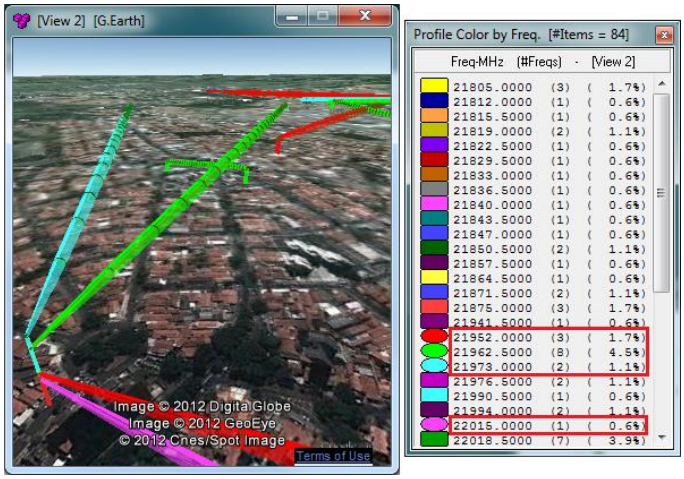
When creating frequency plans, the tool allows users to:

- Plan all channels or only part of them, meaning that previous plans can be expanded or partially modified.
- Block any channel or set of channels on a sector basis. Channel blocking patterns can be used to avoid repetitive typing.
- Freeze sites so neighbor sites and locked sites are considered on the analysis but are no replanned.
- Use combiner spacing on a sector basis.
- Plan the complete requirements or stop planning if certain user specified conditions happen.
- Use frequency channel groups or ad hoc planning specifying minimum reuse distance.

INTEGRATED BACKHAUL PLANNING

The tool offers a fully integrated backhaul design solution. Users can create backhaul links between end points that are exclusive to the backhaul network or between cells and fixed subscribers from the cellular network. The links are displayed as a layer on top of the cellular network and can be turned off when not needed.

Interference analyses can be run per link, for a group of links or for the network as a whole. The tool supports ITU recommendations, offering features such as built-in rain and refractivity gradient maps with automatic parameter selection option.



Backhaul network shown with Google Earth background