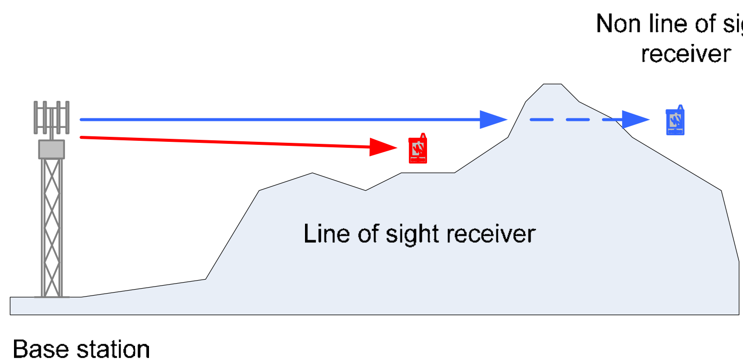
Types of Terrain Database

Accurate prediction of radio coverage and the potential for interference at specific positions on the Earth's surface is dependent upon having good information about the characteristics of the location under study. In particular, radio wave propagation will depend to a large degree upon the terrain (such as the hills and valleys) and also the clutter (such as buildings and vegetation). To model these within tools that analyse radio systems it is therefore necessary to have access to databases that contain information about the terrain and clutter.

But where can this data be found and what are the different types of terrain and surface databases? This White Paper describes some of the key attributes of terrain databases, such as resolution, type, reference geoid etc, and also identifies where some of these databases can be found on the web.

1 Introduction

One of the factors that can influence the strength of a received signal, whether wanted or interfering, is the terrain between the transmitter and the receiver. For example consider the scenario in the figure below.



The base station is transmitting to two mobiles: the red one is in line of sight but the blue one is on the other side of a hill and so the signal will be reduced or attenuated due to diffraction loss.

In this and other similar scenarios, the signal received depends upon the terrain characteristics along the path from the transmitter.

But where can we get this terrain data and is all terrain data the same?

2 Types of Data

Terrain data is almost always stored in a database arranged in a grid of spot heights, where the grid can be aligned with lines of latitude and longitude, or with a local reference frame, such as the National Grid in the UK.

However there are important differences that need to be taken into account when using terrain data for radio communications analysis.

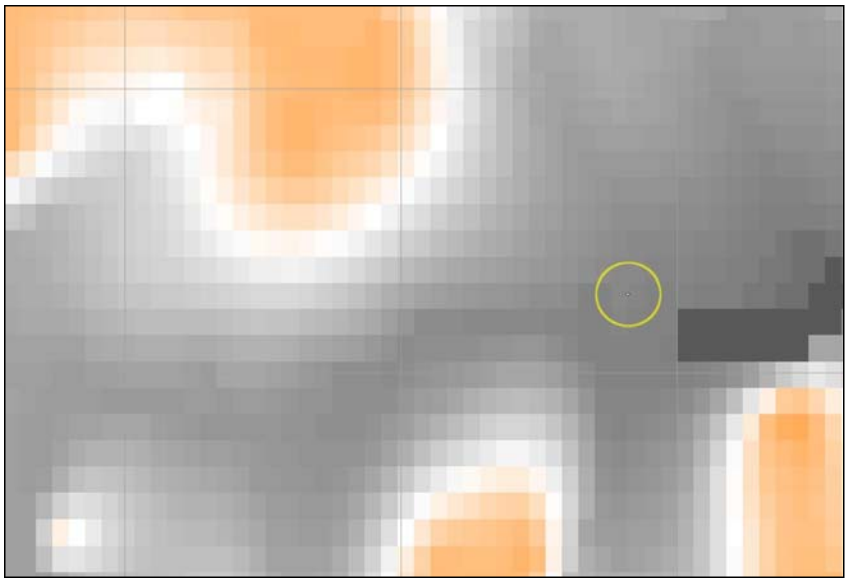
2.1 Resolution

The first and most important characteristic is the resolution of the terrain data. This is the spacing between the spot heights and the higher the resolution (i.e. the smaller the distance between samples) the better.

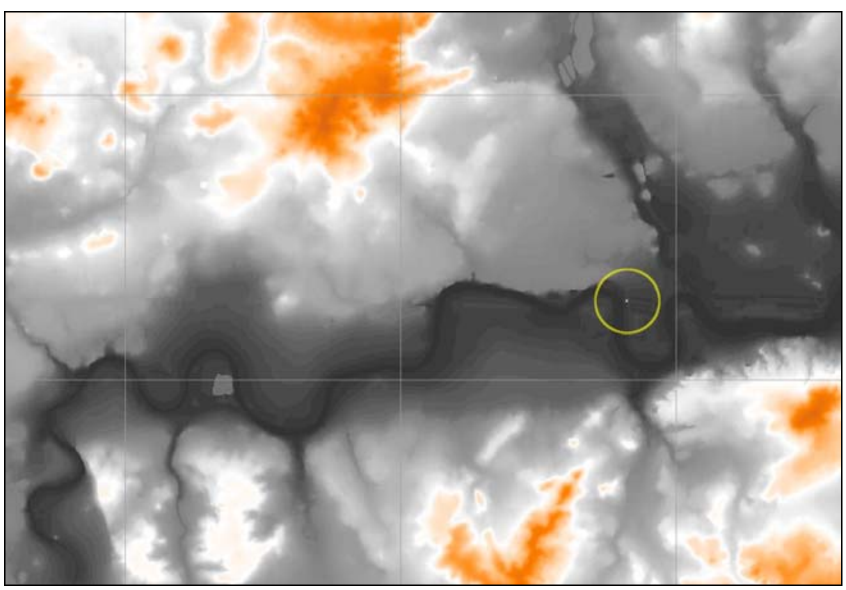
For example consider the following two figures made using Visualyse Professional which show the topography around London using different resolution terrain databases.

To help with comparison with later figures, the circle shows the location of London's Docklands and the grid lines are spaced every 10 km. In addition all use the same colour scheme.

GTOPO30: a 30 arc second i.e. 900m terrain database:



Ordnance Survey terrain data, sampled every 50m:

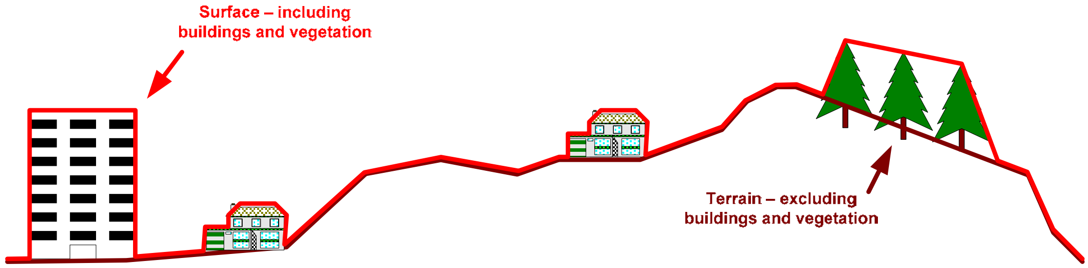


It can be seen that the latter is significantly higher resolution and would give much more accurate predictions.

However the higher resolution data also requires significantly greater memory and so for analysis over large areas it can be better to use the lower resolution data, or to use high resolution data only for around the transmit and receive sites.

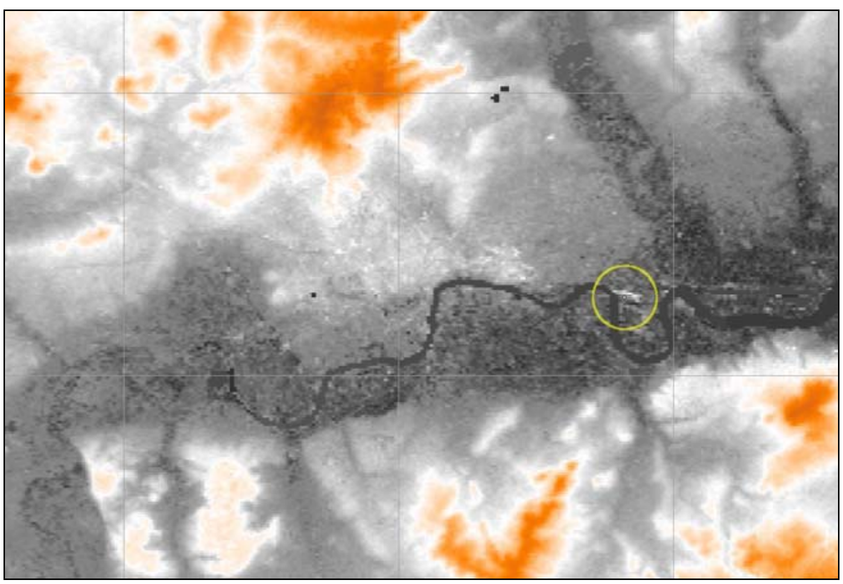
2.2 Terrain vs. Surface

Another difference to be aware of is between terrain and surface data. Terrain data excludes objects like buildings and vegetation that sits upon the terrain while surface database includes it, as in the figure below.



The figure below uses a surface database taken by radar from a Space Shuttle mission. It contains measurements of where the radar waves are reflected, which could be terrain but also be from structures like buildings sitting on the terrain. This data is freely available and can be downloaded from the USGS web site.

SRTM Surface Database, sampled every 3 arc seconds i.e. 90m:



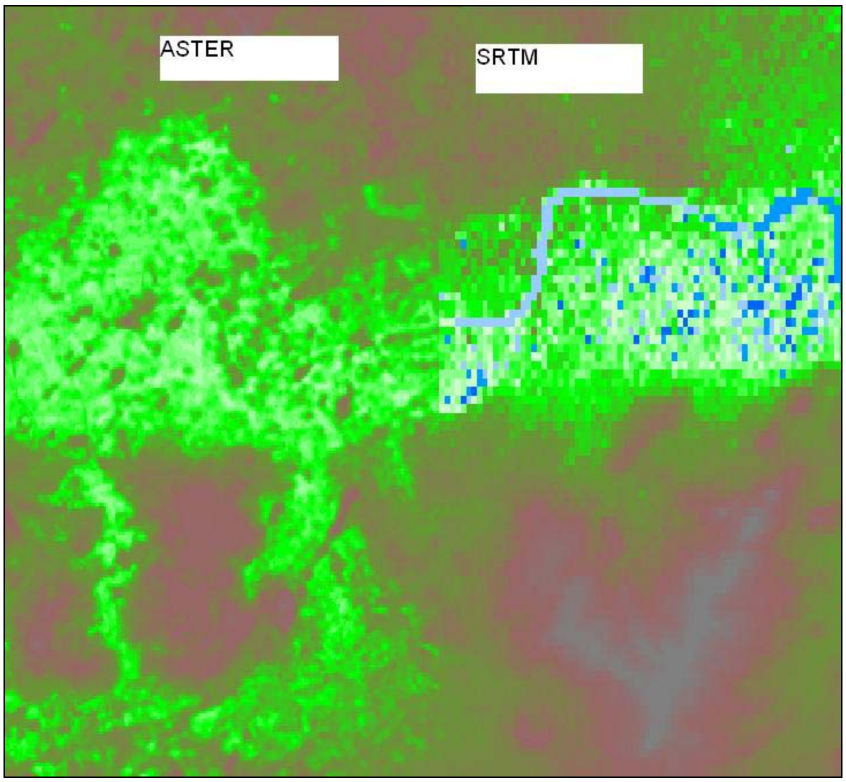
Additional features can be seen which include roads, railways, and buildings. The circled feature is the Docklands development to the east of London. It can be seen that there are structures in white, which are the large office towers, which are not shown in the previous OS database, which excludes surface objects like buildings.

Using surface data can improve the accuracy of predictions as the radio waves will actually propagate over the surface rather than the terrain. However to significantly improve accuracy this can require much higher resolution – such as use of LIDAR whereby surface data with resolutions of under 5m can be generated.

Note that use of a clutter database should be combined with a terrain but *not* a surface database. This is to avoid the double counting that can come from modelling the additional loss due to buildings twice.

2.3 Quality of Data

Noise and resolution can be a problem, in particular for surface databases. For example the ASTER dataset, which is currently in beta release, should be "better" than SRTM as it is provided in 30 m resolution rather than 90 m outside the US. However noise means the actual quality of the data is probably lower as can be seen in the figure below.



The SRTM is to the right and the Thames can be picked out. However on the ASTER data to the left while the pixels are small it is much harder to pick out this significant geographic feature due to the greater noise or variation in height at each pixel.

Indeed the validation report on the ASTER web page[1] noted that "*ASTER GDEM is not as sharp as the SRTM DTED2 and appears to contain less spatial detail*." It concluded "*the spatial detail resolvable by the ASTER GDEM, at least of the data tested, is slightly better than 120m*."

[1] http://asterweb.jpl.nasa.gov/gdem.asp

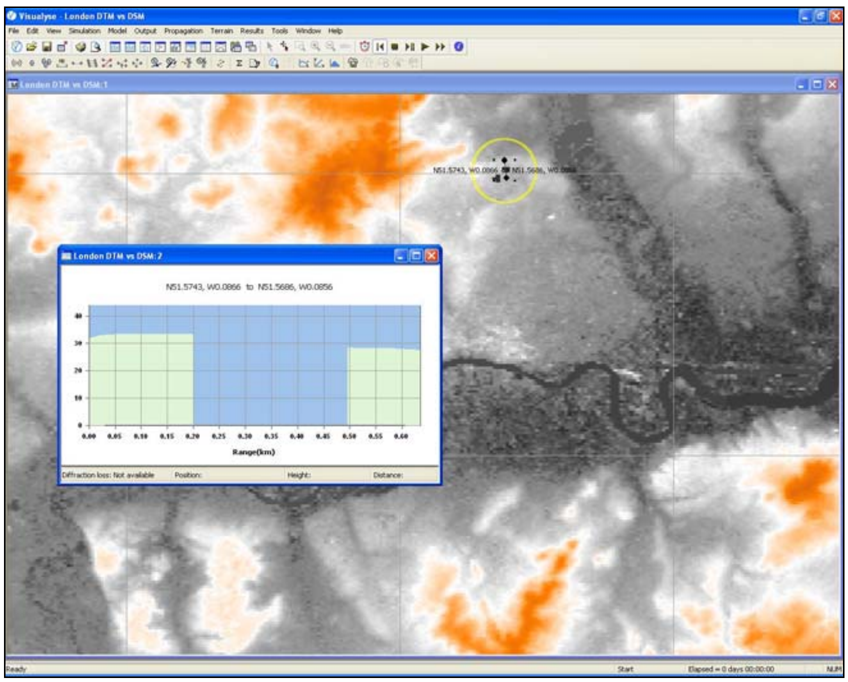
2.4 Database Coverage Restrictions

Some database can be restricted in range. For example the UK Ordnance Survey 50m database only covers mainland Britain, and so wouldn't be helpful elsewhere.

The SRTM database has wider coverage, though there are two known limitations. Firstly it is only available between 60°S and 60°N in latitude. Secondly due to gaps between Space Shuttle ground tracks and processing errors, there are a number of holes in the data.

For example in the SRTM graphic of London below there is circled one of a number of black spots to the north of the centre. If you take a path profile through these areas it can be seen that within them the height drops to zero: this does not occur in reality!

Data hole in SRTM Surface database:



2.5 Reference Geoids

A final point to be aware of is that different terrain databases can use different Earth geoids and the locations of stations entered should be consistent with the reference frame used for terrain data.

For example consider the figure below which compares the SRTM terrain data with the RadDEM for part of the Australian south coast along the Great Ocean Road[2]:

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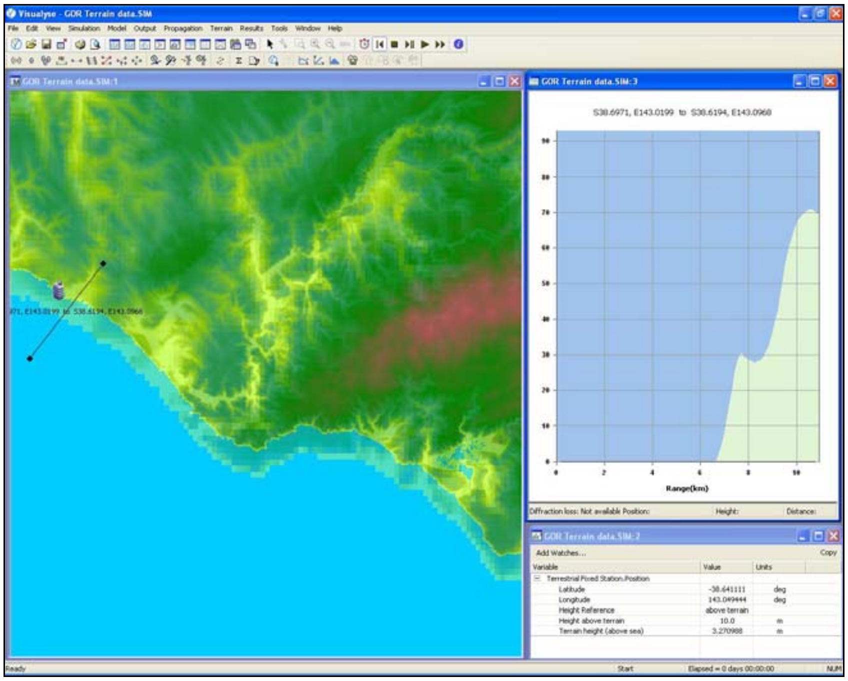
[2] See http://en.wikipedia.org/wiki/Great_ocean_road

SRTM vs. RadDEM terrain databases:



The two databases are using different reference geoids, namely:

- SRTM: WGS84 / GPS coordinate system
- RadDEM: Australian Geodetic Datum 66 (AGD66)

These result in a slight offset of the coastline. Marked on the figure is the location of the structure called the Twelve Apostles using the GPS coordinates from Wikipedia which in reality is just offshore: it can be seen to align well with SRTM rather than RadDEM.

Note also that different geoids can also have different reference zero height points.

More information about WGS84 and reference geoids can be found online in articles such as this one:

http://en.wikipedia.org/wiki/WGS84

3 Sources of Data

This section describes some of the most popular terrain databases: contact us for more information or if you have any suggestions of additional data sources.

We have split this section into two sub-sections that give examples firstly of global databases and then some national databases.

3.1 Global Databases

3.1.1 USGS GTOPO 30

The United States Geological Survey (USGS) Global Topographic database is a relatively old database that give world-wide coverage but at low resolution. Its 30 arc second grid corresponds to about 900 m, which too low for most applications.

It does have some advantages in that it can be used to model large areas without excessive memory requirements. It can therefore be feasible to combine fine resolution terrain data immediately around specific sites and then user lower resolution data over larger distances. This approach is described in more detail below.

The USGS web site for downloading GTOPO30 data is:

http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30_info

3.1.2 USGS SRTM Level 1

USGS SRTM Level 1 is a 3 arc second (about 90m) global land masses terrain database covering locations below 60 degrees in latitude. The world is split into tiles of size 1° by 1°. Sea and land masses are not given in the main database but a separate 900 MB sea and water body database (SWBD). The reference geoid is WGS 84 and the data is described further at this web site:

http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/SRTM

Both the terrain database and SWBD can be downloaded from the USGS seamless web site (see NED data below) or at:

http://edcsns17.cr.usgs.gov/NewEarthExplorer/

Note that we at Transfinite have a version of SRTM processed together with SWBD to take account of land / sea boundaries and hence can be loaded faster into our Visualyse Professional study tool.

3.1.3 ASTER

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data is available from the NASA Warehouse Inventory Search Tool (WIST) site at:

https://wist.echo.nasa.gov/wist-bin/api/ims.cgi?mode=MAINSRCH&JS=1

It is a 30m global surface database in GeoTIFF format using WGS84 reference frame. A validation report gives the estimated accuracies as 20 meters at 95 % confidence for vertical data and 30 meters at 95 % confidence for horizontal data.

As noted above, it has less resolution and greater noise than the SRTM dataset. However it is available for latitudes greater than 60° which is the limit of SRTM.

3.2 National Databases

3.2.1 National Elevation Dataset (NED)

This is a terrain database for the United States and at most locations in a range of resolutions including 30m, 10m and in some locations 3m while for Alaska the resolution is 60m. The reference geoid is the North American Datum of 1983 (NAD 83).

NED data can be downloaded from in a number of formats including GeoTIFF from:

http://seamless.usgs.gov/

3.2.2 USGS SRTM Level 2

USGS SRTM Level 3 – 1 arc second (about 30m) for the United States of America for latitudes below 60° North. It can be downloaded from the same source as the USGS SRTM Level 1 and uses the WGS84 reference frame.

3.2.3 UK Ordnance Survey

This dataset is available for free download from this web address:

https://www.ordnancesurvey.co.uk/opendatadownload/products.html

The "Land-form Panorama" dataset is relatively old, dating from 1980 but relatively good quality (low noise) and 50 m terrain resolution.

A range of download options are available such as DTM grid format which use the UK's National Grid to define the locations of tile corners.

3.2.4 RAD DEM

This database covers Australia and is available for a small charge in CDROM format from the Australian Communications and Media Authority (ACMA) at:

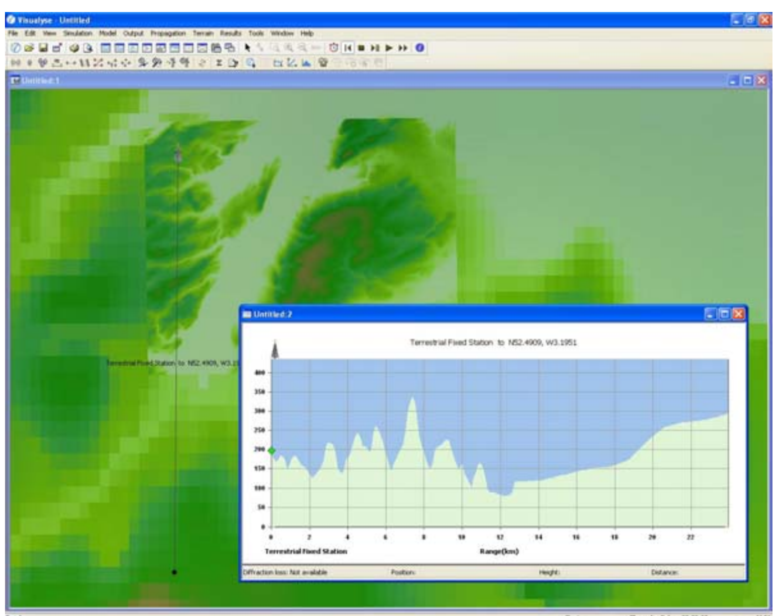
http://www.acma.gov.au/WEB/STANDARD/pc=PC_1613

Contact Transfinite for more information about using this dataset within Visualyse Professional.

4 Combining Databases

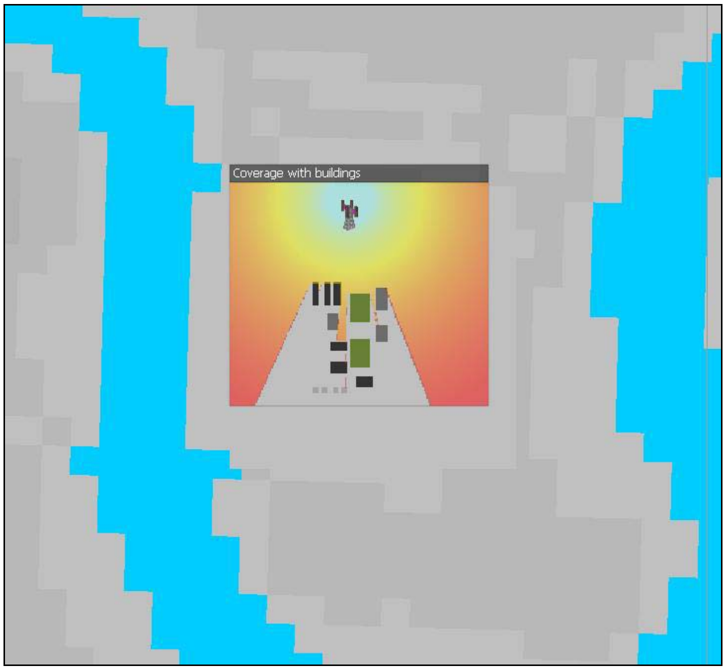
You needn't be restricted to a single terrain database. For example you might want very high resolution terrain data in the vicinity of the transmitter / receiver, but it would require excessive memory to continue with the same resolution all along the path.

An example can be seen in the figure below where a high resolution terrain region is overlaid on top of a larger low resolution terrain region. The path profile can be seen to be highly detailed at the start and be less detailed when it crosses into the lower resolution area.



This feature can be used to model locations in high detail to specify objects such as buildings. A surface (i.e. terrain plus buildings) database can be created and read into simulation tools overlaid upon a terrain database (i.e. excluding buildings). This high resolution surface data could be generated by using LIDAR measurements or generated from building databases.

An example of this is shown below using Visualyse Professional where 50 m terrain data of London is combined with a user generated tile defining buildings to a resolution of 5 m



5 Contact Transfinite

If you have any questions about terrain and surface databases, please contact us at:

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