

NAME

splat – A Surface Path Length And Terrain analysis tool

SYNOPSIS

splat [-t *transmitter_site.qth*] [-r *receiver_site.qth*] [-c *coverage_area_in_miles (float)*] [-p *terrain_profile.ext*] [-e *elevation_profile.ext*] [-o *topographic_map_filename.ppm*] [-b *cartographic_boundary_filename.dat*] [-s *site/city_database.dat*] [-d *sdf_directory_path*] [-n] [-N]

DESCRIPTION

SPLAT! is a simple, yet powerful terrain analysis tool written for Unix and Linux-based workstations. **SPLAT!** is free software. Redistribution and/or modification is permitted under the terms of the GNU General Public License as published by the Free Software Foundation, either version 2 of the License or any later version. Adoption of **SPLAT!** source code in proprietary or closed-source applications is a violation of this license, and is *strictly* forbidden.

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INTRODUCTION

SPLAT! analyzes point-to-point terrestrial RF communication paths as well as the service area of transmitters and repeater systems, providing data useful to communication system designers and site engineers. **SPLAT!** provides great circle distances, bearings, antenna elevation angles (uptilt), depression angles (downtilt), antenna height above mean sea level, antenna height above average terrain, bearings and distances to known obstructions, as well as minimum antenna height requirements needed to establish geometric line-of-sight communication paths absent of obstructions due to terrain. **SPLAT!** produces reports, graphs, and highly detailed and carefully annotated topographic maps depicting line-of-sight paths and expected coverage areas of transmitters and repeater systems. In situations where multiple transmitter or repeater sites are employed, **SPLAT!** determines individual as well as mutual areas of coverage within the network specified.

INPUT FILES

SPLAT! is a command-line driven application, and reads input data through files accessible through a workstation's filesystem. Several different types of files are used by the program. Each has its own format. Some files are mandatory for successful execution of the program, while others are optional. Among the mandatory files are SPLAT Data Files (SDF files) and site location files (QTH files). Optional files include city/site location files, and cartographic boundary files.

SPLAT DATA FILES

SPLAT! imports topographic data in the form of SPLAT Data Files (SDFs) that may be generated from a number of information sources. In the United States, SPLAT Data Files are most often derived from U.S. Geological Survey Digital Elevation Models (DEMs) using the **usgs2sdf** utility included with **SPLAT!**. USGS Digital Elevation Models compatible with this utility are available at no cost via the Internet at: http://edcwww.cr.usgs.gov/glis/hyper/guide/1_dgr_dem#dem7.

SPLAT Data Files contain topographic elevations to the nearest meter above mean sea level for 1-degree by 1-degree regions of the earth with a resolution of 3-arc seconds. SDF files can be read in either standard format (*.sdf*) as generated by the **usgs2sdf** utility, or in bzip2 compressed format (*.sdf.bz2*). Since uncompressed files can be slightly faster to load than compressed files, **SPLAT!** searches for the needed SDF data in uncompressed format first. If such data cannot be located, then **SPLAT!** tries to read the data in bzip2 compressed format. If no compressed SDF files can be found for the region requested, **SPLAT!** assumes the region is over water or outside the United States, and will assign an elevation of sea-level to these areas. This feature of **SPLAT!** makes it possible to perform path analysis not only over land, but also between coastal areas not represented by USGS Digital Elevation Model Data since they are void of any land masses. However, this behavior of **SPLAT!** underscores the importance of having all the SDF files required for the region being analyzed if meaningful results are to be obtained.

SITE LOCATION (QTH) FILES

SPLAT! imports site location information of transmitter and receiver sites analyzed by the program from ASCII files having a *.qth* extension. QTH files contain the site's name, the site's latitude (in degrees North), the site's longitude (in degrees West), and the site's antenna height above ground level (AGL). A single linefeed character separates each field. The antenna height is assumed to be specified in feet unless followed by the letter *m* or the word *meters* in either upper or lower case. Latitude and longitude information may be expressed in either decimal format (40.9608333) or degree, minute, second (DMS) format (40 57 39.0).

For example, a site location file describing Edwin Armstrong's radio tower in Alpine, New Jersey (*alpine.qth*) might read as follows:

```
Alpine Tower
40 57 39.0
73 55 23.0
400.0
```

Each transmitter and receiver site analyzed by **SPLAT!** must be represented by its own site location (QTH) file.

CITY LOCATION FILES

The names and locations of cities, tower sites, or other points of interest may imported and be plotted on topographic maps generated by **SPLAT!**. **SPLAT!** imports the names of cities and locations from ASCII files containing the location's name, the location's latitude, and the location's longitude. Each field is separated by a comma. Each record is separated by a single linefeed character. As was the case with the *.qth* files, latitude and longitude information may be entered in either decimal or degree, minute, second (DMS) format.

For example (*cities.dat*):

```
Burlington, 40.074412, 74.854062
Butler, 41.000950, 74.343019
Caldwell, 40.839879, 74.276621
Califon, 40.721236, 74.836147
Camden, 39.938583, 75.110875
Cape May Court House, 39.081392, 74.810071
Cape May Point, 38.937679, 74.965657
```

A total of five separate city data files may be imported at a time. There is no limit to the size of these files. **SPLAT!** reads city data sequentially, and plots only those locations whose positions do not conflict with previously plotted locations.

City data files may be generated manually using any text editor, imported from other sources, or derived from data available from the U.S. Census Bureau using the **citydecoder** utility included with **SPLAT!**. Such data is available free of charge via the Internet at: http://www.census.gov/geo/www/cob/bdy_files.html, and must be in ASCII format.

CARTOGRAPHIC BOUNDARY DATA FILES

Cartographic boundary data may also be imported to plot the boundaries of cities, counties, or states on topographic maps generated by **SPLAT!**. Such data must be of the form of ARC/INFO Ungenerate (ASCII Format) Metadata Cartographic Boundary Files, and are available from the U.S. Census Bureau via the Internet at: <http://www.census.gov/geo/www/cob/co2000.html#ascii> and <http://www.census.gov/geo/www/cob/pl2000.html#ascii>. A total of five separate cartographic boundary files may be imported at a time. It is not necessary to import state boundaries if county boundaries have already been imported.

PROGRAM OPERATION

SPLAT! is invoked via the command-line using a series of switches and arguments. Since **SPLAT!** is a CPU and memory intensive application, this type of interface minimizes overhead, and also lends itself well to scripted operations and user-defined scheduling priority (using the Unix **nice** command). The number and type of switches passed to **SPLAT!** determine its mode of operation and method of output data generation. Nearly all of **SPLAT!**'s switches may be cascaded in any order on the command line when invoking the program to include all the features described by those switches when performing an analysis.

POINT-TO-POINT ANALYSIS

SPLAT! may be used to perform terrain analysis between two specified site locations. For example:

```
splat -t tx_site.qth -r rx_site.qth
```

invokes a terrain analysis between the transmitter specified in *tx_site.qth* and receiver specified in *rx_site.qth*, writes a **SPLAT!** Obstruction Report to the current working directory, and displays it to the console. The report contains details of the transmitter and receiver sites, and identifies the location of any obstructions detected during the analysis. If an obstruction can be cleared by raising the receive antenna to a greater altitude, **SPLAT!** will indicate the antenna height required for a geometric line-of-sight path to exist between the transmitter and receiver locations specified. If the antenna must be raised a significant amount, this determination can take some time.

The *.qth* extensions are assumed by **SPLAT!**, and are optional when invoking the program. **SPLAT!** automatically reads all SPLAT Data Files necessary to conduct the terrain analysis between the sites specified. By default, the location of SDF files is assumed to be in the current working directory unless a *.splat_path* file is present under the user's home directory. If this file is present, it must contain the full directory path to all the SDF files required by **SPLAT!** to perform its analysis for the region containing the transmitter and receiver sites specified. The path in this file must be of the form of a single line of ASCII text:

```
/opt/splat/sdf/
```

and may be generated with any text editor. The default path specified in the *\$HOME/.splat_path* file may be overridden at any time using the *-d* switch:

```
splat -t tx_site -r rx_site -d /cdrom/sdf/
```

A graph of the terrain profile between the receiver and transmitter locations as a function of distance from the receiver can be generated by adding the *-p* switch:

```
splat -t tx_site -r rx_site -p terrain_profile.gif
```

SPLAT! invokes **gnuplot** when generating graphs. The filename extension specified to **SPLAT!** determines the format of the graph produced. *.gif* will produce a 640x480 color GIF graphic file, while *.ps* or *.postscript* will produce postscript output. Output in formats such as PNG, Adobe Illustrator, AutoCAD dxf, LaTeX, and several dozen other formats are available. Please consult **gnuplot**, and **gnuplot**'s documentation for details on all the supported output formats.

A graph of elevations subtended by the terrain between the receiver and transmitter as a function of distance from the receiver can be generated by using the *-e* switch:

```
splat -t tx_site -r rx_site -e elevation_profile.gif
```

The graph produced using this switch illustrates the elevation and depression angles resulting from the terrain between the receiver's location and the transmitter site from the perspective of the receiver's location. A second trace is plotted between the left side of the graph (receiver's location) and the location of the transmitting antenna on the right. This trace illustrates the elevation angle required for a line-of-sight path

to exist between the receiver and transmitter locations. If the trace intersects the elevation profile at any point on the graph, then this is an indication that a line-of-sight path does not exist under the conditions given, and the obstructions can be clearly identified on the graph at the point(s) of intersection.

A topographic map may be generated by **SPLAT!** to visualize the path between the transmitter and receiver sites from yet another perspective. Topographic maps generated by **SPLAT!** display elevations using a logarithmic grayscale, with higher elevations represented through brighter shades of gray. The dynamic range of the image is scaled between the highest and lowest elevations present in the map. The only exception to this is sea-level, which is represented in blue.

SPLAT! generated topographic maps are 24-bit TrueColor Portable PixMap (PPM) images, and may be viewed, edited, or converted to other graphic formats by popular image viewing applications such as **xv**, **The GIMP**, **ImageMagick**, and **XPaint**. PNG format is highly recommended for lossless compressed storage of **SPLAT!** generated topographic output files. An excellent command-line utility capable of converting PPM graphic files to PNG files is **wpng**, and is available at: <http://www.libpng.org/pub/png/book/sources.html>. As a last resort, PPM files may be compressed using the bzip2 utility, and read directly by **The GIMP** in this format. Topographic output is specified using the *-o* switch:

```
splat -t tx_site -r rx_site -o topo_map.ppm
```

The *.ppm* extension on the output filename is assumed by **SPLAT!**, and is optional.

In this example, *topo_map.ppm* will illustrate the locations of the transmitter and receiver sites specified. In addition, the great circle path between the two sites will be drawn over locations for which an unobstructed path exists to the transmitter at a receiving antenna height equal to that of the receiver site (specified in *rx_site.qth*).

It may be desirable to populate the topographic map with names and locations of cities, tower sites, or other important locations. A city file may be passed to **SPLAT!** using the *-s* switch:

```
splat -t tx_site -r rx_site -s cities.dat -o topo_map
```

Up to five separate city files may be passed to **SPLAT!** at a time.

County and state boundaries may be added to the map by specifying up to five U.S. Census Bureau cartographic boundary files using the *-b* switch:

```
splat -t tx_site -r rx_site -b co34_d00.dat -o topo_map
```

In situations where multiple transmitter sites are in use, as many as four site locations may be passed to **SPLAT!** at a time for analysis:

```
splat -t tx_site1 tx_site2 tx_site3 tx_site4 -r rx_site -p profile.gif
```

In this example, four separate terrain profiles and obstruction reports will be generated by **SPLAT!**. A single topographic map can be specified using the *-o* switch, and line-of-sight paths between each transmitter and the receiver site indicated will be produced on the map, each in its own color. The path between the first transmitter specified to the receiver will be in green, the path between the second transmitter and the receiver will be in cyan, the path between the third transmitter and the receiver will be in violet, and the path between the fourth transmitter and the receiver will be in sienna.

DETERMINING REGIONAL COVERAGE

SPLAT! can analyze a transmitter or repeater site, or network of sites, and predict the regional coverage for each site specified. In this mode, **SPLAT!** can generate a topographic map displaying the geometric line-

of-sight coverage area of the sites based on the location of each site, and the height of receive antenna wishing to communicate with the site in question. **SPLAT!** switches from point-to-point analysis mode to coverage mode when the *-c* switch is invoked as follows:

```
splat -t tx_site -c 30.0 -s cities.dat -b co34_d00.dat -o tx_coverage
```

In this example, **SPLAT!** generates a topographic map called *tx_coverage.ppm* that illustrates the predicted regional coverage of *tx_site* to receiving locations having antennas 30.0 feet above ground level (AGL). The contents of *cities.dat* are plotted on the map, as are the cartographic boundaries contained in the file *co34_d00.dat*.

When invoked in coverage mode, **SPLAT!** generates a site report for each station analyzed. **SPLAT!** site reports contain details of the site's geographic location, its height above mean sea level, the antenna's height above mean sea level, the antenna's height above average terrain, and the height of the average terrain calculated in the directions of 0, 45, 90, 135, 180, 225, 270, and 315 degrees azimuth.

DETERMINING MULTIPLE REGIONS OF COVERAGE

SPLAT! can also display coverage areas for as many as four separate transmitter sites on a common topographic map. For example:

```
splat -t site1 site2 site3 site4 -c 30.0 -o network.ppm
```

plots the regional coverage of site1, site2, site3, and site4 based on a receive antenna located 30.0 feet above ground level, and writes a topographic map to the file *network.ppm*. In the map generated, the coverage area of the transmitters are plotted as follows in the colors indicated (along with their corresponding RGB values in decimal):

```
site1: Green (0,255,0)
site2: Cyan (0,255,255)
site3: Medium Violet (147,112,219)
site4: Sienna 1 (255,130,71)

site1 + site2: Yellow (255,255,0)
site1 + site3: Pink (255,192,203)
site1 + site4: Green Yellow (173,255,47)
site2 + site3: Orange (255,165,0)
site2 + site4: Dark Sea Green 1 (193,255,193)
site3 + site4: Dark Turquoise (0,206,209)

site1 + site2 + site3: Dark Green (0,100,0)
site1 + site2 + site4: Blanched Almond (255,235,205)
site1 + site3 + site4: Medium Spring Green (0,250,154)
site2 + site3 + site4: Tan (210,180,140)

site1 + site2 + site3 + site4: Gold2 (238,201,0)
```

If separate *.qth* files are generated, each representing a common site location but a different antenna height, a single topographic map illustrating the regional coverage from as many as four separate locations on a single tower may be generated by **SPLAT!**.

TOPOGRAPHIC MAP GENERATION

In certain situations, it may be desirable to generate a topographic map of a region without plotting coverage areas or line-of-sight paths or generating obstruction reports. There are two ways of doing this with **SPLAT!**. If one wishes to generate a topographic map illustrating the location of a transmitter and receiver site along with a brief text report describing the locations and distances between the sites, the *-n* switch should be invoked as follows:

```
splat -t tx_site -r rx_site -n -o topo_map.ppm
```

If no text report is desired, then the *-N* switch is used:

```
splat -t tx_site -r rx_site -N -o topo_map.ppm
```

If the *-o* switch and output filename are omitted when using either the *-n* or *-N* switches, output is written to a file named *map.ppm* in the current working directory by default.

DETERMINATION OF ANTENNA HEIGHT ABOVE AVERAGE TERRAIN

SPLAT! determines antenna height above average terrain (HAAT) according to the procedure defined by Federal Communications Commission Part 73.313(d). According to this definition, terrain elevations along eight radials between 2 and 10 miles (3 and 16 kilometers) from the site being analyzed are sampled and averaged for each 45 degrees of azimuth starting with True North. If one or more radials lie entirely over water, or over land outside the United States (areas for which no USGS topography data is available), then those radials are omitted from the calculation of average terrain. If part of a radial extends over a body of water or over land outside the United States, then only that part of the radial lying over United States land is used in the determination of average terrain.

When performing point-to-point terrain analysis, **SPLAT!** determines the antenna height above average terrain only if enough topographic data has already been loaded by the program to perform the point-to-point analysis. In most cases, this will be true, unless the site in question does not lie within 10 miles of the boundary of the topography data in memory.

When performing coverage analysis, enough topography data is normally loaded by **SPLAT!** to perform average terrain calculations. Under such conditions, **SPLAT!** will provide the antenna height above average terrain as well as the average terrain above mean sea level for azimuths of 0, 45, 90, 135, 180, 225, 270, and 315 degrees, and include such information in the site report generated. If one or more of the eight radials surveyed fall over water or land outside the United States, **SPLAT!** reports *No Terrain* for those radial paths.

SETTING THE MAXIMUM SIZE OF AN ANALYSIS REGION

SPLAT! reads SDF files into a series of memory "slots" as required within the structure of the program. Each "slot" holds one SDF file. Each SDF file represents a one degree by one degree region of terrain. A *#define MAXSLOTS* statement in the first several lines of *splat.c* sets the maximum number of "slots" available for topography data. It also sets the maximum size of the topographic maps generated by **SPLAT!**. *MAXSLOTS* is set to 9 by default. If **SPLAT!** produces a segmentation fault on start-up with this default, it is an indication that not enough RAM and/or virtual memory (swap space) are available to run **SPLAT!** with this number of *MAXSLOTS*. In this case, *MAXSLOTS* may be reduced to 4, although this will greatly limit the maximum region **SPLAT!** will be able to analyze. If 118 megabytes or more of total memory (swap space plus RAM) is available, then *MAXSLOTS* may be increased to 16. This will permit operation over a 4-degree by 4-degree region, which is sufficient for single antenna heights in excess of 10,000 feet above mean sea level, or point-to-point distances of over 1000 miles.

ADDITIONAL INFORMATION

Invoking **SPLAT!** without any arguments will display all the command-line options available with the program, as well as a brief summary of each.

The latest news and information regarding **SPLAT!** software is available through the official **SPLAT!** software web page located at: <http://www.qsl.net/kd2bd/splat.html>.

FILES

```
$HOME/.splat_path
```

User-generated file containing the default path to the directory containing the SDF data files.

AUTHOR

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