SAF
Path Calculator
User Guide V1.0

Overview

The present User Guide describes the SAF Tehnika proprietary Path Calculator - a point-to-point radio link calculation tool designed to calculate various parameters, essential for planning and installing the digital microwave data transmission systems, e.g. link availability, fade margin, received signal level, etc. This guide is organized in three steps that are accompanied by pictures and comments.

The Path Calculator assists system designers in selecting the equipment with appropriate specifications, considering the climatic conditions, necessary link capacity and available site coordinates. The Path Calculator provides an opportunity to choose between wide range of operating frequencies, equipment configuration options and operating parameters in order to establish reliable and efficient data transmission.

The Path Calculator is based on the ITU-R recommendation P.530-11 and is designed as a web tool. The web based Path Calculator replaces the previous Path Calculator version that was implemented in Microsoft Excel.

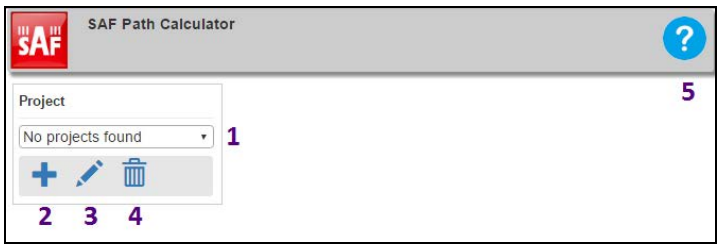
Prior to proceeding with a calculation, some parameter values should be known in advance:

- Distance between the antenna sites or geographic coordinates of the sites
- Antenna height above ground level
- Required link capacity
- Required frequency and channel bandwidth
- Confirmed LoS (Line of Sight) and Fresnel zone clearance

When the calculation is complete, it is possible to make a judgement, whether the selected parameters (link availability, fade margin, received signal level, etc.) ensure necessary system performance, considering the needs of the customer. If the customer requires better availability or fade margin, it is possible to choose different antennas or antenna sizes, channel bandwidth, modulation, radio output power, or a different operating frequency, so that the desired parameter values are achieved.

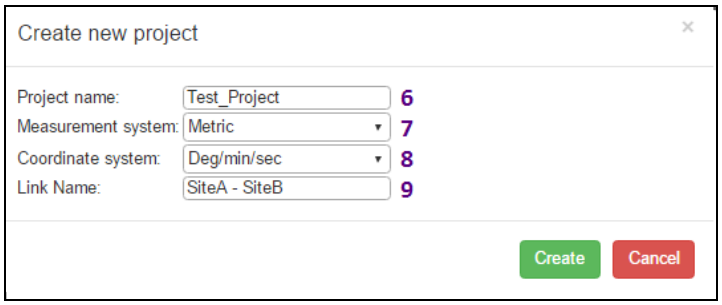
First Step - Creating a Project

Open the Path Calculator (https://www.saftehnika.com/PathCalc/calculator.php) and begin a new project by clicking on the "**+**" button.



1. Select from the list of available projects.
2. Create a new project.
3. Edit the selected project.
4. Delete the selected project.
5. Show the list of ITU-R recommendations followed by Path Calculator.

A new window will be opened. Fill in the fields and click "Create". This will create a new project with a single radio link.

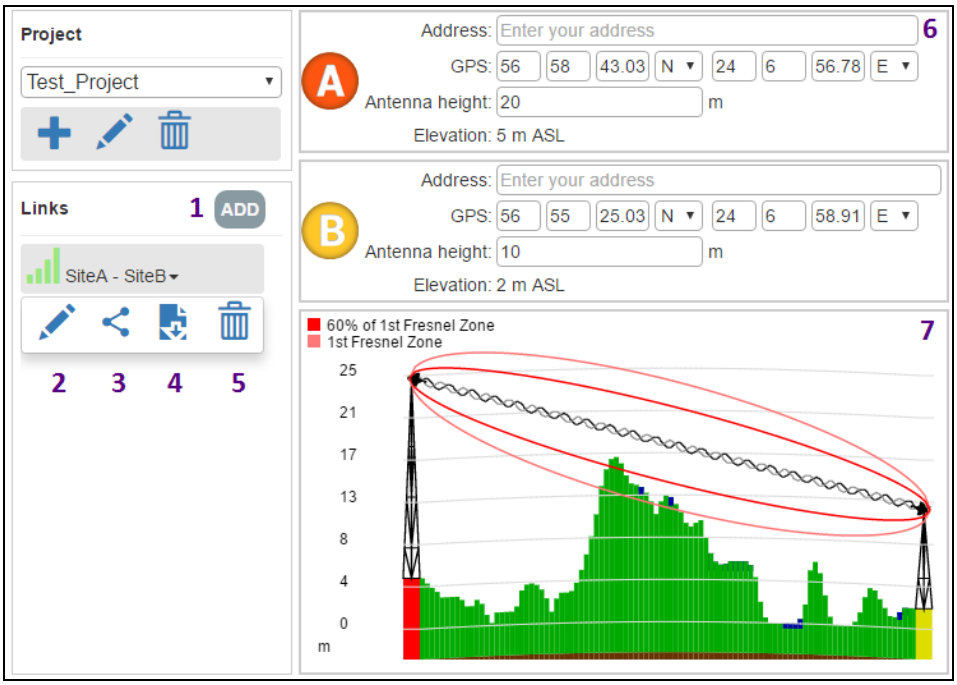


6. Enter the project name.
7. Select the measurement system of the project.
8. Select the coordinate system of the project.
9. Enter the radio link name.

Second Step – Creating a Link

When the project is created, the Path Calculator page will appear with the settings and results for the default link. In order to create your custom link, you will need to input your specific values and make the appropriate choices from the drop-down lists.

Creating a link with the Path Calculator is straightforward, but a brief description for each field is given below.



1 Add links to the selected project.

2 Edit the name of the link.

3 Generate and share a hyperlink for the selected link.

4 Download the link calculation report in PDF format.

5 Delete the selected link.

6 Enter "A" and "B" site information.

- **Address** – Google Maps address, in case precise coordinates are unknown.
- **GPS** – site coordinates.

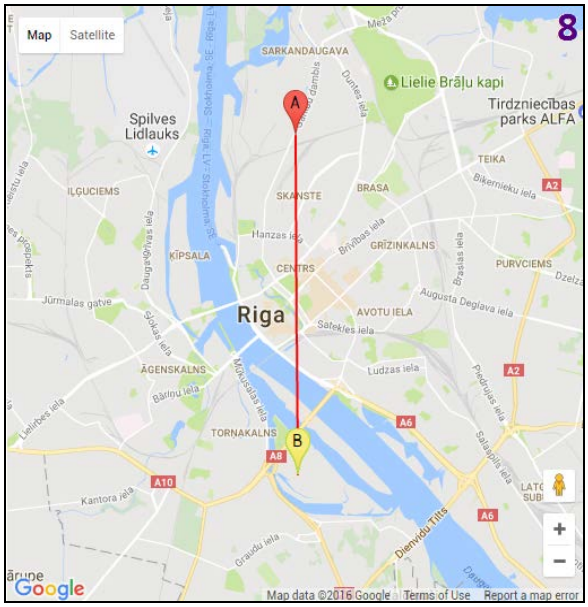
> In case "Decimal degree" format is used, North and East hemispheres are marked positive (+), while South and West hemispheres are marked negative (-).

- **Antenna height** – height above ground level.
- **Elevation** – site ground elevation above sea level.

7 Profile view.

- **Ground profile** is based on Google Maps API data.
- **1st Fresnel zone** 100% and 60% areas are shown.

> Path Calculator doesn't include diffraction losses due to obstructions, so it is necessary to visually assess 60% clearance of the Fresnel zone.



8 Top view. This view is projected on an embedded Google map. Here are useful tips:

- Change site coordinates by manually dragging site markers.
- Switch to "Satellite" view to find sites visually (tower/building/etc) and place markers more precisely.
- Click somewhere along the link in Profile view - ground elevation will be shown on a Top view map.

9 Distance between two sites.

10 Enter distance manually, but note that site "B" coordinates will be changed.

11 Indication of Fresnel zone obstruction by ground. In case there are obstructions to the inner 60% of the 1st Fresnel zone - received signal will be weakend. This must be monitored visually, because Path Calculator doesn't take diffraction losses into account when calculating RSL (dBm). Indications:

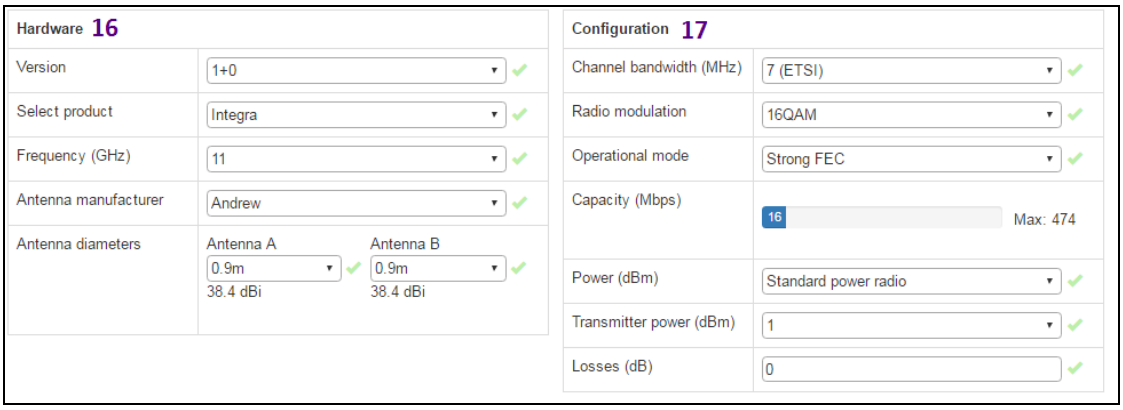
- **"60% of the 1st Fresnel zone…"** - obstructions to the inner 60% of the 1st Fresnel zone.
- **"1st Fresnel zone…"** - obstructions to the 1st Fresnel zone.
- **No indication** - 1st Fresnel zone is clear from obstructions.

12 Enter the regional rain rate. This value can be looked up in the rain rate reference (**14**) or ITU-R P.837-4 recommendation. Note that this rain rate is not equal to widely used monthly average (mm/h) or annual precipitation (mm).

13 Enter regional temperature. This value can be looked up in the temperature reference (**15**).

14 Rain rate reference.

15 Temperature reference.



16 Select your hardware.

- **Version** – hot standby protection or frequency/space diversity.
- **Select product** – SAF product to be used.
- **Frequency (GHz)** – operating frequency.
- **Antenna manufacturer** – select antenna brand. All possible options are: *Integrated*, *Andrew*, *LEAX Arkivator*, *Tongyu*, *RFS*, *Grante*, *Jirous*, *Aerial* and *RSA-10Y*. Available options will depend on radio product selected.
- **Antenna diameters** – ranges from 0.3m to 4.6m. Antenna gain will vary with the size and manufacturer selected.

17 Configure your link.

- **Channel bandwidth (MHz)** – ranges from 0.25MHz to 112MHz. It is selected based on the license from the local regulator. A wider bandwidth allows achieving higher capacities.
- **Radio modulation** – ranges from 4QAM to 2048QAM. It is recommended to design a link with the highest modulation possible, considering ACM (Adaptive Coding and Modulation) availability at lower modulations.

> ACM is hitless for Integra/-S/-W/-WS/-G/-GS, CFIP Lumina, CFIP PhoeniX, CFIP PhoeniX C, CFIP Marathon II, CFIP-106/108 and FreeMile 17/24.

- **Operational mode** – optimization of forward error correction (FEC). Strong FEC will optimize for better sensitivity (and therefore link stability), Weak FEC – for higher capacity.
- **Capacity (Mbps)** – indicates resulting link capacity according to bandwidth, modulation and FEC operational mode chosen out of maximum available for the selected product.
- **Power** – select from standard, high or very high power radio options (if available for the selected product).
- **Transmitter power (dBm)** – select transmitter output power.
- **Losses (dB)** – enter any additional losses that must be included.

Third Step – Getting Results

After the link information is entered, hardware and configurations are chosen, calculated received signal level will be displayed in **Signal Quality** section. Click "Calculate" to get more detailed results on link performance.

Signal Quality

	Threshold	Results
RSL (dBm)	-86.5 1	-51.28 2
RSSI (V)		0.77 3
Fade margin (dBm)		35.22 4
EIRP (dBm)		39.4 5

1 Received signal level threshold (dBm). This shows the lowest acceptable signal level for this radio, bandwidth and modulation.

2 Received signal level (dBm). This is the calculated signal level.

3 RSSI (V) value corresponds to calculated received signal level. RSSI (V) is necessary to perform precise antenna alignment using a voltmeter/multimeter connected to RSSI port.

4 Fade margin (dB) is the difference between RSL threshold and RSL calculated value.

5 EIRP (dBm) is the system's radiated power. It is dependent on transmitter power, line losses and antenna's gain.

Availability

	Vertical	Horizontal
Annual multipath availability (%) 6	100	100
Annual rain availability (%) 7	100	100
Annual multipath + rain availability (%) 8	100	100
Unavailability time per year (HH:MM) 9	0:00	0:00

This table gives calculated link availability for cases of both vertical and horizontal polarization. Annual availability is the percentage of time in a year when link is not experiencing outages due to rain attenuation, multipath effect or both.

6 Only outages due to multipath effect are considered.

7 Only outages due to rain attenuation are considered.

8 Outages due to both multipath effect and rain attenuation are considered.

9 Total outage time in a year due to either rain attenuation or multipath effect.

Availability per Modulation 10

Modulation	Capacity, Mbps	TX power, dBm	Availability vert. (%)	Availability hor. (%)	Fade margin, dB
4QAM Strong FEC	8	26	100	100	66.72
16QAM Strong FEC	16	25	100	100	59.22
32QAM Strong FEC	20	24	100	100	55.22
64QAM Strong FEC	27	23	100	100	51.22
128QAM Strong FEC	33	23	100	100	47.22
256QAM Strong FEC	39	22	100	100	43.22
256QAM Weak FEC	41	22	100	100	41.22

10 This table gives link performance results for all available modulations. This is especially useful when ACM function is used. In addition to link performance, highest transmission powers (dBm) and link capacities (Mbps) are also shown.