ONLINE
LINK BUDGET CALCULATOR

USER MANUAL

It is recommended to use desktop computer or laptop.
This calculator is not optimized for smartphones.

For inquiries related to the use of this calculator, please contact us by E-mail: sales@elva-1.com
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1. Link Budget Calculation for E-band, Q-band and Ka-band

1.1 General information

To calculate the energy budget of ELVA-1 radio links, also called the "link budget" an online calculator has been developed by ELVA-1 team.

ELVA-1 calculator is available for free without registration at http://pathcalc.elva-1.com/.

April 2020 update:

- http://linkbudgetcalc.elva-1.com/ new version of calculator featured with ability to save your results as PDF, also Passloss 5 software users could download ELVA-1 radios data files for Passloss 5.

1.2 Evaluate or Accurately Calculate

You can use the calculator in two possible ways:

• **Estimated mode** — calculate link budget without entering the exact coordinates of installation points, just by approximate distance. The rain zone is determined also approximately from the map by pressing **ITU rain zone** button. Select link model and rain zone, enter distance between radios and get estimated availability and other parameters.

• **Accurate calculation mode** - calculate link budget with exact coordinates of installation points. Use precipitation level taken accordingly to International Telecommunication Union (ITU) methodology.

To estimate the link budget, select link model and rain zone, enter distance and press **Calculate** button to get the numbers of estimated availability and other parameters. To understand the data in the results table, see below section "How to understand the results of link budget calculation".

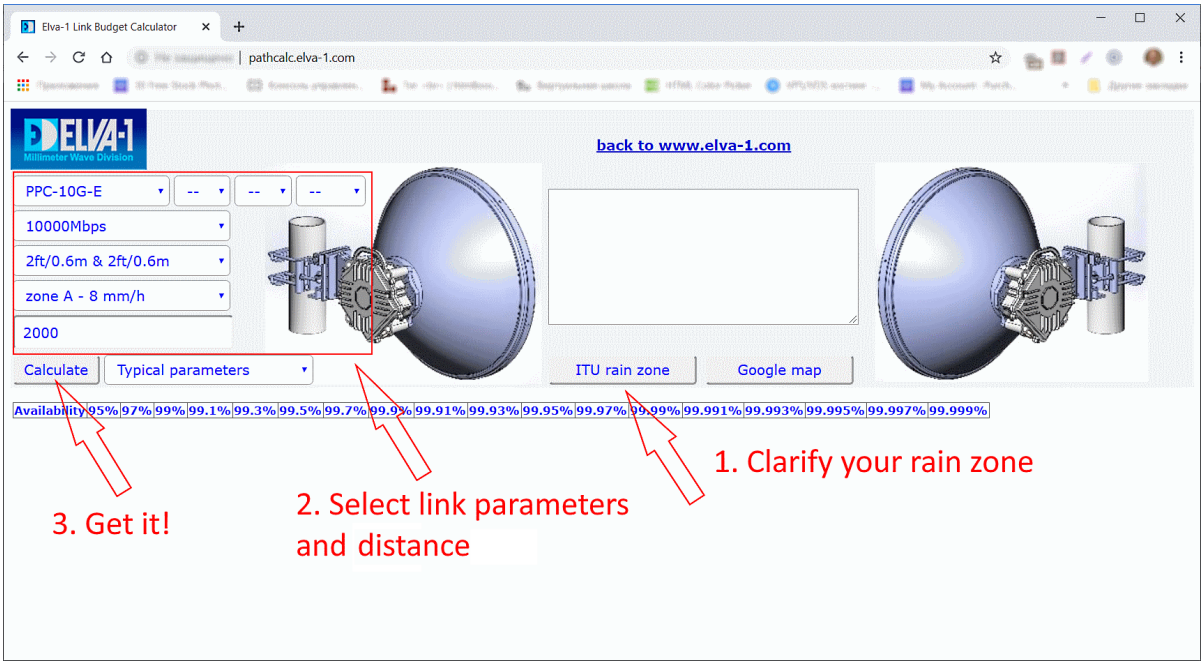


Fig.1. Three steps to calculate estimated availability of your wireless link

1.3 Link Budget Precise Calculation — Steps to Do

1. Get to the calculator webpage http://pathcalc.elva-1.com/.

2. Press **Google map** button first. Map window will open with Google map and panel for entering the coordinates of the installation points A and B. For better user experience, the test path of ELVA-1 link in Tallinn, Estonia has already been shown as an example on the map. You can now just re-enter points of installation on the left panel according to your link.

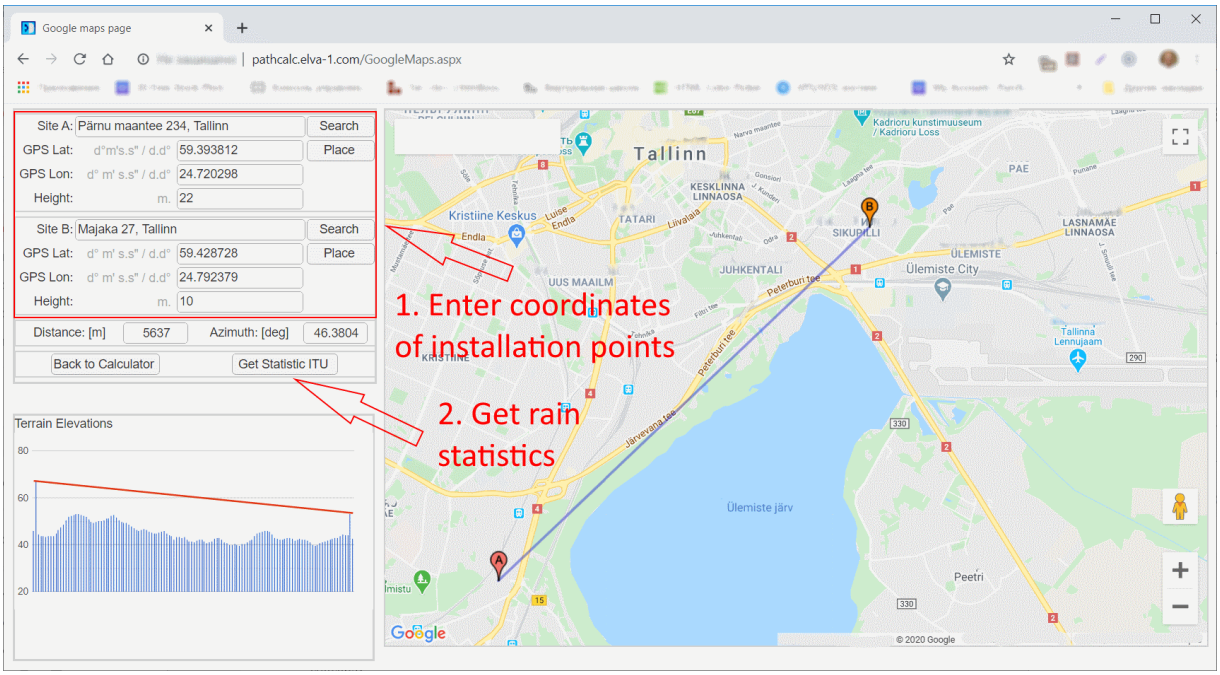


Fig. 2. Window with Google map to enter points of installation

3. Enter the coordinates of point A of your data. There are three ways to enter points from the map to the panel

- Type the post address of point A in **Site A** line and click **Search** buton.
- Type GPS coordinates.
- Drag the marker "A" on the map to your real coordinates (this may not be the best choice if your link is far from the test link).

In all above cases, the system will ask for confirmation that the selected point is correct.

Below is an example:

a. Enter the address of your first installation point in the **Site A** line.

b. Click **Search** button, the map would adjust to your installation point A.

c. Using the **+** button on the map (or using the mouse wheel on the PC, or expanding the map on the touch screen), increase the map scale to the maximum, set the marker exactly in the place of the building where the radio is actually mounted and click **Place** button. A confirmation dialog box will arise, click **OK**, then coordinates of point A will be automatically filled in to the panel.

d. Enter the height of the radio from the ground at point A.

e. Repeat steps a - d for point B. The **Distance (m)** will be calculated as the accurate length of the wireless path.

f. Check that in the **Terrain Elevation** window there is no intersection of the red line of sight and the surface profile. If this happens, look to increase the height of one radio or both of them.

Attention: the surface profile on the map does not take into account the presence of artificial structures (buildings, etc) on the line of sight.

4. Next, an assessment has to be made of the effect of rainfall throughout the year. To do this, press the **Get Statistics ITU** button (see Fig. 2). A new window will open (Fig. 3) with a map of the planet and a statistically accurate amount of precipitation on your particular wireless path with a probability of 0.01%. Remember or write down the precipitation value (the topmost digit in the left panel, for example, 22 mm/h will be indicated). Close this window with the rain zones.

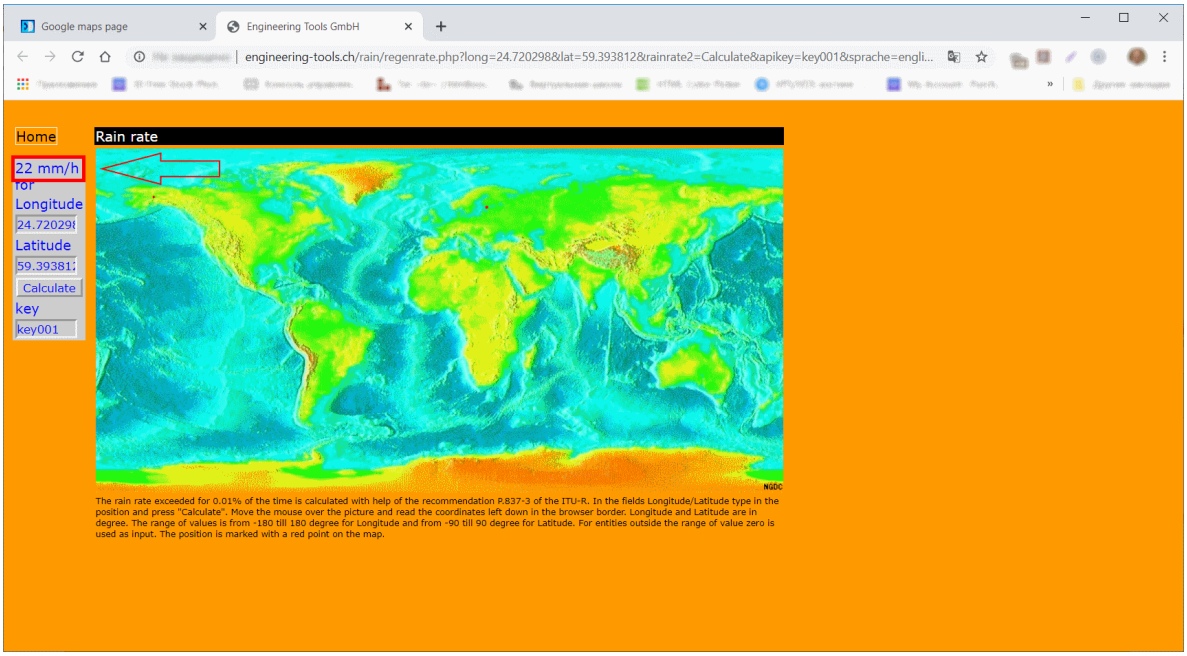


Fig. 3. Remember or write down the precipitation value for your link path

Rain zones show the probability of rainfall of varying intensity and their duration at the installation site. ITU Recommendations divide the planet into 15 zones, designated from A to Q, in which the intensity of precipitation during the year with a probability of 0.01% is chosen as a marker.

5. Click the **Back to Calculator** button. This window will be closed, and the distance of the link path from the Google map will be entered in the corresponding line on the main screen.

6. In the drop-down list of rain zones, select the zone closest in value to the rainfall in Fig. 3. For example, it was indicated something like 24 mm/h, then select "**zone E - 22 mm/h**" in the list.

7. Choose the link model (models with the E index mean the spectrum range 71–76 / 81–86 GHz, with the Q index - 40.5–43.5 GHz, with the Ka index - for 37-40 GHz):

a. Choose link model, for example PPC-10G-E;

b. Choose the power of the transmitters (two dashes mean basic model, HP - high power, LP - low power);

c. Choose switch L2 or not (two dashes mean no switch). Mind that switch does not affect link availability and energy budget parameters;

d. Choose backup or aggregation (two dashes mean basic model, others are 2+0 or 1+1). Mind that backup or aggregation does not affect link availability and energy budget parameters;

e. Choose the desired channel capacity (except for the nominal channel capacity, 10G link can be sold with a software-defined speed limit for the channel, if the full rated capacity is not needed to telecom operator at the moment. Then it will necessary, channel capacity can be restored to the max 10G throughput upon request to ELVA-1;

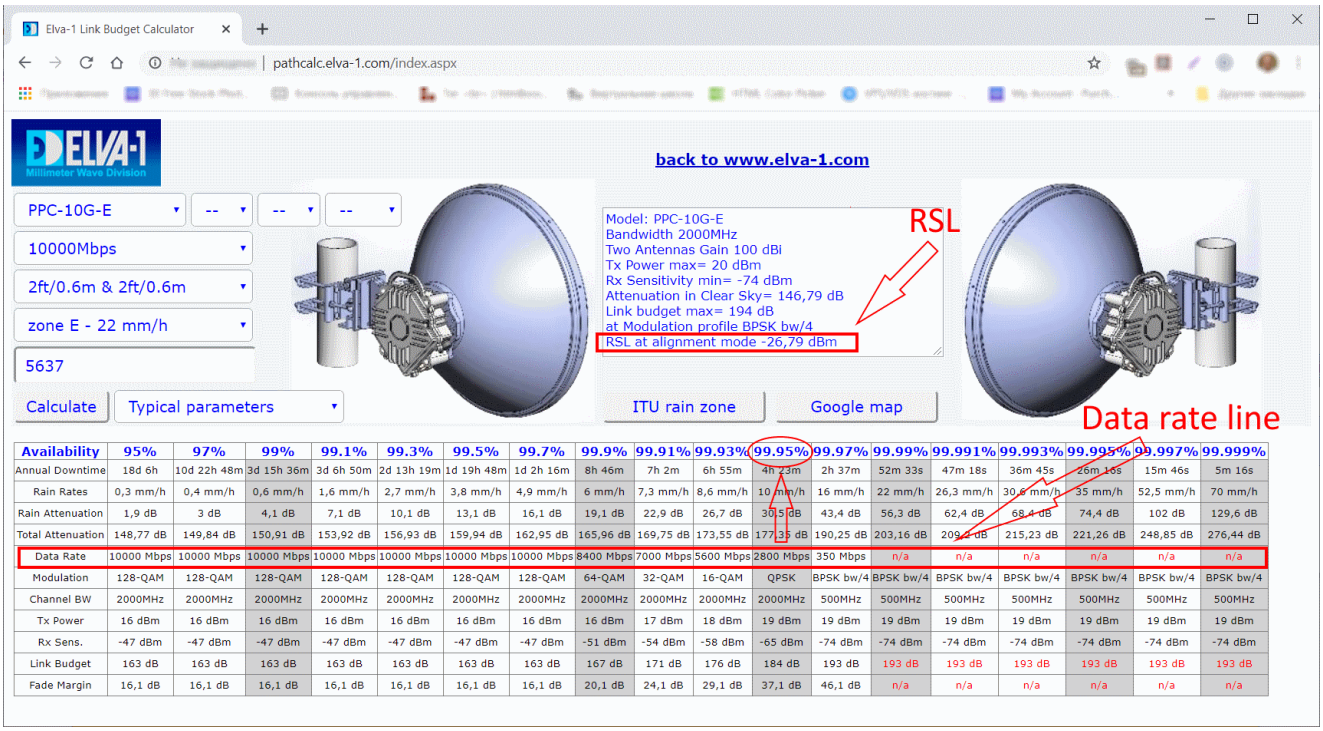
f. Choose antenna size (30 cm, 60 cm or 90 cm), size 90 cm is available only for the 40.5–43.5 GHz band, 38 dBi flat antennas are intended for short-range links only;

g. Choose parameters of the radio (out of production it come out with slightly different parameters due to the variation in the characteristics of components, when ordering for a long path, you can select "Best Parameters" and ask ELVA-1 sales for delivery of such link. Guaranteed parameters mean the lowest from production line).

7. Press **Calculate** button, the results will be generated as a table.

In the next section, an example of calculation will be considered and explained.

1.4 How to Understand Results of Link Budget Calculation



Availability	95%	97%	99%	99.1%	99.3%	99.5%	99.7%	99.9%	99.91%	99.93%	99.95%	99.97%	99.99%	99.991%	99.993%	99.995%	99.997%	99.999%
Annual Downtime	18d 6h	10d 22h 48m	3d 15h 36m	3d 6h 50m	2d 13h 19m	1d 19h 48m	1d 2h 16m	8h 46m	7h 2m	6h 55m	4h 23m	2h 37m	52m 33s	47m 18s	36m 45s	26m 16s	15m 46s	5m 16s
Rain Rates	0,3 mm/h	0,4 mm/h	0,6 mm/h	1,6 mm/h	2,7 mm/h	3,8 mm/h	4,9 mm/h	6 mm/h	7,3 mm/h	8,6 mm/h	10 mm/h	16 mm/h	22 mm/h	26,3 mm/h	30,8 mm/h	35 mm/h	52,5 mm/h	70 mm/h
Rain Attenuation	1,9 dB	3 dB	4,1 dB	7,1 dB	10,1 dB	13,1 dB	16,1 dB	19,1 dB	22,9 dB	26,7 dB	30,5 dB	43,4 dB	56,3 dB	62,4 dB	68,4 dB	74,4 dB	102 dB	129,6 dB
Total Attenuation	148,77 dB	149,84 dB	150,91 dB	153,92 dB	156,93 dB	159,94 dB	162,95 dB	165,96 dB	169,75 dB	173,55 dB	177,35 dB	190,25 dB	203,16 dB	209,4 dB	215,23 dB	221,26 dB	248,85 dB	276,44 dB
Data Rate	10000 Mbps	10000 Mbps	10000 Mbps	10000 Mbps	10000 Mbps	10000 Mbps	10000 Mbps	8400 Mbps	7000 Mbps	5600 Mbps	2800 Mbps	350 Mbps	n/a	n/a	n/a	n/a	n/a	n/a
Modulation	128-QAM	128-QAM	128-QAM	128-QAM	128-QAM	128-QAM	128-QAM	64-QAM	32-QAM	16-QAM	QPSK	BPSK bw/4	BPSK bw/4	BPSK bw/4	BPSK bw/4	BPSK bw/4	BPSK bw/4	BPSK bw/4
Channel BW	2000MHz	2000MHz	2000MHz	2000MHz	2000MHz	2000MHz	2000MHz	2000MHz	2000MHz	2000MHz	2000MHz	500MHz	500MHz	500MHz	500MHz	500MHz	500MHz	500MHz
Tx Power	16 dBm	16 dBm	16 dBm	16 dBm	16 dBm	16 dBm	16 dBm	16 dBm	17 dBm	18 dBm	19 dBm	19 dBm	19 dBm	19 dBm	19 dBm	19 dBm	19 dBm	19 dBm
Rx Sens.	-47 dBm	-47 dBm	-47 dBm	-47 dBm	-47 dBm	-47 dBm	-47 dBm	-51 dBm	-54 dBm	-58 dBm	-65 dBm	-74 dBm	-74 dBm	-74 dBm	-74 dBm	-74 dBm	-74 dBm	-74 dBm
Link Budget	163 dB	163 dB	163 dB	163 dB	163 dB	163 dB	163 dB	167 dB	171 dB	176 dB	184 dB	193 dB	193 dB	193 dB	193 dB	193 dB	193 dB	193 dB
Fade Margin	16,1 dB	16,1 dB	16,1 dB	16,1 dB	16,1 dB	16,1 dB	16,1 dB	20,1 dB	24,1 dB	29,1 dB	37,1 dB	46,1 dB	n/a	n/a	n/a	n/a	n/a	n/a

Fig. 4. Example of link budget calculation

Most of interest in the calculation table are parameters "**Availability**" and "**Data Rate**", calculated for rain of various intensities.

Using ELVA test path as an example, it can be seen that a nominal transfer rate of 10 Gbps is guaranteed for rain no more than 4.8 mm/h (availability 99.7%).

More or less affordable data rate of 2800 Mbps could be at 10 mm/h rain (availability 99.95%). Further, the transmission speed drops dramatically. When it is rain with an intensity of 22 mm/h or more, the connection can fail at all.

Please have a closer look at parameters in the table of calculation results:

- **Availability**, %. The main indicator that determines the quality of communication service. Corporate customers often add the availability value to the contract with the provider.

- **Annual Downtime**. The value shown in days, hours, minutes, and seconds is the inverse of the availability value. It shows the total predicted time when the connection due to rain will be with a data rate limit or completely failed.

- **Rain Rates**, mm/h. The values of rain intensity in this row are taken from the ITU recommendation for the rain zone. The main indicator of the rain zone is the rain intensity for link availability of 99.99%.

- **Rain Attenuation**, dB. It shows the attenuation of the wireless signal over the path in decibels by rain of various intensities.

- **Full Attenuation**, dB. Includes free space & atmospheric attenuation (for clear weather) plus rain attenuation.

- **Data Rate**, Mbps. This is the data transfer rate that radio provides under rain of various intensities. The value of **n/a** means that for a given rain intensity and path length, the wireless connection will not work.

- **Modulation**. The type of modulation used in rain of varying intensity to ensure connectivity.

Modern mm-wave radios have an adaptive modulation function that changes the type of modulation from complex types (256 QAM, 128 QAM) to simpler (QPSK, BPSK) to improve the link budget depending on the intensity of rainfall. The goal is to keep the connection alive. After the rain ends, the radio automatically restore the most complex type of modulation (according to its specification) to ensure maximum throughput.

- **Channel BW**, MHz. The spectrum occupied by the signal for various types of modulation (according to the specifications for radio).

- **Tx Power**, dBm. The power of the transmitter signal at the antenna path. It depends on the type of modulation. Tx power is indicated in dBm (decibels to milliwatt), i.e. how many decibels this power is greater than 1 mW. There are calculators for converting dBm to mW on the Internet.

- **Rx Sens**, dBm. This is receiver sensitivity.

- **Link Budget**, dB. The energy budget of a radio link for different types of modulation.

- **Fade margin**, dB. Rainfall tolerance for signal loss for a given data rate.

In addition, pay attention to the parameters and values that are displayed in the list above the main table (between images of two radios). Most of the interest is **RSL at alignment mode**. The RSL (Receive Signal Level) value should be used when pointing the antennas to each other.

1.5 Using RSL Value from Calculator for Antenna Alignment

Each ELVA-1 radio comes with a tuning console, which is connected to the "Console" jack while adjusting the antennas and real-time RSL is displayed on this console. Using screws to change the position of the antenna mount, the engineers ensure that the console displays RSL value equal to or as close as possible to the RSL value from the calculator (a difference of no more than 2 dBm is recommended).

Fig. 5. RSL value from calculator has to be achieved when do antennas alignment of the radio link

During radio lifetime, pointing the antennas to each other may go wrong due to very strong winds and other unforeseen influences. In such cases, the RSL value has to be checked using the web interface to the radio and, if necessary, the antenna re-alignment has to be done using the tuning panels.

For more information on antenna alignment, see User Manual for your ELVA-1 radio.

1.6 How to Improve Availability of the Radio

If the estimated availability values from calculator are too low for your wireless service, try the following:

- Make a calculation for radio with high power transmitters (with HP index);
- Make a calculation for antennas with larger diameter (30 cm -> 60 cm -> 90 cm);
- Instead of unlicensed 71–76/81–86 GHz band, try the calculation for the licensed 40.5–43.5 GHz band, in which signal propagation is less susceptible to rain.
- Consider splitting a long path into two or more sections by organizing a chain of radios (i.e. relay mode).

For any questions related to the use or improvement of link budget calculator, contact ELVA-1 by e-mail: sales@elva-1.com.

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