VisTools

User Guide and Technical Annex

Copyright Information

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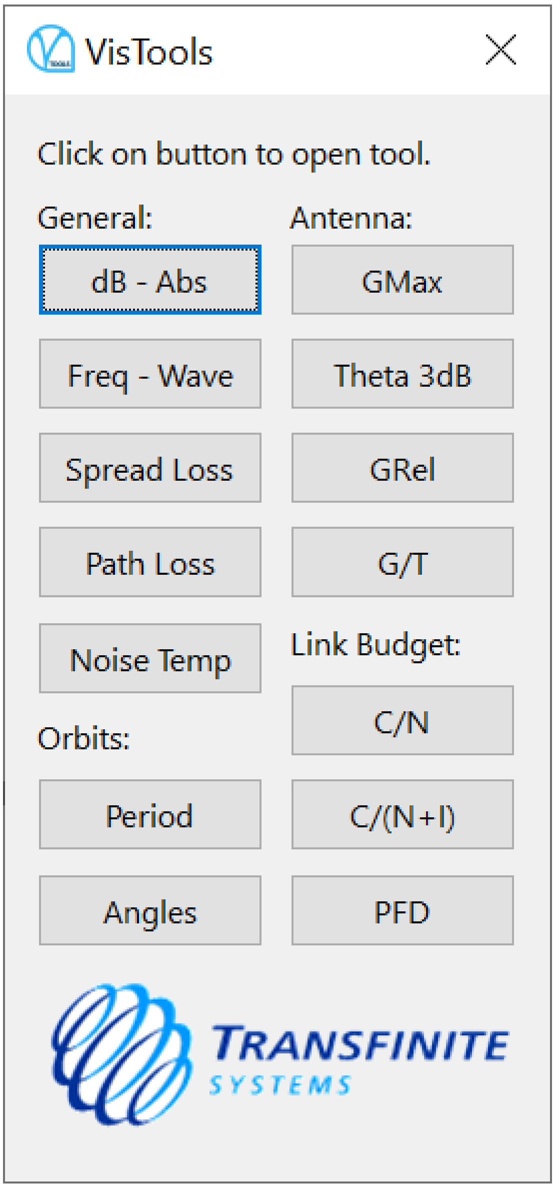
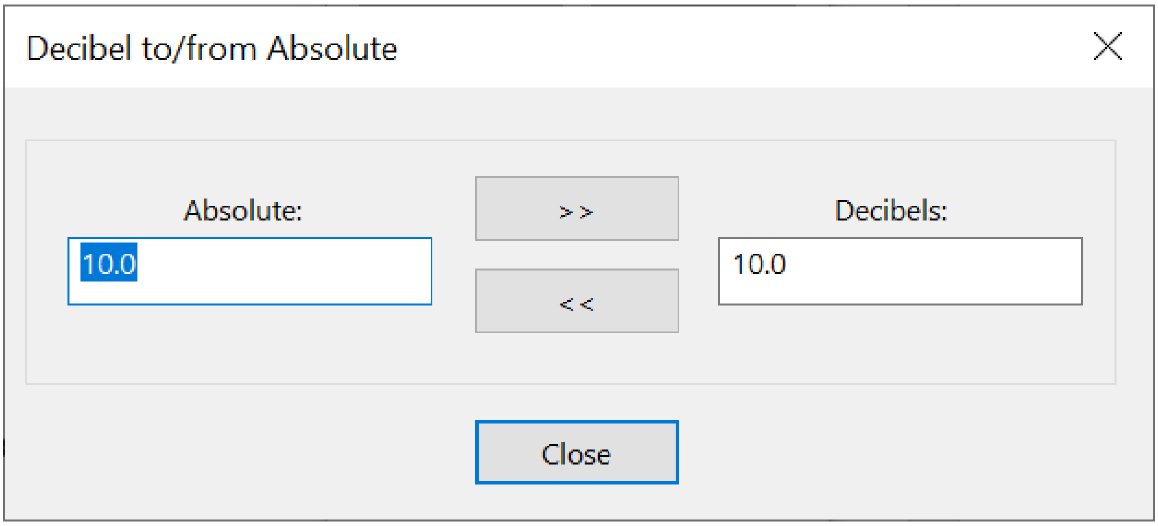
1 Introduction

This document describes the calculations in the Visualyse Professional stand-alone engineering tool kit, VisTools. This application runs on a Windows PC and has interface as shown in the figure below:



Each of the button activates a different dialog as described in the following sections.

2 dB to/from Absolute

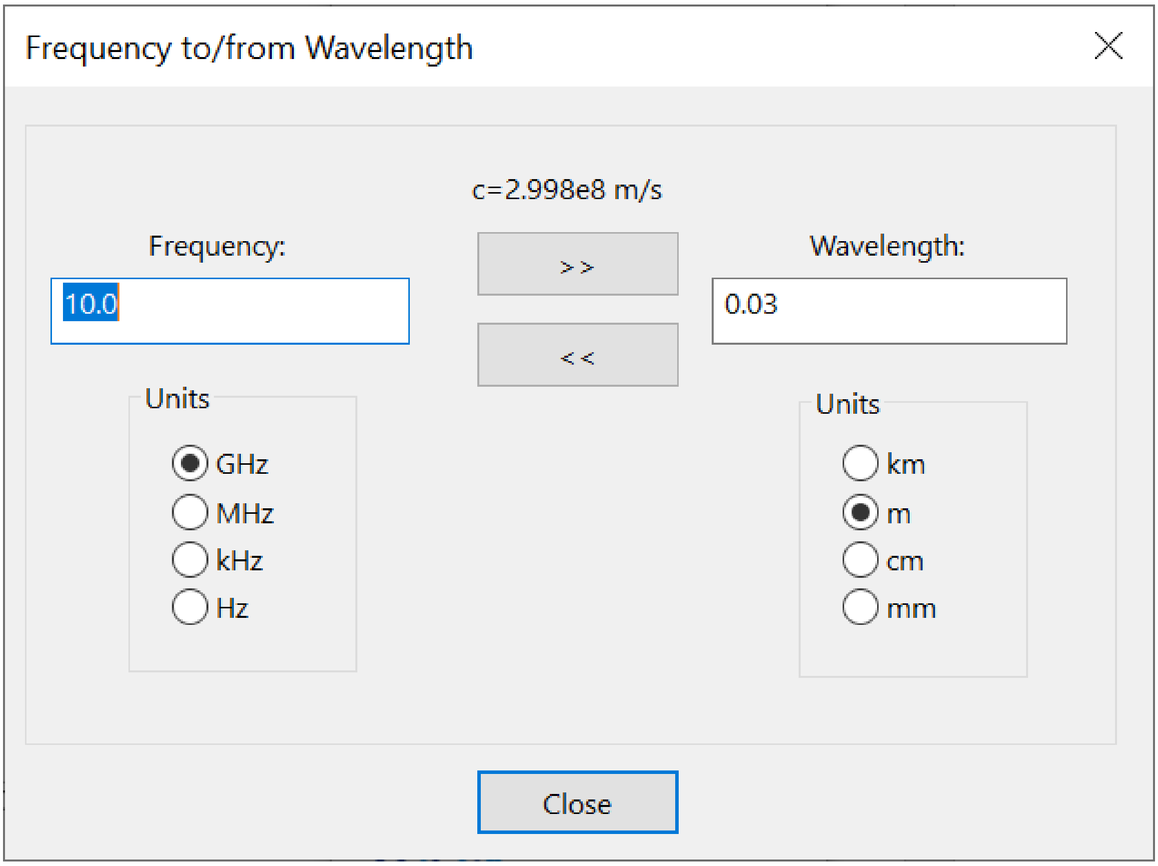


The dB tool converts between dB (d) and absolute (a) using:

$$a = 10^{d/10}$$

$$d = 10\log_{10}(a)$$

3 Frequency to/from Wavelength

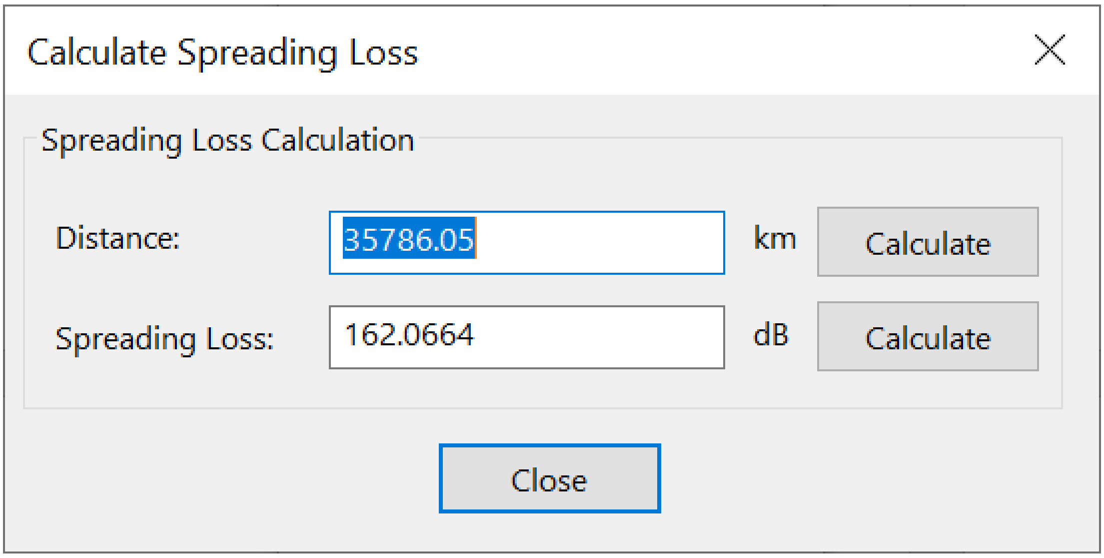


The Frequency tool converts between frequency f and wavelength λ using:

$$c = f\lambda$$

where c is the speed of light = 299,792,458 m/s.

4 Calculate Spreading Loss



The spreading loss tool calculates the spreading loss used to calculate PFD. The parameters used are:

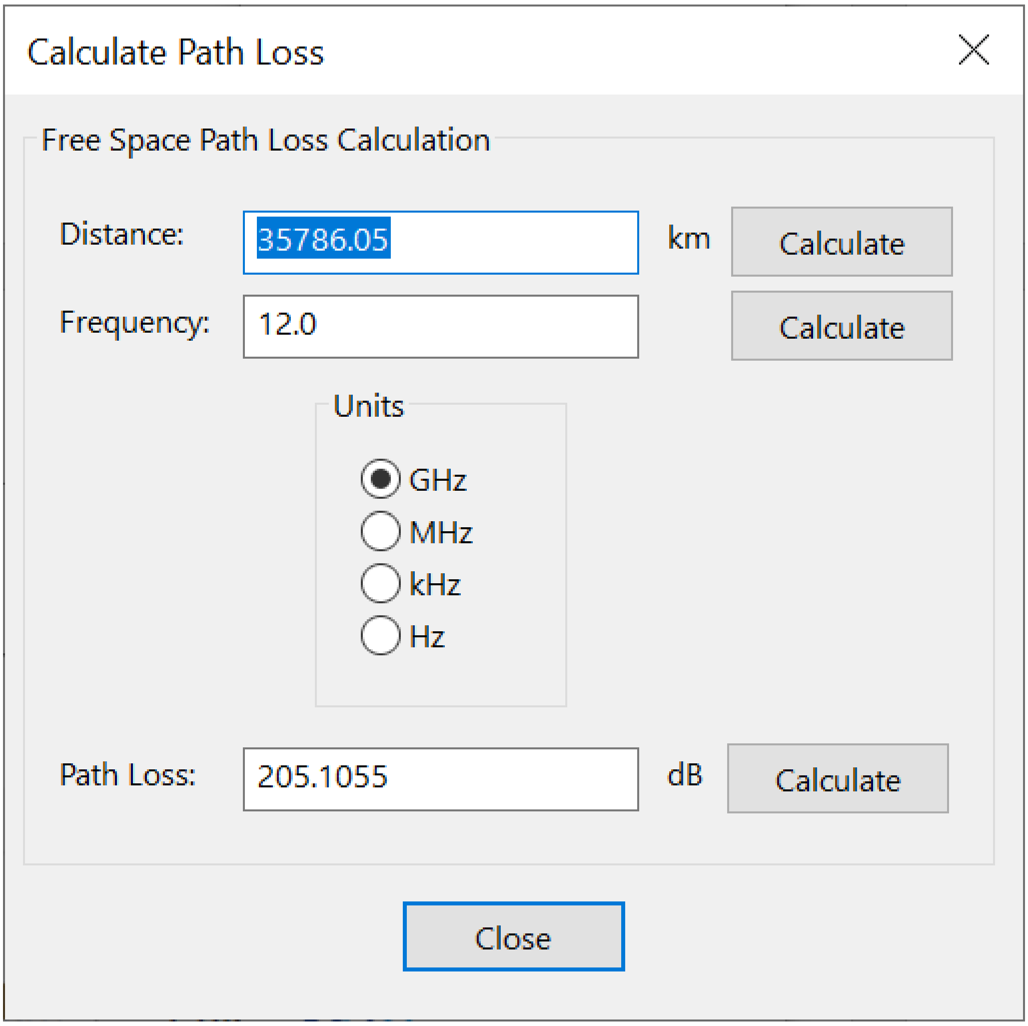
- d_{km} = path length (km)
- L_{sl} = spreading loss (dB/m^2)

Each of these three can be calculated from the other using:

$$L_{sl} = 10log_{10}(4.\pi.d_m^2)$$

Note that the distance is given in km but the spreading loss is per m^2.

5 Calculate Path Loss



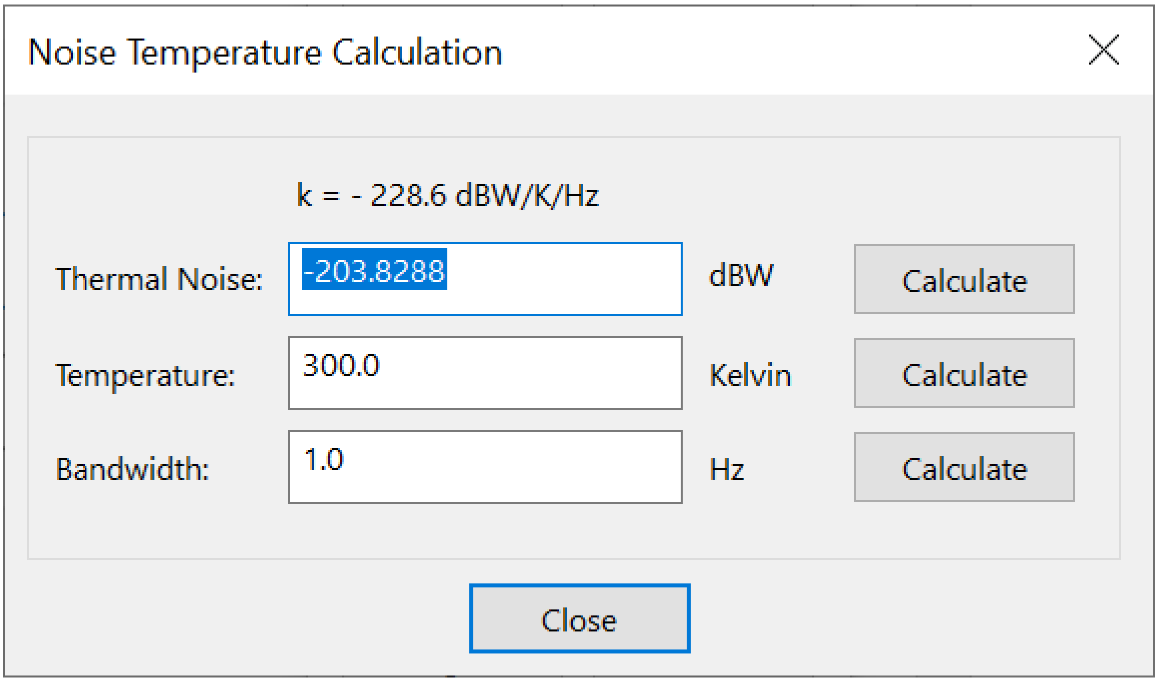
The path loss tool calculates the free space path loss. The parameters used are:

- *f* = frequency and Frequency units
- *D* = distance or path length (km)
- L_{fs} = Path loss (dB)

Each of these three can be calculated from the other using:

$$L_{fs} = 32.45 + 20log_{10}(d_{km}) + 20log_{10}(f_{MHz})$$

6 Noise Temperature Calculation



The noise tool converts between temperature in Kelvin to noise in dBW/Hz. The following parameters are used:

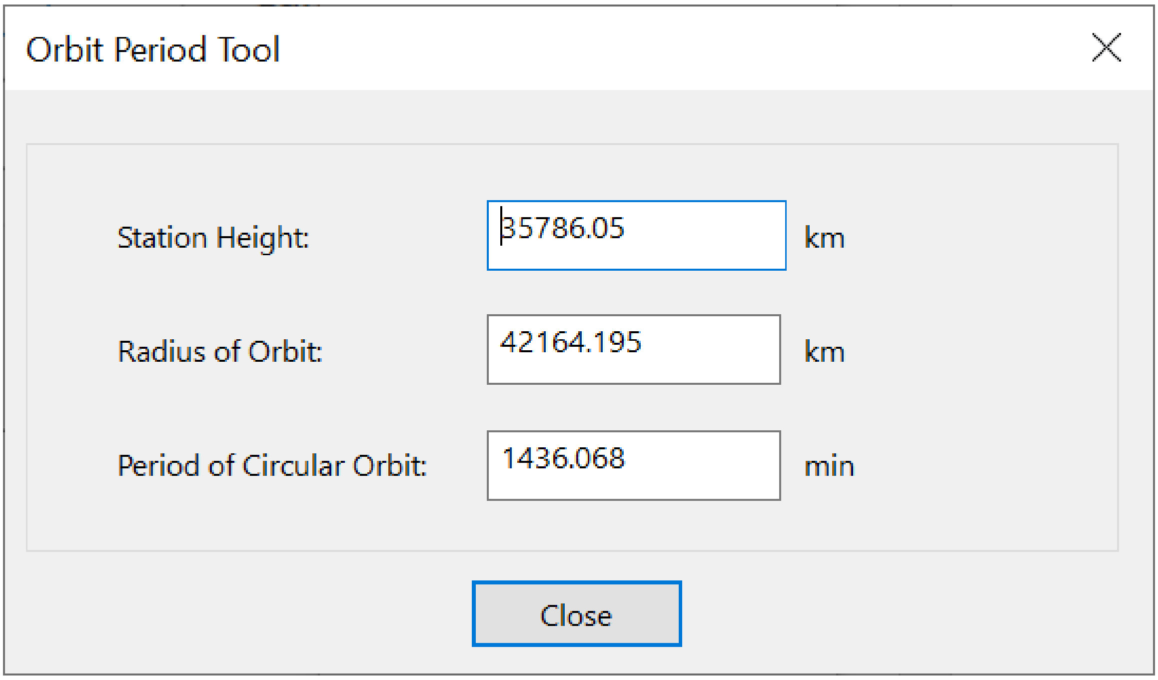
- T = temperature Kelvin
- N = noise in dBW in bandwidth
- B = bandwidth in Hz

These parameters are related using the following equations:

$$N = k + 10log_{10}(TB)$$

where k=-228.6 is Boltzmann's constant in dBW/Hz/K.

7 Orbit Period Tool



The orbit period tool can covert between orbit height and radius and calculate the associated period. The parameters are:

- h = height of satellite (km)
- R = radius of orbit (km)
- T_P = period of circular orbit (minutes)

The equations are:

$$R = R_e + h$$

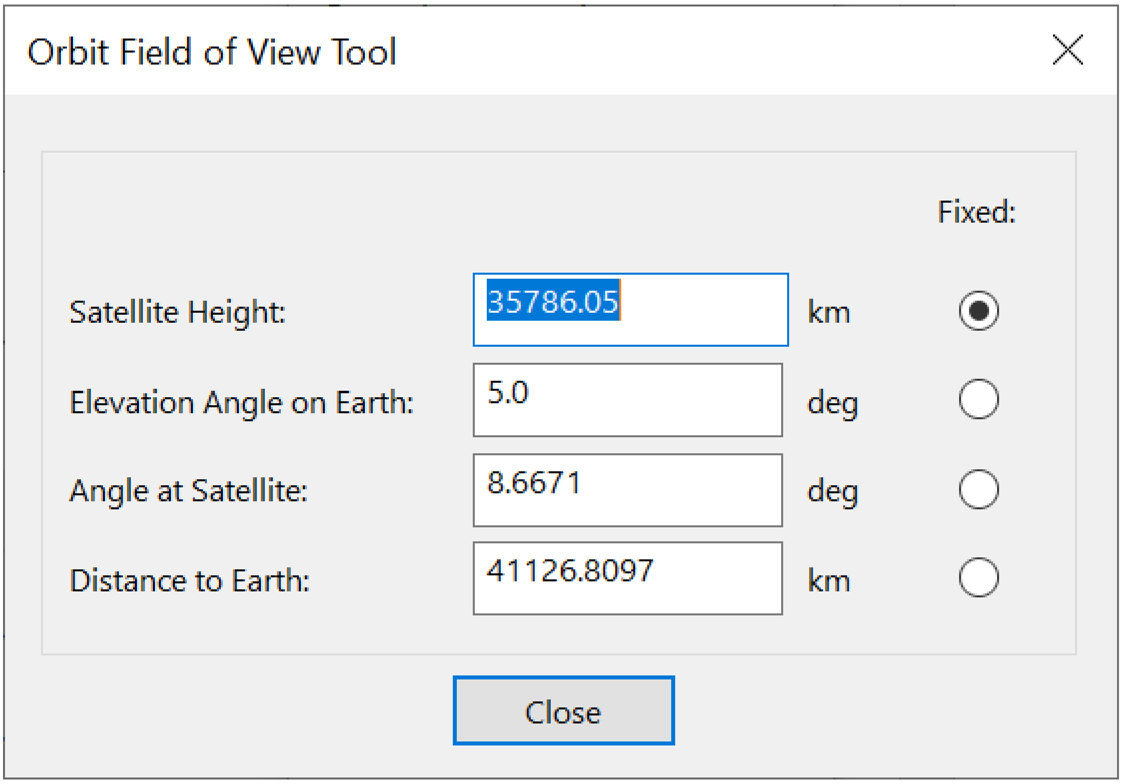
Where R_e = 6378.145 km.

Then the period in seconds can be calculated using:

$$P_S = 2\pi\sqrt{\frac{R^3}{\mu}}$$

Where μ = 398600.4418 km^3/s^2.

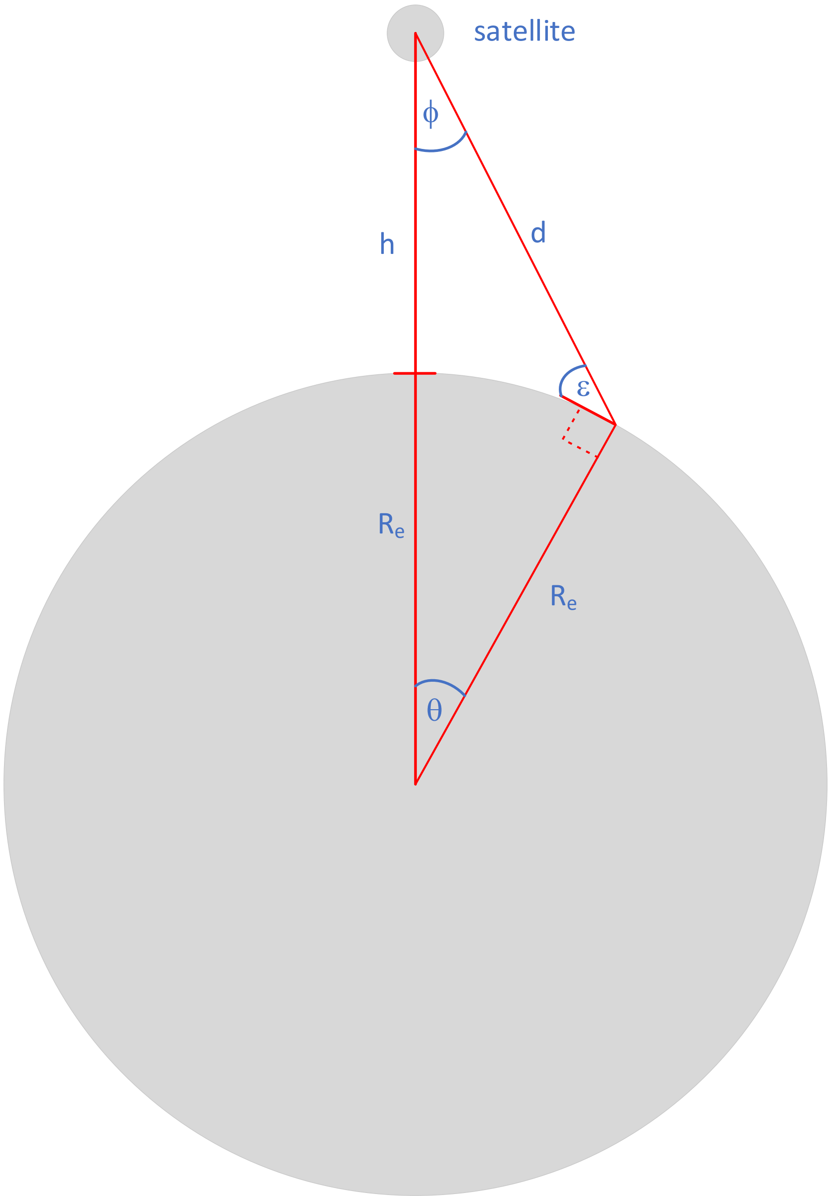
8 Orbit Field of View Tool



The angles tool provides information about satellite angles and distances. The parameters are:

- *h* = height of satellite (km)
- ε = elevation angle on the ground (deg)
- ϕ = half angle at satellite (degrees)
- *d* = distance to Earth (km)

These parameters are shown in the figure below:



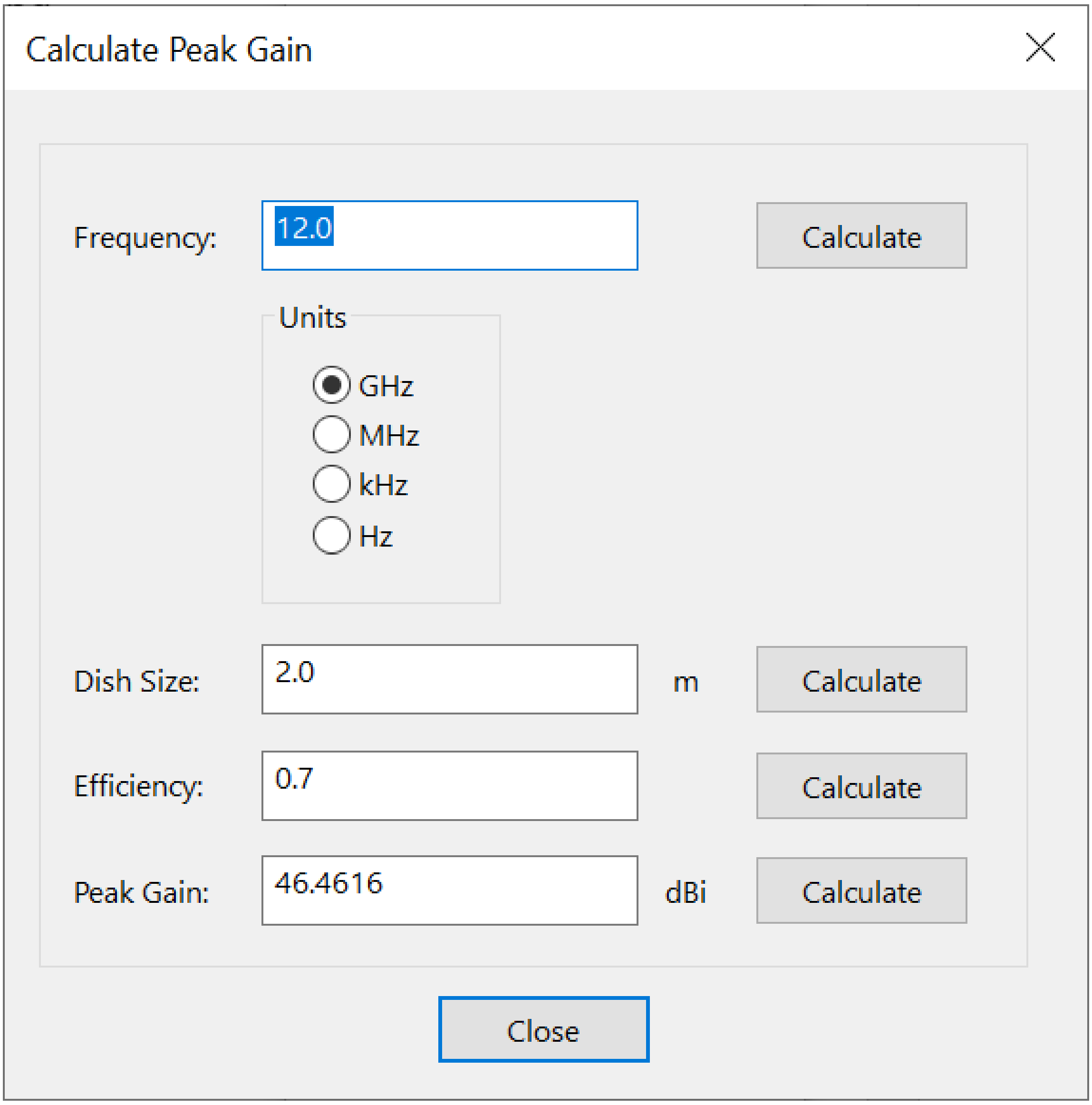
The equations are:

$$sin(\phi) = \frac{R_e}{R_e + h} sin(90 + \varepsilon)$$

$$\theta = 90 - \varepsilon - \phi$$

$$d^2 = R_e^2 + (R_e + h)^2 - 2R_e(R_e + h)\cos(\theta)$$

9 Calculate Peak Gain



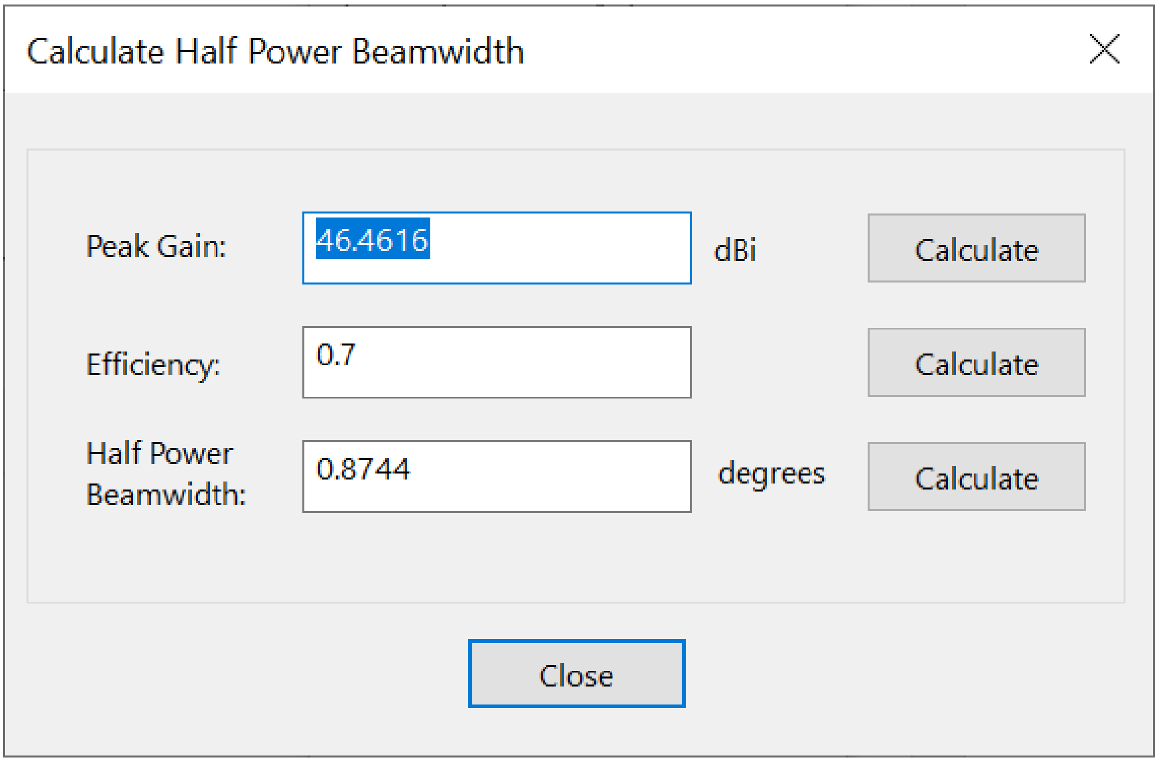
This tool calculates peak gain based on the following parameters:

- *f* = frequency and frequency units
- *D* = dish size (m)
- η = efficiency
- G_{max} = peak gain (dBi)

These parameters are related using the following equation:

$$G_{\max} = \eta\left(\frac{\pi D f}{c}\right)^2$$

10 Calculate Half Power Beamwidth



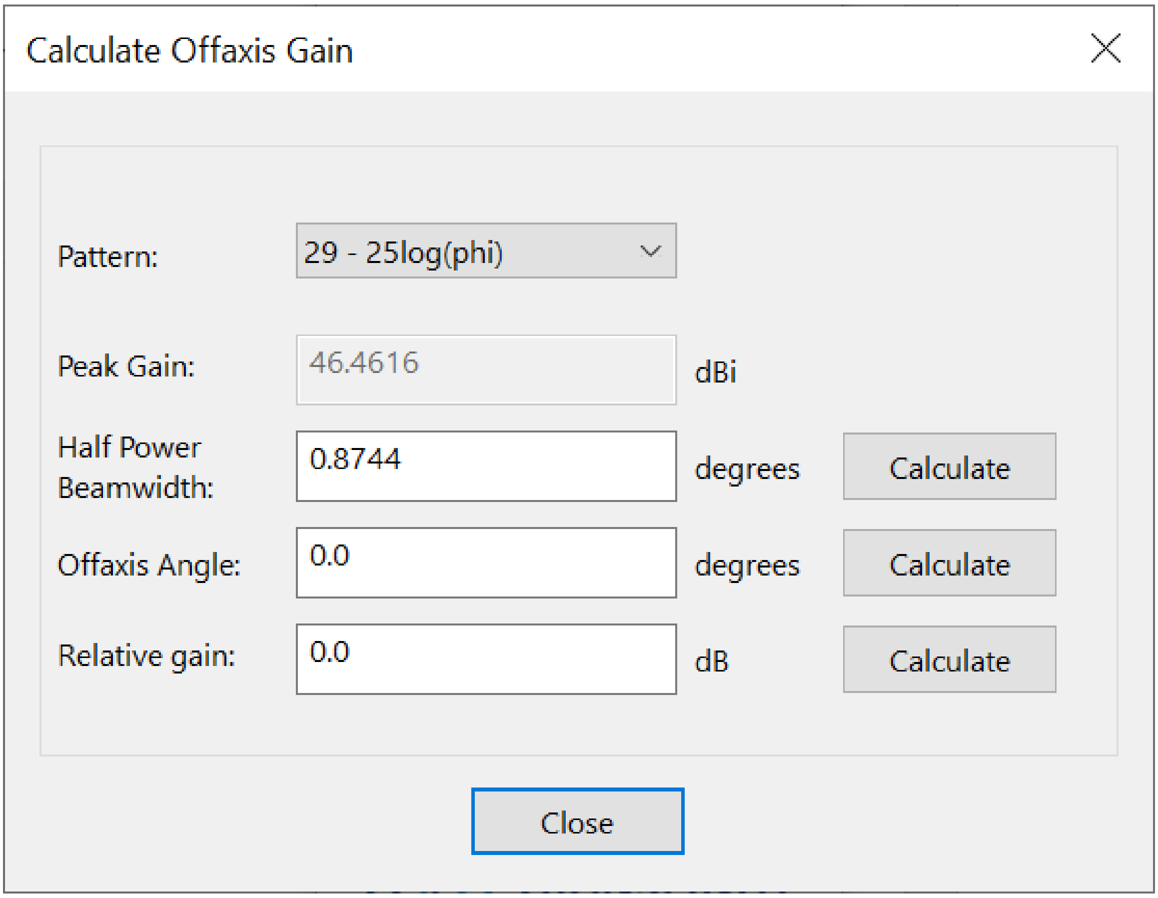
The half power beamwidth tool calculates half power beamwidth based upon the following parameters:

- G_{max} = peak gain (dBi)
- η = efficiency
- θ_{3dB} = half power beamwidth,

These parameters are related using the following equation:

$$G_{\max} = \eta\left(\frac{\pi 70}{\theta_{3dB}}\right)^2$$

11 Calculate Relative Gain



The relative gain tool calculates offaxis gain based upon the following parameters:

- G_{rel} = gaiin relative to peak (dB)
- θ_{3dB} = half power beamwidth (deg)
- ϕ = offaxis angle (deg)

Three gain patterns are available:

- Pure parabolic
- Side lobe with 29-25log(ϕ)
- Side lobe with 32-25log(ϕ)

The sidelobe equations also use the peak gain calculated using the half power beamwidth tool.

These parameters are related using the following equations:

Parabolic:

$$G_{rel,p} = -12\left(\frac{\phi}{\theta_{3dB}}\right)^2$$

Sidelobes:

$$G_{SL,29} = 29 - 25log_{10}(\phi)$$

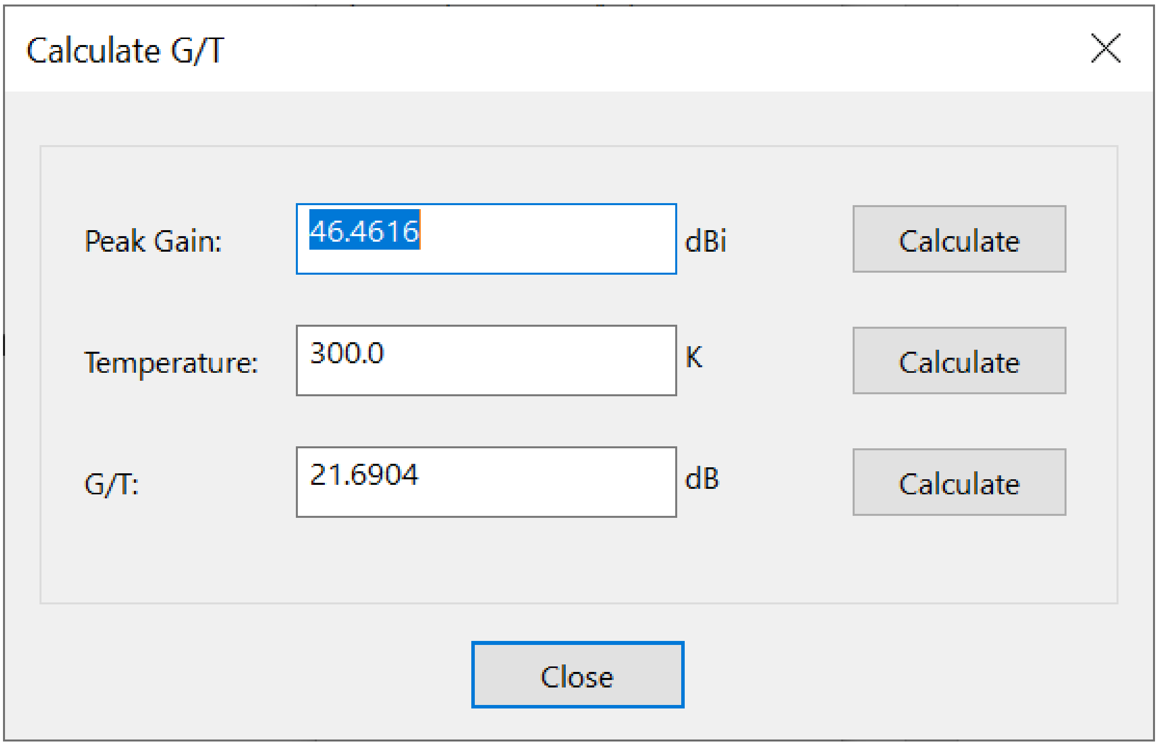
$$G_{SL,32} = 32 - 25log_{10}(\phi)$$

Then:

$$G_{rel,SL} = G_{max} - G_{SL}$$

When the gain pattern is parabolic, the first equation is used. When the sidelobes are used then the gain pattern follows the parabolic equation until it reaches the sidelobe, then continues until the gain = -10 dBi.

12 Calculate G/T



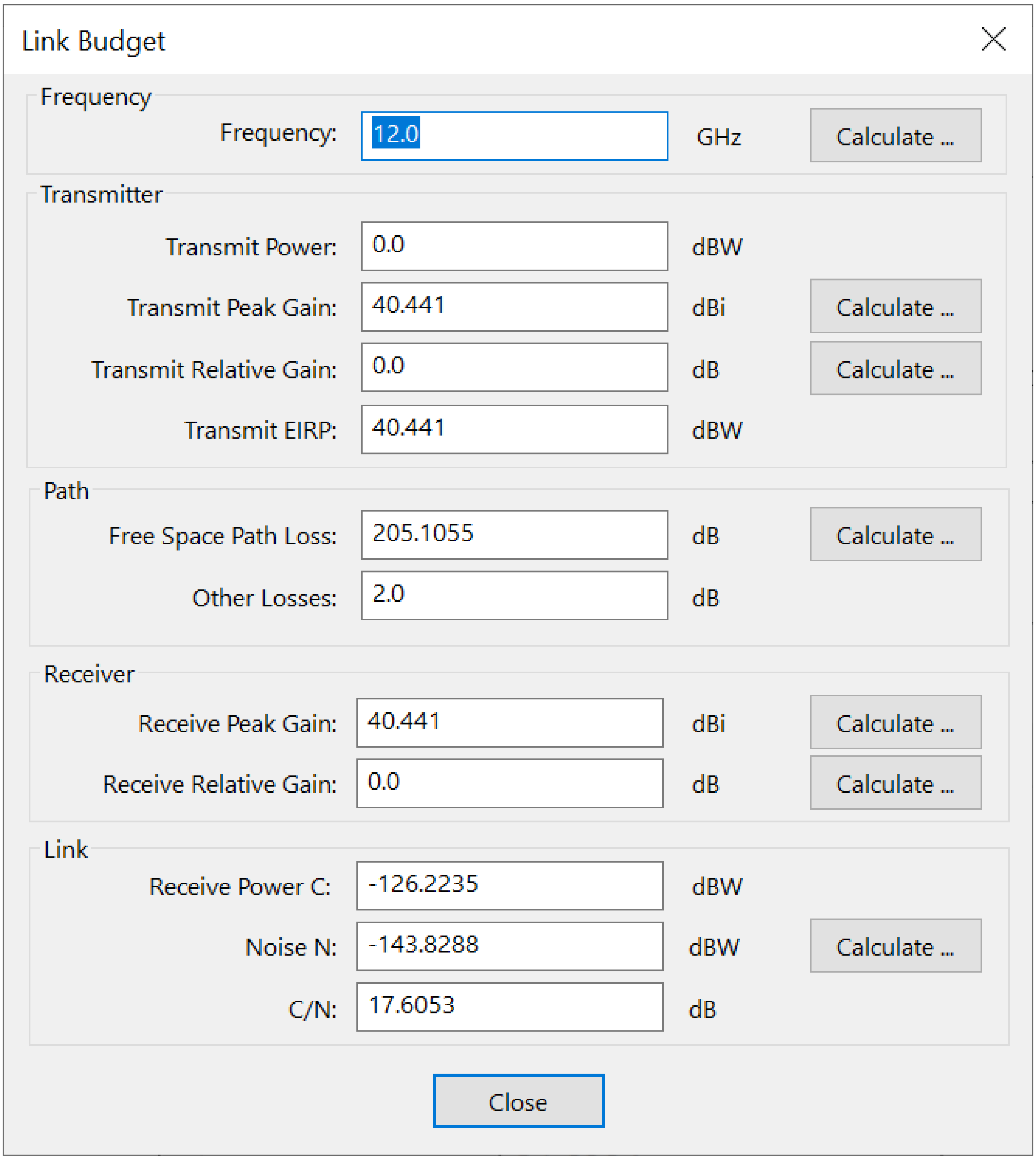
The G/T tool converts between peak gain and temperature in Kelvin to G/T. The following parameters are used:

- G_{max} = peak gain (dBi)
- T = temperature in Kelvin (K)
- (G/T) = ratio of gain to temperature in dB/K

These parameters are related using the following equations:

$$\left(\frac{G}{T}\right) = G_{max} - T$$

13 C/N Link Budget



These various tools are combined to produce a link budget tool with the following parameters:

- *f* = frequency, entered either directly or using the frequency tool
- P_{tx} = transmit power, entered directly, or calculated from transmit EIRP
- $G_{tx,peak}$ = transmit peak gain, entered either directly or using the peak gain tool
- $G_{tx,rel}$ = transmit relative gain, entered either directly or using the offaxis gain tool
- *EIRP* = transmit EIRP, either entered directly or calculated from C or using:

$$EIRP = P_{tx} + G_{tx,peak} + G_{tx,rel}$$

- L_{fs} = free space path loss, either entered directly or using the path loss tool
- L_{other} = other losses, entered directly
- $G_{rx, peak}$ = receive peak gain entered either directly or using the peak gain tool
- $G_{rx, rel}$ = receive relative gain, entered either directly or using the offaxis gain tool
- *C* = receive power, either entered directly or calculated from *EIRP* or *C/N* or using

$$C = EIRP - L_{fs} - L_{other} + G_{rx,peak} + G_{rx, rel}$$

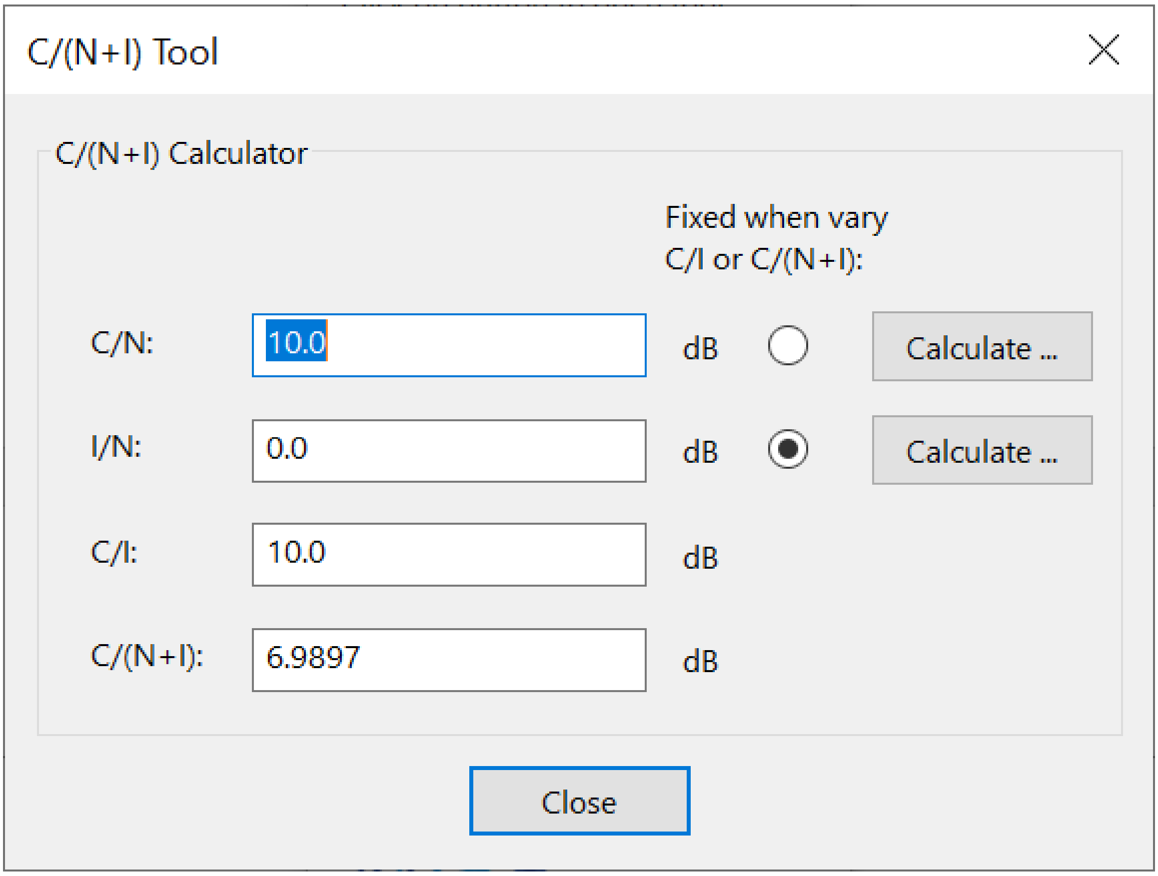
- *N* = receive noise, either entered directly or using the noise tool. Note that the noise tool includes the bandwidth
- Receive *C/N*, either entered directly or calculated using:

$$C = C - N$$

Note that:

- If *C* is changed directly the *C/N*, *EIRP* and transmit power fields update accordingly
- If the *EIRP* field is changed directly, the *C*, *C/N*, and transmit power fields update accordingly
- If the transmit power field is changed directly, the *EIRP*, *C* and *C/N*, fields update accordingly
- If the *C/N* field is changed directly the *C*, *EIRP*, and transmit fields update accordingly

14 C/(N+I) Tool



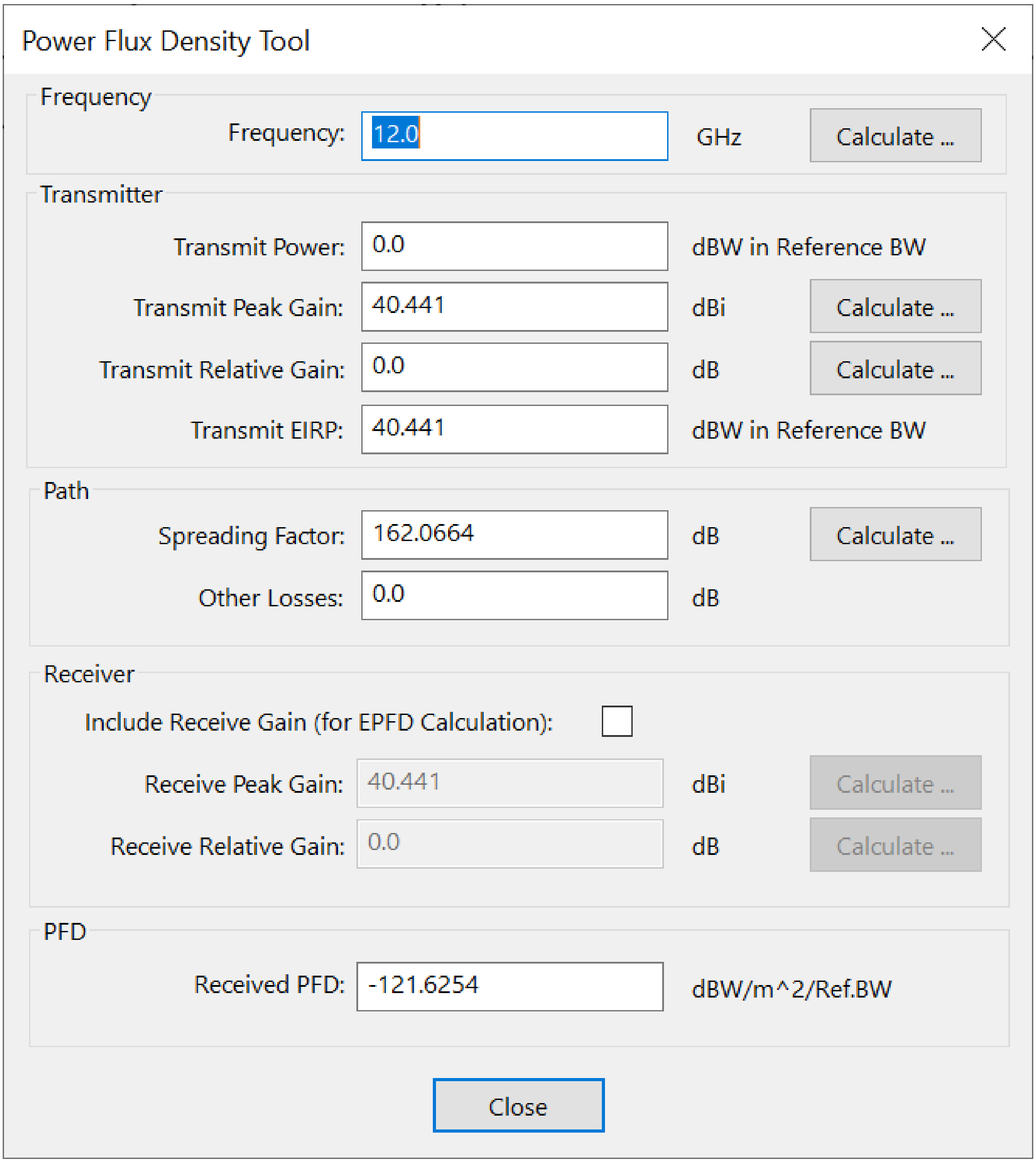
These tools can be used to calculate the link metrics {C/N, I/N, C/I, and C/(N+I)}.

In this tool the:

- C/N "Calculate" button goes to the Link Budget tool which can be used to calculate the C/N
- I/N "Calculate" button goes to the Link budget tool which can be used to calculate the I/N

When the I/N or C/(N+I) are changed, this could be due to changes in the C or I and an option allows the user to select which is fixed.

15 PFD / EPFD Tool



These various tools are combined to produce a PFD and EPFD tool with the following parameters:

- f = frequency, entered either directly or using the frequency tool
- P_{tx} = transmit power, entered directly, or calculated from transmit EIRP
- $G_{tx,peak}$ = transmit peak gain, entered either directly or using the peak gain tool
- $G_{tx,rel}$ = transmit relative gain, entered either directly or using the offaxis gain tool
- *EIRP* = transmit EIRP, either entered directly or calculated from C or using:

$$EIRP = P_{tx} + G_{tx,peak} + G_{tx,rel}$$

- L_{sl} = spreading loss, either entered directly or using the spreading loss tool
- L_{other} = other losses, entered directly
- $G_{rx,\ peak}$ = receive peak gain entered either directly or using the peak gain tool
- $G_{rx,\ rel}$ = receive relative gain, entered either directly or using the offaxis gain tool
- *PFD* = receive power flux density calculated from *EIRP* using

$$PFD = EIRP - L_{fl} - L_{other}$$

- *N* = receive noise, either entered directly or using the noise tool. Note that the noise tool includes the bandwidth
- Receive *C/N*, either entered directly or calculated using:

$$C = C - N$$

If the receive gain is included for EPFD calculations then:

- *EPFD* = receive power flux density calculated from *EIRP* using

$$EPFD = EIRP - L_{fl} - L_{other} + G_{rx,rel}$$

Note that:

- If *PFD* or *EPFD* is changed directly the *EIRP* and transmit power fields update accordingly
- If the *EIRP* field is changed directly, the *PFD/EPFD* and transmit power fields update accordingly
- If the transmit power field is changed directly, the *EIRP* and *PFD/EPFD* fields update accordingly