

# User Manual 4.1 Properties and models: Link budget

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## Introduction

### Scope

This section contains the description of the RF properties associates to an antenna (which is represented by a part of an Assembly) and the RF link budget computation model.

### Javadoc

The classes described in this section are available in the packages :

#### Library

#### Javadoc

Patrius [Package fr.cnes.sirius.patrius.assembly.models](#)

Patrius [Package fr.cnes.sirius.patrius.assembly.properties](#)

Patrius [Package fr.cnes.sirius.patrius.groundstation](#)

### Links

None as of now.

### Useful Documents

None as of now.

## Package Overview

None as of now.

## Features Description

### RF properties for a satellite antenna

These properties represent the features of the transmitter; they are used when calculating the RF link budget between the satellite antenna and a ground station.

If  $\theta$  is the polar angle related to +Z axis of antenna frame  $[0, \pi]$ , and  $\phi$  is the azimuth angle from X to Y  $[0, 2\pi]$  of the vector representing the direction of the ground station in the frame of the transmitter antenna, the properties are the following:

- $P_T$ : the amplifier output power [dB];
- $G_T$ : the antenna gain diagram. Gain is a function of  $\theta$  and  $\phi$  [dB];
- $r_1$ : the factor of ellipticity. The factor of ellipticity is a function of  $\theta$  and  $\phi$  [dB]; Warning: conversion in dB uses formula  $20\log(\dots)$  and not  $10\log(\dots)$ .
- $L_{rt}$ : the technological losses by the satellite transmitter [dB];
- $L_T$ : the losses between TX and antenna [dB];
- $R_b$ : the bit rate for nominal mode [bps];
- $f_{\text{freq}}$ : the emission frequency [Hz];

The class `RFAntennaProperty` contains all these parameters; the associated property type is **RF**.

The value of the gain or the factor of ellipticity for given  $\theta$  and  $\phi$  are obtained by interpolation by spline of the input values; as this type of interpolation can not be performed for less than three values for  $\theta$  and  $\phi$ , an exception will be raised when the size of the  $\theta$  and/or  $\phi$  arrays is less than three; however, this does not apply if their size is equal to 1 (in that case the interpolation is not necessary).

### RF model for a ground station antenna

These properties represent the RF antenna model for a ground station; this antenna is described by a topocentric frame (which coincides with the ground station frame) and the following parameters:

- $G/T$ : the factor of merit of the ground antenna (Gain / noise temperature) [dB/K];
- $L_{rg}$ : the technological losses by the ground antenna [dB];
- $r_2$ : the factor of ellipticity, used to calculate the polarisation losses of the antenna [dB]; Warning: conversion in dB uses formula  $20\log(\dots)$  and not  $10\log(\dots)$ .
- $L_{23}$ : the atmospherical losses (iono+tropo+rain) as function of the elevation [dB];
- $L_4$ : the pointing losses as function of the elevation [dB];

- $PC$ : the loss due to the combiner of the antenna [dB];

The class `RFStationModel` contains all these parameters.

## Computation of the link budget

The link budget is the accounting of all of the gains and losses from the transmitter (the satellite), through the medium to the receiver (the ground station).

To compute the link budget at a given date one must know the direction of the ground antenna in the satellite antenna frame and the transmitter and ground receiver RF parameters.

The class `RFLinkBudgetModel` contains the algorithm to compute the link budget; a detector (`RFVisibilityDetector`) can also be used during the propagation in order to know when the link budget value exceeds a certain threshold value (see the `[MIS_STASAT_Home satellite/ground station event detectors page]`).

The RF link budget value is computed as follows:

- $KdB$ : Boltzmann constant (in decibels);
- $distance$ : distance between the spacecraft and the ground station;
- $dr_1$ : factor of ellipticity of the satellite antenna (in the decimal numeral system) at the current polar angle and azimuth;
- $dr_2$ : factor of ellipticity of the ground station antenna (in the decimal numeral system);

$$L1 = - \left[ \frac{(dr_1 + dr_2)^2}{(1 + dr_1^2)(1 + dr_2^2)} \right]_{\text{decibel}}$$

$$L = L1 + L23 + L4;$$

$$L_{fs} = \left[ \left( \frac{4 \pi \cdot distance \cdot freq}{lightSpeed} \right)^2 \right]_{\text{decibel}}$$

**Warning** : this value in dB is actually computed as  $20 \log(L_{fs})$ .

$$RF_{\text{link budget}} = PT + GT - LT + G/T - KdB - L_{fs} - R_b - L_{rg} - L_{rt} - L - PC;$$

where

- $PT$  is the amplifier output power (dB)
- $GT$  the antenna gain (dB)
- $LT$  the loss between the emitter and the antenna (dB)
- $R_b$  the bit rate (dB)
- $L_{rt}$  the technological losses by the satellite transmitter (dB)

## Getting Started

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## Interfaces

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## Classes

Class	Summary	Javadoc
<b>RFStationAntenna</b>	This class represents an RF antenna model for a ground station; it is used when calculating the RF link budget.	...
<b>RFAntennaProperty</b>	This class represents an RF antenna property for a part of the assembly; it is used when calculating the RF link budget.	...
<b>RFLinkBudgetModel</b>	This class contains the algorithm to compute the link budget knowing the satellite transmitter and ground receiver parameters	...

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