



An Introduction to Microwave Radio Link Design

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1 Introduction

Radio Link engineering begins by doing a link budget analysis. A given radio system has a system gain that depends on the design of the radio and the modulation used. The gains from the antenna at each end are added to this gain. Larger antennas provide higher gain. The free-space loss of the radio signal as it travels over the air is then subtracted from the system: the longer the link the higher the loss.

The energy of microwave radio signals is absorbed by rain; rain can cause an outage if enough energy is absorbed so that the receiver loses the signal. The engineering of radio links to accommodate the effects of rain attenuation is based on ITU or Crane global rain models. These models are derived from meteorological observations combined with the attenuation.

These calculations result in a "fade margin" for the link. Anything that affects the radio signal within this margin will be overcome by the radio; if the margin is exceeded, then the link could go down. The next step, then, is to analyze impediments that could potentially affect the radio signal.

The goal is to get good availability and performance.

2 Radio Link Engineering main steps¹

2.1 Make Path profile

A Path Profile is a graphical representation of the path traveled by the radio waves between the two ends of a link. The Path Profile determines the location and height of the antenna at each end of the link, and it insures that the link is free of obstructions, such as hills (Microwave radio link must be on Line-of-sight (LOS)), and not subject to propagation losses from radio phenomena, such as multipath reflections.

The endpoints of link must have unobstructed radio line-of-sight. Radio line-of-sight is not the same as optical line-of-sight (that is, the ability to see one end of a link from the other). Microwaves have a lower frequency than visible light and, therefore, behave differently in response to environmental conditions. Radio line-of-sight requires more clearance than optical line-of-sight to accommodate the characteristics of microwave signals. An electromagnetic wave does not travel in a straight line: the wave spreads out as it propagates. Also, the individual waves that make up a radio signal do not travel at the same phase velocity. A French physicist, Augustin Fresnel, defined the propagation of a radio wave as a three-dimensional elliptical path between the transmitter and receiver. Fresnel divided the path into several zones based on the phase and speed of the propagating waves.

The size of each Fresnel Zone varies based on the frequency of the radio signal and the length of the path. As frequency decreases, the size of the Fresnel Zone increases. As the length of the path increases, the size of the Fresnel Zone also increases. A Fresnel Zone radius is greatest at the midpoint of the path. Therefore, the midpoint requires the most clearance of any point in the path.

¹ This is only an overview of steps required to ensure successful installation. This material will help to make rough calculation. In order to get accurate calculation it is recommended to entrust it to qualified planning experts.

2.2 Calculate Free Space Loss (FSL)

Before determine if a link is feasible, at first the Free Space Loss must be calculated.

Free Space Loss is the expected attenuation of a signal as it travels away from the transmitting device. When a signal radiates from the antenna, it spreads out over an increasingly larger distance. As the area covered increases, the power density (or the amount of power per unit area) decreases. This effectively weakens the radio signal.

$$FSL = 32.44 + 20 \lg F + 20 \lg D$$

Where:

F= frequency, MHz

D= distance between link endpoints, km

2.3 Calculate Link Budget

Receiver Sensitivity (Rx)

The minimum RF signal power level required at the input of a receiver for certain performance (e.g. BER).

EIRP (Effective Isotropic Radiated Power)

The antenna transmitted power. Equal to the transmitted output power minus cable loss plus the transmitting

antenna gain.

P_{out} = Output power of transmitted in dBm

C_t = Transmitter cable attenuation in dB

G_t = Transmitting antenna gain in dBi

G_r = Receiving antenna gain in dBi

FSL = Path loss in dB

C_r = Receiver cable attenuation is dB

S_i = Received power level at receiver input in dBm

P_s = Receiver sensitivity is dBm

$$S_i = P_{out} - C_t + G_t - FSL + G_r - C_r$$

$$EIRP = P_{out} - C_t + G_t$$

Link Budget Calculation

$$\text{EIRP} = P_{\text{out}} - C_t + G_t$$

$$\text{FSL} = 32.4 + 20 \times \log F(\text{MHz}) + 20 \times \log R(\text{Km})$$

$$S_i = \text{EIRP} - \text{FSL} + G_r - C_r$$

The received signal power should be above the sensitivity threshold.

Link Feasibility Formula

To determine if a link is feasible, compare the calculated Receive Signal Level (S_i) with the Receiver Sensitivity Threshold.

The link is theoretically feasible if

$$S_i \geq R_x$$

If the Receive Signal Level is greater than or equal to the Receiver Sensitivity Threshold then the link may be feasible since the signal should be strong enough to be successfully interpreted by the receiver.

2.4 Calculate Fade Margin and Link Availability

Fade Margin is the difference between the unfaded Receive Signal Level and the Receiver Sensitivity Threshold. Each link must have sufficient Fade Margin to protect against path fading that weakens the radio signals. Fade Margin is the insurance against unexpected system outages.

Fade Margin is directly related to Link Availability, which is the percentage of time that the link is functional. The percentage of time that the link is available increases as the Fade Margin increases. A link will experience fewer system outages with a greater Fade Margin. A link with little or no Fade Margin may experience periodic outages due to path fading phenomena.

Climate Conditions and Path Fading

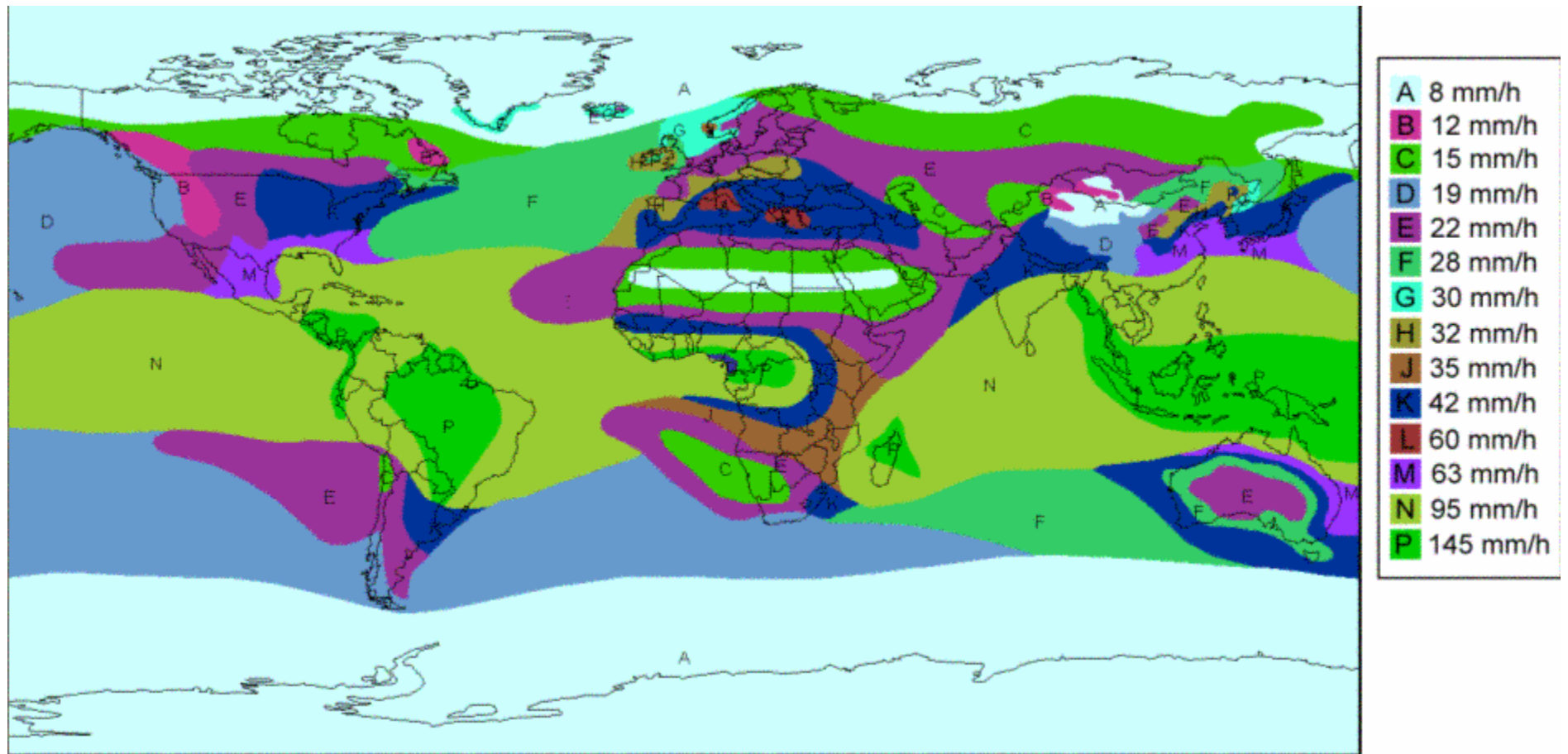
Path fading occurs more frequently in flat, humid environments than in rough, dry locations. Therefore, a link in flat and humid area requires a greater Fade Margin to achieve the same level of Link Availability as a link in a rocky and dry location. When calculating link performance the Climate factor must be taken in consideration.

Climate factor

2.0	Maritime temperature, Mediterranean, coastal or high-humidity- and temperature climatic regions.
1.5	Maritime sub-tropic climatic regions
1.0	Continental temperature climates or mid-latitude inland climatic regions with average rolling terrain.
0.5	High dry mountainous climatic regions.

You may use SAF Tehnika's Performance Calculator to determine the amount of Fade Margin required to achieve a desired level of Link Availability.

3 Rain Zone Map



4 SAF Tehnika A/S Contacts

Most up to date contacts of SAF Tehnika A/S could be found at Web site www.saftehnika.com.

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