Training Program : Point-to-Point Radio Link Design

Course : Introduction & Basics

COMPLEMENTS to Lesson 1 : Introduction

Early Radio Communications experiments

Guglielmo Marconi (1874-1937) was an Italian self-taught scientist, a pioneer in the field of wireless communications. He was the first to demonstrate that EM signals can be transmitted and received at a distance of hundreds of meters (1896) and across the Atlantic (1901).

Experimental results were transferred to the design and production of the first radio equipment; as an entrepreneur, Marconi was the founder of "The Wireless Telegraph & Signal Company", which later became the Marconi Company.

In 1909 Marconi was awarded the Nobel Prize for Physics.

The role of wireless communications in maritime rescues was clear in 1912, when a SOS message was sent from the sinking Titanic, thus allowing to save 710 passengers. Britain's Postmaster-General, referring to the Titanic disaster, wrote: "Those who have been saved, have been saved through one man, Mr. Marconi ... and his marvelous invention."

From a Marconi's speech [1] : "There have been three great moments in my life as an inventor. One when my early wireless signals rang a bell at the other side of the room in which I was carrying out my experiment [1895]; the second when the signals from my station at Poldhu in Cornwall found response in the telephone receiver I was holding to my ear at St. John's, Newfoundland, 1,800 miles away over the Atlantic [1901]; and today [December 1935] when I quietly contemplate the possibilities of the future and feel that my life's work has provided a sure foundation on which the workers of today and tomorrow may build."

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Propagation Models

Propagation Models [2] can be classified as Deterministic, Statistical, or Mixed.

Deterministic Models are useful to investigate “Hypothetical” or “Typical” conditions (for a better understanding of specific events); they require complete specification of propagation environment (geometry, electrical parameters, etc.).

Application to Radio Link design is possible in a very simple scenario or to provide a bound in performance predictions.

Heavy data input and computational load is required in complex scenarios (for example in computer applications like ray tracing, GTD, etc.). In order to take account of variable conditions, it is necessary to proceed with model iterations with different parameters and to weigh results according to assumed parameter statistics.

Statistical Models are widely used in Radio Link design and performance predictions (e.g., multipath fading, rain attenuation), at least for every-day applications, with low-moderate computational effort. They include environment variability on a medium-long-term basis. For this reason, it can be not easy to match model predictions with specific observations of extreme events.

ITU-R “Worst Month” concept [3] is a tool useful to take account of seasonal periodicity of critical events (average of worst data over a long-term period).

Criteria for model selection

Propagation Models are selected as a trade-off between design requirements and credibility, computational load, possibility of detailed environment description, cost / time effort, etc.

Long-term experience using a given model improves Model Credibility. Some examples of well-established models are:

- Bell Labs Multipath Activity Model (Barnett-Vigants)
- Longley-Rice (Irregular Terrain Model)
- Crane Rain Model (revised a couple of times)

An additional criterion for model credibility is the Model Source. Under this aspect, internationally agreed models (like ITU-R Recommendations) are to be considered

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highly reliable. A possible drawback is that quite often such models are subject to frequent revisions, so Model Stability (a further criterion for model selection) is not guaranteed.

It is useful to stress that, in the Design process, the selection of a given Propagation Model can be viewed also as the result of a “mutual agreement” among people playing different roles in System Design, Installation, and Operation.

Agreement on Propagation Model is complementary to similar agreements on performance objectives, compliance with international, regional or national standards (ITU-R, Radio Regulations, ETSI…), and other key factors in the overall Design Process.

Useful References

[1] Guglielmo Marconi Foundation

[2] K. Haneda, R. Rudd, E. M. Vitucci , "Radio propagation modeling methods and tools", Elsevier Ltd., 2021

[3] ITU-R Rec. P.581-2, "The concept of 'Worst Month'", 1990

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