RAIN ATTENUATION ESTIMATED FROM RADAR MEASUREMENTS FOR MOBILE SATELLITE SYSTEMS AND BASED MOBILE UNIT TERMINALS

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DEDICATION

Dedicated to my beloved mother and father for their patience and encouragement.

To my family, who inspires me.

To all my friends, who supports and encourages me.

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ABSTRACT

Future satellite mobile communication systems designed for mobile user applications will use extremely high frequency carriers to provide more capacity and smaller equipment. At these frequencies, the extra attenuation due to rain is a primary cause of communications impairment on satellite-earth paths, especially above 10 GHz. Rain seriously influences the performance of a communications satellite link. **A** good knowledge of the statistical behavior of rain attenuation in a particular region is vital.

The ability of radar to scan a wide area around the radar site and not just a particular path made it a very attractive for many types of investigations. Radar can be used to measure the rainfall rate indirectly. For this study, the 1 km range bin is more useful and thus, the volumetric scan. Measuring of specific attenuation is done using the 1 km range bin for the volumetric scan. An important information in this method that we have to work up and to define in which azimuth angle, elevation angle and the n- range of the attenuation is occurred from the radar station. To get the total rain attenuation path, we have to sum up all the specific attenuation under the rain height. This project focus more on the method of measuring attenuation per unit distance that had been observed using Kluang meteorological radar. This method is also an important parameter for microwave link because it enables the attenuation due to rain to be determined. The information of this method is useful for microwave link applications, designing mobile communication systems and also set up specification of the new meteorological radar.

ABSTRAK

Pada masa hadapan sistem komunikasi bergerak lebih banyak menggunakan pembawa frekuensi tinggi bagi membolehkan sistem ini mempertingkatkan penggunaannya serta dapat memperkenalkan peralatan yang lebih kecil Peningkatan dalam penggunaan frekuensi tinggi lebih terdedah dan di pengaruhi oleh hujan. Oleh yang demikian, ia akan mengganggu sistem komunikasi diantara satelit dan bumi terutamanya penggunaan frekuensi yang melebihi 10 GHz. Hujan merupakan masalah utama yang mempengaruhi prestasi sistem komunikasi satelit. Kemampuan radar mengesan keadaan sekeliling di kawasan yang lebih luas menyebabkan ia selalu digunakan dalam pelbagai bentuk penyiasatan Radar juga boleh digunakan untuk megukur hujan secara langsung. Pengukuran rosotan isyarat dilakukan dengan menggunakan julat pengukuran per km mewakili unit isipadu. Untuk mendapatkan rosotan hujan keseluruhannya, maka rosotan hujan per kilometer akan dijumlahkan sehingga di bawah paras ketinggian hujan. Parameter yang penting yang perlu diperolehi dari projek ini adalah untuk mendapatkan maklumat tentang rosotan hujan yang berlaku dengan memperolehi sudut azimuth, sudut dongakan dan bilangan julat yang ke berapa rosotan isyarat telah berlaku. Projek ini lebih menerangkan cara perlaksanaan untuk mengukur rosotan isyarat yang berlaku pada setiap kilometer yang dikesan oleh radar Kluang. Kaedah ini amatlah penting dalam mengetahui rosotan isyarat yang berlaku dalam perambatan gelombang mikro apabila berlakunya hujan. Kesemua maklumat dalam kaedah ini amatlah berguna dalam penggunaan gelombang mikro, merekabentuk sistem komunikasi bergerak dan juga dapat membantu dalam merancang spesifikasi radar yang sesuai untuk sesuatu kawasan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

A_R	-	Rain Atenuation
As	-	Specific Attenuation
Az	-	Azimuth Angle
dB	-	Decibel
f	-	Frequency
GEO	-	Geostationary Earth Orbit
GHz	-	Giga Hertz
h	-	Height of Satellite
ITU	-	International Telecommunication Union
L	-	longitude between satellite and terminal meridians
La	-	Latitude
LEO	-	Low Earth Orbit
Lo	-	Longitude
L_S	-	Slant Path Lenght
l_S	-	subsatellite point latitude
l_e	-	terminal latitude
N	-	North
$\mathbf{r}_e$	-	Earth Radius
$\mathbf{r}_s$	-	Satellite Radius from the center of eath
R	-	Rain Rate
S	-	terminal to satellite distance
W	-	West
Σ	-	Summation
γ	-	coverage angle

θ	-	Elevation Angle
α	-	Azimuth Look Angle

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Attenuation due to rain has long been recognized as the main source of atmospheric attenuation in terrestrial and satellite links beyond 10GHz. Knowledge of the rain attenuation at such frequency range is desirable in the planning of a reliable communication system at any location. This will be more crucial in tropical regions because of their high intensity rainfall. For a tropical country like Malaysia, rain occurs almost yearound and in most instances, the rainfall rate is much higher when compared to temperature regions

Rainfall rate statistics specified on a percent of time basis, that is the percent of time in a year or a month that the rain rate equals or exceeds a specific value is used in the rain attenuation prediction. The ITU rain attenuation method is based on 0.01% of a year rain rate parameter[1]. Rain attenuation is caused by the overall rainfall intersecting the propagation path. This is usually modeled as the integration of the specific attenuation (attenuation per unit of distance) along the path.

Mobile satellite communication is affected, of course, not only by rain but also by shadowing, blockage, and multipath[2]. This project focuses on rain attenuation only.

Notice, however , that at the end of a future technological breakthrough in “smart” antennas (phased arrays with a lot of signal processing), which may largely reduce the impact of multipath by ad hoc processing, rain will remain the irreducible cause of fading and system outage (if obstruction and shadowing are avoided) and must be considered.

A source of data suitable for this kind of project is the radar data. The Meteorological Department of Malaysia operated several meteorological radars throughout the Malay Peninsular, Sabah and Sarawak. These radar data can be utilized to extract the rainfall rate in Malaysia. However, in this study, only the Kluang radar data, located in the southern part of the Malay Peninsular is utilized[3].

1.2 Objective of study

The main objective of this project is to obtain specific attenuation and rain path attenuation between mobile unit to mobile satellite system that had been observed from Kluang meteorological radar.

The information gained from this method is important to predict the performance of mobile satellite communication system in Malaysia and also useful for microwave link system planning and link budget estimation.

1.3 Scope of Project

The work undertaken in this project is limited to the following aspects:

I. Literature review.
   Reviews on the existing mobile satellite communication and choose one satellite in LEO orbit as a mobile satellite.

II. Satellite visibility angle

Calculate the mobile satellite visibility angle (γ - coverage angle). By knowing visible angle, calculate azimuth and elevation angles of mobile unit due to mobile satellite.

III. Selection of desire location.

Select several locations from kluang radar as a mobile moves on. The range of the kluang radar station is from 4 km up to 512 km in a radial direction, but data were collected only up to 150 km. The range bin is 2 km for the composite PPI scan and 1 km for the volumetric scan.

IV. Radar scanning

For volumetric scan, the antenna beam will pass or rotates azimuthally 15 times in the duration of 5 minutes. After each pass or rotation, the antenna beam is elevated to a higher elevation angle.

V. Azimuth and elevation angle of radar

Azimuth angle were covered 360° and the elevation angle were covered from -2° to 90° .

VI. ITU-R (P.838-3)

Using ITU-R (P.838-3)[4] prediction to calculate specific attenuation.

1.4 Research Methodology

The methodology of this research is shown in the flow chart in Figure 1.4 below:-

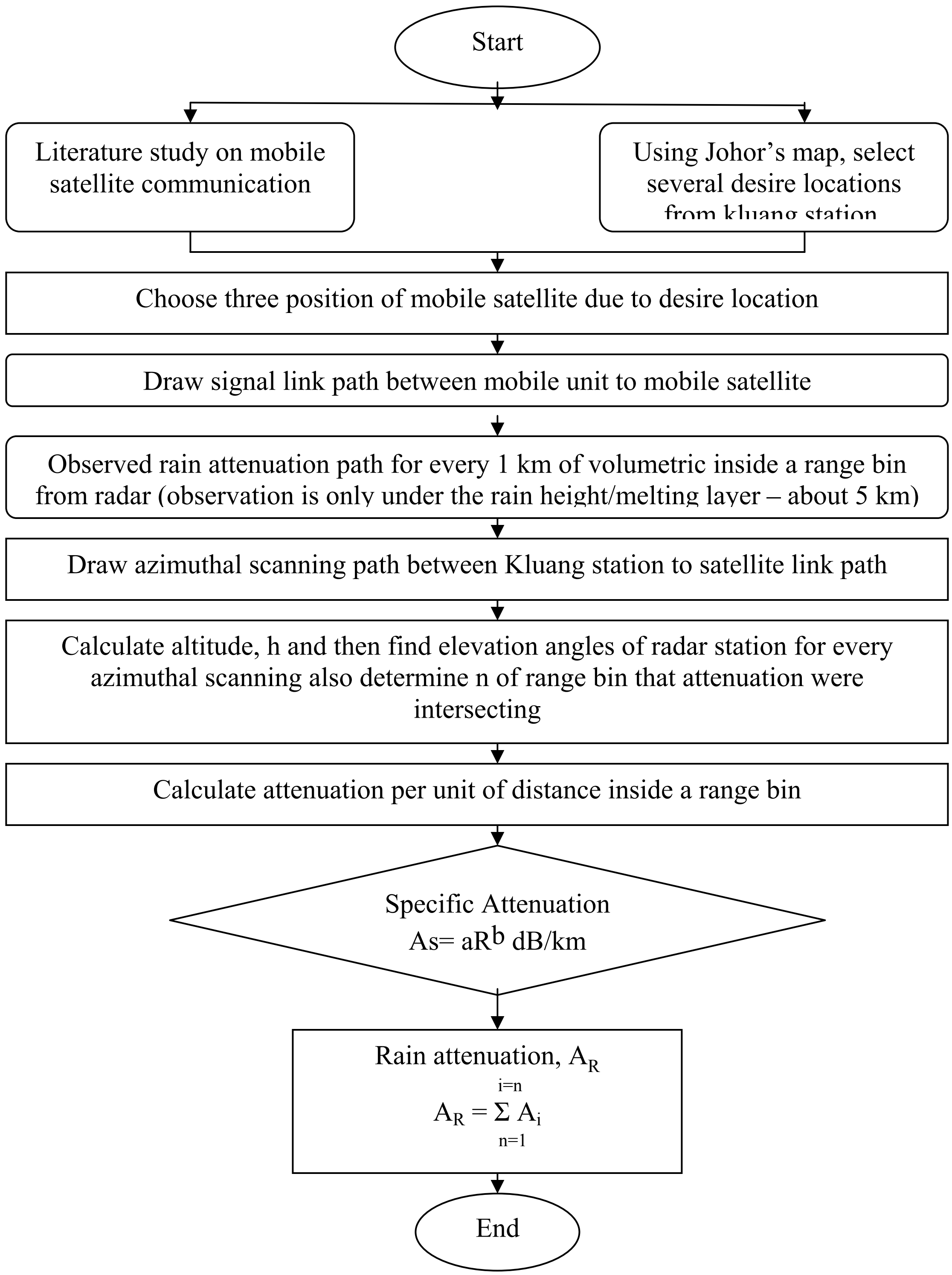

Figure 1.4 Research methodology flow chart

In the beginning, there are two tasks that need to be done simultaneously. Besides of doing literature review for mobile satellite communication, selection of desired location around Kluang radar station must be considered.

Then, choose three position of mobile satellite with different longitude, latitude and visible angle due to desire location. Also calculate azimuth and elevation angles of desired location to mobile satellite. Draw signal link path between mobile unit to mobile satellite.

Observation is done by draw a line for every 2^0 of azimuth angle from radar station to mobile unit. Calculate altitude, h and from there find elevation angle for every azimuthal scanning. Observed rain attenuation path for every 1 km of volumetric inside a range bin from radar station. Observation is done under the rain height or melting layer is about 5 km. In this project n of range bin that rainfall were intersecting must be also considered.

Using ITU-R recommendations, calculate specific attenuation (dB/km) or attenuation per unit distance. Finally, sum up all the specific attenuation to calculate rain attenuation (dB).

1.5 Layout of Thesis

This section outlines the structure of the thesis. Chapter 2 is the literature review of the project. It covers the basic concept of the mobile satellite communication, the orbit system, classification of polarization, visibility of mobile satellite and azimuth and elevation angle formula.

In Chapter 3 describes the theory of Meteorological radar, which is used to observe the data scan. The mechanism and specifications of radar, specific attenuation and rain attenuation are also mentioned in this chapter.

The methodology of signal path is presented in this chapter 4. The geometrically analysis has been shown in this chapter to determine the distance between desired location and radar station in Kluang. The signal path from the desired location respected to mobile satellite is also calculated.

Chapter 5 shows the calculation on specific attenuation and rain attenuation for several locations that had been observed from the radar station.

The summary of the results and recommendation for future works will be presented in Chapter 6.