# CHAPTER 1

## INTRODUCTION

This thesis aims to serve as a basis in performance analysis of target detection in the presence of sea clutter. It is explained in such simple manner so that any of the interested audience for this document can understand it fully. This chapter discussed in brief the fundamentals of radar system, the research objective, the scope, the problem statement and the methodology used through out the period of research.

## 1.1 FUNDAMENTALS OF RADAR SYSTEM

The term RADAR is an acronym for RAdio Detection And Ranging. Radar is an electromagnetic system that usually operates at microwave frequencies. It is a method of using radio waves to detect the existence of an object and its position with respect to a known point, the radar antenna.

Radar rotates and transmits thousands of radio waves in a second; each one could reach a target and return to the radar. The target maybe localized (point target) such as ship, building or personnel or distributed such as rain and ocean. Figure 1.1 illustrates the basic principle of radar [1].
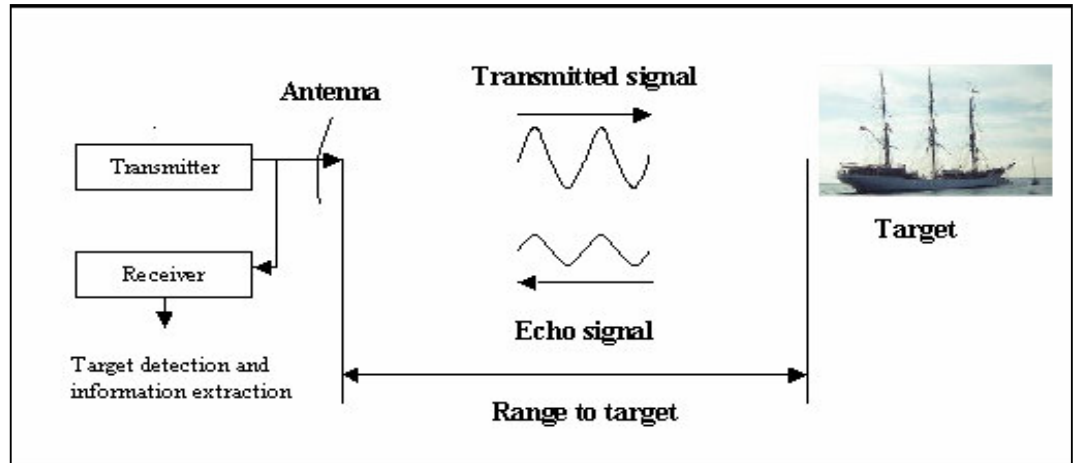
Figure 1.1: Basic principle of radar

The concept of radar dates back to 1886, when Hertz discovered the metallic and dielectric objects reflect radio waves [2]. The most rapid development of radar occurred during the Second World War, originally meant for target detection and early warning. As the technology emerges, radar is being used in other various applications such as navigation, mapping and speed measuring.

1.2     RESEARCH OBJECTIVE

As the title suggest, the main objective of this research is to theoretically measure the performance of radar system with the ocean as the physical environment of interest.

In radar, the detection of a target depends on two probabilities; the probability of radar will detect a specified target at a particular range (Probability of Detection, $P_D$) and probability of radar making a false detection when actually no target echo is present (Probability of False Alarm, $P_F$). The performance of radar is best analyzed through a parametric plot of $P_D$ versus Signal to Noise Ratio (SNR), with $P_F$ as the parameter called the Receiver Operating Characteristic (ROC).

In analyzing the radar performance in the presence of sea clutter, these two objectives should meet:

     i.      To analyze the effect of low SNR

     ii.     To analyze the effect of different clutter distributions

## 1.3    RESEARCH SCOPE

As mentioned in the research objective, this research aims to measure the theoretical performance of radar concentrating in two main factors of radar performance, the SNR and clutter distribution. The list of other factors that can affect radar performance is given in Appendix A. Although radar performance is usually measured based on its ability to detect and estimate the location of objects accurately, it is important to note that this research only focus on the detection part of radar.

Since this research aims to obtain the theoretical measure of radar performance, there will be no hardware and software components involved except some aid of MATLAB programming. It is assumed in this research that all radar equipments (hardware and software) are designed and working ideally and are set to the maximum performance. It is also assumed that no internal noise is present.

## 1.4    RESEARCH PROBLEM

Radar operating in maritime application has serious limitation imposed in their performance by unwanted sea echoes. The main motivation to come out with this research is due to the practical problem faced by our surveillance radar (at Tanjung Piai) on difficulties to detect small objects (small boats). This problem inspired me to go into details on radar performance in the presence of sea clutter.

During early stage of radar development, the clutter echoes were considered as Gaussian distributed. However, with the development of modern radar system where radar is operating at low grazing angle with high-resolution capacities, the statistic of sea clutter is observed to deviates from the normality. The disturbance of sea clutter is spikier than the Gaussian distribution and forces the radar target detector to process them as targets, which is not. Thus, cause the false alarm to increase.

The unknown prior probabilities, distribution and presence of sea clutter make detecting a target difficult in radar detection. Small objects have low Signal to Noise Ratio (SNR). In Receiver Operating Characteristic (ROC) of Likelihood Ratio Test (LRT), the lower the SNR, the smaller the separation between the two hypotheses (presence or absence of a target), and hence, Probability of Detection ($P_D$) for a fixed Probability of False Alarm ($P_F$) will be smaller, which indicates the correct detection for small objects is harder to be achieved.

1.5     RESEARCH METHODOLOGY AND PLAN

This research is being carried out in two semesters. The first semester is to get familiar and to obtain as much information about the research topic via literature review. During the second semester, the implementation of the research is done. The fundamental interest of this research is to come out with parametric plot of $P_D$ versus SNR (ROC) of small target detection in Gaussian and non-Gaussian clutter distribution for optimum detection in maritime radar application. These plots will then be used for analysis of the radar performance.

Listed below is the chronological methodology on how this research being carried out:

1. Learn the fundamentals of radar system
2. Technology review
3. Literature review on research area
4. Evaluate ROC under Gaussian distribution (coherent)
5. Evaluate ROC under Gaussian distribution (non-coherent)
6. Evaluate ROC under non-Gaussian distributions (Rayleigh and K)
7. Study the effect of small target size
8. Analyze the radar performance under different clutter distributions
9. Draw conclusion based on findings
10. Thesis writing

Table 1.1: First Semester Research Plan

| Tasks | June | | | | July | | | | August | | | | September | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Choose topic | / | | | | | | | | | | | | | | | |
| Topic review | / | / | | | | | | | | | | | | | | |
| Discussion with supervisor | | / | / | / | | / | | | / | | / | | | | | |
| Research proposal submission | | | | / | | | | | | | | | | | | |
| Literature on radar | | | | / | / | / | | | | | | | | | | |
| Literature on research area | | | | / | / | / | / | / | / | / | | | | | | |
| Theoretical foundation | | | | | / | / | / | / | / | / | / | / | | | | |
| Research proposal report writing | | | | / | / | / | / | / | / | / | / | / | / | / | | |
| Research proposal report submission | | | | | | | | | | | | | | / | | |
| Research proposal presentation | | | | | | | | | | | | | | | / | |

Table 1.2: Second Semester Research Plan

| Tasks | December | | | | January | | | | February | | | | March | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Calculation of ROC (Gaussian distribution) | / | / | | | | | | | | | | | | | | |
| Calculation of ROC (Rayleigh distribution) | | | / | / | | | | | | | | | | | | |
| Calculation of ROC (K distribution) | | | | | / | / | | | | | | | | | | |
| Study on effect of low SNR | | | | | | | / | / | | | | | | | | |
| Analysis on effect of different clutter distribution | | | | | | | | | / | / | | | | | | |
| Draw conclusion | | | | | | | | | | | / | / | | | | |
| Thesis presentation | | | | | | | | | | | | | | / | | |
| Thesis writing | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | |
| Thesis draft submission | | | | | | | | | | | | | | | / | |
| Thesis submission | | | | | | | | | | | | | | | | / |