77 GHz FM-CW Radar for FODs detection

K. Mazouni [1], A. Kohmura [2], S. Futatsumori [2], N. Yonemoto [2],
J-Y. Dauvignac[1], Ch. Pichot [1], C. Migliaccio [1]

[1]*Laboratoire d'Electronique Antennes et Telecommunications*
Université de Nice-Sophia Antipolis/UMR-CNRS 6071
250 rue A. Einstein, bât.4
06560 Valbonne, France
karim.mazouni@unice.fr

[2] *Electronic Navigation Research Institute*
7-42-23 Jindaijihigashi-machi, Chofu
Tokyo 182-0012,Japan

***Abstract*-Foreign objects and debris (FODs) may cause accidents or disasters. The crash of a Concorde jet in France that killed 113 people in 2000 is an example of the danger created by a thin metal strip that fell from another airplane. Recently, FOD detection systems have been developed and tested on airports. Most of them are based on the association of a mm-Wave radar and an optical sensor. This paper describes the investigation, conducted together with the ENRI and LEAT on a wide band mm-Wave radar module. It is composed a 76-81 GHz front-end and a quasi-optical antenna that is a printed Fresnel reflector operating with circular polarization. The purpose of this paper is to compare the measured responses of selected. This work is conducted within a Sakura project funded by the French and Japanese Ministries of Foreign Affairs.**

I. INTRODUCTION

The crash of a Concorde jet in France in 2000 is an example of disasters due to foreign objects and debris (FODs). Moreover, US$ 4 billions are spend each year by the airlines for repairing the damages caused by FODs to the aircrafts. Additional is the cost of the delays resulting in the time taken for identification and FOD removal. In order to overcome this problem, several companies have proposed and tested on the airports automated FOD detection systems. The main ones are listed below:

- Tarsier system [1] developed by Qinetiq. It consists of a 94.5 GHz radar and a with powerful day and night camera system. Actually in place at Vancouver and Heathrow airports.
- FODetect [2] developed by Xsight. It consists of a 76-77 GHz radar and an optic sensor with NIR illumination. Actually in place at Boston Airport.
- iFerret [3] developed by Stratec using a self-calibrated camera with enhanced image processing. Actually in place at Singapore airport.

Additionally, companies or academics are investigating sub-systems, mainly mm-Wave radar modules, for this application [3-6]. Looking back to radar modules of the existing systems, two approaches have been tested. The first one [1] consists in using one or two powerful radars. Each of them is placed on a high tower outside of the runway and covers about 1.5 km range. On the other hand, [2] is a distributed system, placed together with the runway-lights. Each radar module is very compact and covers only a pre-determined portion of the runway. This second approach has also been chosen in this paper. It is a joined work between the by the ENRI (Electronic Navigation Research Institute, Tokyo, Japan) and the LEAT (Laboratoire d'Electronique Antennes et Télécommunications, University of Nice, France) within the frame of a Sakura project. In comparison to [2], a wide band radar 76-81 GHz modules has been developed in order to improve the range resolution.

Until recently, investigations were conducted without real regulations but in August 2009, the Federal Aviation Administration (FAA) recommended the guidance and specifications in the Advisory Circular for implementing and conducting a FOD management program [7]. For example, a stationary radar system, located within 200 ft (60 m) from the runway centre line, should detect 1 inch (2.5 cm) diameter and 1 inch height cylinder on the runway surface at a range of 150 ft (46 m) from the sensor.

The purpose of this paper is to evaluate the mm-Wave radar module performances using selected targets. The paper is organized as follows: section II deals with the antennas conception and measurements. Section III describes the mm-Wave front-end while the measurements results obtained with the selected targets are presented in section IV.

II. ANTENNA DESCRIPTION

FOD detection requires high gain, low loss. For this purpose, a quasi-optical antenna is the best choice due to the high feeding losses of line-fed arrays at mm-Waves. In addition to that, the antenna should be as compact as possible since we aim to install the system near the runway. Printed reflectors, like Fresnel reflector or reflectarrays is a good candidates. The main advantages of printed reflectors over lenses are their low weight and cost. Moreover, it is quite easy to control the radiation pattern shape or the antenna polarization. This is due to the phase control done by a simple change in the size of the elementary cells.

Let us first describe the printed reflector. It is of Fresnel type because the phase correction is done into a pre-determined number of zones, *P*. A Fresnel zone corresponds to a phase correction of $2\pi n\lambda/P$ where n varies from 0 to $(P-1)$. Each zone contains several patches but all of them are of the