Design of COTS Dual-Circularly Polarized Conical-Scan Cassegrain Antenna for Rocket Tracking

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***Abstract*— The purpose of this project is to design a Dual-Circularly-Polarized Cassegrain Antenna used for tracking of DTI's experimental rocket. Conical-scan tracking scheme is used for simplicity of the design and development instead of electronic scanning. Dual polarizations, LHCP and RHCP, have been used to tackle the change of polarization during the approach of the rocket to the ground station and the departure away from it. As a low-cost prototype, main structure of the antenna consists mainly of a COTS parabolic dish, a CNC-machined hyperbolic sub-reflector and an FR-4 based dual-circularly polarized Microstrip patch feeder. Various dimensions are optimized to reduce blocking ratio to best suit small parabolic dish as well as to achieve optimal beam shape. One RF channel has been dedicated for tracking purposes in order to maximize the scanning rate while the other is solely used for data reception. Tracking rate and accuracy are designed to match with speed of the rocket acquired from the study of Concept of the Operation (CONOP).**

Keywords*— *Rocket Tracking; Dual Circular Polarization; Conical Scan; Cassegrain Antenna, Hyperbolic Subreflector; Parabolic Dish Antenna; Microstrip Feeder; CONOP; Tilting Mechanism; PAN Device;

I. INTRODUCTION

As part of ground support system for dynamic test of DTI's medium range rocket, a few tracking antennae are needed to track telemetry signal from the rocket along the whole flight path. Together with a high-speed wireless Ethernet LAN, hand-off and synchronization data can be sent from a GPS Time Server locating at the launch control center to the tracking antennae along the flight path.

Here, a low-cost conical tracking antenna is designed and demonstrated using free simulation software. Motorized conical scan with adjustable off-boresight angle mechanism is used for design simplicity. System modularity and the use of COTS equipment have been emphasized. The challenge lies in the integration of many current technologies into a mobile unit for demonstration purposes while taking into account all tactical constraints during the design.

In this paper, a broad view of the project is given together with user's requirement and Concept of Operation (CONOP), followed by system design using a software simulation tool. Once most of design parameters are obtained, system architectural design and subsystem selection are taking place based on the calculation and available COTS equipment in the market. The last part of the paper covers detailed design of each subsystem based on worst case scenario and equipment limitation.

II. SYSTEM REQUIREMENT AND SYSTEM DESIGN

A. *System Requirement and CONOP*

It is assumed that the rocket is to be launched into open sea with a maximum operational range of 20 km and the highest speed of 3 Mach respectively. Fig. 1 illustrates the CONOP where a fixed directional antenna is used behind the launcher and a little to the back to get a good view of the rocket for couple of 10 kilometers before passing on to tracking antennae situating along the way. It is recommended that the antenna behind the launcher be off to the side a little so as to avoid the effect from ion plume from the rocket which behaves as if it is a ground plane and therefore prevents effective communication from the rocket to the ground. A balloon receiving station towed to a buoy should be used in the vicinity of the impact point so that the communication from the rocket can be maintained up to very last seconds before impact. Also, the tracking antenna situated by the side of the flight path should be agile enough to cope with speed of the rocket. This has to be carefully designed and traded off during site selection as the distance off the center line varies inversely with the agility.

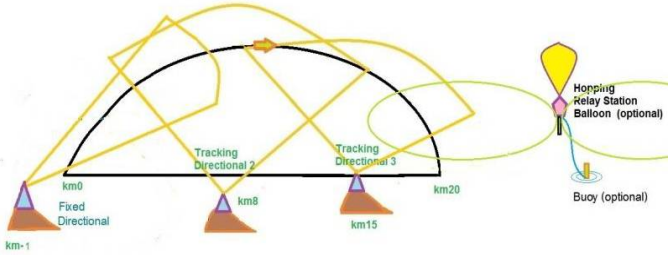

Fig. 1. Shows tracking antennae situating by the side of flight path

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