A PORTABLE 35 GHZ CROSS-TRACK INTERFEROMETER FOR TOPOGRAPHIC AND SURFACE CHANGE MEASUREMENTS

Paul Siqueira, Harish Vedantham, Tony Swochak

University of Massachusetts
Dept. of Electrical and Computer Engineering
Amherst MA

1. INTRODUCTION

The sensitivity of a cross-track interferometer is governed in part by the the size of the antennas and the separation between them. That is, increasing the along-track dimension of the antenna can be used to produce a narrow beam in the azimuth, which in turn improves the signal to noise ratio. For a fixed phase measurement accuracy, the interferometric baseline can be increased to improve the sensitivity to topographic features. Often, physical size limitations exist which constrain the degree to which these dimensions can be increased, and therefore a compromise is made for the overall performance of the interferometric system. This is a limitation that can be especially true for spaceborne systems, where the consequence of having a non-trivial baseline in low earth orbit leads to having two satellite platforms, instead of one; or alternatively relying on repeat-pass observations for achieving similar goals, but at the consequence of noise being introduced by target decorrelation over time.

In this paper we introduce one solution to the set of limitations described above, which is to use a high frequency (Ka-band 35 GHz) carrier, which has the effect of reducing the scale of the overall interferometer when compared to conventional lower frequency (1-10 GHz) systems. Difficulties that arise in using a higher frequency system are the increased sensitivity to geometric variations in the millimeterwave components, and issues related to obtaining a satisfactory signal to noise ratio. In order to overcome these problems, the Microwave Remote Sensing Laboratory (MIRSL) at University of Massachusetts in Amherst has constructed a fixed location Ka-band interferometer for the purposes of prototyping components for a spaceborne system, and for use as an interferometer in its own right. The interferometer uses a 1W solid state amplifier and a 100 MHz FMCW chirp for obtaining good range resolution and sufficient signal to noise ratio to create interferograms that are limited by grazing angle and shadowing effects more than thermal noise, out to a range of 6 km from a 250m height above terrain (an 85 degree look angle). In what follows, we present initial results from the interferometer and discuss the processing strategy used for creating and interpreting the interferometric observations.

2. SYSTEM DESCRIPTION

The interferometric system consists of four fundamental sections. These are: i.) signal generation and timing, ii.) RF upconversion (to 35 GHz) iii.) RF downconversion, and iv.) digital sampling. Further processing (digital) occurs downstream in order for creating interferometric phase measurements and projecting the results onto a geographic coordinate system. Signal generation and timing takes place through the interaction of a National Instruments PXI system (including a MS Windows based controller) and an arbitrary waveform generator, for creating the swept frequency waveforms. The generated signals are created in the complex-domain using in-phase and quadrature components, in order for driving the upconversion stage while also suppressing the signal's image. A copy of the transmitted signal is used by the downconverter to stage to perform chirp compression and to reduce the data rate. Prior to transmission, the signal is amplified by a 1W solid state amplifier and fed to a slotted waveguide antenna, identical to the two receive antennas. Signals returned by reflections from the target are fed into the downconverter system, which reduces the frequency of the signal down to a 5 to 105 MHz range, suitable for sampling by a National Instruments digital oscilloscope card, co-mounted in the PXI chassis with the signal generation and timing system. This data is then stored onto a RAID system, capable of storing many hours of observations, which may then be later post-processed into meaningful data products. An image of the system, as it is deployed on a building top on the University of Massachusetts campus is shown in Figure 1a.

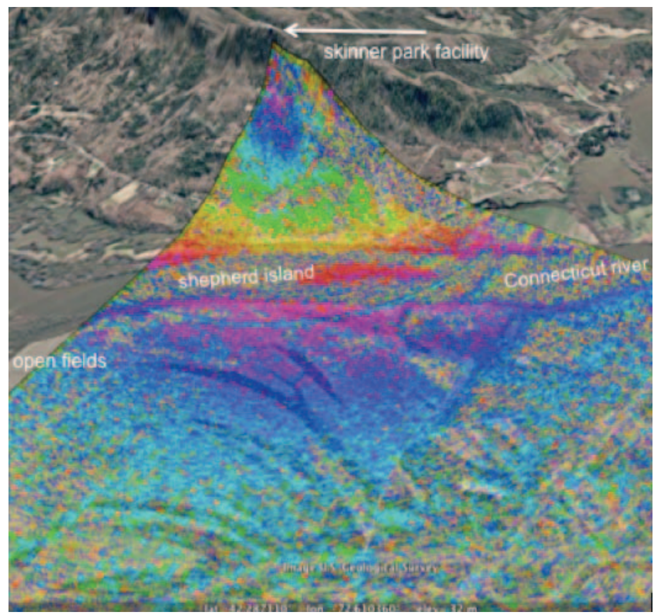
3. RESULTS

Testing of the 35 GHz interferometer has taken place in multiple stages. Initially in the laboratory, where gain, phase balance, and analog to digital conversion are tested within a controlled environment. The interferometer was then taken outdoors and used to image the side of buildings local to the UMass campus, taking the conventional geometry of an interferometer looking downward, and turning it on its side. First tests of the interferometer outdoors demonstrated that fringes and backscatter power were being collected by the system and could be correlated to features of the terrain and buildings. The next stage was to move the system to the top of one of the tallest buildings on campus (known as the Laederle Graduate Research Tower, LGRT) and images made from there. Although 70m is considered a good height for making backscatter measurements, for the interferometric system, more altitude was required to overcome the effects of geometric decorrelation as well as to increase the observable ground range at incidence angles less than grazing. Hence, the system was moved to a local state park (Skinner), that is located along the Holyoke Mountain range, some 270m above the local terrain. An image of the interferometric phase projected onto the local terrain is shown in Figure 1b. The slow change in phase as a function of range is indicative of the phase progression associated with a flat earth. Further analysis has been used for converting this phase into the height of the terrain above the local topography.

4. CONCLUSION

The Microwave Sensing Laboratory at the University of Massachusetts has developed a portable 35 GHz interferometric radar that can be deployed in a variety of observing geometries. The interferometer is shown to produce meaningful fringes that can be related to geographic features in the terrain. In this paper we will describe the system in more detail and demonstrate observed and processed results.

(a) Photograph of the 35 GHz interferometric system



(b) Interferometric phase projected over terrain

Fig. 1. System image and observations