Analysis and Simulation for a Spotlight-Mode Aircraft SAR in Circular Flight Path

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* The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a Contract with the National Aeronautics and Space Administration.

ABSTRACT

A wide azimuth beam SAR can offer higher resolution or wider azimuth viewing angle; two factors that help better characterize the backscattering property of targets for various science applications. One disadvantage of wide beam SAR is that a much higher pulse repetition frequency (] '10') is usually required since PRF is proportional to the radar beam angle. This problem can be resolved using a spotlight-mode concept: steering a narrow beam SAR to a fixed spot 011 the ground. The drawback of a spotlight-mode SAR is its limited coverage. A conventional spotlight-mode SAR operates along a straight line path as shown in Figure 1. It can be shown that spotlight-mode SAR that follow's a straight line path has difficulty in achieving the ultimate resolution of $\lambda/4$. It also cannot utilize the full 180 degree of azimuth viewing angle that can be attained only when the synthetic aperture length approaches infinity.

A spotlight-mode SAR can also be operated from a circular flight path as shown in Figure 2. This type of spotlight-mod e SAR offers several advantages: (]) relatively easy to achieve the ultimate azimuth resolution, (2) it allows a full 360 degree of viewing angle, (3) there is 110 need to steer the radar, and (4) the required PRF can be scaled down according to the ratio between the radius of the radar spot to the radius of the flight path.

Several algorithms were presented for processing spotlight-mode SAR data or the rotating object data. These algorithms include the well known range-l)o])p]cr algorithm applied to subapertures, the backprojection processing method (Munson, ct. al., [1]) commonly used in computer-aided tomography (CA']'), and the polar format processing algorithm (Ausherman, ct. al [2]). One essential assumption required for both the CAT and polar algorithms is that the dimension of the imaged area is much less than the radar to target distance. Other processing algorithms devised for imaging rotating object include a tomographic extension of Doppler processing algorithm (Mensa, ct. al. [3]) and a range-Doppler processing algorithm (Walker, J. [4]). The first method is suitable only for imaging sparse arrays of objects due to its higher integrated sidelobe ratio (1 S1,1{); and both algorithms also rely on the assumption of large radar to target distance. An exact solution for a circular aperture acoustic imaging system was presented by Norton [5]. This algorithm requires the implementation of a quasi-fast Hankel transform [6] which is not very efficient.

The difficulty in processing s})otliglt-mode SAR data collected from a cicular path is that the Doppler history of a point target involves many higher order terms and that the deptl I of focus is very shallow. To overcome the first problem, the algorithm proposed here

make usc of an exact 2-1) spectrum of a point target (Jin, 1992 [1 o]) in a range Doppler like processing approach. To overcome the second problem, this algorithm updates its reference function as frequent as required using a special process that generates kernels from which reference functions can be derived efficient 1 y.

In summary, this paper gives a detailed analysis of the circular path spotlight-mode SAR system, a complete description of the processing algorithm, and results from processing simulations.

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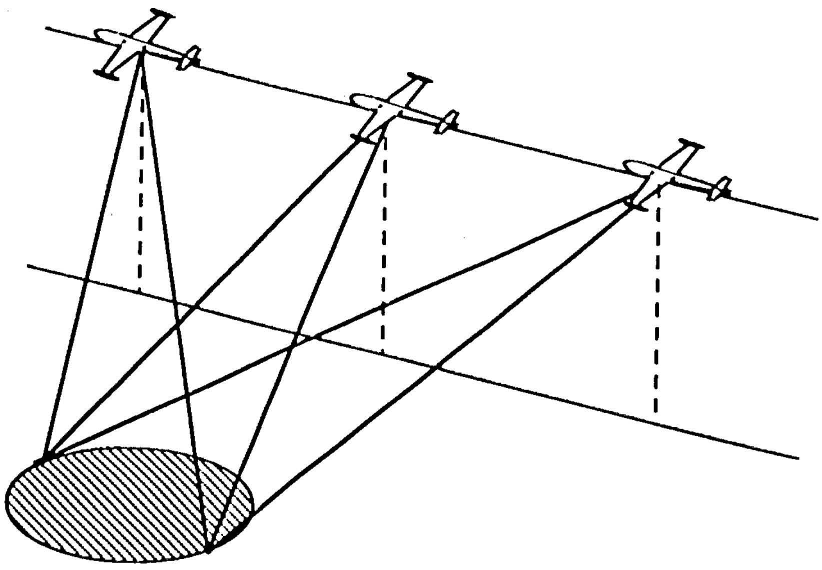

Figure 1. A straight line path Spotlight-mode SAR platform

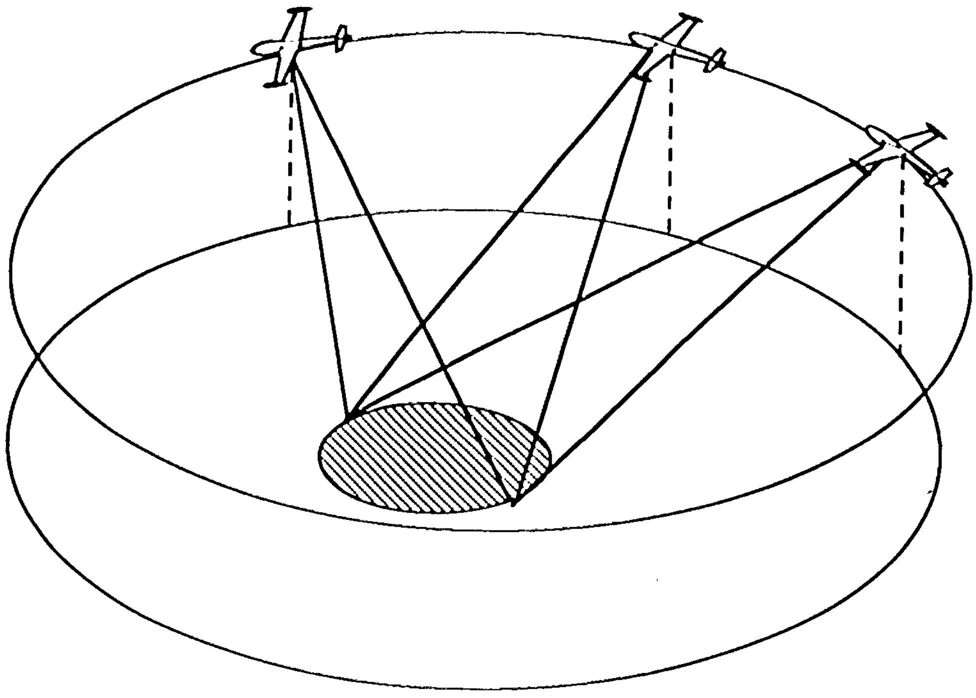

Figure 2. A circular path Spotlight-mode SAR platform