Background Synthetic Aperture Radar (SAR) offers the ability to image the Earth from space during daytime, at night, and in any weather. Synthetic Aperture Radar is an advanced form of radar which employs the relative motion between the radar sensor and the target to create a high resolution image. The radio waves transmitted from the sensor can penetrate the darkness and any weather or other optical obscurants providing a reliable source of high quality images. Existing space SAR imaging systems are large, very expensive spacecraft which have been funded exclusively by governments e.g. Germany (TerraSARx), Italy (Cosmo Skymed), Canada (RADARsat-2), and Japan (ALOS-2). SAR images provided commercially from these systems on the open market are prohibitively expensive (e.g. 1m resolution SAR images collected from low earth orbit by TerraSARx are $140 per sq km for a 1m resolution image). The high cost of space SAR imagery from these sources dramatically limits the application of this reliable earth imaging capability to only the few who can afford it. Dozens of commercial, government, and non-profit applications for a low-cost space SAR imaging capability have been identified including agricultural, petroleum, supply chain management, insurance, high value asset protection, and illegal fishing enforcement.

Recent developments in affordable small spacecraft components coupled with emerging low cost high-performance radio frequency transceivers and deployable antenna technologies have the potential to dramatically reduce the cost of collecting SAR imagery from low earth orbit. Trident Space has designed a promising affordable small satellite SAR system however the effort is hampered by lack of an effective testing approach which mimics the geometry of a low earth orbit SAR small satellite data collection. A comprehensive portfolio of SAR data collections representative of low earth orbit geometries is required to support the continuing development of the SAR small satellite payload and overall spacecraft system.

Objectives An elegant solution to this challenge is to employ an inverse SAR image processing approach for testing where the SAR satellite sensor would be placed on a tracking gimbal in a fixed position on the Earth. Objects of opportunity orbiting within view of the sensor location could then be imaged by the gimbal mounted SAR sensor on the ground using an inverse SAR processing approach. This inverse SAR geometry is analogous to a conventional SAR sensor orbiting above the Earth and imaging fixed locations on the ground except that ISAR technology utilizes the movement of the orbiting object rather than the SAR sensor to create the synthetic aperture. Experimentation in X-band with various pulse widths, pulse repetition frequencies and bandwidths up to 800MHz would allow for a broad scope of SAR data collection testing.

Trident Space will establish a ground test site in Bluemont Virginia for the developmental SAR small satellite payload configured with the Trident Multi-function RF Electronics Unit (MFREU) X-band Test bed payload electronics. This X-band SAR payload will be adjustable in bandwidth in a frequency band from 9200-10000 MHz and will operate with a maximum 800MHz of bandwidth in a pulsed mode using a linear FM chirp with an average power of 200W (1000W peak at max duty cycle of 20%). A typical SAR image collection event with this test system will be limited to 3 to 20 seconds of radar operation while pointing at an object in low Earth orbit such as a spent booster rocket. The antenna is a 1.8m parabolic dish with a custom designed X-band feed horn. The antenna has an f/D of .3 and 1.12 degree half-power beam width. The antenna will be mounted on a pan/tilt unit, less than 4 feet off ground and will have the ability to pan 360 degrees azimuth, and tilt 45 degrees from the vertical. The surrounding area has many hills, trees and buildings that will limit the beam propagation near the ground. This combined with a very short duration of transmission (3-12s) will dramatically reduce the probability of the beam intercepting an aircraft.

Trident Space will conduct a SAR Image Data Collection Research and Experimentation Program to collect inverse SAR imagery of orbiting objects at image resolutions, bit depth, grazing angles, sizes, and image quality (i.e. noise equivalent sigma zero) consistent with the SAR imagery collected by existing and emerging SAR smallsats. Inverse SAR image collection events will be conducted approximately once per quarter over a period of two years from a single fixed antenna on the ground in Bluemont Virginia. Continuous communications with the local ground control operator during imaging operations will allow "stop button" capability in the event of reported interference.

Trident Space will create a digital portfolio containing the collected SAR data sets to include the raw radar I & Q data, the GPS position and orbiting object orbit/position data necessary to form the SAR images, as well as processed complex SAR imagery at several resolutions (e.g. .5m, 1m, 3m) for each data set. These SAR image data sets will be made widely available to researchers in Government, academia and industry. The initial inverse SAR Image Data collection will be conducted in September 2017.

Contribution to utilization of the radio art This program of experimentation will support the realization of a low-cost SAR imaging small satellite which will dramatically reduce the cost of collection of affordable, reliable complex SAR image data from low Earth orbit. The test data collected will offer researchers in Government, academia and industry the opportunity to experiment with processing techniques for the new small satellite data and will be an important contribution to the expansion and utilization of the radio art regarding the future employment of affordable synthetic aperture radar images.