Background: Synthetic Aperture Radar (SAR) offers the ability to image the Earth from an aircraft or 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 providing a reliable source of high quality images. Interpretation and exploitation of Synthetic Aperture Radar (SAR) imagery products have traditionally been the domain of the human image analyst. Deep Learning Neural Networks (DLNN) and other advanced image processing algorithms are emerging which can identify objects of interest in SAR imagery.

The application of these promising emerging DLNN image processing techniques to SAR imagery has been hampered by the lack of readily available open source SAR imagery and the cost of available commercial SAR imagery (e.g. 1m resolution SAR images collected from low earth orbit by TerraSARx are $140 per sq km for a 1m resolution image). SAR offers significant advantages over Electro Optic (EO) including the ability to obtain images at night and through clouds or other optical obscurants. Complex SAR images also contain phase information that can be exploited in addition to amplitude data. An affordable, reliable source of complex SAR image data in sufficient quantities is required to provide the basis for development, training and evaluation of DLNN and other advanced image processing techniques that are tailored to exploit the unique characteristics of SAR imagery.

Dozens of commercial applications for these emerging data analytic capabilities have been identified including vehicle, container, and ship detection and classification however; a lack of relevant sample SAR imagery data and training data sets have limited the ongoing SAR data analytics development activities. A comprehensive portfolio of SAR imagery for selected commercial applications is required to support the continuing development of SAR data analytics.

Objectives: Conduct a SAR Image Data Collection Research and Experimentation Program to collect SAR imagery of commercial targets of interest using an airborne platform at image resolutions, bit depth, grazing angles, azimuth angles, sizes, and image quality (i.e. noise equivalent sigma zero) consistent with the SAR imagery collected by existing and emerging SAR smallsats. All required airspace operations approvals will be obtained from the local authorities prior to commencing flight operations. Continuous communications with the aircraft during imaging operations will allow “stop button” capability in the event of reported interference. Trident will employ a Cessna 206 aircraft configured with the Trident Multi-function RF Electronics Unit (MFREU) X-band Test bed payload electronics. This X-band SAR payload will be tunable 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 20W (500W peak at max duty cycle of 4%). Trident Space will utilize two distinct antennas. The first set of antennas is a pair of 20 dB standard gain horns (Pasternack PE9856-20) with 16 degree azimuthal and elevation half-power beam widths, one for transmit and one for receive. The second is a patch array antenna with 3.9 degree azimuthal half-power beam width and 8.7 degree vertical half-power beam width.

SAR imagery will be collected in areas which include container storage locations, oil tanks, pipeline and power transmission line right-of-ways, vehicle parking lots, ship loading docks, ship anchorages, fishing areas and other commercial activities of interest. Imagery will be collected at 800 MHz of instantaneous bandwidth for each target area from at least six different azimuth angles and at least two different grazing angles that are representative of the geometries expected from a SAR smallsat operating in LEO at a 45 degree inclination. Multiple collections for each target area will be conducted over several days

to provide data sets supporting change detection processing and DLNN design, development, testing, and training. Trident will create a digital portfolio containing the collected SAR data sets to include the raw radar I & Q data, the GPS and IMU 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 SAR Image Data Flight Program collection will be on the East Coast in July 2017 and include port areas in the vicinity of Bayonne, New Jersey and Baltimore, Maryland over a period of approximately two weeks.

Contribution to utilization of the radio art: This program of experimentation will result in collection of affordable, reliable complex SAR image data in sufficient quantities to provide the basis for development, training and evaluation of DLNN and other advanced image processing techniques that are tailored to exploit the unique characteristics of SAR imagery. The unrestricted availability of the SAR image data sets to researchers in Government, academia and industry represent an important contribution to the expansion and utilization of the radio are regarding the automatic extraction of information from synthetic aperture radar images.