Introduction
QinetiQ have developed a model to simulate the corruption of wideband radio waveforms propagated through a non-homogeneous ionosphere. The model is capable of simulating measurements from the ALTAIR VHF/UHF wideband satellite tracking radar on Kwajalein Atoll. Performance aspects of space-based Synthetic Aperture Radar (SAR) have also been simulated.

The Wideband Model
A multiple phase screen, split-step Parabolic Equation technique is used to describe the propagation of the complex electromagnetic field in planes normal to the propagation vector.

Phase screens are produced as stationary random functions whose spatial power spectra average to an ideal profile. This may be a log-log-linear spectrum parameterised by spectral index and strength of turbulence, and defined between inner and outer irregularity scale sizes. Elongation and orientation of the irregularities relative to both the geomagnetic field and propagation vectors are included in the model.

Measurement of Ionospheric Irregularities from Ascension Island
To provide ionospheric irregularity (spatial) spectra in the highly structured equatorial anomaly region, Total Electron Content (TEC) and 50Hz scintillation measurements have been made from a dual-frequency GPS receiver deployed on Ascension Island in 2004.

Temporal power spectra of TEC have been analysed and, using a model estimate of the ionospheric drift velocity, the RMS phase variation within the beam of a proposed foliage-penetrating space-based SAR has been determined. This quantity determines the ability of such a radar to apply autofocus techniques in forming an image.

Measurement and Simulation of Linear FM Chirp Propagation from the ALTAIR V/UHF Radar on Kwajalein
An experimental campaign has been conducted at the ALTAIR radar facility on Kwajalein Atoll (9.4˚N, 166.8˚E). Linear FM chirp waveforms were transmitted with 6MW power into a 42m dish (Figure 4) which tracked satellite calibration spheres of uniform radar cross section. The chirp bandwidth was either 7MHz on a 158MHz carrier or 18MHz on a 422MHz carrier. Sample results of the power distribution of returned 158MHz chirps are presented in Figure 2 as a function of Doppler and Delay.

Figure 4: The 42m ALTAIR 6MW radar at Roi, Kwajalein Atoll.

Simulation of SAR Point Spread Functions
The point spread function (PSF) has been simulated for existing and proposed satellite SAR operating between 500MHz and 5.3GHz for a range of ionospheric turbulence conditions (see example in Figure 5). The model records parameters such as beamwidth (azimuthal resolution), RMS and mean shift of peak (SAR image shift) and sidelobe levels which determine contrast in the SAR image.

Figure 5: An example of the modelled degradation of the SEASAT (1.3GHz) azimuthal PSF under moderate ionospheric scintillation conditions (S₄=0.2). Calculated parameters of the PSF are shown in the table (right).

Conclusions
The QinetiQ wideband propagation model provides a method of predicting and analysing trans-ionospheric radar performance. Low latitude TEC measurements in Ascension I. and wideband VHF and UHF radar measurements in Kwajalein are helping to parameterise and improve this model.