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Geospace Radar Architecture and Design

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1. Extended Abstract

Discussions of incoherent scatter radar (ISR) design have traditionally been dominated by concepts derived from the construction of dish based radar systems. More recent efforts to apply phased array radar technology has resulted in new radars and a growing body of experience in how this technology can be applied effectively. Design efforts have also generally focused on optimization for the single application of incoherent scatter measurement in the context of a large scale facility. Measurement of the Geospace environment using incoherent scatter requires radar systems with a sufficiently large power-aperture per unit temperature product. Key architectural choices include radar geometry (mono-static, locally bi-static, bi-static, and multi-static), operating frequency, antenna aperture size (transmit / receive), transmitter power level, transmission duty cycle, achievable receive system temperature, polarization capability, spatial coverage, imaging capabilities, and element count (for array radars). In practice, existing radar systems have seen diverse scientific application beyond incoherent scatter. It can be useful to consider architectures that better enable studies of the lower atmosphere, magnetosphere, heliosphere, and astronomical space environment. Software radio when combined with low frequency astronomical radio array technology has also enabled a different set of choices with regard to Geospace radar design. Recent work in highly integrated phased arrays such as simultaneous transmit and receive apertures (STAR) and conformal apertures also leads to new possible radar configurations. We apply the MIT ISR Performance Simulator (MIPS) to evaluate architectural choices for the design of Geospace radars, discuss the results, and show examples of approaches optimized for different applications such as scientific discovery, space weather monitoring, easy relocation, wide spatial coverage, or fast three dimensional parameter measurements. We also discuss selected technical efforts that may enable new incoherent scatter capable Geospace radar systems.