Wireless communication systems have rapidly evolved over the past decade which has led to an explosion of mobile data traffic. Since more and more wireless devices and sensors are being connected, the transition from the current 4G/LTE mobile network to 5G is expected to happen within the next decade. In order to improve signal-to-noise ratio (SNR), system capacity, and link budget, beam-steerable antenna arrays are desirable due to their advantage in spatial selectivity and high directivity. Electronically steerable parasitic array radiator (ESPAR) that can achieve low-cost continuously beamsteering using varactor diodes have attracted a lot of attention. This dissertation explores bandwidth enhancement of the ESPAR using frequency-reconfigurable microstrip patch and cavity-backed slot (CBS) antennas.

In chapter 2, an ESPAR of three closely-coupled rectangular patch elements that do not use phase shifters is presented; the beamsteering is realized by tunable reactive loads which are used to control the mutual coupling between the elements. Additional loading varactors are strategically placed on the radiating edge of all the antenna elements to achieve a 15% continuous frequency tuning range while simultaneously preserving the beamsteering capability at each operating frequency. Therefore, this frequency-reconfigurable ESPAR is able to provide spectrum diversity in addition to the spatial diversity inherent in a frequency-fixed ESPAR. A prototype of the patch ESPAR is fabricated and demonstrated to operate from 0.87 to 1.02 GHz with an instantaneous fractional bandwidth (FBW) of ~1%. At each operating frequency, this ESPAR is able to scan from −20 to +20 degrees in the H plane. However, the beamsteering of the patch ESPAR is limited in the H-plane and its instantaneous S11 fractional bandwidth (FBW) is very narrow.

This dissertation also explores how to achieve 2-D beamsteering with enhanced FBW using CBS antennas. A 20-element cavity-backed slot antenna array is designed and fabricated based on a CBS ESPAR cross subarray in chapter 5. This ESPAR array is able to steer the main beam ±45° in the E plane and ±40° in the H plane, respectively, without grating lobes in either plane. The impedance matching is maintained below 10 dB from 6.0 to 6.4 GHz (6.4% fractional bandwidth) at all scan angles. In addition, the CBS ESPAR exhibits minimum beam squint at all scan angles within the impedance matching bandwidth. This array successfully demonstrates the cost savings and associated reduction in required number of phase shifters in the RF front end by employing ESPAR technology.