In Nonlinear Finite Element Analysis (FEA) applied to structures, displacements at which the tangent stiffness matrix becomes singular are called critical points, and correspond to instabilities such as buckling or elastoplastic softening (e.g., necking). Prior to Arc Length Methods (ALMs), critical points posed severe computational challenges, which was unfortunate since behavior at instabilities is of great interest as a precursor to structural failure. The initial ALM was shown to be capable in some circumstances of continued computation at critical points, but unattractive features of the formulation were noted and addressed in extensive subsequent research. The widely used Crisfield Cylindrical and Spherical ALMs may be viewed as representing the 'state-of-the-art'. The more recent Stiff Arc Length method, which is attractive on fundamental grounds, was introduced in 2004, but without implementation, benchmarking or performance assessment. The present thesis addresses (i) implementation and (ii) performance comparisons of the Crisfield and Stiff methods using simple benchmarks formulated to incorporate elastoplastic softening. It is seen that, in contrast to the Crisfield methods, the Stiff ALM consistently continues accurate computation at, near and beyond the critical points.