Usually, direction-of-arrival (DOA) estimators are derived under the assumption of uniform white noise, whose covariance matrix is a scaled identity matrix. However, in practice, the noise can be nonuniform with an arbitrary unknown diagonal covariance matrix. In this situation, the performance of DOA estimators may be deteriorated considerably if the noise nonuniformity is ignored. To tackle this problem, iterative approaches to subspace estimation are developed and the corresponding subspace-based DOA estimators are addressed. In our proposed methods, the signal subspace and noise covariance matrix are first determined by maximizing the log-likelihood (LL) function or solving a least-squares (LS) minimization problem, both of which are accomplished in an iterative manner. Then, the DOAs are determined from the subspace estimate and/or noise covariance matrix estimate with the help of traditional DOA estimators. As the signal subspace and noise covariance matrix can be computed in closed-form in each iteration, the proposals are computationally attractive. Furthermore, the signal subspace is directly calculated without the requirement of the exact knowledge of the array manifold, enabling us to handle array uncertainties by incorporating conventional subspace-based calibration algorithms. Simulations and experimental results are included to demonstrate the superiority of the proposed approaches.