Linear Gaussian state-space models are ubiquitous in signal processing, and an important procedure is that of estimating system parameters from observed data. Rather than making a single point estimate, it is often desirable to conduct Bayesian learning, in which the entire posterior distribution of the unknown parameters is sought. This can be achieved using Markov chain Monte Carlo. On some occasions it is possible to deduce the form of the unknown system matrices in terms of a small number of scalar parameters, by considering the underlying physical processes involved. Here we study the case where this is not possible, and the entire matrices must be treated as unknowns. An efficient Gibbs sampling algorithm exists for the basic formulation of linear model. We extend this to the more challenging situation where the transition model is possibly degenerate, i.e., the transition covariance matrix is singular. Appropriate Markov kernels are devised and demonstrated with simulations.