In this paper, we consider the problem of estimating a signal of interest embedded in noise using a sparse signal representation (SSR) approach. This problem is relevant in many radar applications. In particular, estimating a radar scene consisting of targets with wide amplitude range can be challenging since the sidelobes of a strong target can disrupt the estimation of a weak one. Within a Bayesian framework, we present a new sparse-promoting prior designed to estimate this specific type of radar scene. The main strength of this new prior lies in its mixed-type structure which decorrelates sparsity level and target power, as well as in its subdivided support which enables the estimation process to span the whole target power range. This algorithm is implemented through a Monte-Carlo Markov chain. It is successfully evaluated on synthetic and semiexperimental radar data and compared to state-of-the-art algorithms.