A three-dimensional dynamic posture prediction model for simulating in-vehicle seated reaching movements is presented. The model employs a four-segment 7-DOF linkage structure to represent the torso, clavicle, and right upper extremity. It relies on an optimization-based differential inverse kinematics (ODIK) approach to estimate a set of four weighting parameters which quantify a time-constant, inter-segment motion apportionment strategy. In the development phase, 100 seated reaching movements performed by 10 subjects toward five typical in-vehicle targets were modeled, resulting in 100 sets of weighting parameters. Statistical analysis was then conducted to relate these parameters to target and individual attributes. In the validation phase, the generalized model, with parameter values statistically synthesized, was applied to novel data sets containing 700 different reaching movements (towards different targets and/or by different subjects). The results demonstrated the model’s ability to generate close representations the overall mean time-averaged angle error = 5.2°, and median = 4.7°, excluding reaches towards two extreme targets (for which modeling errors were excessive). The model’s general success in prediction and its unique characteristics led to implications with regard to the performance and underlying control strategies of human reaching movements.