Consolidation carriers transport shipments that are small relative to trailer capacity. To be cost-effective, the carrier must consolidate shipments, which requires coordinating their paths in both space and time, i.e., the carrier must solve a Service Network Design problem. Most service network design models rely on discretization of time, i.e., instead of determining the exact time at which a dispatch should occur, the model determines a time interval during which a dispatch should occur. While the use of time discretization is widespread in service network design models, a fundamental question related to its use has never been answered: “Is it possible to produce an optimal continuous time solution without explicitly modeling each point in time?” We answer this question in the affirmative. We first present an iterative refinement algorithm using partially time-expanded networks that solves continuous time service network design problems. An extensive computational study demonstrates that the algorithm is not only of theoretical interest, but also performs well in practice. We next present enhancements to this algorithm that enable it to solve more instances and in less time as well as show how it can be adapted to constraints seen in practice. Finally, we discuss how the algorithm can be adapted to inform shipper-carrier negotiations regarding delivery windows.