Choosing goods and services that satisfy individual needs has become possible in many consumer markets today. Technological advancement in sales and production enabled a variety of products, from automotive to apparel, to be mass customized in a profitable manner. Over time, these companies learned to handle the negative impact of a resulting increase in architecture complexity. In contrast, engineer-to-order firms, which core business is to create bespoke product variants engineered to specific needs, could not benefit to the same degree from the progress towards mass customization. Though customizing engineering products has a wide-ranging impact on companies’ architecture. The interconnected and hardly standardized design combined with highly varying processes makes the specification and fulfillment of customization requests difficult to handle. Moreover, although likewise affected with rising complexity levels and stronger customization responsiveness, their challenges and motivations towards mass customized solutions have seldom been discussed. To address this challenge, this thesis elaborates on state-of-the-art research in architecture design and specification processes development and defines general capabilities to facilitate mass customization in engineer-to-order firms. The established understanding is complemented with interviews of practitioners from 18 engineering companies to obtain further insight into essential aspects of the research field. Based on the gained experience, eleven empirical studies have been conducted to develop relevant concepts and methods aiming at enhancing the identified capabilities. This close collaboration with industries ranging from construction to process plants and machinery applications promoted the development of a practical tool, termed Integrated Design Model (IDM). The IDM tool integrates adjacency matrices, node-link diagrams and generic modelling methods, to improve the explicitness and visibility of architectures. Connected to advanced expert systems, such as product configuration systems, the tool enables a formalized procedure for managing the design of complex architectures using aspects of visual analytics and computational structural analyses. Finally, the evaluation of the obtained results indicates a strong managerial and theoretical potential for the establishment of mass customization in engineer-to-order industries and pinpoints areas for further investigation.