Physical variation in mechanical products is always present. If not managed well, the variation may impact customer satisfaction and safety, and cause loss of profit for the manufacturer. This thesis contributes to the area of variation risk management, especially the field of identifying variation risk, i.e., identification of areas in the product where variation is likely to appear and where it will impact customer satisfaction negatively and significantly.

Most current literature focuses on top-down variation risk identification approaches, especially in static assemblies. This has led to a dearth of tools for identifying and prioritizing variation risk in highly integrated, moving mechanisms with multiple structural states, i.e., with shifting interfaces.

Based on mode-of-action descriptions, this thesis contributes two sets of design support for designers working in the early stages of the product development process, i.e., the conceptual and early embodiment design stage. The first set of design support consists of the Variation Effects and Aspects of Mode of Action (VEAMoA) theory, which explains 1) how variation will be present and propagate in the physical aspects of how a mechanical product works (the mode of action), 2) a modeling language for communicating and clarifying the mode of action, and 3) an approach for identifying the variation issues and behavior-critical interfaces. The second set of design support consists of the Mode of Action (MoA) Complexity theory explaining how 1) variation accumulates according to the complexity of the mode of action of the product, i.e., in the most active bodies and structural state transitions of the product, 2) a metric for quantitatively comparing and estimating in which bodies and structural states transitions variation will accumulate and thus be most likely, and 3) an approach for calculating the metric.

The VEAMoA design support increases the certainty of finding the most behavior-critical interfaces, while the MoA Complexity design support increases the certainty of finding the most variation-prone interfaces. Together, the two design support sets increase the certainty of identifying variation risk in the early stages of the product development process. This will contribute to increasing the certainty of variation risk management and consequently increasing product robustness, quality, and customer satisfaction.