# Step-Stress Models: Statistical Inference and Optimal Design of Experiments

Accelerated life testing (ALT) is widely used in reliability analysis with applications in diverse fields, ranging from material sciences and quality control to biomedical sciences and ecology statistics. Step-stress models form an essential part of ALT. Under a step-stress ALT (SSALT) model, the test units are exposed to stress levels that gradually increase at intermediate time points of the experiment. Statistical inference is then developed for, e.g., the mean lifetime under each tested stress level. The estimation of the mean lifetime under normal (not tested) operating conditions is possible by means of estimating the parameters of an appropriate link function that connects the stress level to the associated mean lifetime. The assumptions made about the time points of stress level change, the termination point of the experiment, the underlying lifetime distributions, the type of censoring, if present, and the way of monitoring, lead to respective models.

We discuss SSALT models and their options for flexible modelling. We focus on a model that considers a general scale family of distributions, which allows for flexible modelling and leads to explicit expressions for the maximum likelihood estimators of the scale parameters of the underlying lifetime distributions. The approach is presented for Type-I censored experiments under continuous as well as interval monitoring of the test items. Statistical inference, frequentist and Bayes, is considered while the issue of optimal designing an SSALT experiment is also discussed. Finally, we deal with SSALT modelling of heterogeneous populations, when, based on their aging behaviour, the test items are split in groups. In this case, heterogeneity is captured through a mixture model approach.