Reliability estimation from field return data

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Abstract In this article statistical inference for the failure time distribution of a product from “field return data”, that records the time between the product being shipped and returned for repair or replacement, is described. The problem that is addressed is that the data are not failure times because they also include the time that it took to ship and install the product and then to return it to the manufacturer for repair or replacement. The inference attempts to infer the distribution of time to failure (that is, from installation to failure) from the data when in addition there are separate data on the times from shipping to installation, and from failure to return. The method is illustrated with data from units installed in a telecommunications network.

Keywords Bayesian inference · Field return data · Reliability · Warranty

Our collaborator on writing this paper, Ed Lisay of Alcatel-Lucent, passed away suddenly in October 2008. As a tribute, we can state that Ed had an energetic and vigorous charisma in the application of his skills. He brought a sense of fun to his many interests, such as his achievement of becoming a master electrician. Ed is sadly missed by his family, friends and colleagues.

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1 Introduction

Manufactured products generally carry a warranty. This promises different levels of product replacement and after sales service to the customer in the event that the product is unfit for use. Most manufacturers maintain records of warranty claims that record the date that a product was shipped from the factory and the date that it returned to be repaired or replaced under the warranty claim. Such data are called “field returns”. One use of these data is to infer the reliability of the product i.e. to estimate the distribution of the time to failure of the product. There is increasing realization that better use should be made of these data to manage field reliability and maintenance (Loll 2006). Reporting field returns also forms a part of the TL9000 quality standard for telecommunications equipment; see the QuEST FORUM at http://www.questforum.com.

In this paper we study a particular problem associated with field return data which is that the times recorded are not the times that the product functioned, since they include an initial period of time between shipping the product and it being switched on (the installation time) and a period of time between the product failing and delivery to the manufacturer to be repaired or replaced (the return time). In many applications the installation and return times can be a significant proportion of the total time between shipping and return. This has importance in predictions for warranty costs if the start of the warranty occurs at installation rather than at production. One such application of direct interest to the authors is for products that form part of a telecommunications infrastructure, e.g. the hubs and routers from which an information network is built. We describe a Bayesian method that allows the failure time distribution of a product to be inferred from field return data, taking account of the installation and return time, in the case where there are some data on the duration of the installation and return times. A Gibbs’s sampling scheme implements the method.

Straightforward estimation of the failure time distribution, treating the field return times as failure times, would lead to an overestimate of the reliability of the system. This is similar to the effect of ignoring truncation and censoring of data (Kalbfleisch and Lawless 1992). This can cause several problems for the manufacturer:

- Early life reliability may be overestimated because no failures will be recorded in the early period of production, before any customer has installed the product;
- A cluster of failures occurring after an apparent failure-free period in early life may lead to the mistaken perception of an accelerating hazard function;
- Inaccurate assessment of early life reliability will lead to the erroneous provision of too many or too few replacement units in future months. This will lead either to a shortage of spares and customer displeasure, or cost overruns due to excess inventory holding;
- Similarly, a mistaken perception by management of reliability performance will lead to the deployment of engineering resources to address lesser priorities.

There has been relatively little work on field data analysis, at least when compared to data analysis during development and production. Kalbfleisch and Lawless (1988) was one of the first detailed investigations of the problem, which concentrated on likelihood methods and regression models for time to failure. Related work, that is closer in spirit to our work, is in Kalbfleisch et al. (1991), where warranty claim data were...