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Reliability Analysis of Geometric Performance of Onboard Satellite Sensors: A Study on Location Accuracy

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Abstract : The location accuracy of data products is a critical parameter in assessing the geometric performance of satellite sensors. This study focuses on reliability analysis of onboard sensors to evaluate their performance in terms of location accuracy performance over time. The analysis utilizes field failure data and employs the weibull distribution to determine the reliability and in turn to understand the improvements or degradations over a period of time. The analysis begins by scrutinizing the location accuracy error which is the root mean square (RMS) error of differences between ground control point coordinates observed on the product and the map and identifying the failure data with reference to time. A significant challenge in this study is to thoroughly analyze the possibility of an infant mortality phase in the data. To address this, the Weibull distribution is utilized to determine if the data exhibits an infant stage or if it has transitioned into the operational phase. The shape parameter beta plays a crucial role in identifying this stage. Additionally, determining the exact start of the operational phase and the end of the infant stage poses another challenge as it is crucial to eliminate residual infant mortality or wear-out from the model, as it can significantly increase the total failure rate. To address this, an approach utilizing the well-established statistical Laplace test is applied to infer the behavior of sensors and to accurately ascertain the duration of different phases in the lifetime and the time required for stabilization. This approach also helps in understanding if the bathtub curve model, which accounts for the different phases in the lifetime of a product, is appropriate for the data and whether the thresholds for the infant period and wear-out phase are accurately estimated by validating the data in individual phases with Weibull distribution curve fitting analysis. Once the operational phase is determined, reliability is assessed using Weibull analysis. This analysis not only provides insights into the reliability of individual sensors with regards to location accuracy over the required period of time, but also establishes a model that can be applied to automate similar analyses for various sensors and parameters using field failure data. Furthermore, the identification of the best-performing sensor through this analysis serves as a benchmark for future missions and designs, ensuring continuous improvement in sensor performance and reliability. Overall, this study provides a methodology to accurately determine the duration of different phases in the life data of individual sensors. It enables an assessment of the time required for stabilization and provides insights into the reliability during the operational phase and the commencement of the wear-out phase. By employing this methodology, designers can make informed decisions regarding sensor performance with regards to location accuracy, contributing to enhanced accuracy in satellite-based applications.

Keywords : bathtub curve, geometric performance, Laplace test, location accuracy, reliability analysis, Weibull analysis
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