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ROBERT LUSSER AND LUSSER'S LAW

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The well-known product law for reliability in series systems was at one time known as Lusser's Law. This paper describes Lusser's career and makes an assessment of his contribution to the development of safety and reliability.

1. INTRODUCTION.

Imagine a system having components with reliabilities R_1, R_2 -- R_n in such a configuration that any one component failure will lead to system failure. In a case where the failure modes are completely independent of one another the system reliability R is given by the product of the component reliabilities, that is:

$$R = R_1 \times R_2 \times \text{----} \times R_n$$

This well-known law of 'series' reliability and the corresponding 'parallel' law came into extensive use in the 1950's and 1960's when reliability and technology was under rapid development. At that time the series law was frequently referred to as Lusser's Law. It is clear that Robert Lusser played a prominent part in its introduction but its origins were complex. These matters are considered in this paper.

2. ROBERT LUSSER.

Lusser was born at Ulm in Germany in 1899. A photograph in the Deutsches Museum at Munich shows him as a pilot in the First World War. He later became an aeronautical engineer. An article written soon after his death in Zeit Magazine [1] reports that Lusser had taken part in the development of the Messerschmitt Me109,110 and 261 before working on the V1 'flying bomb'. This revolutionary pilotless vehicle, powered by a ram-jet, was designed and commissioned under difficult wartime conditions and within a very short period of time. No technical reports of this project have been located but two good general descriptions, written in the 1960's are available, [2,3]. Lusser was Technical Director of Fieseler, the Kassel company responsible for V1 airframe, but he also held a senior rank in the German airforce. His role in the V1 project was clearly an important one as evidenced by his receipt of a personal telegram of congratulation from Reichsmarschall Goering in June 1944 at the start of the V1 operating phase [1]. Lusser's account of the reliability aspects of the project, written some years later, is discussed in the next section. Lusser moved to the United States in 1948 [1] and worked on missile and aircraft technology.

In 1961 he returned to employment with his former company Messerschmitt as

Director of the Technical Bureau responsible for maintenance of the German version of the F-104G aircraft. These had a terrible reliability record and Lusser was strongly critical of the quality of the electronic systems that had been installed in them. He left this post in 1963. The Zeit article [1] reports that in his last days he concentrated on marketing a ski binding that he had designed. He died in March 1969.

3. LUSSER's RELIABILITY PUBLICATIONS.

The most frequently quoted publication on reliability by Robert Lusser was produced in 1950 at the US Naval Air Missile Test Centre, Point Mugu, California [4]. This report was produced only two years after Lusser's arrival in the United States and although it is intended as a general discussion of reliability problems, it makes frequent reference to the V1 project.

The product law for series components is discussed at an early stage in the report and charts are given relating overall reliability to component reliability for varying numbers of components. Lusser is obviously aware of the improvements to be obtained by the use of components in parallel and quotes the pilot in an aircraft as providing parallel backup to counteract failures and contrasting this to the case of a missile where no such backup is present. He does not quote the corresponding parallel product law however, and his emphasis is on design simplicity and the maintenance of high component reliability rather than on reliability enhancement through parallel operation.

The report also contains a somewhat unsophisticated discussion of safety margins, which assumes that both the ultimate strengths of a component type and the spread of stresses to which they are to be subjected will have clearly defined limits. Later however he relates failure probability to the statistical distribution shape for the ultimate strengths given a critical maximum stress level. A very much better treatment of this problem was already available in the open literature at that time [5].

Lusser also describes a 'reliability chart' system in which component or sub-system reliabilities are plotted in order of decreasing failure rate in the same way as a Pareto plot. Superposed on the plot are curves which show percent overall reliability on the somewhat dubious assumption that the component type reliabilities have a normal distribution. The system provides a method of determining priorities for reliability improvement and of studying reliability growth, a topic which is also discussed in some detail. The rapid reliability improvements made to the V1 during development and commissioning suggest that the system was highly effective that instance.

Of particular note in Lusser's report is the attention paid to human aspects of reliability control. He points out that categorisation of failure modes as 'initial', 'random' and 'wearout' is relatively meaningless for a missile with a maximum flight time of seconds or minutes. On the other hand, tracing failure to the design, testing, fabrication, assembly, transportation, storage, maintenance and operation phases allows clear allocation of management responsibility for improvements to be made. Lusser also recommends that each project should have a Reliability Co-ordinator reporting to a Reliability Board in order to supervise and improve reliability standards.

Other reports written by Lusser in the United States are listed [6-10]. Their availability is not known.

4. LUSSER's LAW.

The basis for 'Lusser's' Law was developed in the 1930's, particularly in Germany. Von Mises introduced the concept of sample space in a publication of 1931 [11]. A.N. Kolmogorov developed a complete axiomatic treatment of probability theory including such concepts as unions, intersections, conditional probability and statistical independence. His work was published in Germany in 1933 [12]. A Russian translation followed in 1936 and although the first full translation into English only appeared in 1956 [13] the concepts had already been incorporated into an undergraduate text by 1950 [14].

It seems reasonable to assume that those working in the field, both English and German speaking, would be aware of the new developments by the start of World War II. Certainly good use was made of them in Operational Research both in the United States and Britain. Morse and Kimball for example [15] give an account of this work in a 1951 publication and it is apparent that probability densities and conditional probabilities were in routine use. Lusser's Law follows from such considerations as a particularly simple case while probability densities allow a cross link from reliability to load and strength characteristics.

Bazovsky [16] writing in 1961 recounts how the V1 development team at first assumed that failure could be modelled with analogy to the 'weakest link' theory for a chain. Breakdown would always be at the weakest link of a chain or at the least reliable component of a system. This clearly was not so as a wide range of components were found to fail with varying frequencies. Bazovsky reports that it was Erich Pieruschka, an associate of Lusser's who suggested that the product law for series systems would provide a more appropriate model.

Pieruschka himself [17] does not claim authorship of the product law which he relates had long since been described in another context by Jakob Bernoulli in 1713. Pieruschka points out that Lusser had strongly advocated the use of the law however and had in this and in many other ways made an important contribution to the development of reliability technology. All evidence supports this view, although one gets the clear impression that it was in reliability management rather than in reliability theory that Lusser's undoubted strength lay.

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