I would like to have your opinion on this general question and, if possible, information on your personal experience with field detection and observation of software failures.

K. STRANDBERG: As far as I can see, the term failure in your question can be changed to error without changing the meaning. This would mean that your questions read:

Are software errors unambiguously observable in practice?

The answer is of course no, as you already indicated in your comments.

When we started our study, we surveyed many articles on software reliability modelling. We then observed that:

1. Different authors had different definitions of software reliability.
2. Many authors seemed to treat the problem, as if the answer to your question was yes.
3. Most of the models presented treated the problem of how to determine the initial or remaining number of errors.

We therefore thought that a different approach was needed. This led us to the model we have shown in our paper.

As you say, the best way to determine the value of a model is to compare it with field observations. This, however, requires a large amount of data, to an extent we do not believe we have at the moment. From this point of view, I hope that it will soon be possible to acquire much more data.

T. DOWNS (Australia): Software reliability is largely a reflection of human reliability. Various human reliability models have been constructed in the past (for various human activities). Have any of these been found useful in your studies? If not, can you see any potential usefulness in such models?

K. STRANDBERG: I think that the answer to this question depends on what you mean by software reliability. It is true that failures of the software during execution are to a great extent dependent on humans involved in software design. This is by comparison, also valid for hardware. In both cases the inherent abilities of the item are influenced. If these qualitative characteristics are included in the reliability concept, models of human reliability could be relevant to include in the analysis.

If the reliability of software is defined along the lines presented in our paper, human reliability will influence the failure liability of the program. Failure liability is a parameter in our model, but, since we do not intend to make predictions, human reliability models do not seem to be of interest in our case. We therefore have not specifically studied human reliability models and I cannot see any immediate use for such models, in our modelling case.
2. I believe the mathematical treatment does apply to GoS step-functions.
3. a. I agree a number of indicators may be needed.
   b. Different mathematical treatments may be required.

A.H. FREEMAN (Australia) : Your paper deals with the effect of totally faulty devices, but many call failures are caused by partly faulty devices which carry successfully nearly all calls offered. Could you indicate how your treatment could be extended to cover such partial failures?

J.L. SMITH : We think that it should be possible to consider the incidence of partial faults in much the same way as the totally faulty device. The only difficulty might be in predicting the effect of grade of service (i.e. the proportion of incorrectly handled calls) which will arise from a particular partial fault. This will not always be straightforward.

Paper No. 415

Authors : F. TOLENDANO and E. JENSEN (Spain)

G. MIRANDA : Other contributions on this problem only split up the considered group into two subgroups with respect to holding time distributions. Is there any advantage of permitting a further upsplitting of the groups, as you have done in your paper?

E. JENSEN : Yes certainly, because the devices in the considered group might for instance be connected further with other equipment, whose malfunctioning might lead to different types of improper service performed by each individual or subgroup of devices in the considered group. This in practice requires that a group might have to be split up into various subgroups, each of them homogeneous with respect to faults.

If one tries to substitute two or more such subgroups by one, one is confronted with the problem of determining the resulting holding time distribution in that subgroup, and this can only be done exactly by solving the problem with the original fault-homogeneous subgroups.

One might try to establish this holding time distribution by the straight-forward weighted sum of the holding time distribution of each of the devices. But then one will certainly overestimate the traffic performance of the total group.

E. RAMALHO (Brazil) : Have you studied any fault detection test based on the holding time of faulty devices, that is, base the statistical test on the holding times instead of on seizures?

E. JENSEN : Tests might be developed also for holding times and usage. We have found the test based on number of seizures to be the more suitable.

Paper No. 416

Authors : H. ANDERSSON and K. STRANDBERG (Sweden)

G. MIRANDA : Your paper presents a solution to the determination of the trafficability of delay systems with failed devices. This is one of the possible extensions Jensen and Toledano mention in their paper. Are there other kinds of extensions possible for your model?

K. STRANDBERG : Our model can for example be generalized to allow the different devices to have different holding times up to the limit where every device has its own holding time. A further extension would be to allow the holding times for each individual device to be drawn from exponential distributions with different means.