1. Introduction

A forum was held to discuss issues and needs in bridging the gap between macro-, micro-, and nano-wear. As it turned out, the primary focus was on the macro-to-nano gap in tribology in general with some discussion of wear as well. The following summarizes the author's introduction and the audience input.

2. First item to consider: "Is there a gap?"

In addition to the gap in physical scales and our current inability to directly apply findings from nano-tribology to macro-tribological systems I believe there is a gap in understanding between the various branches of tribology. This has probably always been so, at least since serious application of tribological principles was first attempted. It is so because the field is highly multi-disciplinary and nobody can be a true expert in all of its aspects, from fluid dynamics to chemistry, from contact mechanics to system dynamics, from materials science to surface engineering, from molecular dynamics to finite element applications, from system design to materials selection, etc.

Thus, it is not unexpected that there should be a gap in understanding between the "traditional" tribologists and the newest branch of the field, nano-tribology. This new branch has evolved rapidly over the past decade for two primary reasons. One is the need to solve actual nano-tribology problems, such as those found in hard disk and other hardware systems of the age of information technology, and in processes to produce these systems, such as chemo-mechanical polishing of silicon wafers for IC chips. The other reason is the rather recent and sudden availability of a whole new set of instrumentation and modeling capabilities, which allow us to model friction interactions, conduct indentation and sliding experiments at the nano-scale, and image individual atoms and even manipulate them. This new instrumentation has made it appear possible to gain a much better knowledge of tribology basic, of what really happens at the surface during tribological events.

In the specific area of wear there may well be an even greater gap than for friction and lubrication. Wear at the macroscale has been the subject of much study and many of the general mechanisms are reasonably well understood. At the nano-scale this is not so. Wear occurs, but the mechanisms are largely unknown and not readily determined. They certainly do not produce wear particles of the size seen in common engineering systems, although they may well be operational there, as well. So far, there have been
too many other interesting phenomena to explore at the nano-scale but wear mechanism studies should come soon.

The new instrumentation has nurtured the perception that since we can now quite clearly see and model what happens in the top one or two layers of atoms then we should be able to extrapolate to a complete and full understanding of tribological events at the macro-scale. This perception is often promulgated by the enthusiasm of the many new practitioners of nano-surface science and nano-tribology, who for good reason tend to be untempered by exposure to what the traditional tribologists consider "real" tribology problems.

At the moment it often seems as if the various branches of the research community each approach the topic of tribology in total in the same manner as the group of blind men who each describe the whole elephant from the limited information they each get from the small part of the animal that they can touch. Also, it seems that each branch of tribology is convinced that only it knows best in which direction the field should move.

Is there a Gap?

It is not new that the field of tribology has added a new community to its ranks. Since Amontons' paper in 1699, three hundred years ago, major changes in research emphasis have occurred a number of times. The main focus of studies from the time of Amontons' novel approach was the nature of friction and most of these studies were done by physicists. This persisted, at a modest rate, for about 170 years until oil was discovered. At that point, the need to lubricate the railroads and the availability of this new lubricant shifted the focus of tribologists to hydrodynamic lubrication and then