Lecture Notes in Applied and Computational Mechanics Vol. 19

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The Aerodynamics of Heavy Vehicles: Trucks, Buses, and Trains

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Introduction

It is our pleasure to present these proceedings from the United Engineering Foundation Conference on The Aerodynamics of Heavy Vehicles: Trucks, Buses and Trains held December 2-6, 2002, in Monterey, California. This Department of Energy, United Engineering Foundation, and industry sponsored conference brought together 90 leading engineering researchers from around the world to discuss the aerodynamic drag of heavy vehicles. Participants from national labs, academia, and industry, including truck manufacturers, discussed how computer simulation and experimental techniques could be used to design more fuel efficient trucks, buses, and trains.

Conference topics included comparison of computational fluid dynamics calculations using both steady and unsteady Reynolds-averaged Navier-Stokes, large-eddy simulation, and hybrid turbulence models and experimental data obtained from the Department of Energy sponsored and other wind tunnel experiments. Advanced experimental techniques including three-dimensional particle image velocimetry were presented, along with their use in evaluating drag reduction devices.

We would like to thank the UEF conference organizers for their dedication and quick response to sudden deadlines. In addition, we would like to thank all session chairs, the scientific advisory committee, authors, and reviewers for their many hours of dedicated effort that contributed to a successful conference and resulted in this document of the conference proceedings. We also gratefully acknowledge the support received from the United Engineering Foundation, the US Department of Energy, Lawrence Livermore National Laboratory, Volvo Trucks America, International Truck and Engine Corporation, and Freightliner LLC. Finally, we would like to thank Helen Magann for her efforts in collecting the papers and reviews and formatting and organizing them in this publication.

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Aerodynamics and Other Efficiencies in Transporting Goods

Paul B. MacCready, Key Note Speaker

AeroVironment Inc., Monrovia, CA

Abstract

Recognizing both the pollution effects of fuel use and the likely increases of fuel cost in coming decades puts high priority on alternative energy for trucks, buses and trains. There are still gains available in decreasing aerodynamic drag and rolling friction, using efficient engines, and minimizing fuel waste, but it is appropriate to explore decisions that would be suitable if fossil fuel were deemed unattractive. One then would consider utilizing natural energy (sunlight, wind, wave), getting energy from braking, employing hydrogen, putting different priorities on trucks vs. buses vs. trains, exploring integration with water deliveries and automatic local air transport, etc. Such an investigation might illuminate early alternatives that would at least permit partial improvements.

Introduction

This presentation is aimed at raising our insights about how we might fare in providing the future now handled by standard buses, trucks, and trains. The time scale is 15, 25, and even 50 years.

Humankind operated with limited potentials into the 19th century. Global population and living expectancy grew only slowly, and materials for supporting life with food, housing, and clothing came, as they always had, primarily from the earth's surface. As consumption of coal grew rapidly throughout the 19th century, and fossil fuel was added throughout the 20th century, the global population grew. In 1925, the year I was born, the population was 1.7 billion. Now it's 6.3 billion, 3.7 times a large, and is likely to be over 8 billion in 25 years.

Coal and oil consumption have been an integral part of all our lives – so much so that it is hard to think of a world without them. Yet both cause pollution, especially CO_2, with likely significant effect on the earth's future atmosphere. Also, the fossil fuel is nearing its limit. The U.S. sources peaked about 30 years ago, and globally the peak is expected in just another 10 years or so. Fossil fuel is particularly valuable for its many non-engine uses, and for

the propulsion system of airplanes for which no other technology appears viable. It will probably not be viable for the cars, buses, and trucks 25 years from now, both because of its pollution and its general cost for availability. This puts priority on thinking about how we can do the job of heavy hauling with much more efficiency than at present, and we're looking toward other energy sources in the long run.

The Present Challenge

Rachel Carson, through her 1962 book "Silent Spring", got people thinking about the big view of humans vs. the global environment and natural wildlife. About the same time Charles A. Lindbergh, who had been the figurehead for the growth of aviation after his 1927 solo flight across the Atlantic, in his later years, perhaps between 1955-60, asked himself when gazing from a hill in Kenya: "If we could have birds but not airplanes, or airplanes but not birds, which would I choose?" He realized his choice would have been "birds" – and he devoted the remaining portion of his life to fostering environmental awareness.

In 1982, preparing a presentation to the Lindbergh Foundation, I realized many of my emotions were in agreement with Charles Lindbergh's and Rachel Carson's. I tried viewing the earth as would a galactic explorer making its rounds every 10,000 years, finding this latest trip showed a far different global situation than had existed 10,000, or 100,000 years ago.

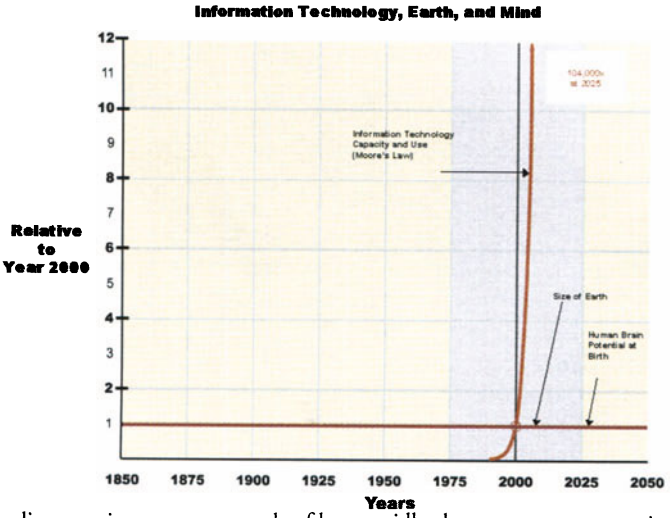

Fig. 1. This diagram gives one an example of how rapidly changes are now occurring. Moore's empirical "law" is a symptom of the rate of increase of our computer use and capability. The horizontal line shows the steady size of the earth and the constant potential of the human brain at birth. It's obviously a new world now.

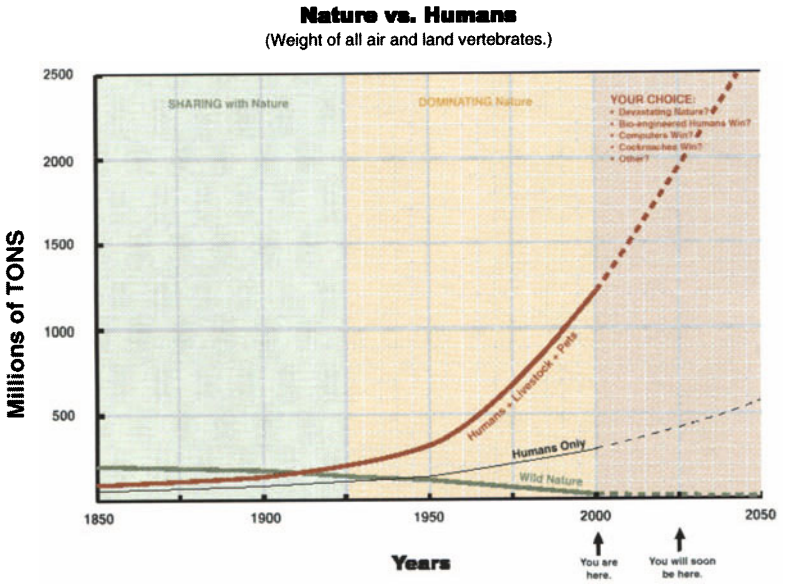

Fig. 2. This plot of the mass of all air and land vertebrates shows that the portion devoted to humans + livestock + pets is now about 98%, and wild nature is about 2%. As humans were just beginning agriculture some 10,000 years ago, the 98% portion was less than 0.1%. We humans have won, and do not even think about the course of events that has created the present picture. Our growing global population is not sustainable with the consumption to which we in the United States have become accustomed.

This sort of thinking, stemming to a considerable extent from thoughts in 1977-78 subsequent to the Gossamer Condor human power airplane project, has had an important impact on my more recent work. We still deal with fossil fuel, and heavy energy demands, but efficiencies improve and sometimes better alternatives arrive.