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THEORY OF ROAD TRAFFIC FLOW - ASHTON,WD

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BOOK REVIEWS

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The Theory of Road Traffic Flow, by Winifred D. Ashton. London: Methuen, 1966, viii + 178 pages.

Whenever books are published in young disciplines with a fast scientific progress, they face the danger of being outdated at the time of their publication. Although the text by Ashton on traffic flow theory has not been able to escape this fate completely, it nevertheless represents the most comprehensive and up-to-date work on this subject in the mid-Sixties. Since then, traffic research has continued its rapid development, as exemplified by the periodic International Symposium on the Theory of Traffic Flow.

The investigation of the principles of traffic flow in networks is largely a response to complicated traffic problems which grew with the explosion of both population and mobility. The traditional tools based on experience and intuitive judgment were supplemented and partially replaced by scientific models on traffic flow. They constitute the main subject of this book. After a general introduction to the field in Chapter 1, the basic traffic stream parameters (flow, concentration, speed) are developed, and a first expository description of the fundamental diagram for traffic (flow per unit time vs. density per unit length) is given in Chapter 2. The third chapter presents the theories which study traffic flow in a single lane at the microscopic level (follow-the-leader models). First a linear version of the car following model—change of speed as a product of the driver's (constant) sensitivity and the difference in speed with regard to the preceding car—is used to investigate the "local" stability of traffic. The well-known inequalities determining the types of oscillations generated by a perturbation are derived. Steady state equations relating speed to density are deduced for the nonlinear case, where the driver's sensitivity is not constant but a function of his car's speed and the distance

to the preceding car. Although comparison of the theoretical results and empirical findings produces some encouraging correspondencies, the author stresses that the existing models are too simple to simulate adequately the driver's decision-making as it derives from certain intentions, information, and available strategies. He apparently was not aware of the work by Gazis [2, 3] formulating the driver's behavior as optimization of an objective function subject to a set of constraints.

A second approach (Chapter 4) to traffic flow uses its partial analogy to fluid motion, thus treating the flow phenomenon as a continuum. This permits the derivation of the propagation of density waves in general terms. By varying the concentration parameter, the author demonstrates the close relationship with a variety of empirical traffic situations and the application of the mathematical theory to the engineering problem of measuring the capacity of road junctions. Another promising analogue is the kinetic theory of gases, and it is unfortunate that Ashton does not supplement the mathematical treatment with a more extensive discussion of the flow-concentration relationship and its partition according to individual vs. collective flow. In concluding the first part on flow models, several theoretical versions of the fundamental diagram are deduced and compared.

Chapter 6—"From Traffic Signals to Traffic Cybernetics"—displays a rather abrupt change in style. Except for Webster's estimation of delay at signal-controlled intersections, it consists largely of verbal (sometimes trivial) descriptions concerned with signal design and operation alternatives and empirical observations from the British scene. The term cybernetics refers to some proposals as to how to use computers in the control of networks. Chapter 7 gives derivations for the Poisson and the negative binomial distribution (why?) and shows how these and Pearson's beta and gamma distributions can be used to fit empirical traffic distributions. This is followed by a review of the relevant queueing theory.

Chapter 8 presents stochastic approaches to static delay problems at priority and signal-controlled intersections. In the first case (priority intersections), the models discussed do not consider the formation of queues, thus reducing their applicability substantially. As to the models dealing with signal-controlled intersections (the author concentrates on those by Clayton and Newell) one misses a profound discussion on the optimal setting of traffic lights going beyond Webster's early contribution (Chapter 6). This is partially due to the fact that some of the major research advances have been made after the publication of this book. But the contributions by Dunne [1], Gazis [2, 3], and Gazis and Potts [4] are not mentioned at all.

Chapter 9 gives a sketch of the principles of simulation as a research tool, when analytical methods fail, and reports results from priority intersection simulations, taking queues into account. The following chapter offers a survey of theoretical distributions which have been applied in the study of accident data. This is the last chapter, and the reader, waiting for the extension of the theory of traffic in single lanes and intersections to a theory of flow in networks will be disappointed Thus, the claim of the author to have produced a comprehensive textbook on traffic flow theory is extravagant. But considering that it is one of the first general texts on this topic, Ashton has accomplished an excellent review and partial integration of the field. The best parts of the book are probably the clear, concise presentations

of the mathematical theories. But it also avoids the frequent danger to study theoretical models as a rewarding exercise in themselves, by focusing constantly on the test results and their value in terms of practical applicability. Excluding the topic of traffic theory for transportation systems, this text is, in the judgment of the reviewer, still one of the best available.

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