4 Basis of Three-Phase Traffic Theory

4.1 Introduction and Remarks on Three-Phase Traffic Theory

To explain empirical spatiotemporal features of congested patterns, in 1996–1999 the author introduced three-phase traffic theory, in which the empirical complexity of freeway traffic was explained in terms of diverse spatiotemporal features of three traffic phases: free flow, synchronized flow, and wide moving jam [205,207–211].

In this and the next chapters of Part I of this book, we will try to show from the fundamental hypothesis of three-phase traffic theory (Sect. 4.3) and from empirical spatiotemporal traffic pattern features [166,167,203,205,207–211] (Sect. 2.4) how the main conclusions and results of the three-phase traffic theory [205,207–211,218] can be derived without complex mathematical formulae or mathematical traffic flow models.

The three-phase traffic theory is a qualitative theory. This should help readers understand the main ideas and results of this theory. Detailed considerations of the empirical basis [166, 167, 203, 205, 207–211, 218] and of mathematical results of three-phase traffic theory [329–331] are considered in Parts II and III of this book, respectively.

To make the three-phase traffic theory as easy as possible to understand, we neglect and simplify certain real traffic features. However, we try to retain salient freeway traffic features. For example, in this simplification we do not consider the very real difference between traffic in different lanes of multilane traffic. All vehicles and all drivers are considered to have the same mean parameters and characteristics, e.g., all vehicles have the same length, all drivers have the same desired (maximum) speed in free flow, they exhibit the same reaction time, and so on. We also neglect or simplify some other (sometimes seemingly important) effects. These simplifications enable us to highlight in the three-phase traffic theory some of the most important features of traffic.

We will see that fundamental qualitative features of congested pattern emergence observed in empirical investigations [208,218] (Sect. 2.4) can be explained in the three-phase traffic theory even when all drivers are suggested to have the same characteristics and all vehicles are suggested to have the...
same parameters [218, 329, 331]. Obviously, in real traffic there can be very
large differences in driver behavioral characteristics and in vehicle param­
eters. However, these differences are responsible for some specific effects and
they change usually quantitative characteristics of fundamental spatiotempo­
ral congested pattern features only (see Chap. 20). Therefore, differences in
driver characteristics and in vehicle parameters can first be neglected when
fundamental spatiotemporal congested pattern features are studied.

Three-phase traffic theory discussed in this chapter and Chaps. 5–8 be­
low is an attempt to explain the author’s three-phase traffic theory [205,
207–211, 218] in the simplest way, beginning with some basic empirical back­
ground [166, 167, 203, 205, 207–211].

In 1992–1995, when the author began to work in traffic science, he had
strongly believed that the fundamental diagram approach would be the cor­
correct mathematical approximation for a description of empirical traffic flow
phenomena (see early papers by the author et al. [366, 367, 381, 382]). The
empirical findings [205, 207–211] were the reasons why the author was forced
in 1996–1999 to change his mind fundamentally about the correctness of the
well-known and generally accepted fundamental hypothesis of the fundamen­
tal diagram approach to traffic flow theory and modeling (see Chap. 3).1
That is why the author introduced and developed the three-phase traffic the­
ory [205, 207–211], which rejects almost all earlier theoretical results about
features of spatiotemporal congested patterns and phase transitions in free­
way traffic.

4.2 Definition of Traffic Phases in Congested Traffic
Based on Empirical Data

4.2.1 Objective Criteria for Traffic Phases
in Congested Traffic

In Chap. 1 when we discussed Fig. 1.2 and also in Sect. 2.4, we men­
tioned the empirical (objective) criteria for two phases in congested traffic,
“synchronized flow” and “wide moving jam.” These objective criteria are re­
lated to some spatiotemporal congested patterns features. Here we consider
these objective criteria in more detail.

1 The author was fortunate to work in 1994–1995 for the traffic engineering con­
sulting firm Heusch/Boesefeldt GmbH in Aachen (Germany), where he met many
good traffic engineers. Here he had his first opportunity to begin a study of em­
pirical data on congested freeway traffic. The author thanks all colleagues at
this firm, in particular Heinz Heusch, Jochen Boesefeldt, Heribert Kirschfink,
Hubert Rehborn, Ulrich Uerlings, and Thomas Scheiderer, for their help, critical
discussion of earlier traffic flow theories, and their fruitful cooperation.