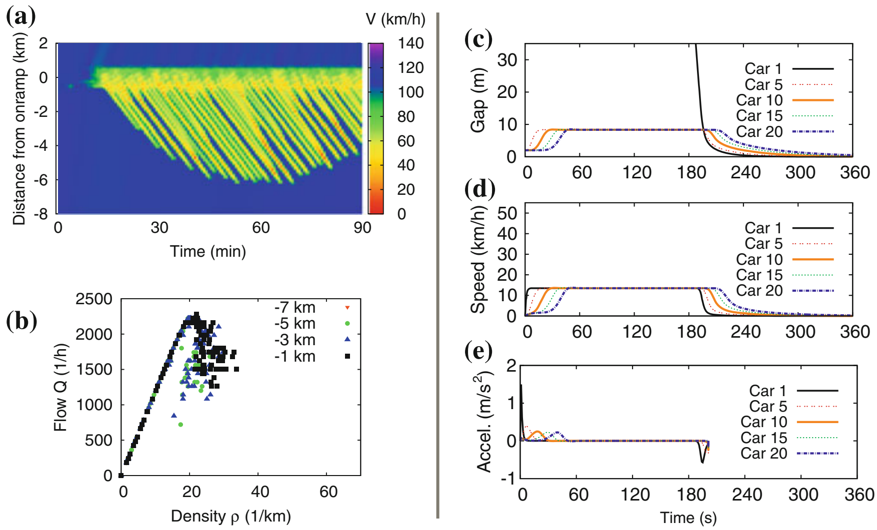

Fig. 10.6 Fact sheet of the Full Velocity Difference Models (FVDM), Eq. (10.23), with the OV function (10.21), the sensitivity $\gamma = 0.6\,\text{s}^{-1}$, and the speed adaptation time $\tau = 5\,\text{s}$. The vehicle length and the parameters v_0, β and Δs of the OV function are given by Table 10.1. The simulation scenarios are discussed in detail in Sect. 10.5

In fact, the maximum speed in the city scenario of the model fact Sheet of Fig. 10.6 is less than 15 km/h (see Problem 10.4 for a quantitative analysis).

Improved Full Velocity Difference Model. In the following, we show how a model developer would proceed to resolve this problem. Obviously, the sensitivity to speed differences must decrease with the gap s and tend to zero as $s \to \infty$. This can be realized by replacing the contribution $-\gamma\,\Delta v$ of Eq. (10.23) by a multiplicative term $-\tilde{\gamma}\,\Delta v/s$. However, now the sensitivity diverges for $s \to 0$ which is unrealistic. Furthermore, $\tilde{\gamma}$ has a different unit compared to γ (and, consequently, a different numerical value) which should be avoided if possible.[18] The arguably simplest approach to resolve these new problems consists in applying the inverse proportionality only if the gap is larger than the interaction length $v_0 T$. Hence, the resulting acceleration equation of the new "complete" variant of the FVDM is given by

$$\dot{v} = \frac{v_{\text{opt}}(s) - v}{\tau} - \frac{\gamma\;\Delta v}{\max[1, s/(v_0 T)]}. \tag{10.24}$$

Figure 10.7 displays the city scenario for this model variant. It turns out that model (10.24) is able to realistically simulate the cruising phase, in contrast to the

[18] Three principles for improving existing models are the following: (i) Introduce as few new parameters as possible (ideally zero), (ii) do not change the meaning of existing parameters, (iii) keep it as simple as possible, but not simpler.

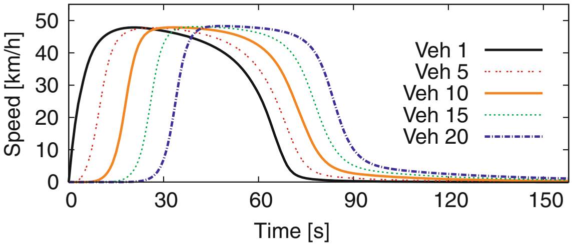

Fig. 10.7 The city scenario of Fig. 10.6 for the "complete" Full Velocity Difference Model (10.24) with the OV function (10.21). The model parameters are the same as in the original simulation

original model (10.23), and produces realistic accelerations, in contrast to the OVM. However, the robustness problem is not resolved.[19]

10.8 Newell's Car-Following Model

Newell's car-following model is the arguably simplest representative of time-discrete models of the type (10.7). Its speed function is directly given by the optimal speed function (10.22) corresponding to the triangular fundamental diagram (10.22) with $s_0 = 0$,

$$\boxed{v(t+T) = v_{\text{opt}}(s(t)), \quad v_{\text{opt}}(s) = \min\left(v_0, \frac{s}{T}\right) \quad \text{Newell's Model.}} \qquad (10.25)$$

When restricting to the car-following regime, Newell's model has two parameters: The time gap or reaction time T, and the (effective) vehicle length l_{eff}. Since in this regime the kinematic wave velocity is constant and given by

$$w = c_{\text{cong}} = -l_{\text{eff}}/T,$$

the set of model parameters can alternatively be expressed by $\{T, w\}$ or by $\{l_{\text{eff}}, w\}$. The standard value for the time gap is $T = 1$ s while the wave speed should be within the observed range $w \in [-20\,\text{km/h}, -15\,\text{km/h}]$ corresponding to a plausible effective vehicle length l_{eff} of about 5 m. The minimum condition of the optimal velocity function makes the model complete by defining a free-flow regime and introducing the desired speed v_0 as a third model parameter. It is straightforward to generalize Newell's model by replacing Eq. (10.22) with other microscopic fundamental diagrams.

Newell's model can also be considered as a continuous-in-time model with a time delay assuming that the drivers have a constant *reaction time* $T_r = T$. In this interpretation, Eq. (10.25) has the mathematical form of a *delay-differential equation*

[19] The reader can verify this by simulating the improved FVDM on the book's website www.traffic-flow-dynamics.org and changing the sensitivity γ.