Improving driver-less cars:

Traffic flow
Travel duration
Energy consumption

using speed profiles

INTRO
Finding speed profiles to improve traffic flow, travel duration, and energy consumption of Autonomous Vehicles (AVs).

What are the speed profiles?
• \( v(x) \) is the desired speed of an AV in lane \( i \) according to its position.
• A road of length \( 0 < L \leq x \) is equipped with RF signs that transmit the desired speed at their current location \( v(x) \).
• For \( i \) to \( i+1 \), \( v(x) \) compares its current speed \( v_i(x) \) with the desired speed \( v(x) \).
• Required acceleration \( a_i(x+\Delta t) \) in order to acquire \( v(x) \) within \( \Delta t \) time period.

Profiles examined:
1. Constant profile: The vehicle is required to reach the desired speed immediately as it passes \( x_0 \), that is:
   \[
   v(x) = v_0
   \]
2. Linear profile: The vehicle is to accelerate constantly throughout the road portion:
   \[
   v(x) = v_0 + \frac{v_f - v_0}{L} x
   \]
3. Sigmoid profile: Vehicles change speed only in a certain segment of the road of length \( L \), using the error function:
   \[
   v(x;\alpha_0,\alpha_1,\beta;\beta_0,\beta_1) = \frac{v_f + v_0}{2} + \frac{v_f - v_0}{2} \tanh \left( \frac{x - \beta}{\beta_0} \right)
   \]
   The center position of this road segment is marked by \( 0 < \beta < L \), at 0, \( v_f \), and at \( v_0 \) are the final speed and initial speed respectively.

Conclusions:
1. AVs can reach a flow of over 3000 veh/h, at high densities of over 28 veh/km per lane, while speeding of almost constant, i.e., for long stretches, the speed profile, and by using a distance sensor alone.
2. The linear profile – for acceleration, deceleration, and combined scenarios – showed highest flows for low energy consumption and small travel duration.

Fig. 1A snapshot of the simulation. Gradual deceleration of a vehicle flow (rectangles) from 3000 veh/h in to lane, from left to right following profile 5: the destination is at \( x = L \). Note the gap deceleration of the vehicle present.