A continuous speed model for roundabouts

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Relevance of this topic

- Speed is considered as the most important variable in roundabout geometric design (FHWA, 2000)
- Different ways to address speeds at roundabouts:
  - UK guidelines – geometric check of the fastest path
  - Dutch guidelines - correlation of basic design elements
  - US guidelines - calculation of the speed in horizontal curve
- Existing methods have limited applicability (e.g. circular roundabouts) and/or do not provide the full speed profile

Objective

- Develop a simple model to predict speeds on unconventional roundabouts along the full trajectory

Data collection

- Only unrestricted drivers
- Extraction of trajectories from drone videos (ai.datafromsky)
  - Insufficient precision along the full path
  - Limited field of view (max. height 120 m)
  - Useful to identify "typical" trajectories"
  - Shows how incorrect driver behavior is linked to poor roundabout design
- Extraction of trajectories from a single vehicle / driver (GPS datalogger – DL1 club from Race Technology)
  - 9 roundabouts, 27 trajectories (full path)
  - 11 roundabouts, 15 trajectories (min speed and radius)

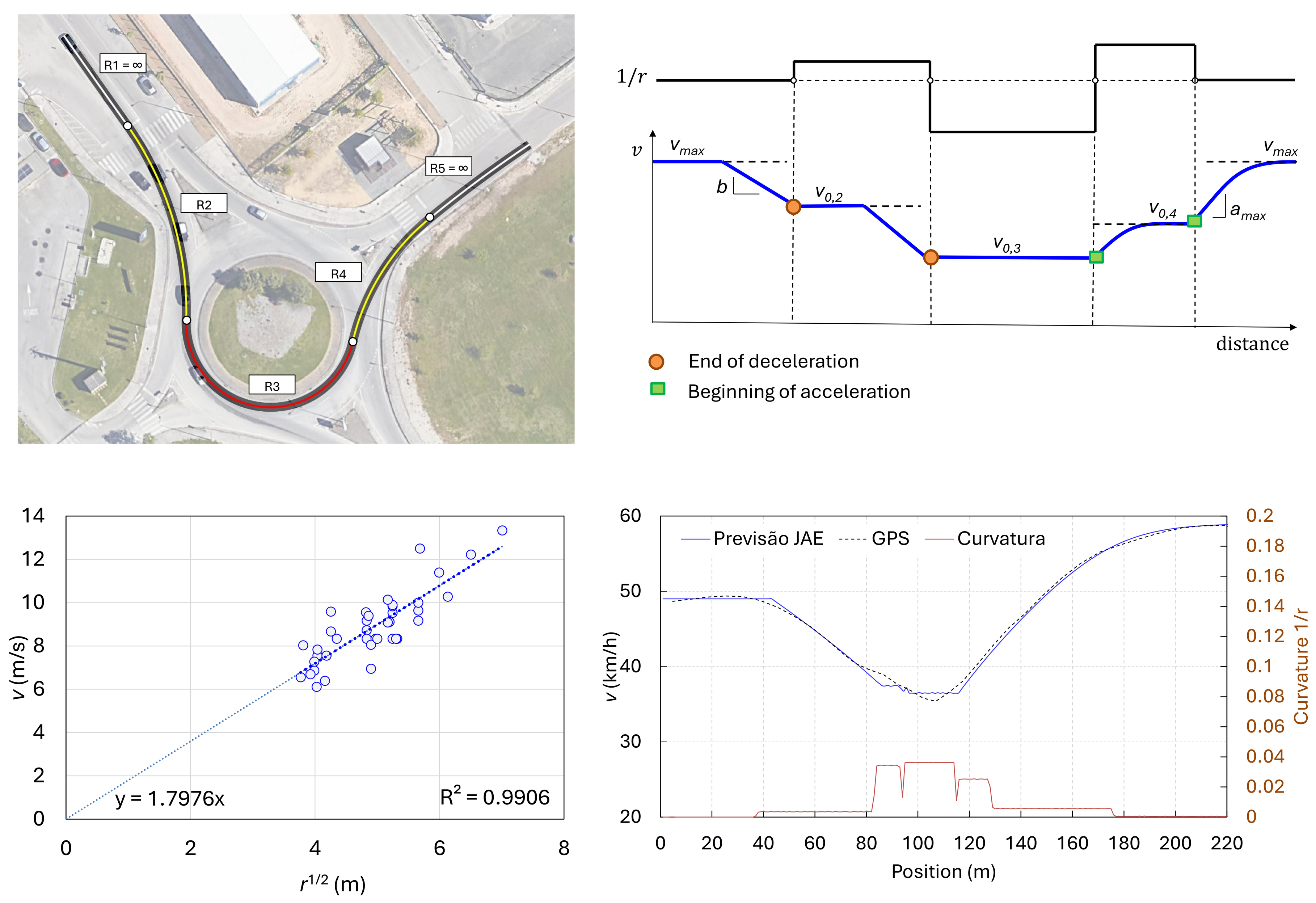
Proposed speed model

Adapted from the Portuguese JAE road design guidelines

1. Draw the fastest path (minimize curvature, keep 1 m offset to kerb lines)
2. Calculate the desired sped of each segment: v_0
   - Straight segments ($r = \infty$): $v_0 = v_{max}$ (observed at a section outside the roundabout influence area)
   - Curved segments: the speed depends on the maximum centripetal acceleration each driver accepts
     $a_N = v^2/r \rightarrow v_0 = \sqrt{a_N \cdot r}$

Proposed speed model (cont.)

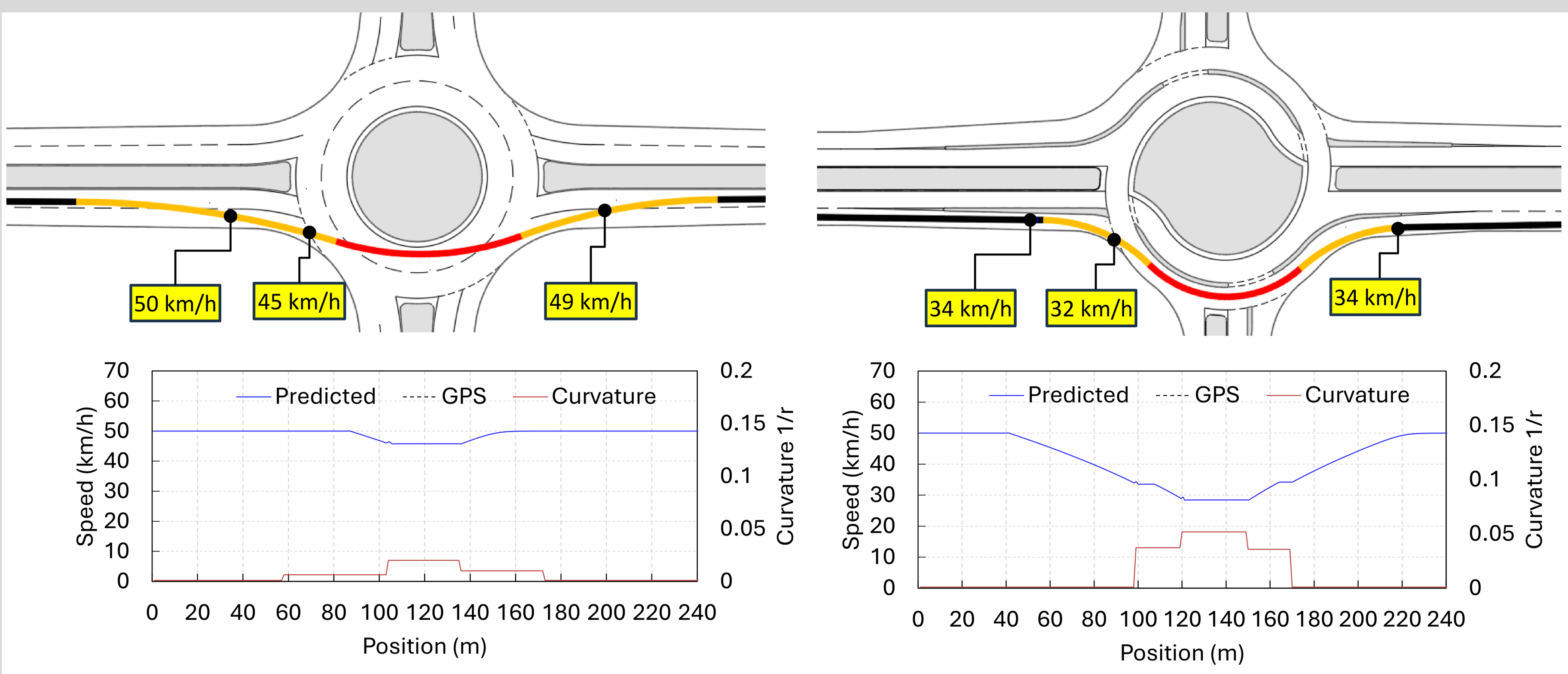
3. Speed transitions
   - Constant deceleration b
   - Variable acceleration $a = a_{max}\,[1 - (v/v_{max})^{\delta}]$
   - Deceleration ends at the beginning of the curve, acceleration starts at the end of the curve
4. Implementation
   - Start: $x = 0$, $v = v_{max}$
   - Calculate deceleration to every point ahead $b^* = (v_1^2 - v_2^2)/2d$
   - If $b^* < b_{max}$ maintain v or accelerate to v_{max}, otherwise apply deceleration b
   - Update time, vehicle speed and position (simple cinematic formulas)



Calibrated parameters: $a_N = 3.2$ m/s², $b = 0.91$ m/s², $a_{max} = 1.02$ m/s², $\delta = 46$

Sample application

- How effective is a turbo-roundabout to limit speeds at the critical roundabout sections, compared to a two-lane roundabout?
- Assumptions: $v_{max} = 50$ km/h; calibrated values from sample driver



Future developments

- Improve the deceleration model (smooth transition from v_{max})
- Validate the model with independent data and different drivers
- Implement the model in an easy-to-use spreadsheet.