The capacity of single-track rural lanes: an initial investigation

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1) Introduction
2) Objectives of the research
3) The literature
4) Methodology
5) Results and Discussion
6) Conclusion
7) What next?

The capacity of single-track lanes
Argument by anecdote...

The TA:

“I have seen no record that this [existing] use has caused serious traffic congestion”; and

“Where congestion does not occur, it is acknowledged that up to 10% additional traffic will not make significant impact”; so

“It is clear that the proposal should be considered acceptable”

The residents:

“The new facility has generated a significant increase in traffic”

“The volume and size of lorries has increased... this beautiful countryside should not be marred with so many vehicles”

“The lorry traffic on [this road] is... constant”
...makes for confused officers
The capacity of single-track lanes

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What I wanted to do

1. Determine whether S-Paramics can produce results correlating with those found in previous research

2. Determine at what level of flow the S-Paramics model suggests an effective capacity is reached

3. Determine whether tidal flow has a significant impact on the capacity of a single track road
The capacity of single-track lanes

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Walker et al. (1967)

LR71 Single Track Roads in the Scottish Highlands
(Further Traffic Studies 1964)

• Four stretches of Scottish lane (reg surveys)

• Found capacities 100 – 220 veh/hr

• Found linear relationship...
Fig. 6. COMPARISON OF SPEED-FLOW RELATIONSHIPS
Walker et al. (1967) (cont’d)

\[ V = A - 0.085q \]

**Fig. 6. COMPARISON OF SPEED–FLOW RELATIONSHIPS**

- **Free-flow speeds** \((A)\)
- **Capacities** \((q)\)
Walker et al. (1967) (cont’d)

\[ V = A - 0.085 \, q \]

*But…*

• Equation fails where \( A < 20 \text{ mph} \) (assumed to be minimum acceptable speed)

• Why should relationship be linear when approaching capacity?
Burrow (1977)

*Delays on single-lane roads with passing places (Working Paper TSN 29R)*

- Fortran model
- Test Track experiment
Burrow (1977) (cont’d)

*Fortran Model*

- 180m stretch of ‘road’ with ‘passing spaces’
- Many assumptions
  - Perfect visibility (i.e. no backing up)
  - 15 mph
  - No acceleration/deceleration
- Found capacities 100 veh/hr – 300 veh/hr depending on number of spaces
Burrow (1977) (cont’d)

*Test track experiment*

• Still assumes perfect visibility and slow speeds - but:
  • Acceleration/deceleration
  • Human element

• Delay almost always higher than in simulation

• Discrepancy greater when flows unbalanced
Summary of the literature

• Very limited research

• Empirically derived relationship $V = A - 0.085q$
  • But limited sample
  • Fails at low speed
  • Over 40 years old!

• Experimental/simulated results make very broad-brush assumptions

• Consensus of capacity approx 100-300 veh/hr
The capacity of single-track lanes

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Methodology

An S-Paramics model was developed to try to replicate the Burrow (1977) model:

- Two-lane approaches separated by 180m single-lane stretch
- 0-3 passing spaces
- ‘Speed limit’ at 15 mph
- 100% cars
Methodology (cont’d)

• Modelled using signals and loops
• Need for a ‘release valve’ to be coded
• Demand matrices to replicate previous modelling
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Average delay in S-Paramics model vs Burrow model for corresponding flows
Paramics vs 1977 model

- Limited correlation

- What are the differences between Paramics and Burrows’ model (1977)?
  - Modelling of acceleration/deceleration
  - Interaction between vehicles

\[ y = 0.3535x + 8.9878 \]
\[ R^2 = 0.0753 \]
Paramics vs 1977 experiment

Delay in S-Paramics vs Burrow experiment for same flows and passing spaces
Paramics vs 1977 experiment

- Limited correlation (again) – very low $R^2$
- What are the differences between Paramics and Burrows’ experiment (1977)?
  - In theory, less than for model
  - Small sample
  - Psychology?
- Or – is my Paramics model simply no good?!
Paramics vs 1964 observations

Average speed vs flow in S-Paramics (2 passing spaces)

\[ y = -0.0105x + 14.854 \]

\[ R^2 = 0.4888 \]
Paramics vs 1964 observations

Average speed vs flow in S-Paramics

No passing spaces

2 passing spaces

1 passing spaces

3 passing spaces

$y = -0.0069x + 14.195$

$R^2 = 0.2005$

$y = -0.0106x + 14.854$

$R^2 = 0.4688$

$y = -0.0143x + 15.607$

$R^2 = 0.5209$

$y = -0.0099x + 14.156$

$R^2 = 0.4353$
Paramics vs 1964 observations

- In 1964 Walker et al. found:
  \[ V = A - 0.085 \ q \]

- Similar linear relationship in Paramics, but a much lower coefficient:
  \[ V \approx A - 0.01 \ q \]

- Could be partly due to lower speed limit, with \( A = 15 \); much lower than in Scottish study

- Correlation relatively poor
Average speed vs flow in S-Paramics (equal flow in each direction)
The capacity of single-track lanes

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Can S-Paramics produce results correlating with those found in previous research?

- S-Paramics replicates to some extent a linear relationship
  \[ V = A - g q \]
  but with a very different value of \( g \)
- I suggest this may fail as \( q \) approaches link capacity
Conclusion (2)

At what level does S-Paramics suggest an effective capacity is reached?

• Delay appears to increase significantly at 300-400 veh/hr - but represents ideal conditions

• In reality is the range 100-220 (Walter et al., 1967) correct? What about changes in vehicle performance? Vehicle size and mix?
Conclusion (3)

Will tidal flow have an impact on capacity?

• It does appear so

• Lowest capacity appears to be around a 1:1 ratio
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Future research

• Observational studies
  • Bluetooth/ANPR/video?
  • Obtain data over an extended period of time at a range of sites
• Refine S-Paramics model
  • Different speeds
  • Vehicle mix
• Consider other forms of model
  • QUADRO?
  • Cell transmission model?
• Can problems with modelling reversing be overcome?
Finally...

- Every lane will be unique
- Based on the available information, I believe that:
  - Effective capacity of a single-track lane with passing spaces lies somewhere between 100-300 veh/hr
  - Tidal flow is significant
- This isn’t the ‘final word’ but an attempt to encourage further investigation and discussion.
- Have I missed anything?!
Thank you for listening

And to…
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Written paper available: [http://sdrv.ms/UPR3Up](http://sdrv.ms/UPR3Up)
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