User Costs Model for Road Management Systems

A Simplified Approach for Portuguese Conditions

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User Costs Model for Road Management Systems - A Simplified Approach for Portuguese Conditions

Introduction

The material presented in this paper is part of a PhD research work finished in 2008 and recent new developments.

✓ Objective

Develop a Simplified Road User Cost Model to use in Portuguese road management systems.

✓ Aiming at

Simplicity; reduced data requirements; easy calibration; easy application and trustworthy results.
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Introduction

Portuguese RUC Model conceptual framework was based in simplifications of:

- HDM-4 equations for VOC
- COBA and HDM-4 approach for AC
- JAE Model and HDM-4 equations for VOT

Other models studied:
- NZVOC
- TxDOT Manual
The proposed model was developed taking into account:

- Recognized conceptual principles
- Application to trunk roads
- Impact of each component on total RUC
- Portuguese conditions
- Availability of Portuguese official data
- Four vehicle classes: PC, U, HT, HB
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**Methodology**

**Simplified Road User Costs Model**

- **Vehicle Operating Costs** (fuel, tyres, vehicle maintenance and depreciation)
- **Accident Costs** (for accident and casualty)
- **Value of Travel Time**
- **Tolling Costs**

Recent refinements were made to include the effect of working zones and pavement conditions.
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Formulation

\[
RUC_{\text{total}} = RUC \times L + RUC_{\text{M&R}} \times L_{\text{M&R}} + RUC_{\text{PSI}} \times L_{\text{PSI}}
\]

\[
RUC = VOC + AC + VOT + Toll
\]

\[
RUC_{\text{M&R}} = dCf + dVOT
\]

\[
RUC_{\text{PSI}} = VOC \times F_{VOC,\text{PSI}}
\]

\[
VOC = AADT \times \sum_{i=1}^{4} (VOC_i \times p_i)
\]

\[
AC = AADT \times \left( \sum_{i=1}^{3} AC_i + \sum_{k=1}^{3} CC_k \right)
\]

\[
VOT = AADT \times \sum_{i=1}^{4} (VOT_i \times p_i)
\]

\[
Toll = AADT \times \sum_{i=1}^{4} (ctoll_i \times p_i)
\]
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Model Validation

Passenger Car VOT and VOC distribution

<table>
<thead>
<tr>
<th>Model</th>
<th>VOT</th>
<th>VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTRUC (2006)</td>
<td>66.3</td>
<td>33.7</td>
</tr>
<tr>
<td>HDM-4 (2006 Portuguese conditions)</td>
<td>78.9</td>
<td>20.4</td>
</tr>
<tr>
<td>COBA (2002)</td>
<td>88.6</td>
<td>11.4</td>
</tr>
<tr>
<td>NZVOC (2002)</td>
<td>100.0</td>
<td>0.0</td>
</tr>
<tr>
<td>TxDOT Manual (1998)</td>
<td>100.0</td>
<td>0.0</td>
</tr>
<tr>
<td>JAE RUC (1995)</td>
<td>65.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Average Mod</td>
<td>77.5</td>
<td>22.3</td>
</tr>
</tbody>
</table>
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Model Validation

Heavy Truck VOT and VOC distribution

<table>
<thead>
<tr>
<th>Method</th>
<th>VOT</th>
<th>VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTRUC (2006)</td>
<td>15.8</td>
<td>84.2</td>
</tr>
<tr>
<td>HDM-4 (2006)</td>
<td>6.5</td>
<td>93.5</td>
</tr>
<tr>
<td>COBA (2002)</td>
<td>13.6</td>
<td>86.4</td>
</tr>
<tr>
<td>NZVOC (2002)</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>TxDOT Manual (1998)</td>
<td>12.9</td>
<td>87.1</td>
</tr>
<tr>
<td>JAE RUC (1995)</td>
<td>11.0</td>
<td>89.0</td>
</tr>
<tr>
<td>Average Mod</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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Sensitive Parameters of the Model

- Vehicle operating speed
- Fuel consumption and cost

Main parameters in determining additional RUC due to work zones and pavement condition
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**Additional RUC due to Work Zones**

More important in trunk roads

*Decrease of operating speed*

*Additional fuel consumption*

More significant in two lanes roads with “medium” design standards

Increases VOT

Increases VOC

Work Zones
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Additional RUC due to Work Zones

\[
RUC_{\text{M&R}} = dCf + dVOT
\]

\[
dCf = \text{AADT} \times \sum_{i=1}^{4} (0.2 \times C_{f_i} \times p_i) \quad \text{for} \quad s_{M&R_i} \leq \frac{1}{3} \times s_i \quad \text{and ER, EN}
\]

\[
dVOT = \text{AADT} \times \sum_{i=1}^{4} (VOT_{M&R_i} \times p_i) - VOT
\]

\[
VOT_{M&R_i} = \frac{1}{s_{M&R_i}} \times \sum_{m=1}^{4} (T_{C_m} \times O_{R_{i,m}})
\]
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**Additional RUC due to Pavement Condition**

- Not significant in trunk roads
- **Decrease in operating speed**
- **Increase in non-fuel VOC**
- More important in trunk roads
- Increase VOT
- Increases VOC

Pavement Condition
**Additional RUC due to Pavement Condition**

<table>
<thead>
<tr>
<th>PSI</th>
<th>IRI (m/km)</th>
<th>Correction factors for VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.25</td>
<td>1.15</td>
</tr>
<tr>
<td>2.0</td>
<td>3.50</td>
<td>1.05</td>
</tr>
<tr>
<td>3.5</td>
<td>2.00</td>
<td>1.00</td>
</tr>
<tr>
<td>4.7</td>
<td>0.50</td>
<td>0.95</td>
</tr>
</tbody>
</table>

\[
RUC_{\text{PSI}} = VOC \times F_{\text{VOC, PSI}} \\
F_{\text{VOC, PSI}} = -0.0017 \times \text{PSI}^3 + 0.0139 \times \text{PSI}^2 - 0.0712 \times \text{PSI} + 1.15 \\
\text{PSI} = 5 \times e^{-0.0002598 \times \text{IRI}/2} - 0.002139 \times R^2 - 0.03 \times (C + S + P)^{0.5}
\]
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**RUC Model Applications Results**

<table>
<thead>
<tr>
<th>Costs</th>
<th>Scutvias (A23) Average values</th>
<th>Scutvias (A23) Work Zone PSI=2.0</th>
<th>Aenor (A7 and A11) Average values</th>
<th>Aenor (A7 and A11) Work Zone PSI=2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC</td>
<td>2.267 € 60%</td>
<td>2.379 € 56%</td>
<td>1.352 € 53%</td>
<td>1.419 € 49%</td>
</tr>
<tr>
<td>AC</td>
<td>83 € 2%</td>
<td>83 € 2%</td>
<td>73 € 3%</td>
<td>73 € 3%</td>
</tr>
<tr>
<td>VOT</td>
<td>703 € 19%</td>
<td>1.055 € 25%</td>
<td>505 € 19%</td>
<td>758 € 26%</td>
</tr>
<tr>
<td>Toll</td>
<td>742 € 19%</td>
<td>742 € 17%</td>
<td>637 € 25%</td>
<td>637 € 22%</td>
</tr>
<tr>
<td>RUC</td>
<td>3.795 € 100%</td>
<td>4.259 € +12%</td>
<td>2.567 € 100%</td>
<td>2.887 € +12%</td>
</tr>
</tbody>
</table>
The developed RUC Model constitutes a suitable model to Portuguese reality. The main improvements of the proposed model over the existing ones are the reduced amount of data, its availability and a simple and flexible model formulation. The incorporation of the Additional RUC due to the explicit consideration of work zones delays and involving a explicit pavement condition indicator will allow more accurate RUC calculations to be use in asset management systems.
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THANK YOU FOR YOUR ATTENTION!!!