Three Level Diamond – Single Controller or Multiple Controllers

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Study Objective

• Evaluate interchange operation using
  – *Single controller*
    • Three phase
    • Four phase
  – *Four controller*
    • Existing condition
• Use hardware in the loop simulation
Three Phase Sequence - 1

Transportation Operations Group

External Movements

Three Phase Sequence - 2

Transportation Operations Group

Internal Movements
Three Phase Constraints

Three Phase Movements
Three Phase - Summary

- Two external approaches operating simultaneously
- Internal clearance phases follow
- **Advantages**
  - Efficient
  - Maintains progression
  - Smaller cycle length
- **Disadvantages**
  - Limited in phase length duration
  - Smaller cycle length
- **Existing four controller operation is similar to a three phase type operation**

Four Phase Sequence - 1

External Movement
Four Phase Sequence - 2

Overlap Movements

Four Phase Sequence - 3

External Movement
Four Phase Sequence - 4

Overlap Movements

Four Phase Sequence - 5

External Movement
Four Phase Sequence - 6

Overlap Movements

Four Phase Sequence - 7

External Movement
Four Phase Sequence - 8

Overlap Movements

Four Phase Movements
Four Phase - Summary

- One external approach operating at a time
- Overlap movements to improve efficiency
- Advantages
  - No constraints on external phase durations
  - Maintains progression
  - Larger cycle length
- Disadvantages
  - Larger cycle length

Evaluation Procedure

- Collected volume, geometric, and timing data
- Created a CORSIM simulation model
- Used hardware-in-the-loop simulation
  - Traffic signal controller replaces CORSIM controller
  - Brings realism to simulation
Hardware-in-the-Loop

HITL Simulation – Four Controllers
### HITL Simulation – One Controller

![HITL Simulation Image](image)

### MOE’s – Delay (Hours)

<table>
<thead>
<tr>
<th></th>
<th>AM Peak</th>
<th>Noon Peak</th>
<th>PM Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing</strong></td>
<td>42.3</td>
<td>38.5</td>
<td>40.6</td>
</tr>
<tr>
<td><strong>Four Phase</strong></td>
<td>39.6</td>
<td>33.7</td>
<td>33.6</td>
</tr>
<tr>
<td><strong>Three Phase</strong></td>
<td>43.4</td>
<td>38.9</td>
<td>38.9</td>
</tr>
<tr>
<td><strong>Reduction</strong></td>
<td>6.2%</td>
<td>12.5%</td>
<td>17.4%</td>
</tr>
</tbody>
</table>
### MOE’s – Stops

<table>
<thead>
<tr>
<th></th>
<th>AM Peak</th>
<th>Noon Peak</th>
<th>PM Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing</strong></td>
<td>4747</td>
<td>4366</td>
<td>4325</td>
</tr>
<tr>
<td><strong>Four Phase</strong></td>
<td>4522</td>
<td>3698</td>
<td>3736</td>
</tr>
<tr>
<td><strong>Three Phase</strong></td>
<td>4307</td>
<td>3709</td>
<td>3794</td>
</tr>
<tr>
<td><strong>Reduction</strong></td>
<td>4.1%</td>
<td>7.5%</td>
<td>7.2%</td>
</tr>
</tbody>
</table>

### MOE’s – Fuel Consumption (Gal.)

<table>
<thead>
<tr>
<th></th>
<th>AM Peak</th>
<th>Noon Peak</th>
<th>PM Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing</strong></td>
<td>146.0</td>
<td>137.8</td>
<td>138.2</td>
</tr>
<tr>
<td><strong>Four Phase</strong></td>
<td>139.9</td>
<td>127.5</td>
<td>128.2</td>
</tr>
<tr>
<td><strong>Three Phase</strong></td>
<td>145.7</td>
<td>136.2</td>
<td>136.4</td>
</tr>
<tr>
<td><strong>Reduction</strong></td>
<td>4.1%</td>
<td>7.5%</td>
<td>7.2%</td>
</tr>
</tbody>
</table>
Cycle Lengths (Seconds)

<table>
<thead>
<tr>
<th></th>
<th>AM Peak</th>
<th>Noon Peak</th>
<th>PM Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>79</td>
<td>70</td>
<td>79</td>
</tr>
<tr>
<td>Four Phase</td>
<td>103</td>
<td>104</td>
<td>104</td>
</tr>
<tr>
<td>Three Phase</td>
<td>100</td>
<td>80</td>
<td>76</td>
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</table>

Yearly User Savings

- Based on 300 days
  - $12.50 for each hour of delay reduced
  - $0.15 for each stop reduced
  - $2.25 for each gallon of fuel consumption reduced
- Savings equaled $275,000 per year
Comparison

• Single Controller
  – Can operate fully actuated
  – Cycle length changes on demand
  – Easy to fine-tune the settings
  – Need good detection to operate efficiently

• Four Controller
  – Can operate only coordinated
  – Cycle length changes by TOD
  – Complicated to fine-tune the settings
  – In case of detector failure, will operate to keep the interior clear
3-Level Diamond Signal Operations

Signals at U.S. Highway 84 Frontage Roads and State Highway 6 Frontage Roads

Outline

• Definition
• Area Traffic Patterns
• Traffic Operations
• Improvements
• Q & A
3-Level Diamond Interchange

Area

City of Waco, Texas

February 2, 2007
Traffic Operations

• Four Signals/Four Controllers
• Time Space Diagram
• Basic Philosophy
  – Goals
  – Constraints
  – Rationale
• Is it broken?
Improvements

- Detection $7,260
- Signage $20k - $30k
- U-Turn Bridge $1.1 Million*
- Single Controller $250k - $350k**
Potential Guide Signs

Westbound US 84 approach

Southbound SH 6 approach

Q & A