Issues with Advance Train Preemption of Traffic Signals

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Location
Rail Preemption

- Designed to **transfer right-of-way** to the track movement and **clear vehicles** off the track(s) before the train arrives
- Preemption sequence in traffic signal controller:
  - Initiated by a signal from the rail equipment
  - Transfer right-of-way to track movements
  - Service and terminate track movements
  - Must be done before **train arrives**!

Current Design Methodology

- Use maximum right-of-way transfer time
- Assumes a heavy vehicle stopped on track
- Calculates time to get that vehicle off track
- Track clearance green time set to this value
- Request advance preemption time, if needed
- Assures vehicle is off track when train arrives
Design Case

Question

- Is this good enough to guarantee safe operations?

No!
Operations

- **Variability** impacts preemption operations

  - Variability in traffic signal operations
    - Due to unknown controller state at preemption initiation
    - Affects right-of-way transfer time

  - Variability in rail operations
    - Due to “train handling”
    - Affects warning times

Data Collection

- Train monitoring opportunities at TTI
  - Instrumented rail corridor in College Station, TX
  - Good relationship with City of College Station

- Train data collection
  - Logged signal changes
  - Logged preemptions
  - Logged lights & gates
  - Logged train arrivals
Problem

- Exists with **advance preemption**
- Preemption initiation and warning device initiation are **independent** processes
"Uncoupling" of Events

Operations (1)

Preempt to Controller

Lights Start to Flash

Train Arrives At Crossing

Advance Prescription Time (APT)

Railroad Warning Time

Minimum Warning Time (20 sec)

Warning Time

Lights

Gates

Signal

Queue

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Operations (2)

Preempt To Controller

Warning Time
- Advance Preemption Time (APT) (variable)
- Minimum APT (fixed)

Lights Start To Flash
- Railroad Warning Time
- Minimum Warning Time (20 sec)

Lights
- Flashing

Gates
- Fixed Delay
- Gates Descending
- Gates Down

Signal
- RWIT
- Track Green
- Yellow
- Red / Dwell

Queue
- Queue Clearance Time
- Separation Time

Train Arrives At Crossing

Queue Clearance Time
- Separation Time

Operations (3)

Preempt To Controller

Warning Time
- Advance Preemption Time (APT) (variable)
- Minimum APT (fixed)

Lights Start To Flash
- Railroad Warning Time
- Minimum Warning Time (20 sec)

Lights
- Flashing

Gates
- Fixed Delay
- Gates Descending
- Gates Down

Signal
- Track Green
- Yellow
- Red / Dwell

Queue
- Queue Clearance Time
- Separation Time

Train Arrives At Crossing

Queue Clearance Time
- Separation Time
“Preempt Trap”

- Track clearance green may end before warning lights start to flash
- Vehicles have no indication of impending train arrival and may cross tracks
- But the track clearance interval has already expired!

Solutions

Treat the symptoms and / or
Treat the cause
Treat the Symptoms

Preempt To Controller | Lights Start To Flash | Train Arrives At Crossing
---|---|---
Warning Time | Advance Preemption Time (APT) (variable) | Railroad Warning Time (variable) | Minimum Warning Time (20 sec)
Light | Preempt Timer | Lights Flashing |
Gates | fixed delay | Gates Descending | Gates Down |
Signal | Track Green | Extra Green | Yellow | Red / Dwell |
Queue | Queue Clearance Time | Separation Time |
Treat the Symptoms

- Provide **more than the minimum** required track clearance green
- Balance probability of preempt trap with operational efficiency
- For example:
  - Set track green to APT + 15 seconds
  - Design for measured APT times

Treat the Cause (one method)

- Reduce variability in rail operations:
  - Reduce variability in advance preemption time
  - Use a “not-to-exceed” timer to **control maximum APT** as per 2000 AREMA Signal Manual
**Treat the Cause (one method)**

<table>
<thead>
<tr>
<th>Preempt To Controller</th>
<th>Lights Start To Flash</th>
<th>Train Arrives At Crossing</th>
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</thead>
<tbody>
<tr>
<td><strong>Warning Time</strong></td>
<td><strong>Railroad Warning Time</strong></td>
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<tr>
<td>Advance Preemption Time (APT) (variable)</td>
<td>Minimum Warning Time (20 sec)</td>
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<td>Minimum APT (fixed) (variable)</td>
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<td><strong>Lights</strong></td>
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<td>Preempting Traffic fixed delay</td>
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<td><strong>Gates</strong></td>
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<td>Fixed delay</td>
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Conclusion

- Be aware of the potential problems of advance preemption
- Take the necessary steps to avoid (or at least minimize the probability of) the preempt trap
- Consider design and operational scenarios

For More Information

- http://transops.tamu.edu/content/gradecrossing.cfm
- More extensive presentation
- Manual on good practice
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Questions?