NCHRP Report 812
SIGNAL TIMING MANUAL
Second Edition

Slides Courtesy of the Transportation Research Board, National Cooperative Highway Research Program
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Focus for the Second Edition

- **Focused information** written for new practitioners and those desiring a better understanding of signal timing fundamentals.
- **Addition of four new chapters** for more advanced users.
- Material organized so that it is *presented once and referenced as needed* elsewhere in the document.
- Inclusion of **essential information only** (i.e. no “nice to know” information).
- **References to other documents**, instead of repeated material.
- **Expanded use of graphics** to aid in the explanation of more complex topics.
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Chapter 1. Introduction

The second edition has an increased focus on signal system users and their priorities, and introduces an outcome based approach to signal timing.

- Focus for the Second Edition
- Introduction to the Outcome Based Process
- STM2 Organization
Chapter 2. Signal Timing Program

Signal timing programs assure that signal timing parameters are appropriate over the life of the traffic signal system, by monitoring all aspects of traffic signal implementation, operations, and maintenance consistent with community needs.

- Leadership
- Self-Assessment and Evaluation
- Funding Mechanisms
- Training Programs
- Public Involvement and Outreach
- Benefits of Regional Signal Timing Programs
Chapter 3. Signal Timing Concepts

This chapter provides an overview of signal timing basics, organized using the outcome based process. The outcome based process is a modern approach to signal timing that encourages practitioners to consider all system users.

- Common Signal Components and Interactions
- Basic Signal Controller Concepts
- Outcome Based Process
- Data Collection
- Operational Objectives and Performance Measures
Chapter 3 introduces common signal components, interactions, and signal controller concepts…
Followed by an explanation of the steps in the outcome based process.

- **STEP 1**: Define the Operating Environment
- **STEP 2**: Identify Users
- **STEP 3**: Establish User and Movement Priorities
- **STEP 4**: Select Operational Objectives
- **STEP 5**: Establish Performance Measures
- **STEP 6**: Develop Timing Strategies and Timing Values
- **STEP 7**: Implement and Observe
- **STEP 8**: Monitor and Maintain
Chapter 4. Signal Design

Effective signal timing requires appropriate signal design. This chapter discusses signal design elements that directly influence signal timing.

- Detection
- Signal Cabinet Equipment
- Displays
- Signalized System Design
- Lessons Learned
Chapter 4 describes the relationship between detectors, signal cabinet equipment, and displays…
Followed by detailed information about detection (including decision zone protection)…
Detailed information about signal cabinet equipment...
And detailed information about displays for vehicles, pedestrians, bicycles, and transit users…
Concluding with a description of communications equipment between signals.
Chapter 5. Introduction to Timing Plans

This chapter is part of a three-part series about developing signal timing plans. It describes basic signal timing concepts that a practitioner should understand before defining signal timing values.

- Movements and Phases
- Ring-and-Barrier Concept
- Left-Turn Phasing
- Overlaps
- Detector and Load Switch Assignments
- Critical Movement Analysis
- Software Models and Considerations
Chapter 5 explains movement and phase numbering…

Note: The pedestrian phase is generally associated with (and will time concurrently with) the adjacent vehicle phase (as illustrated by the dashed lines).
Using various phasing examples…
Followed by an explanation of ring-and-barrier diagrams…
Using various phasing examples…

φ = Phase Number

→ = Protected Movement

—→ = Permitted Movement

←— = Pedestrian Movement
Concluding with step-by-step instructions for critical movement analysis...
Chapter 6. Intersection/Uncoordinated Timing

This chapter provides guidance on basic signal timing parameters used at uncoordinated intersections (i.e. intersections running in “free” operation).

- Yellow Change
- Red Clearance
- Minimum Green
- Maximum Green
- Passage Time
- Pedestrian Intervals
- Dual Entry
- Recalls and Memory Modes
- Detector Delay
- Detector Extend Time
- Detector Switching
- Time-of-Day Plans
### Typical Values for Maximum Green

<table>
<thead>
<tr>
<th>Phase Type</th>
<th>Facility Type</th>
<th>Maximum Green (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through</td>
<td>Major Arterial (&gt; 40 mph)</td>
<td>50 to 70</td>
</tr>
<tr>
<td></td>
<td>Major Arterial (≤ 40 mph)</td>
<td>40 to 60</td>
</tr>
<tr>
<td></td>
<td>Minor Arterial</td>
<td>30 to 50</td>
</tr>
<tr>
<td></td>
<td>Collector, Local, or Driveway</td>
<td>20 to 40</td>
</tr>
<tr>
<td>Left Turn</td>
<td>Any</td>
<td>15 to 30</td>
</tr>
</tbody>
</table>

### Typical Values for Passage Time

<table>
<thead>
<tr>
<th>Detection Zone Length (Feet)</th>
<th>Passage Time (with a Headway of 3 Seconds) (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Posted Speed (MPH)</td>
</tr>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>2.3</td>
</tr>
<tr>
<td>20</td>
<td>1.9</td>
</tr>
<tr>
<td>40</td>
<td>1.4</td>
</tr>
<tr>
<td>60</td>
<td>0.8</td>
</tr>
<tr>
<td>80</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Chapter 6 provides guidance on signal timing parameters and typical values (e.g., maximum green, passage time)…
As well as an explanation of how timers work and can be applied.
Chapter 7. System/Coordinated Timing

Coordination allows signals to operate as a group, thereby synchronizing movements and allowing for better progression. This chapter explains how basic signal timing parameters can be used in conjunction with coordinated features.

- Application of a Coordinated System
- Time-Space Diagram
- Coordinated Phases
- Cycle Length
- Splits
- Force-Offs
- Permissives
- Yield Point
- Pattern Sync Reference
- Offset Reference Point
- Offsets
- Pedestrian Timing and Walk Modes
- Actuating the Coordinated Phase
- Transition Logic
- Complexities
Chapter 7 describes time-space diagram basics…
And uses them to explain how vehicles move within a coordinated system…
As well as coordinated signal timing parameters…
Followed by information about coordination considerations (e.g., actuating the coordinated phase) and complexities.
Chapter 8. Implementation and Maintenance

This chapter describes taking final timing plans through implementation and to the point where they must be monitored and maintained. Maintenance ensures that the signal timing will continue to operate at the level expected by the operating agency and general public.

- Transfer Plans from Office to Field
- Field Observations and Adjustments
- Performance Studies
- Monitoring
- Maintenance
- Staffing Needs
<table>
<thead>
<tr>
<th>Field Observation</th>
<th>Potential Adjustments</th>
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</thead>
<tbody>
<tr>
<td>Long minor street delay</td>
<td>□ Redistribute green time between major street phases and minor street phases (e.g., minimum green, maximum green, or splits).</td>
</tr>
<tr>
<td></td>
<td>□ Review cycle length.</td>
</tr>
<tr>
<td></td>
<td>□ Review passage settings for major street phases.</td>
</tr>
<tr>
<td></td>
<td>□ Consider actuating the coordinated phase(s).</td>
</tr>
<tr>
<td>Long major street left-turn delay</td>
<td>□ Redistribute green time to major street left-turn phases (e.g., minimum green, maximum green, or splits).</td>
</tr>
<tr>
<td></td>
<td>□ Review passage settings for major street through phases and minor street phases.</td>
</tr>
<tr>
<td></td>
<td>□ Consider left-turn phase sequence.</td>
</tr>
<tr>
<td>Vehicle queuing</td>
<td>□ Redistribute green time to phases with queuing (e.g., minimum green, maximum green, or splits).</td>
</tr>
<tr>
<td></td>
<td>□ Review cycle length.</td>
</tr>
<tr>
<td></td>
<td>□ Review offsets.</td>
</tr>
<tr>
<td></td>
<td>□ Review passage settings for other phases (not experiencing queuing).</td>
</tr>
<tr>
<td></td>
<td>□ Consider left-turn phase sequence.</td>
</tr>
<tr>
<td></td>
<td>□ Consider phase re-service.</td>
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<tr>
<td>Vehicle platoons arriving on red</td>
<td>□ Review offsets.</td>
</tr>
<tr>
<td></td>
<td>□ Consider left-turn phase sequence.</td>
</tr>
<tr>
<td></td>
<td>□ Review cycle length.</td>
</tr>
<tr>
<td></td>
<td>□ Review upstream intersections for early return to green and possible offset adjustment.</td>
</tr>
</tbody>
</table>

As well as guidance for adjusting signal timing based on field observations…
<table>
<thead>
<tr>
<th>Signal Operations Category</th>
<th>Example Public Service Requests</th>
<th>Potential Questions to Identify a Solution</th>
</tr>
</thead>
</table>
| **Not Getting a Green**    | □  “My movement is not getting a green.” | □  Is the intersection part of a coordinated system (that dedicates time to certain phases for progression)?  
□  Have the detectors been damaged?  
□  Is the stopping point well defined (so that vehicles will stop over the detectors)?  
□  Is the detection zone appropriate (e.g., large enough to detect vehicles in a wide approach, sensitive enough to detect bicycles)?  
□  How are the detectors being operated? Is the non-locking setting being used when needed?  
□  Was preemption active? |
| **Short Green**            | □  “My movement gets a green, but the green is too short.” | □  If the intersection is part of a coordinated system, is the correct plan running?  
□  Are the splits appropriate and customized for the intersection?  
□  If the particular phase is on recall, are the detectors working properly?  
□  Was preemption active?  
□  If it is a multi-lane approach, is a lane temporarily out of service due to construction or incomplete snow plowing?  
□  Is the approach on a steep grade, where a slippery road could affect performance? |

Followed by information about monitoring and maintaining signals (e.g., responding to public service requests).
Chapter 9. Advanced Signal Systems

Advanced signal systems are able to make signal timing adjustments based on detection information, thus modifying operations during varying traffic flow conditions.

- Systems Engineering
- Advanced Coordination Features
- Traffic Responsive Plan Selection Systems
- Adaptive Signal Control Technology Systems
Chapter 10. Preferential Treatment

*Preferential treatment is an application that can be used at signalized intersections to adjust operations in favor of particular users.*

- Detection Requirements
- Signal Timing Strategies
- Strategic Recovery
- Data Logging
- Advancements
- Preemption Settings
- Priority Settings
- Considerations for Rail, Emergency Vehicles, Transit, and Trucks
Chapter 10 gives an overview of signal timing strategies (e.g., sequence change)…
Concluding with specific details about preferential treatment for rail, emergency vehicles, transit, and trucks.
Chapter 11. Special Conditions

For special conditions, alternative signal timing may be required to maintain operations.

- Weather Events
- Traffic Incidents
- Planned Special Events
Chapter 12. Oversaturated Conditions

Although the issue of oversaturation is often not resolvable solely through new signal timing, there are several mitigation strategies that can be applied to improve overall system performance and increase short-term capacity.

- Symptoms of Oversaturation
- Maximizing Intersection Throughput
- Queue Management
- Mitigation Strategies
Chapter 12 provides information about oversaturation symptoms (e.g., overflow queue, spillback, blocking, and starvation)…
Followed by mitigation strategies, specifically for maximizing intersection throughput and queue management.
GLOSSARY
180+ Terms Defined

What it is ....

- Focused on signal timing
- Covers signal timing fundamentals
- Intended for new practitioners
- Includes essential information only

What it is NOT ...

- “Cookbook”
- Encyclopedia
- A “Standard”
- Replacement of MUTCD or local policy
- Replacement for good engineering judgement
Questions