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Your Image of Texas?
Regions in Texas
Average Annual Precipitation

Mean Annual Temperature

Legend (in inches)
- Under 14
- 14 to 18
- 18 to 22
- 22 to 26
- 26 to 30
- 30 to 34
- Above 34

This map is a plot of 1961-1990 annual precipitation estimates from NOAA Cooperative stations and USGS nested USDA-NRCS SNOTEL stations. Clida Oily used the ISHM model to generate gridded estimates from which this map derived. The modeled grid was approx. 0.9 km in latitude/longitude, and was then interpolated to 0.5 km using a Gaussian filter. Map performed by Jeromy Weidburg, Funded by USDA-NRCS National IF Climate Center.
Recent Texas Weather Events

“If you don’t like the weather in Texas, wait a few hours – it’ll change!”
Motivation for Project

• US Crashes*
  – 22% of all vehicle crashes are weather-related
  – 73% of weather-related collisions occur on wet pavement, 46% during rainfall

• Crashes on Texas Highways**
  – 9% of all fatalities and 10% of all crashes occurred during inclement weather conditions
  – 11% of fatalities and 15% of all crashes occurred when pavement conditions “poor” due to weather

*Source: Ten-year averages from 2004 to 2013 analyzed by Booz Allen Hamilton, based on NHTSA data
**Texas Motor Vehicle Crash Statistics 2014, Texas Department of Transportation (http://www.txdot.gov/government/enforcement/annual-summary.html)
Project Goals and Objectives

- Quantify impacts of weather on traffic signal operations
- Identify appropriate weather responsive traffic management (WRTM) strategies for signals
- Establish criteria and architecture for deploying WRTM
- Update *Traffic Signal Operations Handbook*
- Develop and pilot test training course
General System Architecture

Intersection Controller Cabinet

Local Controller (E14th St)

Back Panel

Energize Pla

Digital I/O Signal (Contact Closure)

Weather Data (USB)

WRTM Processing System

Sensor Interface Module

Weather Sensor Suite

Pavement Surface Sensor

Coordinated System

Master Controller (E 1st St)

Weather Responsive Timing Plan

Intersection Controller (E4th – E8th)

Alarm
Weather Station

- Davis Instruments
- Wireless Integrated Sensor Suite
  - Rain collector
  - Temperature/humidity sensor
  - Anemometer
  - Wind vane
  - Solar panel/battery backup
- Sensor Interface Module
- Data Logger
- Costs: $1,000
Pavement Surface Sensor

- Non-intrusive pavement sensor
- Detects
  - Surface ice, snow, and water
  - Surface states
  - Surface Grip – relative scale of “grip” state from 100 (best) to 0 (worst)
- Wired or wireless applications
- Cost: $15,000
Visibility Sensor

• Detects
  – Visibility Distance
  – Visibility “State”

• Classify visibility as “acceptable” or “poor”

• Costs: $7,000
WRTM Processing Unit

- Industrial computer
- 10" x 6.0" x 2.7"
- Functions
  - Collects weather data
  - Monitors pavement and visibility sensor inputs
  - Recommend plan change
  - Stores evaluation data
  - Issues weather alerts
- Cellular communications
- Cost: $2,000
Decision Support System

• Implement strategies stored in plan library
• Use special function
• New plans based on reduced speeds

<table>
<thead>
<tr>
<th>Visibility</th>
<th>Surface Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>Acceptable</td>
<td>Normal</td>
</tr>
<tr>
<td>Poor</td>
<td>Plan 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plan 1</th>
<th>Plan 2</th>
<th>Plan 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Coordination Plan</td>
<td>• Coordination Plan</td>
<td>• Red Extension</td>
</tr>
<tr>
<td>• Phase Recalls</td>
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</tr>
<tr>
<td>• Min Green Increases</td>
<td>• Phase Recalls</td>
<td>• Truck Extension</td>
</tr>
</tbody>
</table>

Visibility: Acceptable
Surface Condition: Normal
Plan: 1

Visibility: Poor
Surface Condition: Plan 1
Plan: 2

Visibility: Poor
Surface Condition: Plan 1
Plan: 3

Visibility: Poor
Surface Condition: Plan 2
Plan: 3
Weather Responsive Traffic Signal Timing Strategies

• Adjustments to signal change intervals
  – Red Extension
• Changes in phase durations
  – Increase Minimum Greens
  – Phase Recalls
• New coordination plans
• Special operations plans
Red Extension

- Extend red clearance interval by 1 to 2 second
- Provide additional margin of clearance during poor pavement conditions
- Depending upon approach speed
- May require additional detection zones
- Already supported by some controllers
Increase Minimum Green Times

• Increase minimum greens
  – due to reduction in start-up loss times
  – slower accelerations
• Possible only with some NTCIP controller
Implement Phase Recalls

• Max and/or Min recalls
• Guarantees phases are serviced
• Provides consistency in operations
• Example: Fog
Coordination Plan Changes

• New coordination plans during weather event
• Used Synchro to investigate different Cycle/Split/Offset combinations
• Existing Cycle Length/Existing Splits
  – Existing offset
  – Optimized offset
  – Existing Cycle Length/”Max” Recall on cross-streets
• Optimized Cycle Length
  – Offsets for slower speeds
Truck “Extension” During Bad Weather

- Add truck detector
- Place “Hold” on main-street green, if
  - Detected vehicle is truck
  - Pavement conditions “bad”
  - Limit number of Holds per cycle
- Allows truck to travel through indecision zone (2 secs from intersection)
- May require additional equipment to be installed
Evaluation Test Sites

Roadway: US 287
Location: Dumas
Weather: Ice, Snow
Signals: Isolated/System

Roadway: SH 174
Location: Burleson
Weather: Rain, Ice
Signals: System

Roadway: SH 146
Location: Clear Lake City
Weather: Rain, Fog
Signals: System
Performance Evaluation

• Operational Objective – provide similar level of performance during inclement weather as in normal conditions

• Output
  – Number of weather activations
  – Duration of activations

• Outcome
  – Travel times / travel speeds
  – Number of stops
  – Throughput
  – Weather-related collisions
Issues and Lessons Learned

• Sensor Placement
  – Where do you “look”?

• Calibrating of sensors
  – How do I know sensor is working for all conditions?
    – Different pavement types

• Calibrating thresholds

• Sensor costs
Questions