A Technique for Estimating Queue Length Using Video Imaging Vehicle Detection Systems

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Introduction

- Video Imaging Vehicle Detection Systems (VIVDS)
  - Becoming preferred detection method
  - Uses virtual detectors placed on the roadway
- Queue and Delay Estimation Algorithm (QDA)
  - Queue characteristics provide basis for delay calculation
  - Extracts queue length data from VIVDS
- Advanced statistical/mathematical techniques

Problem Statement

- National Cooperative Highway Research Program (NCHRP) Project 3-79
- Requirements
  - Non-intrusive
  - Real-time queue length estimation
  - Accurate queue length estimates
  - Low cost solution

Objectives

- Estimate queue length during red phase
- Evaluate methods for modeling queue length data
- Implement correction mechanism
- Determine accuracy of method

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Study Location

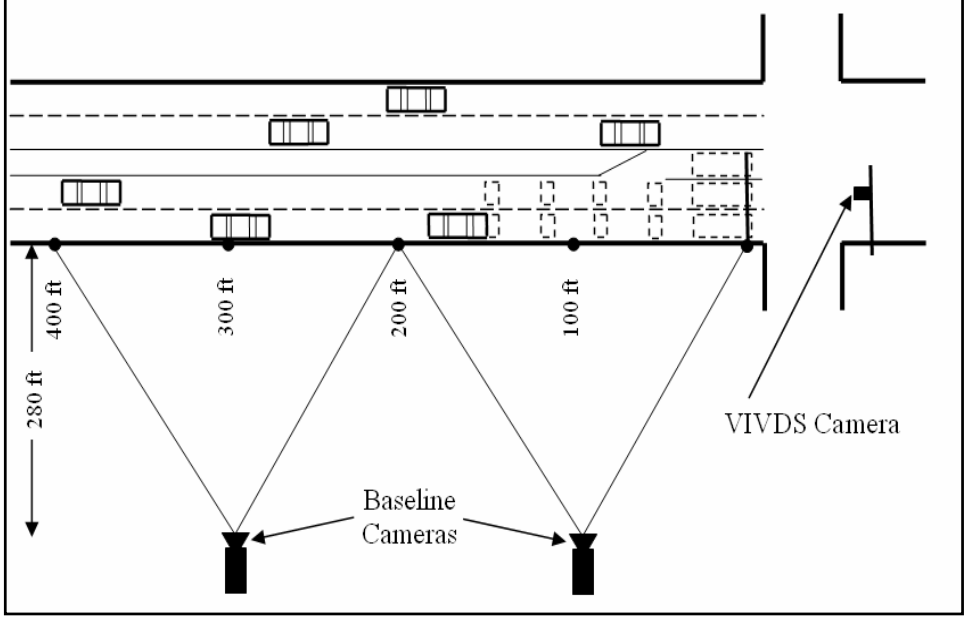
- George Bush Drive and Wellborn Road, College Station, Texas

Data

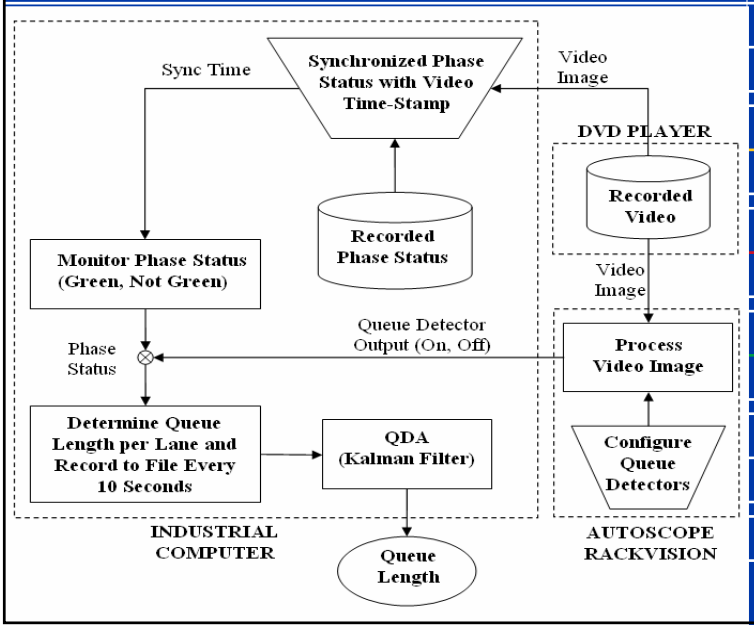
- Three types of data were collected:
  - VIVDS video
  - Phase status
  - Baseline data adjacent to the roadway
- Four hours of data were analyzed
- Same data set used
  - Randomness
  - No one run identical
  - Five trial runs

VIVDS Video Data

Baseline Data Setup



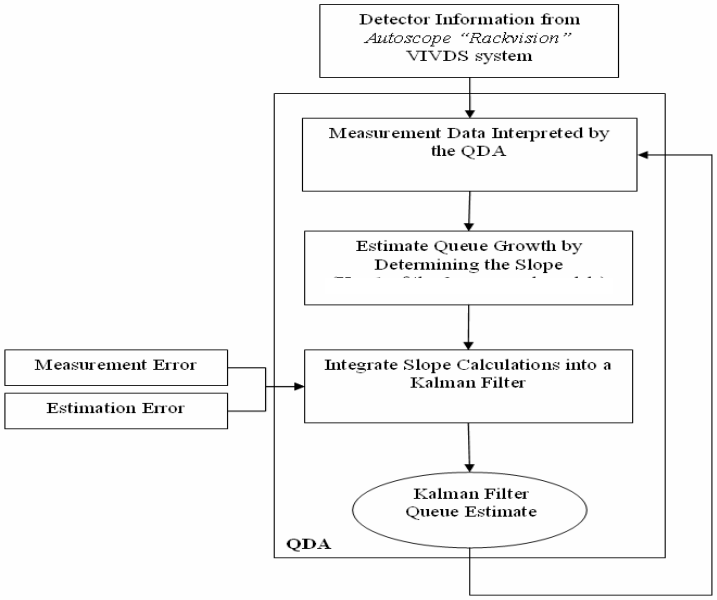
Laboratory Setup



Algorithm Development

- Simulated using measurement data from VIVDS
- Simulated in *Microsoft Excel Visual Basic for Applications*
- Subroutines
  - Queue growth calculation
  - Kalman Filter
- Estimated Queue length during the red phase
- Executed when the first stopped vehicle was detected during red phase
- Terminated at the end of the red phase

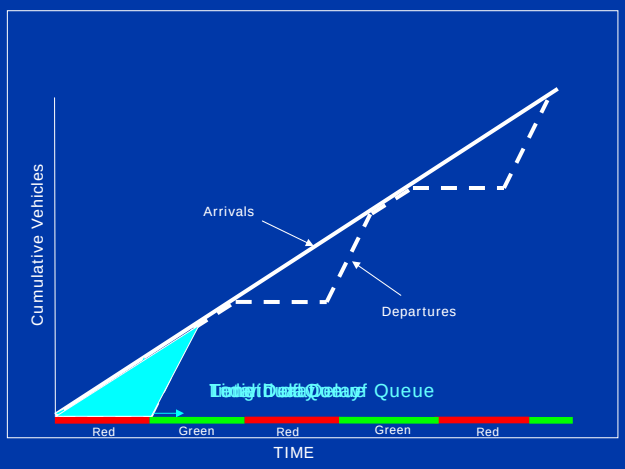
Algorithm Development



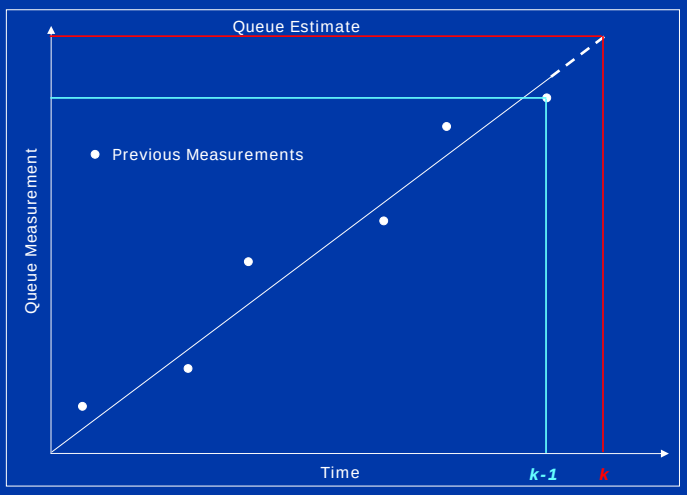
Queuing Theory

- Deterministic Queuing
  - Undersaturated conditions
  - All vehicles are serviced
  - No overflow
- Model allows for the determination of:
  - Time duration of queue
  - Length of queue
  - Individual delay
  - Total delay

Queuing Theory

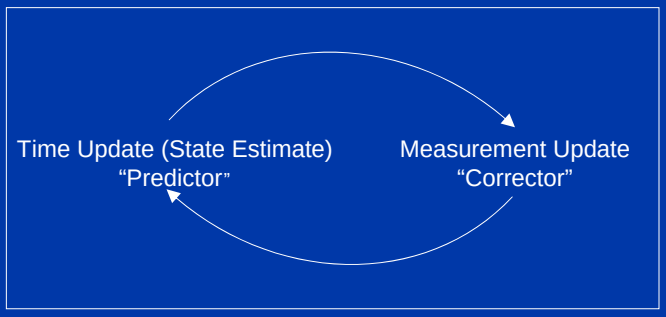


Linear Regression

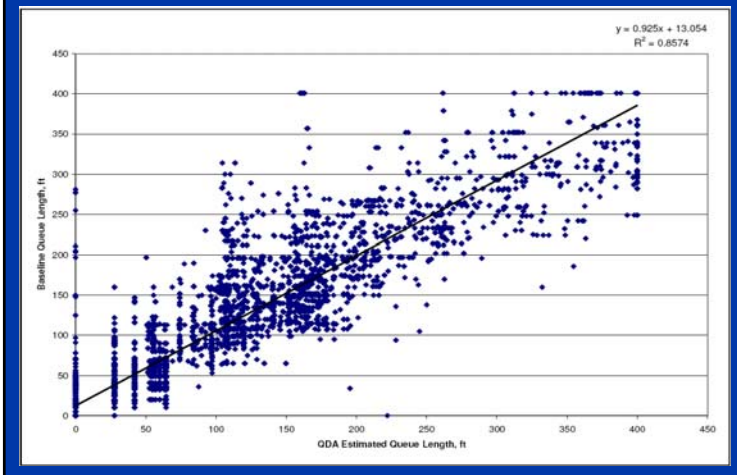


The Kalman Filter

- Multiple-input, multiple-output
- Minimizes the mean-squared error
- Predictor-corrector algorithm



Validation Graphical Statistics



Validation Statistical Analysis

Statistic	Linear Regression
Coefficient of Determination	0.8574
Vertical Intercept (bias), ft	13.054
Ave. Err., ft	12.71
Abs. Ave. Err., ft	22.22
Stdev. Abs. Err., ft	31.04

Discussion

- Number of detectors limits capabilities
- Accuracy highly dependant on model
- Kalman Filter provides a method for controlling queue growth
- Kalman Filter is an intelligent method of merging current estimates and measurements

Benefits

- Cost
- Few equipment upgrades
- Utilizes existing VIVDS operations
- Adaptive
- Real-time MOEs
- Adaptive control or TRSP detection

Conclusions

- Linear regression method produced best model for estimating queue lengths
- Technique capable of describing 85 percent of variance in queue length data
- Improvements are small with other models
- Reaching the limit of detector capabilities

Questions?

Thank You

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