Arizona Department of Transportation

Transportation Technology Group

Freeway Management System Design Guidelines

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CONTRIBUTIONS AND ACKNOWLEDGEMENTS

The 2009 updates to the *2007 Arizona Department of Transportation (ADOT) Freeway Management System (FMS) Design Guidelines* were the result of the coordinated efforts of many groups, research organizations, and government agencies. The 2009 updates to the 2007 version of the FMS Design Guidelines were prepared for ADOT by Kimley-Horn and Associates, Inc. The following list of groups was essential in the preparation of the updated document:

ADOT FMS DESIGN GUIDELINE CONTRIBUTORS:

- Federal Government
- State Government
- Local Governments
- Local Consultants
- Local Contractors

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Chapter 1 Introduction

1.1 Purpose of the Freeway Management System Design Guideline

The Intermodal Transportation Division (ITD) of the Arizona Department of Transportation (ADOT) carries out the responsibilities legislated to ADOT by its governing body, the seven-member Arizona State Transportation Board. The ITD is composed of 11 groups and ten engineering districts. The Division is directed by the state engineer and three deputy state engineers.

The Transportation Technology Group (TTG), one of the 11 groups within ITD, is responsible for deploying technology to improve ground transportation in Arizona, traditionally called Intelligent Transportation Systems (ITS). ITS deployments on urban highways in Arizona are called the Freeway Management System (FMS). This guideline is published by the TTG to support the design of FMS technology and infrastructure.

This set of guidelines is targeted to assist designers to incorporate the basic elements of the FMS in their Plans, Specifications, and Engineer's Estimate (PS&E) documents and to facilitate the ongoing implementation of the FMS. The FMS consists of communications, electronics, and information processing to enhance safety, capacity, and emergency response.

This guideline document is neither a standard nor substitute for engineering experience, skill, knowledge, or judgment. Actual conditions require the use of engineering judgment in using the direction contained in this guideline.

The term *designer* refers to anyone, regardless of title and employer, who prepares PS&E for FMS projects in the state of Arizona. Where the term *Contractor* is mentioned in this guide, it is understood that the role of Contractor is to be viewed from the designer's perspective. The Contractor physically constructs the system. This document is not a substitute for formal documents binding to a Contractor.

FMS projects typically require a planning document, such as:

- Project Assessment (PA);
- FMS Concept Report; or
- If part of a roadway project, a chapter within the Design Concept Report (DCR).

Most projects also require a formal Design Quality Management Plan (DQMP).

The ADOT TTG project manager (PM) reviews all FMS planning and design documents during various stages of design. The designer will consult with various other sections/groups within ADOT during the design process, including:

- Roadway Engineering Group – to incorporate FMS fully into the civil design;
- Roadway Predesign;
- Roadway Design;

- Drainage Design;
- Roadside Development;
- Valley or Statewide Project Management – to ensure compatibility of the FMS with the civil design;
- Federal Highway Administration – for oversight;
- The regional ADOT District – to ensure compatibility of the FMS with regional ADOT goals;
- Contracts & Specifications (C&S) – for guidance in writing special provisions; and
- Others (including Environmental Planning Group, Bridge Group, Traffic Group, Right-of-way Group, Program and Projects Management, and Utility & Railroad Engineering).

1.1.1 History of the FMS Design Guide

The first *FMS Infrastructure Design Guideline* was published in 1989. The first update was published in 1994. The *Guidelines* were further updated in 2000 in conjunction with the FMS Phase 3 work in Phoenix and subsequent projects. The *Guidelines* were again updated in 2002 for the FMS Phase 5 project in Phoenix and the Tucson Phase 1 project. The *2007 Design Guidelines* was the first to drop the word "Infrastructure" from the title. Three new sections were added to address other aspects of the FMS, including some that fell outside the domain of infrastructure: Communication Nodes, OSP data base, and Testing. Ramp Metering was removed and a separate Design Guide was first published in 2003. The *2007 FMS Design Guidelines* also included changing the term Variable Message Sign to Dynamic Message Sign throughout the document. The *2009 FMS Design Guidelines* have been updated to include the latest technology selection decisions by ADOT and to incorporate any Lessons Learned from the Design and Contractor community. The state of Arizona intends to update the FMS Design Guidelines as needed.

1.1.2 FMS Goals and Objectives

ADOT manages an extensive FMS in two urban areas (Phoenix and Tucson), as well as a vast array of intelligent transportation devices in rural Arizona. The FMS Design Guidelines' main focus is freeways; however, some guidelines may be useful for rural highways. This guideline does not address rural Arizona devices such as Roadway Weather Information Sensors (RWIS).

There are two types of traffic congestion in urban areas, namely recurring and non-recurring congestion. Congestion occurs when the demand exceeds the capacity, or when capacity is reduced. Recurring congestion commonly occurs during the morning and evening commutes when traffic demand exceeds the available capacity of the freeway lanes. In addition, non-recurring congestion occurs when crashes, disabled vehicles, debris in the roadway, construction, adverse weather conditions, and other factors reduce the capacity of the freeway to below the traffic demand.

The objectives of the FMS are intended to:

- Reduce the impacts of congestion;
- Minimize the duration and effects of non-recurring congestion;
- Maximize the operational safety and efficiency of the traveling public;
- Provide motorists with relevant traffic information;

- Provide assistance to motorists; and
- Operate a system that provides a service and builds credibility with the public.

The benefits of the FMS for the motoring public include:

- Improving safety;
- Improving efficiency of the motoring public;
- Reducing environmental impact;
- Reducing fuel consumption;
- Enhancing productivity;
- Saving lives through emergency response;
- Reducing secondary collisions;
- Integrating regional traffic management systems; and
- Centralizing management of the freeway system.

1.1.3 Concept of Communications

In general, ADOT FMS communication macro-level design was initially guided by the ADOT *FMS SONET*[•] *Communications Master Plan* (published in 1999). ADOT no longer uses *SONET* technology and communications equipment continues to evolve with emerging technology. In the two largest metropolitan areas of the state, ADOT facilitates the sharing of information between ADOT and local agencies by promoting regional connectivity, as shown in Table 1.1. The ADOT FMS and local cities ITS systems share agreements, which are established through ADOT's Joint Project Agreements Office in the form of a Joint Project Agreement (JPA) or Intergovernmental Agreement (IGA).

Table 1.1 ADOT Regional Connectivity Networks

METRO AREA	ACRONYM	NAME
Phoenix	RCN	Regional Community Network
Tucson	RTDN	Regional Transportation Data Network

For more information, the network documents are available at the respective websites:

MAG = http://www.mag.maricopa.gov

PAG = http://www.azrtdn.net

Generally, it is ADOT's intent to provide communications redundancy for all FMS segments. This redundancy can be accomplished either physically within the segment through a dual trunkline system or technologically through the use of an alternate path, such as via an alternative looped freeway conduit path. Freeway spokes require dual trunklines, but where a continuous loop can be established and the

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Note: ADOT no longer uses the SONET standard for FMS as shown in the *FMS SONET Communication Master Plan*.

communications equipment can travel the distance, the trunkline is constructed on one side of the freeway.

Further, the designer should be versed in communications technologies, including fiber-optics, analog Frequency Division Multiplexing (FDM), digital Time Division Multiplexing (TDM), Coarse Wave Division Multiplexing (CWDM), and Ethernet Based Internet Protocol (IP) technologies. These latter technologies allow for improved redundancy opportunities and efficiencies.

1.1.4 Using this FMS Design Guide with Other Documents

Generally, the ADOT TTG teams follow the PS&E document preparation guidelines for Roadway Engineering. The PS&E documents are to be prepared at the 60%, 95%, 100% (Stages III, IV, and V), and seal stages.

The designer shall be guided by these *2009 FMS Design Guidelines* and by the latest version of several ADOT documents, including but not necessarily limited to:

- Predesign Guidelines (http://www.azdot.gov/Highways/RdwyEng/RoadwayPredesign/Index.asp);
- Design Procedures Manual;
- Roadway Design Guidelines;
- TTG Ramp Meter Design, Operations, and Maintenance Guidelines;
- FMS Standard Drawings;
- FMS Standard Specifications;
- *Stored Specifications* (all, with emphasis on those related to FMS); and
- 2008 ADOT Standard Specifications for Road and Bridge Construction.

Refer to the ADOT website for the latest instructions and to find the respective documents. The designer shall also consult the ADOT TTG PM for recent FMS standards that have not yet been adopted within these published documents.

It is also helpful for the designer to understand the *ADOT TOC Operations Manual* for FMS operations. This manual offers a prospective from the actual users of the system.

The ADOT Traffic Group publishes the *Traffic Signals and Lighting Standard Drawings*. These standard drawings contain several standards that may appear to duplicate FMS standard drawings. The FMS standard drawings take precedence over the *Traffic Signals and Lighting Standard Drawings*.

1.1.5 Definitions

Table 1.2 is a list of commonly used acronyms that appear throughout this document.

Table 1.2 Acronyms

ACRONYMS	DESCRIPTION
AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
APL	Approved Products List
ASTM	American Society for Testing and Materials
AQD	Advance Queue Detector
ATOC	Alternative Traffic Operations Center
CCTV	Closed Circuit Television
CLSM	Controlled Low Strength Material
CWDM	Coarse Wavelength Division Multiplexing
DCR	Design Concept Report
DMS	Dynamic Message Sign
DQMP	Design Quality Management Plan
FDM	Frequency Division Multiplexing
FMS	Freeway Management System
GIS	Geographic Information System
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
HVAC	Heating, Ventilation, and Air Conditioning
IMSA	International Municipal Signal Association
IP	Internet Protocol
ITD	ADOT Intermodal Transportation Division (which includes TTG)
ITOC	Interim Traffic Operations Center
ITS	Intelligent Transportation Systems
LED	Light Emitting Diode
MAG	Maricopa Association of Governments
MUTCD	Manual on Uniform Traffic Control Devices
NEC	National Electric Code
Node	Communications hub for termination of trunkline fiber-optic cables, typically housed inside a climate controlled secure building at a SI (system interchange).

ACRONYMS	DESCRIPTION
NTCIP	National Transportation Communications for ITS Protocol
OSP	Outside Plant
PA	Project Assessment
PAG	Pima Association of Governments
PM	Project Manager
PRIDE	Product Resource Investment Deployment and Evaluation
PS&E	Plans, Specifications and Estimates
PVC	Polyvinyl Chloride
RCN	Regional Community Network (For Phoenix Metro Region)
RMC	Rigid Metal Conduit
RTDN	Regional Tucson Data Network (For Tucson Metro Region)
SDR	Size Diameter Ratio
SI	System Interchange (Freeway to Freeway)
SMFO	Single-Mode Fiber-optic
TDM	Time Division Multiplexing
TI	Traffic Interchange (Crossroad)
TOC	Traffic Operations Center
TTG	Transportation Technology Group
UPS	Uninterruptible Power Supply
VAC	Volts – Alternating Current
VDC	Volts – Direct Current