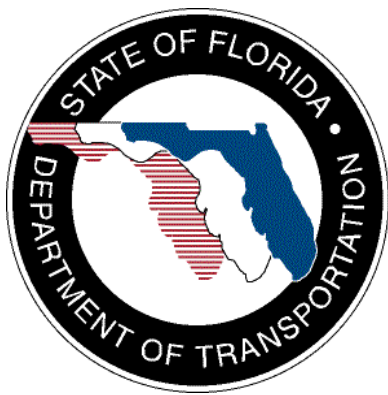


**SunGuide<sup>®</sup>:**

## **Ramp Metering Firmware**

# **Version Description Document**

**SunGuide-RMF-VDD-1.0.13**



Prepared for:

Florida Department of Transportation  
Traffic Engineering and Operations Office  
605 Suwannee Street, M.S. 90  
Tallahassee, Florida 32399-0450  
(850) 410-5600

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Created By:	John Brisco, SwRI®	JSB	02/28/07
	Steve Sprouffske, SwRI	SJS	03/05/07
	Bruce Farmer, SwRI	SBF	03/07/07
Reviewed By:	Steve Dellenback, SwRI	SWD	03/09/07
	Steve Dellenback, SwRI	SWD	04/06/07
	Steve Dellenback, SwRI	SWD	04/12/07
	Steve Dellenback, SwRI	SWD	04/30/07
	Steve Dellenback, SwRI	SWD	06/05/07
	Steve Dellenback, SwRI	SWD	03/17/08
	Steve Dellenback, SwRI	SWD	03/05/09
	Steve Dellenback, SwRI	SWD	04/17/09
Modified By:	John Brisco, SwRI	JSB	04/05/07
	John Brisco, SwRI	JSB	04/12/07
	John Brisco, SwRI	JSB	04/27/07
	Bruce Farmer, SwRI	SBF	05/30/07
	Steve Sprouffske, SwRI	SJS	03/11/08
	Marc Alban, SwRI	MCA	03/04/09
	Marc Alban, SwRI	MCA	04/16/09
Completed By:			

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## **List of Acronyms**

COTS .....	Commercial-Off-The-Shelf
CPU.....	Central Processing Unit
DOT .....	Department of Transportation
EPROM.....	Erasable Programmable Read Only Memory
FDOT .....	Florida Department of Transportation
ITN.....	Invitation to Negotiate
ITS.....	Intelligent Transportation Systems
RMS .....	Ramp Meter Subsystem
ROM .....	Read Only Memory
SwRI .....	Southwest Research Institute®
VDD.....	Version Description Document
W3.....	World Wide Web Consortium

## Revision History

Revision	Date	Changes
1.0.0	March 14, 2007	Initial Release.
1.0.1	April 6, 2007	Changes and additions suggested after initial testing at the TERL.
1.0.2	April 12, 2007	Changed watchdog output toggle rate.
1.0.3	April 30, 2007	Modified the metering algorithm to correctly manage signal light timing in special cases. Moved the Metering LED output to C1 connector pin 8. Moved the memory locations for detector echo and input echo from the F1 page to the C page. Modified the keypad interface memory viewing feature to update in real time the current memory location displayed. Modified detector data collection process to remove interrupt conflicts preventing proper speed trap calculations.
1.0.4	May 21, 2007	Addressed issues #19, #20, #21, #22, #29 and #37
1.0.5	June 6, 2007	Addressed issues #20, #28, #31, and #32
1.0.6	June 14, 2007	Release was for on-site testing, no formal release was performed.
1.0.6	June 15, 2007	Release was for on-site testing, no formal release was performed.
1.0.8	January 21, 2008	Release was for on-site testing, no formal release was performed.
1.0.9	February 18, 2008	Release was for on-site testing, no formal release was performed.
1.0.10	March 17, 2008	Resolved all outstanding issues from IV&V and Acceptance Testing.
1.0.11	February 12, 2009	Addressed issues #1050 and #1076
1.0.12	February 13, 2009	Addressed issue #1079
1.0.13	April, 17, 2009	Addressed issue #1068

# 1. Scope

## 1.1 Document Identification

This document serves as the Version Description Document (VDD) for the Florida Department of Transportation (FDOT) Ramp Metering firmware.

## 1.2 Project Overview

The FDOT is conducting a program that is developing SunGuide<sup>®</sup> software. The SunGuide software is a set of Intelligent Transportation System (ITS) software that allows the control of roadway devices as well as information exchange across a variety of transportation agencies. The goal of the SunGuide software is to have a common software base that can be deployed throughout the State of Florida. The SunGuide software development effort is based on ITS software available from both the States of Texas and Maryland; significant customization of the software is being performed as well as the development of new software modules. The following figure provides a graphical view of the SunGuide software:

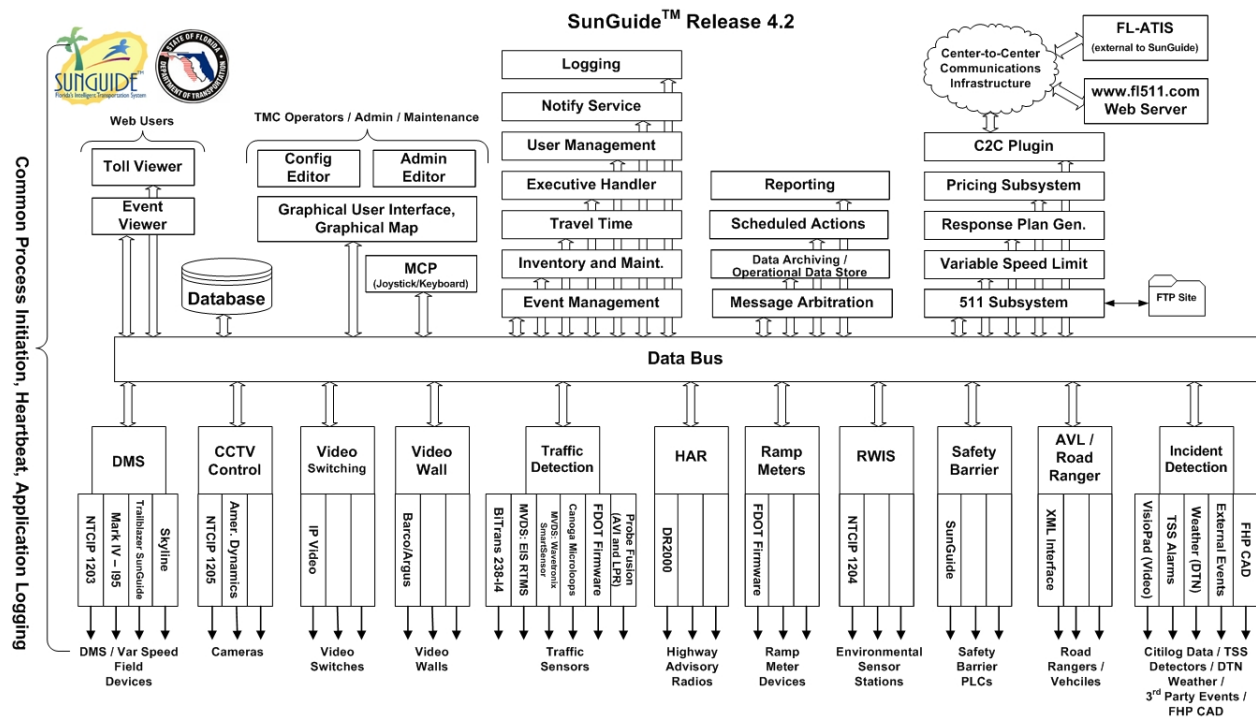


Figure 1.1 - High-Level Architectural Concept

The SunGuide development effort spans approximately two years. After the development, the software will be deployed to a number of districts and expressway authorities throughout Florida and support activities will be performed.

## 1.3 Related Documents

The following documents were used to develop this document:

- Southwest Research Institute (SwRI) Qualification Response: *Response to the Invitation to Negotiate (ITN): Statewide Transportation Management Center Software Library System, Negotiation Number: ITN-DOT-02/03-9025-RR*, SwRI Proposal No. 10-35924, dated: November 18, 2002.
- SwRI Technical Proposal: *Technical Proposal for Invitation to Negotiate (ITN): Statewide Transportation Management Center Software Library System, Negotiation Number: ITN-DOT-02/03-9025-RR*, SwRI Proposal No. 10-35924, dated: January 31, 2003.
- SwRI Cost Proposal: *Cost Proposal for Invitation to Negotiate (ITN): Statewide Transportation Management Center Software Library System, Negotiation Number: ITN-DOT-02/03-9025-RR*, SwRI Proposal No. 10-35924, dated: January 31, 2003.
- SwRI BAFO letter: *Southwest Research Institute® Proposal No. 10-35924, “Invitation to Negotiate (ITN): Statewide Transportation Management Center Software Library System”, Reference: Negotiation Number: ITN-DOT-02/03-9025-RR*, dated: May 5, 2003.
- FDOT procurement document: *Invitation to Negotiate (ITN), Negotiation Number: ITN-DOT-02/03-9025-RR, Statewide Transportation Management Center Software Library System*, dated: October 21, 2002.
- FDOT Scope of Services: *Statewide Transportation Management Center Software Library System: Scope of Services*, September 22, 2003.
- FDOT Requirements Document: *Statewide Transportation Management Center Software Library System: Requirements Specification*, June 3, 2003.
- Southwest Research Institute, *TMC Software Study*, November 15, 2001.
- Southwest Research Institute, *Introduction to an Operational Concept for the Florida Statewide Library*, FDOT – OCD – 1.0, March 31, 2002.
- Washington State Department of Transportation, *Ramp Meter / Data Collection User’s Manual*, Version 4.47, 28 January 2005.
- World Wide Web Consortium (W3) website: <http://www.w3.org>.
- SunGuide Project website: <http://suguide.datasys.swri.edu>.

### 1.4 Contacts

The following are contact persons for the SunGuide software project:

- Elizabeth Birriel, ITS Central Office, [elizabeth.birriel@dot.state.fl.us](mailto:elizabeth.birriel@dot.state.fl.us), 850-410-5606
- Arun Krishnamurthy, FDOT SunGuide Project Manager, [Arun.Krishnamurthy@dot.state.fl.us](mailto:Arun.Krishnamurthy@dot.state.fl.us), 850-410-5615
- David Chang, PBS&J Project Manager, [David.Chang@dot.state.fl.us](mailto:David.Chang@dot.state.fl.us), 850-410-5622
- Khue Ngo, Senior ITS Analyst, [khue.ngo@dot.state.fl.us](mailto:khue.ngo@dot.state.fl.us), 850-410-5579
- Steve Dellenback, SwRI Project Manager, [sdellenback@swri.org](mailto:sdellenback@swri.org), 210-522-3914
- Robert Heller, SwRI Software Project Manager, [rheller@swri.org](mailto:rheller@swri.org), 210-522-3824



## **2. Version Description**

### **2.1 Inventory of Materials**

This version of FDOT Ramp Meter Firmware includes the following software:

- Ramp Meter Firmware V170.1.5 on erasable programmable read only memory (EPROM)
- Ramp Meter Firmware VDD

### **2.2 Inventory of Software Contents**

The FDOT Ramp Meter Firmware is composed of a single EPROM for use in a McCain 170 Traffic controller. Several Commercial-off-the-Shelf (COTS) packages were used to develop the custom firmware.

#### **2.2.1 COTS Packages**

The custom FDOT Ramp Meter firmware was developed using the following commercially available software packages and hardware tools:

- Microsoft® Windows XP Professional Version 2002 with Service Pack 2, Copyright © Microsoft Corporation 1985-2002
- Microsoft® Visual Studio 2005, Copyright © Microsoft Corporation 2005
- Idea6811 C Cross-Compiler, Version 4.4.8, Copyright © Cosmic Software 2005
- Zap 68HC11 Simulator, Kernel Version V3.72c and Processor Version P2.0a, Copyright © Cosmic Software 2002
- Nohau Seehau EMUL68-PC, Version 8.0310B, Copyright 2006 Nohau Corporation
- Nohau 68HC11 In-Circuit Emulator: POD-11FE-PGA-4.0, EMUL-PC/BOX-HSP, and EMUP68-PC/PGA88-PLCC68

#### **2.2.2 FDOT Ramp Meter Custom Software**

The custom software developed for the FDOT Ramp Meter system includes firmware developed for the 68HC11 microcontroller-based McCain 170 Traffic Controller.

### **2.3 Software Changes**

The following patches are included in this Release(1.0.13):

1. Fixed issue with controller not ending metering when transitioning to Local mode. (Issue 1068).

The following patches are included in Release (1.0.12):

1. Modified long stop logic to not include the green part of the cycle in the timeout (Issue 1079).

The following patches are included in Release (1.0.11):

1. Fixed issue where controller locked when started without communication (Issue 1050).
2. Modified the logic for handling the short stop condition (Issue 1076).

The following patches are included in Release (1.0.10):

This release of the VDD covers the changes for interim testing releases and the current release (V170.1.10).

Patches associated with version V170.1.10 of the RM firmware. Issue numbers were reallocated in December 2008 to provide clearer status reporting:

1. Modified volume adjust algorithm to properly calculate adjustment value (Issue 2).
2. Modified metering behavior to stop metering on both lanes in a multi-lane metering mode (Issue 7).
3. Corrected behavior of metering algorithms to enter TOD metering when in a comm. loss scenario (Issue 9).
4. Corrected Advanced Queue and Queue Override algorithms that resulted in erratic adjustment values (Issue 1).
5. Modified long stop operation to ensure 1.5 second minimum green, (Issue: 3).
6. Corrected status reporting to ensure ERD message information is requested by the driver (Issue 4).
7. Added functionality to data entry that blanks previous data on display upon first key stroke of data entry (Issue 8).
8. Modified behavior of controller initialization to include a detector reset instead of a digital input state change (Issue 15).

The following patches were included in Release (1.0.4):

This release of the VDD covers the changes for both the interim release of the RM firmware (V170.1.4 on 05/21/2007) and the current release (V170.1.5).

Patches associated with version V170.1.5 of the RM firmware:

1. Modified the detector activation counting and speed trap processing in the interrupt function to optimize the speed calculation (Issue 31).
2. Corrected a latent deficiency in the metering code that caused erratic queue adjustments when more than one ramp in use (Issues 28 and 32).
3. Changed behavior of demand detector failure to stop metering on affected lane only (Issue 20).

Patches associated with version V170.1.4 of the RM firmware:

1. Modified the display update function to blank the display if no key pressed for a period of 30 minutes; display is reactivated by pressing any key (Issue 29).
2. Modified the initialization sequence to prevent the cabinet monitor from tripping on software reset (Issue 37).
3. Changed metering passage detector counting to use activations instead of releases (Issue 19).
4. Changed behavior of demand detector failure to stop metering on all lanes (Issue 20).

5. Moved monitoring of queue, demand, and passage detectors out of metering code to allow implementation of automatic recovery from detector failures (Issues 21 and 22).

The following patches were included in Release 1.0.3:

1. Changed the detector look-up function to use the total number of detectors rather than the active number of detectors, which prevented the metering algorithm from getting correct detector definitions in certain cases.
2. Modified the metering algorithm to allow stop metering when there is no demand detector activity.
3. Swapped the outputs used for the Metering LED and Signal Light 3 Yellow so that the Metering LED is output on C1 connector pin 8.
4. Moved the memory locations for detector echo and input echo from the F1 memory page to the C memory page.
5. Modified the keypad interface memory viewing feature to update in real time the current memory location displayed.

The following patch was included in Release 1.0.2:

1. The firmware was modified to toggle the watchdog digital output (C1 connector pin 103) every 100 milliseconds as required to prevent the cabinet monitor from tripping.

The following patches (enhancements) were included in Release 1.0.1:

1. The firmware was modified to toggle the watchdog digital output (C1 connector pin 103) every one second as required to prevent the cabinet monitor from tripping.
2. The firmware was modified to update the day of week value in the TOD table when the date/time value is modified via the keypad interface. This enables local metering when not connected to a central computer.
3. The firmware was modified to provide for memory navigation via designated movement keys (increase row, decrease row, increase column, decrease column) when accessing the memory pages via the keypad display.
4. The firmware was modified to provide an additional keypad display mode for viewing arbitrary memory locations.

### 3. FDOT Ramp Meter Firmware Installation

#### 3.1 Preparing FDOT Ramp Meter Controllers

The following steps need to be performed to install the FDOT Ramp Meter firmware:

- Power off the Ramp Meter Controller.
- Ensure proper grounding to prevent static discharge damage to the control components.
- Open the controller front panel, remove the Central Processing Unit (CPU) card and place on a static-controlled surface.
- Remove the existing external Read Only Memory (ROM) device from the card.

#### 3.2 Application Installation

The FDOT Ramp Meter Firmware EPROM is installed into the external ROM socket of control CPU card. Since the ROM socket can accept devices with a greater memory capacity than the 32 Kbyte device used for the Ramp Meter firmware, the installer must be careful to correctly orient the EPROM and place it in the proper location on the socket. Figure 3.1 shows the entire control CPU card and Figure 3.2 shows a close-up of the ROM socket (with EPROM labeled “HC11 Ramp Meter” installed), CPU and the Real-time clock module.



Figure 3.1 - Controller CPU Card

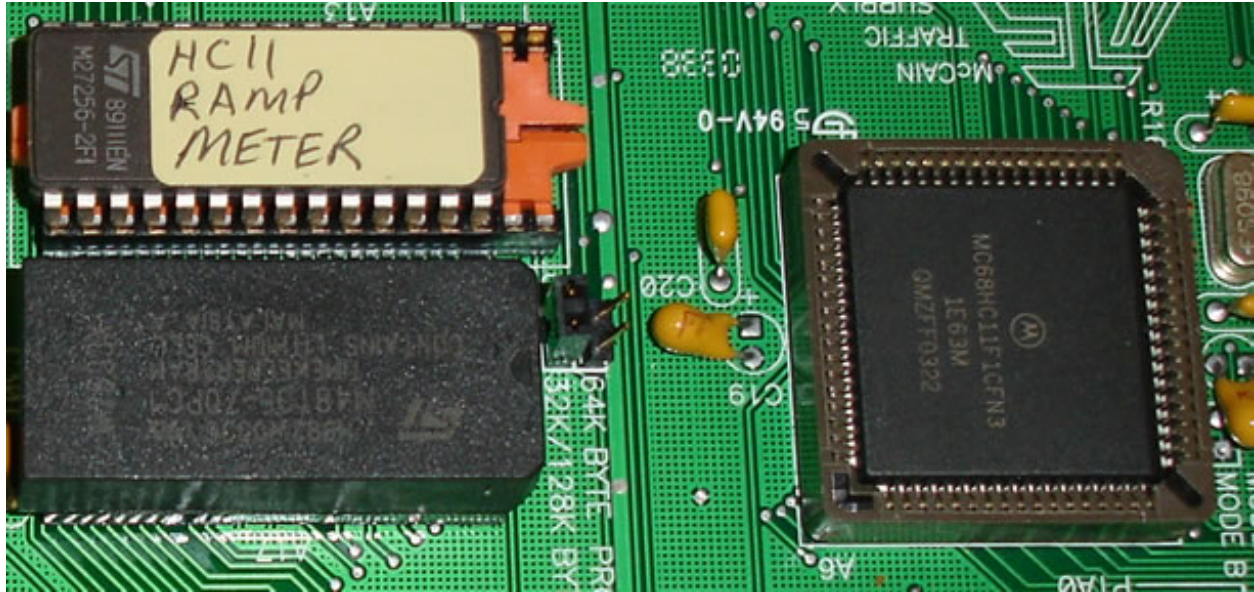


Figure 3.2 - EPROM Close-up

### 3.3 Configuration

The FDOT Ramp Meter firmware has a number of configurable parameters that are used to define the functioning of the ramp meter controller. The names and default values for these parameters are contained in the *ProtocolConfig.xml* extensible markup language file included with the SunGuide Ramp Meter Subsystem software source code.

## **4. Source Code Installation (For Development Purposes)**

Installation of the FDOT Ramp Meter Firmware includes both installation of the COTS tools and FDOT Ramp Meter custom source code on the host platform for software development and installation of the programmed ROM device in the Ramp Meter controller.

### **4.1 Installation on Development Platform**

In order to modify the FDOT Ramp Meter Firmware custom software, it is necessary to install the COTS development tools and the source code for the FDOT Ramp Meter Firmware.

#### **4.1.1 COTS Development Tools Installation**

Microsoft® Windows XP Professional is installed on the development workstation using the operating system setup utility. When installation is complete, Microsoft® Windows XP Service Pack 2 is applied.

Microsoft® Visual Studio 2005 is installed on the development workstation using the compiler setup utility. The C++ component should be installed at a minimum. While the Visual Studio package was used for most of the source file editing, its use is completely optional.

The Idea6811 C Cross-Compiler, Version 4.4.8, is installed on the development workstation using the included setup utility.

The Zap 68HC11 Simulator, Kernel Version V3.72c and Processor Version P2.0a, is installed on the development workstation using the included setup utility. The simulator is an optional tool that is not needed for firmware source editing or binary code generation.

#### **4.1.2 FDOT Ramp Meter Custom Software**

The source files for the FDOT Ramp Meter custom software must be installed on the development system in order to be modified or rebuilt.

##### **4.1.2.1 Source Code Installation**

The FDOT Ramp Meter source code is installed on the development system by copying it from the distribution CD to the development system using Windows Explorer. Because the relative paths to the source code and support files are stored in the Visual Studio workspace and project files used to build the software components, the source files must be copied to the development system with the directory structure intact.

To install the source code on a development workstation, create a destination directory on the development system named **Projects\SunGuide\Source\Rms\Firmware**, and copy the entire contents of the **\Source** directory on the distribution CD to the destination directory on the development system.

##### **4.1.2.2 Build Instructions**

The software components that make up the FDOT Ramp Meter firmware are described in Section 2.2.2. Each component was built using the Integrated Development Environment that accompanies Microsoft® Visual Studio 2005 to ensure all source files are installed. A Microsoft® Visual Studio 2005 solution file (*.sln*) is provided on the distribution CD for building

each component of the FDOT Ramp Meter Firmware system. Prior to building software components you must:

- Install the COTS development tools as described in Section 4.1.1.
- Install the FDOT Ramp Meter Firmware source code as described in Section 4.1.2.1.

#### 4.1.2.2.1 Building the Components

The definition files for the Ramp Meter Firmware component described in Section 2.2.2 are listed in the following table.

Definition File	Purpose
RampMeterHC11.sln	VS 2005 solution file. Defines project content for Visual Studio editing.
RampMeterHC11.prj	Cosmic cross-compiler project file. Defines project content for the cross-compiler.
RampMeterHC11.lkf	Cosmic link definition file. Defines the object files used to build the linker output file: RampMeterHC11.s19.

To build the components the following steps are performed:

1. Start the Cosmic cross-compiler (**Start->Program Files->Cosmic Tools->CXHC11->CXHC11**). From the **Project** menu, select the **Load** menu item to display the **Open Project** dialog. Select the project file for the firmware, located in the folder **Projects\SunGuide\Source\Rms\Firmware\HC11**.
2. From the **Build** menu, select the **Rebuild All** menu item to compile and link the firmware project.
3. Load the Motorola S-Record file generated by the linker into an appropriate ROM device programmer and program the device.

## 4.2 Installation on Target System

The following steps are used to install the FDOT Ramp Meter firmware:

- Power off the Ramp Meter Controller.
- Ensure proper grounding to prevent static discharge damage to the control components.
- Open the controller front panel, remove the CPU card and place on a static-controlled surface.
- Remove the existing external ROM device from the card.
- Place the ROM device programmed with the FDOT Ramp Meter Firmware in the external ROM socket.
- Return the CPU card to the controller.

## **5. Notes**

None.