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A Working Group Draft of the
Advanced Transportation Controller Joint Committee

ITS Cabinet V2 StdRS v01.01

ITS Cabinet Version 2
Standards Requirements Specification (StdRS)

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For approval by: Members of the ITS Cabinet Working Group
For use by: Siva Narla, Chief Engineer and ITS Standards Manager
Institute of Transportation Engineers
Ron Johnson and Robert Rausch, Co-Chairs
ITS Cabinet Working Group
Consulting Team for the ITS Cabinet V2 Project
Ralph W. Boaz, Project Manager/Systems Engineer
Bruce Eisenhart, Systems Engineer
James A. Kinnard, Technical Expert
Members of the ITS Cabinet Working Group

Prepared by: Ralph W. Boaz, Bruce Eisenhart and James A. Kinnard

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CONTENTS

1 PURPOSE OF THE DOCUMENT ............................................................................................................. 7
2 SCOPE OF PROJECT .............................................................................................................................. 7
3 REFERENCED DOCUMENTS .................................................................................................................. 8
4 CONCEPT OF OPERATIONS ............................................................................................................... 9
   4.1 User-Oriented Operational Description ............................................................................................. 9
   4.2 System Overview ............................................................................................................................... 12
   4.3 User Needs ......................................................................................................................................... 14
       4.3.1 General ..................................................................................................................................... 15
       4.3.2 Field Inputs ............................................................................................................................ 18
       4.3.3 Application Computer ............................................................................................................. 18
       4.3.4 Field Outputs ........................................................................................................................ 19
       4.3.5 TFCS Monitoring .................................................................................................................. 20
       4.3.6 Power Filtering and Distribution ............................................................................................... 21
       4.3.7 System Reporting .................................................................................................................... 21
       4.3.8 External Communications ....................................................................................................... 22
       4.3.9 Housing .................................................................................................................................. 22
       4.3.10 Internal Communications ....................................................................................................... 24
   4.4 Operational Environment .................................................................................................................. 24
   4.5 Support Environment ...................................................................................................................... 24
   4.6 Operational Scenarios .................................................................................................................... 24
5 REQUIREMENTS ...................................................................................................................................... 25
   5.1 General .......................................................................................................................................... 26
       5.1.1 General Characteristics ............................................................................................................. 26
       5.1.2 Environmental ........................................................................................................................ 28
       5.1.3 Mechanical ............................................................................................................................ 28
       5.1.4 Electrical .................................................................................................................................. 28
   5.2 Housing ....................................................................................................................................... 29
       5.2.1 ITS V1 Cabinet Housings ........................................................................................................... 29
       5.2.2 Small Size Cabinet .................................................................................................................. 29
       5.2.3 Corrosion Resistant ................................................................................................................. 29
       5.2.4 Aluminum Sheet ..................................................................................................................... 30
       5.2.5 Aluminum Sheet Plating .......................................................................................................... 30
       5.2.6 Stainless Steel Sheet ................................................................................................................ 30
       5.2.7 Cold Rolled Steel ..................................................................................................................... 30
       5.2.8 Cold Rolled Steel Plating ........................................................................................................ 30
       5.2.9 Stainless Steel Hardware ........................................................................................................ 30
       5.2.10 Doors ..................................................................................................................................... 30
       5.2.11 Ventilation ............................................................................................................................. 30
       5.2.12 Cabinet Thickness .................................................................................................................... 30
       5.2.13 Rodent Resistant ...................................................................................................................... 30
       5.2.14 High Security Design ............................................................................................................ 31
       5.2.15 Cabinet Surface Preparation .................................................................................................. 31
       5.2.16 Video Monitor ........................................................................................................................ 31
       5.2.17 Backup Power Batteries .......................................................................................................... 31
       5.2.18 Law Enforcement Access ...................................................................................................... 31
       5.2.19 External Antenna .................................................................................................................... 31
5.3 Application Computer

5.3.1 Application Computer Interfaces .......................................................... 32
5.3.2 Application Computer Protocols .............................................................. 32
5.3.3 Intersection Control Applications ......................................................... 32
5.3.4 Ramp Metering Applications ................................................................. 32
5.3.5 Data Collection Applications ................................................................. 32

5.4 Field Inputs

5.4.1 Commonly-Deployed Input Devices ....................................................... 32
5.4.2 Regular-Density Input File ...................................................................... 32
5.4.3 Number of Regular-Density Inputs ....................................................... 32
5.4.4 Specialty Detection Devices ................................................................... 32
5.4.5 High-Density Input File ......................................................................... 33
5.4.6 High-Density Input File in V1 Cabinet ............................................... 33
5.4.7 Number of High-Density Inputs ............................................................ 33
5.4.8 High-Density Input File 2 .................................................................... 33

5.5 Field Outputs

5.5.1 Regular-Density Output File ................................................................. 33
5.5.2 High-Density Output File ...................................................................... 33
5.5.3 High-Density Output File in V1 Cabinet ............................................... 33
5.5.4 High-Density Output File 2 .................................................................. 33
5.5.5 Supported Field Display Devices ......................................................... 33
5.5.6 Low-Power DC Support ...................................................................... 34
5.5.7 Output Circuit Breakers ....................................................................... 34
5.5.8 Channel-Programmable Flasher Outputs ............................................. 34
5.5.9 Multi-Output Flasher Unit ..................................................................... 34

5.6 Conflict Monitoring

5.6.1 Monitoring Subsystem .......................................................................... 34
5.6.2 Conflict Monitor Unit ........................................................................... 34
5.6.3 Monitor Programmed Field Output States ........................................... 34
5.6.4 Monitor Actual Field Output States ..................................................... 34
5.6.5 Monitor Field Output Interval Length .................................................. 35
5.6.6 Monitor Field Output Voltages and Currents ...................................... 35
5.6.7 Channel Pair Permissive Programming ................................................ 35
5.6.8 Voltage and Current Thresholds ............................................................ 35
5.6.9 Configurable Response ........................................................................ 35
5.6.10 Measure AC Voltage .......................................................................... 35
5.6.11 Measure DC Voltage .......................................................................... 35
5.6.12 Voltage Measurement Interval ............................................................. 35
5.6.13 Measure AC Current ......................................................................... 35
5.6.14 Current Measurement Interval ............................................................. 35
5.6.15 Independent Field Display Monitoring .............................................. 35
5.6.16 Communications Monitoring ............................................................... 36
5.6.17 Password-Protected Configuration ..................................................... 36

5.7 Diagnostic and Status Monitoring

5.7.1 Diagnostic Display Unit Local Display .................................................. 36
5.7.2 Diagnostic Display Unit Remote Display .............................................. 36
5.7.3 Diagnostic Display Unit Historical Data .............................................. 36
5.7.4 Monitoring Bus ..................................................................................... 36
5.7.5 Specific Monitored Conditions ............................................................. 36
5.7.6 Diagnostic Time Required .................................................................... 36

5.8 Power

5.8.1 Nominal AC Input Voltage ................................................................... 37
5.8.2 Nominal DC Input Voltage 1 ................................................................. 37
5.8.3 Nominal AC Input Voltage 2 ................................................................. 37
5.8.4 Clean Power .......................................................................................... 37
5.8.5 Raw Power ............................................................................................ 37
5.8.6 Internal DC Power .................................................................................. 37
5.8.7 Internal AC Inverter ............................................................................... 37
5.8.8 Standby Power ....................................................................................... 37
5.8.9 Backup Power Subsystem ....................................................................... 37

5.9 Internal Cabinet Communications .............................................................. 38
5.9.1 Internal Buses ......................................................................................... 38
5.9.2 Standard Hardware Interfaces and Protocols ........................................ 38
5.9.3 Extensible Protocols ............................................................................. 38
5.9.4 ITS V1 BUS1/BUS2 Support ................................................................. 38

5.10 External Cabinet Communications ............................................................ 38
5.10.1 Remote Protocols and Connectorization ............................................. 38

6 APPENDICES .......................................................................................... 39
6.1 Acronyms ................................................................................................. 39
6.2 Glossary ..................................................................................................... 40
6.3 Needs to Requirements Traceability ......................................................... 40
1 PURPOSE OF THE DOCUMENT

This document is a Standards Requirements Specification (StdRS) for the Intelligent Transportation System (ITS) Cabinet Version 2 (V2) project under the United States Department of Transportation (USDOT) Work Order 14-0701, Tasks 7-12. It combines Concept of Operations adapted from Section 8.4.5 of the "Systems Engineering Guidebook for ITS" (see Section 3 Referenced Documents) with system requirements derived from the user needs identified in the ConOps as a step in the process to create the ITS Cabinet Standard Version 2. This StdRS describes the high-level system concept, defines the environment in which the ITS Cabinet V2 system will operate, identifies the user and system needs, and establishes the system requirements for:

a) The USDOT Joint Program Office (JPO) who is sponsoring the work;

b) The Standard Development Organizations (SDOs) overseeing the development; and

c) The consultants, manufacturers, and public transportation professionals from both the public and the private sectors who participate in the committees and working groups (WGs) which will develop the subsequent work products based on this StdRS.

The majority of the content of this document will be included in the ITS Cabinet Standard Version 2. When this occurs, this StdRS document will no longer be maintained by the ITS Cabinet WG.

2 SCOPE OF PROJECT

The ITS Cabinet V2 project is sponsored by the USDOT JPO as part of an ITS Standards Development Program. The project is to be performed under the direction of the Advanced Transportation Controller (ATC) Joint Committee (JC). The ATC JC is made up of representatives from three SDOs: the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE) and the National Electrical Manufacturers Association (NEMA). The development effort will be carried out by the ITS Cabinet Working Group (WG), a technical subcommittee of the ATC JC, and a paid consultant team.

The ITS Cabinet Standard Version 1.02.17b (also known as Version 1 or V1, see Section 3 Referenced Documents) was published in 2006. It defined a transportation field cabinet system (TFCS) that was highly modular and expandable but the standard was missing formalized user needs and requirements that come from the rigor of a Systems Engineering Process (SEP). The objectives of the ITS Cabinet V2 project are as follows:

1) Develop an ITS Cabinet Standard V2 assessing issues and integrating lessons learned from current deployments of the ITS Cabinet Standard into a Concept of Operation, requirements and design. User needs to be considered, but are not limited to: low-power features, items referred to as "B-List" items by the ITS Cabinet WG, and mercury relay replacement. These items along with all others solicited will be introduced into the Systems Engineering Process (see objective #2) to examine their relevancy.

2) Use a systems engineering process to ensure the completeness and correctness of ITS Cabinet Standard V2 and associated documents. The standard must be traceable and logically consistent.

3) Develop a detailed conformance statement that addresses backwards compatibility and provides clear and unambiguous instruction on how to extend the standard.
3 REFERENCED DOCUMENTS


"ATC Controller Standard Revision v5.2b," ATC JC, 26 June 2006. Available from the Institute of Transportation Engineers.


4 CONCEPT OF OPERATIONS

4.1 User-Oriented Operational Description

The focus of this StdRS and resulting standard is on supporting applications related to traffic management. Specifically, user needs for managing vehicle right-of-way at signalized intersections (also known as intersection control), roadway accessibility via ramp metering (also known as ramp metering), and traffic data collection are identified (see Figure 1). While a TFCS may be used in support of other ITS applications such as automated toll collection, dynamic message sign control and others, the user needs for these applications are not specifically identified herein.

The TFCS can either be the primary field system of a transportation agency or it can be a subsystem of other applications that are the responsibility of other agencies. The TFCS is not a complete solution for any application but a standardized hardware platform/housing that can be used for applications that require field equipment. To be a complete solution, the applications’ operational software must be specified and the appropriate hardware configuration of the TFCS identified.

There are various field architectures for performing traffic management. The TFCSs may operate as:

1) A standalone system at a single field location (e.g. single intersection, ramp meter or road side (for data collection));
2) Under the direct "supervisory control" of a central system;
3) Under the supervisory control of another TFCS (e.g. in a closed-loop system or second TFCS acting as a slave to another TFCS for a large scale intersection application); or
4) Some combination of the first three (see Figure 2).

The term "supervisory control," as used here, implies messages typical of any distributed control system including configuration messages, control messages, status messages, historical reports, and files.

Standalone TFCSs are used when an agency does not use a central system, the location does not have the appropriate communications infrastructure available, or it is simply determined that a supervisory capability for the TFCS at the location is not necessary. When a TFCS is a part of a central system, the TFCS is connected directly or indirectly (routed through other systems or infrastructures) to the central system through a communications infrastructure (e.g. fiber optic, copper, leased lines, dial-up phone lines, etc.). The central system may have intermittent, periodic or sometimes continuous communications with the TFCSs in the field.

When a TFCS is a part of a closed-loop system, the TFCS is connected directly or indirectly to one or more TFCSs through a communications infrastructure. A field management station application program in the supervisory TFCS provides intermittent, periodic or continuous communications with the connected TFCSs. Hybrid field architectures are often found when an agency combines previously standalone and closed-loop systems together under the same supervisory central system.
The users of a TFCS can vary from agency to agency. Small cities or towns without formal transportation departments may consider only supervisory personnel at a remote office as the users of the TFCS. Large cities may have permanent staff that install, configure, monitor and maintain the TFCS and will consider all of their personnel that interact with the cabinet in the field as users (see Figure 3). For the purposes of this StdRS, the users of the TFCS are listed below. It should be noted that motorists and pedestrians are considered beneficiaries of the TFCS, not users.

- **Traffic Maintenance Technicians** – These individuals are required to troubleshoot and repair TFCS failures through wiring replacement, component replacement, or subassembly replacement. They may be trained by the agency or participate in International Municipal Signal Association (IMSA) courses for certification in the maintenance and repair of traffic management devices.

- **Traffic Operations Engineers and Staff** – These individuals are responsible for specifying the TFCS and its internal configuration (subassemblies) based on standardized components and assemblies. They create the procurement documents, the field wiring documents, and physical intersection design.
• Traffic Engineers / Transportation Supervisors – These individuals have knowledge of traffic control policies and practices. They establish the processes and procedures for the use of on-street equipment and central systems. They typically understand how to program and configure on-street traffic control equipment although they may not perform this task operationally. They are responsible for the overall performance of the traffic management infrastructure. They are the end user of the TFCS.

• Communications Engineers – These individuals understand computer based communications systems, networking, wired and wireless connectivity, peer-to-peer and central-to-field communications, etc. They are also responsible for IT policies, network performance, network security and troubleshooting communications issues.

• Law Enforcement Personnel – These individuals use the TFCS to assist in the localized management of emergencies and special events. They typically have limited access to the cabinet subsystems and assemblies and only have the ability to enable, disable, and apply limited local control at the cabinet. This usually means being able to place the TFCS into a flashing operation or manually changing the states of the field outputs (e.g. traffic signals changing Green-Yellow-Red).

Figure 3. TFCS operational users can be field personnel or remote users via other systems (central systems).

4.2 System Overview

The TFCS logical architecture including the system data flows for traffic management applications and the system boundaries are illustrated in Figure 4. This is not intended to be a design but more of a structure for describing the user needs (Section 6) in terms of the functional elements of the TFCS. The functional elements from Figure 4 are described below.

• Field Inputs – This functional element provides for interfaces to the most common vehicle and pedestrian detection technologies in use today including inductive loops, video image processing,
microwave radar, pedestrian detection, magnetometers, acoustic, piezoelectric, optical, and others. This may also include sensing of more specialized operations such as railroad crossings and vehicle preemption/priority requests. The detection technology employed may have various means of bringing the raw sensor data into the TFCS. The raw sensor information is converted to standardized messages (field input data) and sent to the Application Computer for interpretation by an operational program.

- Application Computer – This functional element provides for a field computer which executes the operational programs of the TFCS. For traffic management applications, the Application Computer must accept field input data and execute appropriate changes to the field outputs. It must communicate with the Cabinet Monitoring functional element in a manner that supports the monitoring of the cabinet functions for pre-determined error conditions. Operational programs may also require status information from the Cabinet Monitoring functional element. The Application computer also communicates with systems external to the TFCS via the External Communications functional element.

- Field Outputs – This functional element provides for interfaces to the most common display technologies in use today including incandescent bulbs and light emitting diodes (LEDs). The application computer must be able to access the field output circuits to cause the appropriate changes of state to meet the functional needs of the application. The Field Outputs will switch power to the Traffic Management Displays or other devices accordingly.

- Cabinet Monitoring – This functional element provides a means in which to insure that the TFCS is operating properly. It validates that power levels are within tolerances and the TFCS internal communications are properly taking place. It also validates that the field output data and electrical outputs (e.g. voltages and current) to the various field displays are consistent. It may also be expected to verify minimum timing requirements for the Traffic Management Displays where appropriate. The Cabinet Monitoring functional element can put the TFCS into a flashing operation or other fault condition should an anomaly occur.

- Power Filtering and Distribution – This functional element provides reliable and appropriate power to the devices and subassemblies contained in the TFCS. It also explicitly provides power to the Cabinet Monitoring functional element so that the power levels can be assessed.

- System Reporting – This functional element provides external reports of various forms representative of the assessment of the Cabinet Monitoring functional element.

- External Communications – This functional element provides for communications outside the TFCS using remote field communication technologies (e.g. fiber optic, copper, leased lines, dial-up phone lines, etc.). This external communications capability may be used in support of a secondary TFCS, a closed-loop system or a central system. The External Communications functional element via standardized TFCS internal messages. They are then converted to the appropriate field communication technology.

- Housing (not shown in Figure 4) – This functional element includes the cabinet housing, cabinet finish, doors, latches/locks, hinges and door catches, gasketing, ventilation, assembly supports and mounting.

- Internal Communications (not shown in Figure 4) – This functional element provides for the internal communications between the other functional elements of the TFCS (except Housing).
4.3 User Needs

This section identifies the user needs for the TFCS. Each user need is listed separately with a paragraph number. The rationale behind the need is included. Not all user needs will actually be addressed by every TFCS configuration. Conditions or constraints in such circumstances will be found in the subsequent requirements for the need. The TFCS requirements and design will be based on these needs and included in the subsequent standard based upon this StdRS.
The user needs are listed in the following categories: General, Field Inputs, Application Computer, Field Outputs, Cabinet Monitoring, Power Filtering and Distribution, System Reporting, External Communications, Housing and Internal Communications.

4.3.1 General

This section identifies the user needs that apply across all of the functional elements of the TFCS.

4.3.1.1 Open Architecture

The user needs the TFCS to be specified as an open architecture. This is an open standard for the TFCS and any manufacturer/developer should be able to build products for this system.

4.3.1.2 Modular

The user needs a TFCS that has a modular internal structure. Modular means having an internal structure such that there is separation in the functions of its subsystems and assemblies and flexibility in the way they are combined. Modularity reduces time to configure a system, reduces time in the field to maintain the system, it increases the utility of the system and increases testability of the system.

4.3.1.3 Scalable

The user needs the TFCS to be scalable. Scalable means that it can be deployed as a solution to a range of user applications. There are applications of the TFCS that range from small central business district applications to large arterial intersections.

4.3.1.4 Expandability

The user needs the TFCS to be expandable. Expandable means that it can be deployed as a solution for an application and if the application later requires more capability, it can be readily accommodated. An example would be load switches or detection devices that are added to a TFCS when a lane or signal head is added to a field location.

4.3.1.5 Extensibility

The user needs the TFCS to be extensible. Extensible means that the system is designed to allow extensions to the aspects of the system such as interfaces defined by the standard to accommodate local needs. The standard will define interfaces for the internal assemblies. Users may want to define additional capabilities (e.g. additional diagnostic messages). The standard will be created to make this a manageable process.

4.3.1.6 Space Efficient

The user needs the TFCS to be space efficient. Physical space externally and internally is a concern to many users. Space efficiency allows users the choices of using a smaller cabinet enclosure, gaining space for internal expansion, or for higher density internal devices.

4.3.1.7 Reliable and Continuous Operation

The user needs the TFCS to be designed for reliable and continuous operation without user intervention. The TFCS will perform traffic management operations at signalized intersections where any downtime is considered a safety concern. In other applications, such as ramp metering and traffic monitoring, downtime has a negative effect on traffic flow, data collection and traveler information systems. The
TFCS will be deployed at field locations and along roadsides where it could be hours before a technician can correct a failed component. This need does not exclude temporary system down time for periodic planned maintenance or the occasional replacement of failed components.

4.3.1.8 Operational Life

The user needs the TFCS to be designed so that it has a long operational life. Replacement life cycles for large scale TFCS deployments can take 7-10 years (many times longer) to achieve. An operational life of at least 10 years is important for TFCS deployments.

4.3.1.9 Quality Construction

The user needs the TFCS to be constructed using quality standards for workmanship, electronic design and manufacturing. Adherence to applicable standards such as those from the American Welding Society and the IPC-Association Connecting Electronics Industries is important to developing a system that will reliably provide the continuous operation of the system.

4.3.1.10 Extreme Temperatures and Humidity

The user needs the TFCS to operate under extreme hot, cold and humid environmental conditions. The TFCS must operate year round in the diverse climates of North America including the extremes of Alaska, central Arizona and the areas surrounding the Gulf of Mexico.

4.3.1.11 Limit Electronic Emissions

The user needs the TFCS to have limited electronic emissions that cause radio frequency interference (RFI) and electromagnetic interference (EMI). RFI must be limited as to not interference with radios and cell phones in the vicinity of the cabinet. EMI must be limited to avoid interference with the operation of electronic components used within the TFCS.

4.3.1.12 Susceptibility to Electronic Interference

The user needs the TFCS to be designed to limit the susceptibility to electronic interference external to the TFCS. There are many sources of electronic interference, e.g. cell phones, which will be in the proximity of the system. Any susceptibility the TFCS has to these sources could have a detrimental impact on the continuous operation of the system.

4.3.1.13 Limit Audible Noise

The user needs the TFCS to have limited audible noise. TFCSs will be deployed in suburban areas sensitive to ambient sound.

4.3.1.14 Withstand Vibration and Shock

The user needs the TFCS to withstand vibration and shock. This would include common roadside and bridge vibrations due to vehicle traffic. This need also includes the vibration and shock of occasional events such as common carrier shipping, earthquakes, roadwork, etc.
4.3.1.15 Quick Transfer of Configuration and Application Information

The user needs the TFCS to provide a means to quickly transfer cabinet and application data from an external computer to a TFCS or from one TFCS to another. The mechanism must be able to be left in the cabinet, store the most updated cabinet information, and be used to transfer this information to a replacement cabinet in case of a "knock down."

4.3.1.16 User Safety

The user needs the TFCS to be safe for use by field personnel. This safety need includes electrical safety where users are protected from high voltage wiring, arc flash hazards, and physical safety from sharp edges and falling objects.

4.3.1.17 Adherence to the National Electrical Code

The user needs the TFCS to follow best practices for the safe installation for electrical wiring and equipment as established by the National Electrical Code (NEC). TFCSs are deployed near public and private buildings and structures and in public walkways. They need to be electrically safe. [THIS USER NEED IS BEING RESEARCHED BY A SUBGROUP OF THE ITS CABINET WORKING GROUP FOR THE APPLICABILITY OF UL508 REFERENCES]

4.3.1.18 Energy Efficient

The user needs the TFCS to be energy efficient. The goal is to minimize the average power consumption of the cabinet and its components. Agencies are concerned with greenhouse gases and energy costs.

4.3.1.19 No Components Containing Liquid Mercury

The user needs the TFCS to be designed so that no components containing liquid mercury are used in the cabinet. Liquid mercury components are considered an environmental hazard and are in the process of being prohibited across the United States.

4.3.1.20 Previously Deployed ITS Cabinets

The user needs the TFCS design to support the use of subassemblies and devices defined by Version 2 to be usable in cabinets compliant to ITS Cabinet Standard Version 1. A number of version 1 cabinets will still be in use by agencies and they would like to be able to put subassemblies and devices compliant to Version 2 to be usable in the Version 1 compliant cabinets.

4.3.1.21 Diagnostic Testing

The user needs the TFCS to be designed to provide diagnostic testing. This includes the TFCS as a whole, its subsystems and components. Users must be able to easily confirm proper operation and identify failed components.

4.3.1.22 Electrostatic Discharge Resistant

The user needs the TFCS to be resistant to electrostatic discharge (ESD). It is common for there to be ESD when maintenance personnel interact with the TFCS. The TFCS needs to be designed to dissipate ESD to avoid damaging electronic components.
4.3.1.23 Minimize Time for Maintenance Personnel

The user needs the TFCS to be of a design that reduces the time required for maintenance personnel to perform maintenance actions in the field. When a TFCS is being repaired there can be a safety hazard for both the motorist and the field maintenance personnel. The TFCS must be designed for quick diagnostics, component switch out, and TFCS expansion.

4.3.2 Field Inputs

This section identifies the user needs of the TFCS related to the Field Inputs functional element.

4.3.2.1 Commonly Deployed Field Sensors

The user needs the TFCS to support the use of commonly deployed field sensors (external to the cabinet). These field sensors include inductive loops, pedestrian detectors, vehicle pre-emption devices, transit priority devices, as well as a wide variety of vehicle detection and monitoring devices. This need stems from the desire to extend the use of existing infrastructure.

4.3.2.2 Commonly Deployed Field Input Devices

The user needs the TFCS to support the use of commonly deployed field input devices (internal to the cabinet). This includes detector sensor units, emergency vehicle interface, AC and DC isolators and other input file compatible devices. This need stems from the desire to extend the use of existing inventory.

4.3.2.3 High Density Input Devices

The user needs the TFCS to support input devices that are higher density than commonly deployed field input devices. This need supports the long term trend in the industry to create higher density devices, which can have advantages in reliability or reduce the size of the cabinet needed to support a specific set of input devices.

4.3.3 Application Computer

This section identifies the user needs of the TFCS related to the Application Computer functional element.

4.3.3.1 Application Computer Interface

The user needs the TFCS to have an application computer that supports the cabinet interfaces defined in this standard. The ITS Cabinet V2 Standard will provide only the definition of the interface between the cabinet and the application computer. Application computers are defined in their own standards. These interfaces provide a universal interface to the field inputs, the field outputs and the cabinet monitoring functional elements of the TFCS.

4.3.3.2 Intersection Control Applications

The user needs the TFCS to have configurations suitable for intersection control applications. This is also known as the management of vehicle right-of-way at signalized intersections. Included in this application area are railroad preemption, emergency vehicle preemption and signal priority. This has been identified as one of major application areas of the TFCS.
4.3.3  Ramp Metering Applications

The user needs the TFCS to have configurations suitable for ramp metering applications. Ramp metering manages vehicle access to highways via the use of control devices such as traffic signals, signing, and gates to regulate the number of vehicles entering or leaving the highway in order to achieve operational objectives. This has been identified as one of major application areas of the TFCS.

4.3.3.4  Data Collection Applications

The user needs the TFCS to have configurations suitable for roadside data collection applications. Data collection is needed to produce information used by suppliers of transportation services to improve operational, planning, and investment decisions; and by consumers of these services to improve their travel choice. This has been identified as one of major application areas of the TFCS.

4.3.4  Field Outputs

This section identifies the user needs of the TFCS related to Field Output functional element.

4.3.4.1  Commonly Deployed Field Output Devices

The user needs the TFCS to support the use of commonly used traffic output devices. Specifically, switch packs, flashers, transfer relays, and traffic signal displays. This need stems from the desire to extend the use of existing inventory.

4.3.4.2  High Density Output Devices

The user needs the TFCS to support the use of output devices that are higher density than the commonly used output devices. This need supports the long term trend in the industry to create higher density devices, which can have advantages in reliability or reduce the size of the cabinet needed to support a specific set of output devices.

4.3.4.3  Field Displays

The user needs the TFCS to support the use of commonly used field displays. Specifically, signal heads and pedestrian signs. This need stems from the desire to extend the use of existing inventory.

4.3.4.4  Electrically Safe Field Outputs

The user needs the TFCS to provide operational outputs that are electrically safe. This provides protection in case of a signal knock down during a storm or traffic accident. The intent is to have voltage and current levels below those which are dangerous to humans.

4.3.4.5  Fault Operation

The user needs the TFCS to support configurable continued operation based on the specifics of the component/circuit failures. For example, in the event of a single short circuit in the field wiring supplying the operating voltage to a field display, it may be desirable to continue “normal operation” on the remaining circuits as preferable to traditional flashing operation.
4.3.5 TFCS Monitoring

This section identifies the user needs of the TFCS related to the Monitoring functional element.

4.3.5.1 TFCS Status

The user needs the TFCS to provide a status monitoring capability. This includes monitoring of door status, UPS status, law enforcement personnel controls, and cabinet temperature devices. The center that remotely manages the TFCS as well as the field maintenance personnel want to see the operational status of the cabinet.

4.3.5.2 Field Output Monitoring

The user needs the TFCS to provide a configurable field output monitoring capability. This includes independent monitoring of each field output voltage and current level. At a minimum, this needs to be at a level of capability described in Section 4 of the NEMA TS2 Standard (see Section 3 Referenced Documents). In order to identify and to react to potentially unsafe conditions, the TFCS must be able to detect when an unsafe conditions exists.

4.3.5.3 Field Display Monitoring

The user needs the TFCS to provide a configurable capability to independently monitor each field display to ensure that the actual state of the field display matches the state of its corresponding application computer output, and indicates an anomaly when they do not match. This provides confirmation that signal heads and other field displays (e.g. “prepare to stop” and “stopped traffic ahead”) at intersections and/or ramp meters will be as commanded, otherwise the TFCS will be placed in a benign state.

4.3.5.4 Internal Communications Monitoring

The user needs the TFCS to monitor internal communications. This monitoring is to detect improper operations of the internal communications.

4.3.5.5 User Interface

The user needs the TFCS to provide a display for the maintenance personnel to view the malfunction, anomaly, or status information. Some of the assemblies typically put into the TFCS do not have any display of their outputs and this need would correct that condition.

4.3.5.6 Response to Malfunction or Anomaly

The user needs the TFCS to be capable of a configurable response to each malfunction or anomaly detected as part of system monitoring. The monitoring capability allows the center or field personnel to detect malfunctions or anomalies within the TFCS. It is important for the TFCS to provide the most appropriate action in response to each malfunction or anomaly that is detected.

4.3.5.7 Configuration of Monitoring

The user needs the TFCS to have a configurable monitoring capability. The different types of monitoring described in this section should in general be configurable so that the definition of a malfunction or anomaly can be defined by the system user.
4.3.5.8 Controlled Access to Monitoring Configuration Information

The user needs the TFCS to have a means to control access to the monitoring configuration information. The TFCS has needs relating to a monitoring capability. Creating this capability will mean that a set of monitoring configuration parameters must be defined. These parameters must identify what constitutes a malfunction or anomaly and define what response or action will be taken. It is important that there be controlled access to this monitoring configuration information either remotely or locally.

4.3.6 Power Filtering and Distribution

This section identifies the user needs of the TFCS related to the Power Filtering and Distribution functional element.

4.3.6.1 Service Power

The user needs the TFCS to operate with a variety of service power. Service power is usually provided by a utility and in North America is universally 120 VAC. There are a variety of alternate power sources that may include DC or low voltage AC.

4.3.6.2 Clean Power Distributed

The user needs the TFCS to distribute clean power within the cabinet, i.e. power that is protected against surges and spikes and is filtered to regulate electrical noise. The sensitive electronic equipment within the cabinet requires clean power (that is isolated from the raw power used for external devices) so that the equipment is not damaged.

4.3.6.3 Raw Power Distributed

The user needs the TFCS to distribute raw power externally to field displays. Raw power must be protected against surges and spikes but it is not necessary to regulate for electrical noise. The TFCS provides power to external field displays and raw power is used for this. The raw power is also used to power some of internal equipment such as fans, lights, and service outlet.

4.3.6.4 Power Conversion

The user needs the TFCS to convert power for use by internal devices. The assemblies internal to the TFCS require either AC or DC power to operate. The cabinet must provide power to these assemblies, which include traffic control devices, routers, switches, and modems.

4.3.6.5 Backup Power Provisions

The user needs the TFCS to provide a method for continued operations when there are service power interruptions. There are various backup power methods available. This is not intended to select a method but provide an electrical interface or interfaces specifically for this purpose. The need for continuous operations coupled with the real possibility of service power interruptions provides the reason for this need.

4.3.7 System Reporting

This section identifies the user needs of the TFCS related to the System Reporting functional element.
4.3.7.1 System Reports

The user needs the TFCS to provide system reports and logs that include the output of system monitoring. *System reports include diagnostic reports on malfunctions and anomalies for the field inputs, the field outputs, cabinet monitoring, application computer, and internal TFCS communications. This reporting is key not only to real time diagnostics, but to historical analysis of data.*

4.3.7.2 System Reporting Distribution

The user needs the TFCS to be capable of providing system reports locally or to remote system using a standardized interface and protocol. *Currently, most system reporting is achieved by direct proprietary connection to the TFCS via a laptop computer. This need is for reporting through both a local and external interface.*

4.3.7.3 Non-Volatile Information

The user needs the TFCS to have a non-volatile method of maintaining the system reports and logs. *This capability is needed so that a TFCS can quickly be restored to operational conditions when a replacement system is required.*

4.3.8 External Communications

This section identifies the user needs of the TFCS related to the External Communications functional element.

4.3.8.1 External Communications Capability

The user needs the TFCS to accommodate a variety of communications equipment and media for communications external to the system. *External communications relates to communications with field devices as well as communications with other TFCS, or with remote centers. Some of the types of communications that must be supported are serial communications, telephone-based communications, networked communications, and wireless communications. The capability to provide wireless communications also includes the mounting of the wireless antenna to the cabinet.*

4.3.8.2 Standardize External Interfaces

The user needs the TFCS to provide standardized external interfaces and protocols. *This includes mountings and connectors so that limited customization or modification of the cabinet is required.*

4.3.9 Housing

This section identifies the user needs of the TFCS related to the Housing functional element.

4.3.9.1 External Mounting

The user needs the TFCS to have mounting capabilities which accommodate existing transportation industry base, pedestal, and pole mountings. *This will allow installation of a new cabinet or replacing a cabinet at locations with existing mounts.*

4.3.9.2 Corrosion Resistant Material

The user needs the TFCS structure to be made of materials that are resistant to rust and corrosion. *The cabinet is in harsh weather conditions subject to corrosion.*
4.3.9.3 Cabinet Access

The user needs the TFCS to include one or more doors to support easy user access to subsystems and assemblies. This includes the associated door latches, hinges and door catches. Note that this may include front doors, rear doors, side doors, and special compartment doors depending on the final design and equipment located within the cabinet. The doors are needed so that maintenance personnel can access assemblies inside the cabinet.

4.3.9.4 Physical Environment

The user needs the TFCS to protect its subsystems and assemblies from heat, wind, snow, dust and rain. This includes adequate ventilation, water drainage away from the cabinet structure, and structural strength to withstand severe weather conditions.

4.3.9.5 Animal and Insect Resistant

The user needs the TFCS to protect its subsystems and assemblies from small animals and insects. Rodents are known to seek shelter in field cabinet systems and can damage electrical components and wiring.

4.3.9.6 Vandalism and Theft Resistant

The user needs the TFCS to be resistant to vandalism or theft. Much of the TFCS is recyclable and can be a target for thieves or those who simply wish to damage public property. Some of the equipment might be taken for use in another system.

4.3.9.7 Graffiti Resistant

The user needs the TFCS to have an external finish that is resistant to graffiti and bill posting. Field cabinets are often a target for those wishing to make public statements and those who simply wish to deface public property.

4.3.9.8 Video Monitor Provision

The user needs the TFCS to provide space and electrical connections for a small video monitor. Monitors are commonly used for maintenance with TFCS deployments that use video detection field inputs.

4.3.9.9 Battery Housing Provision

The user needs the TFCS to provide internal space for housing batteries commonly used to provide backup power. Deployers currently attach battery housings to the external housing of the cabinet in a variety of manners.

4.3.9.10 Law Enforcement Personnel Access

The user needs the TFCS to provide law enforcement personnel limited access to the TFCS to the extent necessary for direct intersection control while restricting access to the remainder of the cabinet. This is to allow law enforcement personnel intersection control for emergencies and special events.
4.3.9.11 Limited Enclosure Access

The user needs the TFCS to provide limited enclosure access to the TFCS for other personnel. These personnel could include communications contractors. In some locations there is equipment in the cabinet operated by other personnel and they need to access their equipment.

4.3.10 Internal Communications

This section identifies the user needs of the TFCS related to the Internal Communications functional element.

4.3.10.1 Internal Communications Capability

The user needs the TFCS to have an internal communications capability that can be used to communicate between its subsystems and assemblies. The communications are used operationally and for monitoring and reporting purposes.

4.3.10.2 Standardized Interfaces

The user needs the TFCS to provide standardized internal interfaces and protocols. Standardized internal interfaces increases configuration flexibility and facilitates maintenance.

4.4 Operational Environment

The specific operational environment will vary from agency to agency. The general operational personnel are described in Section 5. The physical environment for a TFCS includes that of any city in the United States. This means there are radical differences in weather conditions, existing transportation infrastructures, types and quality of external communications, and quality of power.

4.5 Support Environment

The support personnel are some the users of the system and are already been listed in Section 5. In addition to those listed there are installers. These are typically contractors who perform who perform electrical wiring of the intersection according to plans. They are used during initial TFCS installations or upgrades to the intersection’s electrical systems. They understand the electrical code and safe practices for high voltage systems.

4.6 Operational Scenarios

There are no special operational scenarios for this StdRS.
5 REQUIREMENTS

The TFCS requirements in this section were derived from the needs identified in Section 4 (ConOps).

Requirements must be testable. Good requirements will generally take the form: [Actor] [Action] [Target] [Constraint] [Localization]. The localization and constraint portions are important, but not all requirements will have both. The constraint identifies how you will measure success or failure of the requirement. The localization identifies the circumstances under which the requirement applies.

The TFCS functional architecture is illustrated in Figure 5. This diagram provides the relationship the TFCS logical architecture illustrated in Figure 4 and a physical architecture where the logical elements are grouped together into likely physical subassemblies (long horizontal blocks). The matching colors illustrate the logical-physical connections between the functional elements and physical subassemblies. The requirements for the TFCS are organized accordingly as described below.

- General – These requirements apply across multiple TFCS functional areas.
- Housing – These requirements apply to the TFCS cabinet housing.
- Application Computer – These requirements are applicable to the field computer which executes the operational programs of the TFCS.
- Field Input – These requirements apply to vehicle and pedestrian detector technologies.
- Field Output – These requirements apply to interfaces to LED and incandescent field display technologies.
- Conflict Monitoring – These requirements address the need to monitor the TFCS operation for proper operation and to respond appropriately to unsafe conditions.
- Diagnostic and Status Monitoring – These requirements address the need for more direct diagnostic and monitoring capability.
- Power – These requirements address the need for reliable and appropriate power to the devices and subassemblies contained in the TFCS.
- Internal Cabinet and External Cabinet Communications – These requirements address standard interfaces and protocols for all TFCS communications.

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Figure 5. Functional Architecture Diagram
5.1 General

5.1.1 General Characteristics

The requirements on the general characteristics of the TFCS are as follows:

5.1.1.1 No Patents or Copyrights

The TFCS's assemblies and subsystems shall not be protected by trademark or patent or copyright.

5.1.1.2 Commonly-Available Components

The TFCS’s interfaces shall use standardized and commonly-available electrical and mechanical components.

5.1.1.3 19-Inch Rack

The TFCS shall utilize an EIA industry standard 19 inch rack for its subsystems and assemblies.

5.1.1.4 Well-Defined Modules

The TFCS subsystems shall contain modules with well-defined sizes and connectorization.

5.1.1.5 Hot-Swappable

The TFCS modules shall be hot-swappable without the use of tools.

5.1.1.6 Future Upgrades

The TFCS shall be designed to facilitate future upgrades to individual subsystems.

5.1.1.7 Future Subsystems

The TFCS design shall accommodate the incorporation of future, enhanced subsystems without forcing the obsolescence of existing subsystems.

5.1.1.8 Well-Defined Subsystems

The TFCS shall have well-defined subsystems for each functional element.

5.1.1.9 Subsystem Quantities

The TFCS design shall facilitate deployment of a predefined minimum and maximum number of each subsystem, with said minimum and maximum to be defined independently for each subsystem.

5.1.1.10 Module Quantities

The TFCS subsystems which contain functional modules shall be internally scalable between minimum and maximum module capacities, as defined by each subsystem, with no impact on the overall operation of the TFCS.
5.1.1.11 Subsystems Not Interdependent

The TFCS subsystems (except those related to safety or safety-related monitoring) shall not be interdependent (absence of or changes to one subsystem shall not cause a malfunction in another subsystem).

5.1.1.12 No Specific Locations

The TFCS design shall not require individual subsystems to occupy specific locations within the internal cabinet structure.

5.1.1.13 Continuous Operation

The TFCS subassemblies and modules shall be designed for continuous operation.

5.1.1.14 MTBF

The TFCS subassemblies and modules shall have a designed MTBF of no less than 200 years/failure (assuming a 10-year design life and a 5% failure rate).

5.1.1.15 Design Life

The TFCS subassemblies and modules shall have at least a 10-year design life under continuous operation.

5.1.1.16 Derating

All components used by the modules and subassemblies within the TFCS shall not be operated at greater than 80% of their rated values, unless permitted by exception.

5.1.1.17 Quality of Construction

The TFCS shall meet the following TBD quality standards.
(various quality standards, or subsets/extracts therein, to be referenced here)

5.1.1.18 Electronic Emissions

The TFCS shall meet the following TBD electronic emissions requirements.
(relevant IEC standard is 61000-4-3)
(prepare simpler test to address this need)

5.1.1.19 Susceptibility to Electronic Emissions

The TFCS shall meet the following TBD requirements regarding its susceptibility to electronic emissions.
(relevant IEC standard is 61000-4-3)
(prepare simpler test to address this need)
5.1.1.20 Electronic Discharge

The TFCS shall meet the following TBD requirements regarding resistance to electronic discharge.

(relevant IEC standard is 61000-4-2)
(prepare simpler test to address this need)

5.1.2 Environmental

The environmental requirements on the TFCS are as follows:

5.1.2.1 Operating Temperature Range

The TFCS operating ambient temperature range shall be from -37 degreesC to +74 degreesC.

5.1.2.2 Storage Temperature Range

The TFCS storage temperature range shall be from -45 degreesC to +85 degreesC.

5.1.2.3 Noise Level

The TFCS shall have no component, module or subassembly that emits an audible noise level exceeding a peak level of 55 dBA (all doors open) when measured at a distance of one meter away from its surface, except as otherwise noted. No item, component or subassembly shall emit a noise level sufficient to interfere with processing and communication functions of the controller circuits.

5.1.2.4 Shock

The TFCS shall be designed to withstand a shock of 10g (+/-1g).

5.1.2.5 Vibration

The TFCS shall be designed to withstand a vibration of 0.5 g with a frequency of 5 Hz to 30 Hz. applied in each of three mutually perpendicular planes.

5.1.2.6 Relative Humidity

The TFCS shall operate with a relative humidity of up to 95 percent non-condensing over the temperature range of -37 degreesC to +74 degreesC.

5.1.3 Mechanical

The mechanical requirements on the TFCS are as follows:

5.1.3.1 No Sharp Edges

The TFCS shall have all sharp edges and corners rounded and free of burrs.

5.1.4 Electrical

The requirements relating to electrical, power, and memory are as follows:
5.1.4.1 NEC Compliance

The TFCS shall fully support all relevant sections of the NEC, specifically those related to wire sizing and ampacity.

5.1.4.2 Power Factor

The TFCS shall maintain an overall power factor (PF) of 0.8 or greater, as measured at the service entry, when operating from AC power. The Application Computer shall not be included in this requirement and shall be isolated from the TFCS AC supply for any such measurement.

5.1.4.3 Power Supply Efficiency

Power supplies within the TFCS shall be designed to operate with an average efficiency of 80% or greater under expected loading. The Application Computer shall not be included in this requirement.

5.1.4.4 Solid-State Contactor

The TFCS shall fully support the use of a solid-state version of the traditional mercury contactor used for primary signal power.

5.1.4.5 No Liquid Mercury

The TFCS shall contain no components that use liquid mercury.

5.1.4.6 Insulating Devices

The TFCS shall contain insulating devices which protect technicians from accidentally coming into contact with hazardous voltages within the cabinet.

5.1.4.7 Cabinet Configuration

The TFCS shall contain a non-volatile memory device which contains cabinet configuration information data. This device shall have an interface, both hardware and protocol, which permits it’s access via the cabinet’s internal communication bus.

5.2 Housing

5.2.1 ITS V1 Cabinet Housings

The TFCS shall be available in Cabinet Housings 1, 2 and 3 as specified in the ITS Cabinet V1 Standard.

5.2.2 Small Size Cabinet

The TFCS shall be available in a small-size cabinet (SSC) for use in central business district (CBD) applications. The SSC shall support pole mounting and have a single front door.

5.2.3 Corrosion Resistant

The TFCS shall be constructed of materials that are inherently corrosion resistant or have been treated so as to be corrosion resistant.
5.2.4 Aluminum Sheet

Aluminum sheets used in the construction of the TFCS shall be Type 3003-H14 or Type 5052-H32 ASTM Designation B209 aluminum alloy.

5.2.5 Aluminum Sheet Plating

Aluminum sheeting used in the construction of the TFCS internal subassemblies shall treated using clear chromate conversion per MIL-C-5541, Class 3.

5.2.6 Stainless Steel Sheet

Stainless steel sheets used in the construction of the TFCS shall be annealed or one-quarter-hard complying with ASTM Designation A666 for Type 304, Grades A or B, stainless steel sheet.

5.2.7 Cold Rolled Steel

Cold rolled steel sheet, rod, bar and extruded used in the construction of the TFCS shall be Type 1018/1020.

5.2.8 Cold Rolled Steel Plating

Cold rolled steel used in the construction of the TFCS shall be plated using either cadmium plating meeting the requirements of Federal Specification QQ-P-416C, Type 2 Class I or zinc plating meeting the requirements of ASTM B633-85 Type II SC4.

5.2.9 Stainless Steel Hardware

All bolts, nuts, washers, screws, hinges and hinge pins used in the construction of the TFCS shall be stainless steel unless otherwise specified.

5.2.10 Doors

The TFCS cabinet designs shall include door(s) with appropriate door frames, seals, gaskets, strikers and three-point locking mechanisms.

5.2.11 Ventilation

The TFCS cabinet housings shall be designed with thermostatic ventilation in the event that the internal cabinet temperature exceeds the pre-programmed temperature. Incoming air shall be filtered.

5.2.12 Cabinet Thickness

The TFCS cabinet housing shall be fabricated of 0.125 inch minimum thickness aluminum sheet.

5.2.13 Rodent Resistant

The TFCS cabinet housings shall be designed to reduce or eliminate any openings which might permit rodents or insects to enter the cabinet.
5.2.14 High Security Design

The TFCS shall support a high-security cabinet design which permits the usage of 3/16” sheet aluminum for the cabinet housing.

5.2.15 Cabinet Surface Preparation

The aluminum surface shall be cleaned, etched and rinsed. The cleaning and etching procedure shall be to immerse in inhabited alkaline cleaner at 71 degrees C for five minutes (Oakite 61A, Diversey 909 or equivalent in mix of the 6 to 8 ounces per gallon to distilled water). Rinse in cold water. Etch in a sodium solution at 66 degrees C for 5 minutes 90.5 ounce sodium fluoride plus 5 ounces of sodium hydroxide mix per gallon to distilled water. Rinse in cold water. Desmut in a 50% by volume nitric acid solution at 20 degrees C for 2 minutes. Rinse in cold water. Dry surfaces by preheating in an oven for 15 minutes at 400 degrees F. Remove and coat the surfaces using TCI Wheel Silver # 9811-0110 with a minimum film build of not more than 2 mils total thickness. Place back into preheated oven for 10 minutes minimum at 360 degrees F to gel the base coat. Remove and coat the surfaces using TCI Anti-graffiti Clear # 9810-0231. Place back into oven and fully cure at 380 degrees F for 40 minutes.

5.2.16 Video Monitor

The TFCS shall provide storage and electrical power for a small (handheld?) video monitor.

5.2.17 Backup Power Batteries

The TFCS design shall include a cabinet configuration that provides internal space for the housing of batteries used to provide backup power.

5.2.18 Law Enforcement Access

The TFCS shall provide protected access by law enforcement personnel to the following cabinet functions:

- Signals ON/OFF
- FLASH / AUTO operation
- Manual Control Enable (MCE)
- Interval Advance (IA)

5.2.19 External Antenna

The TFCS shall provide, for all types of cabinet housings, a standard method for the mounting of an external antenna.

5.2.20 Limited Enclosure Access

The TFCS requirements for limited enclosure access are TBD.
5.3 Application Computer

5.3.1 Application Computer Interfaces

The TFCS shall have one or more interfaces suitable for connection of an Application Computer into the internal cabinet communication architecture.

5.3.2 Application Computer Protocols

The TFCS Application Computer interface(s) shall have well-defined connectorization and protocol details.

5.3.3 Intersection Control Applications

The requirements for the TFCS for providing Intersection Control Applications are TBD.

5.3.4 Ramp Metering Applications

The requirements for the TFCS for providing Ramp Metering Applications are TBD.

5.3.5 Data Collection Applications

The requirements for the TFCS for providing Data Collection Applications are TBD.

5.4 Field Inputs

5.4.1 Commonly-Deployed Input Devices

The TFCS shall contain accept input from commonly-deployed field sensors, such as inductive loops, pedestrian detectors, transit priority and preemption devices.

5.4.2 Regular-Density Input File

The TFCS design shall include a regular-density input file capable of supporting current-technology two-channel detector modules, as well as all other commonly-deployed field input devices, in each standard-width slot.

5.4.3 Number of Regular-Density Inputs

The TFCS regular-density input file design shall include support for a minimum of 24 discrete inputs.

5.4.4 Specialty Detection Devices

The TFCS design shall include support for connection of specialty detection devices, such as video detection units, directly into the internal cabinet bus architecture without requiring the use of input file interface modules.
5.4.5 High-Density Input File

The TFCS design shall include a high-density input file capable of directly supporting current-technology four-channel detector modules (Type 242 or equivalent with half-width front panel) in each standard-width slot.

5.4.6 High-Density Input File in V1 Cabinet

The TFCS high-density input file and associated modules shall operate in existing ITS v1 cabinet bus architectures (DB25 TP BUS1/BUS2 and CAT5 BUS3 cabling).

5.4.7 Number of High-Density Inputs

The TFCS high-density input file design shall include support for a minimum of 48 discrete inputs.

5.4.8 High-Density Input File 2

The TFCS design shall also include support for high-density input devices in a combined input/output file subsystem. This subsystem will integrate a reduced number of high-density input and output modules into a single assembly for smaller cabinets and for application deployments which do not require large numbers of either inputs or outputs.

5.5 Field Outputs

5.5.1 Regular-Density Output File

The TFCS design shall include regular-density output files capable of supporting current-technology field output devices, such as single-channel switch packs and traditional traffic signal displays. As a minimum, output files supporting six and 14 output channels shall be available.

5.5.2 High-Density Output File

The TFCS design shall include high-density output files capable of supporting multi-channel output modules at a higher per-module density than the regular-density output files. A preliminary design goal should be a 2x increase in operational density. As a minimum, output files supporting 12 and 28 output channels shall be available.

5.5.3 High-Density Output File in V1 Cabinet

The TFCS high-density output file and associated modules shall operate in existing ITS v1 cabinet bus architectures (DB25 TP BUS1/BUS2 and CAT5 BUS3 cabling).

5.5.4 High-Density Output File 2

The TFCS design shall also include support for high-density output devices in a combined input/output file subsystem. This subsystem will integrate a reduced number of high-density input and output modules into a single assembly for smaller cabinets and for application deployments which do not require large numbers of either inputs or outputs.

5.5.5 Supported Field Display Devices

The TFCS shall support output subsystems capable of driving the following field display devices:

- low-power AC, LED signals (< 15W)
- low-power DC, LED signals (< 10W)
- medium-power AC, incandescent signals (< 130W total per output)

5.5.6 Low-Power DC Support

The TFCS shall support an internal configuration which operates using only low-power DC field outputs and displays.

5.5.7 Output Circuit Breakers

The TFCS design shall include circuit breakers or other similar protection devices for all field output circuits.

5.5.8 Channel-Programmable Flasher Outputs

The TFCS shall provide the means for selecting the specific flasher output used for each channel's display when in flashing operation.

5.5.9 Multi-Output Flasher Unit

The TFCS shall support a multi-output flasher unit of from two to eight channels.

5.6 Conflict Monitoring

5.6.1 Monitoring Subsystem

The TFCS shall contain a monitoring subsystem, consisting of (at least) the following elements:
- Conflict Monitor Unit (CMU)
- Monitoring and Diagnostic Bus (MDB)
- Diagnostic Display Unit (DDU)

5.6.2 Conflict Monitor Unit

The TFCS shall contain a programmable Conflict Monitor Unit (CMU) which is capable of detecting anomalous conditions in TFCS operation and taking the appropriate action per the pre-programmed configuration.

5.6.3 Monitor Programmed Field Output States

The TFCS CMU shall be capable of monitoring and comparing the field output states with the Application Computer programmed states and producing a unique response (or responses) in the event of a mismatch.

5.6.4 Monitor Actual Field Output States

The TFCS CMU shall be capable of monitoring and comparing active and inactive field output states and producing a response in the event of a conflict.
5.6.5 Monitor Field Output Interval Length

The TFCS CMU shall be capable of monitoring the length of selected field output intervals and producing a response in the event that the duration of one or more outputs is too short.

5.6.6 Monitor Field Output Voltages and Currents

The TFCS CMU shall be capable of monitoring field output voltages and currents and producing a response in the event that one or more outputs is out of range.

5.6.7 Channel Pair Permissive Programming

The TFCS CMU shall have channel pair permissive programming for the maximum number of field output channels available.

5.6.8 Voltage and Current Thresholds

The TFCS CMU shall have configurable thresholds for field output voltage and current monitoring.

5.6.9 Configurable Response

The TFCS CMU response (or responses) to each monitored condition shall be configurable.

5.6.10 Measure AC Voltage

The TFCS shall measure the RMS voltage of each AC field output to within +/- 2.0V.

5.6.11 Measure DC Voltage

The TFCS shall measure the voltage of each DC field output to within +/- 0.1V.

5.6.12 Voltage Measurement Interval

The TFCS shall measure the voltage of each field output at least 30 times per second.

5.6.13 Measure AC Current

The TFCS shall measure the RMS current of each field output to within +/- 0.005A.

5.6.14 Current Measurement Interval

The TFCS shall measure the current of each field output at least 30 times per second.

5.6.15 Independent Field Display Monitoring

The TFCS shall provide the capability, via the monitoring bus, to monitor field displays which are capable of verifying their display status independently from the output which drives it.
5.6.16 Communications Monitoring

The TFCS shall contain a module which monitors the integrity of all internal cabinet communication. The result of this monitoring shall be available via the monitoring bus.

5.6.17 Password-Protected Configuration

The TFCS will provide password-protected access to the monitoring configuration information.

5.7 Diagnostic and Status Monitoring

5.7.1 Diagnostic Display Unit Local Display

The TFCS shall contain a Diagnostic Display Unit (DDU) which supports local display of both historical and current cabinet status and log data collected by the monitoring subsystem.

5.7.2 Diagnostic Display Unit Remote Display

The TFCS shall contain a Diagnostic Display Unit (DDU) which supports remote reporting of both historical and current cabinet status and log data collected by the monitoring subsystem using a standardized interface and extensible protocol.

5.7.3 Diagnostic Display Unit Historical Data

The TFCS shall contain a Diagnostic Display Unit (DDU) which maintains historical cabinet status and log data in a non-volatile fashion.

5.7.4 Monitoring Bus

The TFCS shall contain a monitoring bus, separate from the primary internal cabinet communication bus, which provides a standardized hardware interface and protocol between cabinet devices which either report or retrieve/display cabinet status.

5.7.5 Specific Monitored Conditions

The TFCS shall provide the capability to monitor (at least) the following cabinet conditions and shall make this information available to reporting devices via the monitoring bus:

- door open status
- UPS status
- Signals ON/OFF
- FLASH / AUTO operation
- Manual Control Enable (MCE)
- Interval Advance (IA)
- cabinet temperature

5.7.6 Diagnostic Time Required

The TFCS design shall allow maintenance personnel to diagnose problems within the cabinet and to exchange defective subassemblies and modules in no more than five minutes.
5.8 Power

5.8.1 Nominal AC Input Voltage

The TFCS shall be capable of operating from a nominal voltage of 120VAC, 60Hz (+/- 3.0Hz).

5.8.2 Nominal DC Input Voltage 1

The TFCS shall support a configuration which operates from DC service power at 48VDC.

5.8.3 Nominal AC Input Voltage 2

The TFCS shall support a configuration which operates from DC service power at 12-24VDC, as might be provided by one or more solar panels.

5.8.4 Clean Power

The TFCS shall provide for the distribution of clean power (raw power with additional filtering to reduce electrical noise) within the cabinet.

5.8.5 Raw Power

The TFCS shall provide for the distribution of raw power (service power with devices to protect against power surges and spikes) within the cabinet.

5.8.6 Internal DC Power

The TFCS subsystems shall be designed to internally operate from a single DC power source at 24VDC. This power source may be one of the following:

- 120VAC-to-24VDC power supply
- 48VDC-to-24VDC power supply
- Direct 24VDC standby power source
- 24VDC solar power charging and storage system

5.8.7 Internal AC Inverter

Should the TFCS be operating from DC power only, an AC inverter shall be provided for those components which require AC power.

5.8.8 Standby Power

The 120VAC-to-24VDC power supply shall include support for an external 48VDC standby power source.

5.8.9 Backup Power Subsystem

The TFCS shall include support for a backup power subsystem. As a minimum, this shall include standardized connectorization from the standby source to the TFCS DC power source as well as procedures for switching to and from standby power in the event of a main power failure.
5.9 Internal Cabinet Communications

5.9.1 Internal Buses

The TFCS shall contain one or more internal communications buses to facilitate communication between subsystems.

5.9.2 Standard Hardware Interfaces and Protocols

The TFCS internal communication shall utilize one or more standardized hardware interfaces and operational protocols.

5.9.3 Extensible Protocols

The TFCS internal communication protocols shall be designed to be extensible in support of future enhancements.

5.9.4 ITS V1 BUS1/BUS2 Support

The TFCS shall contain support for Serial Bus 1/Serial Bus 2 as defined by the ITS Cabinet Standard v1.02.17b.

5.10 External Cabinet Communications

5.10.1 Remote Protocols and Connectorization

The TFCS shall define connectorization and protocol elements for all cabinet communication features which may be accessed remotely.
6 APPENDICES

6.1 Acronyms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>AC</td>
<td>alternating current</td>
</tr>
<tr>
<td>ATC</td>
<td>Advanced Transportation Controller</td>
</tr>
<tr>
<td>ConOps</td>
<td>Concept of Operations</td>
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<tr>
<td>DC</td>
<td>direct current</td>
</tr>
<tr>
<td>EMI</td>
<td>electromagnetic interference</td>
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<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>I/F</td>
<td>interface</td>
</tr>
<tr>
<td>I/O</td>
<td>input/output</td>
</tr>
<tr>
<td>IMSA</td>
<td>International Municipal Signal Association</td>
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<tr>
<td>IPC</td>
<td>Formerly, the Institute for Printed Circuits. This same institution was later called the Institute Interconnecting and Packaging Electronic Circuits. It is now referred to as IPC-Association Connecting Electronics Industries.</td>
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<tr>
<td>ITE</td>
<td>Institute of Transportation Engineers</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transportation System</td>
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<tr>
<td>JPO</td>
<td>Joint Program Office</td>
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<tr>
<td>LED</td>
<td>light emitting diode</td>
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<tr>
<td>NEC</td>
<td>National Electrical Code</td>
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<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
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<tr>
<td>NRTL</td>
<td>Nationally Recognized Testing Lab</td>
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<tr>
<td>NTCIP</td>
<td>National Transportation Communications for ITS Protocol</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association</td>
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<td>RFI</td>
<td>radio frequency interference</td>
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<tr>
<td>SDO</td>
<td>Standard Development Organization</td>
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<td>SEMP</td>
<td>System Engineering Management Plan</td>
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<td>SEP</td>
<td>Systems Engineering Process</td>
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<td>StdRS</td>
<td>Standards Requirements Specification.</td>
</tr>
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<td>TFCS</td>
<td>transportation field cabinet system</td>
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<tr>
<td>UPS</td>
<td>Uninterruptible Power Source</td>
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<tr>
<td>USA</td>
<td>United States of America</td>
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<td>USDOT</td>
<td>United States Department of Transportation</td>
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<td>VAC</td>
<td>voltage alternating current</td>
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<td>VDC</td>
<td>voltage direct current</td>
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<td>Working Group</td>
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</table>
6.2 Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>arc flash hazard</td>
<td></td>
</tr>
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</tr>
<tr>
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</tr>
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</tr>
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</tr>
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<td>raw power</td>
<td></td>
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<td>service power</td>
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6.3 Needs to Requirements Traceability

The Needs to Requirements Traceability Matrix (NRTM), presented below, maps the user needs defined in Section 4 to the requirements defined in Section 5. The matrix table can be used by:
- A user or specification writer to indicate which requirements are to be implemented in a project-specific implementation; and
- The supplier and user, as a detailed indication of the capabilities of the implementation.

<table>
<thead>
<tr>
<th>Needs Id</th>
<th>Needs Title</th>
<th>Requirements Id</th>
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</tr>
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<tbody>
<tr>
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</tr>
<tr>
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</tr>
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<td>Relative Humidity</td>
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<td>Limit Audible Noise</td>
<td>5.1.2.3</td>
<td>Noise Level</td>
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<tr>
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<td>Withstand Vibration and Shock</td>
<td>5.1.2.4</td>
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<td>5.1.4.7</td>
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<td>5.1.4.1</td>
<td>NEC Compliance</td>
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<td>4.3.1.18</td>
<td>Energy Efficient</td>
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<td>Power Factor</td>
</tr>
<tr>
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<td>5.4.6</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>5.4.6</td>
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</tr>
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<td>5.5.4</td>
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<td>5.5.6</td>
<td>Low-Power DC Support</td>
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<td>5.5.7</td>
<td>Output Circuit Breakers</td>
</tr>
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<td>4.3.4.5</td>
<td>Fault Operation</td>
<td>5.5.8</td>
<td>Channel-Programmable Flasher Outputs</td>
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<td>4.3.4.5</td>
<td>Fault Operation</td>
<td>5.5.9</td>
<td>Multi-Output Flasher Unit</td>
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<tr>
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</tr>
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<td>5.7.5</td>
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</tr>
<tr>
<td>4.3.5.2</td>
<td>Field Output Monitoring</td>
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<td>Measure AC Voltage</td>
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<tr>
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<td>5.6.11</td>
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</tr>
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</tr>
<tr>
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<td>Current Measurement Interval</td>
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<td>5.6.15</td>
<td>Independent Field Display Monitoring</td>
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<td>4.3.5.4</td>
<td>Internal Communications Monitoring</td>
<td>5.6.16</td>
<td>Communications Monitoring</td>
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<tr>
<td>4.3.5.5</td>
<td>User Interface</td>
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<td>Diagnostic Display Unit Local Display</td>
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<tr>
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<td>5.7.2</td>
<td>Diagnostic Display Unit Remote Display</td>
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<td>5.7.3</td>
<td>Diagnostic Display Unit Historical Data</td>
</tr>
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<td>Response to Malfunction or Anomaly</td>
<td>5.6.2</td>
<td>Conflict Monitor Unit</td>
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<td>5.6.3</td>
<td>Monitor Programmed Field Output States</td>
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<td>Monitor Actual Field Output States</td>
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<td>Monitor Field Output Interval Length</td>
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<td>5.6.6</td>
<td>Monitor Field Output Voltages and Currents</td>
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<tr>
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<td>Response to Malfunction or Anomaly</td>
<td>5.6.7</td>
<td>Channel Pair Permissive Programming</td>
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<td>Response to Malfunction or Anomaly</td>
<td>5.6.8</td>
<td>Voltage and Current Thresholds</td>
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<td>Response to Malfunction or Anomaly</td>
<td>5.6.9</td>
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<tr>
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<td>Configuration of Monitoring</td>
<td>5.6.7</td>
<td>Channel Pair Permissive Programming</td>
</tr>
<tr>
<td>4.3.5.7</td>
<td>Configuration of Monitoring</td>
<td>5.6.8</td>
<td>Voltage and Current Thresholds</td>
</tr>
<tr>
<td>4.3.5.7</td>
<td>Configuration of Monitoring</td>
<td>5.6.9</td>
<td>Configurable Response</td>
</tr>
<tr>
<td>4.3.5.8</td>
<td>Controlled Access to Monitoring Configuration</td>
<td>5.6.17</td>
<td>Password-Protected Configuration</td>
</tr>
<tr>
<td>4.3.6.1</td>
<td>Service Power</td>
<td>5.8.1</td>
<td>Nominal AC Input Voltage</td>
</tr>
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<td>4.3.6.1</td>
<td>Service Power</td>
<td>5.8.2</td>
<td>Nominal DC Input Voltage 1</td>
</tr>
<tr>
<td>4.3.6.1</td>
<td>Service Power</td>
<td>5.8.3</td>
<td>Nominal AC Input Voltage 2</td>
</tr>
<tr>
<td>4.3.6.2</td>
<td>Clean Power Distributed</td>
<td>5.8.4</td>
<td>Clean Power</td>
</tr>
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<td>4.3.6.3</td>
<td>Raw Power Distributed</td>
<td>5.8.5</td>
<td>Raw Power</td>
</tr>
<tr>
<td>4.3.6.4</td>
<td>Power Conversion</td>
<td>5.8.6</td>
<td>Internal DC Power</td>
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<tr>
<td>4.3.6.4</td>
<td>Power Conversion</td>
<td>5.8.7</td>
<td>Internal AC Inverter</td>
</tr>
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<td>4.3.6.4</td>
<td>Power Conversion</td>
<td>5.8.8</td>
<td>Standby Power</td>
</tr>
<tr>
<td>4.3.6.5</td>
<td>Backup Power Provisions</td>
<td>5.8.9</td>
<td>Backup Power Subsystem</td>
</tr>
<tr>
<td>4.3.7.1</td>
<td>System Reports</td>
<td>5.7.1</td>
<td>Diagnostic Display Unit Local Display</td>
</tr>
<tr>
<td>4.3.7.2</td>
<td>System Reporting Distribution</td>
<td>5.7.2</td>
<td>Diagnostic Display Unit Remote Display</td>
</tr>
<tr>
<td>4.3.7.3</td>
<td>Non-Volatile Information</td>
<td>5.7.3</td>
<td>Diagnostic Display Unit Historical Data</td>
</tr>
<tr>
<td>4.3.8.1</td>
<td>External Communications Capability</td>
<td>5.2.19</td>
<td>External Antenna</td>
</tr>
<tr>
<td>4.3.8.2</td>
<td>Standardize External Interfaces</td>
<td>5.10.1</td>
<td>Remote Protocols and Connectorization</td>
</tr>
<tr>
<td>4.3.9.1</td>
<td>External Mounting</td>
<td>5.2.1</td>
<td>ITS V1 Cabinet Housings</td>
</tr>
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<td>4.3.9.1</td>
<td>External Mounting</td>
<td>5.2.2</td>
<td>Small Size Cabinet</td>
</tr>
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<td>Corrosion Resistant Material</td>
<td>5.2.3</td>
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</tr>
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<td>Corrosion Resistant Material</td>
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<td>Corrosion Resistant Material</td>
<td>5.2.5</td>
<td>Aluminum Sheet Plating</td>
</tr>
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<td>Corrosion Resistant Material</td>
<td>5.2.6</td>
<td>Stainless Steel Sheet</td>
</tr>
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<td>Cold Rolled Steel Plating</td>
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<td>Corrosion Resistant Material</td>
<td>5.2.9</td>
<td>Stainless Steel Hardware</td>
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<tr>
<td>4.3.9.3</td>
<td>Cabinet Access</td>
<td>5.2.10</td>
<td>Doors</td>
</tr>
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<td>4.3.9.4</td>
<td>Physical Environment</td>
<td>5.2.11</td>
<td>Ventilation</td>
</tr>
<tr>
<td>4.3.9.4</td>
<td>Physical Environment</td>
<td>5.2.12</td>
<td>Cabinet Thickness</td>
</tr>
<tr>
<td>4.3.9.5</td>
<td>Animal and Insect Resistant</td>
<td>5.2.13</td>
<td>Rodent Resistant</td>
</tr>
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<td>4.3.9.6</td>
<td>Vandalism and Theft Resistant</td>
<td>5.2.14</td>
<td>High Security Design</td>
</tr>
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<td>4.3.9.7</td>
<td>Graffiti Resistant</td>
<td>5.2.15</td>
<td>Cabinet Surface Preparation</td>
</tr>
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<td>4.3.9.8</td>
<td>Video Monitor Provision</td>
<td>5.2.16</td>
<td>Video Monitor</td>
</tr>
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<td>Battery Housing Provision</td>
<td>5.2.17</td>
<td>Backup Power Batteries</td>
</tr>
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<td>Law Enforcement Personnel Access</td>
<td>5.2.18</td>
<td>Law Enforcement Access</td>
</tr>
<tr>
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<td>Limited Enclosure Access</td>
<td>5.2.20</td>
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<td>5.9.1</td>
<td>Internal Buses</td>
</tr>
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<td>Standardized Interfaces</td>
<td>5.9.2</td>
<td>Standard Hardware Interfaces and Protocols</td>
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<td>5.9.3</td>
<td>Extensible Protocols</td>
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<td>5.9.4</td>
<td>ITS V1 BUS1/BUS2 Support</td>
</tr>
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