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# Multi-Modal Traveler Information System

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## GCM Corridor Architecture
## Functional Requirements
## Document #17200.02

GARY-CHICAGO-MILWAUKEE CORRIDOR
MULTI-MODAL TRAVELER INFORMATION SYSTEM
GCM COORIDOR ARCHITECTURE
FUNCTIONAL REQUIREMENTS

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# 1. INTRODUCTION

## 1.1 PROJECT OVERVIEW

The Multi-Modal Traveler Information System (MMTIS) project involves a large number of Intelligent Transportation System (ITS) related tasks. It involves research of all ITS initiatives in the Gary-Chicago-Milwaukee (GCM) Corridor which are currently deployed as well as proposed ITS identified in regional strategic plans and early deployment studies. This information will be used to recommend an MMTIS Corridor Architecture that best suits the characteristics of the diverse needs and resources within the Corridor.

The deployment of the Gateway Traveler Information System (TIS) will provide a comprehensive, integrated, and multi-modal transportation system that serves the needs of travelers and operators within the GCM Corridor. This system will focus on the collection and distribution of transportation related information and the coordination of regional multi-modal transportation systems for the benefit of the Corridor. It will also provide the communications mechanism for the implementation of cooperative control procedures for cross agency control of ITS devices.

There will be a minimum of a two phased implementation for the GCM Corridor Gateway TIS. "Initial" and full build-out or "Ultimate." The primary difference between the initial and ultimate phases of the Gateway TIS will be the type of data connections to the data source systems. The Gateway serves as the central collection and distribution hub for traveler information within the GCM Corridor. Together with the regional hubs and connections to ITS subsystems within the Corridor it composes the Gateway TIS.

## 1.2 PURPOSE

The purpose of this document is to identify and define the overall functional requirements for the components of the Corridor Architecture and Gateway TIS in support of the Multi-Modal Traveler Information System.

These requirements are identified in order to support the design of the systems within the Corridor, especially the regional hubs and hub interfaces. They provide details regarding interfaces between the Gateway defined in Document #17150 (*Gateway TIS System Definition Document*) and the remainder of the Corridor Architecture. This document, in combination with Document #17300 (*Corridor Architecture Interface Control Requirements*) is intended to be used to gain a more complete understanding of the system. These requirements are intended as testable statements of system design and operation.

## 1.3 GOALS

This document has the following goals:

- Provide a set of requirements to serve as a baseline for the Gateway TIS design, system integration, validation, and verification.

- Reduce the cost of the design and development effort for the Gateway TIS by minimizing omissions, misunderstandings, and inconsistencies early in the design cycle.

- Provide a basis of understanding among the system designers, participants, and users.

- Provide input to the design and update of ITS projects within the Corridor, in order to facilitate communications and connection to the Gateway and the Gateway TIS.

These requirements will be changing, evolving, and expanding over time. This document will be revised to reflect the changing requirements of the Corridor Architecture. The scope and behavior of a number of ITS projects within the GCM Corridor have not been completely identified or determined at the initial writing of this document.

The Gateway TIS development is targeted in two phases, the initial and the ultimate. These requirements are directed towards both phases. The goal is for complete implementation of these requirements for the ultimate phase.


## 1.4  INTENDED AUDIENCE

This document is intended for:

- The GCM Architecture, Communication, and Information Work Group and the Deployment Committee.

- Members of various design groups that have development responsibility for the Gateway, the Gateway TIS, and for other ITS projects within the Corridor.

- ITS agencies who wish to communicate with the Gateway and through the Gateway TIS.

- Other parties who may be contemplating the design of a similar ITS communication infrastructure.


## 1.5  DOCUMENT ORGANIZATION

This document is organized into different sections. **Within each section, specific requirements will be distinguished by being formatted to the fifth heading level (i.e., 9.1.2.3.1).** Section 2 presents an overview of the Gateway system and its position and purpose within the Corridor Architecture. Section 3 discusses requirements for physical connections between Corridor Architecture regional hubs, various ITS subsystems, and the Gateway. Section 4 discusses requirements for data exchange between regional hubs, the Gateway, and various ITS subsystems. Section 5 reviews the interfaces between the regional hubs and the Gateway system. Section 6 reviews the ITS subsystems which will connect to the Illinois regional hub and the interfaces between these systems and the Illinois Hub. Section 7 discusses the requirements for output from the Gateway through the Corridor Architecture, to Information Service Providers (ISPs), and through the Internet.


## 1.6  TERMINOLOGY

In the text of this document, the term "shall" means the statement calls out a necessary requirement which must be included in the design of the Gateway TIS.

The term "may" means the statement indicates a potential capability which need not be initially implemented in the Gateway TIS, but that the Gateway TIS design must allow for that capability to be implemented in the future.

## 1.7 DEFINITIONS, ACRONYMS AND ABBREVIATIONS

Document #17100-1 (*MMTIS Project Glossary*) contains all definitions, acronyms, and abbreviations associated with this project along with pertinent TIS, communications, computer technology, and other standards in general.

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|---|---|
| Base GCM LRMS | The location referencing message specification that will be used throughout the GCM Corridor. The profile that will be used initially will be the Geographic Coordinate Profile (latitude, longitude, altitude and street name) with the possibility of supporting more profiles in the ultimate phase. |
| Borman ATMS | The Indiana regional hub responsible for collecting and disseminating traveler data and information to/from the various ITS subsystems within Northwestern Indiana and providing that information to the Gateway. It will also serve as the interface between these subsystems and the Gateway. |
| CDSI | Communication and Data System Infrastructure - The Wisconsin Regional Hub responsible for collecting and disseminating traveler data and information to/from the various ITS subsystems within Southeastern Wisconsin and providing that information to the Gateway. It will also serve as the interface between these subsystems and the Gateway. |
| Corridor Architecture | The standards and practices associated with the design of the MMTIS which provide a recommended design for ITS subsystems, data sharing, and cooperative control within the Corridor. |
| Data Pipe | The communication network interconnecting the Gateway, regional hubs and ITS subsystems within the GCM Corridor. |
| Gateway | The physical hardware and software, resident in a central facility, that is responsible for collecting, routing and disseminating all the traveler information collected by the regional hubs. |
| Gateway TIS | The logical collection of regional hubs and ITS subsystems connected within the GCM Corridor to the Gateway, excluding field devices. |
| GCOM | GCM Corridor Object Model - The Corridor wide object models which describe ITS objects in the Corridor as well as additional control and coordination objects needed to support the Gateway and other systems within the Corridor. |
| Illinois Regional Hub | The facility responsible for collecting and disseminating traveler data and information to/from the various ITS subsystems within Northeastern Illinois and providing that information to the Gateway. It will also act as the interface between these subsystems and the Gateway. |
| ITS Subsystem | A facility within the GCM Corridor which is capable of providing and/or receiving traveler information to/from the Gateway TIS. |
| MMTIS | Multi-Modal Traveler Information System - The combination of all traveler modes and forms of transportation systems operated through various ITS subsystems within the project limits of the GCM Corridor. |

## 1.8  RELATED DOCUMENTS AND WORKING PAPERS

This document is a part of a series of documents and working papers produced to support the design of the GCM Corridor Multi-Modal Traveler Information System.

Related documents and working papers include:

- Document #17001 - *Project Operating Plan*
- Document #17100-1 - *Project Glossary*
- Document #17150 - *Gateway TIS System Definition Document*
- Document #17250 - *Gateway Functional Requirements*
- Document #17300 - *GCM Corridor Architecture Interface Control Requirements*
- Document #17350 - *Gateway Interface Control Requirements*
- Working Paper #18250 - *Cellular 911 - State of the Practice*
- Working Paper #18380 - *Corridor User Needs and Data Exchange Elements*
- Working Paper #18400 - *Current and Proposed ITS Initiatives*
- Working Paper #18500 - *GCM MMTIS Strategic Plan*
- Working Paper #18520 - *Performance Criteria for Evaluating GCM Corridor Strategies and Technologies*
- Working Paper #18550 - *Alternative GCM Corridor Technologies and Strategies*
- Working Paper #18600 - *System Interfaces and Information Exchange*
- Working Paper #18700 - *Information Clearinghouse - Initial Administrative Network*
- Working Paper #18790 - *Information Clearinghouse - Final Network*
- Working Paper #18830 - *Weather Detection System Standard Message Sets*
- Working Paper #19140 - *Gateway Phased Implementation Plan*
- Working Paper #19210 - *Lessons Learned*
- Working Paper #19220 - *Gateway Design Options*
- Working Paper #19840 - *Variable Message Signs (VMS)/Highway Advisory Radio (HAR) State of the Practice*
- Working Paper #19845 - *Variable Message Signs (VMS)/Highway Advisory Radio (HAR) Suggested Guidelines*

## 2. CORRIDOR REQUIREMENTS

This section provides a list of the general functional requirements for the GCM Corridor Architecture including the Gateway TIS and the exchange of information and the cooperative control of field devices among the various ITS subsystems located within the Corridor.

## 2.1 SYSTEM REQUIREMENTS

The National ITS Architecture Project was recently completed by the U.S. Department of Transportation and Federal Highway Administration. Figure 2-1 shows the ITS subsystems identified by the National ITS Architecture and the communication channels between the subsystems. What remains to complete the Architecture is the defining of the system standards. Working Paper # 19220 (*Gateway Design Options)* identifies the standards that are being developed as part of the National Architecture. It is the standards that will provide consistency throughout the country and enable interconnection between systems. Those standards that are being developed as part of the National ITS Architecture that most affect the design of the GCM Corridor Architecture are the National Transportation Communications for ITS Protocols (NTCIP).
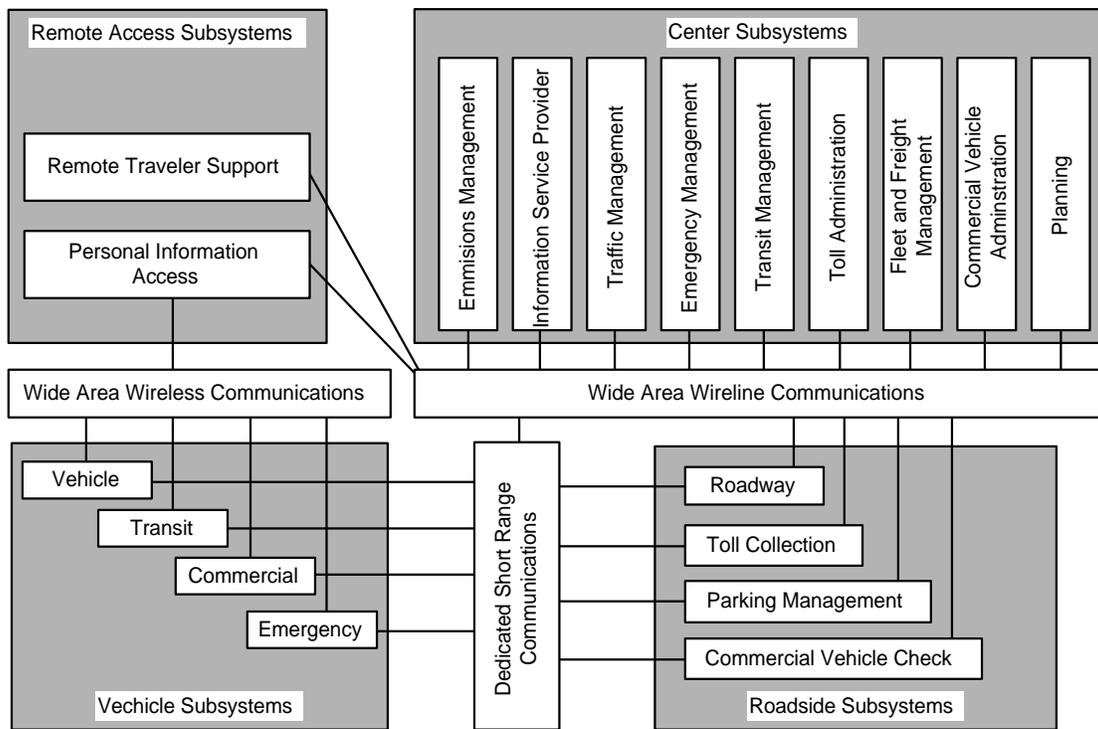


*Figure 2-1 - National ITS Architecture*

## 2.1.1 System Architecture

2.1.1.1.1 The Gateway TIS project and the GCM Corridor Architecture shall be designed to maximize compliance with the National ITS Architecture. Full compliance may not be possible

at this point in time due to the large number of existing systems in the Corridor.  Additionally, the National ITS Architecture is continuing to evolve.

The GCM Corridor Architecture shall conform to the National Intelligent Transportation System (ITS) architecture as shown in Figure 2-1.



Legend

○  - Regional Hubs

△  - ITS Center Subsystems (Traffic Management, Emergency Management, Transit Management, Information Service Providers, etc.)

◯  - Field Devices (CCTV, VMS, HAR, Detectors, Probes, etc.)

◄─────►  - Distributed Data  Exchange

◄─ ─ ►  - Peer-to-peer data exchange.

*Figure 2-2 - GCM Corridor Architecture*

2.1.1.1.2  A distributed architecture, based on open standards, consisting of multiple servers and clients shall be utilized within the Corridor to provide the necessary computing power, data communications, user interfaces, and data storage to meet the data exchange and cooperative control requirements within the GCM Corridor.

2.1.1.1.3  The Gateway TIS system shall correspond to Figure 2-2.

2.1.1.1.4  This architecture shall be capable of supporting the heterogeneous, multi-vendor platforms and communications techniques of the various ITS subsystems.  Commonality shall be established in two ways:

- The definition of a set of Corridor Architecture standards and practices that new systems can adopt or that existing systems can be modified to support.

- Use of "interface systems" which convert between the hardware and protocols used by an ITS subsystem and those of the Corridor Architecture and the Gateway TIS.

2.1.1.1.5  A comprehensive, integrated and multi-modal information system (Gateway TIS) shall be provided to serve the needs of travelers and operators within the GCM Corridor.

2.1.1.1.6  The Corridor Architecture shall be designed as a hybrid, distributed architecture with strategically located "regional hubs" which will provide connectivity and information sharing to local ITS subsystems.

2.1.1.1.7  A central hub, the Gateway, shall provide server functionality for the regional hubs.

2.1.1.1.8  Operator workstations or terminals shall be attached as clients to their respective hub.

2.1.1.1.9  The regional hubs shall function as clients to the Gateway, and as servers to the various connected ITS subsystems within the Corridor.

2.1.1.1.10  The various agency systems (Center Subsystems) shall function as clients to their respective regional hub.

2.1.1.1.11  All connections to a regional hub shall conform to the standards adopted by the GCM Corridor Architecture.

2.1.1.1.12  The Gateway TIS shall field a communications network which shall be organized as a Wide Area Network (WAN).  This Gateway TIS WAN shall be part of the Corridor-wide GCM Data Pipe.

2.1.1.1.13  The Gateway, regional hubs and ITS subsystems (through hub interface computers [refer to section 2.4 of this document]) shall be connected to the Gateway TIS WAN.

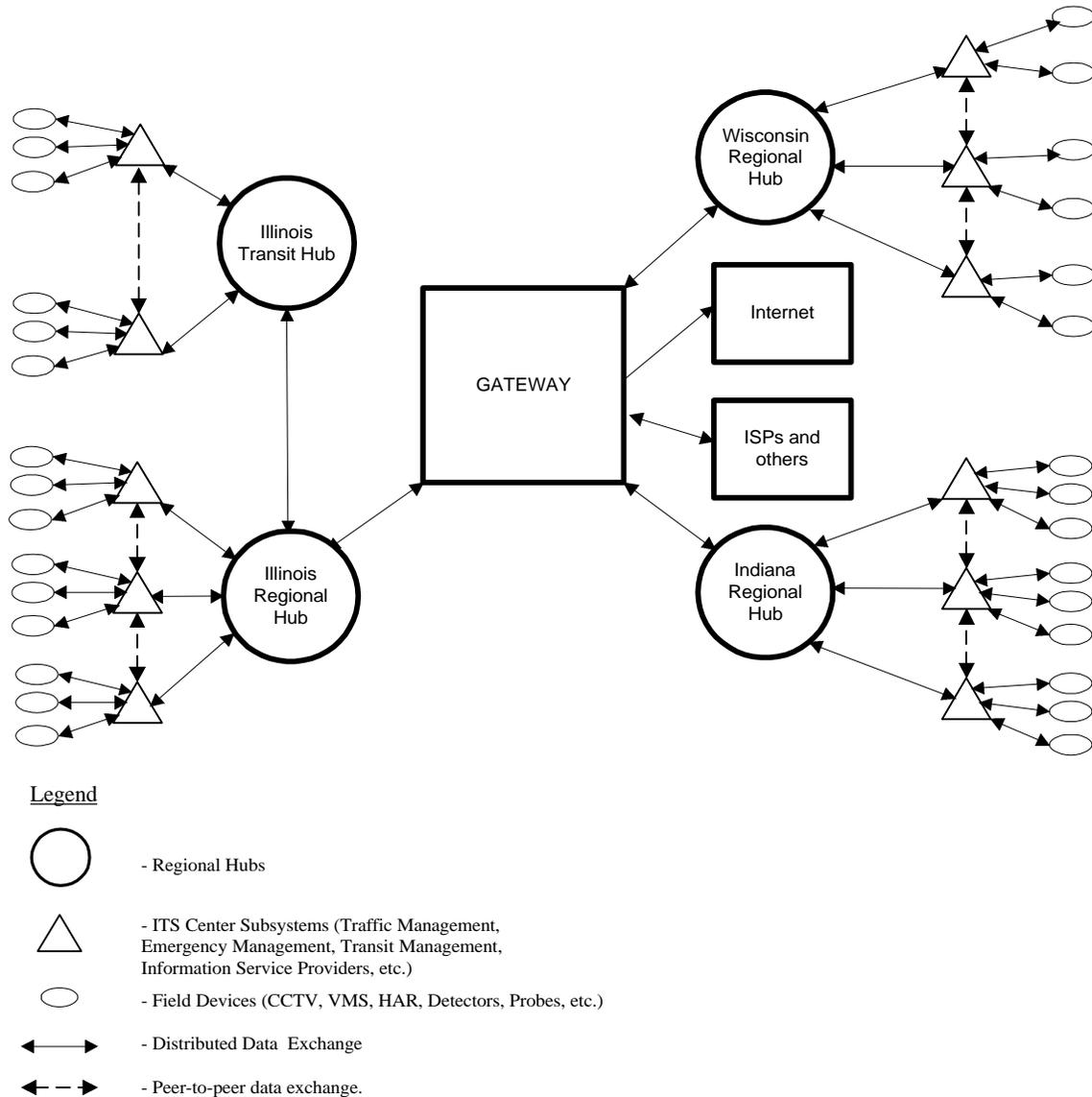2.1.1.1.14  Various Architecture compliant ITS subsystems may also be connected to the WAN at the option of the ITS subsystem agency.

2.1.1.1.15  ITS subsystems which cannot directly conform shall achieve conformance by locating a "hub interface" computer between their system and the regional hub which shall perform the necessary conversions to achieve conformance.

2.1.2  Open System

2.1.2.1.1  The GCM Corridor Architecture, including all system level software, hardware and networking, shall provide interoperability, interconnectivity, portability and scalability across various hardware platforms and networks (fostering vendor neutrality).  To accomplish this, the system level software shall be compliant with established and mature open system characteristics.

2.1.2.1.2  An open system architecture shall exhibit the following characteristics (as defined by X/Open, an international standards house):

- interconnectivity, or general networking ability to connect and seamlessly exchange information with other systems,

- interoperability, or the seamless access of distributed data across hardware and among software applications,

- vendor neutral, both hardware and software,

- portability, or the ability to move applications from one vendor's computer system (hardware and operating system) to another with minor or no modifications required,

- scalability, or the ability to run applications without modification on more or less capable computer systems.

2.1.2.1.3  By basing the Corridor Architecture on open system characteristics, the following system attributes shall be exhibited:

- integration of future technologies with existing or legacy systems,

- maintainability,

- modularity.

### 2.1.3  Provision for Future ITS Technologies

2.1.3.1.1  The Gateway TIS shall be capable of incorporating future ITS technologies as they are developed and have applicability to the GCM Corridor Architecture with minimal changes to existing systems.

### 2.1.4  Security

2.1.4.1.1  Communication links connecting the Gateway and regional hubs, as well as other individual systems, shall be protected from unauthorized access by using at least one of the following:

- use of secure, dedicated lines;

- password access for dial-up lines (modems);

- data encryption for public networks (such as the Internet).

### 2.1.5  Privacy

2.1.5.1.1  The stripping of private or proprietary information shall be accomplished at the data source before transmission to a regional hub or the Gateway.  This data includes, but is not restricted to, names of individuals, phone numbers, individual's address, toll tag Ids, license plate numbers, etc.  Where necessary a hub interface shall perform this function.

### 2.1.6  Reliability

2.1.6.1.1  The Gateway TIS shall provide safe, reliable and efficient control and monitoring operations under a full range of working conditions, continuously 24 hours per day for the design life of the system, subject to having reasonable regular scheduled maintenance.

2.1.6.1.2  Any data transferred within the Gateway TIS shall incorporate error-checking methods to make sure that data is delivered correctly.  If the data link does not provide error checking, then the data shall be verified at the application layer.

2.1.7  Availability

2.1.7.1.1  The Gateway TIS shall be capable of supporting 24 hours a day, 7 days a week, 365 days a year unattended operation.

2.1.7.1.2  Attended operation with a high level of user interaction will generally occur during normal working hours.  The Gateway and regional hubs shall automatically operate unattended, monitoring the subsystems and providing event and status logging, at all other times.

2.1.7.1.3  Systems within the Corridor shall provide reasonable system operation without the full complement of system equipment (i.e., be able to perform its functions with the loss of some or several external interfaces to the extent practical).

2.1.8  Maintainability

2.1.8.1.1  Systems within the Corridor shall provide for a minimum shutdown time during periods of maintenance or repair.

2.1.8.1.2  The impact of periods of maintenance or repair upon system operation shall be minimized to the extent possible.

2.1.8.1.3  Systems within the Corridor shall use reliable equipment that can be easily replaced at the end of its life.

2.1.9  Fault Detection and Recoverability

2.1.9.1.1  Systems within the Corridor shall be capable of identifying component or subsystem failure and erratic operation, localize the effect and identify the source of the foregoing conditions.

2.1.9.1.2  Unrecoverable faults, or unusual system or equipment conditions, exhibited by any equipment in the Gateway TIS shall be detected by the Gateway and shall be automatically and safely terminated in an orderly manner to the extent possible.  Such events shall be logged and reported to the Gateway operators.  Examples of unrecoverable faults can include: CPU failure, unexpected CPU halt, memory failure, disk failure, other peripheral equipment failure and communications failure.

2.1.9.1.3  Systems within the Corridor shall be capable of returning to operation automatically with little or no operator intervention required.  This shall include the following: no file system operations (transactions) will be left incomplete and the structure of disk volumes will remain intact without the need to run a disk repair utility, database operations shall roll-back to the time of failure.

2.1.10  Performance Requirement

2.1.10.1.1  The Gateway TIS shall be capable of receiving information and exchanging data among all external data interfaces with no frequent, continual, noticeable loss of system performance (such as: transfer speed, reliability, etc.) due to maintenance activities.

2.2  HUBS

2.2.1  General Requirements

2.2.1.1.1  The Gateway shall interface with each of the regional hubs and the regional hubs shall interface with their respective ITS subsystems.  The nature of each subsystem interface shall be determined as a requirement as each subsystem is identified and is ready for connectivity to the Gateway TIS.

2.2.1.1.2  Regional hubs shall provide for the collection, translation (where necessary) and fusion of data from transportation modes, i.e. agency systems and subsystems, located within a particular geographical area.

2.2.1.1.3  Hub systems shall exchange data using the base GCM LRMS format.

2.2.1.1.4  The following are identified as regional hubs for the GCM Corridor:
- Indiana regional hub (Borman ATMS)
- Illinois regional hub
- Wisconsin regional hub (CDSI)
- Illinois transit hub

2.2.1.1.5  Regional hubs shall function as a server to the various agency clients (ITS subsystems); and, shall function as a client to the Gateway.

2.2.1.1.6  Regional hubs will, in general, provide a store and forward function for data exchange among their various ITS subsystems and between those agencies and the Gateway.

2.2.1.1.7  The capability shall exist to connect to these and other, as yet unidentified, ITS subsystems as they become available.

2.2.2  Gateway

2.2.2.1.1  The Gateway will be the central hub of the Gateway TIS for gathering and disseminating traveler information from the other regional hubs within the Corridor, for the exchange of data between systems in the Corridor, and for sharing control and monitor operations. The specific Gateway requirements will be found in Document #17250 (*Gateway Functional Requirements*) and Document #17350 (*Gateway Interface Control Requirements*).

2.2.2.1.2  The Gateway shall provide a database for the temporary storage of real-time travel information from the various sources throughout the GCM Corridor.

2.2.2.1.3  The Gateway shall compile and coordinate the collected transportation data into a corridor-wide source of real-time transportation information.

2.2.2.1.4  The Gateway shall provide for the collection and fusion of data from all transportation modes within the GCM Corridor and distribute this information to those who operate and use the transportation system.

2.2.2.1.5  The Gateway shall be capable of providing all weather data available from SSI sensors throughout the GCM Corridor.  This information is to be provided by IDOT District One, possibly through the COM Center connection.

2.2.2.1.6  The Gateway shall be responsible for detecting errors (in cooperation with the regional hubs) within the Gateway TIS and reporting those errors to the appropriate operators and logs.

Additional details regarding the Gateway are contained in Documents #17250 (*Gateway Functional Requirements*) and *#17350 (Gateway Interface Control Requirements*).

### 2.2.3  Illinois Regional Hub

2.2.3.1.1  The Illinois regional hub shall function as the regional hub for the six counties incorporating the Chicago area (Cook, DuPage, Kane, Lake, McHenry and Will).

2.2.3.1.2  The Illinois regional hub shall aggregate/synthesize traffic, incident, transit, and other travel information within Illinois for distribution to various users, including the traveling public, the media, traffic system managers, transit operations managers, law enforcement and emergency service officials, and interstate commerce representatives.

2.2.3.1.3  The Illinois regional hub shall coordinate this information and provide it to the Gateway.

2.2.3.1.4  Agency systems within the northeastern Illinois area shall be capable of electronic connectivity to other systems within this area, and with connectivity to the GCM Corridor through the Illinois regional hub.

Additional details regarding the Illinois regional hub are contained in Documents #17250 (*Gateway Functional Requirements*) and *#17350 (Gateway Interface Control Requirements*).

### 2.2.4  Wisconsin Regional Hub

2.2.4.1.1  The regional hub for southeastern Wisconsin will be the Communications and Data System Infrastructure (CDSI).

2.2.4.1.2  The Wisconsin regional hub shall aggregate/synthesize traffic, incident, transit, and other travel information within Wisconsin for distribution to various users, including the traveling public, the media, traffic system managers, transit operations managers, law enforcement and emergency service officials, and interstate commerce representatives.

2.2.4.1.3  The Wisconsin regional hub shall coordinate this information and provide it to the Gateway.

2.2.4.1.4  Until completion of CDSI, Wisconsin ITS subsystems (such as MONITOR [the Wisconsin Department of Transportation's existing freeway management system]) shall connect directly to the Illinois regional hub.

2.2.4.1.5  ITS subsystems within the southeastern Wisconsin area shall be capable of electronic connectivity to other systems within this area, and with connectivity to the GCM Corridor through the Wisconsin regional hub.

### 2.2.5  Indiana Regional Hub

2.2.5.1.1  The regional hub for Northwest Indiana is the Borman Advanced Traffic Management System (ATMS).

2.2.5.1.2  The Indiana regional hub shall aggregate/synthesize traffic, transit, and other travel information within Indiana for distribution to various customers, including the traveling public,

the media, traffic system managers, transit operations managers, law enforcement and emergency service officials, and interstate commerce representatives.

2.2.5.1.3  The Indiana regional hub shall coordinate this information and provide it to the Gateway.

2.2.5.1.4  ITS subsystems within the northwest Indiana area shall be capable of electronic connectivity to other systems within this area, and with connectivity to the GCM Corridor through the Indiana regional hub.

### 2.2.6  Illinois Transit Hub

2.2.6.1.1  The Illinois transit hub shall serve as the regional hub for transit agencies in the Chicago area.

2.2.6.1.2  The Illinois transit hub shall gather information from other transit agencies (Regional Transit Authority [RTA], Chicago Transit Authority [CTA], Pace, Metra, etc.) in the Chicago area.  This information shall include, but is not limited to: schedules, schedule adherence,  route information (including incidents), fare rates, etc.

2.2.6.1.3  The Illinois transit hub shall coordinate this information and provide it to the Gateway.

2.2.6.1.4  Initially, the transit hub may not be available and systems shall connect directly to the Illinois regional hub.

## 2.3  SUBSYSTEMS

This section describes the interoperating functional requirements for the various ITS subsystems within the GCM Corridor.  These correspond to the nineteen subsystems identified in the National Intelligent Transportation System Architecture (see Figure 2-1).  Existing or future Corridor agency systems will all exhibit one or more of the functionality present in the National ITS Architecture subsystems as described below.

### 2.3.1  General Requirements

2.3.1.1.1  Each of the following ITS subsystems shall be physically implemented by one or more of the various agency systems in the Corridor.  These subsystem descriptions are provided for informational purposes and completeness along with the functional requirements currently identified.

2.3.1.1.2  Nothing shall preclude one or more of these subsystems from joint operation with other subsystems; or one subsystem having functionality of other subsystems.

### 2.3.2  Center Subsystems

These subsystems are grouped together because of their dependence on wireline communications.  Center Subsystems can be located anywhere as long as there is communications media available.  Examples of potential Center Subsystems include freeway management control centers and bus transit management centers.

2.3.2.1  General Requirements

2.3.2.1.1  A Center Subsystem shall provide the logical functionality to gather/provide traveler related information to/from various sources including, but not limited to that functionality required to accomplish the center's goals.

2.3.2.1.2  A Center Subsystem can be physically located anywhere within the GCM Corridor.

2.3.2.1.3  Each of the following Center Subsystems shall exchange data with the Gateway through a regional hub; however, it may be necessary for two subsystems to interface directly within a region also, and the Corridor Architecture shall not restrict this capability.

2.3.2.2  Emergency Management Subsystems

2.3.2.2.1  This subsystem shall assist in incident detection, provide and coordinate responses to emergency incidents.  Examples of Emergency Management Subsystems include *999 and Northwest Central Dispatch in Illinois.

2.3.2.2.2  Emergency Management Subsystems shall be capable of receiving and providing information on a 24-hours per day, seven days a week basis to/from any existing or planned emergency traffic patrol systems.

2.3.2.2.3  Emergency request messages shall be analyzed, validated and verified.  Part of the analysis may be the determination of the routing, if necessary, to an appropriate destination for responding to the incident.

2.3.2.2.4  All information relating to a person's identity, vehicle license number, address, telephone number, etc., shall be stripped from the data originating in an Emergency Management Subsystem before that data is sent to a regional hub in the Gateway TIS.

2.3.2.3  Transit Management Subsystems

2.3.2.3.1  Transit Management Subsystems shall collect data from transit vehicles and perform strategic and tactical planning for drivers, vehicles and routing.  Examples of these subsystems are the Regional Transit Authority (RTA) and Chicago Transit Authority (CTA) within the Illinois region.

2.3.2.3.2  Transit Management Subsystems shall be capable of using automatic vehicle location (AVL) for capturing, mapping and tracking vehicles for:
- routing and scheduling purposes
- emergency situations
- provide real time vehicle location

2.3.2.3.3  Transit Management Subsystems shall provide real time vehicle locations/information to patrons via the Internet, desktop and laptop computers, and through other Remote Access Subsystems of the Corridor Architecture.

2.3.2.4  Traffic Management Subsystems

2.3.2.4.1  Traffic Management Subsystems shall process traffic related data monitored in real-time using technologies such as vehicle detectors and closed circuit television cameras. Examples of Traffic Management Subsystems within the Illinois area are the IDOT TSC and IDOT Communications Center and in Wisconsin is MONITOR.

2.3.2.4.2  Traffic Management Subsystems shall provide basic traffic data and incident management services through the Roadside (section 2.3.4) and other Corridor Architecture subsystems.  This information shall permit subsystem managers to assess field conditions, prepare responses and notify travelers of conditions.

2.3.2.4.3  Traffic Management Subsystems shall distribute travel related information to travelers and the public via the Gateway (including public broadcasts through Information Service Providers [ISP's]) and regional hubs through the use of Variable Message Signs (VMS), Highway Advisory Radio (HAR), etc.

2.3.2.4.4  Traffic Management Subsystems shall be capable of providing construction and maintenance activities for NHS/SRA roadways throughout the GCM Corridor.

2.3.2.4.5  This subsystem shall be capable of communicating with other Traffic Management Subsystems and the regional hubs.

2.3.2.5  Toll Administration Subsystems

2.3.2.5.1  Toll Administration Subsystems are responsible for processing traffic related data monitored in real-time using technologies such as AVI, transponders, toll tags, etc.  An example of a Toll Administration Subsystem within the GCM Corridor is ISTHA's I-PASS 2000 system.

*2.3.2.5.2*  In general, this subsystem shall provide audit, traffic and revenue analysis, etc., functions for the different Toll Administrations within the Corridor.

2.3.2.5.3  These subsystems shall be capable of processing Tollway related information.

2.3.2.5.4  These subsystems shall be capable of interfacing with other subsystems within each individual state and/or the associated regional hub.

2.3.2.5.5  Toll Administration Subsystems may facilitate traffic management by using AVI technology to provide travel times between readers which, in turn, can be used to provide traffic condition reports.

2.3.2.5.6  These subsystems shall be capable of providing construction and maintenance operations on the tollways.

2.3.2.6  Commercial Vehicle Operation Subsystems

2.3.2.6.1  Commercial Vehicle Operation (CVO) Subsystems shall be capable of providing, but not limited to, the following:

- Incidents along NHS/SRA within the GCM Corridor

- Any emergency construction and maintenance activities along NHS/SRA within the GCM Corridor

- sell credentials

- administers taxes

- maintenance and safety records

- credential check data

2.3.2.6.2  This subsystem shall be capable of exchanging information with other CVO Administration Subsystems and requesters of CVO information through the Gateway TIS.

2.3.2.6.3  Users of CVO Subsystems shall include, but not be limited to, operators of freight carriers, hazardous material carriers, weigh-in-motion, etc.

## 2.3.2.7  Information Service Provider (ISP) Subsystems

2.3.2.7.1  ISPs are typically a private enterprise that collects, processes and provides data from/to a wide variety of systems and users.  This data includes pre-trip travel information, route guidance, Mayday services (emergency dispatch/aid), demand-responsive transit, ride matching and other traveler information services.

2.3.2.7.2  ISP Subsystems shall, in coordination with other subsystems, collect and process transportation and traveler data.  Examples of ISPs include: Shadow Traffic, Mayday services (automatic collision notification, panic buttons, etc.), Metro Networks, etc.

2.3.2.7.3  ISP Subsystems shall provide information and respond to individual information requests from end users or patrons.

2.3.2.7.4  This subsystem shall be capable of providing information to the media (commercial radio, television, etc.) through Internet Web Pages and dedicated telephone lines.

2.3.2.7.5  This subsystem shall be capable of collecting and processing non-traveler identifying probe data from mobile clients in the process of performing dynamic route guidance.  This data may be shared with the other appropriate subsystems such as the Traffic Management Subsystem through the Gateway TIS.

2.3.2.7.6  This subsystem may also provide information for the following user services:
- trip travel information

- route guidance

- ridesharing

## 2.3.2.8  Airports/Ports

2.3.2.8.1  This subsystem shall support connections to major airports within the Corridor and provisions for connectivity to other airports and ports also located in the Corridor.

2.3.2.8.2  This subsystem shall be capable of  collecting and providing relevant traveler information such as schedules, prices, etc.

2.3.3  Remote Access Subsystems

These subsystems provide data to travelers, commercial vehicle operators or motor carriers in support of multi-modal traveling.  The manner in which data are provided could be through a fixed terminal, a portable terminal or other means.  Examples of potential remote access systems are kiosks and pagers used for transportation information functions.

### 2.3.3.1  General Requirements

2.3.3.1.1  Remote Access Subsystems shall provide travelers or carriers with the capability of remotely accessing information from any of the Corridor Subsystems or centers via data exchange through the Gateway TIS.

2.3.3.1.2  Nothing shall preclude an entity or a facility from disseminating its own information or information collected via the Gateway TIS through a Remote Access Subsystem.

2.3.3.1.3  These subsystems shall provide the following remote access capabilities:
- fixed (e.g., Kiosks or home/office computers using wireline communications)

- portable (e.g., using palm-top, lap-top, or 'smart' watches using wireless communications).

These subsystems shall support Internet access that is either publicly located (e.g., a kiosk) or by private connections (e.g., personal computers) through an Internet Service Provider.

### 2.3.3.2  Personal Information Access

2.3.3.2.1  The Remote Access Subsystem shall support access by all types of computers through an Internet Service Provider.

### 2.3.3.3  Remote Traveler Support

2.3.3.3.1  Interactive Kiosks

2.3.3.3.1.1  The Gateway shall gather information from the various regional hubs and other external systems for distribution to interactive kiosks located throughout selected areas within the GCM Corridor.

2.3.3.3.1.2  Information that will be made available to the interactive kiosks through the Corridor Architecture may include:
- incident locations

- travel times

- traffic speeds

- road surface conditions

- construction and maintenance notices

- real time and scheduled transit services (including: bus and train schedules, fares, etc.)

2.3.3.3.1.3  These kiosks generally shall be capable of providing this information in an informative and easy to use manner.

2.3.3.3.2   Telephone Services

2.3.3.3.2.1   The Corridor Architecture shall be capable of supporting telephone-based pre-trip traveler information systems such as Traveler Advisory Telephone (TATS) and Automated Trip Planning Services.

2.3.3.3.2.2   The telephone services may be wire-connected or wireless through touch-tone telephones.

2.3.3.3.3   Cable TV Video Feed

2.3.3.3.3.1   The Corridor Architecture shall be capable of distributing information gathered from the centers and subsystems and distribute it by way of an appropriate video feed to local television and cable television companies.

2.3.3.3.3.2   Information that is to be distributed may include:
- incident locations
- travel times
- traffic speeds
- road surface conditions
- construction and maintenance locations
- real time and scheduled transit services (including bus and train schedules, fare rates, etc.)

### 2.3.4   Vehicle Subsystems

The following subsystems reside in a vehicle and support vehicle-to-roadside communications, vehicle-to-center communications and vehicle-to-vehicle communications.  Vehicle Subsystems include in-vehicle navigation systems and automated vehicle control systems.

### 2.3.4.1   General Requirements

2.3.4.1.1   Vehicle Subsystems shall be installed in vehicles and shall support some combination of communications with Roadside Subsystems (toll-tag, beacon, etc.), Wireless Wide Area 2-way or 1-way communications, or vehicle to vehicle communications.

2.3.4.1.2   Vehicle Subsystems shall utilize automatic vehicle location to the maximum extent possible.

### 2.3.4.2   Private Vehicle

2.3.4.2.1   This subsystem shall include private vehicles that shall have the capabilities of aggregating, interfacing and sharing traffic information with other subsystems and centers using electronic tolling devices, navigation systems, etc.  This includes the use of vehicles as probes on a real time basis.

2.3.4.2.2   This subsystem shall provide functions (e.g. navigation, tolls, emergency messaging, etc.) that may be common across all vehicle types along with the functions identified in the following specialized Vehicle Subsystems.

2.3.4.3  Transit Vehicle

2.3.4.3.1  This subsystem shall support transit vehicles having AVL and other technology for gathering real time traffic conditions, incidents and construction/maintenance activities and providing this information to other centers and subsystems.

2.3.4.3.2  This subsystem shall be capable of:

- providing operational data to the Transit Management Subsystem,

- receiving transit network status,

- providing the traveler with enroute information,

- providing passenger and driver security functions.


2.3.4.4  Public Agency Vehicle

2.3.4.4.1  This subsystem shall include emergency traffic patrol such as, Hoosier Helpers, ISTHA HELP, IDOT Minutemen, etc., as well as other state and local police, fire department vehicles, road maintenance vehicles, etc.

2.3.4.4.2  Where equipped, these vehicles shall be capable of being used as probes to gather real time traffic information, incidents and construction/maintenance activities.

2.3.4.4.3  This subsystem shall provide information concerning vehicle and incident status to the Emergency Management Subsystems and other subsystems requiring such information.


2.3.4.5  CVO

2.3.4.5.1  Where equipped, these vehicles shall be capable of being used as probes or other technology to gather real time traffic information, incidents and construction/maintenance activities.

2.3.4.5.2  The Corridor Architecture shall support the CVO Subsystems for the collection, storage and distribution of: safety data; tracking of hazardous material; driver, vehicle and carrier identification numbers; last check event data; weigh-in-motion, etc.

2.3.4.5.3  The Corridor Architecture shall support vehicle roadway signage for driver pass/pull-in messages for weigh stations.

2.3.5  Roadside Subsystems

This group of subsystems also relies on wireline communications or at least some form of point-to-point communications, but they must be collocated with a roadside transportation system to enable access to sensors, signals, programmable signs, or interfaces with travelers, vehicles and fleet operators.  Examples of Roadside Subsystems include toll collection systems and the field hardware (e.g.. variable message signs [VMS], detectors, etc.)  to support freeway management systems.

2.3.5.1  General Requirements

2.3.5.1.1  Roadside Subsystems shall include functions that require convenient access to a roadside location for deployment of sensors, signals, VMS, HAR, or other interfaces with travelers or vehicles.

2.3.5.1.2  These subsystems shall support stationary point-to-point communications for messages to/from one or more Center Subsystems.

2.3.5.1.3  These subsystems may require the capability for toll-tag, beacon/transponder communications, or wide area communications to some or all vehicles passing through a specific roadside deployment area.  The information collected may be communicated to other subsystems such as the Toll Administration Subsystem or Commercial Vehicle Operation Subsystem for:

- the collection of tolls and identification of violators.

- performing commercial vehicle checks including collection of credential and safety data from the vehicle, determination of conformance to requirements and recording results of the preceding as well as providing the information driver.

2.3.5.1.4  This subsystem shall support traffic management surveillance, signals and signage for traveler information.

2.3.5.1.5  The Corridor Architecture shall support the real-time and static dissemination of information to a traveler through Variable Message Signs (VMS), CCTV's, etc.

2.4  HUB INTERFACES

2.4.1.1.1  ITS subsystems within the Corridor which cannot be directly interfaced with the Corridor WAN shall connect through a hub interface computer.

2.4.1.1.2  Hub interface computers shall be used in the following circumstances:
- ITS subsystems which cannot communicate to their regional hub through CORBA.

- ITS subsystems which desire a firewall between their systems and the Corridor WAN.

- ITS subsystems which cannot connect to their regional hub through a Corridor standard communications technique.

2.4.1.1.3  Hub interface computers shall be connected to the ITS subsystems and to the Corridor WAN and shall translate data from the ITS subsystems to a format which can be received by the regional hub.

2.5  DOCUMENTATION AND CORRESPONDENCE EXCHANGE

The Information Clearinghouse (ICH) will provide a common source of non-real-time information for participating GCM agencies in the form of draft documentation and working papers concerning the various GCM Corridor projects.  The Public Information Center (PIC) will provide the repository for the finalized documents and working papers to the general public.  The following section provides the general requirements of ICH and PIC as it relates to the Corridor Architecture.  The specific Information Clearinghouse requirements can be found in *Working Paper #18700 - Information Clearinghouse - Initial Administrative Network* and *Working Paper #18790 - Information Clearinghouse - Final Network*.

2.5.1   Information Clearinghouse

2.5.1.1.1   The Information Clearinghouse (ICH) shall provide a repository for draft GCM documents that are not intended to be publicly distributed and/or are considered works-in-progress.

2.5.1.1.2   The ICH shall be accessible only by authorized users who will have different access levels/privileges for placing and retrieving files.

2.5.1.1.3   The ICH shall be easy to use so as to allow frequent and periodic use without resorting to user manuals or other references.

2.5.1.1.4   The ICH shall be capable of providing other functionality, such as teleconferencing over the Internet, when the demand for such functionality warrants it.

2.5.1.1.5   The ICH shall have firewalls that will not allow users to access other nodes that may be connected to the ICH.

2.5.1.1.6   The ICH shall use existing computing infrastructure employed by each authorized user.

2.5.2   Public Information Center

2.5.2.1.1   The Public Information Center (PIC) is a library of, final and approved documents.

2.5.2.1.2   The PIC shall provide general public access to finalized reports, publications and other pertinent information regarding the GCM Corridor and various GCM projects as well as items like budgets, meeting minutes and other items.

2.5.2.1.3   The PIC shall be implemented as an Internet home page.  Reports and publications can be downloaded and printed by the public.

2.6   OPERATIONAL PROCEDURES REQUIREMENTS

2.6.1.1.1   When joint control/monitoring of field devices is implemented, security measures must be enacted to ensure that the proper agency has control over the device and that another agency cannot override that authority.  This section describes the shared control and monitoring functionality between the Gateway, the regional hubs, and the various ITS systems communicating through the Gateway TIS.

2.6.2   Shared Monitoring/Control

2.6.2.1.1   Many agencies within the Corridor are in the process of developing, or have developed, real-time data, live video, and wireless communication techniques to improve real-time traffic monitoring, provide integrated control, and support advanced control operations. The Corridor Architecture shall be capable of supporting these initiatives and facilitate the exchange of data among the agencies.

2.6.2.1.2   The ability shall exist for one agency to access another agencies field devices to monitor and/or set the timing of signal controls, as well as control of monitoring equipment (e.g., CCTV or video camera view adjustment).

2.6.2.1.3  The Corridor shall provide  the capability for an interested agency to request the owning agency of a field device to display certain VMS messages.

2.6.2.1.4  Control requests between agencies in adjoining regions or states shall be in the form of direct connection through the Gateway TIS.

2.6.2.1.5  The Corridor Architecture shall be designed to provide safe, reliable and efficient control of field devices.

2.6.2.1.6  Control requests shall only be granted upon valid and verified access privileges and the approval of the owning agency.

2.6.2.1.7  Through an operator user interface, users located at either a local site or a remote site, within the Gateway TIS, shall be able to control a CCTV camera by issuing control commands such as pan, tilt, zoom, select preset camera position of a specified camera, and receive a static, time-captured or live image of each camera's view by scheduling different user's requests accordingly and provide control priority without affecting system operations.

## 3. LOCATION REFERENCING REQUIREMENTS

There are many different location referencing schemes currently in use within the GCM Corridor. This poses a problem in how the data will be transferred from one location referencing scheme to another so that the information is readable and correctly interpreted by sharing agencies. The purpose of the following requirements is to encapsulate those requirements necessary for storing and manipulating location information. For a further, detailed discussion of the Location Reference Message Specifications (LRMS) and its applicability to the GCM Corridor Architecture refer to Document #18600 (*System Interfaces and Data Exchange*).

### 3.1 GENERAL REQUIREMENTS

3.1.1.1.1  A common method of referencing transportation links and nodes shall be used so that the data exchange between ITS subsystems and the regional hubs will be based upon an unambiguous reference to the same transportation links, ramps and intersections. The current application for this will be in the form of the Location Referencing Message Specification (LRMS) as proposed by the Viggen Corporation and the Oak Ridge National Laboratory (ORNL).

3.1.1.1.2  The Corridor shall establish a base GCM LRMS based on datum points within the Corridor area.

3.1.1.1.3  The Gateway TIS shall store and communicate data using the base GCM LRMS.

3.1.1.1.4  It is the intention that other ITS subsystems within the Corridor eventually adopt and implement the base GCM LRMS format for the ease of sharing and comprehending location dependent traveler data.

3.1.1.1.5  A review shall be conducted to determine the compatibility between various map databases at use within the Corridor.

3.1.1.1.6  Various GCM datum points shall be established within the Corridor to anchor various map databases and the base GCM LRMS database.

### 3.2 PROFILES

3.2.1.1.1  The LRMS currently uses several different profiles or schemes to reference locations. The GCM Corridor shall use the Geographic Coordinate Profile as the base profile. This profile consists of latitude/longitude/altitude and a street name.

3.2.1.1.2  The Corridor Architecture shall be able to handle all other location referencing profiles throughout the Corridor and translate into the base Profile. The other profiles include:

- Address Profile
- Cross Streets Profile
- ISP-Vehicle Profile
- Linear Referencing Profile
- Point/Link ID Interface Profile
- Text Profile

3.3  TRANSLATION

3.3.1.1.1  Until all existing sources are modified to utilize the base GCM LRMS, it will be necessary to provide a translation for received data that is not LRMS compliant.

3.3.1.1.2  Translation methods from a specific agency to the GCM Corridor standard include:

- "hub interface computers" at each specific agency (where necessary), translating their location referencing scheme to the base GCM LRMS standard;

- each regional hub receiving their local information and performing the translation into the base GCM LRMS;

- or by the connected agencies adopting the base GCM LRMS profile.

3.3.1.1.3  The Gateway shall be able to work with data that is provided in any LRMS profile and will export data only in the base GCM LRMS..

3.3.1.1.4  Where necessary, the Gateway may augment location data provided in the base GCM LRMS format with anecdotal information such as if a location is on a ramp, or what lane of a roadway is being referenced.

3.4  LRMS DATABASE

3.4.1.1.1  An LRMS database shall be established within the Gateway TIS based on the GCM datum points to provide the necessary information to translate between agency based location referencing formats and the base GCM LRMS.

3.4.1.1.2  The LRMS database shall be based on a non-proprietary software package than can accommodate all types of location information that may be input into the Gateway TIS.

3.4.1.1.3  This map database shall be capable of being modified or updated to handle situations where streets are added or street names are changed.

3.4.1.1.4  Database requirements identified in Section 4.2 apply to the LRMS database.

## 4. DATA EXCHANGE REQUIREMENTS

This section will discuss traveler information needs and those requirements that describe the types of information that the system will receive, process, and store from the various systems located in the corridor. In addition, the requirements of the types of information provided to the traveler is identified.

### 4.1 EXTERNAL DATA INTERFACE REQUIREMENTS

#### 4.1.1 General Requirements

4.1.1.1.1 Data exchange between different/various agencies shall be seamless and executed in an efficient, timely manner.

4.1.1.1.2 The preferred physical method of data exchange through the Gateway TIS shall be via leased or user owned electronic communication lines.

4.1.1.1.3 The preferred software method for data exchange shall be through CORBA.

4.1.1.1.4 The preferred method for data distribution to the various Corridor systems and subsystems from the Gateway and regional hubs is at regular intervals using a variety of media including Internet home pages, internally through electronic communication lines, and through ISP's.

4.1.1.1.5 To support legacy ITS subsystems within the Corridor, the regional hubs shall provide a variety of additional external interfaces in addition to the preferred methods.

Figure 4-1 shows a data flow graph of data within either a regional hub or the Gateway. These systems shall conform to the figure.
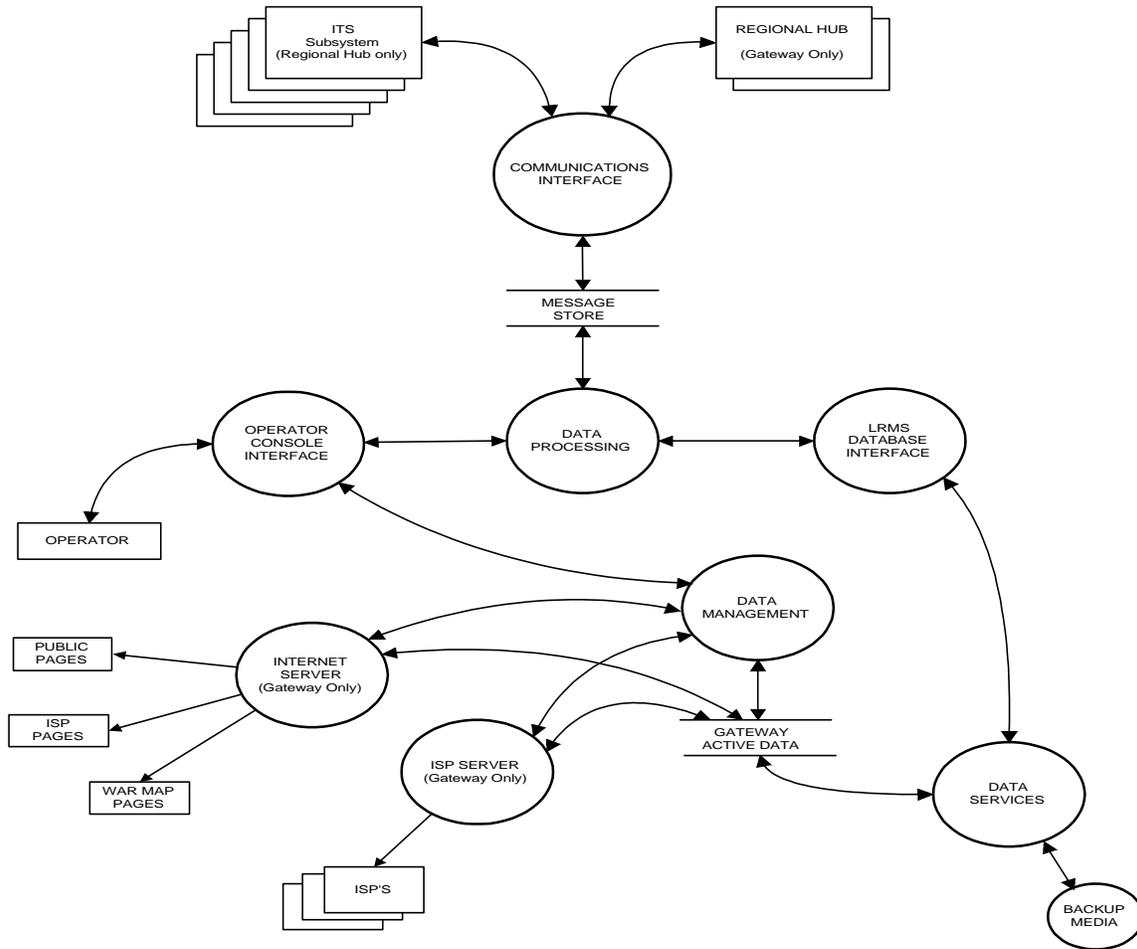


*Figure 4-1- Gateway/Hub Data Flow*

### 4.1.2  GCM Corridor Object Model

As part of the Gateway TIS design, a Corridor wide object model shall be established which describes the real objects within the Corridor and additional conceptual objects which are manipulated by systems in the Corridor (these are often referred to as business objects).

4.1.2.1.1  The GCM Corridor Object Model (GCOM) shall be designed in cooperation with other ITS subsystems and agencies within the Corridor.

4.1.2.1.2  Data passing to and from the Gateway and regional hubs shall comply with the GCOM.

4.1.2.1.3  The use of the CORBA system shall be used to allow processes modeling GCOM objects to communicate.

4.1.2.1.4  The GCOM shall be designed to be compatible with the NTCIP.

4.1.3  Data Exchange Types Supported

4.1.3.1.1  The regional hub systems shall be capable of supporting these types of incoming data:

- fax reception, followed by operator entry into the system,

- fax received by computer program and automatically entered (or subject to operator verification),

- pager reception, followed by operator entry into the system,

- pager received by computer program and automatically entered (or subject to operator verification),

- e-mail, followed by operator entry into the system,

- e-mail analyzed by computer program and automatically entered (or subject to operator verification),

- other text reception (telephone, mail, pagers, anecdotal information), followed by operator entry into the system,

- serial data interface through standard modems,

- distributed video, and,

- networked connection communication through CORBA.

4.1.3.1.2

4.1.3.1.3  The preferred method for providing data between regional hubs and ITS subsystems is networked electronic connections using CORBA.  Other techniques may be supported; however, all connections should include a plan for moving to the preferred method of data sharing.

4.1.4  Capacity

4.1.4.1.1  The Gateway shall be capable of handling up to 10 external data interfaces.  These shall be high speed connections to regional hubs, Internet connections, etc.

4.1.4.1.2  The Gateway ISP server and the regional hubs shall be capable of handling up to one hundred and twenty (120) external data interfaces.  These can be a combination of telephone lines/modems, leased lines, etc.

4.1.4.1.3  Each line and associated hardware/software shall be capable of handling information at a rate of at least 56 kbps, but modems shall also be capable of adjusting to accommodate modems with slower transfer rates.  A minimum rate of 28.8 shall be used by the ITS subsystems.

4.1.5  Performance

4.1.5.1.1  Data exchange between the regional hubs and between individual ITS subsystems shall be at rates so as to not impact any user's requests and without affecting any agency or Center operations (GUI, processing, etc.).

4.1.5.1.2  For networked data exchange, the use of various network security measures, such as firewalls, secure server, remote database server, etc., shall not impact the data exchange throughout the GCM Corridor.

4.1.6  Frequency

4.1.6.1.1  Systems within the Gateway TIS shall be capable of exchanging data at a frequency sufficient to enable a successful, efficient and useful data exchange.

4.1.6.1.2  The information and frequency of data that the Gateway will provide shall be directly related to when and what information will be available for other regional hubs and ITS subsystems.

4.1.7  Data Verification and Validation

4.1.7.1.1  Data verification and validation shall be done at the source.  This, however, does not preclude the requirement for data verification and validation to be done within the Gateway TIS. The requirements for this data verification and validation will be done on a case by case basis as the individual agency systems are to be interfaced and the nature of the data and any associated verification / validation can be determined.

4.1.7.1.2  The Gateway and regional hubs shall be capable of fusing data from multiple sources.

4.1.8  Data Access

4.1.8.1.1  The Gateway TIS shall support provision of direct network access for obtaining the current status of system components directly from a participating agency.

4.1.8.1.2  The Gateway shall receive and transmit data to/from a regional hub for obtaining current status information, for those ITS subsystems connected to a regional hub.

4.1.9  Internet

4.1.9.1.1  The Corridor Architecture shall support provision of GCM Corridor web pages on the Internet.

4.1.9.1.2  The Gateway TIS shall support public and protected web pages utilizing, among other things, video capture from surveillance cameras, area map displays showing traffic conditions, detailed incident and construction information, route planning and directions, airline schedules, transit schedules and fares.

4.1.9.1.3  The Gateway TIS shall support GIF and HTML formats, as well as emerging technologies (e.g., Java applets), for the export of  bitmap graphics for display purposes.

4.1.9.1.4  The GCM web pages shall be available 24 hours per day, 7 days a week.

4.1.9.1.5  The web pages shall provide a map for the Corridor with at least a display for each of the three different states of the Corridor.

4.1.9.1.6  The Corridor web page maps shall be capable of displaying the following information in both text and graphical formats:

- National Highway System (NHS) / Strategic Regional Arterials (SRA) highways and road route numbers and names,

- congestion data,

- incidents denoted by icon and incident type,

- construction and maintenance information,

- travel times (actual), by link and whole routes,

- a link to public transportation schedules and related information,

- VMS status and messages,

- ramp metering status,

- video locations denoted by icon and when clicked, provide the video feed from that camera (if the feed is available).

4.1.9.1.7  The GCM web pages shall also allow privileged users, including separate connections for agencies to utilize the "war map" and different private media ISPs, access to additional features including the following (which shall be password protected):

- weather conditions for the corridor,

- incident details,

- such other data identified as private, confidential or proprietary in nature.

4.1.9.1.8  All volatile data on the GCM web pages shall be updated at least every five minutes.

## 4.2  DATABASE REQUIREMENTS

These requirements define the standards and data structures that the system will use for manipulating information within the GCM Corridor.

### 4.2.1  Database Architecture

4.2.1.1.1  The Gateway shall provide a central server which periodically receives data updates from the regional hubs and stores the data in a central database.

4.2.1.1.2  The regional hubs shall provide appropriate database capabilities to stage incoming data before transmission to the Gateway.

4.2.1.1.3  The regional hubs may optionally provide additional database storage for responding to user queries and other local uses.

4.2.1.1.4  The Gateway database shall provide the capability of extracting two days worth of "active" information for responding to Gateway operator queries.

4.2.1.1.5  The Gateway shall not provide services for warehousing data for the Corridor.  This shall be the responsibilities of either the ITS subsystems themselves or of an ISP.

4.2.1.1.6  The Gateway and regional hub databases shall also be used to store usage information, log operator actions and system status.

4.2.1.1.7  Data archived for the Gateway TIS  (usage information, operator logs and system status) shall be for the use of the Gateway TIS operators and administrators and shall not be made available to other agency systems or the public at large except at the option of IDOT or other authorized GCM agencies.

4.2.2   Database Access

4.2.2.1.1   The Gateway TIS shall acquire data by either a direct, password-authorized access to a client system's database, or the client system will periodically transmit the data to the server in an agreed-upon format.

4.2.2.1.2   It shall be the responsibility of the individual ITS subsystems to provide for storing of information they are providing, or an agreed upon ISP.

4.2.2.1.3   A SQL-compliant database and source code level APIs shall be used.

4.2.3   Create, Read, Update and Delete Records

4.2.3.1.1   The database shall provide for creating, inserting, updating, reading and deleting records.

4.2.4   Data Integrity

4.2.4.1.1   The Gateway TIS databases shall prohibit the corruption or contamination of data exchanged with regional hubs.

4.2.4.1.2   The Gateway TIS databases shall maintain concurrency control by locking data at the record level in order to prevent inconsistent views of the data.

4.2.4.1.3   The Gateway TIS databases shall not permit partial commits.

4.2.5   Data Storage

4.2.5.1.1   The Gateway shall contain enough disk storage capacity to store two days of  active data.  In addition, the Gateway shall be capable of storing ten days of retrieved data from an archive system concurrent with the two days of active data.

## 5. COMMUNICATION REQUIREMENTS

### 5.1 NETWORK ARCHITECTURE/DATA PIPE

5.1.1.1.1  The GCM Corridor shall utilize a hybrid network architecture which is a combination of centralized and distributed communications architecture.

5.1.1.1.2  Each regional hub will operate independently in a distributed networked architecture with ITS subsystems directly connected.

5.1.1.1.3  Corridor networking elements are required to facilitate data exchange through message passing only.  Any data processing such as translation, aggregating or fusion shall be provided by the various Corridor subsystems, the regional hubs, and the Gateway.

5.1.1.1.4  The GCM Data Pipe shall provide a corridor-wide backbone network for high speed communications between the Gateway, regional hubs and the ITS subsystems for real-time data collection and distribution.

5.1.1.1.5  Within the Gateway TIS the Data Pipe shall be organized as a wide area network.

5.1.1.1.6  The Data Pipe shall provide an integrated network that eliminates duplication of functions and facilities within the Corridor and supports appropriate modes of communication.

### 5.2 OPEN NETWORKING

5.2.1.1.1  The GCM Corridor Architecture supports requirements for standard communication interfaces at several levels between the various communication elements and the various Corridor subsystems.  These standards shall be open, not proprietary.

### 5.3 NTCIP

Within the GCM Corridor, there are many agencies that collect and distribute their own traveler information utilizing unique ways of representing and storing information.  In order for this information to be distributed to other agencies and the general public through the Gateway TIS, it is necessary to translate/convert their data into a common, single format for easier distribution and understanding.  In order for the GCM system to achieve interoperability and joint control of field devices, it is necessary to provide seamless transactions between heterogeneous hardware and software systems.  In order to provide seamless transactions, protocol standards are needed. A communications protocol is a set of rules for how messages are coded and transmitted between electronic devices.  The equipment at each end of a data transmission must use the same protocol to successfully communicate.  The NTCIP is a family of protocols that defines message structures as well as transmission rules which enable data and messages to be sent between electronic devices used in Intelligent Transportation Systems.  For purposes within the GCM Corridor, NTCIP Class E protocol for Center-to-Center communications will be the main focus.

Note:  These requirements for the GCM Corridor Architecture relies upon the development of the NTCIP; however, as of the writing of this document established standards for this protocol (Class E) have not been adopted and are still considered in "draft" form.  Refer to Document #18500.01 (*GCM MMTIS Strategic Plan*) for further information regarding NTCIP, its development, current status, and the various protocols currently supported and being developed.

5.3.1.1.1  A common message format shall be defined, developed and supported for use within the GCM Corridor.  This format shall be compliant with the existing/developing National Transportation Communication ITS Protocol (NTCIP).

5.3.1.1.2  The Corridor Architecture shall be robust enough to permit compliance with an evolving NTCIP standard.

5.3.1.1.3  The data conversions / translations into the Corridor format shall be performed at the regional hubs or through hub interface computers located at the source, so as to limit the extent of processing done at the Gateway.

## 5.4  CONNECTIVITY

### 5.4.1  General

5.4.1.1.1  High speed communications (utilizing ATM) between the regional hubs and the Gateway shall be supported by the GCM Data Pipe.

### 5.4.2  Information Service Providers / Media

5.4.2.1.1  The Gateway TIS shall provide for real-time information to the media for further dissemination to the public.

5.4.2.1.2  The media data feed will be through a server connected to the Gateway for multiple media and Information Service Providers (ISPs) access within the Illinois area and through regional hubs in the Wisconsin and Indiana areas.

### 5.4.3  Wire/Landline

5.4.3.1.1  Wide area network (WAN) wireline communications shall be used for connecting ITS subsystems and regional hubs.

5.4.3.1.2  The WAN wireline communications shall be augmented by WAN wireless for connecting subsystem centers to vehicles, centers, or personal computers.

5.4.3.1.3  The WAN elements shall be either dedicated networks or privately deployed networks owned and operated by a communication service provider.

5.4.3.1.4  More than one wireline or wireless network may exist in the Corridor.  These networks shall be connected, or interworked, to support data exchange between subsystems that are attached to different networks.

5.4.3.1.5  Corridor networking shall be capable of supporting both public and private data networks.

### 5.4.4  Traveler Advisory Telephone Systems (TATS)

5.4.4.1.1  The Corridor Architecture shall be capable of supporting Traveler Advisory Telephone Systems (TATS) for providing telephone-based pre-trip information, transit information, weather information or enroute information to the traveler using either landbased telephone or cellular telephone.

5.4.5  Twisted Pair Cable

5.4.5.1.1  In general, the use of twisted pair cable shall be restricted for low speed transmission (e.g., 1200 - 9600 bps) of data between Center Subsystems and field devices over moderate distances.

5.4.6  Wireless

5.4.6.1.1  The Corridor Architecture shall be capable of supporting wireless communication elements including:

- one-way broadcast (e.g. fm-subcarrier)

- spread spectrum radio

- microwave

- cellular radio

- cellular digital packet data

- mobile data

- wireless messaging

5.4.6.1.2  Wireless communications shall be capable of supporting direct communications between vehicles and roadside equipment and consist of, but not limited to:

- uni-directional or bi-directional toll tags which use a tag mounted on the vehicle that communicates either  one-way (transmit only) or two-way (transmit/receive transponder) to Roadside Subsystems

- beacon short range

- area broadcast

5.4.7  Video

5.4.7.1.1  The Corridor Architecture shall support closed circuit television (CCTV),video teleconferencing, and the associated exchange of video-based images and data.  CCTV is used by Corridor agencies for both incident detection and verification as well as traffic monitor and control

5.4.7.1.2  The Corridor Architecture shall support video imaging over the Web.

5.4.8  Internet

5.4.8.1.1  The Gateway TIS shall provide a web server which will provide updated Corridor map-sets at least every five minutes using the map image based upon the current state of the database.

5.4.8.1.2  The Gateway TIS shall provide for a user to connect to private and public pages depending upon the access privileges (password).

5.4.9  Electronic Mail

5.4.9.1.1  The Gateway TIS shall support inter-agency communications through the use of electronic mail (e-mail) utilizing on-line services or electronic postal delivery.

5.4.10  Voice

5.4.10.1.1  Voice processing systems, such as voice mail or voice messaging, shall be supported.

5.4.11  Facsimile

5.4.11.1.1  Inter-agency communications in the Corridor using facsimile shall be supported.

## 6. HARDWARE REQUIREMENTS

The following high level hardware requirements are applicable to the Gateway TIS (specifically the Gateway, the regional hubs, and any hub interface systems) and are guidelines suggested for all hardware used by ITS subsystems operating within the GCM Corridor.

## 6.1  GENERAL REQUIREMENTS

6.1.1.1.1  The Gateway TIS shall exhibit hardware independence; i.e., it shall be capable of executing applications on different vendor platforms.

6.1.1.1.2  The Gateway TIS shall utilize existing hardware components up to the point where additional components are essential to system operation.

6.1.1.1.3  The Gateway TIS shall be capable of being ported to other similar hardware platforms and scaleable in terms of the number of I/O connections, processes, user interface features, etc., that are supported.

6.1.1.1.4  The Gateway TIS shall contain components that are capable of handling a heavy processing load.  They shall be capable of handling multiple users simultaneously along with the processing of incoming data and outgoing information.

6.1.1.1.5  The Gateway TIS shall be capable of adding additional on-line disk storage without interruption of services.

6.1.1.1.6  The Gateway TIS shall contain the necessary random access memory to avoid excessive swapping of program or data to disk.

6.1.1.1.7  The Gateway TIS shall contain components that are scaleable and capable of handling heavy processing loads including database activity.

6.1.1.1.8  The Gateway TIS shall be capable of handling multiple users simultaneously along with the processing of incoming data and outgoing information.

## 7.  SOFTWARE REQUIREMENTS

The following high level software requirements are applicable to the Gateway TIS (specifically the Gateway, the regional hubs, and any hub interface systems) and are guidelines suggested for all hardware used by ITS subsystems operating within the GCM Corridor.

## 7.1  GENERAL REQUIREMENTS

7.1.1.1.1  The software shall be modular.  Modularity is characterized by the ability to add, modify, replace, or delete modules without affecting other modules.  Modularity is attained by minimizing coupling, or interdepency, between modules or applications and maximizing functional cohesion.

7.1.1.1.2  The software shall be easily maintainable.  To achieve maintainability the use of well-defined system interfaces, modularity, high-level programming languages, layering and abstraction, up-to-date system documentation, and adherence to industry standards will be maximized.

7.1.1.1.3  The software shall be flexible.  Flexibility is the ability to adapt the software for different environments and domains, while minimizing code changes and recompilation. Flexibility is supported through parameterization (obtaining environmental parameters from input files, database, conditional compilation, etc.), data-driven approaches, and the use of object frameworks and proxies.

7.1.1.1.4  To the extent possible, the software shall be designed to be parameter driven and to obtain specific details regarding its operating environment and connections from input parameters, compilation parameters, parameter files, database entries, and from the CORBA trader or naming services.  Global variables and shared memory shall be avoided to the extent possible.

7.1.1.1.5  The Gateway design shall allow new attributes and methods to be added to objects without requiring existing interfaces to be rewritten.

7.1.1.1.6  Communication links connecting the Gateway and regional hubs, as well as ITS subsystems, shall be protected from unauthorized access by using one of the following:

- use of secure private, dedicated lines,

- password access for dial-up lines (modems),

- data encryption for public networks (such as the Internet).

7.1.1.1.7  The Gateway TIS design shall allow for future security features.

7.1.1.1.8  Security for the Gateway TIS shall include moving the implementation into the CORBA ORB itself using an OMG Security Service.  The CORBA Security service will verify each object access against the assigned authorization of the user associated with the process making the CORBA requests.

7.2  OPERATING SYSTEM

7.2.1.1.1  POSIX-compliant operating systems  with ANSI- and POSIX-compliant source code shall be used.  As a minimum the following shall be met:

- POSIX.1003.1          System Application Program Language Interface

- POSIX.1003.2          Shell and Utility Interface

- POSIX.1003.4          Real Time Services

7.2.1.1.2  No proprietary operating systems shall be used.

7.2.1.1.3  The operating systems shall be multitasking and multi-user.

7.2.1.1.4  Maintenance and diagnostic software shall be provided to support the hardware.

7.2.1.1.5  The software shall identify the existence, location and type of malfunctions, and shall check all phases of system operation.  As a minimum, these tests shall include individual tests of the following:

- memory access, tested by reading and writing entire memory

- individual registers

- instruction execution

- interrupt and trap response

- I/O transfers, including all peripheral equipment

- all digital input/output equipment furnished

7.2.1.1.6  The operating system shall support distributed file systems, directory services, and remote procedure calls.

7.2.1.1.7  The operating system shall provide real-time extensions (reference POSIX 1003.4) for process priorities and preemptive scheduling.

7.2.1.1.8  The operating systems shall support the CORBA software.

7.3  APPLICATION

7.3.1.1.1  The Corridor Architecture shall support data fusion, or the capability of combining disparate data from various sources, into a common format for storage in a common database. This requirement encourages minimal processing within the Corridor Architecture relying upon, wherever possible, the data source system to provide as much of the data processing as possible.

7.3.1.1.2  The programming language for all newly developed application software shall be a high level, state-of-the-art ANSI-compliant higher order language (similar to C, C++, or Java).

7.3.1.1.3  Utilization of extensions to programming languages provided by vendors for a specific compiler shall be avoided.

7.3.1.1.4  Object oriented technology shall be used for designing, developing, and implementing the application software.

7.3.1.1.5   Object oriented technology shall be used for data modeling.

7.3.1.1.6   Distributed objects implemented through CORBA will be used for application to application interfaces.

7.3.1.1.7   CORBA Interface Definition Language (IDL) shall be used to define the application to application interfaces.  IDL facilitates language independent development.


## 7.4   USER INTERFACE

7.4.1.1.1   Software and hardware for the Gateway and regional hubs shall accommodate system control and operation, on-line operator interaction with the software and databases, report generation from the Gateway TIS and system support activities.

7.4.1.1.2   The user interface shall be a graphical-based user interface (GUI) with pull down menus and "hot" keys.

7.4.1.1.3   The graphical displays shall use color where appropriate.

7.4.1.1.4   User commands and responses shall be in accepted traffic engineering or other non-specialist terms that can be readily comprehended by a trained operator and shall not be cryptic.

7.4.1.1.5   All user inputs which affect system operation (e.g., changing a parameter, stopping a process, etc.) shall be adequately protected from operator errors.

7.4.1.1.6   The Gateway and regional hubs shall provide for multi-user capability, whereby different users can interact with the system by means of the GUI simultaneously from different terminals.

7.4.1.1.7   The terminals shall have full and complete access to the application software and the operating system software dependent only on the access level of the user logged on.

7.4.1.1.8   There are two (2) means by which the user can request actions to be taken by the Gateway and regional hub systems:

- Operator request.  Operator requests shall take place immediately and shall have priority over activity scheduler.  Operator requests include standard reports, map displays, data inputs, and data modification.

- Activity scheduler.  Operator generated requests which are scheduled for completion by time of day and day of week.  Examples includes: reports, tape backups, file and log maintenance, etc.

7.4.1.1.9   The user interface shall be capable of providing the ability to:

- display data in real time including the ability to display color coded congestion maps and tabular reports,

- manually enter data and to modify anecdotal and incident data received electronically from other sources where needed,

- monitor accuracy and efficiency of all processes on a system including the receipt and transmittal of data,

- list and/or print all system database and system monitoring information,

- maintain a record of actions by the operator in the form of a time sequential log including the details of the input commands and data,

- provide statistical information on system operations and run simple queries,

- provide for user configurable reports,

- allow for reports to be printed at scheduled times,

- be seamless to the operator when accessing various menus, reports and status's,

- display a visual alarm and an audible alarm when a process has failed or has experienced an unusual condition,

- maintain and display process status lights or other means which provide a way of identifying the occurrence of a processing error condition or when a process has failed including both the operation of the process and data flows into and out of the process.

7.4.1.1.10  The operator shall be able to display a corridor map showing at least all roadways involved in the GCM Corridor data collection.  In general, these roads include all NHS/SRA roads in the GCM Corridor.

7.4.1.1.11  The corridor map shall display icons which represent incidents, road closures, lane closures, CCTV cameras, VMS displays, ramp meters, loop detectors, weather sensors/conditions, which are either manually or automatically entered.

7.4.1.1.12  The corridor map shall be able to display the entire corridor area on one screen and selectively show underlying information with the use of layering.

7.4.1.1.13  The corridor map shall allow for reasonably quick zooming and scrolling.

7.4.1.1.14  The entire corridor area map shall be decomposable at least to a regional area; i.e., to a Gary, Chicago, or Milwaukee level.  Additional zooming and scrolling capability shall be provided with in the regional area map display.

7.4.1.1.15  The corridor map shall be able to display with user settable parameters, including, but not limited to, road levels, road colors and road names.

7.4.1.1.16  The corridor map shall be able to display state and jurisdictional boundaries.

7.4.1.1.17  The corridor map shall provide a display showing the location of all traveler information and collection devices and distribution sources including: detectors, sensors and field devices and TMC locations, appropriately labeled with their names.

7.4.1.1.18  The corridor map shall provide underlying details for a given icon by clicking on that icon.

7.4.1.1.19  Through the corridor map, the operator shall be able to manually input incident data using the map display and a menu, including the ability, where needed, to modify data received electronically or previously entered.

## 7.5  DATA MONITORING

7.5.1.1.1  The Gateway and regional hubs shall be capable of displaying data in the GUI in real-time as it arrives.

7.5.1.1.2  Monitoring of events and graphical displays shall be updated automatically at the data receipt rate when being viewed by the operator; i.e. the operator should not have to perform a display 'refresh' in order to view the latest data received.

7.5.1.1.3  The operator shall be capable of displaying statistics on all traveler information gathered, by either pre-defined or user settable reports.

## 7.6  DATA ENTRY

7.6.1.1.1  Data entry shall be constructed so that it minimizes the operator's use of keystrokes, mouse clicks,  and time by adhering to the following data entry requirements:

- the operator can enter a minimum number of keystrokes in order to access a function,

- the operator shall not be required to memorize any commands,

- on-line help shall be available for all features,

- the primary input device shall be the mouse,

- the secondary input device shall be the keyboard utilizing hot keys.

7.6.1.1.2  The operator interface shall incorporate consistency checks into the data entry process. This would check for interrelationships between entry fields and limit entries based on programmed instructions (limitations) and data type and range checking where appropriate.

## 7.7  PERFORMANCE

7.7.1.1.1  The operator interface shall meet the following performance requirements:

- ability to present desired screen, window or process no later than five (5) seconds after the request is made at least 95% of the time,

- ability to begin printing a desired, predefined report no later than ten (10) seconds after the request is made, assuming an empty print queue,

- ability to scroll the map screen in a smooth manner without the need for excessive screen refresh.

## 7.8  DATABASE REQUIREMENTS

### 7.8.1  General Database Requirements

7.8.1.1.1  A standard database access method using direct database access shall be provided using industry standards such as Open DataBase Connectivity (ODBC) and Standard Query Language (SQL).

7.8.1.1.2  The Gateway TIS databases shall be used for storing working information such as logs, process information, input logs, etc.

7.8.1.1.3  Database file maintenance functions shall be provided to allow files to be created and updated on disk, to allow files to be transferred from disk to tape and to restore files back onto disk from tape.

7.8.1.1.4  The capability shall be provided to allow the creation of a duplicate copy of the database on tape, disk cartridge, or other suitable media form, and to restore the same upon request through an operator terminal.

7.8.1.1.5  The databases shall be designed and function in a way as to minimize any impact on operations while maximizing efficiency, speed, reliability, etc.

7.8.1.1.6  The databases shall be scaleable (i.e., additional disk or memory shall increase database storage and throughput capabilities).

7.8.1.1.7  The databases shall support the ability to coordinate data access among processes with data locking facilities.

7.8.1.1.8  The databases shall support multiple, simultaneous transactions without corruption.

7.8.1.1.9  The databases shall support extended transactions and shall not allow partial commits (i.e., will allow rollbacks of transactions).

7.8.2  Archiving

7.8.2.1.1  The system shall provide off-line data store for archived/historical information on a computer readable removable media.

7.8.2.1.2  An automated or operator initiated data migration from the active system to the archive system shall be supported.

7.8.2.1.3  For automated archiving, the system shall support archiving without operator intervention to insert additional media.

7.8.2.1.4  For operator initiated data migration, the system shall prompt the operator to insert additional media during the data migration, if necessary.

7.8.2.1.5  Computer readable removable media may include tape, floppy, or CD-ROM; however, the media shall be capable of storing data without operator intervention.

7.8.2.1.6  Sequential or random access media shall be used.

7.8.3  Backup

7.8.3.1.1  Both full and incremental backup capability for database and system files shall be provided.

7.8.3.1.2  The backup shall have no significant, sustained impact on system operation.

7.8.3.1.3  A full database backup or system backup shall take no longer than four (4) hours.

7.8.3.1.4  A daily database or system incremental backup shall take no longer than one (1) hour.

7.8.3.1.5  The system shall provide the ability to perform backups of data, logs, and selected files with no significant impact to on-line operation.

7.8.3.1.6  An automated or operator initiated backup of the active system  shall be supported.

7.8.3.1.7  For automated backup, the system shall support archiving without operator intervention to insert additional media if there are multiple media drives.

7.8.3.1.8   For operator initiated backup the system shall prompt the operator to insert additional media during the data migration, if necessary.

7.8.3.1.9   The system shall be capable of performing a backup of each physical disk to an appropriate media.

7.8.3.1.10   The system shall be capable of performing a database backup independently of a physical disk backup.

7.8.3.1.11   The backup process shall perform a backup media verification process in that the contents of the file on disk will be compared with the contents of the backup media and an operator alert will be generated for manual backups and a log file maintained for automatic backups.

## 7.9   OPERATIONS

7.9.1.1.1   The Gateway and regional hubs shall provide for controlled shutdown and startup.

7.9.1.1.2   The Gateway and regional hubs shall include self diagnostic routines for determining errors or system parameters which are near tolerance.

7.9.1.1.3   Shutdown of the Gateway and regional hub systems shall be performable in 10 minutes or less.

7.9.1.1.4   Startup of the Gateway and regional hub systems shall be performable in 10 minutes or less.

## 7.10   INTERPROCESS COMMUNICATION REQUIREMENTS

7.10.1.1.1   Interprocess communication between Gateway TIS programs shall exclusively use the CORBA standard.

7.10.1.1.2   Only where significant speed factors can be shown shall base level sockets communications be allowed between processes or between computers.  These sockets level communications shall be kept to the absolute minimum possible.

7.10.1.1.3   An ORB server shall operate on each server machine.

7.10.1.1.4   If possible, a single vendor of CORBA software shall be used.

7.10.1.1.5   The system shall also support a range of CORBA services including the following:
- Naming Service
- Event Service
- Security Service

7.10.1.1.6   TCP/IP shall be used for the lower transport, network, and data link levels.