GeoFocus Vehicle Information Management System

The GeoFocus Vehicle Information Management System (VIMS) is a network-based, state-of-the-art system that supports the use of a 100Base-T LAN as an intra-car trainline to deliver high-speed data to the major communication subsystems of a car. The same 100Base-T LAN may also be used to support an inter-car trainline to provide communications between other vehicles in the consist by using a network like the GeoFocus Reliable Ultra-fast Network for Rail (RUNR™) (patents pending). The RUNR system uses non-contact technology to provide true 100 Mbit/sec bandwidth for networked trainline communications across couplers.

Implementation of the GeoFocus VIMS components is easy and straightforward. The primary VIMS control element is the Vehicle Information Controller (VIC). The communication capabilities of the VIC are designed to take advantage of the 100Base-T LAN to stream audio, video, control and communications data throughout the electronic subsystems in the cars. As a focal point, the VIC interfaces and manages the control functions of all major on-board communication subsystems. These systems typically include:

- Controller Area Network
- 100Base-T LAN Reliable Ultra-fast Network for Rail (RUNR™)
- GeoFocus Video Management System
- Monitoring and Diagnostic System
- Public Address System
- Automatic Passenger Counting System
- Passenger-to-Operator-Intercom
- Signage
- Data and Voice Radios
- GPS/SDGPS
- Wireless LAN
- Train Operator Displays
- Communication Control Panel
- Switching Hub
The **Controller Area Network (CAN)** module enhances and expands capabilities of the VIC by increasing the number of I/O ports that can be monitored and controlled. The CAN module converts discrete digital inputs into a serial data bus that is used by the VIC to monitor and control various on-board systems.

Most of the microcontroller's I/O ports are interrupt capable, thus enabling very short response times. The CAN features an optically-isolated field bus interface and a battery-buffered Real-Time Clock (RTC). It contains 256 Kbytes static RAM and 256 Kbytes Flash memory and supports two galvanic-isolated power supply inputs that are protected against reverse polarity.

The CAN module supports up to: 24 digital inputs; 10 digital outputs; and 8 relay outputs. Additional configurations can also be provided. These inputs/outputs are used by the VIC to monitor and control systems and subassemblies such as: cameras, passenger intercoms, video recorders, volume controls, alarms, PA system, speaker zones, radio control, lights and flange lubrication.

**Reliable Ultra-fast Network for Rail (RUNR™)** is a (patent pending) high speed trainline (Ethernet) used to carry CCTV, VIMS audio (VOIP for PA, POIC, CCIC, etc), MDS, and other optional digital data. GeoFocus developed this non-contact technology to provide true 100 Mbit/sec bandwidth for networked trainline communications across couplers to interface with and control subsystems within its own car and other connected vehicles within the consist.

As an example of using RUNR™, audio data, such as a PA announcement, can be sent directly to the subsystem that uses that information in each vehicle. This efficient approach focuses functional processing in the subsystems on each car that use the data, keeping other subsystems free to handle their own processing activities. Developers can take advantage of the full processing power of each subsystem without accommodating unnecessary overhead. As opposed to separate buses for video, audio, signs, and MDS, an Ethernet network requires only one interconnection between vehicles, dramatically improving overall system reliability and reducing car wiring.

The **GeoFocus Video Management System (VMS)** is a rugged, mobile system that provides a complete solution for the routing and recording of video streams in the rail environment. Composed of a Master Controller, a Digital Video Recorder and an Intelligent Video Node, the GVMS can manage up to 16 high-resolution CCTV cameras (720x480) at video rates up to an aggregate of 240 frames-per-second to create a comprehensive closed-circuit TV system.
The Master Controller is a fully PC-compatible architecture that uses the industry standard Windows XP Embedded Operating System. The Controller and other components communicate over a 100 Mbps Ethernet network, conveyed between cars by the GeoFocus RUNR™ (Real-time Ultra-fast Network for Rail).

The Digital Video Recorder (DVR) compresses video to provide for weeks of visual information before video must be downloaded or overwritten. Different display and recording rates may be specified for individual cameras based on time-of-day or travel patterns, or can be programmed to respond to triggered events or emergency circumstances. Images may be sent to multiple monitors in Operator cabs. The DVR can handle up to 16 high-resolution cameras at 15 fps and can record up to 2 audio channels for each video channel.

The main function of a Monitoring and Diagnostics Subsystem is to collect, process, and report information to the crew and maintenance personnel regarding the vehicles subsystems operational status. The MDS Chassis is supported by a Monitoring and Diagnostics Logic (MDL) unit that is used to gather vehicle status from discrete analog and digital I/O lines and interface with the VIC via the Ethernet network. Vehicle status is processed and displayed on a Train Operator Display (TOD) screen to provide the Operator with general system information and actions to be performed in the event a system fault is detected. Information is reported via a Train Operator Display (TOD) located in the cab console of each cab. The information between the MDL and the various individual subsystems is exchanged via a Local Vehicle Network based on the LonWorks IEEE 1473-L protocol and various discrete inputs; the control and status information exchanges are performed via LonWorks network variables. Information is exchanged between the MDS unit in the Active Cab and MDS units of other cars in the Consist via a train network so that all MDS units on a train have access to the same information.

Typical status information normally collected/monitored by the MDS consists of:

- Odometer pulse
- Coupled Indication
- Vehicle Direction
- Active Cab
- Door status changes
- Consist determination
- Car ID
- Time
- Passenger to Operator Intercom status
- Fault information
The **Public Address Subsystem** permits automated messages and messages from Operator Communication Control (OCC) panels to be played either to interior and/or exterior speakers of the vehicle. PA systems are designed to provide uniformly distributed interior minimum sound pressure levels set by the amplifier and speakers used in a particular installation. The PA Systems output audio quality allows all messages to be intelligible and acoustically pleasing under the specified operating range. Speech and tone peaks are typically limited to approximately 3dB above the average input level. Exterior speaker volume is capable of automatic volume reduction during quiet periods such as early mornings and at night. Exterior volume may be electronically controlled independent of interior volume, depending on location and time of day considerations. Different zones may be programmed for: different messages; volume levels; and messages based on triggered events.

The PA amplifier is rated for appropriate output power and normally features a transformer coupled input, sound operated automatic level adjustments, and two output zone controls permitting selection of interior and/or exterior speakers. When no output is selected the PA amplifier is effectively muted; the amplifier will not emit noise when there is no active output or at the time when the amplifier is powered-on. The amplifier has a built-in Automatic Gain Control (AGC) that eliminates the need for a separate microphone for ambient noise sensing.

The GeoFocus VIMS system accommodates **Automatic Passenger Counting** systems to aid in revenue operation. The Automatic Passenger Counter subsystem, as its name implies, counts passengers as they enter and/or exit a door of the vehicle. Placing an APC at each door effectively counts passengers entering and/or exiting the vehicle. The system typically uses sensors that include a passive and active infrared component. Used in combination these passive and active elements permit 95% accuracy in passenger count without resorting to a mechanical device such as a turnstile.

The passive component utilizes a difference in heat radiation as an input. Every person emits heat radiation which results in a temperature difference compared to the environment. This heat radiation (long-wave and infrared radiation) can be measured with pyro-electrical detection devices. The significant feature of these detection devices is they do not register heat radiation itself, but changes in that radiation. A uniformly heated floor, for example, will produce no signal at the detector output. However, if there is an abrupt change in the heat radiation, the detector will emit a corresponding signal. This abrupt heat change will occur when a person passes within the measuring range of the detector.

The active component of the sensor uses light radiation as an input. Each person partially reflects the light hitting that person (short-wave infrared radiation). The active component of this sensor transmits infrared light toward the floor. This light beam is reflected by persons either crossing the light beam or standing within the measuring range of the sensor. A portion of this reflected beam reaches the receiver causing the sensor to emit a corresponding signal.
The signals of the passive component and the active component caused by persons passing the measuring range of the sensor will together undergo a pattern analysis. Persons entering and exiting are detected and the counts stored separately for each door during the counting procedure. APC units are connected to the VIC by means of a serial interface.

The **Passenger-to-Operator Intercom (POIC)** system provides passengers the ability to communicate with the operator in the event of safety or medical emergencies. Connection to the VIC allows the POIC to not only carry on communications but also allows that communication to stimulate other operations in response, such as initiating a video/audio recording of the event. The intercoms incorporate a “press-to-latch” feature allowing communication with the train operator without the need of continually press the push button to talk.

The IC-POC implements both an audio and a control bus. The audio bus permits a single audio connection to be “daisy-chained” between all POIC units within a vehicle. The control bus utilizes an RS485 interface to communicate when the passenger “press-to-latch” pushbutton is pressed, controls the direction of the conversation, and selects which POIC is active.

**On-vehicle signage** — the Vehicle Information Controller (VIC) controls interior and/or exterior information signs, displaying text announcements and destination/time information for passengers. The VIC can be defined to operate autonomously or with control through a centralized Operations Control Center (OCC).

The Passenger Information components primarily consist of the Destination Displays and Information Displays. The displays will be supervised by the Auto Announcer functions integrated into the Vehicle Information Controller (VIC). These type signs permit display of flashing, scrolling or paged messages. Signs are normally specified to meet the ADA requirements of character width-to-height ratio. The VIC supports the capability of displaying more than one type of font to allow the user to select longer non-ADA messages if necessary.

Each sign consists of one or more Display Boards which connect to a common Sign Control Board. The Display Boards may support either monochrome or color capabilities. The Sign Control Board contains the MPU, memory, and control circuitry necessary to drive the Display Boards; the common Sign Control Board is interchangeable with all sign types. Each sign stores a predefine initialization message which will be displayed on power up; no other predefined messages are stored.

The messages to be displayed are received from a serial EIA RS485 2-wire interface. The interface provides isolation between the sign and the sign network which is internal to the vehicle. Each sign is addressed by its Sign Identifier Code, the Sign Type and Sign Location (part of a proprietary sign message protocol), for sign messages and status information. Upon power-on each sign reads its Sign Identifier Code from a non-volatile
memory device; this device is contained in the same harness that provides power and implements a one-wire communication system.

The sign message protocol defines messages between the (VIC) and the Sign System. The VIC communicates with the network of passenger information and destination signs through the protocols defined in this section. The sign system normally consists of the following sign types:

- Front Destination Sign
- Side Exterior Destination Sign
- Interior Information Message Sign

**Voice and Data Radios** are controlled via analog and digital I/O. Ethernet compatible radios use the LAN to communicate with the VIC, which allows the radios to become an integral part of the VIMS. The VIMS uses the voice and data radios to facilitate 2-way communication with the Operation Control Center (OCC).

The VIC supports a **Global Positioning System (GPS)** based on GPS or Satellite Differential Global Positioning System (SD-GPS). Satellite Differential GPS systems improve the accuracy, integrity, and availability of the basic GPS signals. This type of system monitors and calculates its position using a network consisting of:

- ground reference stations across the USA
- master stations located at the East Coast and West Coast
- two geostationary satellites located above the equator

This network operates in conjunction with existing GPS satellites.

The ground reference stations are located at known positions and receive data continuously from the GPS satellites. The ground reference stations transmit their data to the master stations, which calculate the error of the GPS-received positions, and generate corrections data.

The master stations send their corrected 'differential' signals to the two geostationary satellites which broadcast the corrected data on the standard GPS frequency.

Note that the VIC supports other GPS subsystems and alternative means of determining vehicle location such as a wheel counter.

A **Wireless LAN** provides a means for connecting a car's Ethernet network to the maintenance facility to offload information and/or update system information allowing data, such as MDS and APC logs, to be uploaded from the vehicle while updates, such as route tables or messages, are downloaded to the vehicle. The wireless LAN is implemented with commercially available 802.11g Plus components so that advances in wireless LAN technology can be quickly implemented. The wireless LAN transceiver connects to the Trainline (Ethernet) through an external omni-directional antenna to
permit greater range and a higher transmission rate. The range and rate are a tradeoff between the antenna size, the desired coverage area, and the time required to transmit the data. As the vehicle approaches the Maintenance Facility the Wireless LANs will sense the presence of a compatible unit and begin data rate negotiations. Once the data rate is established the vehicle must then establish communications with the Maintenance Facility machine; only then does data transmission begin. The time to transmit the data will depend on the data rate negotiated and the quantity of data to be sent. The vehicle must be in reliable communications with the Maintenance Facility during the entire negotiation and transmission sequence which establishes the time and distance requirements.

The **Train Operator Display (TOD)** is a stand-alone Ethernet-connected touch screen device which acts as both a system monitor for the operator and provides TOD-based interactive control functions. The display screen structure includes a set of tabs which are selected (touched) to enable various system interfaces.

The **Communications Control Panel (CCP)** is a unit featuring a 20 position keypad, a backlit 4 line by 20 character LCD display, an RS422 interface, and an input supply range of 9 - 28 VDC. The CCP provides an interface for the train Operator to perform requested functions such as:

- Activates the public address system to initiate a live public address announcement
- Answer a passenger call on the Passenger to Operator Intercom (POIC)
- Activates the consist operator intercom.
- Enabled the voice radio from the operator's cab
- Select the route number for the current run
- Play a stored announcement over the public address system

The CCP is normally be used in conjunction with the Operator Handset, Push to Talk (PPT) switch and cradle.

An 8-port Ethernet **Switching HUB** is typically used to support intra-car communications hardware. It directs digitized audio and data to its intended destination, making the primary network connection to the Digital Video Recorder, the Monitoring and Diagnostic Logic, the Train Operator Display, and the Wireless LAN, as well as the Train Interface Unit (part of the hardware equipment for the RUNR 100Base-T LAN inter-car communication network).