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Vehicle Electronic Programming Stations (VEPS) System Specification for Programming Components at OEM Assembly Plants

Foreword—Along with the development of SAE J1708 and SAE J1587, methods were developed to exploit these communication resources for component customization at component vendor and vehicle OEM assembly operations. SAE J1924 documents the conventions that were established for component customization at vehicle assembly plants. These conventions established the terms Vehicle Electronic Programming Station (VEPS) and Vendor Communication Program (VCP).

The following System Specification in SAE J2214 supersedes SAE J1924. The system specification amends the VEPS computer system and identifies the interfaces used by Vendor Component Programs to customize vehicle electronic components. The principal change is the use of a common communications software interface for SAE J1708/J1587 communications by Vendor Component Programs. Each SAE J1924 Vendor Communication Program was permitted to assume that a unique means for conducting SAE J1708/J1587 communications was provided for it, the Vendor Interface Tool (VIT).

The requirements set forth here are intended to provide an orderly transition from Vendor Communications Programs defined in SAE J1924 to Vendor Component Programs defined in SAE J2214. The specification content was developed by tailoring the System/Segment Specification Data Item Description, DI-CMAN-8008, that is used with DoD-STD-2167A.

The organization of the VEPS specifications sets up an environment that is not vehicle network dependent. For example, SAE J2214 and SAE J2286 documents are applicable whether the network is SAE J1708 or SAE J1939 compatible. As new vehicle networks are developed, it is likely that a new CSCI 3 specification will be required.

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1. Scope

1.1 Identification—This system specification, SAE J2214, revises the requirements for Vehicle Electronics Programming Stations (VEPS) set forth in SAE J1924, OEM/Vendor Interface Specification for Vehicle Electronic Programming Stations. The requirements of SAE J2214 supersede the requirements defined by SAE J1924.

1.2 Introduction—The SAE J2214 specification describes the application of the MS-DOS™ environment to the customization of programmable components assembled in heavy-duty vehicles, where the components provide a communication link such as SAE J1708. Because the customization is performed using both OEM-provided and vendor-provided software, the roles and responsibilities of the vendor and OEM elements must be defined to permit the development of common vendor software elements for all Original Equipment Manufacturers (OEMs).

To bound the vendor software elements, the SAE J2214 allocates the system resources of an MS-DOS™ computer between the OEM and component vendors, defines the required elements comprising a Vehicle Electronics Programming Station, and identifies software interfaces needed between OEM-supplied elements and vendor-supplied elements. The software interfaces are described in SAE J2286 and SAE J1683.

By maintaining common elements with SAE J1924, the orderly transition from vendor Communication Programs to Vendor Component Programs will be assured. Beyond clarification of the SAE J1924 document, the changes to VEPS and Vendor Communications Programs are focused on the implementation of a common method for communicating with the vehicle's network for all vendor communications.

1.3 Background—Heavy-duty vehicle OEMs are not vertically integrated; vendors typically supply the same or very similar components to multiple OEMs who assemble them into their vehicle products. Each major vehicle component has multiple vendors who compete for component sales in heavy-duty markets. Individual orders select a set of components from this variety to meet the vehicle's desired performance requirements.

Given the selection process, each customer's order practically defines a unique vehicle. SAE standards for mechanical compatibility addressing flywheels, clutches, and flywheel housings have permitted individual components to appear interchangeable within the design limits of components and the vehicle's chassis. Together, OEMs and vendors offer a broad variety within their products. The addition of electronic component customization has made this variety seemingly infinite.

1.3.1 ELECTRONICS IMPACT—The introduction of electronically controlled components for heavy-duty vehicles such as diesel engines, transmissions, and anti-lock brakes coincided with the introduction of new product features that were integrated within the components' controllers. Functions such as cruise control and road speed limiting required that controllers providing such features be calibrated with specific information related to the equipment installed on the vehicle such as tire size, and rear axle ratio, in addition to desired operating speeds. The information items calibrated within controllers became known by the term, programmable parameters. Programmable parameters are calibrated using the controllers' data links. This act customizes component performance to comply with the customer's intentions.

1.3.2 SAE J1924 FEATURES AND SAE J2214 CHANGE SUMMARY—SAE J1924 describes a common interface format for describing how the OEM could specify the values needed for each programmable parameter. Each parameter's requirement for an assembly job is entered as a record in an ASCII file. This file, the parameter file, is interpreted by Vendor Communication Programs which perform the programming specified. The programming result for each parameter is reported as a record in the verification file. The definition and remarks files document the parameters that can be programmed for a particular electronically controlled product.

SAE J2214 retains all four of the SAE J1924 defined files. SAE J2286 adds record type "F" to clarify the use of files to contain an individual parameter value. Record type "P" is unchanged in the parameter and verification files. A field to identify the Electronic Data Interchange label for a parameter is added to the definition file. Data type conventions for parameters representing Boolean information such as on/off and yes/no or representing an enumeration of option such as on, off, model, and mode2 have been added. Common file format elements are believed to provide the easiest route toward conversion of programming stations from SAE J1924 Vendor Communication Programs to SAE J2214 Vendor Component Programs. The file formats are described in SAE J2286, separating the system description defined by SAE J2214, from the information interface for vehicle assembly job related programming data file.

SAE J2214 requires that communication with the vehicle's network be conducted by all Vendor Component Programs using a common means. The common communications provision for the SAE J1708/J1587 vehicle network is SAE J1683, MS-DOS™ Interface for SAE J1708 Communications. The common communications provision eliminates the proliferation of Vendor Interface Tools needed to support each programmable component under SAE J1924, and eliminates the need to use multiple RS-232 communications ports for Vendor Interface Tools. Thus, the setup record for the communications COM port has been eliminated. A new setup parameter is defined to support identification of the interrupt vector for the common communication facility to Vendor Component Programs.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1587—Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicles
SAE J1683—MS-DOS™ Interface for SAE J1708 Communications
SAE J1708—Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicles
SAE J1924—OEM/Vendor Interface Specification of Vehicle Electronic Programming Stations
SAE J2286—Vendor Component Program Data File Interface for OEM Assembly Operations

2.1.2 DOD STD 21671 RELATED DOCUMENTS—Available from the U. S. Government, DOD SSP, Subscription Service Division, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

Dod STD 2167A—Defense System Software Development
DI-CMAN-80008—System/Segment Specification
DI-MCCR-80026—Interface Requirements Specification
DI-MCCR-80027—Interface Design Document
DI-MCCR-80028—Data Base Design Document

2.1.3 TMC PUBLICATIONS—Available from The American Trucking Association, Alexandria, VA.

TMC RP 1202 Off-Board Diagnostics Standards

3. Abbreviations and Acronyms

ASCII—American Standard Code for Information Interchange
CSCI—Computer Software Configuration Item
DI—Data Item
DoD—Department of Defense
HWCI—Hardware Configuration Item
I/F—Interface
MCCR—Mission Critical Computer Resource
MFG—Manufacturing
MID—Message ID as Defined in SAE J1587
MIS—Management Information System
OEM—Original Equipment Manufacturer
PC—Personal Computer
PID—Parameter ID as Defined in SAE J1587
RP—Recommended Practice
SAE—Society of Automotive Engineers, Inc.
SW—Software
STD—Standard
VCP—Vendor Component Program
VDT—Video Display Terminal
VEPS—Vehicle Electronics Programming Station
VIT—Vendor Interface Tool

3.1 Trademark Acknowledgments

MS-DOS is a trademark of Microsoft, Inc.

4. Requirements—The requirements for Vehicle Electronic Programming Stations (VEPS) are discussed from a functional perspective in 4.1. Section 4.2 reviews the impact of environmental conditions on VEPS equipment. Section 4.3 discusses personnel issues related to the installation and operation of VEPS. Sections 4.4 and 4.5 review quality factors impacting VEPS and its use in OEM assembly plant operations.

4.1 System Definition—Section 4.1 discusses system objectives, enumerates system functions, and allocates individual functions to system elements. The internal and external interfaces among VEPS system elements are described in 4.1.7 and 4.1.8, following the configuration allocation in 4.1.6. Section 4.1.9 divides VEPS system element responsibility between OEMs and vendors.

4.1.1 SYSTEM OBJECTIVES—Figure 1 illustrates the process of programming the electronic components of a vehicle at an OEM assembly plant. The figure shows four assembly jobs progressing down the assembly line. Jobs 1 and 2 have been programmed. Job 3 is being programmed, and job 4 will be presented to the programming station. The station, represented as a desktop PC, has identified that job 3 was presented to it for programming and initiated the programming process.

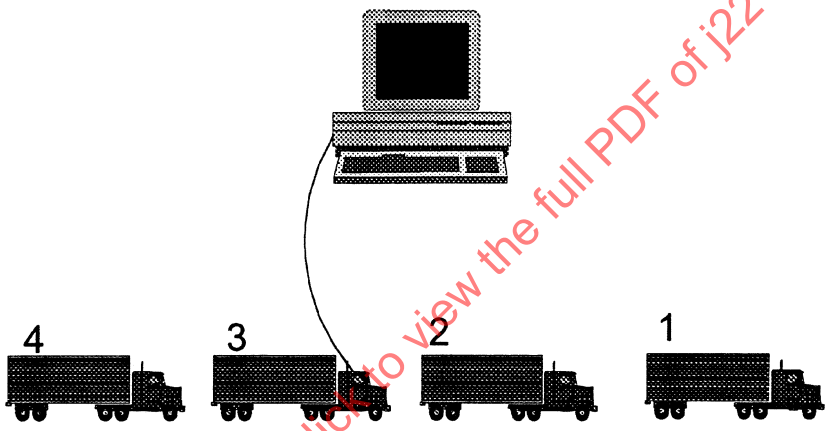

FIGURE 1—Assembly Line Component Programming

SAE J2214 provides the system specification for the programming station illustrated in Figure 1. Objectives to be met by Vehicle Electronics Programming Stations include:

a. Customize electronically controlled components to the customer's desires at vehicle OEM assembly plants.
b. Provide positive indications of programming results.
c. Simplify communications with the vehicle network.
d. Define Vendor Component Programs in such a manner that all component vendors can provide them to OEMs.

4.1.2 IMPLEMENTATION AND PERFORMANCE ISSUES—Two key issues in the implementation of Vehicle Electronic Programming Stations that are discussed as follows are:

a. Programming Process Performance Guidelines
b. Secure Programming Techniques

4.1.2.1 *Programming Process Performance Guidelines*—SAE J1924 established a performance guideline of 30 s for the programming of (individual) vehicle components. Such a process performance guideline clearly depends on the computer being used, the number of components being programmed, and the amount of information being programmed. The 30 s guideline is clearly an area where OEMs and vendors must cooperate to establish effective processes at assembly plants.

The Shop Floor Personal Computer described in 4.3 sets low minimum requirements for processor clock speed and processor type. OEM selection of a particular computer for use as the Shop Floor Personal Computer must be made considering the process cycle time desired for the programming step and the amount of computation to be performed during the programming process.

The most limiting factor may be the vehicle network itself. For example, the SAE J1708 vehicle network operation at 9600 baud can be a challenge for control modules that need a large number of parameters programmed. The vehicle network speed establishes a lower bound beyond which programming cycle time cannot be improved based on the amount of information to be transferred from the Shop Floor Personal Computer to the vehicle component being programmed. While the 30 s guideline should provide sufficient time to program the customer's parameter value selections, it may not be sufficient to address calibration needs beyond customer selected values.

4.1.2.2 *Secure Programming Techniques*—Programming security is another key issue in the development of VEPS as it is described in SAE J2214. Programming security seeks to protect vendor products from unauthorized changes and secure vendor product programming techniques in order to maintain product integrity.

The use of individual vendor interface tools (VIT) for each vendor's components in SAE J1924 permitted vendors a wide degree of latitude toward securing the programming process at OEM assembly plants. For example, VITs can serve as hardware keys designed to enforce software licenses by insuring that single use licenses are enforced. By eliminating VITs, SAE J2214 eliminates this avenue for securing programming techniques.

To permit OEMs to rapidly react to equipment failures in the Shop Floor PC, the use of add-on hardware of any kind to secure programming techniques is prohibited. Thus, only software techniques may be utilized by vendors to secure programming techniques. Software techniques must also meet the following restrictions. Techniques cannot:

a. Restrict the use of Vendor Component Programs to a single computer.
b. Prohibit the OEMs from programming parameters multiple times.

To permit OEMs to recover from failed programming stations, OEMs need the ability to reinstall vendor provided software either from original materials or archived copies. Vendor software that employs install once techniques, copy protection techniques, or techniques that 'lock' onto a computer system unique hardware attribute may not meet an OEM's equipment recovery needs.

While OEMs desire to program components only once, there are occasions where components may be programmed multiple times to account for last-minute equipment substitutions or as part of tune-and-test repair work. Limiting the number of programming attempts to a small number could place an artificial restriction on OEM processes resulting in vehicles that must be handled by the vendor or by some manual programming means prior to delivery. To prevent this, parameters must be capable of being programmed at least 100 times, even though it may be difficult to envision any circumstances where a vehicle would be programmed more than 5 times in normal practice.

4.1.3 SYSTEM MODES AND STATES—The VEPS station has one operating mode. The station conducts the programming of electronic components to customer desires. Potential communications architecture solutions and power provisions for the PC, communications gear, and vehicle components, define multiple states which VEPS station software development should consider.

Figure 2 illustrates two potential communications architectures that could be used to satisfy the SAE J1708 communications requirements. Item a) of Figure 2 exploits an existing RS-232 port which communicates with an external black-box that is connected to the SAE J1708 vehicle network. In item b), the communications facility for SAE J1708 communications is provided by an internal resource of the Shop Floor PC.

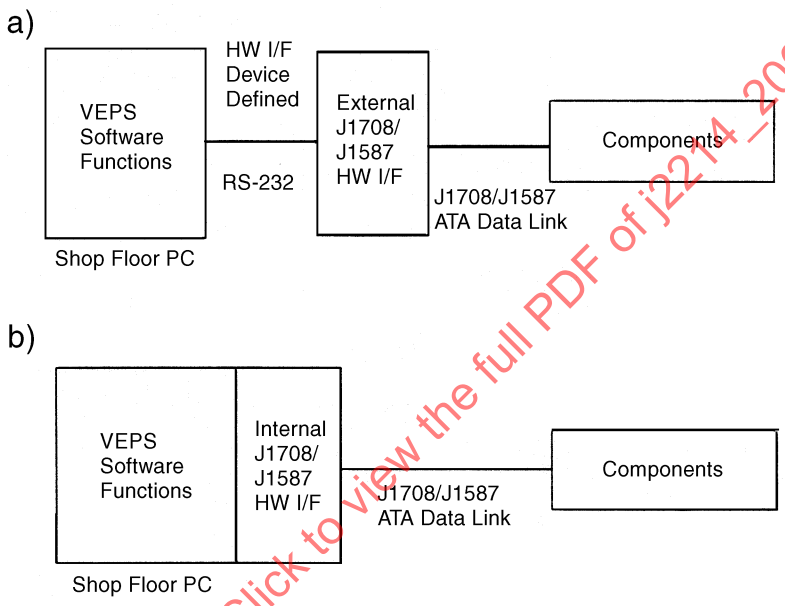

FIGURE 2—Shop Floor PC SAE J1708 Communications Architectures

The following error conditions apply to the architectures displayed in Figure 2. These error conditions evoke multiple states within the single operating mode:

a. SAE J1708 bus conductors are open or shorted...
   1. On the Vehicle
   2. Between the Vehicle and SAE J1708 Communications Device
b. No power is supplied to the vehicle component.
c. No power is supplied to the external communications means (if required).
d. The RS-232 communications lines between the PC and external communications gear are severed or mis-wired.

4.1.4 SYSTEM FUNCTIONS—Vehicle Electronic Programming Stations perform the following functions:

Function 1—Identify Assembly Job
Function 2—Extract Parameter Values
Function 3—Format Parameter File
Function 4—Invoke Programming
Function 5—Audit Parameter Values
Function 6—Program Parameter Values
Function 7—Report Programming Results
Function 8—Receive Vehicle Network Data
Function 9—Transmit Vehicle Network Data
Function 10—Initialize Vehicle Device
Function 11—Report Vehicle Device Status

The following paragraphs describe each function. Much of the processing required to satisfy Functions 2 and 3 can be performed off-line from the vehicle assembly programming process step.

4.1.4.1 *Identify Assembly Job (Function 1)*—Function 1 obtains the identify of the assembly job to be programmed and establishes which electronic components must be programmed at this station for that vehicle.

4.1.4.2 *Extract Parameter Values (Function 2)*—Function 2 extracts the set of data values to be programmed for each electronic component to be programmed at this station.

4.1.4.3 *Format Parameter File (Function 3)*—Function 3 associates a data value for each parameter name, forming the Parameter File for each component to be programmed at this station.

4.1.4.4 *Invoke Programming (Function 4)*—Function 4 initiates the programming sequence (functions 5, 6, and 7) for each component to be programmed at this station. Programming invocation shall assure that the data provided can be traced for each programing attempt to aid after the fact analysis of problems.

4.1.4.5 *Audit Parameter Values (Function 5)*—Function 5 confirms the parameter values provided conform to the vendor's requirements for the component being programmed. At a minimum, all parameters will be compared with a range of valid values. Other logical constraints may be evaluated on subsets of the parameters provided.

4.1.4.6 *Program Parameter Values (Function 6)*—Function 6 sequences and formats the parameter values into messages needed by the component being programmed.

4.1.4.7 *Report Programming Results (Function 7)*—Function 7 interprets the message replies and reports on the programming status. For each parameter, the report provides the resulting (as programmed) values, and audit errors indications (if any). Further, the report indicates various system and component errors.

4.1.4.8 *Receive Vehicle Network Data (Function 8)*—Function 8 provides a facility for functions to receive messages from the vehicle's network.

4.1.4.9 *Transmit Vehicle Network Data (Function 9)*—Function 9 provides a facility for functions to send messages to the vehicle's network.

4.1.4.10 *Initialize Communications Device Driver (Function 10)*—Function 10 initializes the communications device driver (CSCI 3), enabling the use of functions 8, 9, and 11.

4.1.4.11 *Report Communications Device Driver Status (Function 11)*—Function 11 reports the status of the communications device driver and provides network operating statistics.

4.1.5 SYSTEM FUNCTION RELATIONSHIPS—Figure 3 shows one view of system functional relationships. Function 1 is shown initiating functions 2, 3, and 4 based on the programming requirements of the assembly job. Function 4 initiates functions 5, 6, and 7. Elements of functions 2 and 3 can be performed off-line before the vehicle or component is presented to VEPS for programming. In this case, functions 2 and 3 serve to associate the result of function 1 with information stored from the off-line processing.

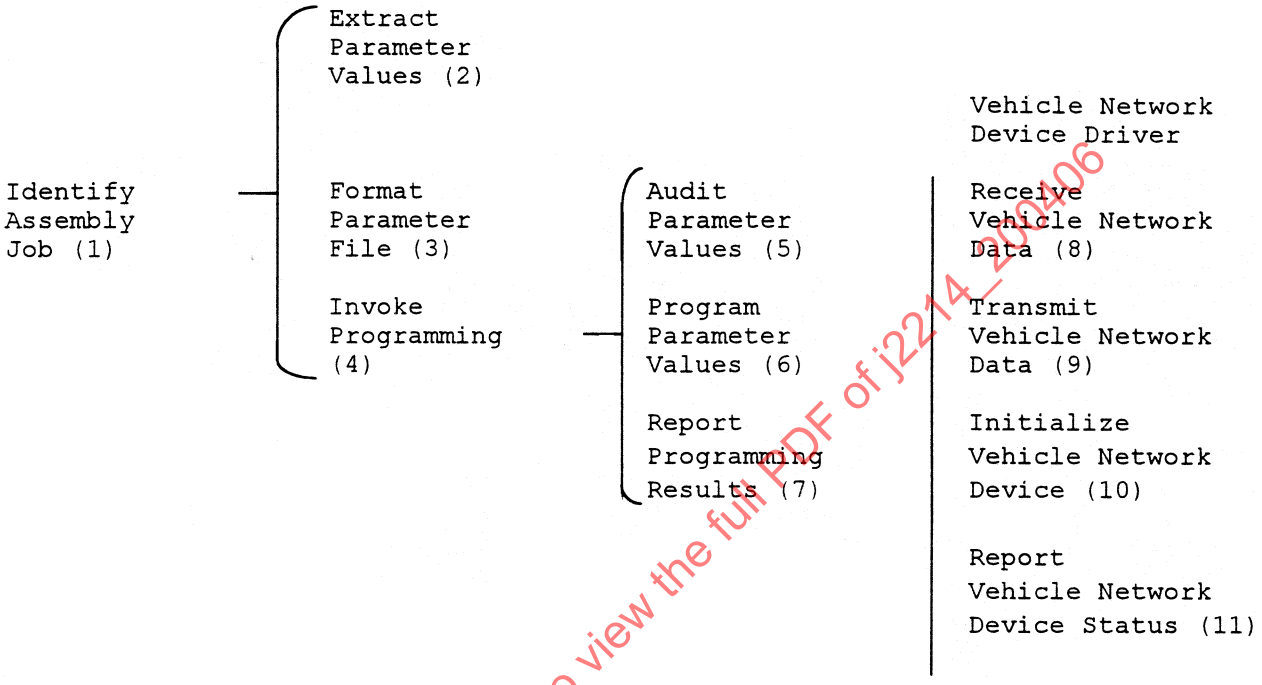

FIGURE 3—VEPS Operating Sequence by Function

Functions 8, 9, 10, and 11 form a device driver for vehicle network communications on a PC. The facility they jointly define may be used by any other function for communicating with the vehicle network. In particular, the vehicle network device driver will be used by functions 5, 6, and 7 to send programming messages to the electronic components installed in the vehicle.

4.1.6 CONFIGURATION ALLOCATION—The VEPS functions are allocated into four configuration items that are shown in Figure 4. Figure 4 also shows the interfaces among the configuration items, the vehicle and off-board resources. The four configuration items comprising Vehicle Electronic Programing Stations are:

a. CSCI 1—OEM Shop Floor Program
b. CSCI 2—Vendor Component Program
c. CSCI 3—SAE J1708 Communications Driver
d. HWCI 4—SAE J1708 Communications Device

Interfaces are discussed in 4.1.7. The following paragraphs describe the assignment of VEPS functions to software (CSCI) and hardware (HWCI) configuration items. The PC hosting these configuration items is discussed in 4.3 Shop Floor Personal Computer.

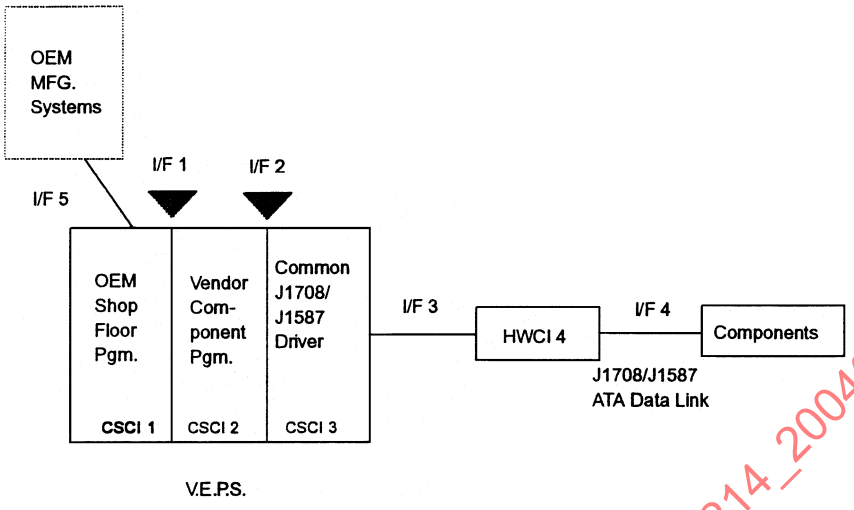

FIGURE 4—VEPS Computer Programs and Interfaces

4.1.6.1 *OEM Shop Floor Program (CSCI 1)*—CSCI 1 encompassed VEPS functions 1, 2, 3, and 4. Together these functions may not represent all the processing functions that an OEM may wish to consider for execution upon the Shop Floor PC. The OEM Shop Floor Program does represent the functions that must be accomplished to support the execution of CSCI 2.

There is no intention to specify the methods by which CSCI 1 processes its data. While it is anticipated that many OEMs will elect to implement some form of off-line processing that is communicated to CSCI 1 by interface 5 (I/F 5), the description of I/F 5 is dependent on OEM's manufacturing information systems architecture and processing equipment. Rather, CSCI 1 is described to facilitate the identification of the requirements for CSCI 2 through I/F 1.

4.1.6.2 *Vendor Component Program (VCP) (CSCI 2)*—CSCI 2 performs functions 5, 6, and 7 using CSCI 3 as the communications facility to assist in accomplishing the function. Through I/F 1, CSCI 1 communicates the desired data values for each parameter to be programmed. A vendor component program need support only one component or family of components produced by an individual vendor.

For the CSCI 3 that uses an SAE J1708 based vehicle network, the following recommendations are made. SAE J1587 defines MID 182 for use by Vendor Component Programs as the communicated with components at OEM assembly plants. SAE J1587 further defines PID 254 as the Proprietary Data Link Escape. MID 182 and PID 254 are the preferred means for Vendor Component Programs and Components to exchange information in programming messages and replies.

4.1.6.3 *Vehicle Network Communications Driver (CSCI 3)*—CSCI 3 serves as the communications facility to be used by VEPS functions 1 through 7. To perform functions 8 through 11, CSCI 3 just also implement interface 3 to obtain the vehicle network's data for use by functions 1 through 7.

When the CSCI 3 is for an SAE J1708 vehicle network, the communications device drivers implement I/F 2 as described in SAE J1683.

4.1.6.4 *Vehicle Network Communications Device (HWCI 4)*—HWCI 4 provides the physical means to conduct vehicle network communications. Figure 2 illustrates that two potential architecture classed based on the location of HWCI 4 (on-board or off-board). Thus, HWCI 4 supports CSCI 3 performance of functions 8 through 11.

4.1.7 VEPS INTERNAL INTERFACES—Figure 4 illustrates three internal interfaces within the VEPS software hosted by the Shop Floor PC. Interface 1 (I/F 1) is file-based between CSCI 1 and CSCI 2. Interface 2 (I/F 2) is between CSCI 2 and CSCI 3 and accomplishes the eventual communications from the Shop Floor PC to the vehicle network. Interface 3 identifies the interface between CSCI 3 and HWCI 4, allowing for the communication between the device driver and the hardware device supporting the vehicle network.

4.1.7.1 *I/F 1–OEM Shop Floor–VCP (CSCI 1–CSCI 2)*—Interface 1 is the bi-directional, file-based interface previously described in SAE J1924. The Parameter File provides the desired values of parameters described by the Definition File to CSCI 2. CSCI 2 returns the results of each parameter requires including system errors in the Verification File. SAE J2286 describes the content and initiation conditions for the Parameter file, Verification File, and Definition file. SAE J2286 also discusses file location in the Shop Floor PC's directory structure, file names, and invocation command line content for CSCI 2 programs.

4.1.7.2 *I/F 2–VCP to Vehicle Network Driver (CSCI 2 to CSCI 3)*—Interface 2 (I/F 2) is between CSCI 2 and CSCI 3 and accomplishes the eventual communications from the Shop Floor PC to the vehicle network.

4.1.7.3 *I/F 3–Vehicle Network Device Driver–HWCI4 (CSCI 3–HWCI 4)*—Interface 3 (I/F 3) supports the implementation of CSCI 3 by providing the means for it to communicate with the vehicle network communications device hardware (HWCI 4) for which CSCI 3 is designed. Because I/F 3 designs are peculiar to given implementations of HWCI 4, I/F 3 must be defined by HWCI 4 designers. Although no physical specifications are shown (or required) for the I/F 3, RS-232 may be used for this purpose, thereby exploiting a hardware resource typically present on the hardware platforms contemplated for the Shop Floor PC.

4.1.8 VEPS EXTERNAL INTERFACES—Figure 5 focuses on the two external interfaces to VEPS. Interface 4 (I/F 4) connects VEPS with the vehicle network permitting access to those components supporting it. Interface 5 (I/F 5) connects VEPS, a manufacturing shop floor system with the OEM's manufacturing information systems. When an OEM implements I/F 5, VEPS interfaces the vehicle electronically with OEM manufacturing information systems, permitting the systems to provide programming requirements electronically from the customer's order.

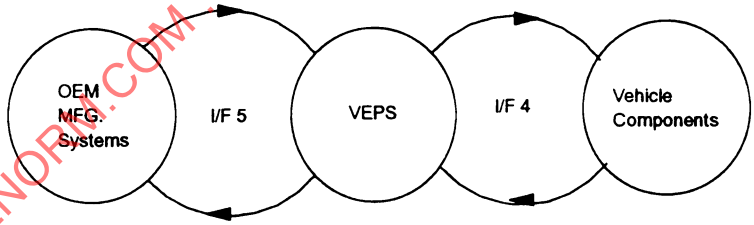

FIGURE 5—VEPS External InTerfaces

4.1.8.1 *I/F 4–SAE J1708 Device–Vehicle (HWCI 4 to Truck)*—Together, CSCI 3 and HWCI 4 form an interface between the shop floor PC and the vehicle. This interface shall conform to all the provisions of vehicle network specifications pertaining to but not limited to bit timing, bus access, bus length, and other electrical parameters. The information content of messages broadcast from the vehicle is defined by the applicable vehicle network specifications (i.e., SAE J1587). The information content of programming messages is defined by component manufacturers.

When I/F 4 is a SAE J1708 vehicle network the Vendor Component Programs should use SAE J1587 MID 182 for communications with components at OEM assembly plants. SAE J1587 defines PID 254 as the Proprietary Data Link Escape. MID 182 and PID 254 are the preferred means for Vendor Component Programs and Components to exchange information over I/F 4.

The OEM manufacturing processes should be designed to insure that the maximum bus length specified by the applicable vehicle network specification (i.e., SAE J1708) is not exceeded by the addition of the cabling used to connect HWCI 4 to the vehicle.

4.1.8.2 *I/F 5–OEM Shop Floor–OEM MFG Systems (CSCI 1 to MIS)*—Since this external interface is wholly controlled by the OEM, each OEM may design and implement this interface in conjunction with his design and implementation of CSCI 1. Interface 5 may be implemented by the OEM to electronically provide the programming requirements to the OEM Shop Floor Program (CSCI 1). Such requirements may include the results of off-line processing for functions 2 and 3. Furthermore, CSCI 1 may relay the programing results obtained from CSCI 2. Likely I/F 5 implementations network the PC to OEM defined information systems that support vehicle manufacture and assembly plant operation.

4.1.9 OEM AND VENDOR FURNISHED EQUIPMENT—Completed Vehicle Electronic Programming Stations combine elements furnished by both the OEM and Vendors. For each station, the OEM shall provide the following station elements:

a. Shop Floor PC (as described in 4.3)
b. OEM Shop Floor Program (CSCI 1)
c. Vehicle Network Device Driver (CSCI 3)
d. Vehicle Network Communications Device (HWCI 4) an cabling.

The vendor shall provide the Vendor Component Program (CSCI 2). Along with the VCP, the vendor shall provide an initial version of the definition file, parameter file, and remarks file as defined by SAE J2286. These files will confirm the programmable parameter content that may be programmed by the OEM for the customer. Section 4.4 discusses the impact of parameter disclosure on OEMs.

4.2 System Characteristics—OEMs control the facilities at their assembly plants and the manufacturing processes used to assemble vehicle. The presence of equipment used for heavy manufacturing and the operation of the assembly line may present an environment that is not suited to the direct use of personal computer equipment designed for the office environment. In their selection of equipment and its installation, OEMs should consider the physical requirements, environmental conditions, and electromagnetic compatibility of the equipment and the vehicle network.

4.3 Shop Floor Personal Computer (Processing Resource 1)

4.3.1 COMPUTER HARDWARE REQUIREMENTS—The Shop Floor PC shall consist of a microprocessor-based architecture computer meeting the requirements commonly referred to as PC-AT, PS/2, or compatible. The Shop Floor PC should have a minimum of 640 K bytes of random access memory, excluding that memory used to support any video display terminal.

4.3.2 COMPUTER OPERATING SYSTEM REQUIREMENTS—The minimum operating system requirement is PC-DOS™ 3.3 or MS-DOS™ 3.3. Vendor Component Programs shall be non-Windows applications. Software developers should also consider that communications network control software may also be co-resident with their software.

4.3.3 PROGRAMMING REQUIREMENTS—To permit the use of PC-AT class computers, CSCI 2 may not use the Intel 80386 instruction set.