PRELIMINARY

Clear Roads Universal In-Cab Performance Specifications and Communications Protocol

Last Revised 8/22/14

CLEAR ROADS

research for winter highway maintenance

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Glossary/Definition of Terms

Various terms are used throughout this document. Whenever one of the following terms is used, the corresponding definition is as follows:

Table 1: Glossary of Terms

COMPATIBLE AVL DEVICE	An AVL device that has been certified to meet the minimum requirements dictated by the Clear Roads organization to be used with this protocol.
COMPATIBLE SPREADER CONTROLLER	An electronic spreader controller system that has been certified to meet the minimum requirements dictated by the Clear Roads organization to be used with this protocol.
RS-232	A common serial communication standard used for connecting devices such as a computer and a printer. RS-232 defines a specific type of signal, timing, and connector pinouts.
ASCII	An acronym for the American Standard Code for Information Interchage, "ASCII" usually refers to data that appears as text - letters, numbers and select punctuation marks. ASCII tends to be more human-readible than other data types such as binary (all 1's and 0's), or hexadecimal (alphanumeric data with values between 0-9 and A-F), for example. Reference *ANSI X3.4-1986 (R1992), Information Systems – Coded Character Sets – 7-Bit American National Standard Code for Information Interchange (7-bit ASCII)*.
AVL	An acronym for Automatic Vehicle Location, which often refers generally to the subject of geographic location of a vehicle, or a vehicle's GPS location.
GPS	An acronym for Global Positioning System, which generally refers to using signals transmitted from satellites orbiting the earth to determine physical geographic location on the earth.
CRC	An acronym for Cyclic Redundancy Check, which is an error-detecting method used to ensure that data received by one device exactly matches the original data sent by the first device. With CRC, a value is calculated from the contents of the data that is being sent, and that CRC value is then sent along with the original data. The receiving device compares the data received with the CRC value, and can determine if the data is correct, or if it has been changed (corrupted) during transmission.
Associated in-cab electronics	The collection of devices, installed in or on the vehicle, that will employ this Clear Roads In-Cab Communications Protocol to communicate data. At the time of publishing, this term was meant to include a compatible Spreader Controller and a compatible AVL Device, but could include additional devices in the future.

Geo-stamp	GPS location data, or the process of adding such data, to a data string for the purpose of associating that data to the geographical location at which it was created. When used in this document, a geo-stamp is intended to include, at a minimum, instantaneous values for latitude, longitude, date and time. If a string is said to be "geo-stamped", it is to be appended with, or otherwise directly correlated to, the latitude, longitude, date and time at which that string was recorded.

PRELIMINARY Clear Roads Universal In-Cab Performance Specification and Communications Protocol

Foreword

This guide has been prepared as a collaborative effort championed by the Clear Roads Plug and Play Initiative to specify a universal bi-directional communications protocol for in-cab electronics, regardless of the manufacturer or service provider. Establishment of this protocol will mutually benefit Clear Roads member states and their vendors by standardizing how critical operational data is shared on modern snow and ice vehicles, namely between compatible Automatic Vehicle Location (AVL) devices and anti-icing/deicing Joystick and Spreader Controller systems.

The protocol defined in this document has been designed to be configurable and dynamic to provide the end user with the maximum available data at the lowest cost. Wherever possible, efforts have been made for this protocol to be backwards-compatible to support legacy equipment already installed across Clear Roads members' fleets, and to support the introduction of new parameters/technologies in the future.

Disclaimer

This is a Clear Roads preliminary draft protocol; it is not final. It has been released solely for the purposes of obtaining public comment and feedback. After the comment period is complete (2/28/14), all comments will be adjudicated and answered by the Clear Roads Technical Advisory Committee. All comments and all responses to comments will be posted on the Clear Roads website.

For Developers and/or Interested Vendors

Companies interested in obtaining a Certificate of Compatibility documenting their support for the protocol described in the General Information section (hereby called Applicant) must provide basic company and product information as outlined below.

Prior to receiving access to the Clear Roads Test Bed Software, Applicants must:

A. Provide a Primary Contact with complete contact information for correspondence during and after evaluation
B. Provide the brand name and type of product for evaluation.
C. Include a product data sheet or website address with additional product details.
D. Agree to the Terms and Conditions to access the Plug and Play Test Bed Software, which protect the Clear Roads Intellectual Property rights.
E. Provide the agency and contact information for any customers that are Clear Roads member states.

Once Clear Roads has that initial information, the Administrator will provide access to the Test Bed Software. Clear Roads will maintain a list of Compatible products on the Clear Roads website.

Applicants will receive Clear Roads Certificate of Compatibility Upon:

A. Successful demonstration to the Clear Roads Committee of Applicant's product against a standardized software model:
    1. If the Applicant's product is to be approved as a compatible AVL Device, it must be demonstrated to work with the software model of a compatible Spreader Controller.
    2. If the Applicant's product is to be approved as a compatible Spreader Controller, it must be demonstrated to work with the software model of a compatible AVL Device.
    3. A successful demonstration against the software models shall include confirmation that the Applicant's product meets the entirety of the specifications included in this document in the General Information section.
B. After a successful demonstration, a certificate will be automatically generated to provide proof of Compatibility.

General Information

A. Hardware Compatibility/Interface Connection

In order to support the Clear Roads Universal In-Cab Performance Specification and Communications Protocol, the associated in-cab electronics must include a minimum of 100kB of non-volatile on-board memory so that raw data can be stored on-board those devices if communication between devices or between the vehicle and the server is interrupted or unavailable.

An essential requirement of all hardware to support the protocol is a bi-directional RS-232 serial port with performance characteristics similar to those described in the specification "*TIA-232-F Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange*" issued in 1997. The Clear Roads Universal In-Cab Performance Specification and Communications Protocol varies from the TIA-232-F specification specifically in the maximum supported data rate, the use of a 9-pin connector and the use of only the TXD, RXD and GROUND signals. There is no requirement for hardware handshaking. It is not the intent of this Clear Roads Universal In-Cab Performance Specification and Communications Protocol to require specific signal timing characteristics, but rather to provide stable communication at the device's advertised max data rate.

With the objective of achieving a consistent hardware installation for compatible devices using broadly available off-the-shelf cables:

A.1 Compatible Spreader Controllers shall provide RS-232 connectivity through a female 9-pin SUB-D connector similar to Figure 1 with (2) 4-40 jack screws and the following pinout:

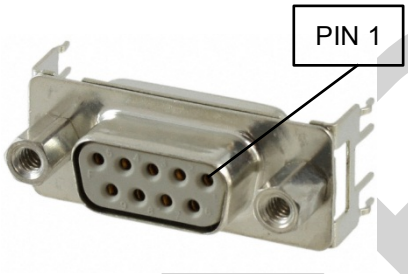

Figure 1: EXAMPLE Female 9-pin SUB-D Connector on compatible Spreader Controller

PIN	DESCRIPTION
1	Not Used
2	TXD
3	RXD
4	Not Used
5	Ground
6	Not Used
7	Not Used
8	Not Used
9	Not Used

A.2 Compatible AVL devices shall provide RS-232 connectivity through a male 9-pin SUB-D connector similar to Figure 2 with (2) 4-40 jack screws and the following pinout:

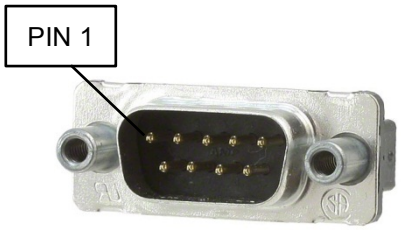

Figure 2: EXAMPLE Male 9-pin SUB-D Connector on compatible AVL Device

PIN	DESCRIPTION
1	Not Used
2	RXD
3	TXD
4	Not Used
5	Ground
6	Not Used
7	Not Used
8	Not Used
9	Not Used

B. Interpretation of Instruction Formats Contained in this Guide

Throughout this guide various examples will be used to aid in the interpretation of the text. The example strings that are transmitted between the Spreader Controller and the attached AVL Device will be contained between double quotes. Information that appears in *ITALICS* inside the double quotes should be replaced with the actual information that is sent or to be received. Control characters will be contained within the following symbols < >. The following table can be used to interpret the ASCII value of the control characters used.

Control Character	**ASCII Equivalent (hexadecimal value)**
<cr> or <CR>	0x0D
<lf> or <LF>	0x0A

C. Communication Setup – Auto Baud Rate Negotiation

C.1 All units shall start out at a baud rate of 19200. Once communication has been established the usage baud rate can be negotiated. The following process is designed to have the AVL device serve as the master for the negotiations.

C.1.1 AVL Device queries the Spreader Controller for the maximum supported baud rate by sending a "%CR_GMBR<CR><LF>" message.
C.1.2 The Spreader Controller shall respond with a string that indicates the maximum supported baud rate for that unit. The string shall appear as "%CR_MBR|*maximum supported rate in bps*<CR><LF>".
C.1.3 The AVL Device can determine usage baud rate by selecting a value between the current baud rate of 19200 and the maximum baud rate. The selected baud rate shall be one of the standard rates: 19200, 38400, 57600, 115200.
C.1.4 The AVL Device shall send the message "%CR_SBR|*new rate*<CR><LF>" to change the baud rate for the remainder of the communication to the Spreader Controller.
C.1.5 The Spreader Controller shall respond with a "%CR_ACK<CR><LF>" to indicate that it has received the instructions.
C.1.6 The Spreader Controller shall then change the baud rate and wait for the AVL Device to re-establish communication.
C.1.7 The AVL Device upon reception of the ACK shall change its baud rate and transmit a "%CR_CONNECT<CR><LF>" at the new baud rate.
C.1.8 The Spreader Controller shall acknowledge the reception of the connect message with a "%CR_ACK<CR><LF>".
C.1.9 The units shall attempt to establish communication at the new baud rate for 30 seconds. If a connection cannot be established, the units shall return to the base baud rate of 19200.

D. Configuring Data from Vehicles

The Clear Roads organization actively maintains a list of data parameters meant to include all pertinent information used by the Snow and Ice Industry. This Data Parameter Library (DPL) is a publicly-available document controlled and hosted by the Clear Roads Committee, and may be amended occasionally as new sensors, treatment practices and technologies become available.

> IMPORTANT NOTE:
>
> The Clear Roads Data Parameter Library is considered a living document, and as such, the Clear Roads Committee may add to the list of available data parameters over time.

Every Clear Road member or other entity using this protocol (hereby referred to as Subscriber) will dictate which of the available data parameters defined in the DPL will be reported by the vehicles in their fleet, depending on available equipment on those vehicles. Therefore:

D.1 Providers of the compatible AVL Devices installed within each vehicle shall:

D.1.1 Provide Subscribers, via a standard web browser or other means, with an accurate list of available data parameters as defined by the Clear Roads DPL which shall be synchronized with the Clear Roads DPL within no greater than 24 hours prior to Subscriber login.

D.1.2 Provide a means for the Subscriber to create, save and edit a *Vehicle Configuration* for each vehicle in their fleet by selecting the desired data (if available), as defined in the Clear Roads DPL, to be collected from each vehicle.

D.1.3 Provide a means to specify the frequency at which the selected data parameters shall be sampled and recorded.

D.1.4 Provide a means to specify the frequency at which data collected by the AVL Device shall be reported from the vehicle (i.e. to the AVL provider's server/storage location).

D.1.5 Provide a means for the latest *Vehicle Configuration* to be pushed to the vehicles in the fleet in accordance with Section E.

D.1.6 Provide a means to confirm a given vehicle's configuration matches the *Vehicle Configuration* that was last saved.

D.2 Compatible AVL Devices shall:

D.2.1 Authenticate with a connected compatible Spreader Controller at power-up. *See Authentication Procedure* in SECTION K.

D.2.2 Receive any on-board/stored data from the Spreader Controller and send it to the server.

D.2.3 Receive and process the most recent *Vehicle Configuration* if pushed from the server.

D.2.4 Communicate a *Vehicle Configuration Header Message* to the connected Spreader Controller

D.2.5 Receive a corresponding message from the compatible Spreader Controller confirming/denying support for all requested data parameters and/or reporting intervals requested

D.2.6 Determine which, if any, of the data parameters requested are available from the AVL Device itself

D.2.6.1 AVL Device shall provide required data from sensors, etc., directly connected to the AVL Device

D.2.6.2 Any data requested in the Vehicle Configuration message that is redundant/duplicate between the AVL Device and Spreader Controller (i.e. date, time, vehicle speed, battery voltage) shall be negotiated and data from the most appropriate source shall be communicated.

D.2.7 Communicate the status of all requested data parameters and/or reporting intervals back to the AVL provider

D.2.8 Begin receiving and transmitting collected data from connected sensors and compatible Spreader Controller as dictated by the *Vehicle Configuration* message.

D.3 Compatible Spreader Controllers shall:

D.3.1 Authenticate with a connected compatible AVL Device at power-up. See Authentication Procedure in SECTION K.

D.3.2 Transmit any event data stored on-board the Spreader Controller to the AVL Device prior to receiving any updates to the *Vehicle Configuration Header Message*.

D.3.3 Provide means to receive the latest *Vehicle Configuration Header Message* from a compatible AVL Device when necessary

D.3.4 Enable/Disable reporting of supported data parameters as described in the *Vehicle Configuration Header Message*

D.3.5 Set reporting intervals for all supported data parameters as described in the *Vehicle Configuration Header Message*

D.3.6 Respond to the AVL Device with a confirmation message (see Section G) declaring:

D.3.6.1 Which data parameters in the *Vehicle Configuration Header Message* are available from the Spreader Controller

D.3.6.2 Which reporting intervals for each of the data parameters in the *Vehicle Configuration Header Message* are available from the Spreader Controller

E. Vehicle Configuration Message

Upon power-up, the AVL Device may receive a push update containing an updated or revised list of data parameters that must be reported by the vehicle.

E.1.1 The Vehicle Configuration Message shall include:
E.1.1.1 Clear Roads DPL revision information
E.1.1.2 Data parameter names, types, max field sizes, and reporting intervals – ALL exactly as documented in the Clear Roads DPL file. For instance, data parameter names shall exactly match the spelling and string length documented in the Clear Roads DPL

All other details concerning this Vehicle Configuration message are left to the AVL Provider to define as appropriate for their means of transferring that data.

F. Vehicle Configuration Header Message

After successful Authentication with the Spreader Controller, the AVL Device will send an ASCII string to the Spreader Controller to identify the data parameters that are to be reported, and potentially the intervals at which to report them.

F.1.1 The Vehicle Configuration Header Message shall be sent as an ASCII string in the following format:

"%VH|CRC|DPSET(x)|DPSET(x+1)|DPSET(x+2)|…<CR><LF>"

WHERE: %VH = string identifier for Vehicle Configuration Header Message
CRC = 16-bit checksum for the %VH string
DPSET(x) = "DPx_Name|DPx_Type|DPx_Interval"
DPx_Name = Data Parameter name as defined in Clear Roads DPL
DPx_Type = Data Parameter type as defined in Clear Roads DPL
DPx_Interval = Data Parameter reporting interval

F.1.2 Each DPSET shall describe a unique data parameter from the Clear Roads DPL as configured by the Subscriber.
F.1.3 There shall be one DPSET data triplet for each requested data parameter
F.1.4 The order in which the data parameters are initially defined in the %VH string:
F.1.4.1 Will replace any previously established field order in the Spreader Control and AVL Device
F.1.4.2 Will set the field order for all future %ST event data strings from the Spreader Controller
F.1.4.3 Will determine the field order for any %P or %E poll requests sent to the Spreader Controller
F.1.4.4 Shall only be changed as a result of a subsequent %VH string.

See Appendix A: for examples and additional information.

F.1.5 Some data parameters cannot be used to trigger generation of a data string, or may not be compatible with interval triggers. The value of the DPx_Interval field within the %VH string will vary depending on availability of interval triggers for that field:

IF:	THEN:
DPx_Interval=0	DPx is a trigger. It will generate a new data string anytime the value of DPx changes from the last reported value. DPx is included in every data string generated.
DPx_Interval=positive integer	DPx will be reported in every data string generated, and DPx is a trigger item that will generate a new data string after the given number of seconds, LBS, miles, etc. have elapsed

DPx_Interval=-1	DPx is NOT a trigger. It will be reported with every string regardless of if the value has changed since the last reported value

F.1.6 The Spreader Controller shall acknowledge receipt of the %VH string with “ACK<CR><LF>”
F.1.7 The Spreader Controller shall respond with “NAK<CR><LF>” if the CRC fails or if the message times out (is not completely received within 30 seconds of the first character of the string being received).
F.1.8 The AVL Device shall resend the %VH string if a “NAK<CR><LF>” is received or if no response is received from the Spreader Controller within 30 seconds of the string being sent.
F.1.9 After 3 unsuccessful attempts to send the %VH string and receive “ACK<CR><LF>”,
F.1.9.1 The AVL Device will record a “SPREADER COM LOST” event if no “NAK<CR><LF>” messages were received, or
F.1.9.2 The AVL Device will record a “SPREADER DATA CORRUPT” event if a “NAK<CR><LF>” message was received.
F.1.10 Optionally, the AVL Device shall sound audible and/or visual alarms to alert the operator to lost communication.

G. Spreader Controller Confirmation Message

After receiving and acknowledging the Vehicle Configuration Header Message from the AVL Device, the Spreader Controller will send a response ASCII string to the AVL Device to confirm the data parameters that are available to be reported by the Spreader Controller, their position in the data strings, their types, sizes and potentially the intervals at which to report them.

G.1.1 The Spreader Controller Confirmation Message shall be sent as a series of ASCII strings in the following format:

"%EH|CRC|MFG|MODEL|SER_NUM|FW|DP_FIELD_CNT<CR><LF>"
"%EI|CRC|DP(x)_FIELD#|DP(x)_Name|DP(x)_Type|DP(x)_Size|DP(x)_Interval<CR><LF>"
"%EI|CRC|DP(x+1)_FIELD#|DP(x+1)_Name|DP(x+1)_Type|DP(x+1)_Size|DP(x+1)_Interval<CR><LF>"
"%EI|CRC|DP(x+2)_FIELD#|DP(x+2)_Name|DP(x+2)_Type|DP(x+2)_Size|DP(x+2)_Interval<CR><LF>"
…
…
"%EU|CRC|DP(x+n)_Name<CR><LF>"
…

WHERE:
%EH = string identifier for Spreader Controller Confirmation Header Message
%EI = string identifier for Spreader Controller Field Information Message
%EU = string identifier for Spreader Controller Unavailable Field message
CRC = 16-bit checksum
MFG = 3-character Manufacturer ID
MODEL = 8-character value describing Spreader Controller model number/name
SER_NUM = 8-digit serial number of the Spreader Controller
FW = 10-character value describing Spreader Controller firmware revision at time of string generation
DP_FIELD_CNT = integer reflecting number of data parameters (fields) available to be reported by the Spreader Controller
DP(x)_FIELD# = Position in the %ST data string that the data parameter will be reported in
DPx_Name = Data Parameter name as the Spreader Controller will report it
DPx_Type = Data Parameter type as Spreader Controller will report it
DPx_Size = Maximum size of value that Spreader Controller will report for this data parameter. NOTE: this is the actual VALUE (LBS, GALs, MI, etc,.) that will be reported, i.e. before rollover. Must fit WITHIN the max size limit documented in the DPL document for the given parameter.
DPx_Interval = Reporting interval set for the data parameter within the Spreader Controller calibration settings
DP(x+n)_Name = name of data parameter that Spreader Controller will not report

G.1.2 The %EH header message shall be sent from the Spreader Controller first, followed by a %EI or %EU field information message corresponding to the first DPSET requested in the %VH message from the AVL Device

G.1.3 Subsequent %EI or %EU messages will be sent, totaling in a number of messages equal to the value of DP_FIELD_CNT in the %EH message; one information message for every DPSET requested in the %VH.

G.1.4 The AVL Device shall acknowledge receipt of each of the %EH, %EI and %EU strings with "ACK<CR><LF>" and shall attach a "geo-stamp" to all received messages.

G.1.5 The AVL Device shall respond with "NAK<CR><LF>" to any of the %EH, %EI or %EU strings if the CRC fails or if the message times out.

G.1.6 The Spreader Controller shall resend any string if a NAK is received for it or if no response is received from the AVL Device.

G.1.7 After 3 unsuccessful attempts to send a string and receive ACK, the Spreader Controller will record an "AVL COM LOST" event and *IGNORE ANY CHANGES RESULTING FROM THE LATEST %VH MESSAGE*. Optionally, the Spreader Controller shall sound audible and/or visual alarms to alert the operator to lost communication.

G.1.8 Any data parameters that were not available from the Spreader Controller, but are available from the AVL Device itself, shall be recorded by the AVL Device and reported with its unique identifier.

H. General Spreader Controller Event Data Generation / Transmission

The Spreader Controller can generate and transmit an event data string for various reasons. Depending on make/model and available options, upon the generation of a new event data string, the string is transmitted to an external device (i.e. AVL Device) through the serial port connector, stored in the internal memory on the Spreader Controller, or transmitted to an external device through the serial port *and* stored in the internal memory on the Spreader Controller for future retrieval.

Some data fields can be used as a trigger to generate a new data string. When the event data field is used as a trigger, a new string is generated when that field differs from its previous value. A new event data string can also be generated whenever an interval trigger, if supported by the Spreader Controller firmware, expires. The interval triggers can be a set time, distance, or material displacement, for example. The Spreader Controller shall limit the number of strings produced to 1 per second and all changes from the last string will be incorporated into the new string.

When event data strings are transmitted directly to a connected AVL Device as soon as they are generated, they begin with "%ST" prefix. If communication between the Spreader Controller and AVL Device is lost, or for any other reason event data strings are stored on-board the Spreader Controller in internal memory and transmitted at a later time, the data strings begin with a "%EB" prefix. NOTE: "Store-and-forward capability between the Spreader Controller and AVL Device is hardware-dependent, and some legacy equipment supporting this protocol may NOT be capable of on-board storage. Store-and-forward from the Spreader Controller may only be available on later models, check with your provider for specific product capabilities.

H.1.1 Every event data string shall be sent with one of the following formats:

"%ST|CRC|DATA<CR><LF>"

OR

"%EB|CRC|DATA<CR><LF>"

WHERE: %ST = prefix for event data strings immediately sent to AVL Device
%EB = prefix for event data strings that had been stored on-board the Spreader Controller but are now being transmitted to the AVL Device
CRC = 16-bit checksum
DATA = pike-delimited data in the field order established.

H.1.2 On power-up, following authentication but BEFORE processing any new %VH Vehicle Configuration Header Messages:

H.1.2.1 The Spreader Controller shall transmit the existing %EH, %EI and %EU information messages, followed by all %EB on-board event data (if available). This will ensure that any data previously generated with a different field order is transmitted prior to any potential changes that would corrupt the stored data.

H.1.2.2 If there is no on-board event data, the Spreader Controller shall still transmit the current %EH, %EI and %EU strings

H.1.3 The AVL Device shall always ACK or NAK every event data string sent by the Spreader Controller

H.1.4 The DATA portion of the event data strings shall consist of a series of pike-delimited fields, each field corresponding to an individual data parameter that is being recorded by the Spreader Controller, as defined by the %EI information messages. Because many of the data parameters reflect values that don't change as often as other values in the string, the data string will often contain mostly pikes with no information between them. However, the number of pikes in the string is always consistent; only the number of empty fields varies.

H.1.5 The Spreader Controller shall always transmit the first event data string as a fully-populated string. Every available data field will contain data in the first string sent after power-up.

H.1.6 The AVL Device shall NOT append GPS location data to %EB stored event data when received from the Spreader Controller[1].

[1]Since %EB data is generated when there is no connection to the AVL Device, there is no guarantee (in fact, it is quite unlikely) that the %EB data string was generated at the location where the %EB data is finally transmitted from the Spreader Controller to the AVL Device.

I. Polling Spreader Controller for Event Data

While most Spreader Controller event data will be generated based on normal interactions of the operator with the controller (changing set rates, pressing Blast, etc.) or by interval triggers, it may be necessary on occasion for the AVL Device to independently request event data from the Spreader Controller. To accommodate this need, the Spreader Controller shall generate and transmit either a fully-populated event data string or selectively-populated event data string in real-time when polled accordingly by a compatible AVL Device.

I.1.1 Compatible Spreader Controllers shall accept poll requests after successfully completing the standard startup procedures as described in Section F and Section G.

I.1.2 Compatible Spreader Controllers shall accept and respond to poll requests if received during the typical operating mode described in Section H.

I.1.3 To generate a fully-populated complete event data string on request, AVL Devices shall transmit a "%P<CR><LF>" message to the Spreader Controller.

I.1.4 To generate a partially-populated complete event data string where all fields defined at Initialization are returned, but only the data fields specified by the AVL Devices will contain values, the AVL Device shall transmit a "%Ezzzzzzzzzzzzzzzzz…<CR><LF>" message to the Spreader Controller,

WHERE: %E = Prefix for poll request of partially-populated event data string
zzz… = binary sequence of 1's and 0's with each "z" sequentially representing the data fields as defined during Initialization. If the value of a given "z" is an ASCII "1" the Spreader Control shall populate that field with the corresponding data, and where if the value of a given "z" is an ASCII "0" the Spreader Control shall leave that field empty.

I.1.5 The Spreader Controller shall reply to all %P and %E poll requests with a properly formatted string as per requirement I.1.1 - identical to strings not generated as a result of polling.

I.1.6 AVL Devices may optionally send one-shot poll requests to the Spreader Controller for individual data fields, or to define a custom-formatted event data string of selected fields by sending a "%PH|CRC|DPSET(x)|DPSET(x+1)|DPSET(x+2)|…<CR><LF>" message,

WHERE: %PH = string identifier for polled message contents
CRC = 16-bit checksum for the %PH string
DPSET(x) = "DPx_Name|DPx_Type|DPx_MaxSize"
DPx_Name = Data Parameter name as defined in Clear Roads DPL
DPx_Type = Data Parameter type as defined in Clear Roads DPL
DPx_MaxSize = An integer representing maximum size (bytes) allowed for the Data Parameter value

I.1.7 The Spreader Controller shall resume typical operating mode upon completion of servicing a poll request, with the same event string configuration that was in place prior to the poll request.

J. Checksum Calculation Algorithm

Data transferred between compatible Spreader Controllers and AVL Devices use a simple 16-bit checksum to help guarantee the data integrity. The data portion of the string consists of the items following the pike after the checksum up to the <CR> which terminates the string. The following algorithm shall be used to calculate the checksum.

J.1 The CRC-16 CCITT algorithm uses the polynomial 0x1021 ($x^{16} + x^{12} + x^5 + 1$). This algorithm assumes an initial value for the CRC of 0xFFFF and does not use the so-called augmented zero bits method.

SAMPLE STRING WITH CHECKSUM

"%ST|7EBC|SAMPLE|STRING||CRC 16|CALC<CR><LF>"

Where 7EBC is the CRC-16 CCITT checksum computed over the data portion of the string and the Data Portion of this example message is "SAMPLE|STRING||CRC 16|CALC".

CRC-16 CCITT Code Sample

```
#include <string.h>
#include <stdio.h>
const unsigned char pstrCurrentin[]= "SAMPLE|STRING||CRC 16|CALC";
const int iCountin = 26;

unsigned short crc16(unsigned char* pstrCurrent, int iCount)
{
unsigned short wCRC = 0xFFFF; //Seed value with 0xFFFF
int iIndex = 0;

// Perform the following for each character in the buffer
while(--iCount >= 0)
{
                        // Get the byte information for the calculation and
                        // advance the pointer
                        wCRC = wCRC ^ ((int)(*pstrCurrent++) << 8);

                        for(iIndex = 0; iIndex < 8; ++iIndex)
                        {
                                        if(wCRC & 0x8000)
                                        {
                                                        wCRC = (wCRC << 1) ^ 0x1021;
                                        }
                                        else
                                        {
                                                        wCRC = wCRC << 1;
                                        }
                        }
}

return (wCRC);
}
int main(void)
{
      short ocrc;

      ocrc = crc16(pstrCurrentin,iCountin);
      printf(" CRC  :  0x%x\n", ocrc);
      return(0);
}

OUTPUT:                                 CRC  :  0x7ebc
```


K. Initialization/Authentication

Once the Spreader Controller and AVL devices have booted to a point where serial communications may be initialized, they must establish a secure bidirectional communications link through a process hereby called Authentication. Authentication ensures compatibility of devices by confirming that only Clear Roads Certified products are connected and that the data being communicated is secure and accurate.

The following process is designed to allow the AVL device and the Spreader Controller to reach the communication ready states in any order.

K.1 Within 180 seconds of power ON event a connection should be established or an error message should be indicated.

K.1.1 Initial device communication shall occur at a baud rate of 19200 bps.
K.1.2 Upon becoming communication ready
K.1.2.1 AVL Device shall transmit a "%CR_AVL<CR><LF>"
K.1.2.2 Spreader Controller shall transmit a "%CR_SPDR<CR><LF>"
K.1.3 The AVL device shall respond to a "%CR_SPDR<CR><LF>" with a "%CR_CONNECT<CR><LF>"
K.1.4 The AVL device shall repeat the "%CR_AVL<CR><LF>" every 30 seconds until communication is established or the system times out.
K.1.5 The Spreader Controller shall respond to a "%CR_AVL<CR><LF>" with a "%CR_SPDR<CR><LF>"
K.1.6 The Spreader Controller shall respond to a "%CR_CONNECT<CR><LF>" with a "%CR_ACK<CR><LF>"

POSSIBLE SCENARIOS:

AVL Device is ready before the Spreader Controller

- The AVL Device will send a "%CR_AVL<CR><LF>" to the Spreader Controller. This message will not be received since the Spreader Controller is not actively receiving messages.
- When the compatible Spreader Controller becomes ready for serial communication it shall send a "%CR_SPDR<CR><LF>" to the AVL Device.
- The AVL Device shall respond with a "%CR_CONNECT<CR><LF>" string.
- The Spreader Control shall acknowledge the connection request with a "%CR_ACK<CR><LF>".
- The system will transition into baud rate negotiation

Spreader Controller is ready before the AVL Device

- The Spreader Controller will send a "%CR_SPDR<CR><LF>" to the AVL Device. This message will not be received since the AVL Device is not actively receiving messages.
- When the AVL Device becomes ready for serial communication it shall send a "%CR_AVL<CR><LF>" to the Spreader Controller.
- The compatible Spreader Controller shall respond with a "%CR_SPDR<CR><LF>" to the AVL Device.
- The AVL Device shall respond with a "%CR_CONNECT<CR><LF>" string.
- The Spreader Controller shall acknowledge the connection request with a "%CR_ACK<CR><LF>".
- The system will transition into baud rate negotiation

L. Loss of Power Event

In order to differentiate between intentional and unintentional loss of communication between compatible Spreader Controllers and AVL Devices, compatible Spreader Controllers shall report a "power down" event to the AVL Device as part of the controlled shutdown process. It shall be understood that this section is intended to specify HOW a power down event shall be communicated WHEN AVAILABLE, but it is not a requirement of this specification that all products conform. It is understood and accepted that some products may not support this feature.

L.1 Upon a controlled loss of power (i.e. ignition OFF or power switch OFF), compatible Spreader Controllers shall report a "power down" event string in the following format:

"%PD_SPDR<CR><LF>"

L.2 This message shall be geo-stamped by the AVL Device and recorded as part of the logged event data from the vehicle.

L.3 After receiving the "%PD_SPDR<CR><LF>" message, the connected AVL Device shall disable communications with the Spreader Controller, as well as silencing related error messages, alarms, etc.

L.4 If power is restored to the Spreader Controller prior to an AVL Device power cycle, the AVL Device shall be ready to receive a new authentication request as defined in Section K.

M. Lost Communication Strategy

In certain situations, it may be necessary for the AVL Device to temporarily stop recording event data messages sent from the Spreader Controller as well as to resume receiving messages in a controlled manner. For example, in the event of lost communication between the AVL Device and a remote server, where the AVL Device is out of on-board memory.

M.1 In the event of lost communication with the Server, the AVL Device shall, at its option:

M.1.1 Continue normal event data operation, but store collected (and geo-stamped) data in the AVL Device on-board memory, OR

M.1.2 Send NACK messages to the controller for all event data messages sent by the Spreader Controller during the communication outage period, OR

M.1.3 Send a "%COM _OUT<CR><LF>" message to the Spreader Controller.

M.1.3.1 The Spreader Controller shall acknowledge the request with "%ACK<CR><LF>" and begin storing event data strings on-board with a "%EB" prefix as explained in Section H.

M.2 To resume normal event data operation with the Spreader Controller, the AVL Device will send a "%COM_IN<CR><LF>" message to the Spreader Controller.

M.2.1 The Spreader Controller shall acknowledge the request with "%ACK<CR><LF>" and:

M.2.1.1 First, send any stored event data from on-board memory to the AVL Device, then

M.2.1.2 Resume sending "live" event data to the AVL Device as events are generated