Site-Specific Management Guidelines

D. Humburg

SSMG-8

Standardization and Precision Agriculture— 'The Promised Land'

Summary

Progress toward increased use of electronic systems for precision farming applications will be enhanced by the introduction of standards for electronic communications on agricultural equipment and translation of spatial data formats. The standard J1939 will provide a uniform approach to communications on tractors and implements. The Transfer Support Layer (TSL) specification will allow for transparent use of maps from many different software companies on any system that adheres to the TSL specification.

Have you ever looked at a picture in a magazine of a progressive farmer with a stack of electronic monitors in the corner of his tractor cab and thought, 'The mechanical aspects of this business are enough. I don't need the headache of all of those additional electronics in my tractor.'? Or perhaps you *are* that farmer in the picture and you think, 'There *must* be a better way of coordinating the control of seed, chemical, fertilizer, and position than this mass of wires and monitor boxes!' Well, there is. Or at least there will be. It is called J1939, and it's coming soon to a theater (OK, field) near you. The J1939 and its international counterpart, ISO 11783, are proposed standards for communication in off-road vehicles and they have the potential to make farm equipment better. Before discussing the function of these standards, let's look briefly at how we got to where we are.

History and Electronics on Implements

If we look at a tractor and planter from the 1960s, it is clear that the machines were mechanical devices. I had an AM radio bolted to the fender, but other than that, and a simple circuit for lights (that occasionally failed), there were few electronics. Eventually we added electronic systems to selected equipment for specific reasons. Planter monitors helped avoid those embarrassing gaps. Sprayer boom switches reduced the plumbing that entered the cab. Since there was no existing wiring harness for these devices the developers necessarily created their own systems to provide control or warnings in the cab. More electronic systems were developed. Radar guns provided better estimates of ground speed. Sprayer controllers reduced unintended variation in application rates. Then the global positioning system (GPS) arrived, and with it, the possibility of doing lots of operations based on *where* we were in the field. However, now some of the electronic subsystems had to share information. Wiring that was originally developed as a part of a proprietary system now must interact with other systems and communicate in a format compatible with a computer. The short-term solution to this has been RS 232.

The standard RS 232 for serial communications has been used in computer applications for some time. It is the protocol that your mouse uses to communicate with your PC. Many peripheral devices for computers have used this as the method for getting information into and out of the computer, so it is not surprising that it has been used to link electronics in agriculture with computer systems. GPS receivers generally send their messages regarding position, speed, heading etc in a "sentence" using RS 232 (and sometimes RS 422). RS 232 is acceptable for providing two-way communication between two devices over reasonably short distances. But herein lies its weakness: ***two** devices* over reasonably *short* distances. If I want to use a notebook computer to control map-based operations, I will need to connect my GPS receiver to one serial port to make the current geographic coordinates available to the mapping software. A second serial port will be needed to communicate a variable such as seeding rate out to the planter. What if I also want to control fertilizer rate? I'll need another serial port. Each port has to have its own set of wires running to the connected device (**Figure 1**). It's as if you needed a separate telephone wire directly to each and every person you ever wished to speak with. Some day you may control seed population, seed variety, multiple fertility variables, herbicide rates, insecticide, innoculants, and who knows what else, simultaneously, but not with today's communications approach.

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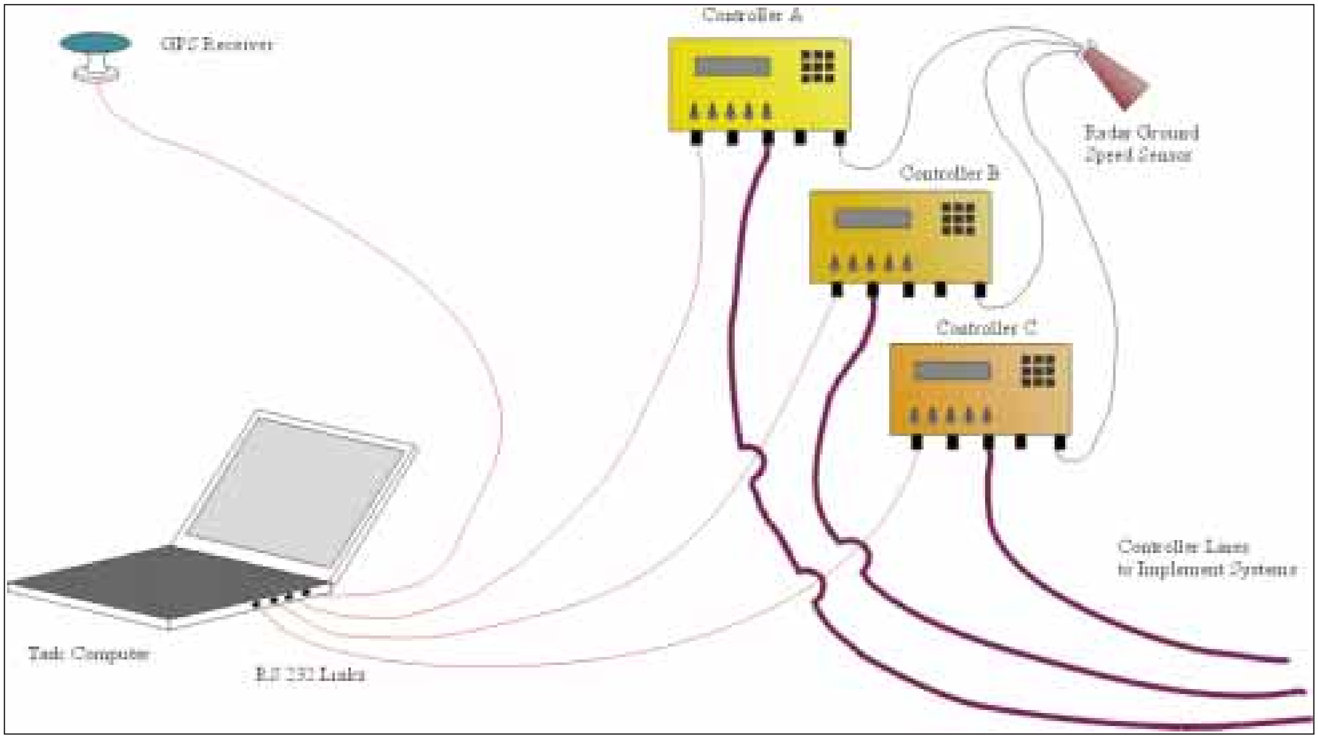

Figure 1. Wiring concept for a three-input variable system. The task computer requires four RS 232 serial ports to communicate.

A Computer Network for Tractors and Implements

So what's the alternative, you ask? Well, to be fair, some manufacturers have developed better networks, but they tend to be specific to their own equipment and not easily connectable or compatible across brands. The standard **J1939** is being developed to solve these and a host of other problems. Without going into all of the gory details, I will describe what the J1939 standard embodies and how it might make your equipment work in the future.

The standard SAE (Society of Automotive Engineers) J1939 is a seven-layer communications network that is similar to the networks that connect computers in business and the internet. The network is a "peer to peer" system. It is like an old party line telephone (which I actually remember). Anyone on the line can listen to anything that is transmitted. Ostensibly, you would only act or respond if someone addresses you, but you can monitor messages or conversations among many different locations (which I *never* did). J1939 uses a CAN bus, or "Controller Area Network", concept. Each device or "node" on the network has an ECU, or electronic control unit, that is able to monitor the network for messages that it requires and perform control functions. *All* of the messages travel to all parts of a single wiring harness. Messages have a unique identifier at the beginning so that the controller at each node can tell if this is one of the messages that it uses. It accepts those that it has been programmed for and ignores all others.

Let's look at a potential example and how this differs from today's approach. In a J1939 compliant system, the GPS receiver would be connected as a "node" on the network and would send its coordinate (geographic location) message out perhaps once per second (**Figure 2**). The task computer that has the map of planned chemical application rates would recognize this longitude-latitude message on the network and accept it. Comparing these coordinates to the management units on the map, the program can then determine the appropriate chemical rate for the current location. The task computer then sends the appropriate rate out as a "chemical rate" message on the network. The chemical application controller on the sprayer recognizes and reads the rate message as it comes around. The chemical controller also needs to know ground speed and which boom sections are *on* to determine the current flow rate. That's not a problem, because radar ground speed from the tractor is another message that is regularly sent out onto the network, as is the boom status. The chemical controller reads all of these messages and calculates the appropriate flow rate to achieve the desired application rate. The current actual rate, as measured at the flowmeter, is sent out by the chemical controller on the network. The task computer recognizes this message and logs it with the current coordinates in the map of applied material for your records. The exact same type of sequence could be used to describe seeding rate or fertilizer rate control. Since the network standard accommodates up to 700 messages per second, there is room to do a lot of things. All of this communication among devices occurs along a single cable that is made up of four strands of wire. Even mundane things like turning on the flashing lights at the back of an air till drill for transport may be done using this system, thus eliminating the need to run a separate set of switched wires from the cab out to those lights. The lights are just another node on the implement "bus".

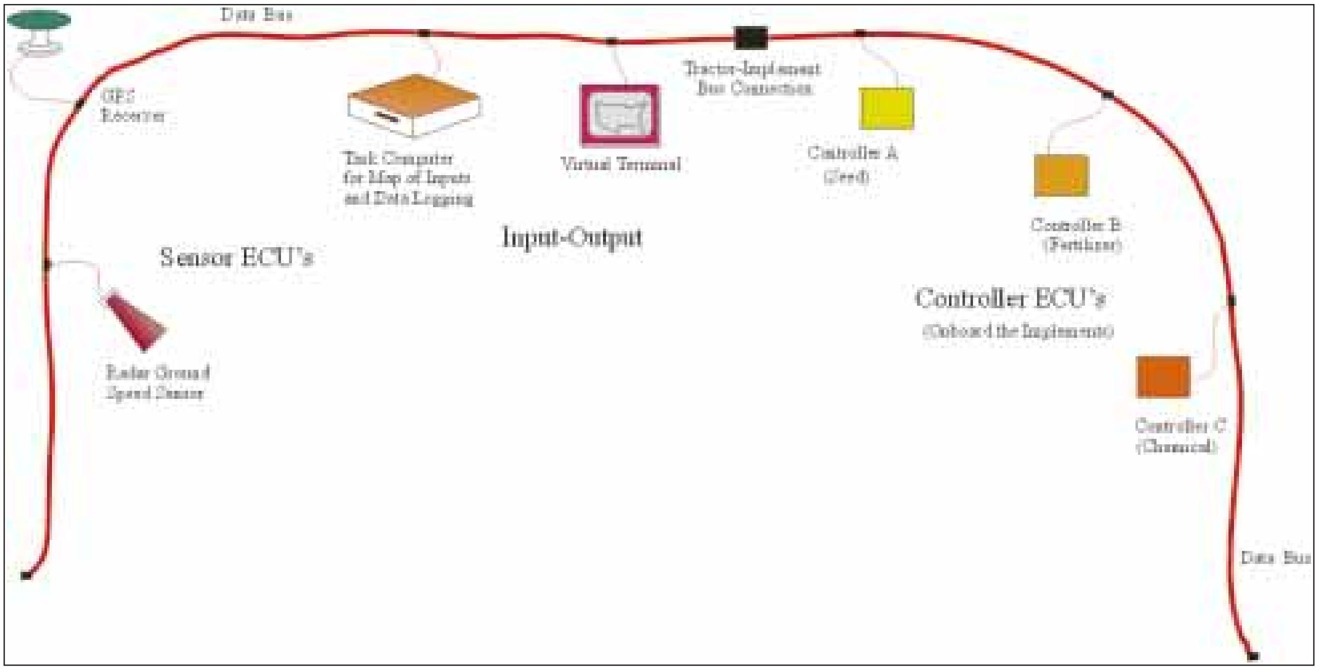

Figure 2. The simplified wiring of a CAN and the J1939 network protocol. All messages from devices on the network are available to other devices. Maps developed on a desktop computer can be loaded into the task computer via a PCMCIA card.

The physical layer of the standard includes the wire types and connectors that will be used in addition to the characteristics of the electrical pulses, or signals, that communicate the messages. The type of electrical signal used in the new standard is more resistant to interference and potential errors than the older RS 232. This signal can also be transmitted over a longer cable with fewer problems, allowing it to reach the remote parts of large implements. Standardization of the connectors means that I can plug the *single* bus connector from my air till drill into the tractor connector of *any make of tractor that is in compliance with the standard,* and I will have access to all of the controllable features on that drill from fertilizer rate, to seed tube monitors, to running lights, all from the cab of the tractor.

Another of the standard's layers is called the "data link layer". The data link layer specifies how messages are formatted by devices that send them and how errors are checked and handled. All messages have a priority level built into them, and that priority insures that the highest priority messages are delivered. Should there be a conflict or collision between messages, the lower priority message is resent while the higher priority message is delivered immediately. A number of standard messages have already been defined, but proprietary messages will also be allowed. Standard messages might include things like the current seeding rate, while a company's proprietary messages may be used to manage unique features of their planting implement.

One of the most challenging layers of the standard to specify is something called a virtual terminal. The virtual terminal or VT is a display and input device that should eliminate the stack of consoles in the corner of the cab. This display would be available to provide information to the operator from any of the nodes and devices that share the network. It will handle graphics such as maps as well as text and should be able to display everything from seeding rate to boom status to bale size.

Where are we in the process of implementing this standard? Tractor companies are now beginning to use the standard in their drive trains to manage information such as oil pressure, gear selection, engine speed etc. No one has it all in place yet, but we are getting close to the point where the use of J1939 will mushroom quickly. Although the sales staff at the local dealership may not know much about it, the engineering departments in the companies developing equipment are very aware of it.

So how does this help you with your purchasing decisions? If you are anxious to get started with variable rate projects you may not want to wait for systems that are fully J1939 compliant. RS 232 connections will work, but with some of the headaches mentioned earlier. You can certainly control one or two variables at mapped rates with current technology. However, you may wish to consider the new standard wherever possible. For instance, Trimble's AgGPS 124 is a GPS receiver that is now advertised as including the CAN/J1939 interface protocol. This means that as you gradually purchase new equipment that also includes the J1939 protocol, your GPS receiver *should* be able to function seamlessly with it, without requiring replacement or modification. If you are not anxious about beginning variable rate applications you may wish to wait and build a totally J1939-compliant system as the parts become available.

Standards for Map-like Data

A second area of standardization that has impact on precision farming systems as well as hardware is related to the Spatial Data Transfer Standard (SDTS). This standard is being developed for use in areas broader than just agriculture. However, the Ag Electronics Association (AEA) is participating in the development of a Transfer Support Layer specification for use in agriculture. The idea is to develop a uniform method of describing spatial data such as field maps. Once in place, the TSL standard would provide a method for translating data from the multitude of mapping and geographic information systems that are being used and sold for the processing of ag data. The link to J1939 and precision ag involves the preparation of prescription maps for use in applying inputs. If I am the manufacturer of a "task computer" (such as the GreenStar system or Case's AFS) that is designed to connect to a J1939 network, I need to know the format of the map that you or your crop consultant has developed for chemical rate, seeding rate, or fertilizer rate. If I know that format, then I can easily write a computer software program, or driver, to adapt that map to my task computer to allow it to be easily loaded for use. The TSL layer would be a file that would accompany the prescription map. Software from the ASF System or GreenStar would utilize the TSL file to know how to translate the map file for field use. As a user, you can have a high level of confidence that it will work when plugged into your tractor network. If you switch mapping programs for some reason you only need to know that the new program can also output a TSL file with its maps, and they will still work with my company's task computer.

The development of standards is by its nature a difficult process. A standard must be built and agreed upon by the competitive manufacturers that will use it. None of those companies want to give up the flexibility that they use to innovate and compete. As a result, the process can take a long time. Once these standards become widely used and appreciated by farmers, manufacturers will generally want to be in compliance with them for the customer satisfaction that results. If a company representative asks you what you would like to see in your next piece of equipment, you might consider saying, "J1939!" ■

This Site-Specific Management Guideline was prepared by:

Dr. Daniel Humburg
Associate Professor
Department of Agricultural and Biosystems Engineering
South Dakota State University
Brookings, SD 57007
Phone: (605) 688-5658
E-mail: DANIEL_HUMBURG@sdstate.edu

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