CASE STUDY

Vehicle Control Processors and Network for Autonomous Mining Trucks

CURTISS-WRIGHT

Challenge

- Support autonomous vehicle control and network interfaces
- Automate mining trucks using rugged COTS-based hardware
- Meet compressed delivery schedule and cost constraints

Solution

- Rugged Intel Core i7 and Atom processor systems with CAN
- Pre-integrated add-on vetronics I/O without NRE
- Small form factor rugged 20-port GbE switch

Results

- COTS-based multi-subsystem architecture within budget
- Quick delivery of hardware to support vehicle installations
- Re-use of autonomy architecture planned for other platforms

Challenge

Some of the largest mine companies in the world are turning to autonomous vehicle technologies to deal with commodity price declines and worker safety concerns, saving money and improving operations safety, productivity and sustainability in the process. In fact, some operators have reported that driverless vehicles are helping increase productivity and truck uptimes by as much as 20%. Unmanned haulage systems can also make open-pit operations much safer, since the work that haul truck operators do can be dangerous and accidents can occur due to fatigue. While robotic haul trucks are quickly becoming the backbone for some major mining operations, their autonomy systems require advanced computer processing, networking, vetronics control and sensor capabilities to support the collection and transmission of vehicle data from a range of devices and sensor inputs (LIDAR, radar, data link, actuation, etc.) over CANbus, Ethernet, serial, and more. Managing system cost, maintaining reliability, minimizing size and weight for electronics, and accommodating the incredible amount of processing and connectivity requirements for these solutions are some of the challenges faced by system integrators.

An experienced autonomous system supplier for both military and commercial vehicle platforms sought reliable COTS electronics hardware to upgrade their multi-platform autonomy kit in support of a mining truck program that was both cost-sensitive and schedule-constrained. The integrator wanted multiple, physically-separated processor systems designed for harsh vehicle conditions (shock, vibration, temperature, dust, water), some running Linux, others a real-time operating system (RTOS), and all integrating Ethernet, serial and CAN to communicate with the vehicle's on-board network, automotive radar/LIDAR sensors, inertial navigation system (INS), actuation system, and more. In addition, the autonomy solution would require a robust network backbone to connect these processors together in an Ethernet network. All subsystems would need to be delivered within a matter of weeks and without NRE cost.

Solution

The customer initially evaluated a high-performance VPX blade architecture with multiple processor cards in a larger chassis, but based on delivery schedule and cost tradeoffs, ultimately selected a distributed architecture with multiple small form factor (SFF) Intel® Core® i7 and Intel Atom®-based mission computer subsystems, along with a standalone Ethernet switch from Curtiss-Wright as part of a vehicle kit that included a total of six boxes. Two Intel E3845-based Parvus DuraCOR 311 miniature computers running Linux were ordered with pre-integrated CANbus and serial modules to serve as dataloggers for vehicle navigation and comms interfaces. Three 4th gen Core i7-based DuraCOR 8041 systems were specified that also integrated add-on CAN cards, two of which ran Linux and one unit ran a Wind River VxWorks® RTOS to serve as on-board processors and a primary vehicle controller. Finally, one DuraNET 20-10 20-port fully managed Gigabit Ethernet (GbE) switch was delivered as the network backbone to interconnect each of these boxes and other IP-enabled devices on-board the mining truck.

Taking advantage of Curtiss-Wright's cost competitive and quick-turn application engineering services, modified COTS (MCOTS) variants of the computer subsystems were successfully and affordably integrated without NRE expense using rugged off-the-shelf mini-PCIe CANbus controller and serial cards. A multi-slot removable 2.5" solid state disk add-on segment was also added to one of the units to host high-capacity, removable solid state media. A VxWorks board support package with all necessary drivers was developed to meet customer requirements. Each of these rugged COTS systems came IP67-rated (dust and water proof), equipped with MIL-STD-1275 compatible vehicle power supplies, and pre-qualified to comprehensive MIL-STD-810G and MIL-STD-461F environmental and EMI tests (including 40 to +71°C fanless operating temperature and tracked vehicle-grade vibration and shock), making them low-risk for the customer's mining vehicle environments. In addition, the SFF of these processor and switch boxes fit well within the vehicle architecture's mechanical constraints.

Results

Specifying low size, weight and power (SWaP) rugged COTS DuraCOR and DuraNET subsystems enabled this autonomous system supplier to stay within budget and on schedule. The integrator received rugged hardware that met the processor performance and system interface requirements at no NRE expense, within weeks, that they could be installed on their customer's mining vehicles to meet technical and schedule expectations. The resulting autonomy solution is expected to fully support the mine operator's vision for a highly efficient, productive, and safe environment accelerated by the innovation of unmanned systems. Not only can the integrator's enhanced autonomy kit now provide advanced haulage automation capabilities, but they view the kit as a baseline that can be re-purposed for other unmanned vehicle applications.

INFO: CURTISSWRIGHTDS.COM
EMAIL: DS@CURTISSWRIGHT.COM