Ground Vehicle Video Management System Integration

Read About

Video system upgrades and component interoperability

Ruggedization and SWaP optimization

Mission displays

Video recording and switching

Introduction

The proliferation of video sources on-board today's tactical ground vehicles has resulted in the need for modern video equipment to ensure the video's usability and availability. Increasing demand for cost-effective, size, weight, and power (SWaP) optimized video management and rugged display solutions is driven by video system upgrades or new video system architectures required to maximize video source usefulness.

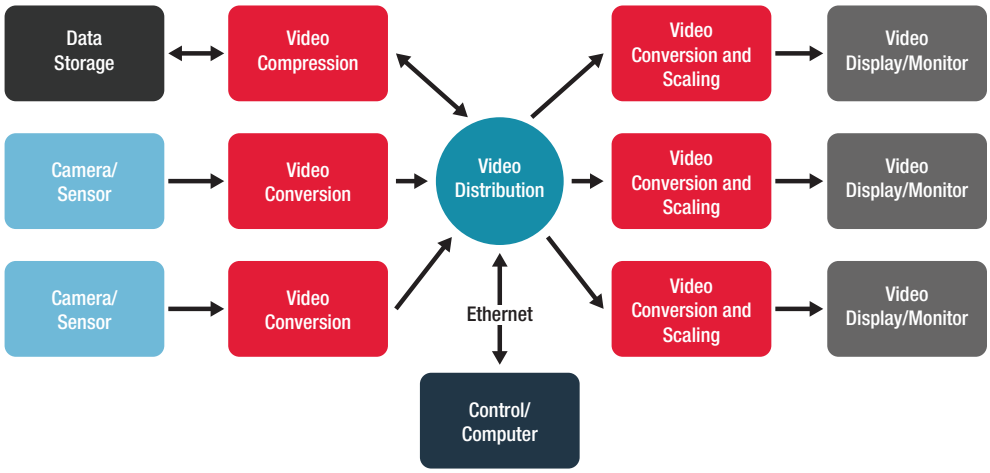

Figure 1: Classic video-centric-system architecture

Choosing the right video system components that will keep system cost and footprint down in an already space constrained environment – while also reducing program risk and time to market – is often challenging due to a number of factors. For example, device interoperability issues can arise both between the ancillary equipment as well as with legacy sensors , which can lead to the need for custom solutions. These often proprietary, stove-piped systems include redundant equipment that consumes excess power and takes up valuable real estate. Ultimately, these factors combine to create a poor, unsafe in-vehicle experience for warfighters, with reduced reliability and an increased chance of mission failure. Furthermore, it is important that all video system components are rugged enough to maintain stable operation in harsh environments. Substituting commercial, lab, or office-based products that are designed for different uses and environments in order to reduce the initial outlay can result in reliability and system footprint issues. While the obstacles can be daunting, choosing the right solution can reduce risk, time to market, and program cost while increasing the probability of mission success. This white paper analyzes these challenges and proposes a winning solution.

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Video Management System Challenges

As global defense and security industry budgets tighten, and the demand for video systems on-board defense and security platforms simultaneously increases, system integrators are challenged with finding cost-effective upgrade or new-build video solutions. With video often serving as the outward eyes of a deployed force, upgrading an EO/IR turret to enable HD video, for example, can provide operators with more detailed and higher resolution images, increasing mission success. This upgrade, however, requires much more than just turret modernization to truly reap the benefits. Because HD video requires faster processing and better display technology, the turret sensor ancillary equipment also requires upgrading to be interoperable with HD video signals. This exponentially increases the overall cost and time required and potentially has an impact on the platform SWaP due to added cabling and hardware.

Interoperability

An HD Video Management System (VMS) typically consists of a combination of multifunction displays, video recorders and an HD video distribution unit, as well as additional equipment such as keyboards for map control. A fully integrated video system gives the user unparalleled control over video signals, allowing the user to select video sources, create different video source views, and manage the downlinked and recorded video channels.

The market is full of HD-compatible switches, displays, mission computers, and recorders, making it relatively easy to build an HD-compatible system. Interoperability issues arise when components are sourced from different suppliers, resulting in incompatible protocols, interfaces, software, or cabling. Using a single source supplier can eliminate these issues and shorten development time, but may not eliminate potential backwards compatibility issues with the existing legacy hardware that the new HD video system also needs to interface with. This can happen when a video system upgrade is only partial – often due to budgetary constraints - leaving existing legacy sensors in play.

It is important not to consider legacy equipment as inferior. With ongoing technical support available from manufacturers and the innovative technology of the time, most legacy equipment will still be a viable mission asset 10-20 years after initial installation. It is essential that a cost-effective VMS of the present is future proof and enables seamless, cost-effective upgrades while easing integration and maintenance.

Fortunately, modern efforts like the U.S. Army's VICTORY (Vehicle Integration for C4ISR/EW Interoperability) initiative and the United Kingdom's Ministry of Defence (MOD) Generic Vehicle Architecture (GVA) are paving the way for a modern battlefield where system upgrades and modifications are quicker and less expensive. Modern frameworks, both GVA and VICTORY architectures are based on a common Ethernet data-bus and rely on the concept of network adaptors or connectors; VICTORY uses SOAP and XML to publish data or provide access to networked systems and GVA uses the Data Distribution Service (DDS) to do the same. Ease of integration of both new and legacy systems is streamlined through the use of scalable, modular, open systems technology. For this reason, both GVA and VICTORY emphasize the use of modular commercial off-the-shelf (COTS) systems.

Environmental Requirements

Too often systems are designed and developed to maintain reliability in a defined set of environmental conditions, then marketed – and subsequently used in – a different or more challenging environment, resulting in poor reliability or performance. Mission displays and other video management equipment, such as switches and format converters, are no exception; often these are purchased and installed in mobile military applications resulting in failure.

Due to the environmentally harsh conditions on-board combat vehicles, cost-effective, commercially available solutions are not an option as they are not tested to the same environmental qualifications that military equipment is. This limits their reliability on-board ground vehicle platforms, in which the video system plays a critical factor in the platform's mission success by providing the crew with situational awareness. For this reason, video solutions for these platforms must provide a high level of reliability under the demanding environmental and Electromagnetic Interference (EMI) conditions common to defense and security applications.

For example, an office or lab-based display is designed for an ambient environment, where the temperature is always controlled, blinds can be closed to keep the sun from producing a glare on the screen, and heat can escape

from built-in frames. This type of display is not designed to withstand extreme temperatures, high vibration and sand and water ingress.

The same applies to video management equipment, whether that be video switching, format converting or recording. All this equipment can be purchased for a benign environment, but to work in a mobile application, left in the environment for days on end, it must be ruggedized to ensure reliability. Mobile applications such as land or ground surveillance can experience temperature extremes of as low as -40°C and as high as +55°C as well as extremely rough terrain which can impact equipment reliability. If sand, dust or water penetrate the chassis, it will get into the electronics and can potentially cause a system shutdown and/or data loss. To prevent this, systems fit for purpose are tested to rigorous military environmental standards and sealed to prevent dust and water ingress, making them ideal for military vehicles and enabling reliable performance.

Size, Weight, Power, and Cost

Whether a fixed-wing aircraft, helicopter, naval or ground vehicle, these mobile platforms are always constrained by SWaP and Cost (SWaP-C) considerations. Especially tactical ground vehicles where there is already little room for operators. Minimizing cabling and redundant equipment means making room for added necessary functionality while reducing the overall system weight. A lower weight vehicle can remain on a mission longer, travel further and faster, and consume less fuel than a heavier version. With the high cost of mobile platforms, extended mission endurance is a vital advantage. No matter the mobile platform, SWaP will prove an important design constraint for system architecture.

Historically, a fully integrated video system that provided video conversion, scaling, windowing, compression, storage, playback, distribution and switching would require a separate device for each video function. For example, a format converter would be purchased separately from the switch, which would be connected to a recorder. To accomplish scaling and windowing, again separate devices and associated cabling would be required. Each of these functional units adds considerable complexity to the topology, integration and cabling, adding to the overall SWaP-C of the system, as well as program time. Additionally, each operator station requires a vast amount of wiring, which increases with recording and downlink capabilities, again affecting SWaP-C.

The Ideal Video System Solution

Today's VMSs must not only interface with legacy equipment; with the ever-increasing portfolio of external devices being used within mission systems, being able to interface with multiple formats is essential. In addition to the recent widespread deployment of digital formats such as SDI (Serial Digital Interface), a number of analog video formats are still in use today. This creates multiple challenges, including image degradation.

Additionally, displaying the imagery of a system that has up to, and in excess of, eight analog video sources is beyond the capabilities of even the most advanced displays on the

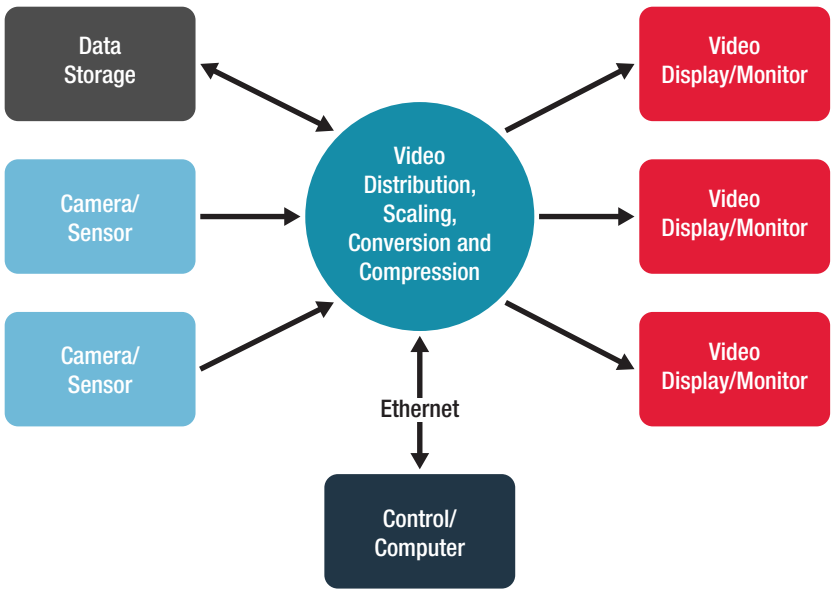

Figure 2: Ideal video-centric-system architecture

market today. Such displays need to enable the operator to view multiple video sources at the same time to make the most efficient use of the system. Despite today's best displays providing different image layouts and windowing, if these layouts are required to be recorded or transmitted by a downlink, the display output will typically mirror what is on the operators screen, thereby limiting the recorded and downlinked imagery to only the operator's view.

For this reason, the ideal modern VMS should be comprised of standard, SWaP-optimized elements that can be "mixed and matched" to meet a range of requirements. A family of compatible devices that can be seamlessly integrated would need to include analog and digital switches, advanced displays, and HD video recorders, designed from the ground up for use on ground vehicle platforms – demonstrably so, with supporting qualification evidence.

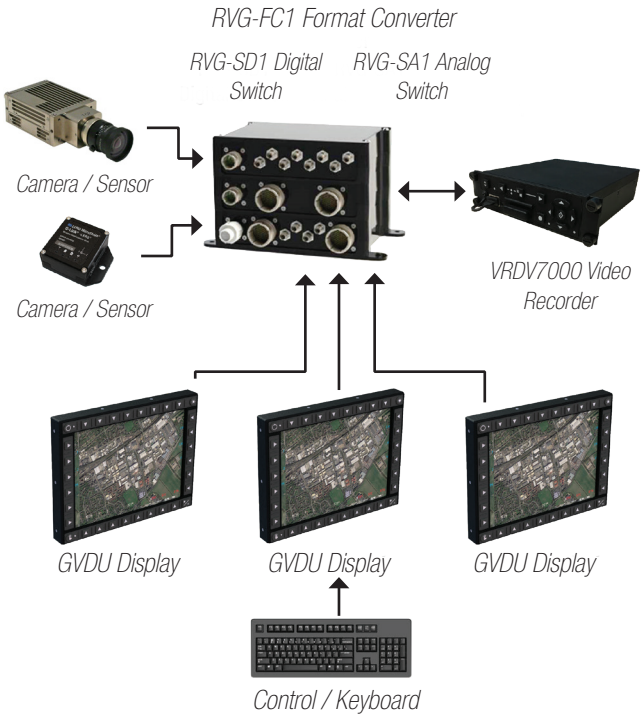

Figure 3: Curtiss-Wright video system solution

The Curtiss-Wright Solution

Curtiss-Wright has developed a family of rugged, interoperable, scalable, modular video management solutions that have been built with these requirements in mind. The family of Rugged Video Gateway (RVG) products provides a set of stackable video management building blocks that together form a complete VMS for platforms where space is at a premium. With common enclosure design, power supply and control, the RVG product line can be combined to provide a customized solution to support a range of different applications.

Video Distribution

An integral part of the system design is the switch that acts as a Video Distribution Unit (VDU) and the central hub for video sources. In doing so, it minimizes system cabling and cost by decreasing the large number of interconnects between video sources, displays and video recorders, resulting in a single cable between the video source and the VDU, and a single cable between the VDU and display.

The rugged RVG line of small form factor video management solutions from Curtiss-Wright offers both analog and digital switches designed to be flexible, rugged, and SWaP-optimized, enabling system designers to quickly and easily route video sources exactly where they best benefit the operator, with minimal cabling.

The RVG-SD1 (digital) and RVG-SA1 (analog) are amongst the smallest video switches available in the market. Both of the switches implement crossbar functionality; the analog switch (SA1) has 12 analog video inputs that can be routed to any of the 12 outputs, giving operators the ability to view different sources on their displays without impacting any other operators' imagery or video that has been selected for downlink or recording, enabling a "fire and forget" switch scenario.

Additionally, the SA1 has four separate RGBHV ports supported by an integrated horizontal and vertical sync switch matrix to support computer VGA interfaces. To further support the use of computer video outputs the SA1 also includes four EDID (Extended Display Identification Data) emulators – these are permanently available for connection to computer video interfaces to provide a consistent and deterministic set of EDID information and display emulation.

The digital switch (RVG-SD1) is optimized for 3G-SDI video and enables any external SD port to be automatically configured as an input or an output, and any input can be routed to any or all the remaining seven ports, for example routing a camera to multiple displays.

Through the use of a command line such as RS-232/422, both the RVG-SA1 and SD1 can be controlled on the fly by direct link. Additionally, through the use of CAN bus protocol, multiple displays can send instructions to multiple switches, allowing the routing of video to multiple locations.

The configurability, modularity and flexibility of the SA1 and SD1 combined with their small footprint and rugged MIL-STD design make them ideal for video systems with multiple video sources and displays in a SWaP-constrained environment.

Format Conversion

When working with a number of different video formats, whether it be a legacy system upgrade or an advanced new system design, video format conversion is often necessary to maximize the usefulness of the video system and ensure all video sources can be displayed properly to the operator. The RVG-FC1 format converter from Curtiss-Wright is the smallest, most rugged device in its class, and provides a flexible building block capable of converting between a range of video formats and resolutions (15 different formats and resolutions are supported). Supporting two independent channels of video conversion and accepting a wide range of analog and digital input formats, the RVG-FC1 scales and rate converts the input signals to a similarly wide range of video output formats, enabling complex and scalable solutions to be built easily and quickly.

Displays

To take advantage of the advanced sensors that are being fit to new or upgrade vehicles, mission displays need to match or exceed the vehicle-mounted sensors' resolution, provide a level of customization for the individual application, have the connectivity and I/O required to interface with the other elements of the VMS, and ensure readability in varying light conditions. Playing many roles, such as a moving map display or quad view operator display, mission display flexibility, usability and reliability are critical features in display design that enable mission success.

Curtiss-Wright offers a complete line of Ground Vehicle Display Units (GVDU) that range in size of 10.4" to 15.6" and resolutions of 1024x768 to 1920x1080, ensuring that they will fit in even the most SWaP-constrained platforms and spaces while providing the highest resolution available from the sensor. The GVDU is the only display on the market that uses industry leading smartphone touchscreen technology and maintains reliability during both gloved and wet operation. Through a unique combination of optically-bonded glass, projected capacitive touchscreen (PCAP), and GVA ready features such as bezel buttons and video over Ethernet, the GVDU is a reliable, interoperable solution that reduces system SWaP while increasing mission effectiveness.

With multiple control inputs including Ethernet, GPIO, RS-232/ 422 and USB, and the most widely used video interfaces including DVI-D or analog input, the GVDU offers maximum flexibility to system integrators while being interoperable with the latest turret and downlink solutions on the market.

With market-leading daylight visibility by means of powerful LED backlights and optical bonding to reduce internal reflection and enhance contrast, the GVDU is suitable for use in conditions of high incident light.

While the internal processor provides DEF-STAN 00-82 video over Ethernet capability, the bezel buttons along the sides of the displays are positioned based on the GVA standard and are fully programmable via USB. Environmental conditions on land vehicles differ slightly from those on aircraft with less incident light and an increased risk of sand and water in the air. Additionally, the user is more likely to be wearing gloves when operating the device. GVDUs are IP67 rated to protect against water and sand ingress and though they still provide a high level of readability in high incident light, the touchscreen has been developed to ensure smooth operation in all conditions, even with wet gloves on. With a variety of sizes available and video over Ethernet streaming capability as per the GVA Def Std 00-82 digital video standard, the GVDU is perfect for rugged ground vehicle applications.

The wide range of rugged, off-the-shelf displays available from Curtiss-Wright enables system architects to choose a display that offers the right functionality, in the right size, at the right price.

Recording

Video recording can provide the crew with important information used for training, debrief or evidential purposes. Curtiss-Wright's SWaP-optimized VRDV7000 video recorder is designed for capturing mission video in demanding environments and delivers industry-leading, broadcast-quality H.264 recording onto CompactFlash cards, providing multiple hours of full quality recording capability.

With support for HD-SDI digital video, two SD-SDI/HD-SDI/3G-SDI video inputs and two outputs, the VRDV7000 supports video resolutions up to 1080p at 60 Hz, with a maximum frame rate of 30 fps for each channel. Furthermore, VRDV7000 supports recording of metadata and audio present on the HD-SDI video inputs.

Additionally, the VRDV7000 records analog video to support existing or legacy equipment. Supporting STANAG-3350A/B/C video formats, facilitating VGA or RGB video connection up to a resolution of 1600x1200 or 1920x1080, and offering two channels of standard definition video (either single-wire CVBS or S-Video) supporting PAL and NTSC, the device is perfect for video system upgrades. These video inputs may be used in different combinations to a maximum of two recorded channels; for example, two HD channels (whether from HD-SDI or RGB), or one HD channel and one SD channel, allowing flexibility as per the platform's requirements. With simultaneous playback and recording, and front panel display or Ethernet control, VRDV7000 operators will have full control while eliminating data loss.

Ruggedization

Curtiss-Wright makes significant investments in environmental test chambers and laboratory tests to validate and certify that its ruggedized products perform as designed. All the devices mentioned in this paper have been tested to MIL-STD-810 and DO-160 to ensure our products will perform under extended temperatures (-40°C to 71°C), shock, vibration, humidity, dust, altitude and EMI. Additionally, they all feature military-grade enclosures that are corrosion-resistant and designed to keep out moisture and dust.

Through the use of off-the-shelf systems that are pre-tested, validated and certified – backed by documentation and conducted at no additional cost to customers – reduces risk and saves the time and expense of testing the systems in-house. As a result, time to market and overall program risk are reduced for platform deployment. To learn more about the affects of being late to market read the white paper "The Financial Impact of Late Delivery and How to Accelerate Your Time-to-Market".

Conclusion

Using modern video sensors on ground vehicle requires the use of equally modern video system management and distribution systems to maximize sensor benefits while minimizing SWaP effects on the platform. Whether upgrading an existing system or creating a new system architecture, interoperability with legacy sensors, system SWaP-C, and ruggedization play critical roles in system design. Displays with ever increasing inputs, digital and analog switching, and recording equipment that can handle all of today's image formats are absolutely necessary components of a modern VMS. High quality format conversion that offers an image in the correct format required by a system, with minimal impact on the image quality, is also essential. Curtiss-Wright's family of RVG products ensure that having a video source that is not usable within a VMS system is a thing of the past. This family of SWaP-optimized, modular video building blocks are simple and quick to install reducing integration efforts and project costs while helping you go further without having to leave equipment behind.

Mission displays play a crucial role in the video system, providing a human machine interface to the on-board sensor system. The line of GVDU displays provide operators with full control of the on-board video sources as well as the video recorder in an easy to use package, providing real time reassurance that the right information is being recorded and that there is enough memory to do so.

The more compact and low weight your installed systems can be, the more equipment you can bring without affecting the mission range. Modular systems allow you to keep wiring mass down by keeping smaller boxes closer in tight spaces. Curtiss-Wright's video management products help you carry more, go further, and stay in the mission longer while reducing integration headaches between legacy and new video equipment. The use of off-the-shelf systems that have been pre-qualified to military standards of ruggedization, as well as working with a proven, trusted leader that can provide the necessary expertise to ensure system interoperability, significantly reduces time to market, risk and program cost.

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