Reducing Latency in Ground Vehicle Video Systems

Read About

Manned and unmanned ground vehicle video systems

Situational awareness

Video system latency

Introduction

Video systems give those who are maneuvering manned and unmanned ground vehicles critical visibility and situational awareness they would not otherwise have. To ensure the safety and security of people and equipment inside and outside the vehicle, this vital visual information needs to be accessible in as close to real-time as possible.

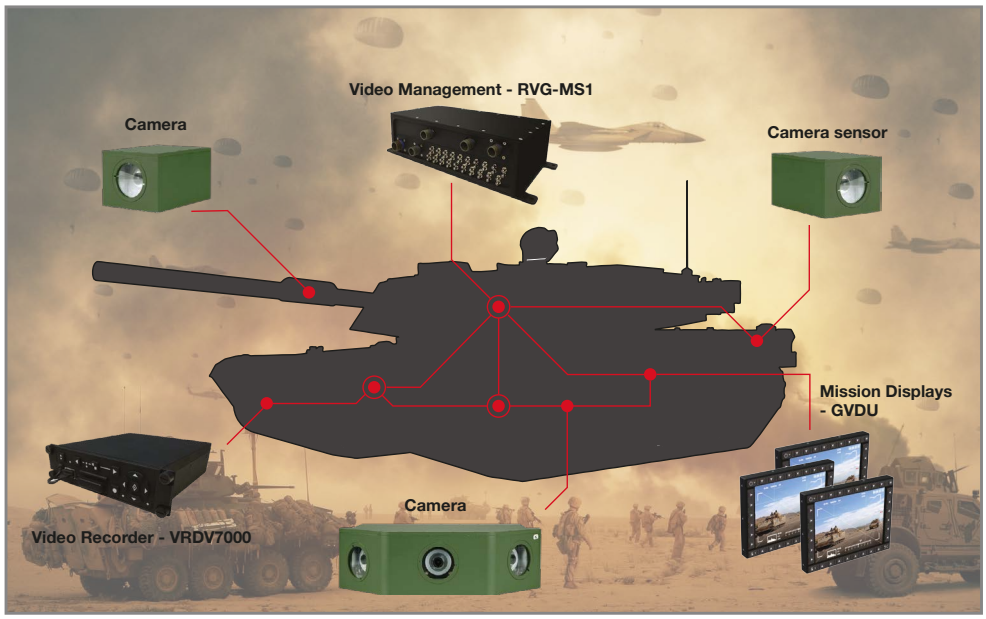

Figure 1: Ground Vehicle Video System

Video Latency Increases Risks

In manned ground vehicles, delayed video images can mean personnel inside the vehicle are unaware of an approaching enemy, an impending man-made or natural obstacle, or the proximity of a warfighter or civilian outside the vehicle until it's too late to appropriately or adequately respond.

The risks increase when vehicles are moving quickly, and when they include large and dangerous moving parts. It doesn't take much imagination to consider the many potential incidents that could occur with delayed video images from a mine-clearing vehicle with flailing chains, rollers, rakes, and blades, or a combat engineering vehicle with buckets and diggers.

Video latency can also cause motion sickness for those inside the vehicle. When the images seen do not match the motion felt in the vehicle, the discrepancy can create inner ear disturbances that lead to nausea, dizziness, and vomiting.

These uncomfortable physical manifestations of motion sickness can easily become a distraction.

While the risks to human safety are less when unmanned ground vehicles are used, the remote location of the vehicle driver means the video stream must travel further before it can be acted upon. This distance naturally increases latency, compounding the dangers associated with delayed video streams.

No matter what the vehicle type, how it is driven, or the mission, video latency makes it extremely difficult for operators to have complete confidence that what they are seeing is the reality at the time. The combination of uncertainty and delayed images can cause hesitancy when responding to threats, collision with obstructions or humans, or to unknowingly drive the vehicle into a dangerous situation or landscape.

Three Sophistication Levels of Ground Vehicle Video Systems

Ground vehicle video systems vary widely in technical sophistication and capabilities, but can be categorized into three levels of sophistication:

+ The most basic video systems allow operators who are in the vehicle, or operating it remotely, to view the images from one vehicle-mounted camera at a time. These systems provide a rudimentary level of visibility but severely restrict situational awareness.
+ Multi-display and picture-in-picture solutions allow operators to see images from multiple vehicle-mounted cameras at the same time. This flexibility considerably increases situational awareness compared to single-view systems as operators can consider their surroundings on all sides of the vehicle at all times. With multiple camera view configurationsto choose from, operators can choose the optimal combination of views for the task or maneuver they are executing.
+ 360° video systems give operators the ultimate level of situational awareness. These highly advanced video systems blend accurate, fully stitched images from all vehicle-mounted cameras into a seamless, panoramic image that most closely resembles what the human eye sees.These images can further be enhanced with sensor fusion, data overlays, augmented reality, and so on to offer enhanced situational awareness, which leads to increased mission effectiveness.

To ensure that operators trust the technology and can execute on missions with complete confidence, every video system at every level of sophistication must be designed to reduce latency end to end.

Overcoming Technical Challenges

The key to reducing end-to-end latency in a video system is to reduce latency in each video system component, from the cameras, to the video distribution and management units, to the displays.

The benchmark for low latency in video systems is not set by vendors competing to sell their solutions, but by military organizations that recognize how important near-real-time video is to warfighters in ground vehicles. For example:

+ A United Kingdom (UK) Ministry of Defence study found that military vehicle drivers could safely drive a vehicle through a visual display when the overall video system latency is 40 ms or less.
+ A study looking into the effects of video latency on general situational awareness found that operators remain adequately aware of their surroundings when overall video system latency is 160 ms or less.

These latency requirements create a number of technical challenges for system architects and designers.

Video Feed Synchronization and Speed

The modern digital cameras used in most video systems operate at 60 frames per second (FPS). That means the duration of each frame is just 16 milliseconds. If that single video feed is sent straight from the camera to the display, the images are visible almost instantly after they are captured.

However, when video streams from multiple cameras are sent through a video switch and combined with other situational awareness data, it becomes far more challenging to keep latency below 40 ms.

The challenge is that none of the video streams are buffered before they reach the display. This means the video streams from all of the various cameras must be synchronized within the display. In addition, diagnostic data, text, and graphics are often added to video images to put the visuals in context. The more images and data there is to process, the more time it takes to synchronize the signals.

This becomes more challenging when video is streamed to a remote location where people need to see the images the driver sees so they can make informed decisions,

or remotely operate the vehicle. In some cases, these locations are kilometers away. Streaming video over these kinds of distances requires extremely fast video encoding and decoding techniques in addition to low latency.

Video Distribution and Wiring

The video distribution technology acts as the central "brain" of the video system. These video gateways, switches, or multiplexers sit in between the cameras and the displays, taking video input from cameras and manipulating the feeds before outputting the results to the displays that operators rely on.

To increase situational awareness, many video distribution solutions provide a range of image configuration options for simultaneous camera views using picture-in-picture technology and window overlays as well as video streaming and blending capabilities. The most sophisticated solutions can simultaneously deliver multiple video streams to each display. They also allow operators to change the viewing configuration with the touch of a button.

This results in the need for very high levels of video processing capabilities with low latency in severely size, weight, and power (SWaP)-restricted ground vehicle environments. The video distribution system must also provide adequate inputs and outputs to support multiple cameras and displays with minimal wiring. For example, all the video streams sent to a single display should travel over a single connection between the distribution technology and the display with minimal latency.

Highly Responsive Displays

Offering advanced features for ease of use without affecting the speed at which warfighters view images presents a challenge for display developers. For example, display screens must respond instantly when operators push buttons or touch the screen. In addition, they must be designed so that operators never have to take the time to remove their gloves or pick up a stylus to switch views or move images on the screen.

Great care needs to be taken to ensure the screen is not overly sensitive to

+ unintentional touch gestures
+ dirt, oily build-up, or water droplets
+ electromagnetic interference (EMI) or radio frequency interference (RFI)

The Ideal Low-Latency Video System

To resolve the technical challenges outlined in the previous section and take latency to the lowest possible levels in every video system component, solution providers must incorporate a very specific set of technical capabilities in their offerings. It is important for military organizations that are evaluating potential solutions to look for these capabilities and to consider how each video system component fits with their short- and long-term requirements.

Distributed Architecture

The ideal system is based on a modular, distributed architecture that fits into a Generic Vehicle Architecture (GVA) or VICTORY infrastructure to enable interoperability and minimize the cost and time it takes for modifications and upgrades. In a distributed architecture, the video processing capabilities and the display are separate components, rather than an all-in-one solution that embeds processing capabilities in the display.

With an all-in-one approach based on smart displays, the high cost of replacing the display and image processing technology at the same time can mean operators are forced to rely on higher latency video systems longer. For more insight into why smart displays are often not the optimal choice, read our white paper Why Smart Displays May Note Be the Cleverest Choice.

A distributed approach provides the flexibility to mix and match the system components that offer the lowest latency. It also makes it faster, easier, and more cost-effective to upgrade individual video system components to even lower latency models as they become available.

Support for Multiple Cameras, Camera Types, and Views

The video system should support a large number (20 or more low-latency, pan-tilt-zoom (PTZ)) of cameras, each capable of 60 FPS. While some vehicles and missions will not require large camera systems, a system that supports this level of expansion offers the flexibility to add sensors as needed to meet new requirements.

To maximize flexibility and leverage existing investments, the video system should support the latest HD cameras as well as older, standard-definition (SD) digital cameras and legacy analog cameras. It should also provide the ability to almost instantly switch between views, and to combine views from any cameras.

Projected Capacitive Touch Screen Displays

Look for ruggedized video displays that provide intuitive touch screens designed for the unique requirements of ground vehicles. For example, they must be easy to read and use in vehicles where there is little or no natural light, and robust enough to reliably perform for long periods of time in harsh environments with extensive sand and moisture in the air.

Ideally, the video display incorporates projected capacitive (PCAP) touch screen technology that allows operators to use the intuitive, multi-touch gestures familiar when using smartphones and tablets, even when wearing gloves.

PCAP touch screens improve viewing clarity, contrast, and readability compared to other touch screen technologies, providing crisper, higher quality images that are easier for operators to see and absorb at a glance in typical light conditions. They also include thinner, lighter, and more scratch-resistant glass than other touch screen displays to reduce weight, improve durability, and extend lifespan in the field, even when subjected to operational and environmental stresses. For more information on the differences between available touchscreen technology, read our white paper Projected Capacitive PCAP Touch Screens Defense Aerospace.

Ready for Tomorrow's Requirements

In addition to evaluating and selecting the capabilities needed today, military organizations must also consider how the video system can be used as a stepping-stone to systems that take advantage of the latest technology innovations and support new requirements.

For example, military organizations will want to consider whether the video system can evolve or scale from a single- or multi-camera system to a

+ full 360° situational awareness solution to increase safety and security in particularly hostile or dangerous territories
+ drive-by-wire solution that enables the driver to rely fully on video technology to steer the vehicle, even at higher speeds
+ video streaming solution that enables real-time, remote oversight and the remote vehicle control that's critical for scouting and road clearing operations

Combining Low Latency with High Performance

Curtiss-Wright understands that reliable, low-latency video systems in military ground vehicles improve safety and situational awareness to give warfighters an important tactical advantage in the field.

For maximum flexibility today and the ability to easily evolve tomorrow, we take a building block approach to video system design, providing ruggedized mission displays, video distribution systems, and video recorders, as well as complete video management systems.

All of our video products and solutions address the key technical challenges associated with reducing latency and providing the essential features and capabilities needed to deploy near-real-time video solutions that meet GVA and Vehicular Integration for Command, Control, Communication, Computers, Intelligence, Surveillance, and Reconnaissance/Electronic Warfare (C4ISR/EW) Interoperability (VICTORY) standards.

Ruggedized, Low-SWaP Solutions Qualified to Military Standards

Our RVG-MS1 Multi-Sensor Rugged Video Gateway provides 25 inputs and 20 outputs in a unit that weighs only 3.25 kg (7.17 lb), requires only 80W of power maximum and offers a low latency video path of 16 ns. This SWaP-optimized video gateway supports single, dual, triple, and quad views in a variety of layouts, and is qualified to key military standards. The RVG-MS1 also acts as an Ethernet gateway, enabling video streaming from vehicles built to the latest GVA and VICTORY standards.

Our Ground Vehicle Display Unit (GVDU) PCAP touch screens are bright, crisp, and high-contrast displays that are designed according to the GVA standard and are fully programmable through a USB connection. These ruggedized mission displays are qualified to established military standards, including

+ MIL-STD-461F for radiated emissions and electromagnetic compatibility
+ MIL-STE-1275E for power and electrostatic discharge
+ MIL-STD-810G for environmental engineering design and testing

They also include MIL-C-38999 connectors for power, video, and other interfaces and support video over Ethernet capabilities.

We also offer some of the smallest video switches on the market, as well as Rugged Video Display Units (RVDUs) for non-mission-critical applications such as vehicle reversing and equipment monitoring.

To ensure that our customers can fully leverage existing investments and interoperate with a wide range of deployed solutions, our video products and solutions can be used with almost any digital and analog cameras. And all of our solutions are designed and built to withstand extreme temperatures, shock, vibration, sand, water, and other challenging environmental conditions to ensure long-term, reliable operation on any terrain and in any weather conditions.

With our dedication to simplifying the relationship between warfighter and machine and to a holistic approach to system development, we deliver trusted and proven video solutions that increase confidence, safety, and situational awareness on the modern battlefield.

How would you rate this white paper?

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- RVDU Displays
- Video Management Solutions
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- Format Converter (RVG-FC1)
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