Defence Research and Development Canada
Recherche et développement pour la défense Canada

DEFENCE R&D DÉFENSE

Use of the GigE Vision Imagery Transport Standard in AFVs

R.H. Chesney
DRDC Suffield

Defence R&D Canada

Technical Memorandum

DRDC Suffield TM 2009-290

December 2009

Canada

Use of the GigE Vision Imagery Transport Standard in AFVs

R.H. Chesney
DRDC Suffield

Defence R&D Canada – Suffield

Technical Memorandum
DRDC Suffield TM 2009 - 290
December 2009

Principal Author

Original signed by Robert Chesney

Robert Chesney

Project Manager ADVANCE Technology Demonstrator Project

Approved by

Original signed by Doug Hanna

Doug Hanna

Head / Autonomous Intelligent Systems Section

Approved for release by

Original signed by Paul D'Agostino

Paul D'Agostino

Chair / Document Review Panel

This work is sponsored under the Technology Demonstrator Program - Advanced Vehicle Architecture for a Net-Enabled Combat Environment (ADVANCE) Technology Demonstrator Project (Project number 12SH)

Abstract

This paper provides guidance on the use of the GigE Vision® (GEV) imagery transport standard within an armoured fighting vehicle (AFV) platform. This standard was originally developed by the Automated Imaging Association (AIA) for use in industrial machine vision environments, but is generally applicable to other environments. The standard provides a variety of technical options. In the context of using the standard in an AFV some of these options are required, some are desirable and some options are undesirable. This paper outlines how the standard should be adapted for use in a vehicle environment.

Résumé

Cet article offre des conseils sur l'utilisation, à l'intérieur d'une plateforme de véhicule blindé de combat (VBC), des normes d'une imagerie des transports appelée GigE Vision® (GEV). Les normes ont été mises au point à l'origine par Automated Imaging Association (AIA) pour être utilisées dans des environnements de vision de machines industrielles mais elles sont généralement applicables dans d'autres environnements. Ces normes procurent une variété d'options techniques. Dans le contexte où on utiliserait ces normes pour un VBC, certaines options sont requises, d'autres sont désirables et quelques options sont indésirables. Cet article souligne la façon dont ces normes devraient être adaptées à un environnement de véhicules.

This page intentionally left blank.

Executive summary

Use of the GigE Vision Imagery Transport Standard in AFVs

[Robert Chesney]; DRDC Suffield TM 2009 - 290; Defence R&D Canada – Suffield; December 2009.

Background: Modern Armoured Fighting Vehicles (AFVs) are increasingly reliant on electronic imagers for observation, targeting and situational awareness. Modern electronic imagers exceed the capability of legacy analogue video transport mechanisms both in spatial resolution (the number of picture elements – pixels – in an image frame) and in dynamic range (the number of brightness or colour values associated with a pixel). Further, both modern imagers and modern multi-function displays are inherently digital devices and maintaining a digital signal path between them preserves image fidelity. While the use of any digital video transport mechanism can preserve image quality, there are additional requirements that motivate the selection of particular transport mechanisms and that further motivate the selection of a common video transport mechanism for all AFV applications. These requirements flow from operational requirements within the vehicles and from the goal of maximizing operational capability while minimizing acquisition and life cycle costs.

Results: After a review of alternative video transport mechanisms it is recommended that Gigabit Ethernet (IEEE standard – 802.3) be used as a transport medium. Standardization of both the medium and the protocol is required to allow any level of interoperability. Therefore, it is further recommended that the GigE Vision® (GEV version 1.1) protocol be used.

Significance: The adoption of GEV as a video standard for AFVs would provide increased operational capability providing higher quality vision sources to be implemented and for all image sources within the vehicle to be viewed from any crew position. Reduced acquisition and support costs can be achieved by exploitation of this commercial-off-the-shelf (COTS) technology and related industrial expertise. The GEV interconnection standard would allow for ready fielding of common imaging systems shared across multiple platforms and provides for plug and play capabilities that allow a broad range of field repair options to maintain essential imaging systems or to improve vehicle availability through cannibalization.

Sommaire

Use of the GigE Vision Imagery Transport Standard in AFVs

[Robert Chesney]; DRDC Suffield TM 2009 - 290; R & D pour la défense Canada – Suffield; Décembre 2009.

Contexte : Les véhicules blindés de combat modernes (VBC) se fient de plus en plus aux imageurs électroniques pour observer, cibler et percevoir une situation. Les imageurs électroniques excèdent les capacités des mécanismes traditionnels de la vidéo des transports à la fois en matière de la résolution spatiale (le nombre d'éléments dans une image, ou pixels, dans une image) et de la gamme dynamique (le nombre de valeurs de luminosités et de couleurs associées à un pixel). De plus, les imageurs modernes et les affichages à fonctions multiples modernes sont tous deux des appareils intrinsèquement numériques et le fait qu'ils maintiennent le parcours du signal numérique entre eux préserve la fidélité de l'image. Bien que l'utilisation d'un mécanisme de vidéo numérique des transports ait l'avantage de préserver la qualité de l'image, il existe aussi d'autres besoins supplémentaires qui justifient la sélection de mécanismes de transport particuliers ce qui justifie entre autres la sélection d'un mécanisme de vidéo des transports commun à toutes les applications VBC. Ces besoins sont attribués aux besoins opérationnels dans les véhicules et au but qui consiste à maximiser la capacité opérationnelle tout en minimisant les coûts d'acquisition et du cycle de vie du matériel.

Résultats : Après avoir étudié des mécanismes vidéo alternes des transports, on recommande que le Gigabit Ethernet (IEEE standard – 802.3) soit utilisé comme support aux transports. La normalisation de ce support et de son protocole est requise pour permettre l'interopérabilité à tous les niveaux. Par conséquent, on recommande aussi que le protocole de Vision® (GEV version 1.1) soit utilisé.

Portée des résultats : L'adoption de GEV comme la norme de vidéo pour les AFV procurerait une capacité opérationnelle accrue à condition que soient implémentées des sources de vision de meilleure qualité et que toutes les sources d'images soient visibles par l'équipage quelque soit sa position à l'intérieur du véhicule. On peut en réduire les coûts d'acquisition et de support en exploitant cette technologie disponible sur le marché et l'expertise industrielle qui en découle. Les normes d'interconnexion GEV devraient permettre la mise en service rapide de systèmes d'imagerie usuels qui seraient partagés entre des plateformes multiples et procureraient des capacités d'auto-configuration. Ceci ouvrirait un grand éventail d'options de réparations visant à maintenir les systèmes d'imagerie essentiels ou bien à améliorer la disponibilité des véhicules par cannibalisation.

Perspectives d'avenir : Le protocole de GigE Vision® évoluera avec le temps pour mieux être adaptés aux besoins additionnels. On prévoit d'effectuer des révisions à ce document si les changements sous-jacents à ce protocole le requièrent.

Table of contents

This page intentionally left blank.

1 Backgound

1.1 Digital Video Standardization

Modern Armoured Fighting Vehicles (AFVs) are increasingly reliant on electronic imagers for observation, targeting and situational awareness. Modern electronic imagers exceed the capability of legacy analogue video transport mechanisms both in spatial resolution (the number of picture elements – pixels – in an image frame) and in dynamic range (the number of brightness or colour values associated with a pixel). Further, both modern imagers and modern multi-function displays are inherently digital devices and maintaining a digital signal path between them preserves image fidelity. While the use of any digital video transport mechanism can preserve image quality, there are additional requirements that motivate the selection of particular transport mechanisms and that further motivate the selection of a common video transport mechanism for all AFV applications. These requirements flow from operational requirements within the vehicles and from the goal of maximizing operational capability while minimizing acquisition and life cycle costs.

Increased operational capability requires that all image sources within the vehicle can be viewed from any crew position within the vehicle so that information can be shared. This provides greater flexibility in managing workload and supports redundant modes of operation. The ability to insert additional sensors over a vehicle lifetime, either through pre-planned upgrades or to exploit new sensor capabilities is also a requirement. Growth potential within the video installation to incorporate image processing for image enhancement or for automation of target detection and recognition is highly desirable. Avoiding excessive weight in cabling is also very desirable for AFV installations, as is tolerance for high levels of radio frequency interference (RFI).

Reducing acquisition and support costs motivates the use of a commercial video transport standard that will allow the exploitation of commercial-off-the-shelf (COTS) technology, design expertise and support tools. The standard should also minimize the software development effort to integrate new sensors or to upgrade existing sensors or display stations. Plug and play capabilities, where the sensor embeds sufficient information to allow the video network and the display to self-configure after installation of a new, or upgraded, sensor is highly desirable.

Adoption of a common video transport standard allows ready use of common imaging systems on a fleet-wide basis, reducing inventory and sparing costs. Common imaging systems, coupled with plug and play capabilities would allow a broader range of field repair options to maintain essential imaging systems or to improve vehicle availability through cannibalization.

After a review of alternative video transport mechanisms it is recommended that Gigabit Ethernet (IEEE standard – 802.3) be used as a transport medium. This is a broadly available commercial standard that has already seen limited use in military applications. It has growth potential to higher speeds (10 gigabit at a minimum) and both copper and fibre implementations are readily available. Ethernet switches are available that allow mixing both fibre and copper segments, allowing selective use of fibre connections to imagers where either electro-magnetic interference (EMI) or radio frequency interference (RFI) is an especial issue. Other transport options such as FireWire® (IEEE 1394, various versions), Universal Serial Bus (USB V2.0 or V3.0), or Camera

Link can support digital video transport, but none of these have the flexibility and intensive commercial support that Gigabit Ethernet provides.

Standardization of both the medium and the protocol is required to allow any level of interoperability. It is further recommended that the GigE Vision® (GEV version 1.1[1]) protocol be used. While other video transport protocols are available for Ethernet, the GigE Vision® standard was developed by the Automated Imaging Association (AIA) for industrial machine vision applications. This industry has experience with supporting industrial automation systems, which have important similarities to military applications, including: designs with uncompromising performance standards, small installation volumes and long support cycles. As a result it is expected that military vendors will be able to better leverage industrial expertise in respect to this standard.

1.2 GigE Vision® Protocol

The GigE Vision® protocol was defined by a committee within the Automated Imaging Association to provide a standard supporting the use of low cost Gigabit Ethernet links between machine vision cameras and applications. It has seen broad use in this context, where a single, or small number of cameras, are connected to a machine vision processing applications by what are essentially, point to point links. Less commonly, a number of cameras are installed in a switched network where data is routed to a number of data users (displays or image processing applications). This is less common, as the bandwidth requirement for a single camera can readily approach the one gigabit per second limit of a single link within such a network. However, the latter configuration is much more likely to occur in a combat vehicle, where data is routed from imagers to the displays based upon the demands of the crew.

The capability to support a switched network is included in the GEV protocol, however, the specification requires limitation or clarification in a few critical instances to safely select components and implement a system that meets typical military requirements. This document details the limitations and extensions of the GEV protocol definition that a designer should adopt in designing a system for military vehicle applications. This document is based upon the specification as defined in Version 1.1 of the GEV standard, adopted in April of 2009. The GigE Vision® standard is expected to evolve over time and the reader should ensure that they understand how evolution of the standard will affect the potential to add sub-systems that are compliant with later versions of the standard.

[1] GigE Vision® is a registered trademark of the Automated Imaging Association.

2 GigE Vision® Guidance

As noted above, this document is intended to further define how to use the GigE Vision® standard in the context of a multi-source[2] (imager), multi-sink (typically a display), switched network employed in a mobile platform. Much of the guidance is straightforward and would be obvious to any reader of the standard, however, this document attempts to illuminate all areas of the standard which define behaviour (either by default, or as an option) that could compromise performance in and AFV.

Where the word *must* appears this implies that the implementation needs to incorporate this capability to prevent undesirable behaviour. The word *should* is used to indicate a desirable feature of an implementation that will reduce the potential undesirable behaviour.

2.1 GEV Version

The version of the standard referenced in the compilation of this document is 1.1.

2.2 Module Addressing

GEV devices selected for implementation *should* support persistent internet protocol (IP) addresses. This mechanism will allow for rapid start up and is consistent with the fixed configuration that would be typical of an AFV variant.

GEV devices *should* support address resolution protocol (ARP) check for address conflict. This will prevent a replacement module from disrupting operation of a working system.

The network *must* support a DHCP server. This will allow a replacement module to be automatically assigned a valid address. A system control application can determine this address and re-configure the module to assign a persistent IP address.

2.3 Device Enumeration

System *should* implement device enumeration as part of power up built in test (BIT). This ensures that the system configuration is consistent with the expected configuration.

Devices *should* support the user defined name option. This allows identical devices to be assigned a position identifier.

System *should* periodically attempt to enumerate any devices missing from expected configuration. This allows the system to accommodate devices that are slow to power up and devices that may be powered off for part of an operational cycle to conserve power.

---

[2] Note: an image processing application that enhances or compresses imagery, may be both a sink (from a camera) and a source (to a display)

2.4 Multicast Management

GEV devices can support multicast streams, but provides no management to: announce availability, announce changes in stream content, or manage connections. This must be addressed outside of the GEV protocol.

2.5 Packet Resend

GEV allows any application to request a stream packet to be resent. This could cause issues in network saturation – especially in multicast streams where a fault in a route to one application could propagate to other routes. System implementations *should* limit packet resend requests to a nominal level (< 1 %).

2.6 Device Configuration Files

Devices selected for implementation *should* provide local copies of configuration files (embedded in device). System *must* provide access to configuration files for any processor implementing a GEV application (in local file store).

2.7 Time Stamps

Implementers should note that GEV time stamps are designed to support inter-frame time measurements rather than assignment of absolute times to images. Where needed a "control application" can access the time stamp counter to develop a mapping between device time stamps and system time or a common time reference such as UTC[3]. It should be noted that due to the way that time stamp requests are handled a "monitoring application[4]" can not access a coherent time stamp value.

2.8 Control Routing

GEV requires an active control process to be operational for any device to operate (even when streams may be multicast or directed to several destinations). The active control process will typically issue a command to every device under control within a heartbeat timeout interval to maintain control (and continue streams). While the heartbeat requirement can be disabled in the device, retention of the mechanism may simplify fault detection. A GEV implementation *should* ensure that the control process for any source provides a method for other applications to adjust device parameters when required (implementing control precedence rules where required).

---

[3] UTC – Coordinated Universal Time

[4] GEV allows applications that do not have control of the device (monitoring applications) to access some data including the time stamp; however, access by a monitoring application doesn't guarantee coherent data and fragments of the time stamp can be asynchronously updated by the imager during the read.

2.9 Control Transfer

Devices selected should support secondary control channels (monitoring by non-control applications). The implemented system should provide a reversionary application to monitor state of GEV devices and provide for continuity of control if the primary control application fails. It should be noted that transfer of control can (will, by default) cause the GEV device to cease streaming video – any reversionary process will need to re-start all streams.

2.10 Compression Support

The GEV protocol provides no “native” compression support. The implementer *should* use file transfer mode (indicating compression type in file type – e.g. x.jp2), but may use a device specific mode. Evolution of the GEV protocol is expected to provide more options for native compression in later versions – potentially through the definition of additional pixel types (only 36 of 4096 currently assigned), or through more complete specification of how file payload types are used to support this functionality.

2.11 Metadata Tagging

The GEV protocol does not provide for direct support of metadata tagging of image frames (other than the time stamp). It is possible to incorporate metadata into imagery by using a “chunk” transfer or by defining device specific transfers. For the majority of real-time data transfers envisioned for an AFV video network, metadata tagging is not relevant. It is of greater importance for data that is exported from the vehicle.

3 Summary

The use of the GigE Vision® standard provides a consistent protocol for integrating a wide range of sensors on combat vehicles. In conjunction with the use of Gigabit Ethernet as a transport medium, it provides a flexible and adaptable platform for all classes of vision sensors. While less well supported in the standard definition, the protocol can also be used with generic data streams from other types of sensors such as surveillance radars. Together these two standards form the key elements of a sensor architecture for combat vehicles. Only minor tailoring of how components are selected or the standard is applied is required to adapt to the vehicle environment.

Gigabit Ethernet is widely available and commercial and industrial take up is so high that one can assume support for the underlying components for an extended period. If required, EMI considerations can be fully addressed through selection of fibre implementations of the standard. The GEV standard has also now achieved a broad level of industrial use and availability. As noted above, it is a creation of the machine vision community which has experience with uncompromising requirements and extended product support cycles. This is well aligned to typical military equipment life cycles.

Once a standardized sensor architecture is adopted the subsequent integration effort to add additional sensors is minimized. A common architecture allows sensors to be replaced with comparatively low levels of engineering effort and qualification, either to exploit higher performance or merely to cope with obsolescence of the original equipment.

List of symbols/abbreviations/acronyms/initialisms

AIA	Automated Imaging Association
AFV	Armoured Fighting Vehicle
ARP	Address Resolution Protocol
COTS	Commercial off the shelf
DHCP	Dynamic Host Configuration Protocol
EMI	Electromagnetic interference
GEV	GigE Vision
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
RFI	Radio Frequency Interference
UTC	Universal Time, Coordinated

This page intentionally left blank.

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.) Defence R&D Canada – Suffield P.O. Box 4000, Station Main Medicine Hat, Alberta T1A 8K6	2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.) UNCLASSIFIED

3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C or U) in parentheses after the title.)

Use of the GigE Vision Imagery Transport Standard in AFVs

4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)

Chesney, Robert H.

5. DATE OF PUBLICATION (Month and year of publication of document.) December 2009	6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 18	6b. NO. OF REFS (Total cited in document.) 0

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Technical Memorandum

8. SPONSORING ACTIVITY (The name of the department project office or laboratory sponsoring the research and development – include address.)

Defence R&D Canada – Suffield
P.O. Box 4000, Station Main
Medicine Hat, Alberta T1A 8K6

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.) 12SH	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.) DRDC Suffield TM 2009 - 290	10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11. DOCUMENT AVAILABILITY (Any limitations on further dissemination of the document, other than those imposed by security classification.)

Unlimited

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Unlimited

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

This paper provides guidance on the use of the GigE Vision (GEV) imagery transport standard within an armoured fighting vehicle (AFV) platform. This standard was originally developed by the Automated Imaging Association (AIA) for use in industrial machine vision environments, but is generally applicable to other environments. The standard provides a variety of technical options. In the context of using the standard in an AFV some of these options are required, some are desirable and some options are undesirable. This paper outlines how the standard should be adapted for use in a vehicle environment.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

AFV; Vetronics; Video; Standard; GigE Vision; GEV

Defence R&D Canada

Canada's Leader in Defence
and National Security
Science and Technology

R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

DEFENCE R&D DÉFENSE

www.drdc-rddc.gc.ca