This is Abaco Systems

Defense Systems and AI-based Vision/Graphics Computing: Challenges and Opportunities
Ross Newman (ross.newman@abaco.com)
Abaco Systems advances the capabilities of the warfighter by providing game changing mission ready embedded systems, components and technologies to defense contractors.

Our products reduce program risk, allow technology insertion with affordable readiness, and ultimately help platforms reach deployment sooner with lower cost.
WE RELY ON A HIGHLY EXPERIENCED TEAM OF 800+ PROFESSIONALS WITH GLOBAL REACH
WE DELIVER COTS AND CUSTOM SOLUTIONS WITH LONG LIFECYCLE SUPPORT AND FIVE RUGGEDIZATION LEVELS

<table>
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<th>Lowest TCO</th>
<th>Rugged</th>
<th>Open standards</th>
<th>Minimal SWaP</th>
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<tr>
<td>Brodest range of COTS options</td>
<td>Temperature</td>
<td>VMEbus</td>
<td>Advanced thermal solutions for fan-less cooling</td>
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<td>Best in class Technology Insertions capabilities</td>
<td>Shock</td>
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<td>Vibration</td>
<td>PC104 / PC104+</td>
<td>Rugged military connectors &amp; sealed enclosures</td>
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<td>Humidity &amp; salt fog</td>
<td>PCI &amp; PCI Express</td>
<td>CompactPCI</td>
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<td></td>
<td></td>
<td>PXI compatible</td>
</tr>
</tbody>
</table>
Deploying GPUs into military applications
Brief Overview of Military **Vehicle Electronics** (Vetronics)

Electronic architectures provide significant benefits.

- Ability to meet mission objectives with increased operational capability.
- Reduce crew numbers through greater autonomy.
- Increase survivability (reduced loss of life).

Systems need to work together sharing information.

- Network enabled architectures.
- Optical systems moving to fully digital.
- Telemetry data storage (HUMS).
- Big data analytics.
- Layered Security protocols.
- Secure data and RF communications.
- Situational awareness across the battlefield.
The argument for open standards / open architectures

Globally there are several initiatives that share a common set of goals. Reduced cost of ownership, interoperability, upgradability to allow for ‘bolt on’ new capabilities and allow for technology advancement and innovation.

- **VICTORY** Vehicular Integration for C4ISR/EW Interoperability 🇺🇸
- **Generic Vehicle Architecture** (DEF-STAN 23-13) 🇬🇧
- *NATO Generic Vehicle Architecture* (STANAG 4754) 🇪🇺
- **AS GVA** DEF(AUST) 11316 🇦🇺

This approach presents significant opportunity for COTS vendors to develop innovative product offerings that incorporate GPU/s performing various rolls within a vetronics system.

*NGVA is an extension of GVA that meets a broader set of requirements including unmanned systems integration*
Architectures need to scale to all platforms.

Reduced through Life costs from:
- Reduced vehicle platform sub system integration risk and cost.
- Reduced time to implement technology changes to vehicle platform architectures.
- Reduced through life costs from commonality of components and HMI.
- Increased competition for 3rd party sub components and systems.
- Reduced crew and maintainer training burden.
- Common vehicle service patterns reducing duplication.

Improved Equipment capability:
- Improved Sub system data integration and interoperability.
- Built in scalability, expandability and growth potential for addition of future vehicle sub-systems.

NATO, AU & MoD open standards approach to vehicle architecture.
Generic Vehicle Architecture, GVA

The Land Open Systems Architecture (LOSA) is the UK MOD’s approach for open systems across the land environment. GVA is the set of standards that apply to vehicles.

Generic Vehicle Architecture (GVA DEF-STAN 23-09)
- Fully Digital architecture
- Distributed Data Service (DDS)
- SNMP
- HUMS (allows for legacy bus/s MilCAN & CAN)
- Precision Time Protocol

VIVOE (great for GPUs!!)
- Vetronics Infrastructure for Video Over Ethernet (DEF-STAN 00-82)
- Real Time Protocol (RTP)
- Session Announcement Protocol (SAP)
- Raw Streaming (uncompressed)
- JPEG 2000 streaming
- H.264 streaming

Vehicle programs: AJAX, Foxhound, F-ATV, Challenger 2 LEP, MRV-P, Warrior CSP, FPBA, LPMR, MIV
Generic Vehicle Architecture, GVA

The nVidia Tegra series of processors are ideally suited for SWaP optimized applications within a vehicle. Roles for embedded GPUs within the vetronics architecture include:

Mission Computers
- Commander Display – Mission objectives, moving map, data aggregation, situational awareness.
- Gunners Display – Firing options, threat detection, image fusion, object classification and localization, segmentation.
- Drivers Display – Real time low latency multicast video.

Storage
- Video Server – Record, Playback, Metadata, Aynalytics
- Data Server – Mission data, maps etc..
- HUMS (Health Usage and Monitoring Systems)
- Network Attached Storage – Cryptographic

Gateway
- Protocol Conversion – Edge of network, legacy interfaces
- Compression – Audio and Video streams for RF transmission

AI & Deep Learning
- Increase autonomy in situational awareness
- Threat detection and identification
- Autonomous resupply delivery and demand forecasting
<table>
<thead>
<tr>
<th>Model</th>
<th>Country</th>
<th>Status</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>AJAX Program (UK)</td>
<td>UK</td>
<td>500+ new</td>
<td></td>
</tr>
<tr>
<td>Challenger 2 (UK)</td>
<td>UK</td>
<td>250 upgrade</td>
<td></td>
</tr>
<tr>
<td>Boxer CRV (Aus)</td>
<td>Australia</td>
<td>211 new</td>
<td></td>
</tr>
<tr>
<td>LAND 400 (Phase 3, AUS)</td>
<td>Australia</td>
<td>450 new</td>
<td></td>
</tr>
<tr>
<td>Germany Lynx KF41 (CHZ/AUS)</td>
<td>Germany</td>
<td>380 upgrade</td>
<td></td>
</tr>
<tr>
<td>Warrior (UK)</td>
<td>UK</td>
<td>508 new</td>
<td></td>
</tr>
<tr>
<td>VBCI (Qatar)</td>
<td>Qatar</td>
<td>490 new</td>
<td></td>
</tr>
</tbody>
</table>

Tracked Infantry Fighting Vehicles (IFV)
Digital Video Standards
## Popular Digital Video Interfaces

### Comparison of Popular Digital Camera Interfaces

<table>
<thead>
<tr>
<th></th>
<th>FireWire 1394.a</th>
<th>Camera Link®</th>
<th>USB 2.0</th>
<th>USB 3.0</th>
<th>GigE / RTP</th>
<th>HD-SDI</th>
<th>GSML</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>800 Mb/s</td>
<td>3.6 Gb/s</td>
<td>480 Mb/s</td>
<td>5Gb/s</td>
<td>1000 Mb/s</td>
<td></td>
<td>1.5Gb/s</td>
</tr>
<tr>
<td><strong>Cable</strong></td>
<td>100m (with GOF cable)</td>
<td>10m</td>
<td>5m</td>
<td>3m (recommended)</td>
<td>100m</td>
<td>300m</td>
<td>15m</td>
</tr>
<tr>
<td><strong>Channels</strong></td>
<td>up to 63</td>
<td>1</td>
<td>up to 127</td>
<td>up to 127</td>
<td>Unlimited</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Connector</strong></td>
<td>9pin-9pin</td>
<td>26pin</td>
<td>USB</td>
<td>USB</td>
<td>RJ45/Cat5e or 6</td>
<td>BNC (Coax)</td>
<td>Coax or STP</td>
</tr>
</tbody>
</table>
RTP example video processing and storage

<table>
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<th>Acquisition</th>
<th>Dissemination</th>
<th>Presentation</th>
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<td>Legacy video standards</td>
<td>Openware switch management software</td>
<td>Embedded (ARM) CPU</td>
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<tr>
<td>Protocol conversion</td>
<td>10 Gig fully managed layer 2/3</td>
<td>Low power</td>
</tr>
<tr>
<td>Colour space conversion</td>
<td>Multicast, IGMP</td>
<td>System on chip nVidia GPU</td>
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<tr>
<td>Video scaling</td>
<td>Quality of service</td>
<td>Vulkan / OpenGL</td>
</tr>
<tr>
<td>Framerate conversion</td>
<td>VLAN</td>
<td>CUDA / OpenCL</td>
</tr>
<tr>
<td>Segmentation</td>
<td>Built In Test (BIT)</td>
<td>VisionWorks (OpenVX) / OpenCV</td>
</tr>
<tr>
<td>Object classification / localization</td>
<td>Out of band management</td>
<td>Compression H.264 / H.265</td>
</tr>
<tr>
<td>10Gig video streaming</td>
<td>VICTORY switch compliant</td>
<td>Video streaming</td>
</tr>
</tbody>
</table>

*Future SWaP recording solution

DDoS = Distributed Data Service (Real Time Publish-Subscribe RTPS)
### Acquisition
- Legacy video standards
- Protocol conversion
- Colour space conversion
- Video scaling
- Framerate conversion
- Segmentation
- Object classification / localization
- 10Gig video streaming

### Dissemination
- Openware switch management software
- 10 Gig fully managed layer 2/3
- Multicast, IGMP
- Quality of service
- VLAN
- Built In Test (BIT)
- Out of band management
- VICTORY switch compliant

### Presentation
- Embedded (ARM) CPU
- Low power
- System on chip nVidia GPU
- Vulkan / OpenGL
- CUDA / OpenCL
- VisionWorks (OpenVX) / OpenCV
- Compression H.264 / H.265
- Video streaming

*Future SWaP recording solution*
What is bayer8 and YUV?

Bayer (8 bits per pixel example)

Y'UV files can be encoded in 12, 16 or 24 bits per pixel.

The Y'UV model defines a color space in terms of one luma (Y') and two chrominance (U and V) components.

Luma values occur twice as frequently as chrominance U and V components i.e.

4 bytes repeat for 2 pixels:

Commonly used in TV and analogue video.

RFC4175 - RTP payload format for uncompressed video.

Also mandated in GVA (DEF STAN 00-82)

OpenGL programmers will be used to RGB (Red, Green, Blue) buffers 24 bits per pixel where primary colours are represented separately but this is much less efficient when streaming.

Commonly used in

GIGE Vision
### Other formats (CSI and Analogue PAL/NTSC)

<table>
<thead>
<tr>
<th>CSI Xavier camera</th>
<th>8 NTSC/PAL inputs, 8 audio inputs*</th>
</tr>
</thead>
</table>

Great news your TX1 / TX2 cameras from previous dev kits will work on Xavier...

```bash
gst-launch-1.0 nvarguscamerasrc ! 'video/x-raw(memory:NVMM),width=1024, height=768, framerate=120/1, format=NV12' ! nvvidconv flip-method=0 ! nvegltransform ! nveglglessink -e
```


Mini PCIe approx. $106

*TX2 support with Linux V4L2 drivers, currently untested on Xavier as of presentation*
Why do we need 10Gig Ethernet?

Military applications demand high quality uncompressed real-time video and audio streaming. Video compression adds additional latency and compression artefacts limiting its use in military applications.

<table>
<thead>
<tr>
<th>Defaults</th>
<th>Height</th>
<th>Width</th>
<th>Colour Space</th>
<th>FPS</th>
<th>Bandwidth (Mb)</th>
<th>Channels</th>
<th>Total (Mb)</th>
<th>Megapixles/sec</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>640x480</td>
<td>640</td>
<td>480</td>
<td>Bayer8</td>
<td>30</td>
<td>9.00</td>
<td>27</td>
<td>243.00</td>
<td>248.83</td>
<td></td>
</tr>
<tr>
<td>1280x720</td>
<td>1280</td>
<td>720</td>
<td>Bayer8</td>
<td>30</td>
<td>27.00</td>
<td>9</td>
<td>243.00</td>
<td>248.83</td>
<td>HD 720p</td>
</tr>
<tr>
<td>1920x1080</td>
<td>1920</td>
<td>1080</td>
<td>Bayer8</td>
<td>30</td>
<td>60.75</td>
<td>4</td>
<td>243.00</td>
<td>248.83</td>
<td>HD 1080p</td>
</tr>
<tr>
<td>3840x2160</td>
<td>3840</td>
<td>2160</td>
<td>Bayer8</td>
<td>30</td>
<td>243.00</td>
<td>1</td>
<td>243.00</td>
<td>248.83</td>
<td>4K</td>
</tr>
<tr>
<td>640x480</td>
<td>640</td>
<td>480</td>
<td>YUV</td>
<td>30</td>
<td>18.00</td>
<td>27</td>
<td>486.00</td>
<td>248.83</td>
<td></td>
</tr>
<tr>
<td>1280x720</td>
<td>1280</td>
<td>720</td>
<td>YUV</td>
<td>30</td>
<td>54.00</td>
<td>9</td>
<td>486.00</td>
<td>248.83</td>
<td>HD 720p</td>
</tr>
<tr>
<td>1920x1080</td>
<td>1920</td>
<td>1080</td>
<td>YUV</td>
<td>30</td>
<td>121.50</td>
<td>4</td>
<td>486.00</td>
<td>248.83</td>
<td>HD 1080p</td>
</tr>
<tr>
<td>3840x2160</td>
<td>3840</td>
<td>2160</td>
<td>YUV</td>
<td>30</td>
<td>486.00</td>
<td>1</td>
<td>486.00</td>
<td>248.83</td>
<td>4K</td>
</tr>
</tbody>
</table>

**NOTE:** H.264 and H.265 compression is most useful where bandwidth is limited such as RF links and off vehicle secure transmission.
Video aggregation using 10Gig Ethernet fibre

NOTE: GVA specification mandates 1GigE 1000-BaseT copper and 10GigE Fibre backbones to carry data around the vehicle.
<table>
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<tr>
<th>What is Gstreamer? What is GigE Vision?</th>
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</thead>
<tbody>
<tr>
<td>GigE Vision using open source</td>
</tr>
</tbody>
</table>

For GigE Vision video acquisition then take a look at Aravis API and Gstreamer plugin.

Abaco systems Jetson Tegra TX2 deep learning demo with TensorRT uses PointGrey cameras for video ingress and Aravis for acquisition with colour space conversion being done using Abacos CUDA functions for real time video.

**Note:** bayer plugin can be found in gstreamer bad plugins.

```bash
sudo apt-get install gstreamer1.0-plugins-bad
```

RTP streaming is described in RFC4175 - RTP Payload Format for Uncompressed Video.

RTP raw streaming is supported in Gstreamer and can be demonstrated using the YUV colour space using the pipeline below:

```bash
gst-launch-1.0 udpsrc address=239.192.1.44 port=5004 caps=application/x-rtp, media=video, clock-rate=90000, encoding-name=RAW, sampling=422:8, width=640, height=480, payload=96 ! rtpvrawdepay ! queue ! xvimagesink
```

**NOTE:** Use appsink to get video into your application. xvimagesink renders the stream on the display in a window.

Aravis is found on [https://github.com/AravisProject/aravis](https://github.com/AravisProject/aravis)

More information on Gstreamer can be found on [https://gstreamer.freedesktop.org](https://gstreamer.freedesktop.org)
Computer vision and deep learning
Resupply scenarios

Resupply at reach

Emergency battle replenishment


Images provided under Open Government Licence v3.0

* MIRA Viking, Centaur Unmanned Ground Vehicle, TITAN, The Black Knight Transformer
Autonomy on the last mile (resupply)

This Defense and Security competition seeks to develop and demonstrate the use of autonomous systems to deliver mission-critical supplies, focusing on the challenging ‘last mile’ resupply in the land environment.

- **Challenge 1**: unmanned air and ground load carrying platforms
- **Challenge 2**: technologies and systems to allow load carrying platforms to operate autonomously
- **Challenge 3**: technologies to autonomously predict, plan, track and optimise resupply demands from military users

Images provided under Open Government Licence v3.0
Why do we need the AI enabled solutions?

- Increased situational awareness
- Greater automation decreasing crew count
- Better, faster decision making

*ImageFlex 2.0 sensor fusion
**SkyBox running on the Jetson TX2
***WRNCH Demo shows at DVD2018
What is deep learning?

Deep learning networks typically have two primary phases of development: **training** and **inference**

**Training**

During the training phase, the network learns from a large dataset of labeled examples. The weights of the neural network become optimized to recognize the patterns contained within the training dataset. Deep neural networks have many layers of neurons connected together. Deeper networks take increasingly longer to train and evaluate, but are ultimately able to encode more intelligence within them.

---

*github.com/abaco-systems* fork of nVidias two days to a demo
Jetson Inference ‘banana’ Demo

Training

- Performed on DIGITS enabled PC featuring Titan X (Pascal) GPUs and 8 core Intel 6th Gen CPU.
- Training data includes 1000 images per object.
- Over 1000 objects in the database
- Database includes 1.2 million images
- Training data approximately 90 Gigabytes
- 1,162 Bananas (none were harmed during the training of this demo)

Inference

- Inference engine running on the TX2
- Live video via Bayer GigE Vision cameras
- Video input 1280x720 @ 30 Htz
- Network (learned knowledge)
  - Alexnet = 233Mb
  - GoogleNet = 52Mb
Identifying future applications for GPUs

Mission Computer
• Increased automation, target classification, object detection, friend or foe?
• Situational Awareness 360 Degree vision systems with greater fidelity (AXIS ImageFlex and SkyBox).
• Leverage Open API such as Vulcan, VisionWorks (OpenVX) and OpenCV for greater software portability and reuse.

Storage
• Move to High Definition (HD) video streaming.
• Need for increased compression H.265 (requires modification to the current GVA standards).
• Data Mining and Deep Learning.

Gateway
• Interfacing with existing systems and the wide battlefield network.
• New codecs offering greater bandwidth efficiency for RF communication
• Intrusion detection, Secure Communication.

Other
• Digital Signal Processing with CUDA
• Communication Intelligence (COMINT)
• Signal Intelligence (SIGINT)
• Electronique Intelligence (ELINT)
• Software Defined Radio (SDR)
• Sensor Processing
• Unmanned vehicles
Abaco Systems nVidia GPU enabled products
Hardware - Fully ruggedized board level GPUs

High Performance OpenVPX NVIDIA GPU architecture. Choose OpenVPX form factor for easy integration and futureproofing GPU upgrade path via technology insertion.

Jetson AXG Xavier ARM + GPU = Low Power Embedded applications. Choose embedded for low Size Weight and Power.

<table>
<thead>
<tr>
<th>3U VPX Desktop (GPU Only)</th>
<th>6U VPX Desktop (CPU + GPU)</th>
<th>Packaged Products High TRL</th>
</tr>
</thead>
</table>

OpenVPX™

OpenVPX™
Accelerated development with AXIS ImageFlex 2.0
Software - NEW AXIS ImageFlex 2.0 Visualization API

ImageFlex
Visualization framework API

- Image creation and management
- CPU to GPU data movement
- 2D “overlay” drawing Image processing API
- Image manipulation
- Lens distortion correction.
- Complex image morphing
- Image fusion
- Image stabilization Interoperability API
- CUDA / OpenCL interoperability API Custom extendibility
- Easy creation of custom OpenGL “shader”
- 2D and 3D Matrix computation functions. Abaco quick start application examples
- “Basics” example, showing all key functionality
- “SkyBox” example for spherical situation awareness
- Image fusion example
- Image stabilization example
- OpenCV and OpenVX interoperability examples
Image Flex Image Annotator speeds up training
NEW ImageFlex Datasheet: https://www.abaco.com/download/axis-imageflex-20-datasheet
Software – AXIS reducing time to deployment

Define and Visualize Dataflow

Choose High Performance Math Libraries

Choose High Performance Communication Libraries

Application Visualization and Control

Analyze App and System Performance

Application Visualization and Control

Analyze App and System Performance

Advanced Integrated Software Development Tool Suite

Perhaps the industry's most advanced, most intuitive embedded software development environment, AXIS enables rapid software development.
Software - AXIS Enabled Middleware for High Performance

Dataflow
AXIS View: ApplicationView
Define dataflow
Visualize dataflow

High Performance Communication Libraries
AXIS Flow
Proprietary
Thread Based
AXIS MPI
Open Standard
Process Based

Performance Analysis
AXIS EventView
Demystify App Perf

Application GUI
AXIS DataView
Control C Variables
Visualize App Data

High Performance DSP Libraries
AXIS RSPL
Proprietary
AXIS VSIPL
Open Standard

Advanced Integrated Software Development Tool Suite
Perhaps the industry's most advanced, most intuitive embedded software development environment, AXIS enables rapid software development.
Whitepapers available from abaco.com

From Machine Intelligence to Deep Learning
Our vision is to be your embedded partner of choice as you design and deploy mission-critical systems for the harshest, most challenging environments.

INNOVATE
Fresh, new thinking to create better ways of solving problems.

DELIVER
We live up to our commitments. Time after time. Every time.

SUCCEED
Our business only succeeds when our customers succeed. Period.
**Serial Digital Interface**

Serial digital interface (SDI) is a family of digital video interfaces first standardized by SMPTE (The Society of Motion Picture and Television Engineers) in 1989.

A related standard, known as high-definition serial digital interface (HD-SDI), is standardized in SMPTE 292M; this provides a nominal data rate of 1.485 Gbit/s.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Name</th>
<th>Bitrates</th>
<th>Example Video Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMPTE 259M</td>
<td>SD-SDI</td>
<td>270 Mbit/s, 360 Mbit/s, 143 Mbit/s, and 177 Mbit/s</td>
<td>480i, 576i</td>
</tr>
<tr>
<td>SMPTE 344M</td>
<td>ED-SDI</td>
<td>540 Mbit/s</td>
<td>480p, 576p</td>
</tr>
<tr>
<td>SMPTE 292M</td>
<td>HD-SDI</td>
<td>1.485 Gbit/s, and 1.485/1.001 Gbit/s</td>
<td>720p, 1080i</td>
</tr>
<tr>
<td>SMPTE 372M</td>
<td>Quad Link HD-SDI</td>
<td>2.970 Gbit/s, and 2.970/1.001 Gbit/s</td>
<td>1080p</td>
</tr>
<tr>
<td>SMPTE 424M</td>
<td>3G-SDI</td>
<td>2.970 Gbit/s, and 2.970/1.001 Gbit/s</td>
<td>1080p</td>
</tr>
</tbody>
</table>

[Link back to Popular Digital Video Interfaces](#)