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WE INNOVATE
WE DELIVER
YOU SUCCEED

23390: Deploying embedded computer vision systems on military ground vehicles

Ross Newman (Field Applications Engineer, Abaco Systems UK)

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

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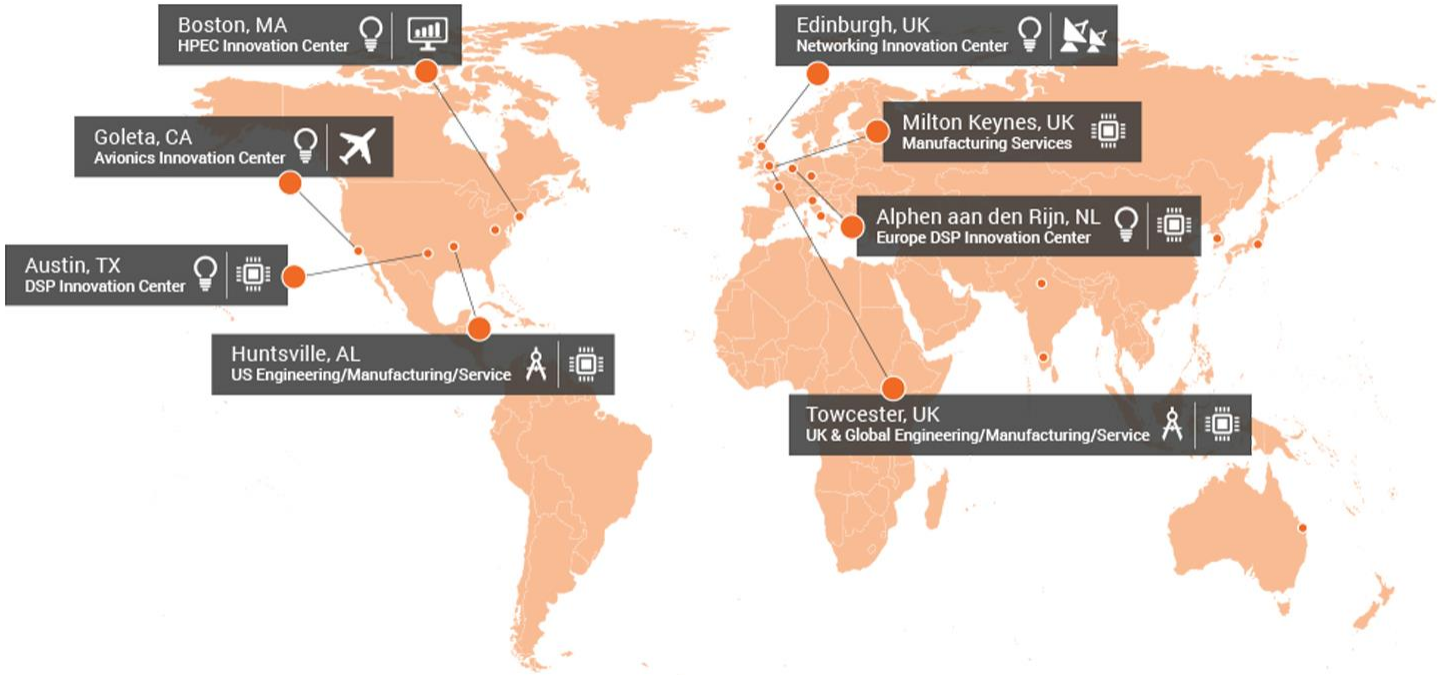
WE RELY ON A HIGHLY EXPERIENCED TEAM OF 800+ PROFESSIONALS WITH GLOBAL REACH



WE DELIVER COTS AND CUSTOM SOLUTIONS WITH LONG LIFECYCLE SUPPORT AND FIVE RUGGEDIZATION LEVELS

Lowest TCO

Broadest range of **COTS** options

Best in class **Technology Insertion** capabilities

Rugged

Temperature

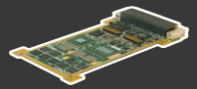
Shock

Vibration

Humidity & salt fog

Open standards

VMEbus

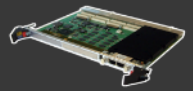


OpenVPX

PC104 / PC104+

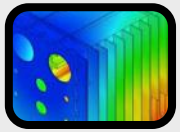
PMC & XMC

PCI & PCI Express



CompactPCI PXI compatible

Minimal SWaP



Advanced thermal solutions for fan-less cooling

Wedgelock restraints

Rugged military connectors & sealed enclosures

Deploying GPUs into military applications

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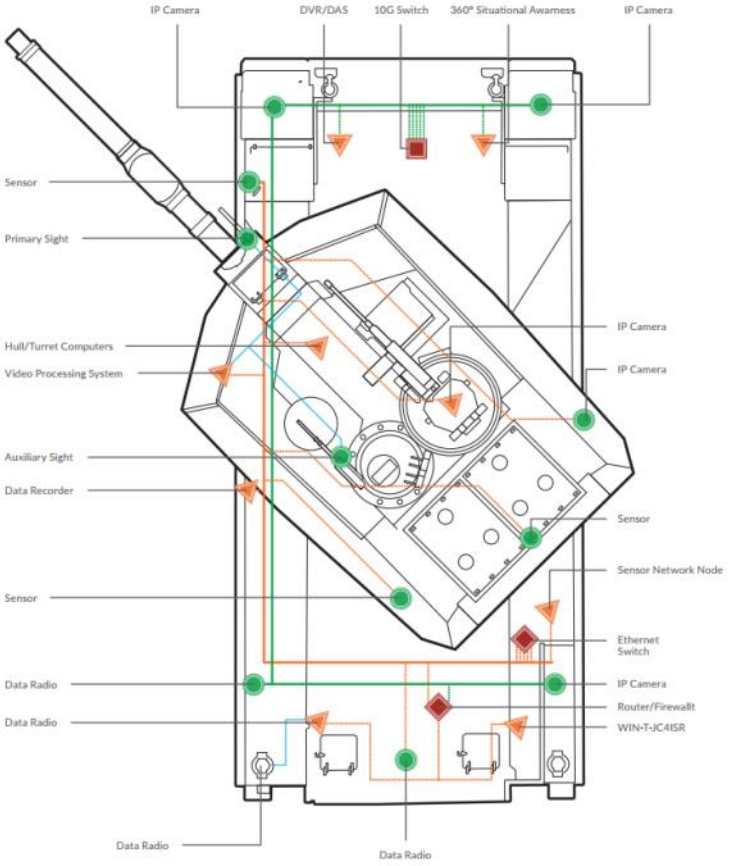
Brief overview of military vehicle electronics (vetronics)

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)

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

Ministry of Defence

EUROPEAN DEFENCE AGENCY

*NGVA is an extension of GVA that meets a broader set of requirements including unmanned systems integration

Generic Vehicle Architecture, GVA

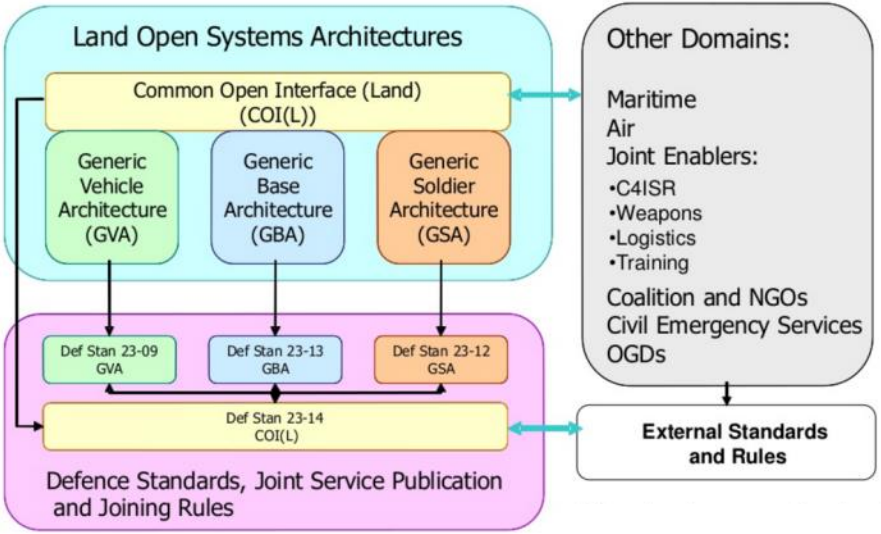
The Land Open Systems Architecture (LOSA) is the UK MOD's approach for open systems across the land environment. GVA is the set of standards that apply to vehicles.

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 Jetson TX series of embedded GPU and desktop GPUs 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 – Automated firing options, threat detection, image fusion, object classification and localization, segmentation.
- Drivers display – Real time low latency multicast video.

Storage
- Video server – Record and playback in real time
- 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

GVC2000 - Rugged GPU and Xeon with configurable IO

NVIDIA GPUs in today's military vehicles

Exploiting the digital video standards

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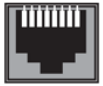
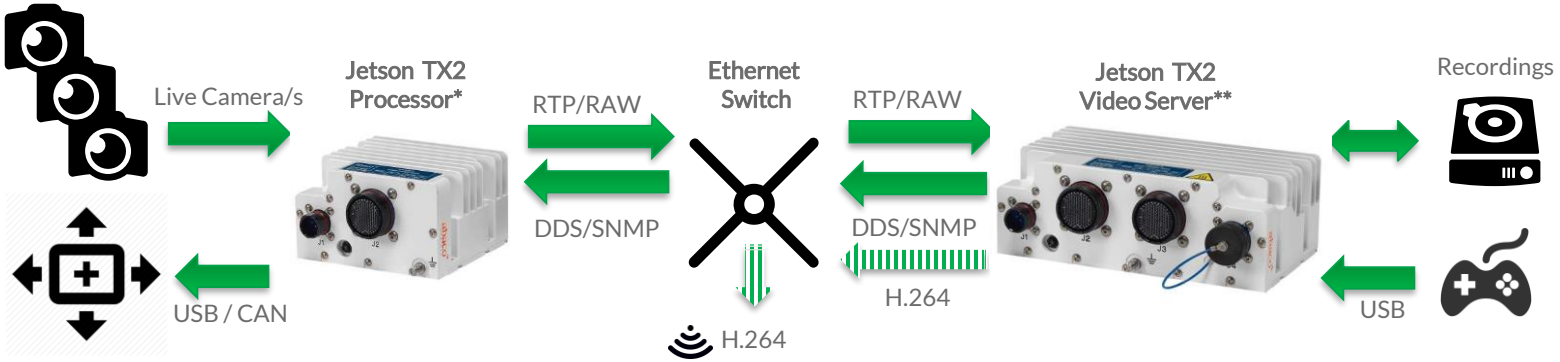
Popular Digital Video Interfaces

Comparison of Popular Digital Camera Interfaces

	FireWire 1394.a	Camera Link®	USB 2.0	USB 3.0	GigE	HD/3G SDI	GSML
							
Speed	800 Mb/s	3.6 Gb/s (full configuration)	480 Mb/s	5Gb/s	1000 Mb/s	3Gb/s	1.5Gb/s
Cable	100m (with GOF cable)	10m	5m	3m (recommended)	100m	300m	15m
Channels	up to 63	1	up to 127	up to 127	Unlimited	1	1
Connector	9pin-9pin	26pin	USB	USB	RJ45/Cat5e or 6	BNC (Coax)	Coax or STP
Notes	Legacy. Only on older PCs. Low CPU load	Special frame grabber. Standard cables are expensive.	CPU loading. Non Standard device drivers. Backwards compatibility.		CPU Loading. PoE for power. Runs on almost any PC. Long cables with PoE	Industrial Standard, Low latency. Special frame grabber.	Automotive standard

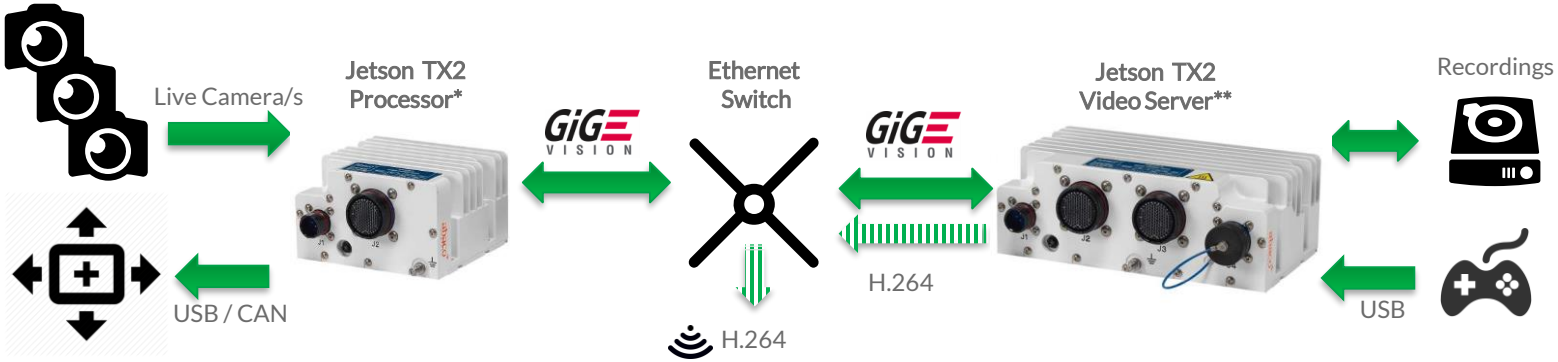
RTP example for video processing and storage



Acquisition	Dissemination	Presentation
Legacy video standards Protocol conversion Colour space conversion Video scaling Framerate conversion Segmentation Object classification / localization 10Gig video streaming	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	Embedded (ARM) CPU Low power System on chip NVIDIA GPU Vulkan / OpenGL CUDA / OpenCL VisionWorks (OpenVX) / OpenCV Compression H.264 / H.265 Object classification

*GVC1000 Launch GTC San Jose 9th May
**Future SWaP recording solution
DDS = Distributed Data Service (Real Time Publish-Subscribe RTPS)
SNMP = Simple Network Management Protocol

GigE Vision example for video processing and storage



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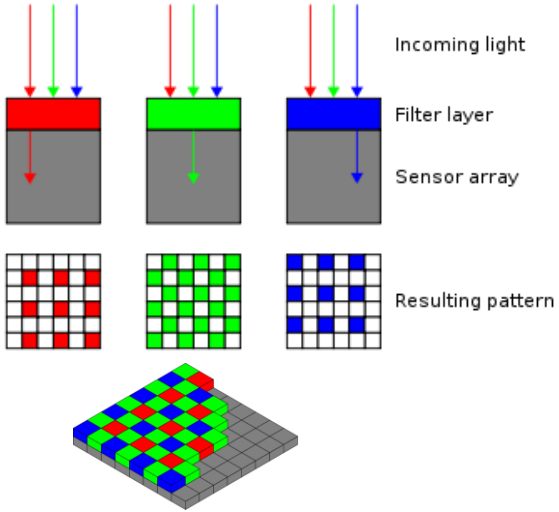
**Future SWaP recording solution

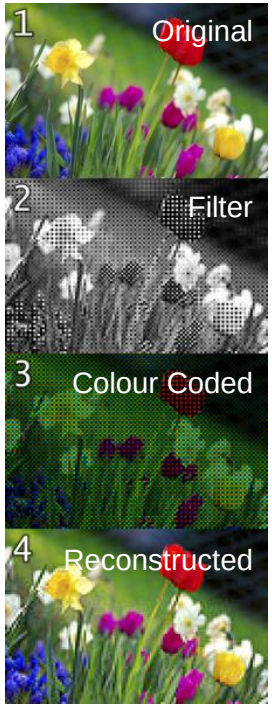
What is bayer8 and YUV?

Bayer (8 bits per pixel example)



Interpolation is used to reconstruct the image missing colour information.

Commonly used in GigE Vision



YUV422 (16 bits per pixel)

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

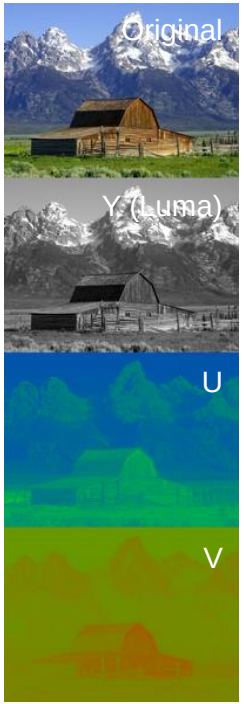
The Y'UV model defines a color space in terms of one luma (Y') and two chrominance (UV) components.

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

4 bytes repeat for 2 pixels:

YUYV	YUYV	YUYV

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.

Acquiring video with Gstreamer?

GigE Vision using open source

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

Abaco systems GVC1000 deep learning demo with TensorRT uses PointGrey cameras for video ingress and **Aravis** for acquisition with colour space conversion being done using Abaco's ImageFlex functions for real time video.

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

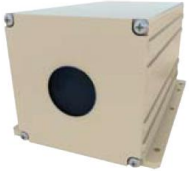
```
sudo apt-get install gstreamer1.0-plugins-bad
```

RTP streaming use Gstreamer

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:

```
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=YCbCr-4:2:2, depth=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
More information on Gstreamer can be found on https://gstreamer.freedesktop.org

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 used in military applications.

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

NOTE: H.264 and H.265 compression is most useful where bandwidth is limited such as RF links and off vehicle secure transmission.

Now we have the video what next?

- Deep Learning, inference at the edge.
- Advanced image processing ISP and compression
- Data parallelism using CUDA for situational awareness

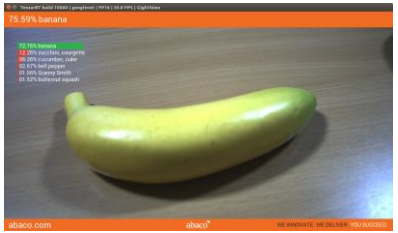
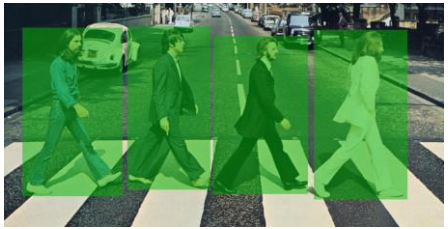


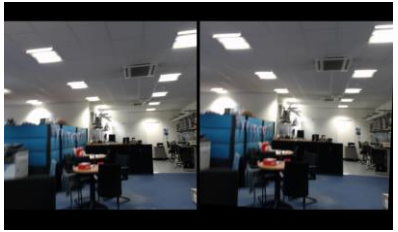
Image Recognition

Segmentation



Object Localisation

*Image Fusion



Stabalization

Tracking

*Image Correction (ISP)

**Situational Awareness

*AXIS ImageFlex sensor fusion
*SkyBox running on the GVC1000

Abaco Systems NVIDIA GPU enabled products

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Hardware - Fully ruggedized board level GPUs

High Performance OpenVPX NVIDIA **Pascal** architecture. Choose **OpenVPX** form factor for easy integration and future proofing GPU upgrade path via technology insertion.

Tegra ARM/GPUs for low power embedded applications. Choose **embedded** for low Size Weight and Power (SWaP)

Embedded Tegra SoM	3U VPX Desktop (GPU Only)	6U VPX Desktop (CPU + GPU)

COM Express®

OpenVPX™

Hardware - Packaged Products with NVIDIA GPUs

Fully integrated board sets ready to deploy (Zero NRE) featuring NVIDIA GPUs.

GVC1000 (Jetson TX2)	GVC2000 Lightning (GM107 + Xeon CPU)

lightning

Software - AXIS enabled middleware for GPU enabled DSP applications

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

AXIS View: HardwareView
& RuntimeView
Visualize system
performance

AXIS

Advanced Integrated Software Development Tool Suite

Perhaps the industry's most advanced, most intuitive embedded software development environment, AXIS enables rapid software development.

Software - NEW AXIS ImageFlex dedicated visualization API with GPU acceleration.

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

AXIS

Advanced Integrated Software Development Tool Suite

Perhaps the industry’s most advanced, most intuitive embedded software development environment, AXIS enables rapid software development.

Autonomous capabilities

Abaco's defence pedigree enables autonomy safely.

SWaP-C - Safety compliance - Redundant communications - Anti-tamper secure boot - Harsh military environmentals - High performance computing - Target tracking - Secure networking - Real-time computing - Sensor processing

SWaP-C - Safety compliance - Redundant communications - Anti-tamper secure boot - Moderate environmentals - High performance computing - Image recognition - Secure networking - Real-time computing - Sensor processing

COMPUTE CAPABILITY + SAFETY + SECURITY + ENVIRONMENTALS + PROCESS TRACEABILITY

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.

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