EXELIS

Visual Information Solutions

Graphical Processing Units to Accelerate Orthorectification, Atmospheric Correction and Transformations for Big Data

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Agenda

- GPU Background
- Earth Science where GPU can be effectively used
- Success Story

What is GPU Acceleration?

>A graphics processing unit or GPU is a specialized processor that offloads 3D or 2D graphics rendering from the main CPU(s)

>In a personal computer, a GPU can be present on a video card, or it can be on the motherboard

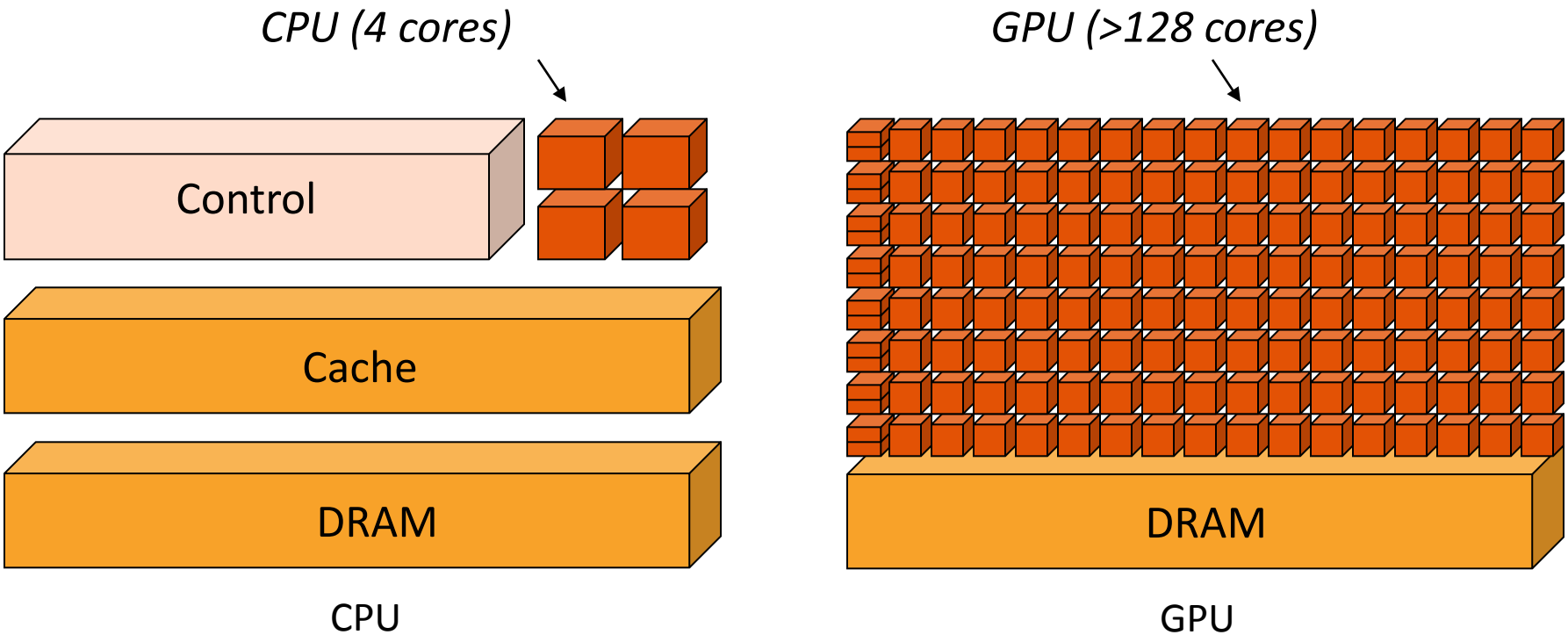
>Their highly parallel structure makes them more effective than general-purpose CPUs for a range of complex algorithms

>Certain algorithms can be run on the GPU to greatly speed up numerical processing

>Most computers, including laptops, today have GPU(s)

High-level GPU Architecture

(Why it can do what it can do)



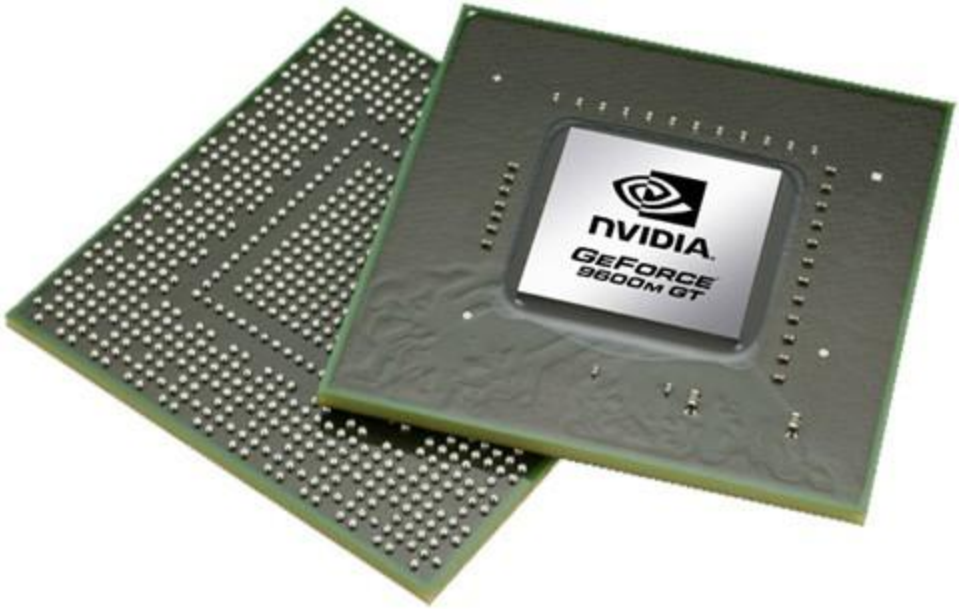
Flow control (If, then)

Compute-intensive
Highly parallel computation

Why aren’t more data processing COTS products GPU enabled?

Many Competing Architectures / Companies

- NVIDIA/CUDA (Compute Unified Device Architecture)
- AMD/Firestream
- Apple, Intel, NVIDIA/OpenCL
- Microsoft/DirectCompute



Exelis VIS GPU Solution

- Developed a CUDA based GPU processing framework that can be redeployed
- Services group develops, this ensures meeting needs of specific architectures
- Worked with groups with BIG data analysis issues with time critical needs
- GPU enabled Existing ENVI and IDL routines, no reinventing the wheel, just make it go faster.

EXELIS VIS GPU Approach

CUDA "Compute Unified Device Architecture"

- Royalty-Free "C Language" – extension to ANSI standard C99
- Complete SDK - Freely distributed
  - API for thread handling, memory management
  - Standard math libraries, BLAS, FFT

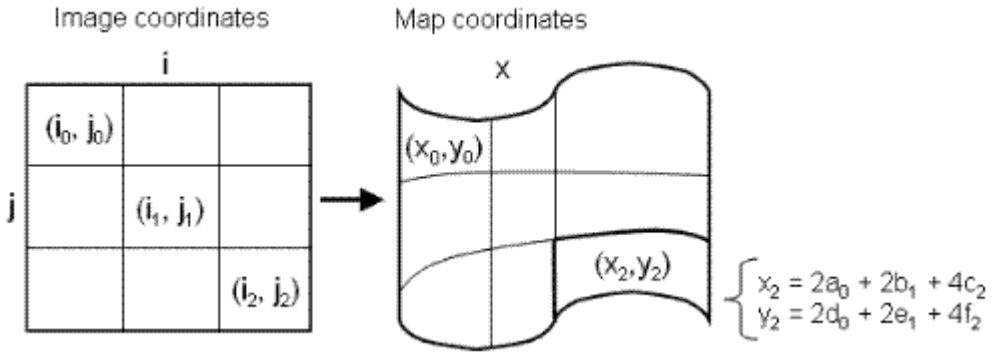
Integrated with ENVI/IDL

- Use of IDL's Internal API to Create a DLM
  - Integrates fully into IDL as a system routine
  - Most flexible solution
  - Recommended for most applications
  - Maximum performance increases are achieved through custom kernel development
  - Can be deployed from ArcGIS

Earth Science Applications – Spatial Processing

Problem: Image projection and registration very slow with standard CPU processing
This can delay using imagery to make time critical decisions where location is important
e.g. Defense and Security, Disaster response/mitigation, Image production

Image projection



Orthorectification

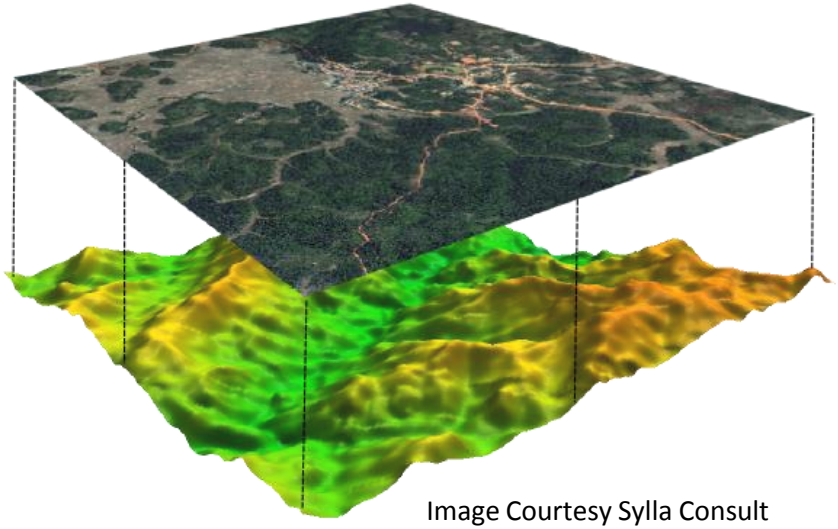


Image Courtesy Sylla Consult

Orthorectification: a process that removes the geometric distortions introduced during image capture and produces an image product that has planimetric geometry, like a map.

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Examples

- Rigorous Frame Camera Model
  - Used in airborne platforms, small / medium format cameras
  - Use GPU to project camera frames to align with GIS layers
  - Resample data to a desired grid

- Large format commercial satellite data
  - Orthorectification using Rational Polynomial Coefficients (RPC)
  - Resample and reproject to desired format

Spatial Processing: Orthorectification Example

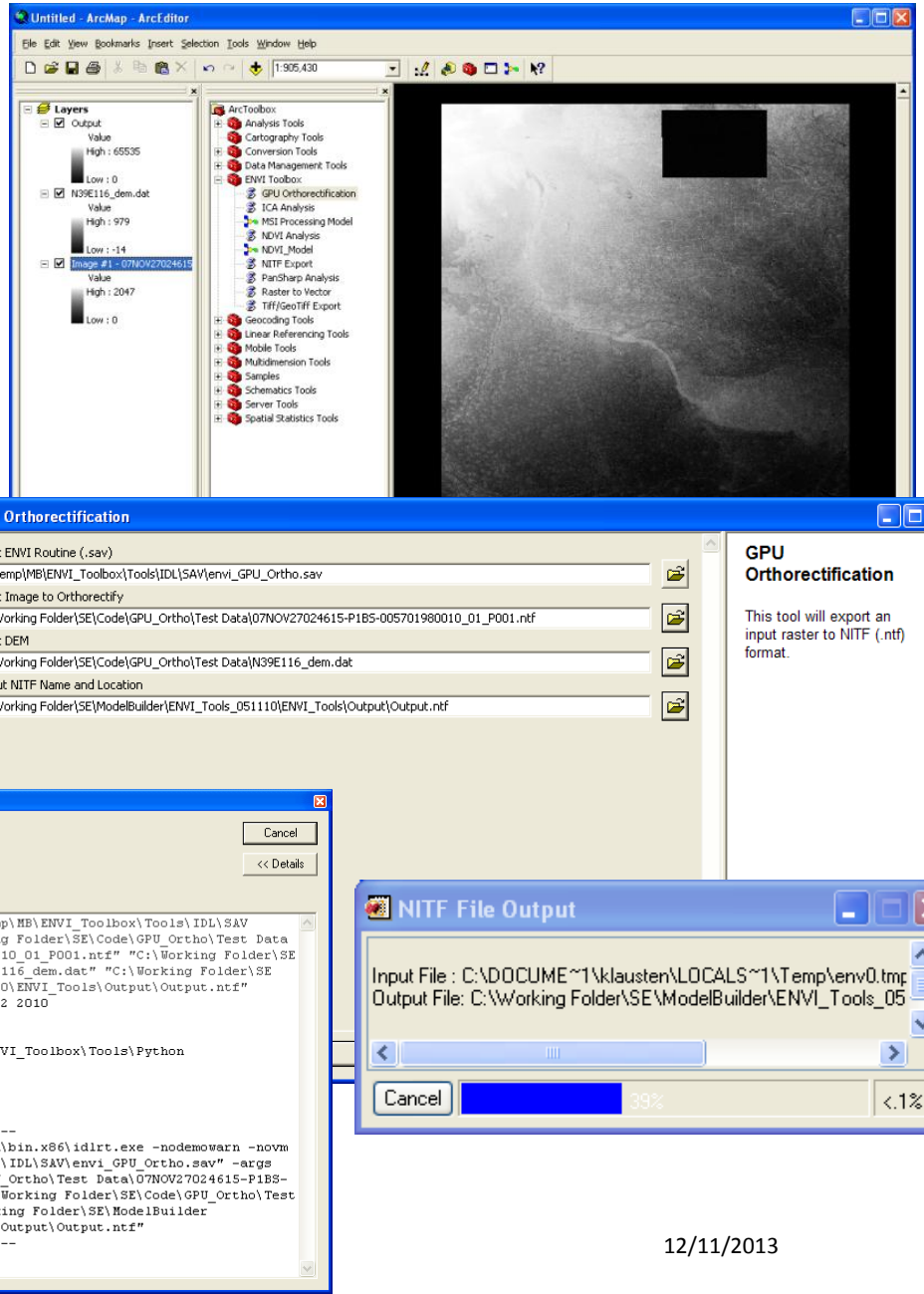
RPC Orthorectification Results

Input / Output	CPU Time	GPU Time
WV1 Point Collect (32k x 32k In, 35k x 35k Out)	2+ Hours	3 Minutes
QuickBird 4-band Image (6878k x 7184k In, 8652k x 9204k Out)	15 Minutes	17 Seconds

Hardware: Intel Core 2 Duo @ 2.6GHz, 4GB RAM, GTX280 GPU
Elevation Model: SRTM Derived DTED
Disk I/O is dominant (60% of total)
GPU is only ~25% utilized!

GPU Ortho – ArcGIS Integration

- With EXELIS VIS' Integration with ArcGIS, call GPU enabled ENVI in an ArcGIS environment
- Available for any ENVI/IDL routine
- Harness GPU in a GIS
- Deploy best image processing practices to GIS users



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Earth Science Applications – Image Transforms

Problem: Many imaging bands are highly correlated. Image transformations help remove correlation and boost signals of hard to find information in imagery or finding change. These transforms are highly computationally expensive

Spectral Processing – ICA/PCA

- Calculations map very well to GPU
  - Functions are called iteratively
  - Very heavy use of matrix multiplication operations
- Tightly integrated with ENVI
- Work performed under government contract, freely available to Intelligence Community
- Already in use at NGIC (National Ground Intelligence Center)

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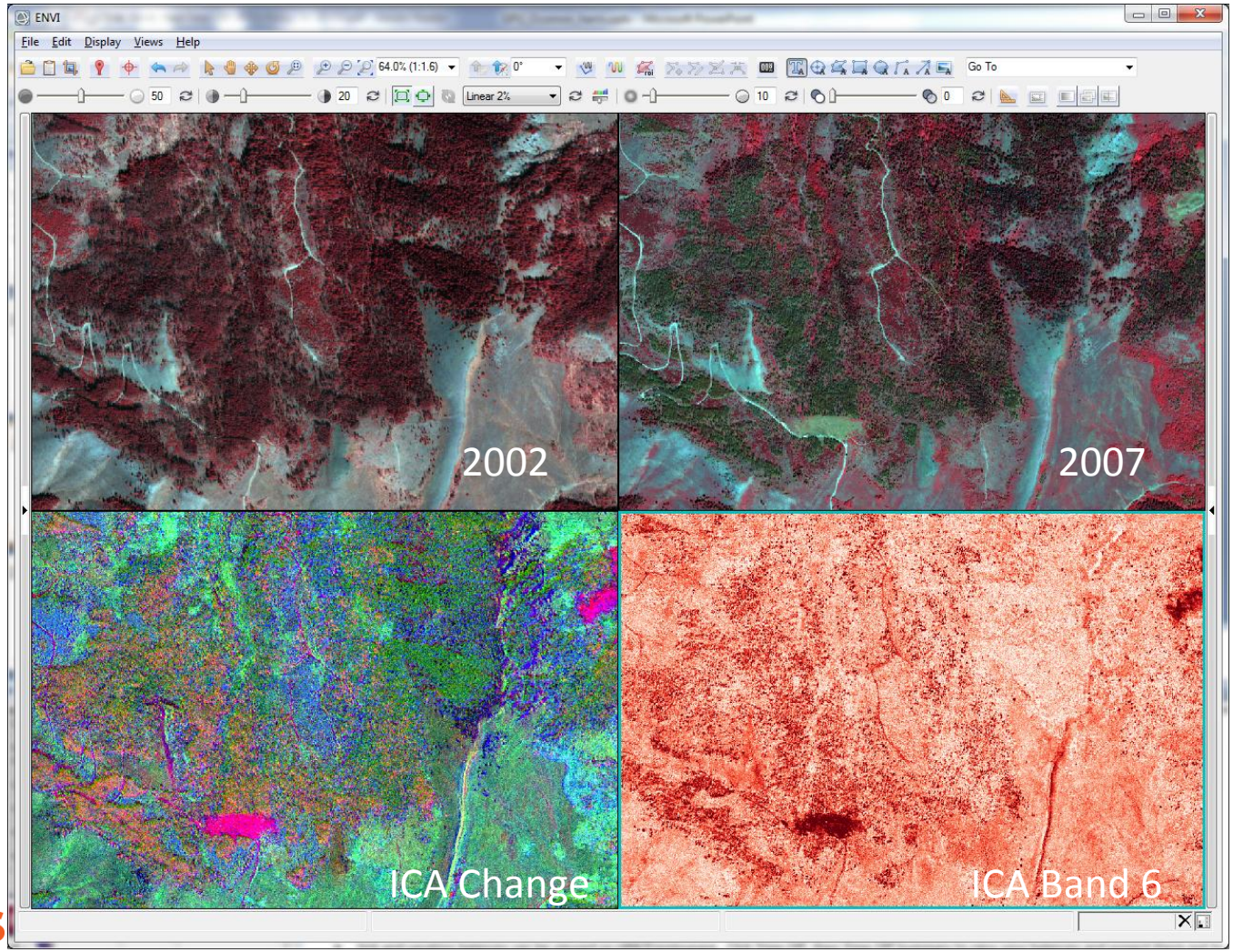


Earth Science Applications – Image Transforms (PCA)

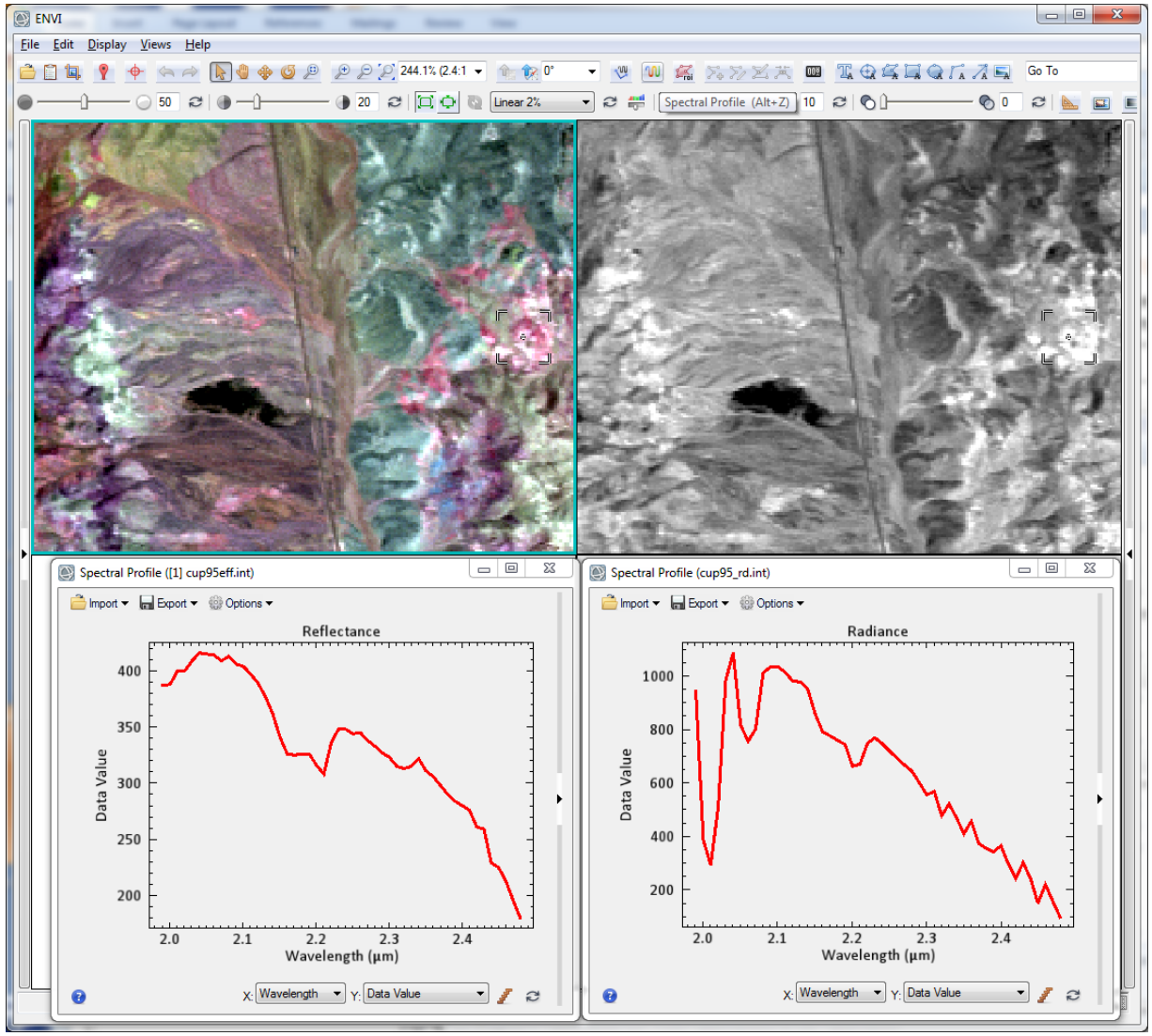
Benchmarks

Input data set
HSI cube: 614 samples x 1024 lines x 244 bands, 16-bit Integer
Hardware
CPU: 6-Cores @ 3.2 GHz, RAM: 6GB
GPU: NVIDIA GTX480, 1GB Video RAM, PCIe 2.0

CPU Time (seconds)	GPU Time (seconds)	Improvement
29.61	2.25	13X

Earth Science Applications: Atmospheric Correction

Problem: Atmosphere interferes with data integrity and needs to be removed to earth science research and analysis, esp. looking an long term trends. This is a computationally heavy application that can easily be modified by GPU processing.



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Earth Science Applications: Atmospheric Correction

Benchmarks

Input data set

HSI cube: 614 samples x 1024 lines x 244 bands, 16-bit Integer

Hardware

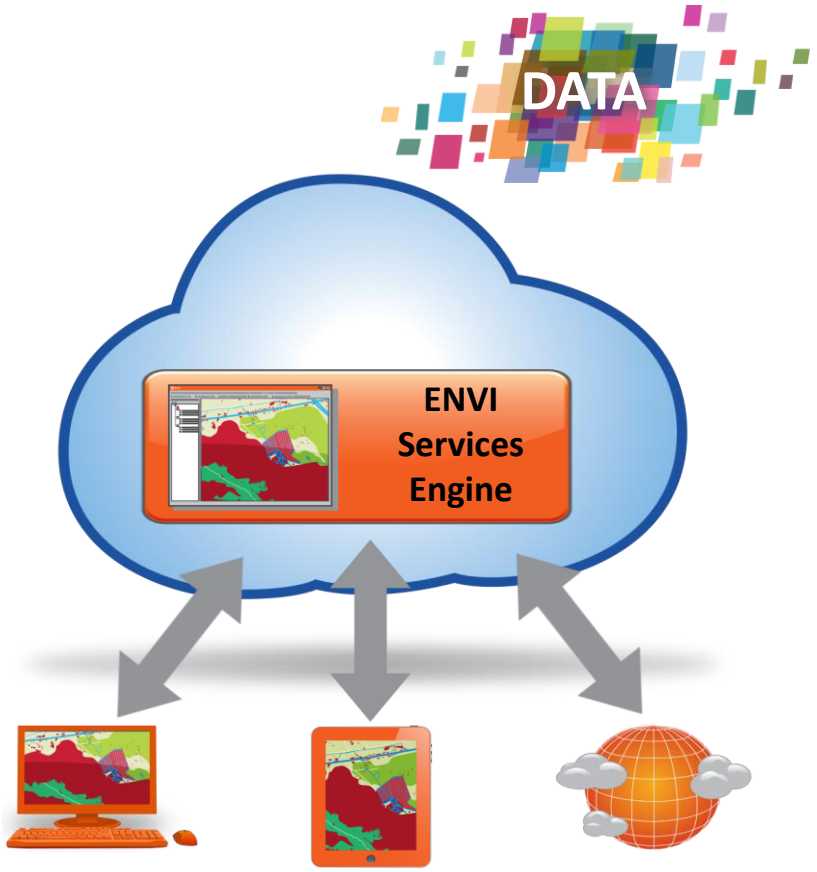
CPU: 6-Cores @ 3.2 GHz, RAM: 6GB

GPU: NVIDIA GTX480, 1GB Video RAM, PCIe 2.0

CPU Time (seconds)	GPU Time (seconds)	Improvement
23.19	2.87	8X

Use ENVI Services Engine to task farm with multiple GPUs

- With multiple GPUs a desktop or laptop can behave as a small super computer
- The ENVI and IDL Services Engine can distribute task to GPU “workers”
- ESE is a COTS product available now
- Limitation is still file I/O, but have potentially 1000s of cores in one machine with GPU use



Success Story: Range and Bearing

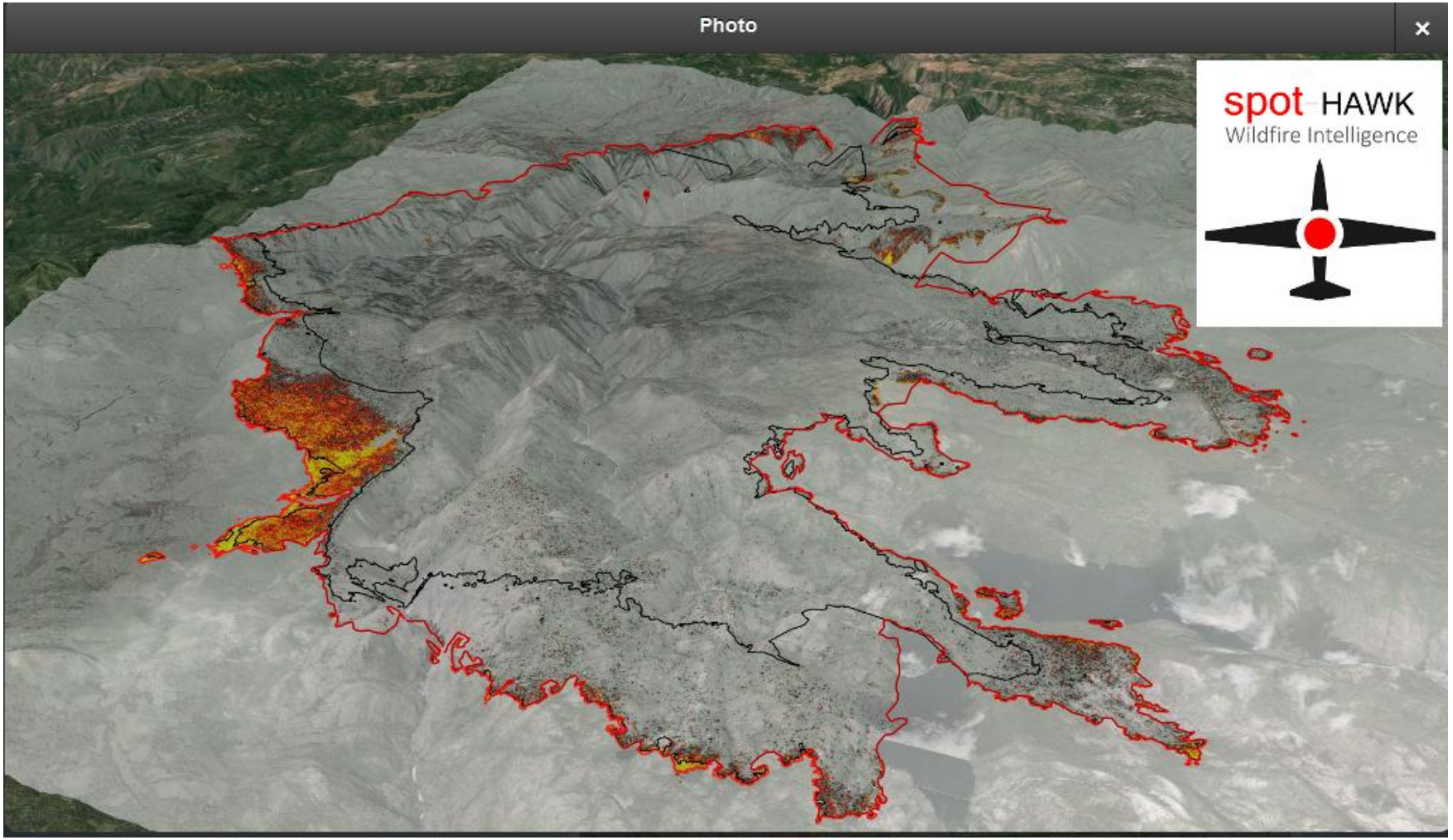
Overview

- Small Aerial Photography Company
- Collects thermal and multispectral imagery, full motion ortho imagery over fires, disasters, pipeline monitoring, environmental assessment—anything where imagery can help the mission in **real time**.
- Acquires MANY images and need to have images ortho'd to accurately show hotspots and change.

Solution

- Contracted EXELIS VIS to develop GPGPU for high-speed ortho
- Images collected and processed on plane with a laptop
- Laptop a low draw on power
- The fire features are exploited from the real-time ortho imagery live.
- Fire features stream into a common operating picture live.

Success Story: Range and Bearing



Success Story: Range and Bearing

> Essentially, the creation of GPU based real-time processing and exploitation enables Range and Bearing's Spot-HAWK platform to provide government, media, and the public live geoint of what the wildfire is doing NOW, not a report of what happened yesterday.
>
> *—Doug Campbell, Range and Bearing President/CEO*

Summary

- Exelis VIS has developed tools with GPU technology to process large volumes of imagery and create meaningful products in near real time
- With multiple GPUs a desktop or laptop can behave as a small super computer
- Image processing, in particular pixel analysis is very well suited for GPUs
- Reusing existing ENVI and IDL functionality keep cost low and maintains analytical repeatability.

Thank you!

For Further information please contact
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