S5576: Applying MapGraph: GPU-Accelerated Merlin Decision Support and COA Generation for Electronic Warfare Operations

3/17/2015: GTC 2015

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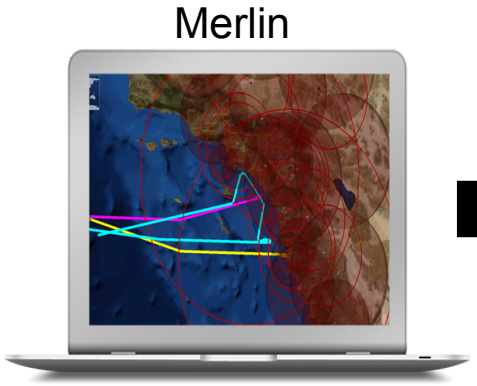
Chesapeake Technology International

systap™

Overview and Agenda

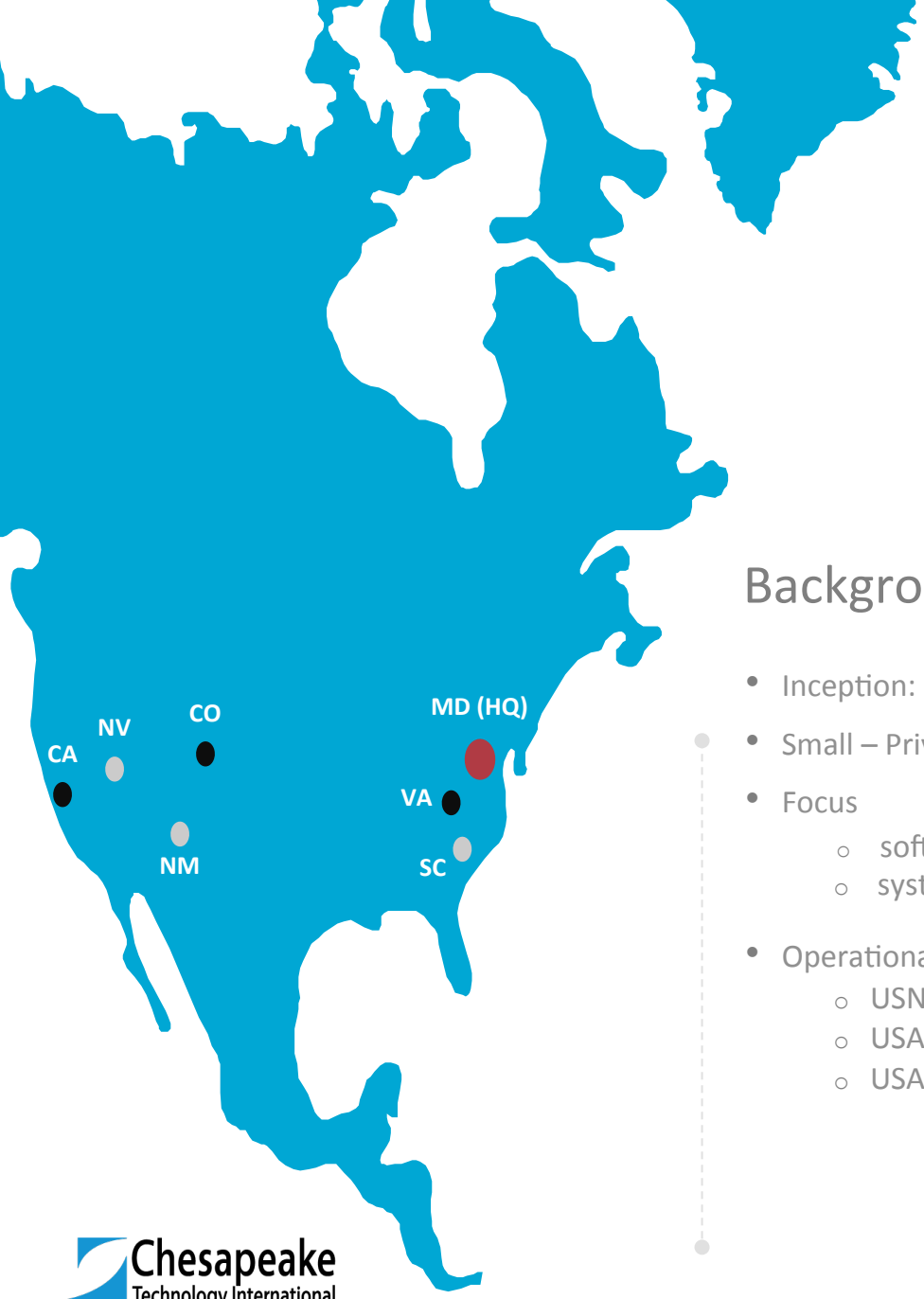


mapgraph™

EW Planning 10X Faster

- Who is CTI?
  - What is Merlin?
- Who is SYSTAP?
  - What is Mapgraph™?
- How did we accelerate the Merlin EW Planning Application by 10X using GPUs?
- Demonstration / Questions

Who is Chesapeake Technologies International (CTI)?



About Us

we bring technology to the fight

Background

- Inception: April 1, 2000
- Small – Private - Veteran-Owned
- Focus
  - software development
  - systems integration
- Operational experience
  - USN / USMC EA-6B (EW)
  - USAF EC-130E (PSYOPS)
  - USA (SIGINT)

- Customer focused
- Highly efficient
- Cost effective
- Hire known experts
- Leverage technology

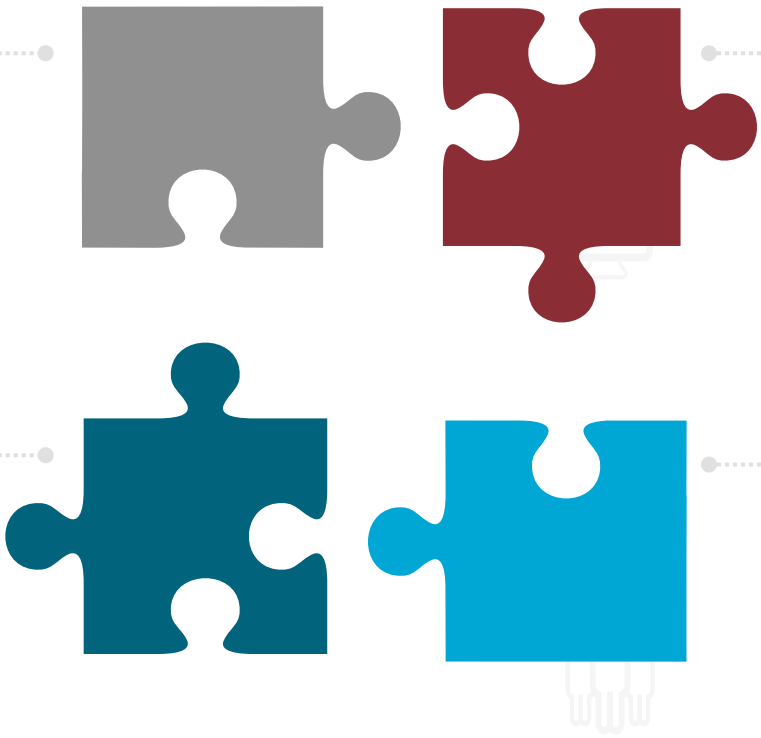
Chesapeake Technology International

What We Do

custom cutting-edge solutions

Mission Areas

Sensor
Tactical Systems
Training & Simulation
EW & RF-delivered Cyber CEMA)
Mission Planning & Decision Support



Innovation

Automation
Optimization
Distribution
Collaboration
Tactical Enterprise
Advanced Research & Development

Technology

SOA
Software
Visualization
Cloud Technologies
Integrated Solutions
Mobile & Embedded Computing

Culture

Personnel
Training
Leadership
Workplace
Community
Philosophy

Corporate Focus

CYBER|EW

Net-Centric Ops

Mission Planning

Situation Awareness

Training & Simulation

EA-6B Aircrew Trainers
Cyber/EW Coordination Cell
ICAP-III Tactical Displays
ALQ-231 | EWSA
Special EW Systems

TACTICAL & UNMANNED SYSTEMS

Integration

Display Software

Sensor Control

Payload Control

Counter-Narcotics
P-8A Increment 3
INVADER
Multi-sensor Integration
Special C4ISR Systems

C4ISR

EO | IR

Radar

Data Links

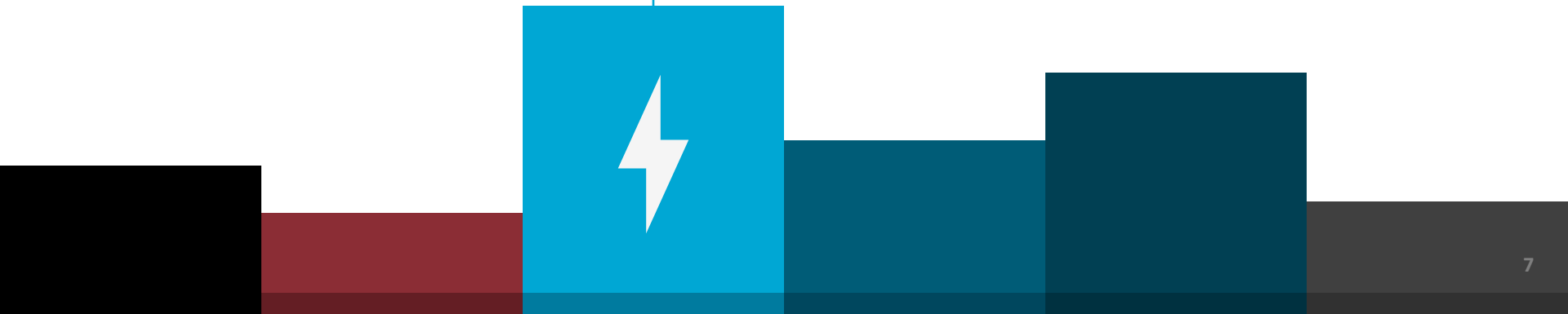
Navigation

RaptorX | OWF
Tactile Situation Awareness
Thunderstorm Fury
EC-130 Commando Solo
NASA CAR Roll Correction

What is Electronic Warfare?

controlling the spectrum

> Electronic Warfare (EW) is any action involving the use of the electromagnetic spectrum, or directed energy, to control the spectrum, attack an enemy, or impede an enemy assault via the spectrum
>
> *- "Electronic Warfare" | Wikipedia 2015*



Electronic Warfare Breakdown

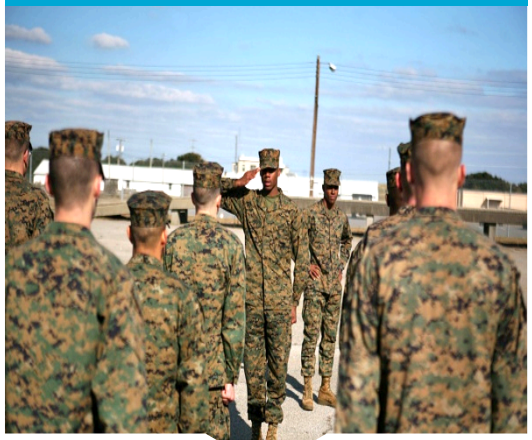
three electronic warfare categories

ELECTRONIC ATTACK (EA)

Attempts to deny, disrupt, degrade, and deceive hostile use of the electromagnetic spectrum

Merlin focus

ELECTRONIC PROTECTION (EP)



The protection of personnel, facilities, and equipment from friendly, neutral, and hostile use of the electromagnetic spectrum, as well as from naturally occurring phenomena (e.g. ECCM)

ELECTRONIC SUPPORT (ES)

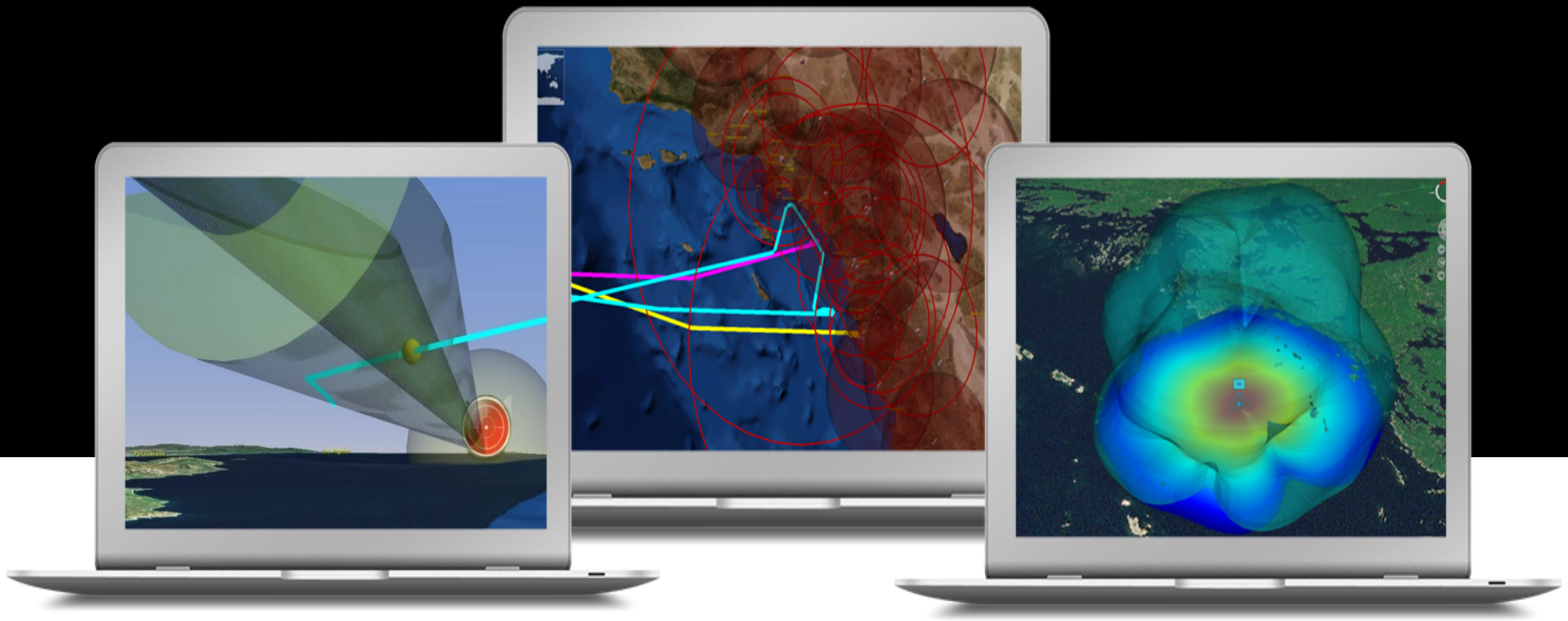
The search, interception, identification, and location finding of electromagnetic signals (e.g. sensors)

Merlin focus

What is Merlin?

Chesapeake Technology International

your analytics wizard



Path Finding Tool

Providing airborne positioning solutions for jammers, sensors, & beyond …

Mission Analysis Tool

Capable of analyzing the electromagnetic battle-space

3D Visualization Tool

Leveraging NASA World Wind, can visualize: antenna patterns, electromagnetic effects, propagated signals, and terrain masking

Extensible Mission Planning Environment

For Electronic Warfare Solutions

GPUs in Tactical Environments

this is game-changing technology

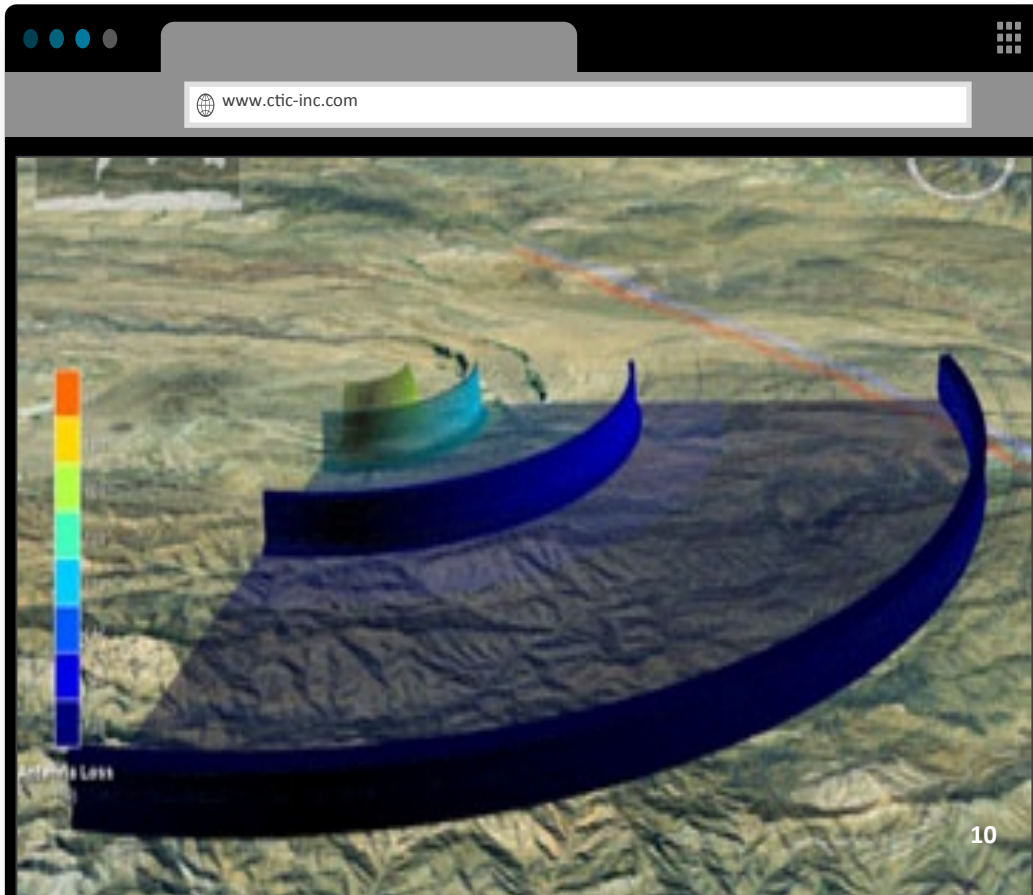
Automation | Computation

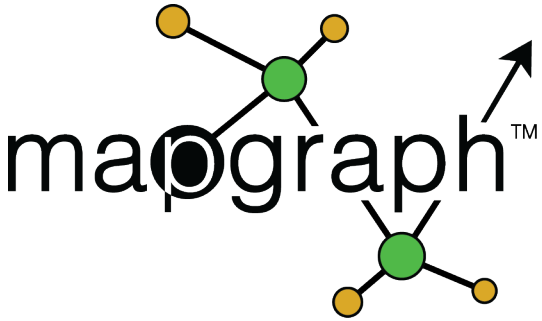
- Near real-time processing of terrain's effect on battlefield
- Accelerating Course of Action (COA) generation
- Enabling tactical use of RF propagation paths

3-D OpenGL Rendering

- High fidelity rendering of RF effects
- Interactive visualizations (>20+ Frames/second)

Mission planning & execution in the future can, and will, be as smooth as a modern computer game





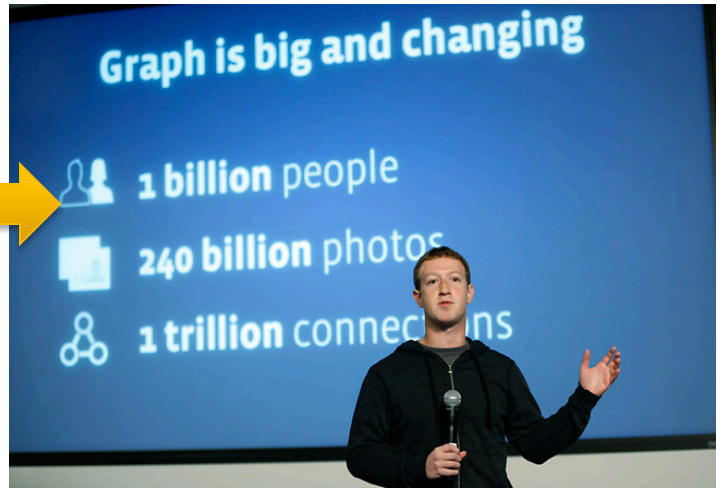
Who is SYSTAP?

About SYSTAP, LLC

- SYSTAP, LLC is a small-business with a vision of building high quality, scalable software solutions for graphs.
- SYSTAP's flagship product, Blazegraph™ is a leader in providing solutions for graphs with both Semantic Web and Property Graph APIs.
- Blazegraph™ powers enterprise applications for customers including EMC, AutoDesk, Yahoo!7, Wikidata, and the financial industry.
- SYSTAP's MapGraph™ is a new and disruptive technology to process large graphs in near-real time using GPU acceleration.
- SYSTAP has demonstrated MapGraph™ HPC achieving performance 10,000X faster than other CPU-based technologies on data-parallel graph analytics.

What makes us unique?

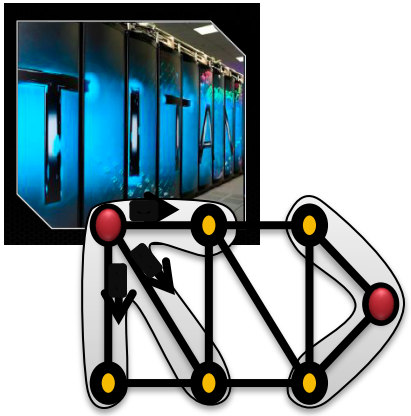
- Lead by examples such as Facebook and Linked-In, businesses face a challenge of exploiting graph data.
  - Mark Zuckerberg sums up the problem!
  - Existing enterprise technologies typically do not scale when applied to graph analytics.
- SYSTAP's technologies make graph analytics up to 10,000X faster using GPUs.
- SYSTAP's technologies make graph analytics cheaper user fewer hardware and power resources.
- SYSTAP's technologies enable new markets for HPC graph analytics by dramatically improving the price / performance ratio.



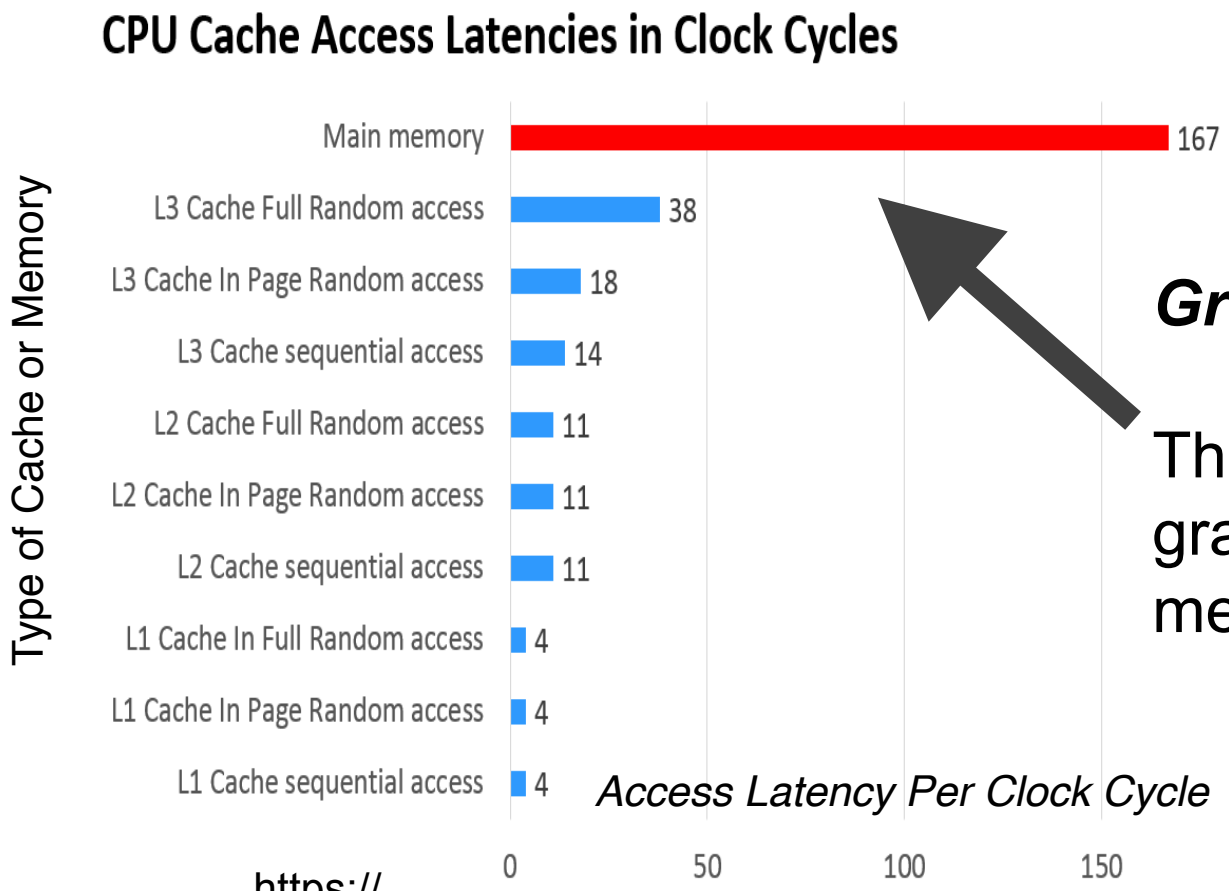
Facebook has ~ 1 trillion edges in their graph. It takes 20 minutes per iteration on the graph. Analytics require multiple iterations. Mapgraph do it in seconds on a cluster of GPUs.

Three Product Offerings

- **Blazegraph™**: RDF and Property Graph Database
  - Blazegraph™ is a market leader in providing solutions for graphs with both Semantic Web and Property Graph APIs using a Java-based platform with High Availability and Horizontal scaling.
  - Blazegraph™ powers enterprise applications for customers including EMC, AutoDesk, Wikidata Query Service, Yahoo!7, and the financial industry.
- **MapGraph™ Accelerator (Beta)**: GPU-Accelerated Graph Analytics for Blazegraph (Launch / Demonstrate at GTC 2015)
  - A plug-in capability for Blazegraph™ to provide single-GPU graph analytics using a Java API.
- **MapGraph™ HPC (Beta)**: a new and disruptive technology for HPC Business Analytics to process large graphs in near-real time using GPU acceleration.
  - A software platform that achieves performance 10,000X faster than other CPU-based technologies on data-parallel graph analytics on GPU Clusters.



Graphs are **different**. You need the **right paradigm** and **hardware** to **scale**.



Graph Cache Thrash

The CPU just waits for graph data from main memory...

https://datatake.files.wordpress.com/2014/09/latency.png

What is Mapgraph?

SCI
www.sci.utah.edu

DARPA

- **Parallel Processing** on GPU Clusters for **Trillion+** Edge Graphs
- **High-Level API**
- **Partitioning** and **Overlapping** Communications
- **HPC** and **DARPA** Pedigree

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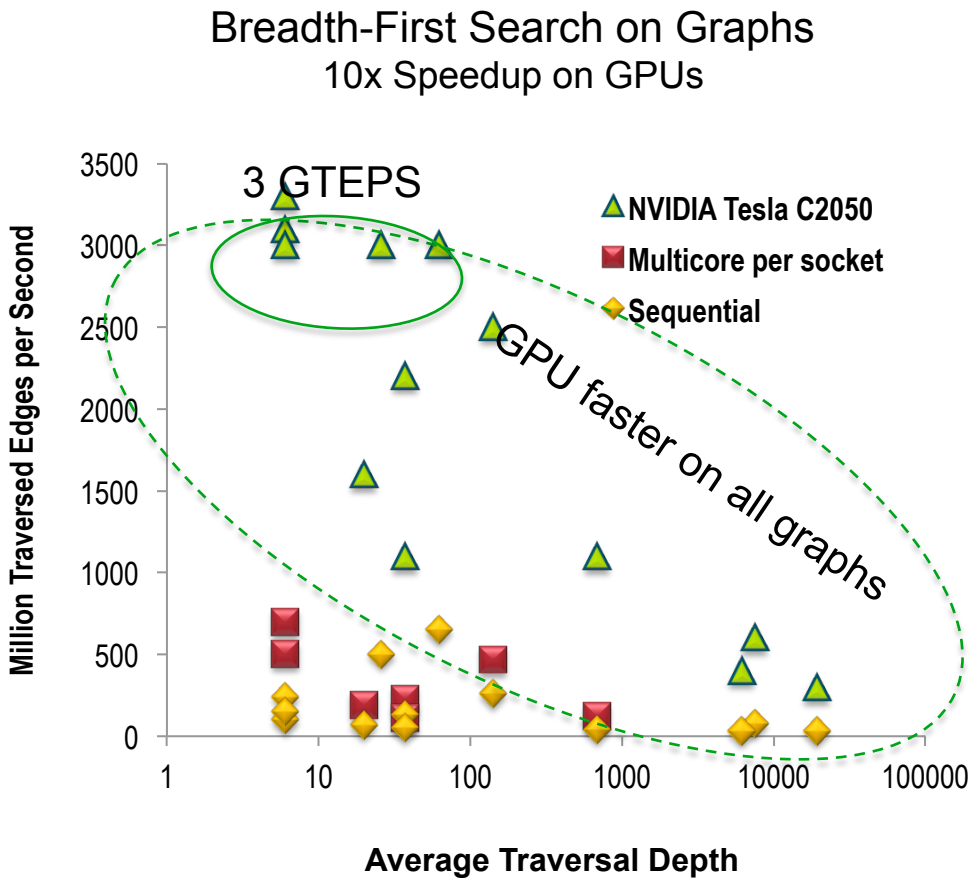
GPUs – A Game Changer for Graph Analytics

- Graphs are a hard problem
  - Non-locality
  - Data dependent parallelism
  - Memory bus and communication bottlenecks
- GPUs deliver effective parallelism
  - 10x+ memory bandwidth
  - Dynamic parallelism



D. Merrill, M. Garland, A. Grimshaw. Scalable GPU Graph Traversal. *PPoPP'12.*

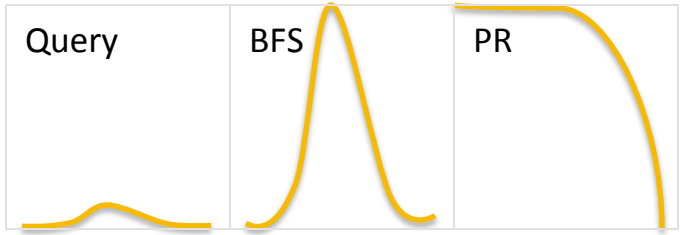
MapGraph: Extreme performance

- GTEPS is Billions (10^9) of Traversed Edges per Second.
  - This is the basic measure of performance for graph traversal.

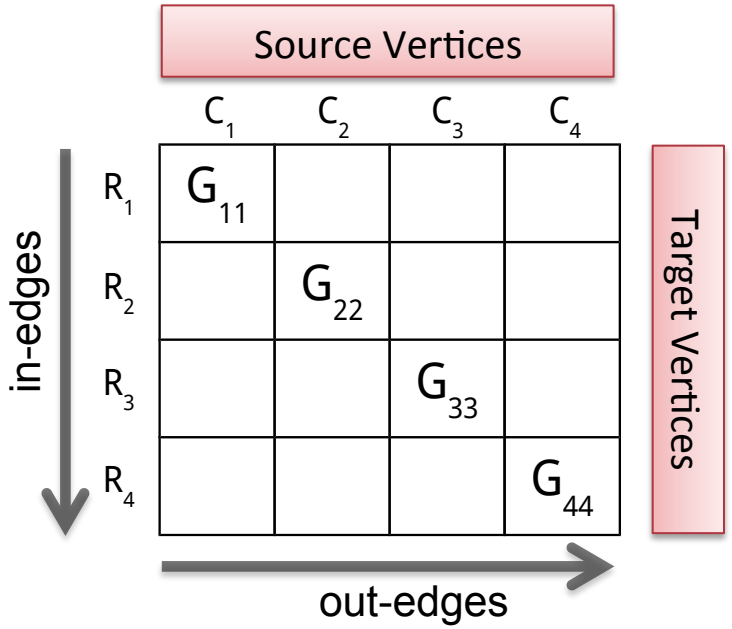
Configuration	Cost	GTEPS	$/GTEPS
4-Core CPU	$4,000	0.2	$5,333
 **4-Core CPU + K20 GPU**	**$7,000**	**3.0**	**$2,333**
XMT-2 (rumored price)	$1,800,000	10.0	$188,000
 **64 GPUs (32 nodes with 2x K20 GPUs per node and InfiniBand DDRx4 – today)**	**$500,000**	**30.0**	**$16,666**
 **16 GPUs (2 nodes with 8x Pascal GPUs per node and InfiniBand DDRx4 – Q1, 2016)**	**$125,000**	**>30.0**	**<$4,166**

2D Partitioning (aka Vertex Cuts)

- p x p compute grid
  - Edges in rows/cols
  - Minimize messages
    - log(p) (versus p^2)
  - One partition per GPU
- Batch parallel operation
  - Grid row: out-edges
  - Grid column: in-edges
- Representative frontiers

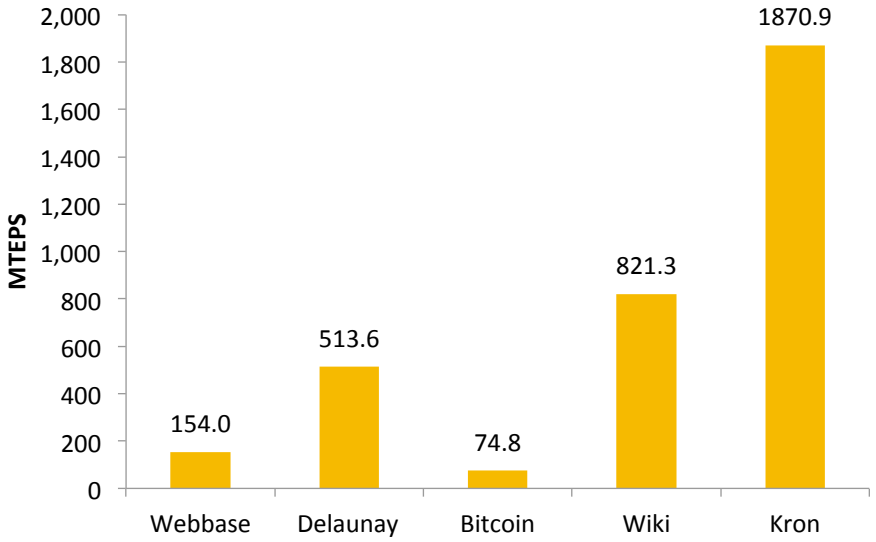


- Parallelism – work must be distributed and balanced.
- Memory bandwidth – memory, not disk, is the bottleneck



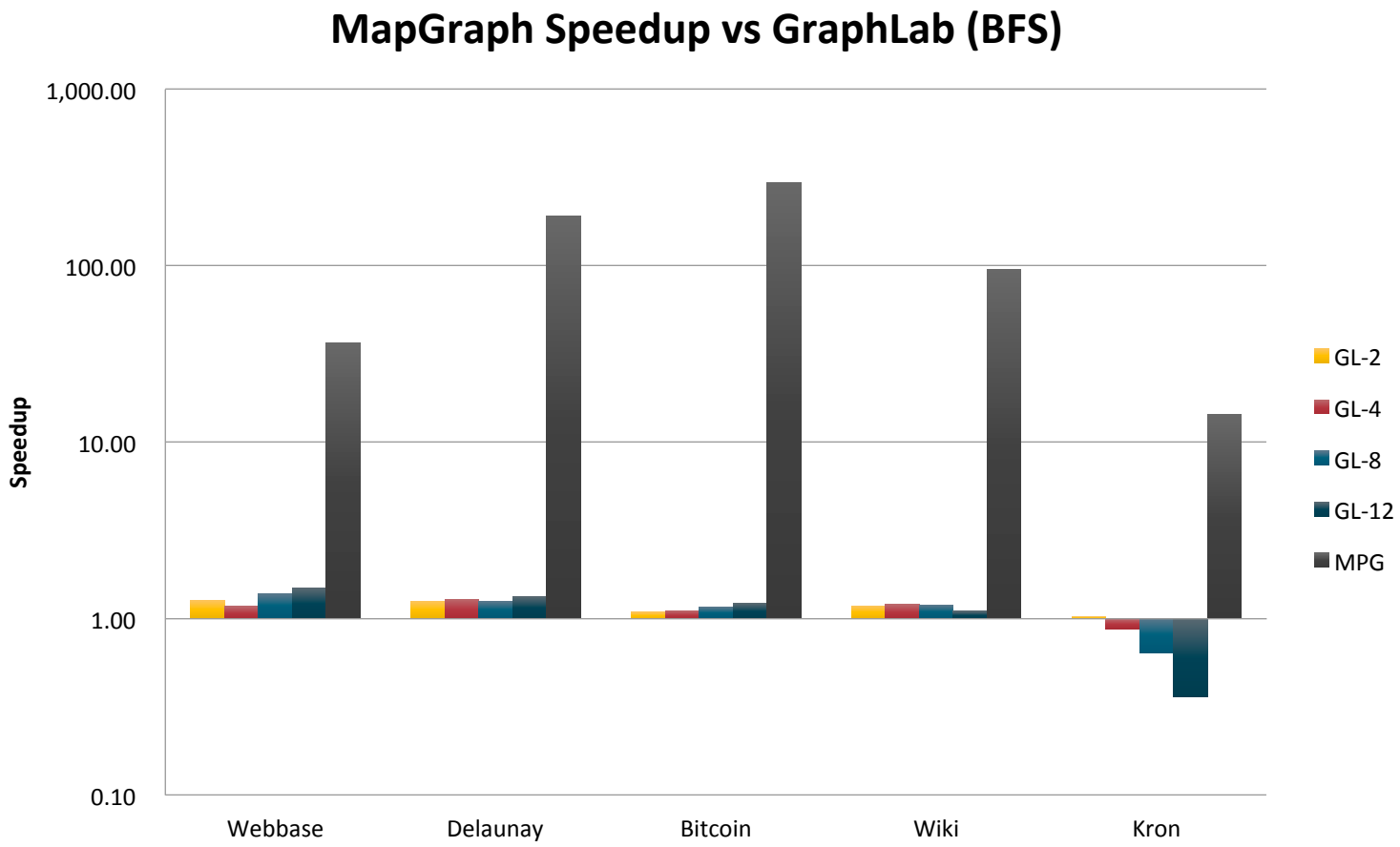
Single GPU MapGraph (BFS)

Dataset	#vertices	#edges	Max Degree	Milliseconds
Webbase	1,000,005	3,105,536	23	1.2
Delaunay	2,097,152	6,291,408	4,700	24.5
Bitcoin	6,297,539	28,143,065	4,075,472	345.3
Wiki	3,566,907	45,030,389	7,061	51.0
Kron	1,048,576	89,239,674	131,505	47.7



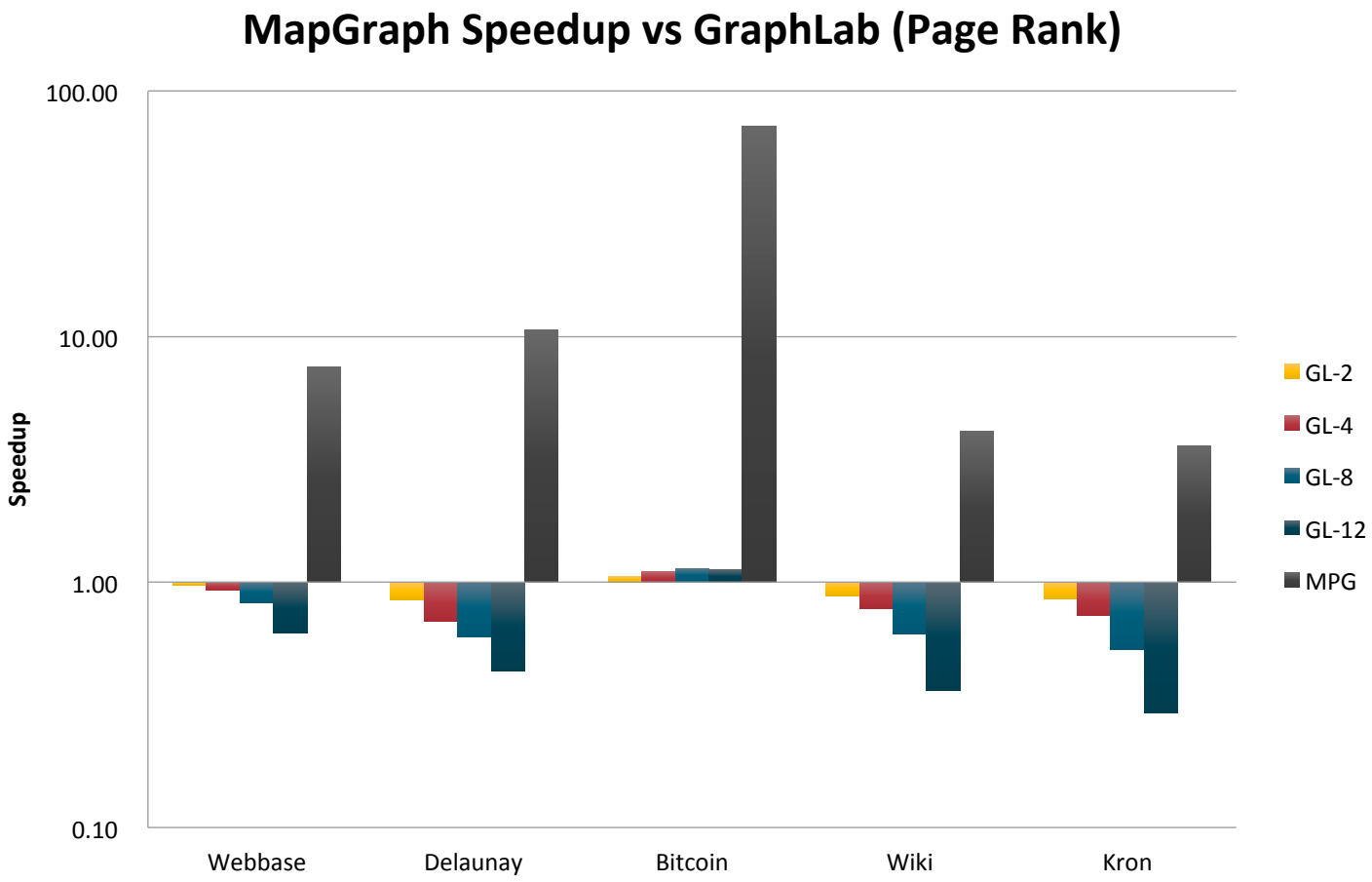
BFS Results : MapGraph vs GraphLab

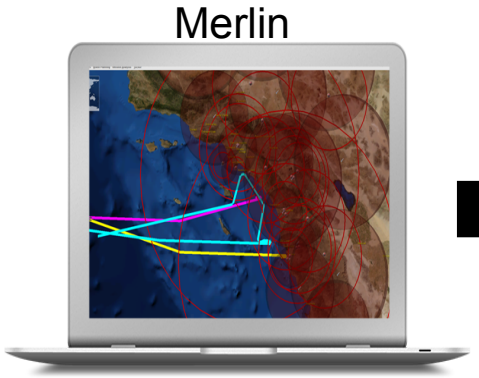
- CPU vs GPU
- GPU 15x-300x faster
- More CPU cores does not help



PageRank : MapGraph vs GraphLab

- CPU vs GPU
- GPU 5x-90x faster
- CPU slows down with more cores!





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EW Planning 10X Faster

Accelerating Merlin with Mapgraph

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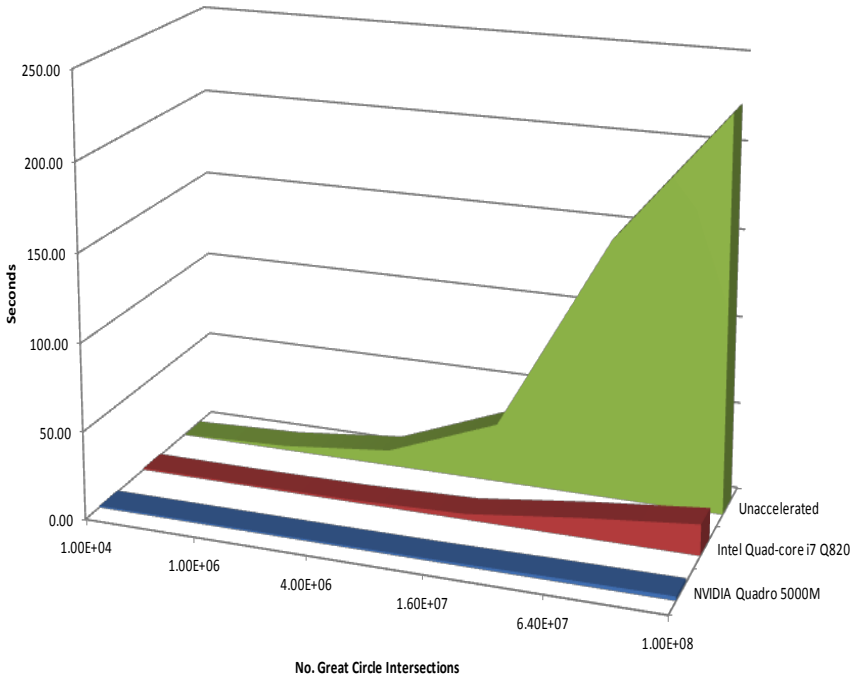
Mission Planning Objectives

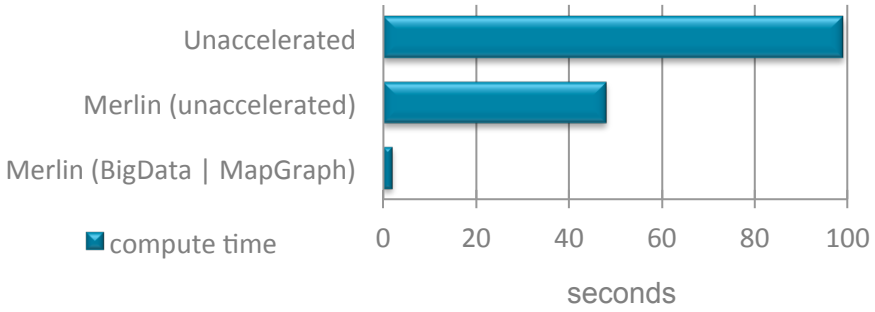
improving automation

Early program goals

Early program goals included the reduction of automation and processing timelines from hours to minutes

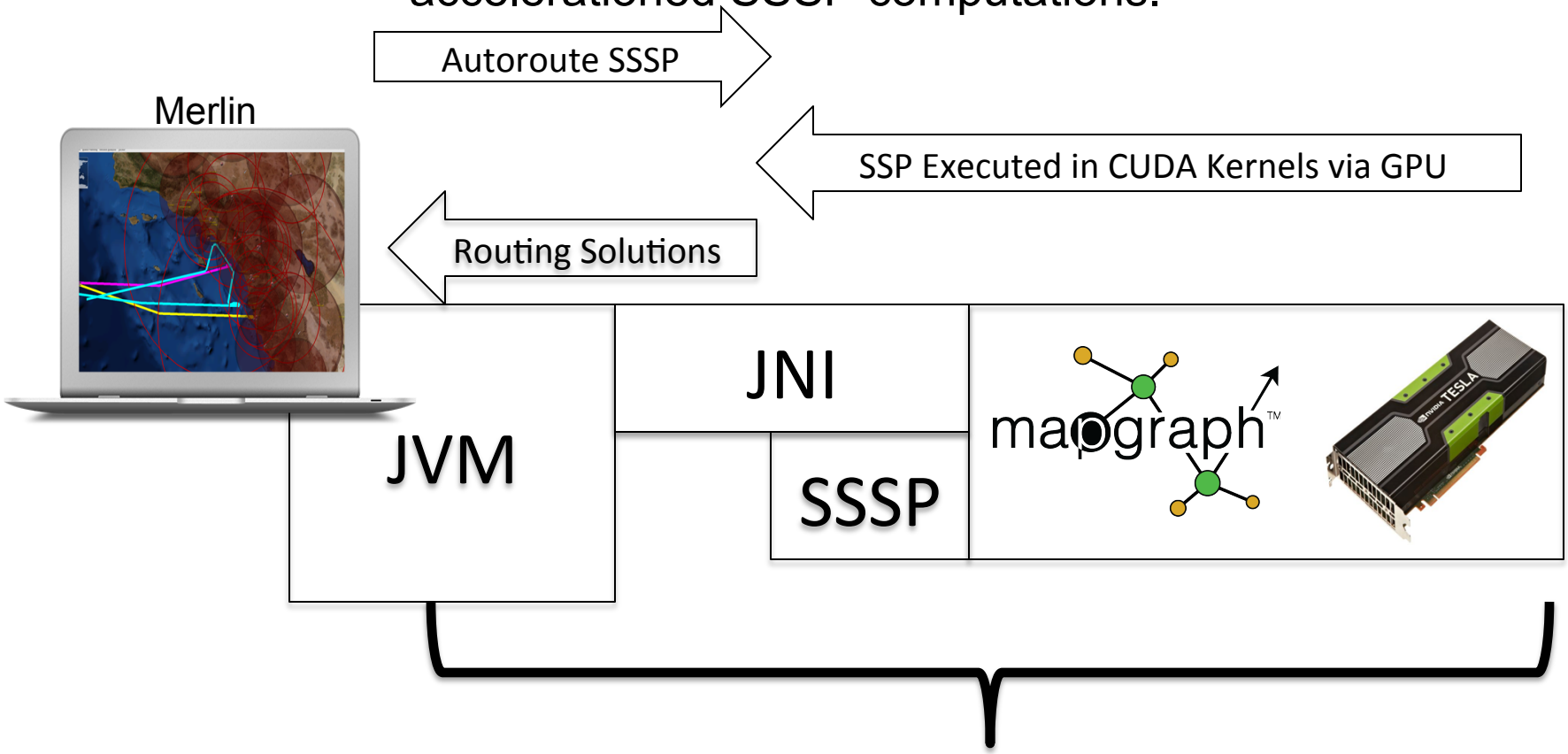
CTI, in partnership with Systap, is progressing towards a MapGraph GPU-driven solution to reduce timelines from minutes to seconds





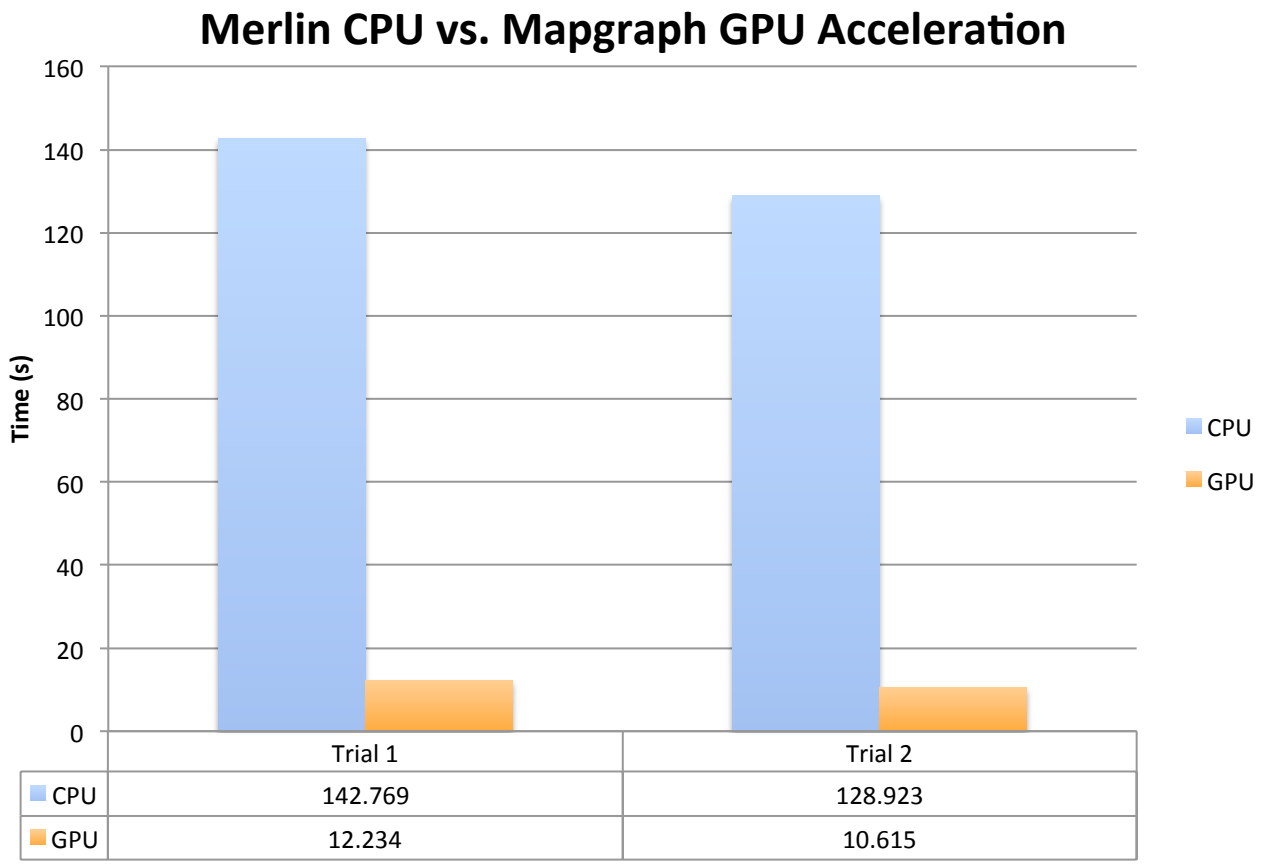
Integration Concept

Compare Autoroute using A* Search (CPU-based) to one with GPU-accelerationed SSSP computations.



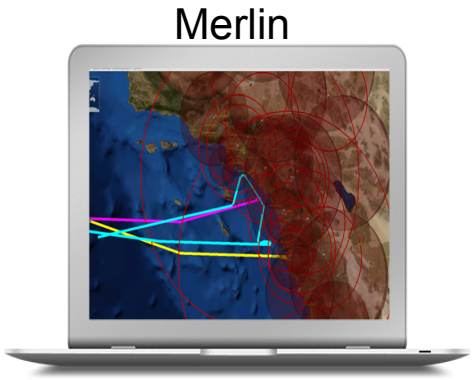
From minutes to seconds on the GPU.

Early Results Show a 10X Speed-up



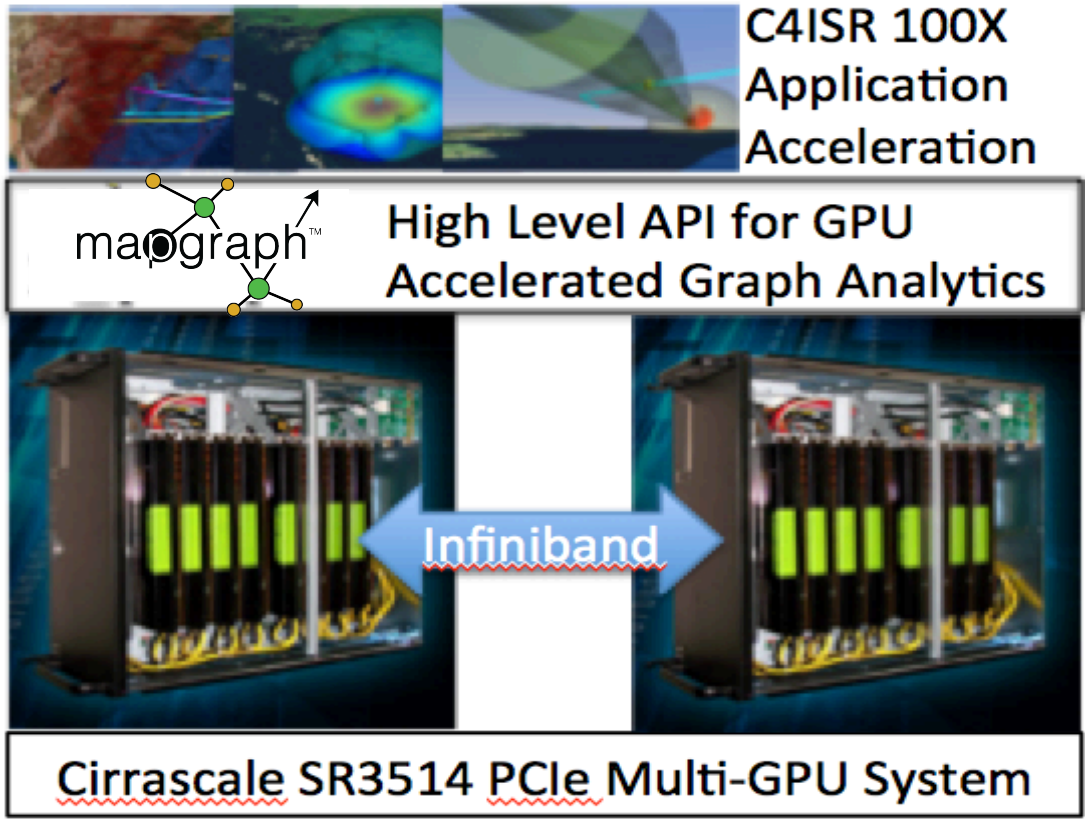
	Trial 1	Trial 2
CPU	142.769	128.923
GPU	12.234	10.615

Next Steps



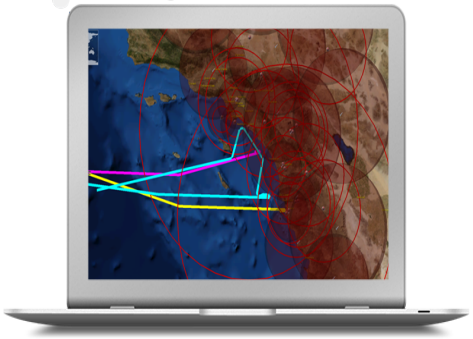
- How to rethink the architecture in a parallel sense
- Additional testing and scaling work for the single-GPU Acceleration
- Expansion to Multi-GPU Mapgraph versions
- Implementation of additional graph algorithms to support EW planning in MapGraph
- Applications to UAV on-board planning applications
- Other DoD Planning Domains: Air Tasking Orders (ATOs), Cyber Planning, C4ISR, etc.

Future: GPU Clusters for C4ISR Acceleration



GPU Clusters for HPC Acceleration of C4ISR Algorithms

Merlin



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Thank you.

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