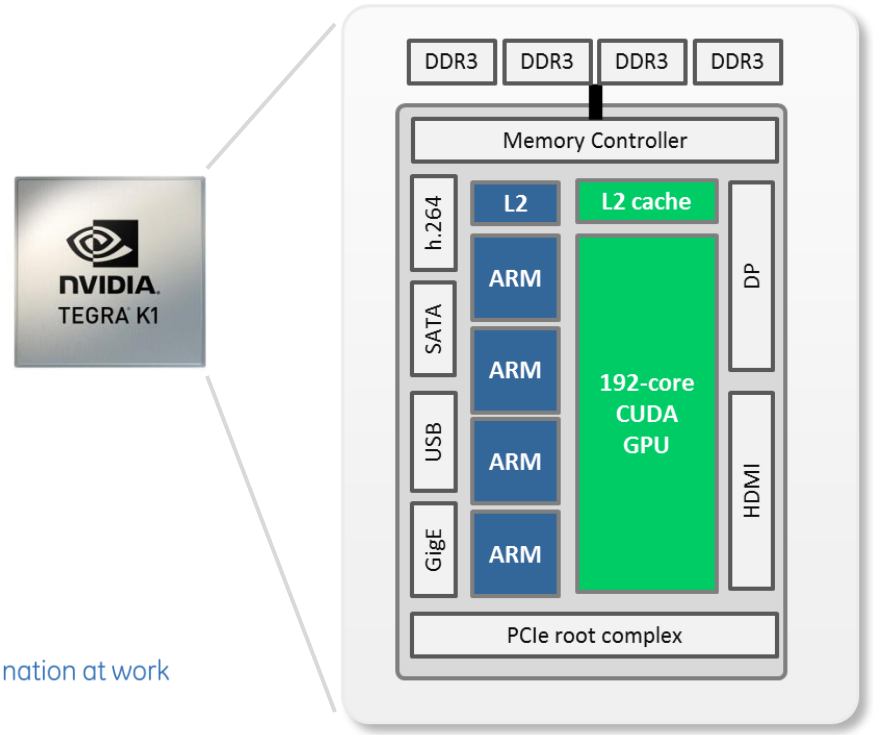
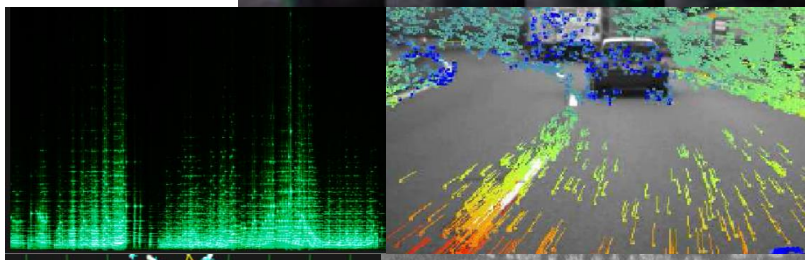

NVIDIA® Tegra K1
IMPOSSIBLY ADVANCED
imagination at work

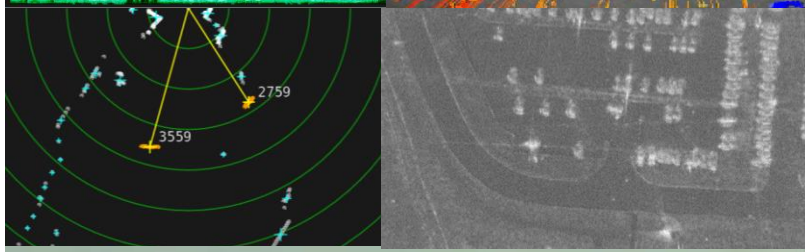
first ARM SoC with integrated CUDA

- deploy battery-powered CUDA for data-intensive applications
- more perception → more autonomy!
- outpace the growth of sensors and increasing algorithmic demands

- rapid development & prototyping in a realtime-capable environment
- wide-ranging CUDA code compatibility → reduced risk & cost
- developer-friendly tools and Linux SW ecosystem



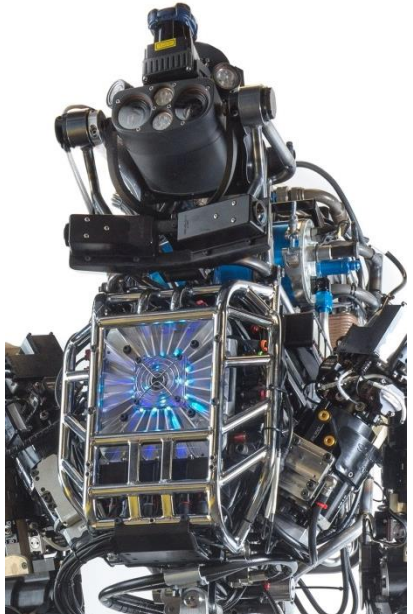




imagination at work

robotics

- UAV UUV UGV
- humanoids, mechs, and cybernetics



Tegra's…in space

imagination at work

sensing, surveying & surveillance

imagination at work

scientific
medical
industrial

- handheld ultrasound, CT, MRI, X-ray

- portable analyzers, sequencers, and scopes

- RF signal processing

imagination at work

GE launches TK1 mini module

New COM Express Module from GE Brings New Levels of Performance to Applications Constrained by Power Consumption and Size

- *mCOM10K1 delivers 326 GFLOPS of performance, consumes 10 watts or less*
- *Benefits from NVIDIA® Tegra® K1 GPU for data-intensive platforms*
- *Allows GE to respond to growing demand for SWaP-constrained solutions*

NUREMBERG, DE— FEBRUARY 24, 2015— GE's Intelligent Platforms business today announced at Embedded World the mCOM10K1 type 10 Mini COM Express module. Based on the NVIDIA® Tegra® K1 system-on-chip (SoC) - enabling it to deliver 326 GFLOPS of performance, well beyond the performance typically associated with Mini COM Express - it is ideal for applications where very high performance in data-intensive applications, rugged reliability in harsh environments and very compact size need to be combined.

As well as extending GE's COM Express offering still further, the mCOM10K1 also brings GE's powerful GPGPU (general purpose processing on a graphics processor) capability within reach of the significant number of applications where power consumption needs to be 10 watts or less.

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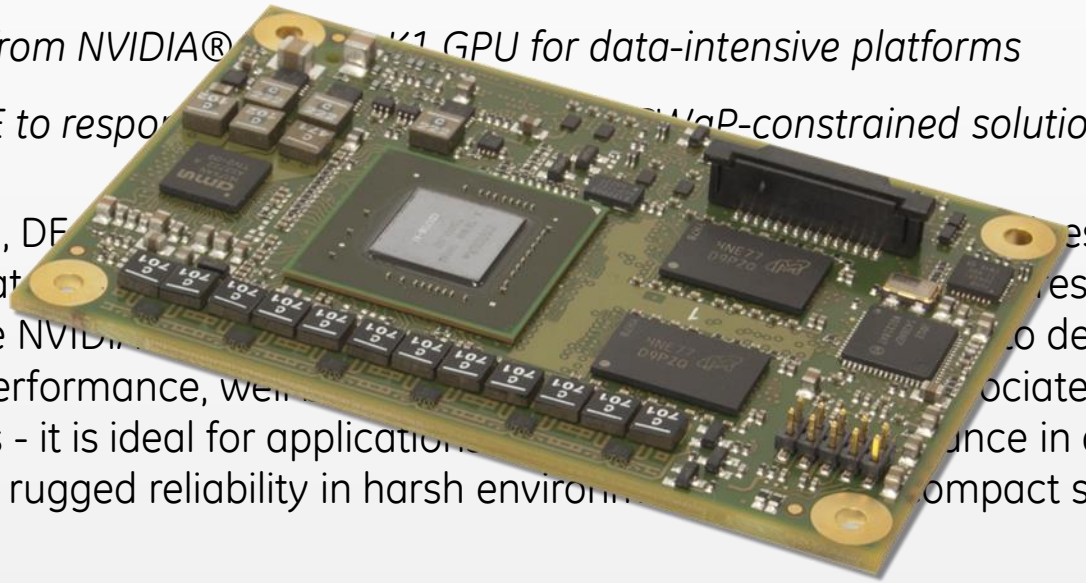

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imagination at work

COM Express mini module

Processor/Chipset
- NVIDIA Tegra K1 SOC
  - 4 Core ARM Cortex-A15 @ 2.0 GHz, <10W TDP
  - 192 Kepler GPU cores (CUDA capable)

Memory
- 2GB of DDR3

Memory
- 4GB of eMMC flash

Graphics Features
- Integrated graphics interface
  - HDMI
  - LVDS

Audio
- Stereo line out / Stereo line in

LAN Port
- 1x Gigabit Ethernet port (SKU-A only)

Serial ATA Interface
- 1x serial ATA interfaces (3 Gb/s)

USB Interface
- 5x USB 2.0 ports
- 1x USB 3.0 ports (SKU-A only)

Extension
- PCIe, 1 port x2 Gen 2 (SKU-A)
- PCIe, 1 port x4 Gen 2 (SKU-B)

I/O Interface
- 8x GPIO ports

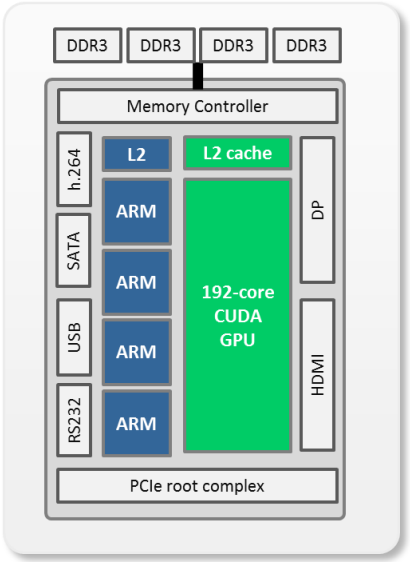
Others
- States: Active, Suspend (LP1), Deep Sleep (LP0)
- Debug port
- convenient MIPI CSI-2 connector port
- pre-mounted passive heat sink/spreader for optimal cooling
- 7-year long lifecycle guaranteed availablity

Power
- Input: 12V
- 10 watts

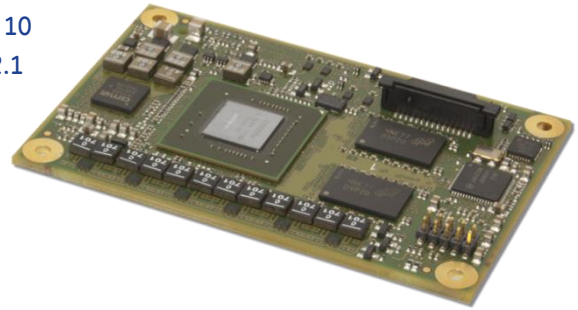
Environmental
- Operating: 0° to +65° C (standard)
- Operating: -40° to +75° C (extended; CPU dependent)
- Vibration: 15 – 2000 Hz, 0.1 g2 / Hz.
- Storage: -40° to +125° C
- Operating humidity: 10% to 90%
- Shock: 40 g, 11 ms
- Vibration: 15 – 2000 Hz, 0.1 g2 / Hz.
- Conformal coating avilable.

Dimensions
- 55 mm x 84 mm
- COM Express mini form factor; Type 10
- Compliance: PICMG COM Express R2.1

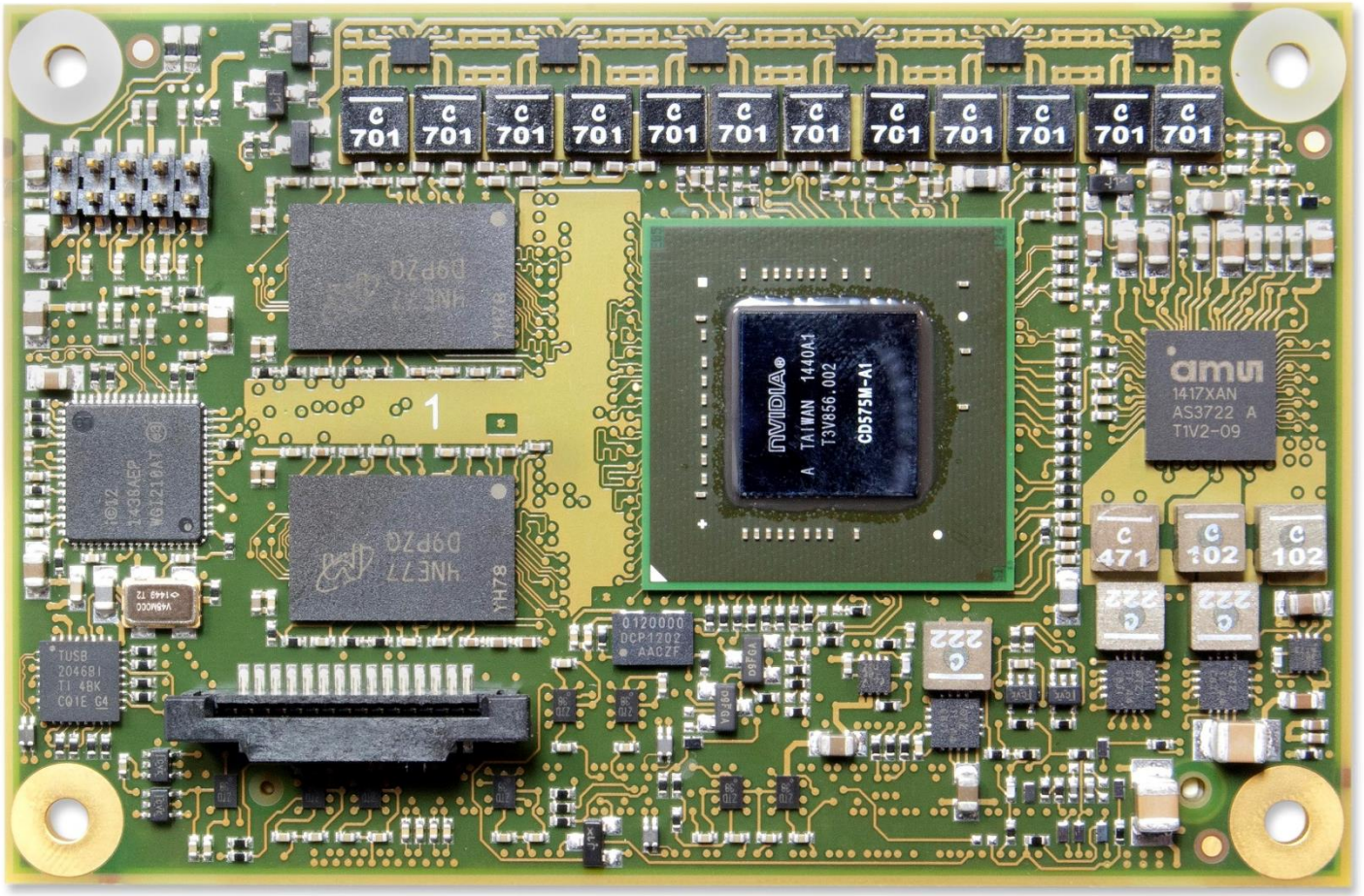
Software Support
- Linux4Tegra (Ubuntu 14.04)
- CUDA Toolkit 6.0 and 6.5
- OpenGL 4



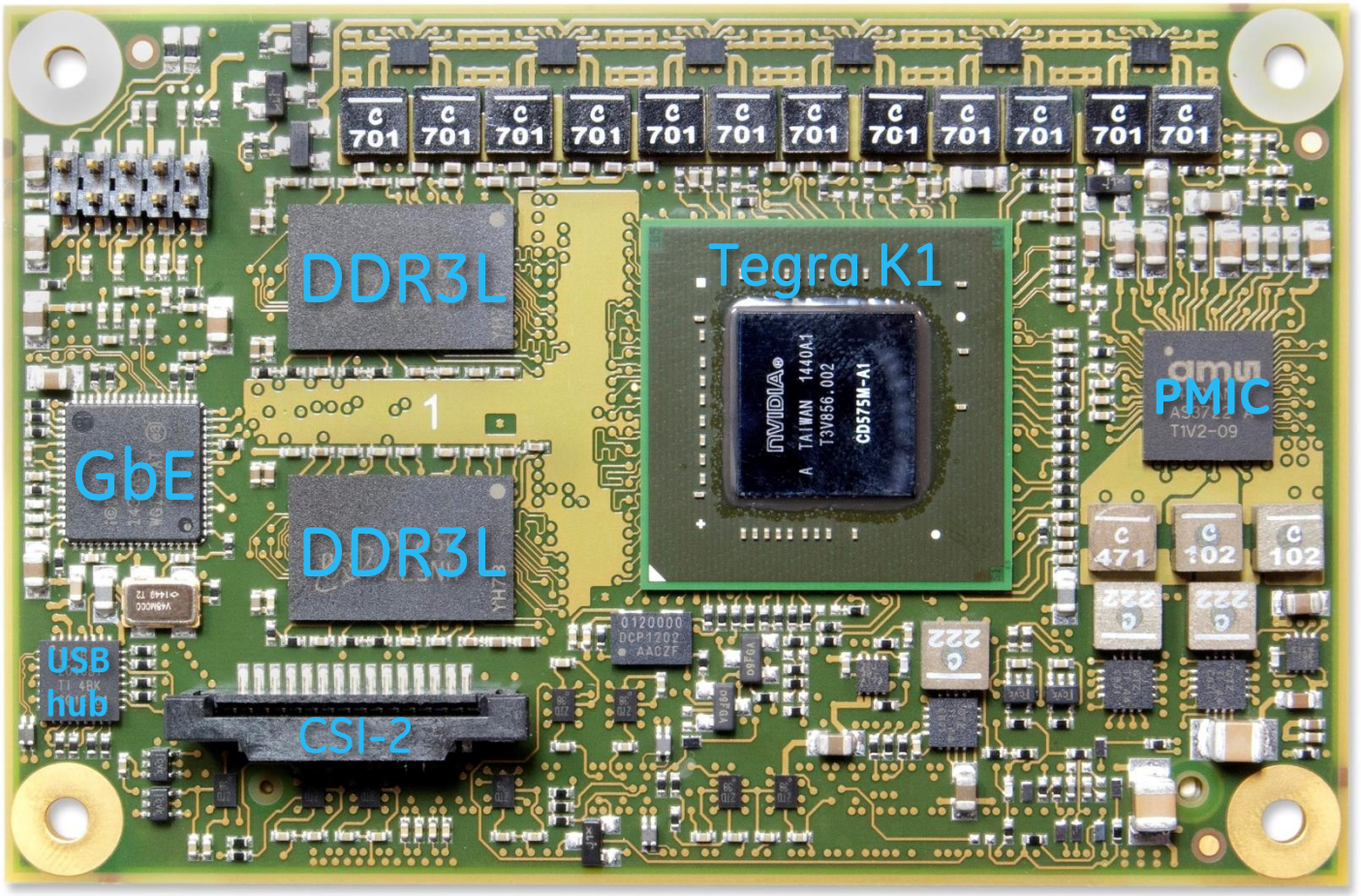
Tegra K1



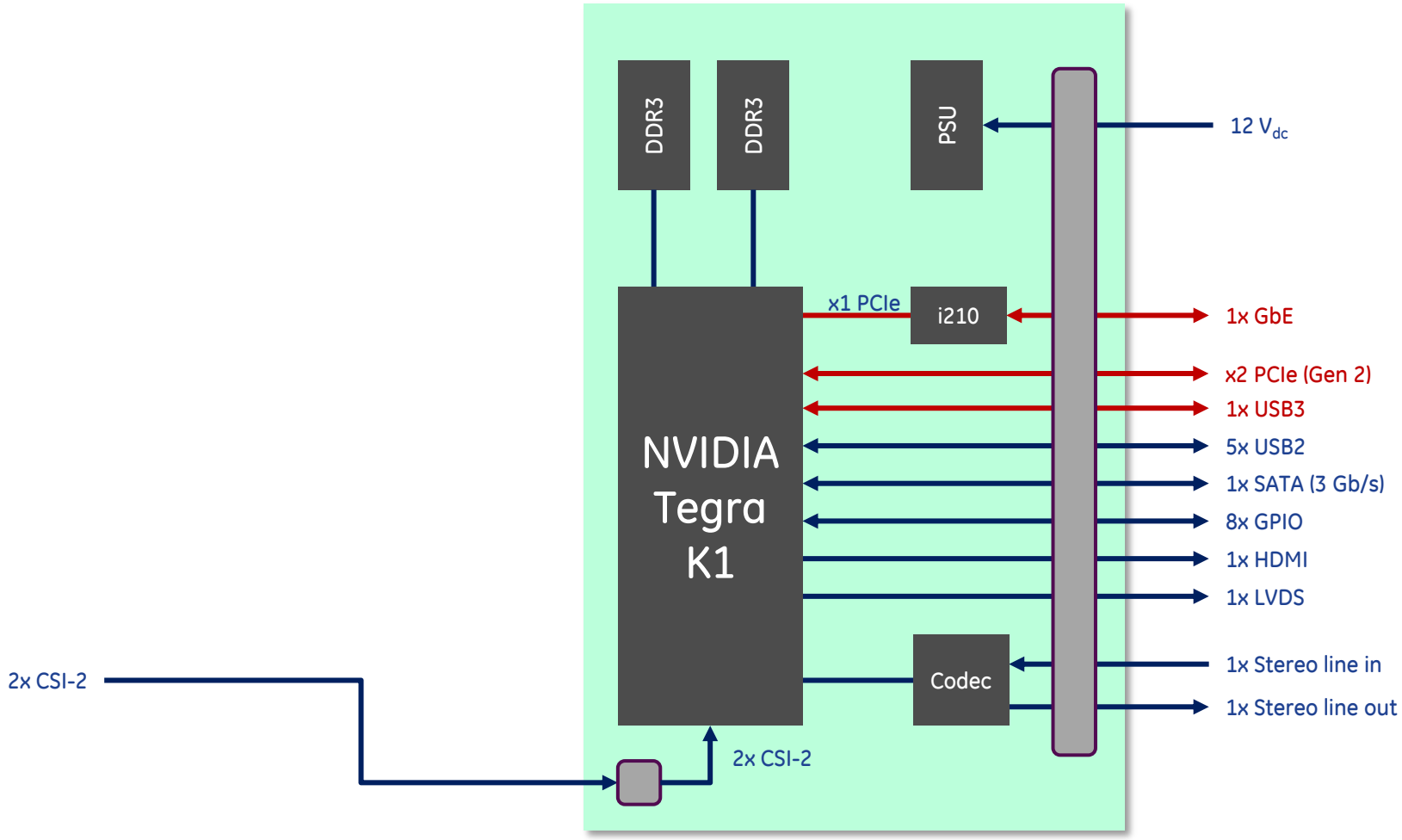
MC10K1 layout



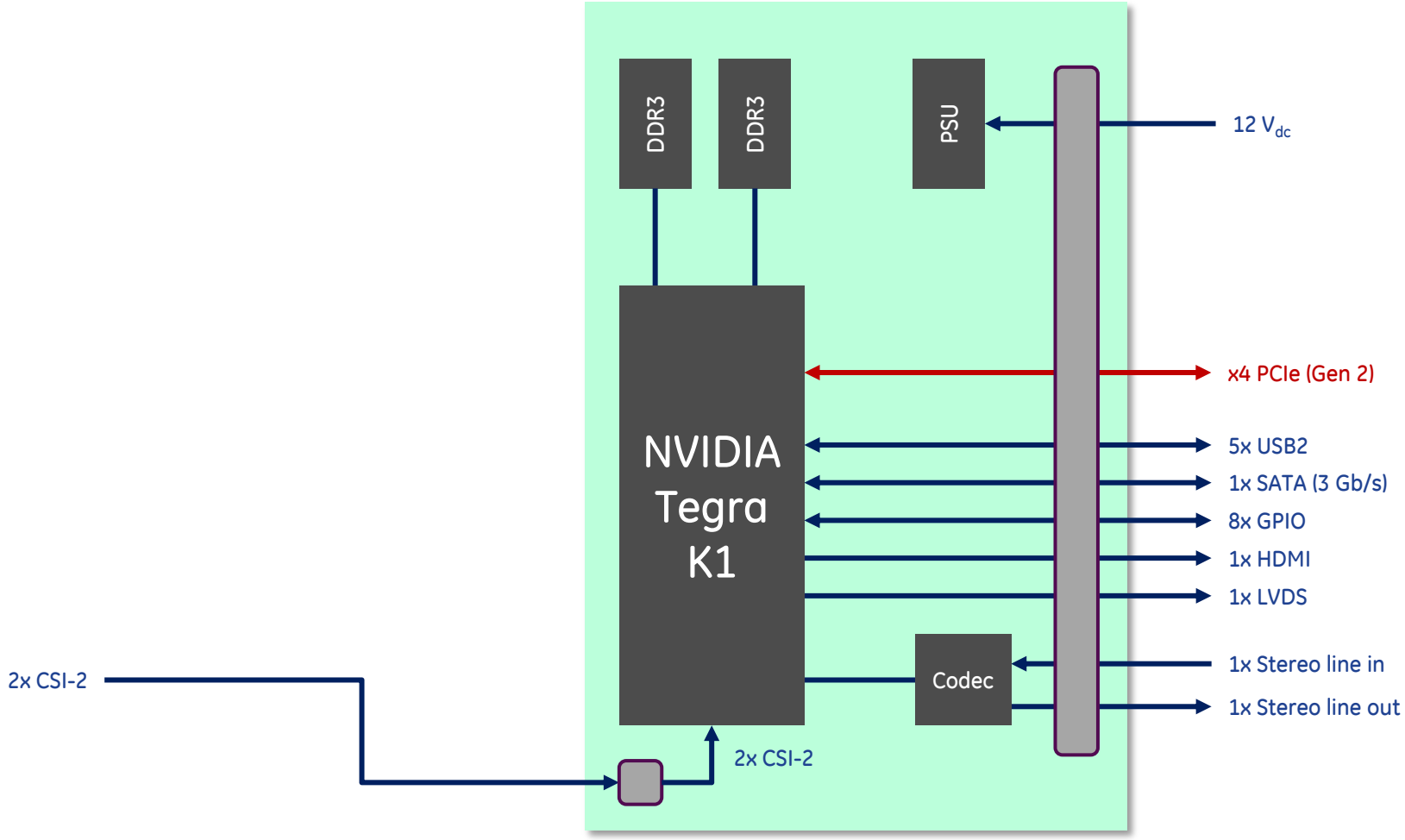
MC10K1 layout



MC10K1 – SKU-A


DDR3
DDR3
PSU
12 V_{dc}
x1 PCIe
i210
1x GbE
NVIDIA Tegra K1
x2 PCIe (Gen 2)
1x USB3
5x USB2
1x SATA (3 Gb/s)
8x GPIO
1x HDMI
1x LVDS
2x CSI-2
Codec
1x Stereo line in
1x Stereo line out
2x CSI-2

MC10K1 – SKU-B


DDR3
DDR3
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x4 PCIe (Gen 2)
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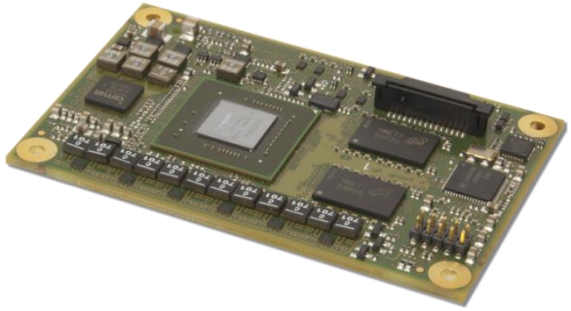
1x SATA (3 Gb/s)
8x GPIO
1x HDMI
1x LVDS
Codec
1x Stereo line in
1x Stereo line out
2x CSI-2
2x CSI-2

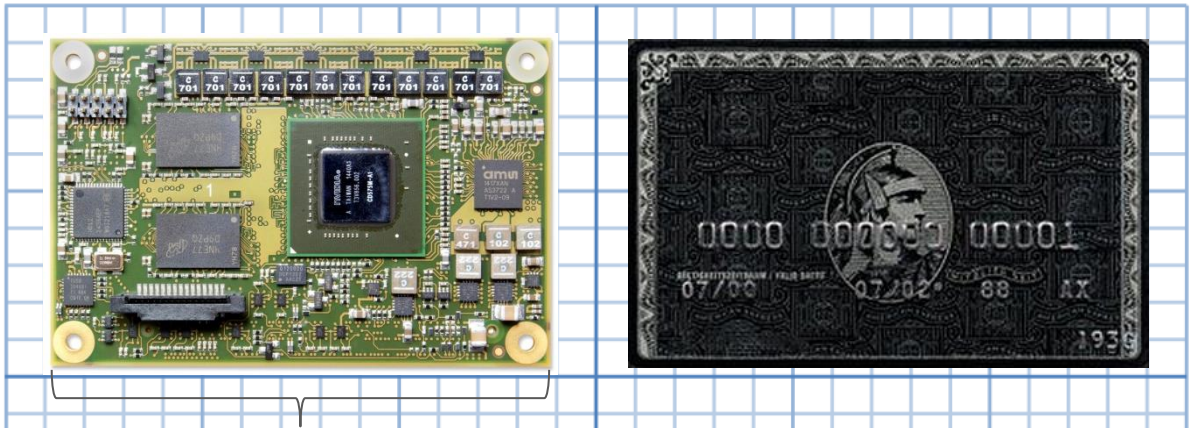
small form-factor (SFF)

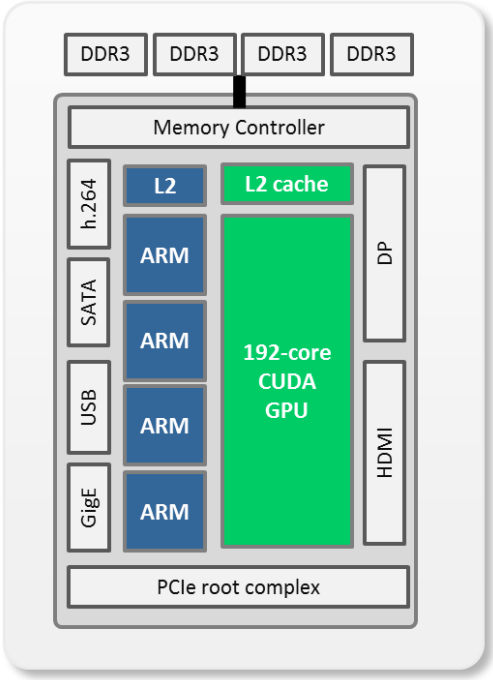
- COM Express mini – among smallest industry-standard form factors

form factor	dimensions	surface area	connector
COM Express compact	95x95mm	9025mm²	mezz
PC/104	90x96mm	8640mm²	stack
SMARC full	82x80mm	6560mm²	edge
Qseven	70x70mm	4900mm²	edge
COM Express mini	55x84mm	4620mm²	mezz
SMARC short	82x50mm	4100mm²	edge

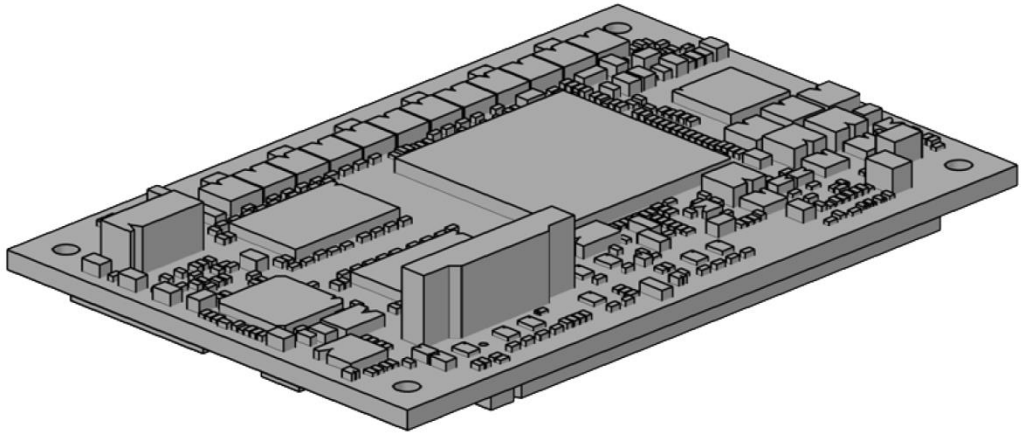


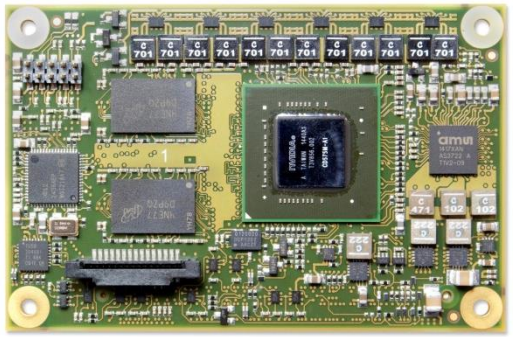
- ruggedization advantage over edge-mount



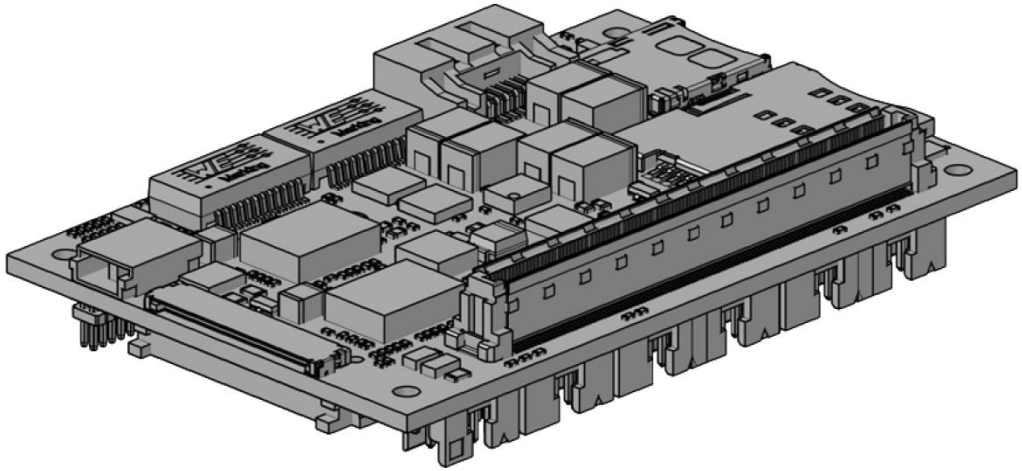


COM Express mini brick





GE mCOM10K1

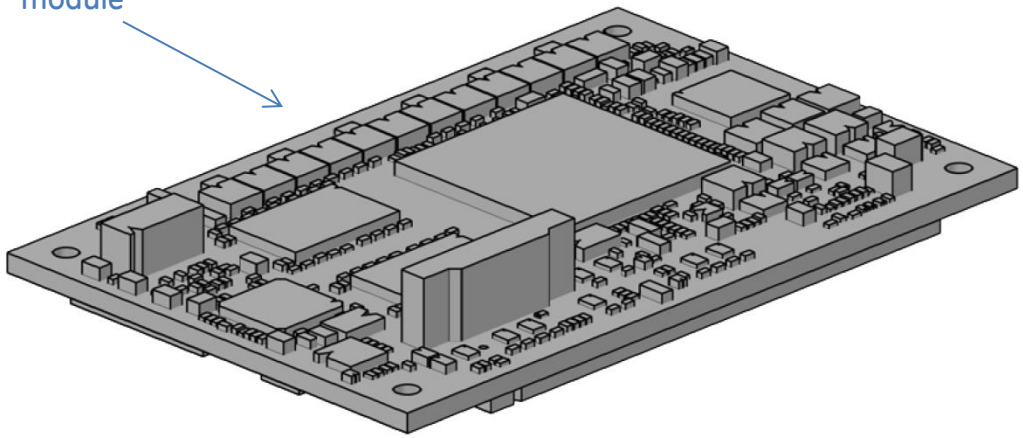


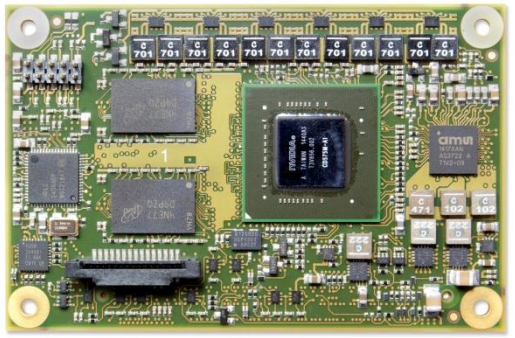
CTI CCG010

imagination at work

COM Express mini brick

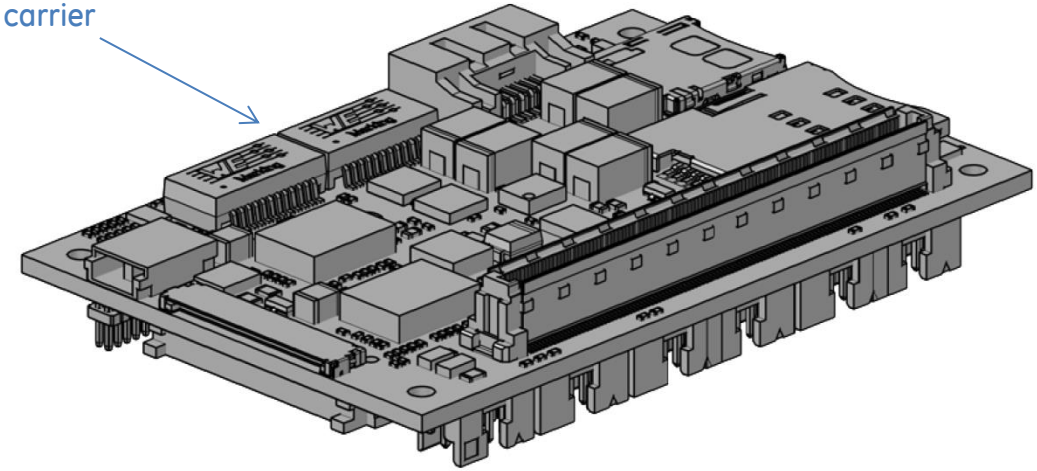
GE mCOM10K1 module

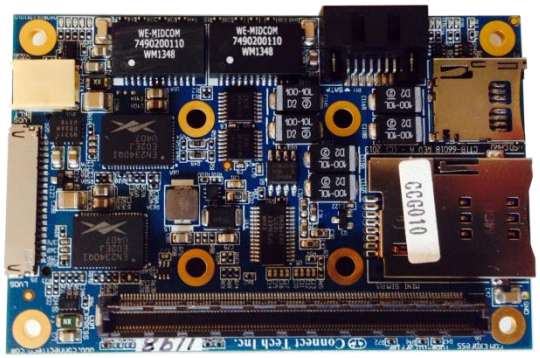




GE mCOM10K1

ConnectTech CCG010 carrier

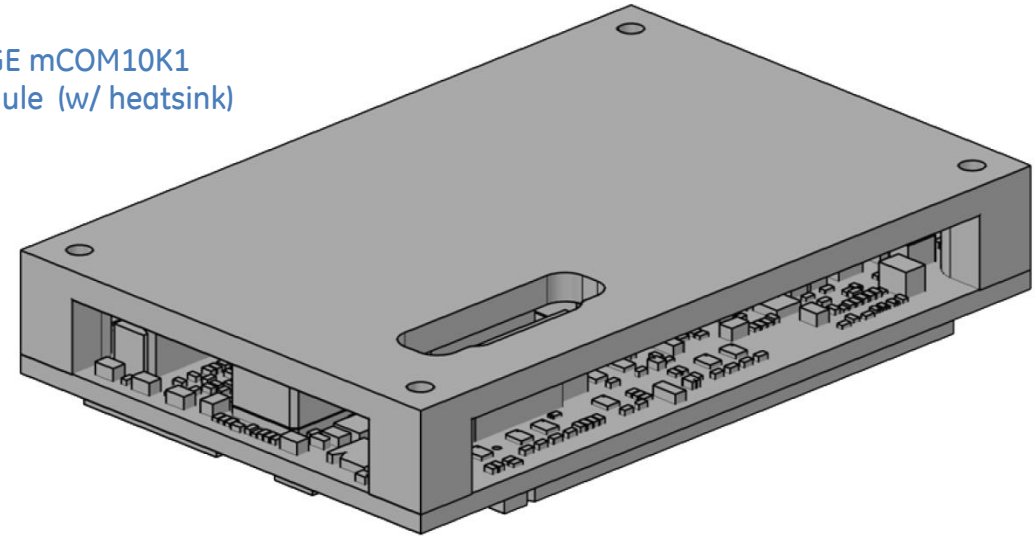


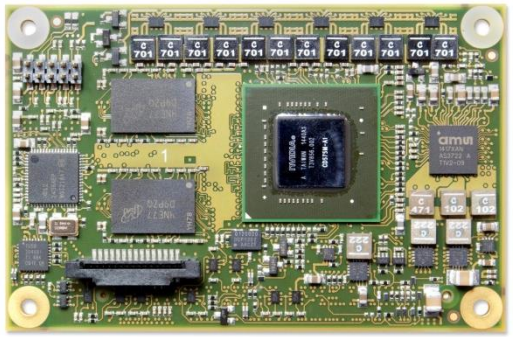


CTI CCG010

COM Express mini brick

GE mCOM10K1
module (w/ heatsink)





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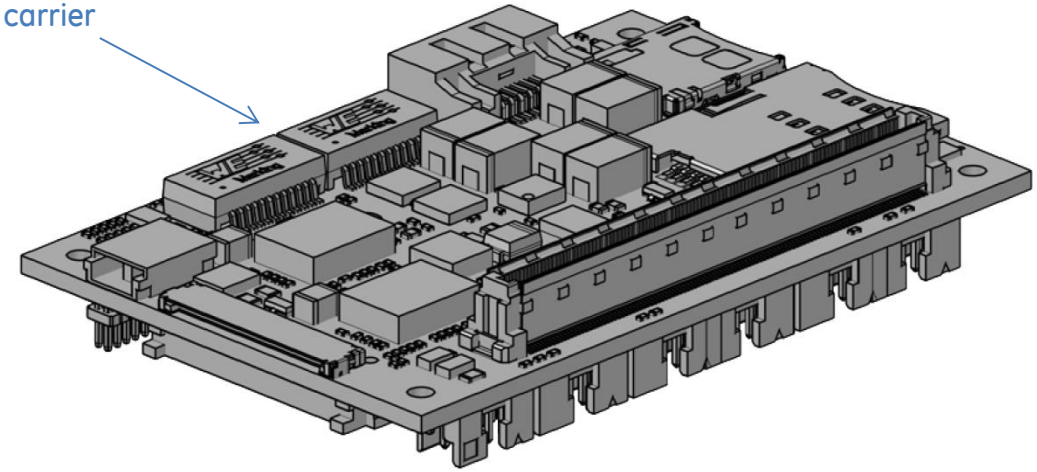
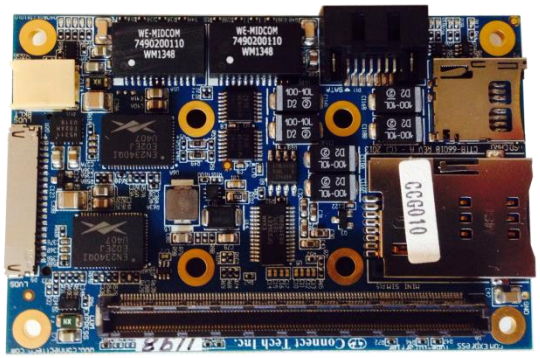
carrier



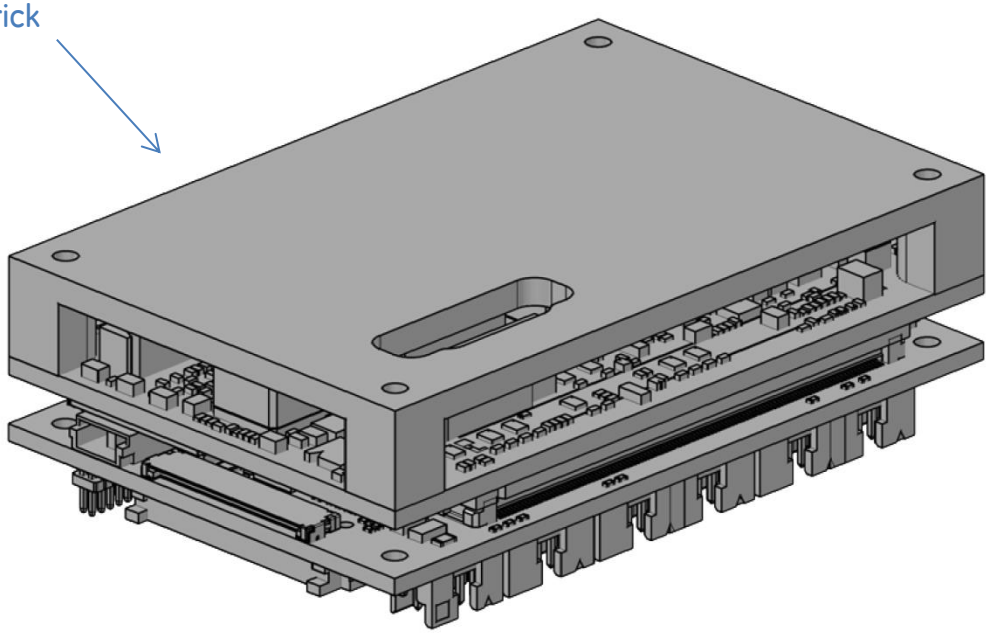


CTI CCG010

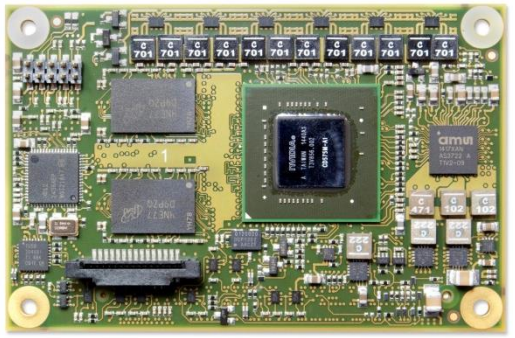
imagination at work

COM Express mini brick

integrated mini brick



35mm (stacked height)



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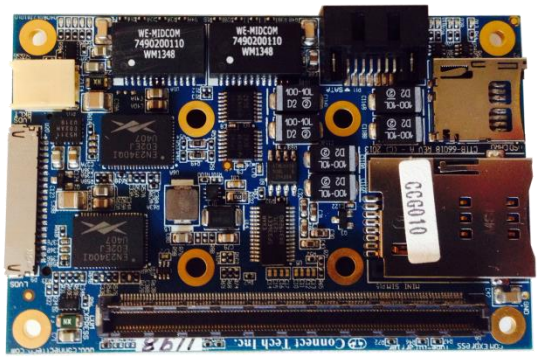

CTI CCG010

imagination at work

rugged CUDA modules

Production
LRIP
Prototypes
Roadmap

discrete

6U VPX

IPN250 (Tesla)
Intel + NVIDIA GT215

IPN251 (Kepler)
Intel + NVIDIA EXK107

IPN251 refresh (Maxwell)
Intel + NVIDIA GM107

NPN240 (Tesla)
dual NVIDIA GT215

MXM940
dual MXM3.0B carrier

3U VPX

GRA111 (Tesla)
NVIDIA GT215

GRA112D (Kepler)
NVIDIA EXK107
dual output

GRA112Q (Kepler)
NVIDIA EXK107
quad output

GRA112V (Kepler)
NVIDIA EXK107
legacy RS170 output

GRA113 (Maxwell)
NVIDIA GM107
640-core 2GB GDDR5

SoC

N/S

tiled TK1 (Kepler)
NVIDIA Tegra K1
custom multi-Tegra

COMe

MC10K1 (Kepler)
NVIDIA Tegra K1
COM Express mini

MC10X1 (Maxwell)
NVIDIA Tegra X1
COM Express mini

rugged CUDA modules

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dual output

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quad output

GRA112V (Kepler)
NVIDIA EXK107
legacy RS170 output

GRA113 (Maxwell)
NVIDIA GM107
640-core 2GB GDDR5

size, weight, power, and cost

SoC

N/S

tiled TK1 (Kepler)
NVIDIA Tegra K1
custom multi-Tegra

COMe

MC10K1 (Kepler)
NVIDIA Tegra K1
COM Express mini

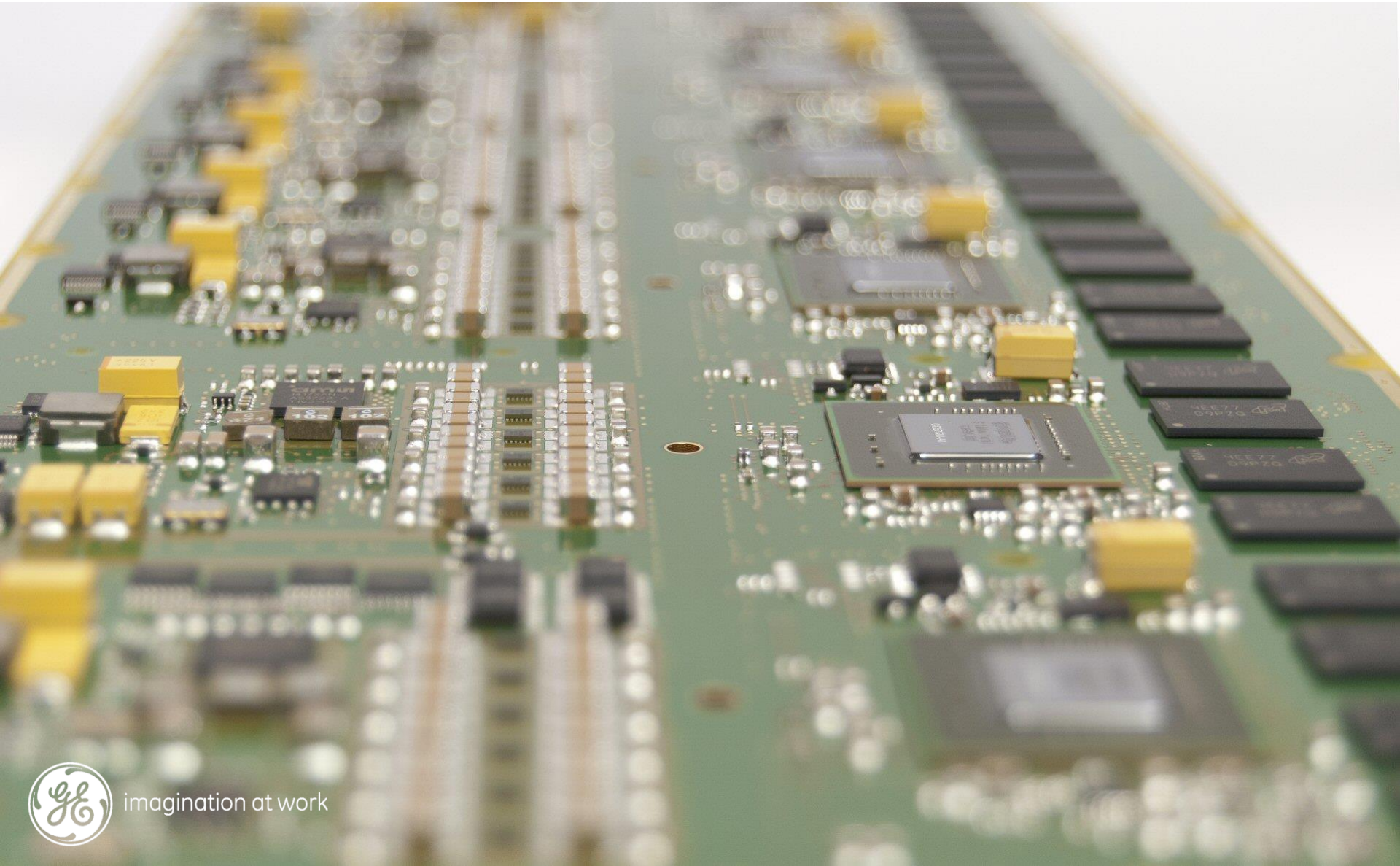
MC10X1 (Maxwell)
NVIDIA Tegra X1
COM Express mini

MIL-spec NVIDIA® modules

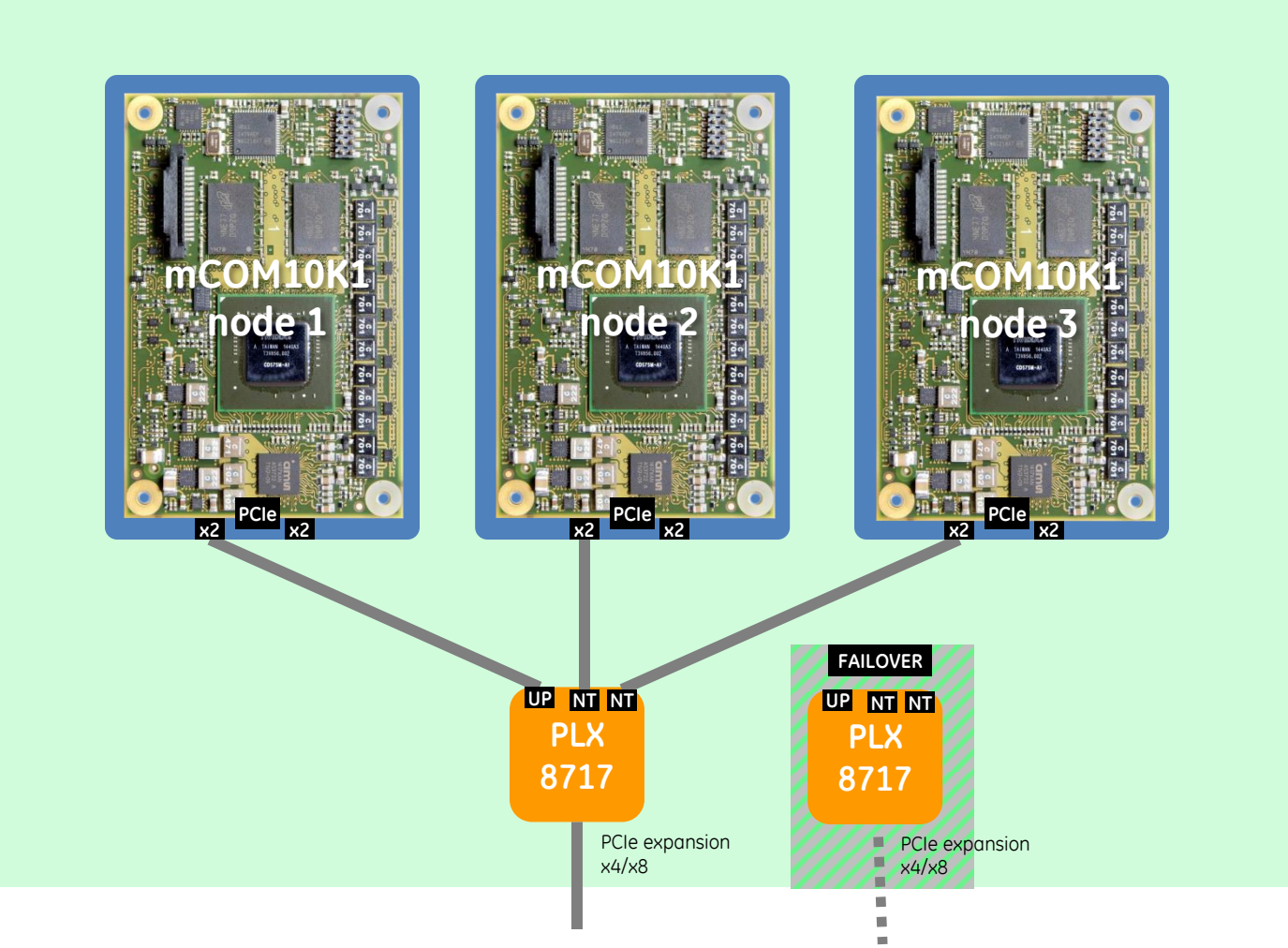
extended-temperature passive cooling
BGA chip-down packaging
efficient GFLOPs/watt & SWaP
smallest industry-standard form factors
long-term lifecycle support
SW/HW-compatible product family

GE, official NVIDIA® partner

tiled Tegra

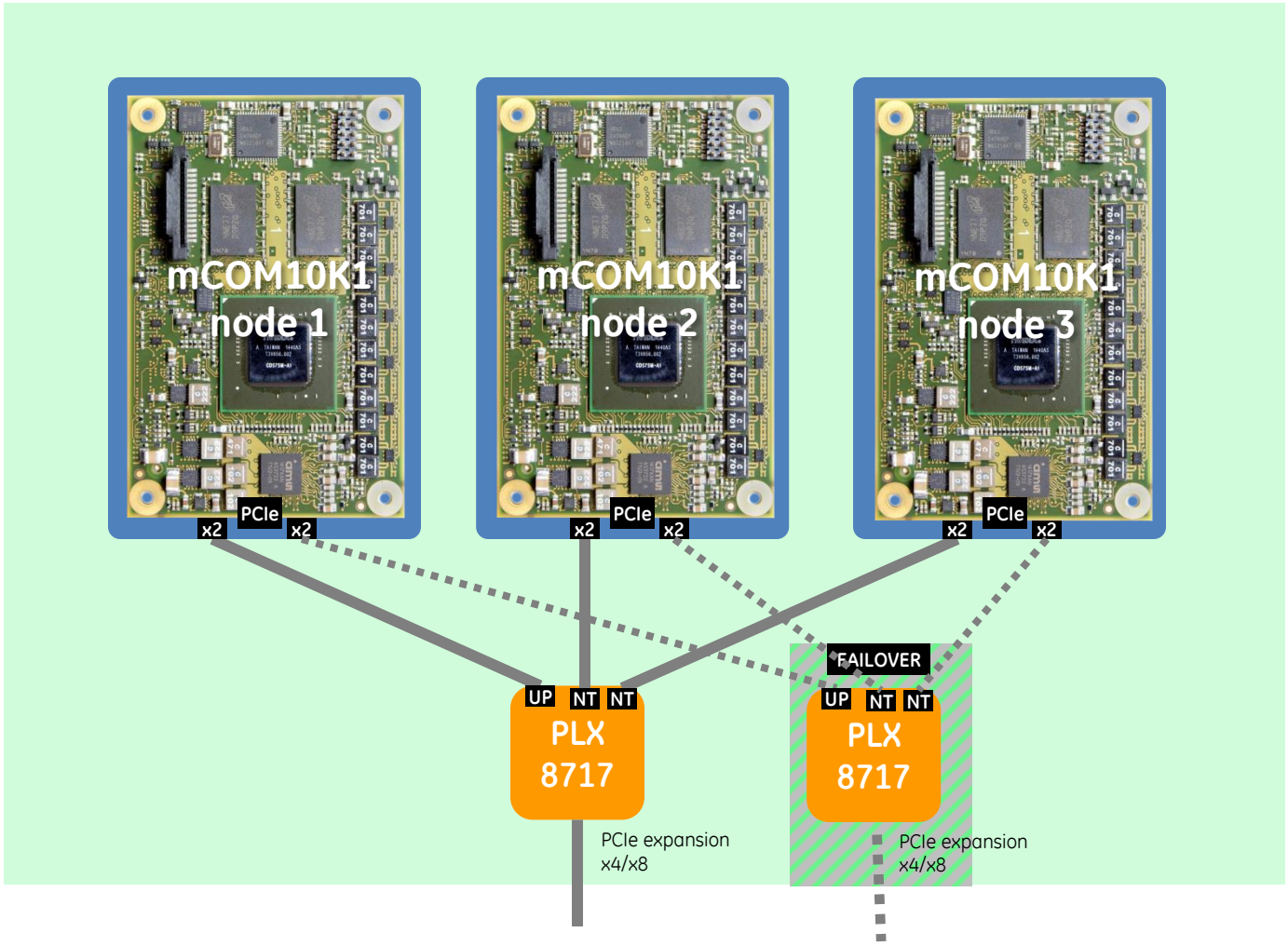


triple-redundant Tegra



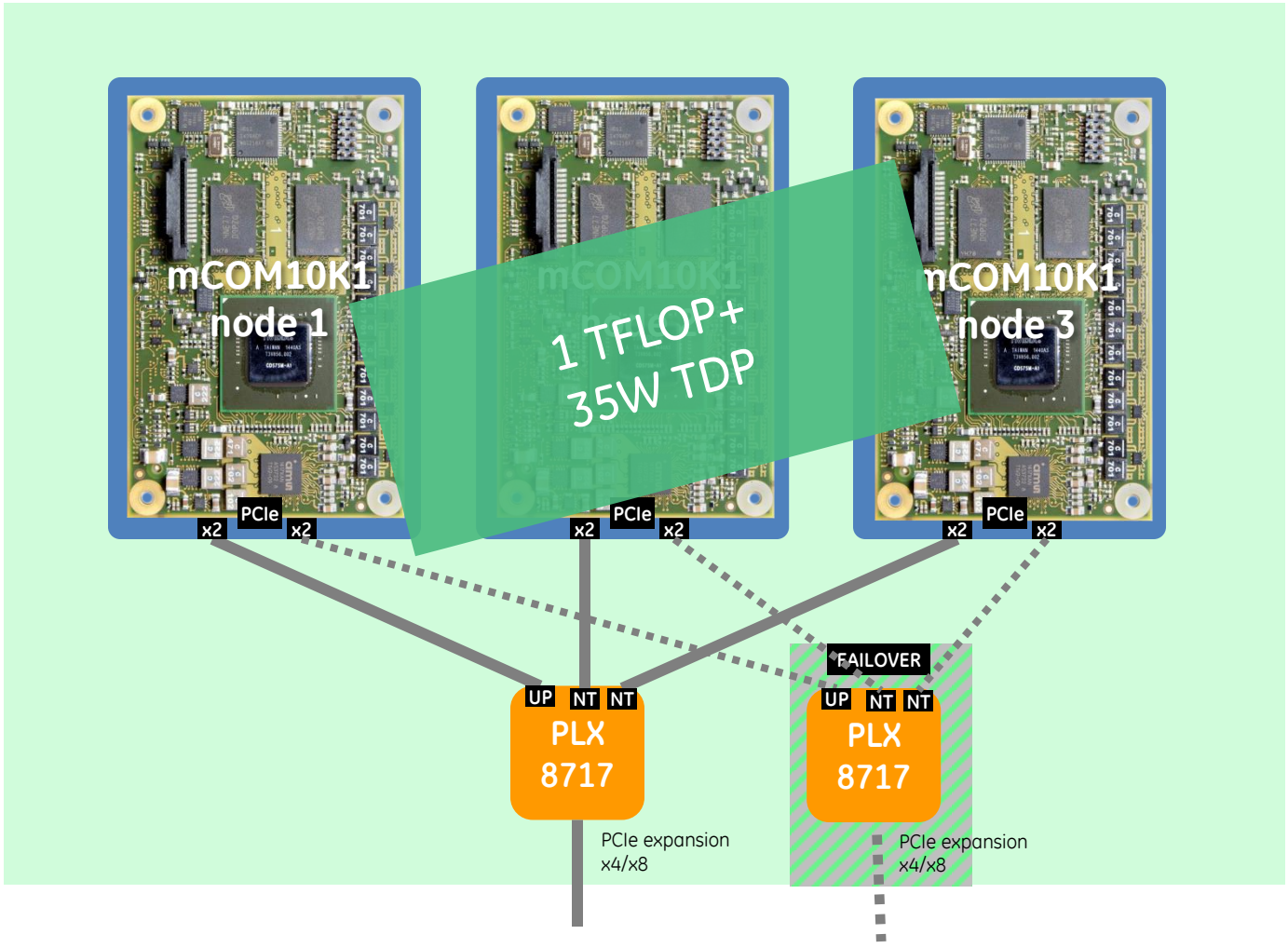
- PCIe provides higher bandwidth than available with GigE, USB3 → 1-2GB/s
- **challenge:** linking multiple Tegra root complexes together
  (via non-transparent bridging on PCIe switch)

triple-redundant Tegra



- PCIe provides higher bandwidth than available with GigE, USB3 → 1-2GB/s
- **challenge:** dual-redundant network (via switch failover)

triple-redundant Tegra



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ASTROBOTIC

imagination at work

GE and NVIDIA go to the Moon with Astrobotic

GE to demonstrate at GTC how Rugged GPU-Enabled Embedded Computing can Enable Moon Landing, Exploration

- *Astrobotic moon lander, rover feature GE/NVIDIA GPU technology*
- *Extreme processing performance, minimal power consumption are key to success*

SAN JOSE, CA.— March 17, 2015— At NVIDIA's annual GTC – the demonstration on GE's GTC stand (# 428) features a moon landing vehicle – "Griffin" - developed by space exploration company Astrobotic as Astrobotic's entry into the Google Lunar XPRIZE competition.

Onboard the Griffin is GE's MAGIC1 rugged display computer, equipped with NVIDIA GPU technology. Data from the lander's onboard cameras, lasers and inertial sensors will be passed to the MAGIC1, which will calculate the lander's position relative to where it is supposed to be, and provide adjustment feedback to the navigation system.

"There are few, if any, more demanding challenges placed on embedded computing than those presented by space flight and lunar exploration," said **John Thornton, CEO, Astrobotic**. "GE has the robust, reliable, high performance – and very cost-effective – technology needed to succeed, and the expertise and experience that has allowed Astrobotic to leverage that technology's potential."

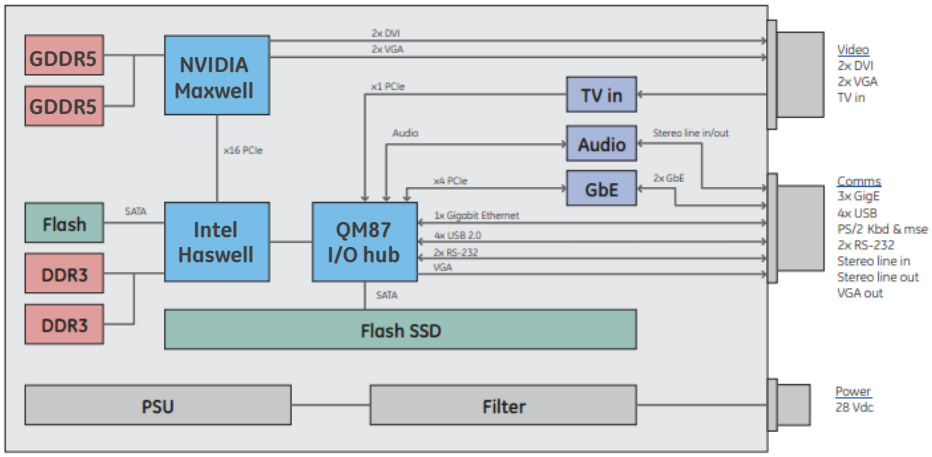
ASTROBOTIC

- so far, only US, USSR, and China have landed on Moon
- launch window second half 2016 aboard SpaceX Falcon9
- GLXP object – land, rove, and stream H.264 video to Earth
- GE pre-qualified systems help satisfy GLXP milestone req's

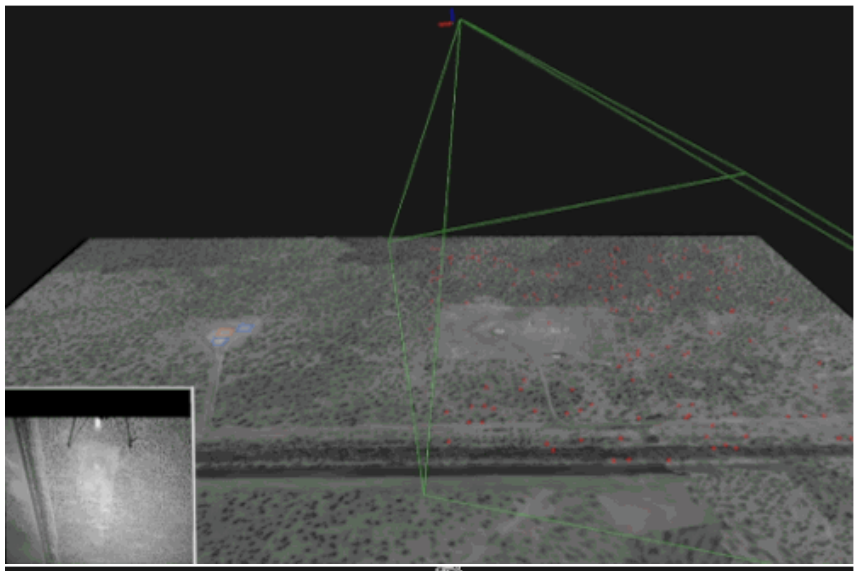
Autonomous Landing & Navigation

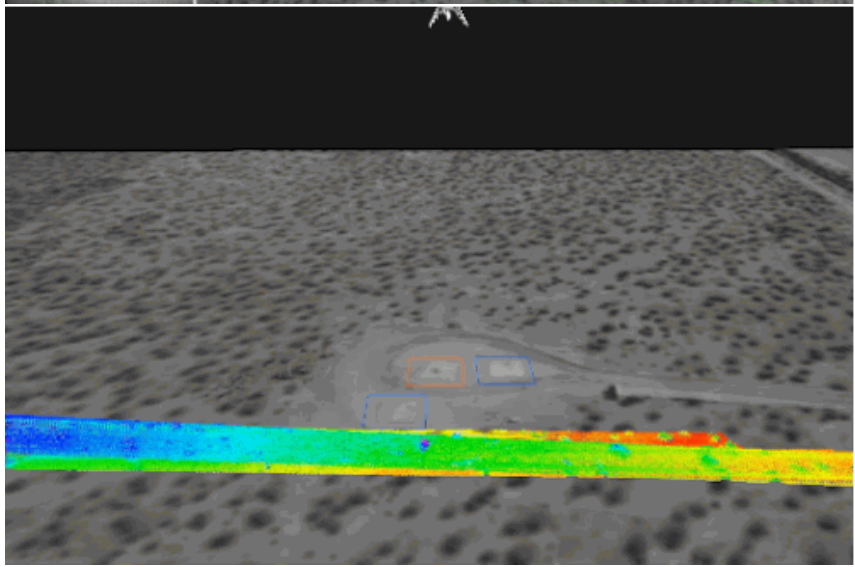
- NVIDIA-equipped MAGIC1 system provides realtime georeferencing onboard the lander, permitting navigation to within 100M radius. (compare to 60's-era moon landings)

MAGIC1



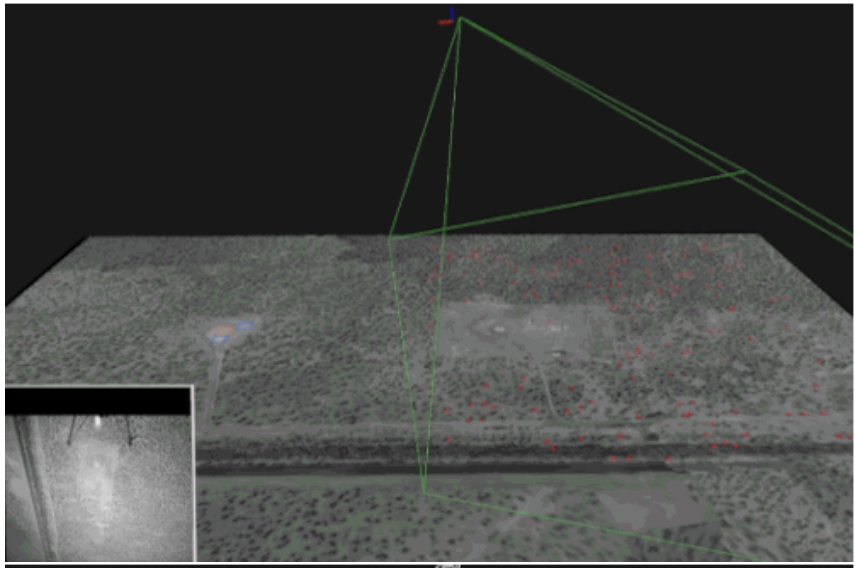
GPS-denied

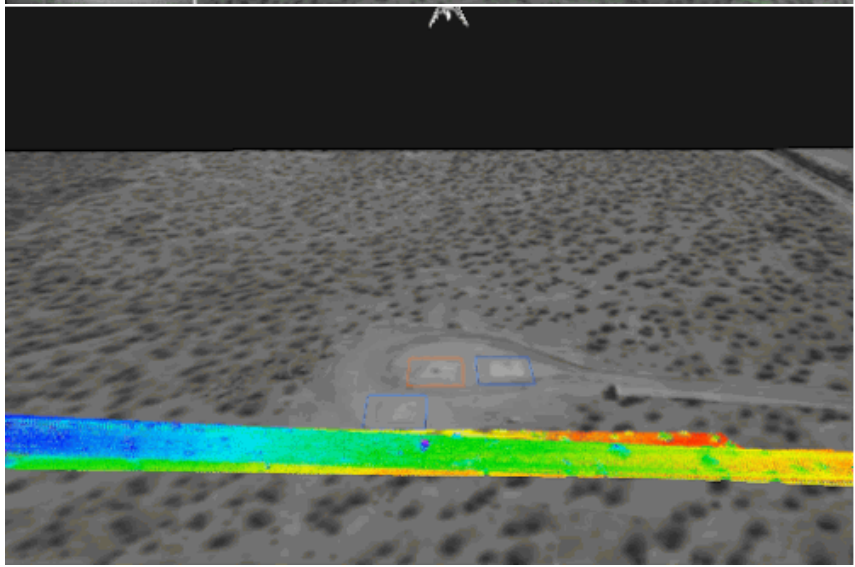




Astrobotic—GLXP Milestone Leader

SUMMARY OF MILESTONE PRIZE WINNERS		
Landing ($1 Million each)	**Mobility ($500,000 each)**	**Imaging ($250,000 each)**
Astrobotic (US)	Astrobotic (US)	Astrobotic (US)
Team Indus (India)	Hakuto (Japan)	Moon Express (US)
Moon Express (US)	Part-Time Scientists (Germany)	Part-Time Scientists (Germany)





NASA technology readiness level

TRL 9
- Actual system "flight proven" through successful mission operations

TRL 8
- Actual system completed and "flight qualified" through test and demonstration (ground or space)

TRL 7
- System prototype demonstration in a space environment

TRL 6
- System/subsystem model or prototype demonstration in a relevant environment (ground or space)

TRL 5
- Component and/or breadboard validation in relevant environment

TRL 4
- Component and/or breadboard validation in laboratory environment

TRL 3
- Analytical and experimental critical function and/or characteristic proof-of-concept

TRL 2
- Technology concept and/or application formulated

TRL 1
- Basic principles observed and reported

- Tegra K1 deployed on rover for H.264 streaming of stereo HD video sensors over Lunar/Earth ethernet network.

imagination at work

- Compressed IP stream is relayed to the lander's high-gain antennae and transmitted to a satellite constellation back in Earth orbit.

imagination at work

- Piped back to Earth…
  it's an **Internet-of-Thing**!

imagination at work

Integrating GPU With Your Program

DEPLOYABLE SOLUTIONS

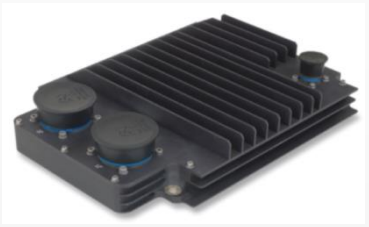
DISCOVER

- Experiment with CUDA on NVIDIA Jetson devkit
- Investigate potential application algorithms for acceleration with CUDA.

DEVELOP

- Use VPX lab system to develop CUDA application.
- Integrate GPU solution with any 3rd-party devices (FPGA)
- Preliminary field tests

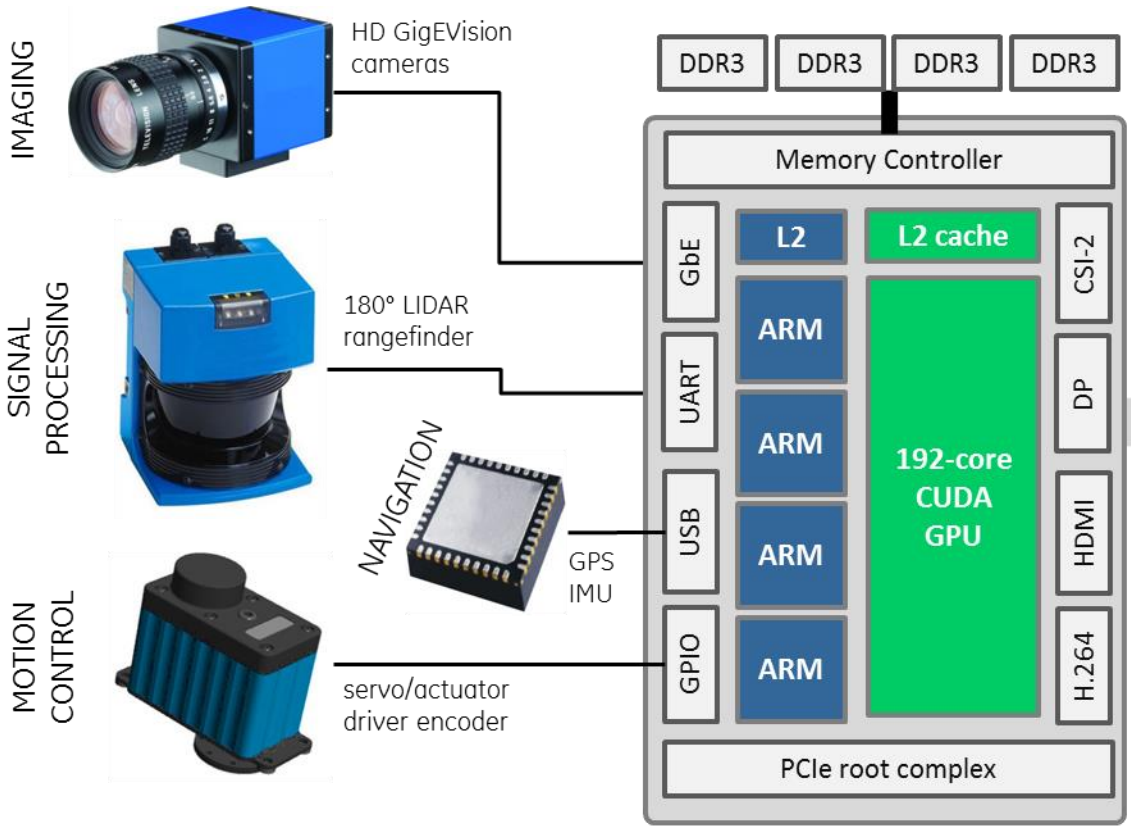
DEPLOY

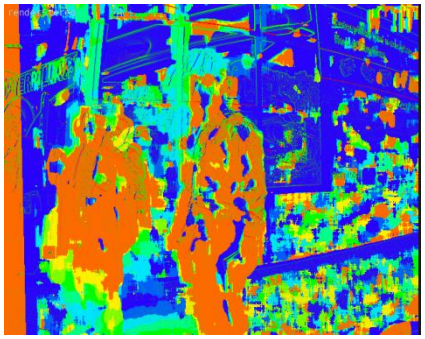


- Production VPX chassis with dedicated backplane and deployable cooling.
- Full environmental testing and qualification.
- Long-Term Support (LTS)

Tegra TURBO

Tegra Unmanned Recon BOt



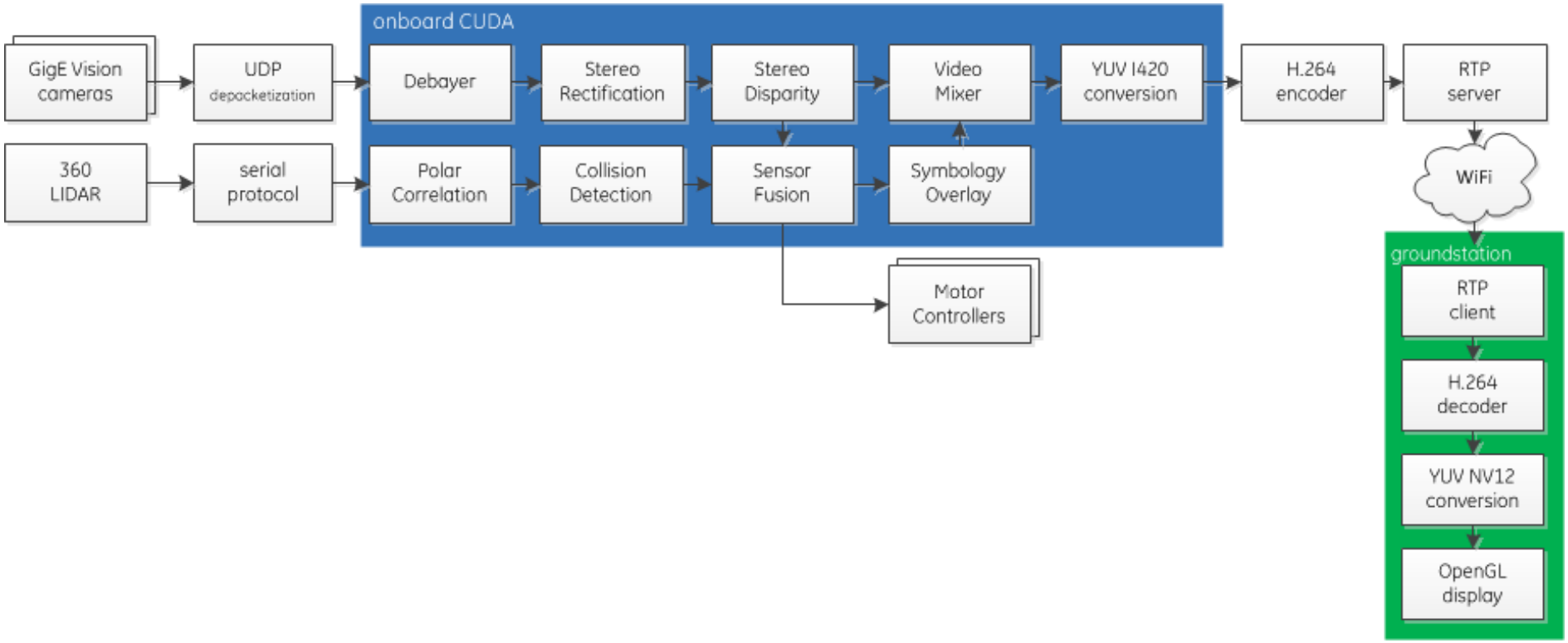


world perception model
obstacle detection & avoidance

objectives:

- demonstrate viability of battery-powered CUDA
- complex multi-sensor pipeline on TK1
- upgrade R&D platform for future Jetson's
- realtime hardware-in-the-loop with TK1

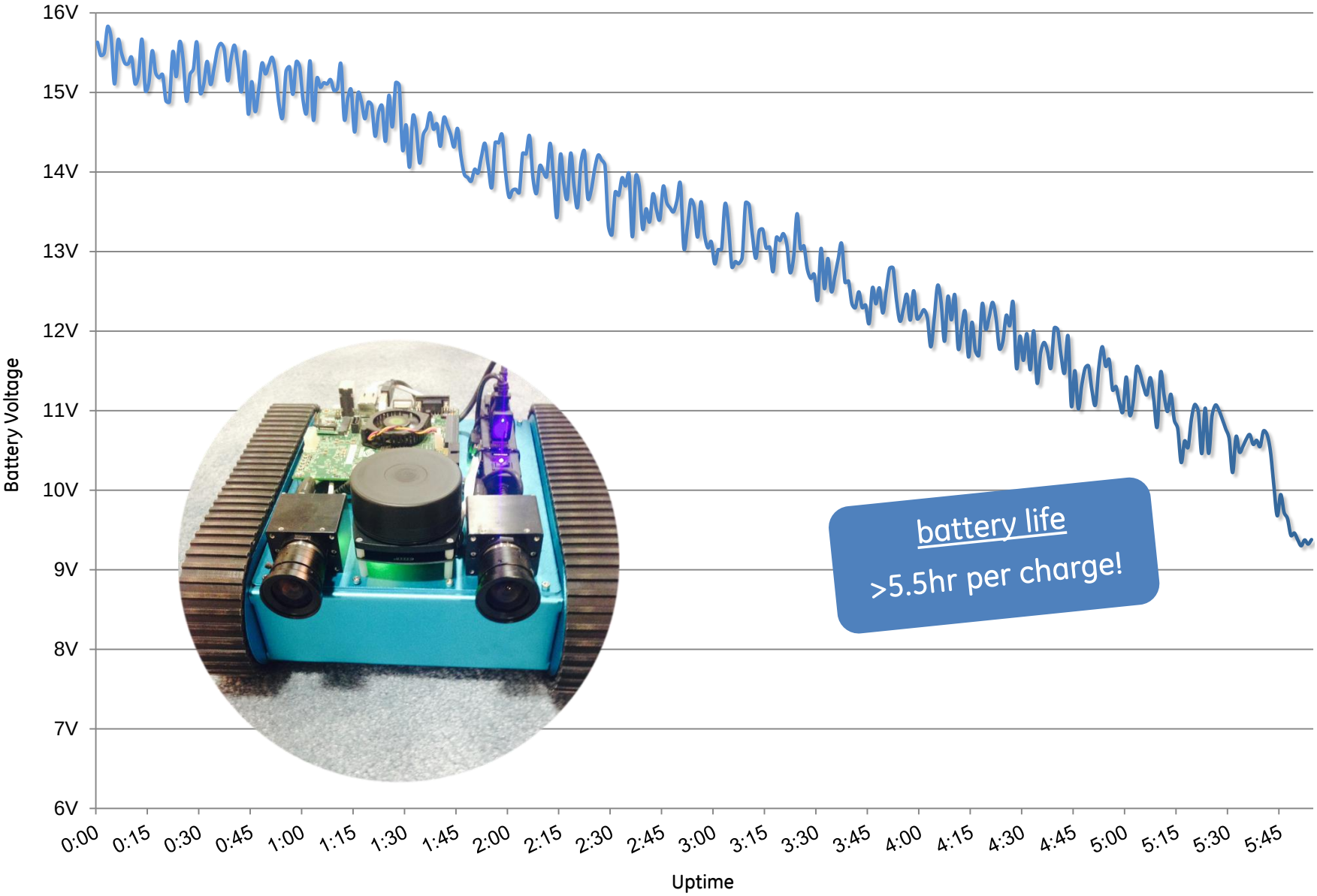
Tegra Unmanned Recon BOt



objectives:

- demonstrate viability of battery-powered CUDA
- complex multi-sensor pipeline on TK1
- upgrade R&D platform for future Jetson's
- realtime hardware-in-the-loop with TK1

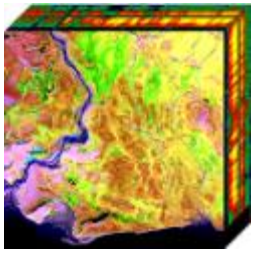
Battery-Powered CUDA



CUDA applications

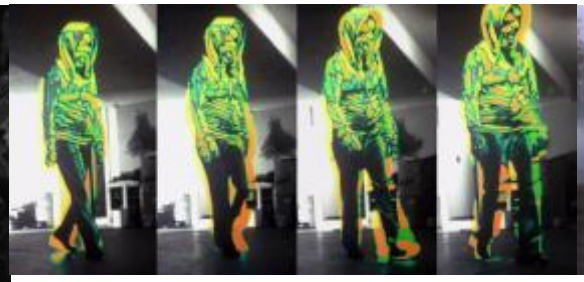
Wide-Area Surveillance

Step/Stare Mosaic – 360SA



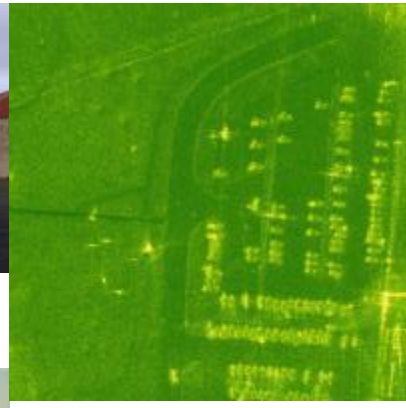
hyperspectral

RADAR + LIDAR



motion detection

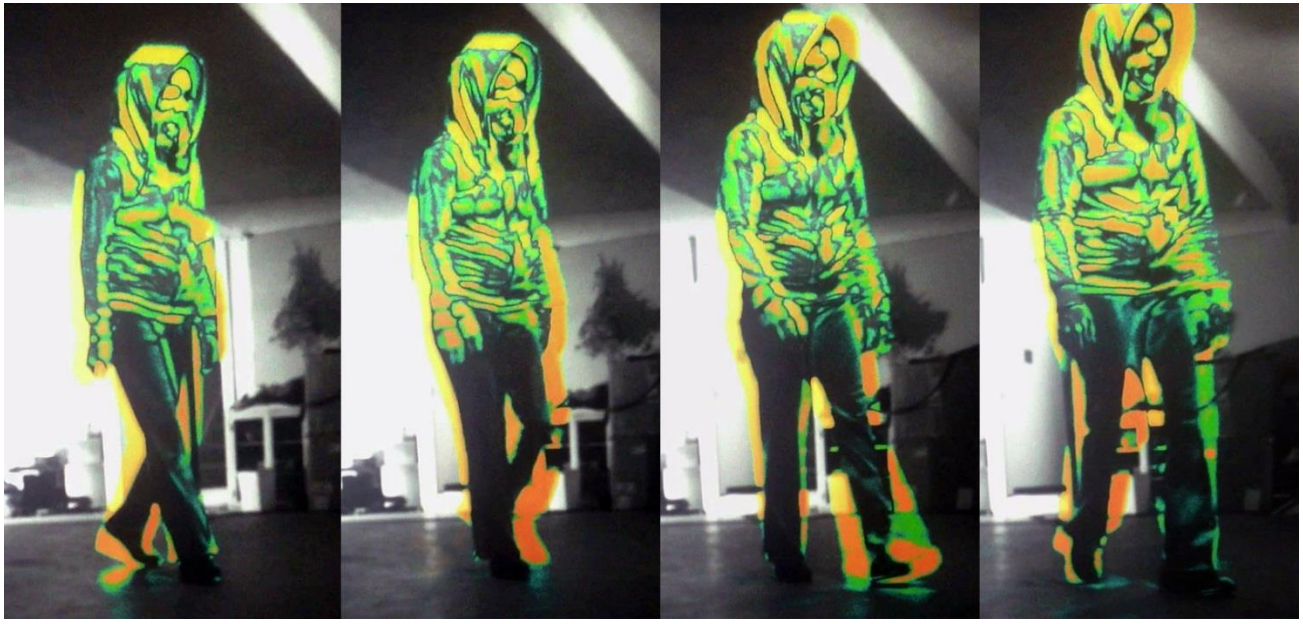
sensor fusion



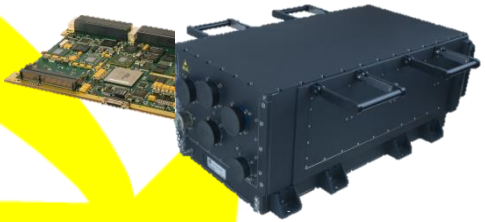
SAR imaging

pedestrian & vehicle detection

tracking



Code-compatible



6U VPX
Up to 2 kW

3U VPX
100 Watts

Tegra COMe
<10 Watts

Performance

Power

imagination at work

Code-compatible

- NVIDIA CUDA/OpenCL
- Intel (or ARM)
- Mellanox (OFED)
- Linux