



# Low Power Computing and Simultaneous Multi-Int processing using IBM's NS16e 16-Chip Neuromorphic Hardware

September 26, 2019

Mr. Mark Barnell

Air Force Research Laboratory - AFRL/RITB

Mr. Chris Cicotta

SRC, Inc.

*Integrity ★ Service ★ Excellence*





# AFRL Information Directorate Mission & Vision



## Mission:

To explore, prototype, and demonstrate high-impact, game changing technologies that enable the Air Force and Nation to maintain its superior technical advantage.



## Vision:

To LEAD the Air Force and Nation in Command, Control, Communications, Computers, and Intelligence (C4I) and Cyber science, technology, research and development.



# BlueRaven: Neurosynaptic Super Computer



Delivered to AFRL/RITB in August 2018

## High Performance Neurosynaptic Hardware



- **Rack-mounted Neurosynaptic TrueNorth development system**
- **Four NS16e V2 platforms each with 16 million neurons and four billion synapses**
- **Capable of implementing large neural models for solving complex multisensory problems**

Specification	Description
<i>Form Factor</i>	2U Server + 2U NS16e Sled
<i>NS16e</i>	4x IBM NS16e PCIe Cards
<i>Neurosynaptic Cores</i>	262,144
<i>Programmable Neurons</i>	67,108,864
<i>Programmable Synapses</i>	17,179,869,184
<i>PCIe NS16e Interface</i>	4x PCIe Gen 2
<i>Ethernet - Server</i>	1x 1 Gbit
<i>Ethernet - NS16e</i>	1x 1 Gbit per NS16e
<i>Training GPUs</i>	2x NVIDIA Tesla P100
<i>Volatile Memory</i>	256 GB
<i>CPUs</i>	2x 10-Core E5-2630



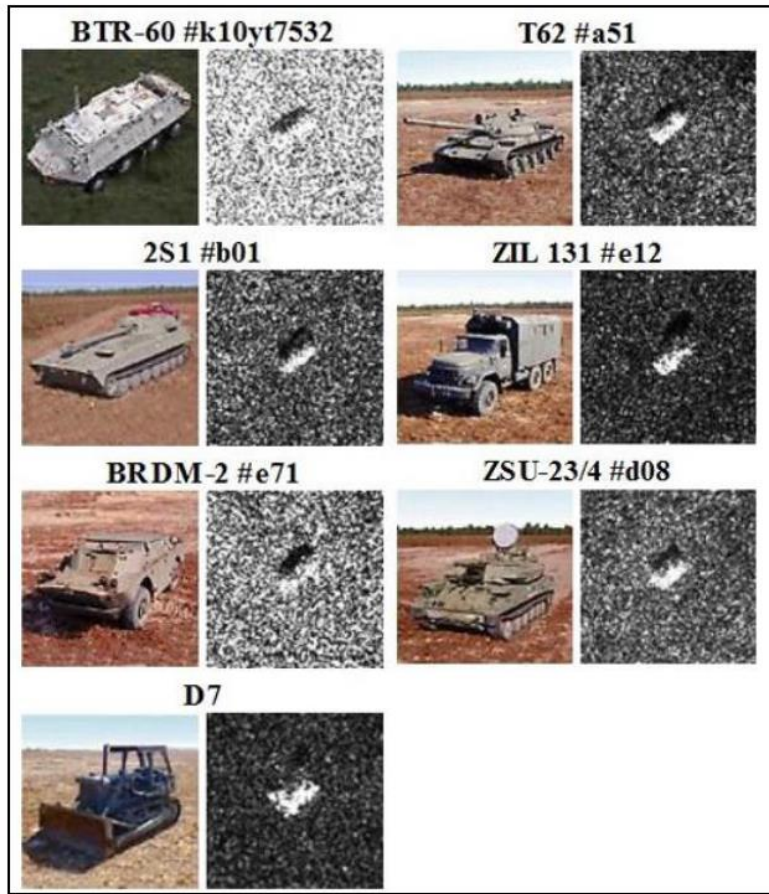




# Data Sets Processed on BlueRaven



USGS overhead EO imagery used to train optical sensor Classifiers for the TrueNorth, with and without vehicles.



SAR imagery used to train networks on TrueNorth, Moving and Stationary Target Acquisition and Recognition (MSTAR)

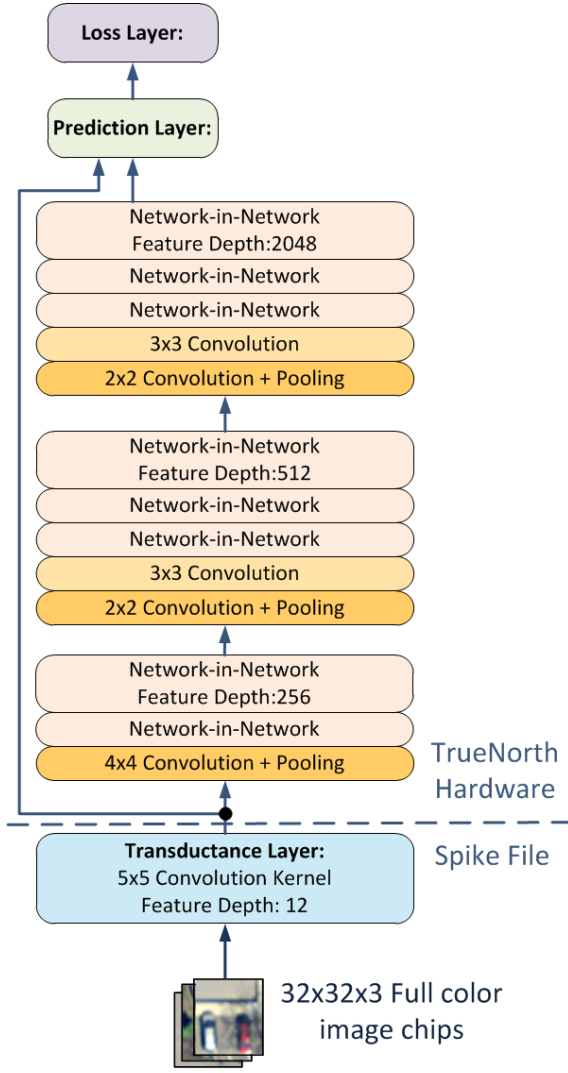
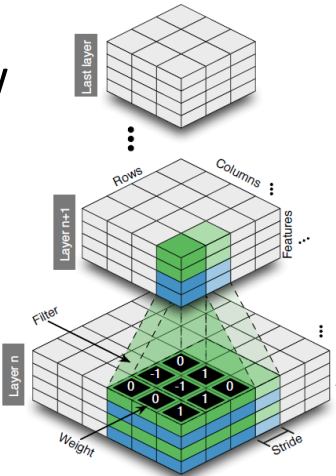




# NS16e Software Framework



- IBM developed Energy Efficient Deep Networks (EEDN) framework for TrueNorth model development
- Allows implementation of high-throughput convolutional neural network classifiers on hardware
- Increased accuracy and classification rate compared to prior framework
- Simplified installation and workflow

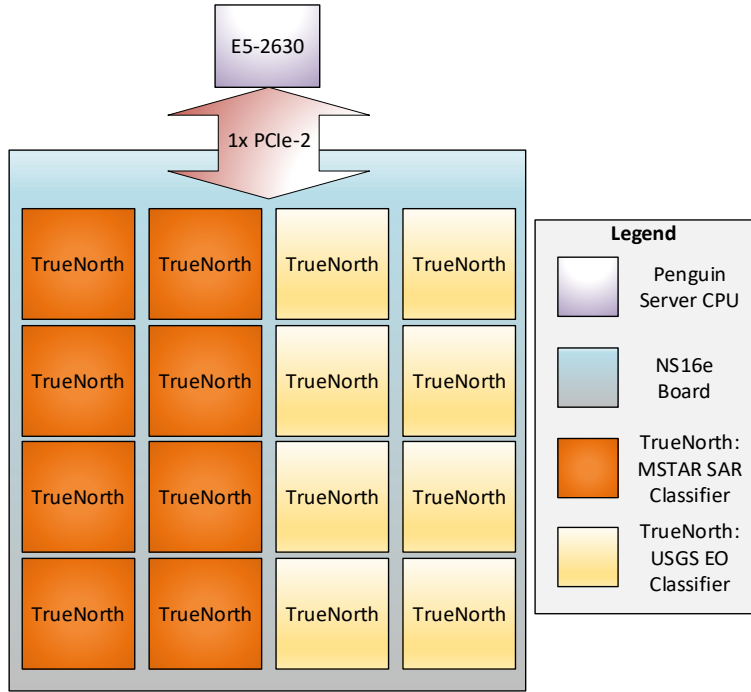




# NS16e Processing Methods



- Multi-Chip Radar Classification
  - 8 parallel classifier networks (1 per chip) dedicated to MSTAR SAR image processing and classification
  - Binary classification network
- Multi-Chip Electro-Optical Classification
  - 8 parallel classifier networks (1 per chip) dedicated to USGS optical image processing and classification
  - 26-class classification network



- Column-level functional placement ensured no input or output spikes would be routed through TrueNorth chips operating on the other functional network's data.





# NS16e Processing Results



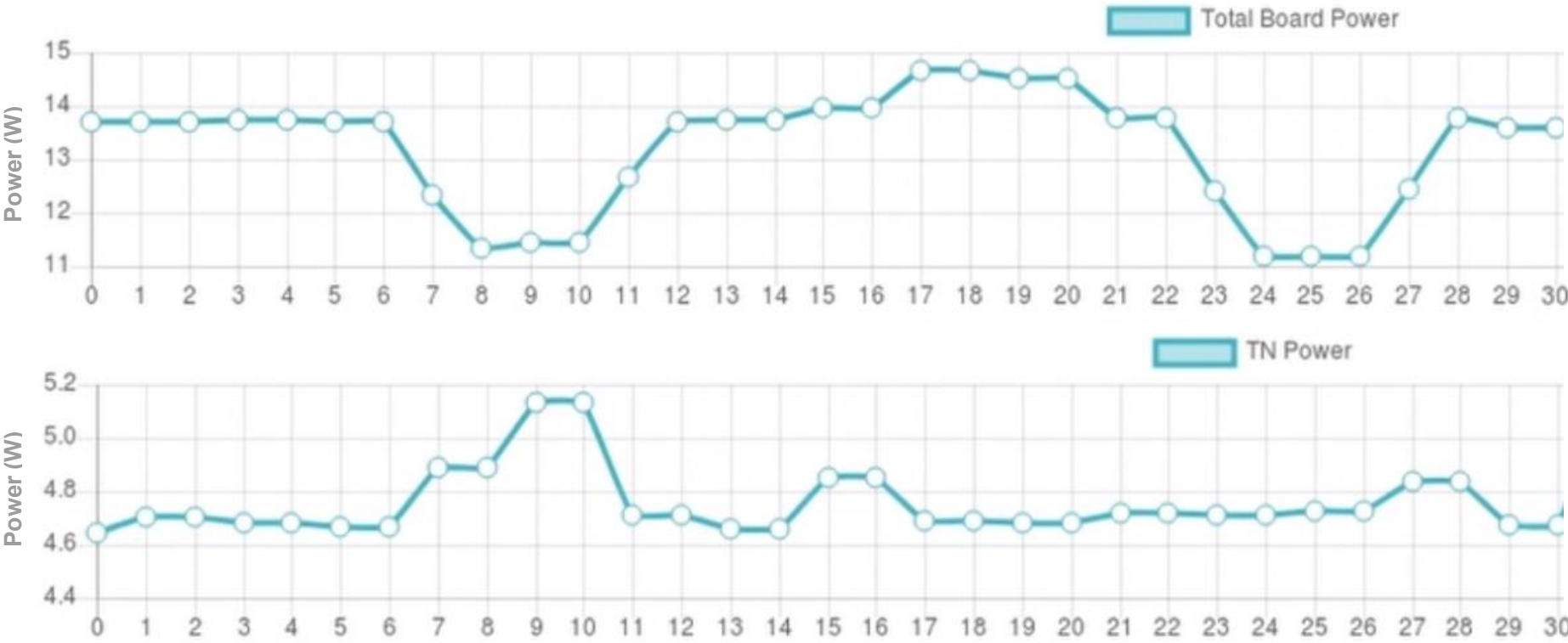
- Throughput
  - 8,000 image chip inferences per second for each data set (16,000 image chip inferences per second total)
  - 3 second inference time for a full 5000x5000 USGS pixel tile
  - MSTAR inference time varied based on input detections produced by filter and threshold preprocessing algorithm
- Efficiency
  - 1,066 Inferences per Watt
    - 16,000 image chip inferences per second
    - 5.5W TrueNorth processor power consumption (worst case)
    - Approximately 340mW per TrueNorth Chip
- Accuracy
  - USGS Optical Data: 99% Classification Accuracy
  - MSTAR and detailed metrics (Confusion matrix, precision, recall, etc.) not currently available for public release



# NS16e Low Power



- NS16e Board Power and TN 16 Chip power while running inferencing model continuously on data sets.



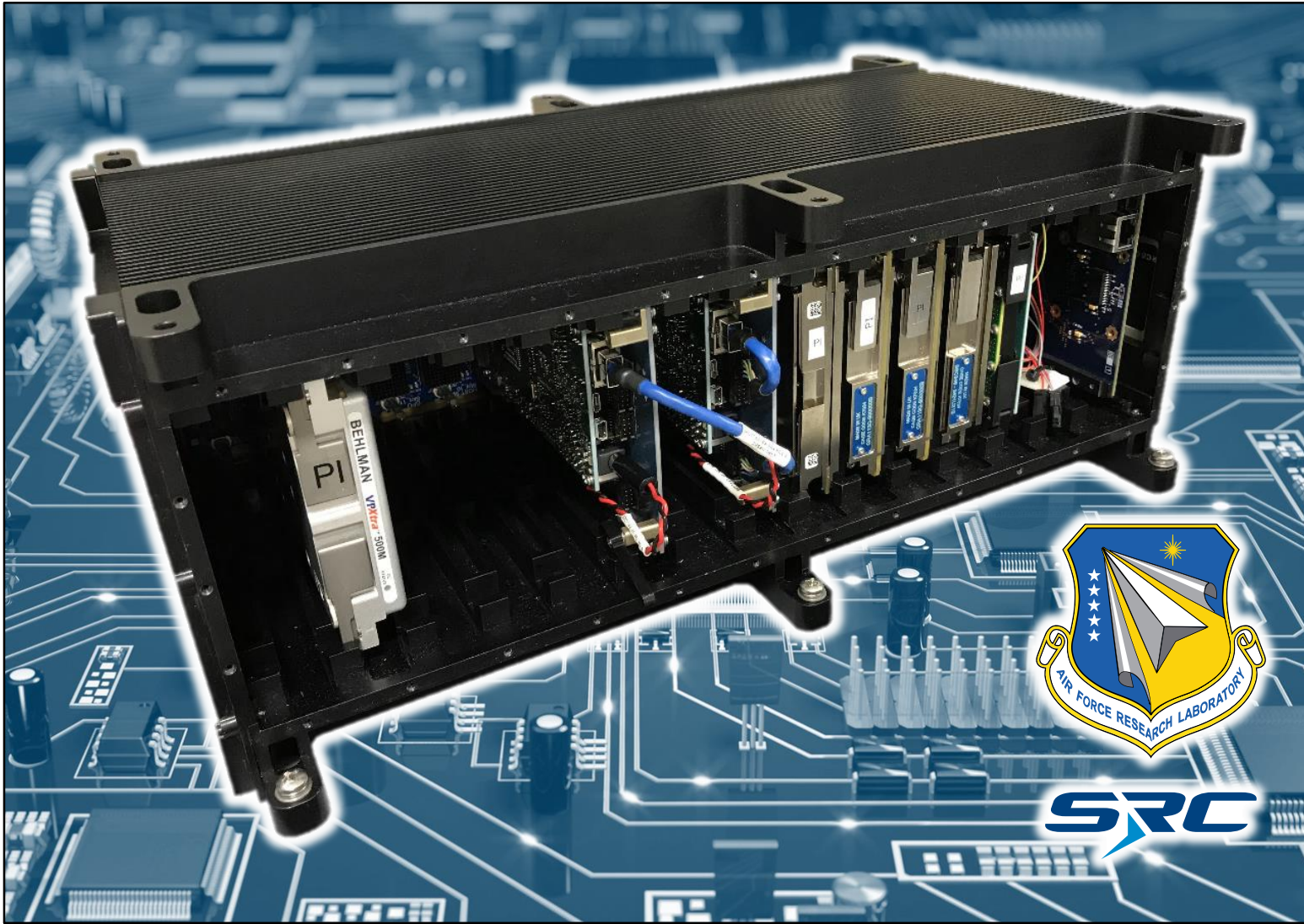
**BlueRaven (4 NS16e boards) total power consumption is under 60 Watts!**







# TrueNorth at the Edge



DISTRIBUTION STATEMENT A



# Questions