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### **BrainChip Achieves Milestone 2 – A Hardware-only Spiking Neural Network (SNN)**

BrainChip Holdings Limited (“BrainChip” or “the Company”) is pleased to advise that it has successfully achieved ahead of schedule its second milestone, the creation of a hardware-only version of its patented and proprietary autonomous learning Spiking Neural Adaptive Processor (“SNAP”) technology.

This significant milestone was achieved via the development of a BrainChip SNN (Spiking Neural Network) working on a Xilinx T2000 FPGA board (Field Programmable Gate Array). FPGA’s are the precursor used to assess new ASIC (Application Specific Integrated Circuit) designs before committing to a silicon-based microchip, that BrainChip anticipates its future technology partners will develop for use in a vast array of potential products.

#### **Highlights**

- Extremely fast processing power confirmed.
- SNAP autonomously learned to avoid the edges of the track in 0.89 seconds, whilst executing 3,571,430 neural update cycles.
- Achieved a neural update rate of 0.25 of 1 microsecond - (0.25 of 1,000,000th of a second).
- Scalability now enabled.
- Demonstrates the disruptive features and benefits of SNAP.
- BrainChip now in a position to demonstrate SNAP to potential development partners with the view to securing licensing and royalty based contracts so that SNAP can be fully commercialized.

Milestone 2 is a significant event for the company and its shareholders, as it clearly demonstrates the disruptive features and benefits of this technology.

An extremely important achievement of milestone 2 is it enables the scaling of the patented SNAP design to much larger SNNs, that can be configured to potentially solve previously unsolvable problems.

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## Massive parallel processing demonstrated in a hardware-only design

In Milestone 1 (announced 13 May 2015) BrainChip demonstrated a software simulation of SNAP versus a traditional genetic algorithm model illustrated by each seeking to navigate a racetrack. The genetic algorithm model, as used by global technology companies, took 15 minutes to complete one circuit whereas the SNAP car completed one circuit of the track in 25 seconds. In Milestone 2 SNAP completes the same circuit in just 0.89 seconds.

SNAP performed 3,571,430 neural update cycles during the 0.89 seconds.

This demonstrates an extremely fast cycle time, and further shows the unparalleled processing power that SNAP can achieve.

Due to the massive parallel processing capabilities of SNAP, it is anticipated that a network of 18,225 neurons will execute 21,578 times faster than a CPU (Central Processing Unit).

## Neuron count versus neuron complexity

Neuron numbers alone are meaningless without considering the features of the neuron and its synapses. The processing power of one hardware-only BrainChip neuron is significantly higher than of sigmoid neurons. One external source estimated that a single spiking neuron performs the same task as 4997 sigmoid neurons.\*

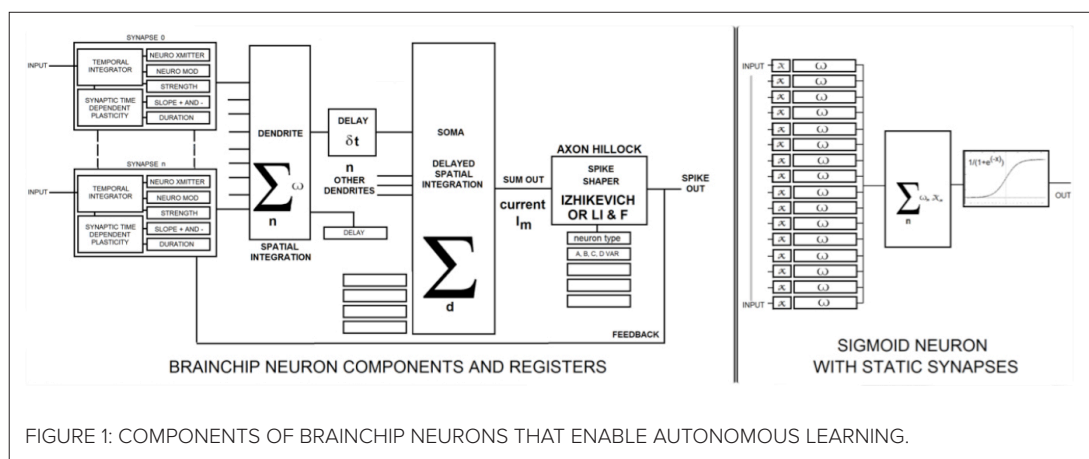


FIGURE 1: COMPONENTS OF BRAINCHIP NEURONS THAT ENABLE AUTONOMOUS LEARNING.

The illustration above serves to demonstrate the complex nature of the BrainChip neurons versus the simpler sigmoid model.

\* <http://papers.nips.cc/paper/1307-noisy-spiking-neurons-with-temporal-coding-have-more-computational-power-than-sigmoidal-neurons.pdf>



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### **True Autonomous Learning**

The complexity of the SNAP neuron and synapse design enables true autonomous learning capabilities unlike current deep learning solutions. This is a truly significant feature. The ability to autonomously learn and extract features is just one opportunity BrainChip can exploit.

Peter Van der Made, CTO and Interim CEO, commented: "We are extremely pleased to have achieved Milestone 2 ahead of schedule. As stated in past announcements we have held discussions with a number of Fortune 500 companies who not only assisted in the design of this milestone but also expressed an interest in partnering with BrainChip to commercialize the technology. Achieving Milestone 2 provides the catalyst to continue discussions with those companies keen to leverage the benefits SNAP offers them. We will continue to deliver further enhancements and updates to the SNAP model that will illustrate the many additional benefits SNAP has to offer."

Peter van der Made  
CTO and Interim CEO

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ANNOUNCING **BRN MILESTONE 2.0**

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BRAINS **ARE SMART.**

There's no faster or more intelligent CPU around.



COMPUTERS **AREN'T.**

They're only programmed to be smart.



BUT WE'RE **FIXING THIS.**

Our hardware technology closely mimics the brain.



ANNOUNCING

# MILESTONE 2.0

BRAINCHIP PROVEN IN HARDWARE.

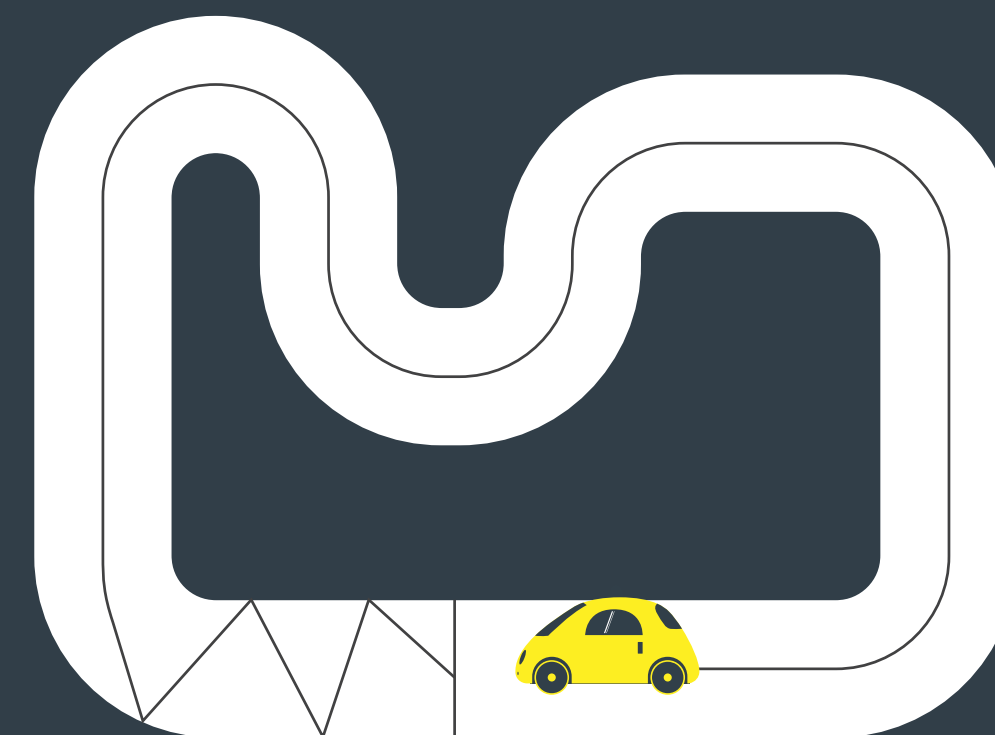
GENETIC ALGORITHM



A GENETIC ALGORITHM CAR LEARNS THE TRACK IN **15 MINUTES.**

VS.

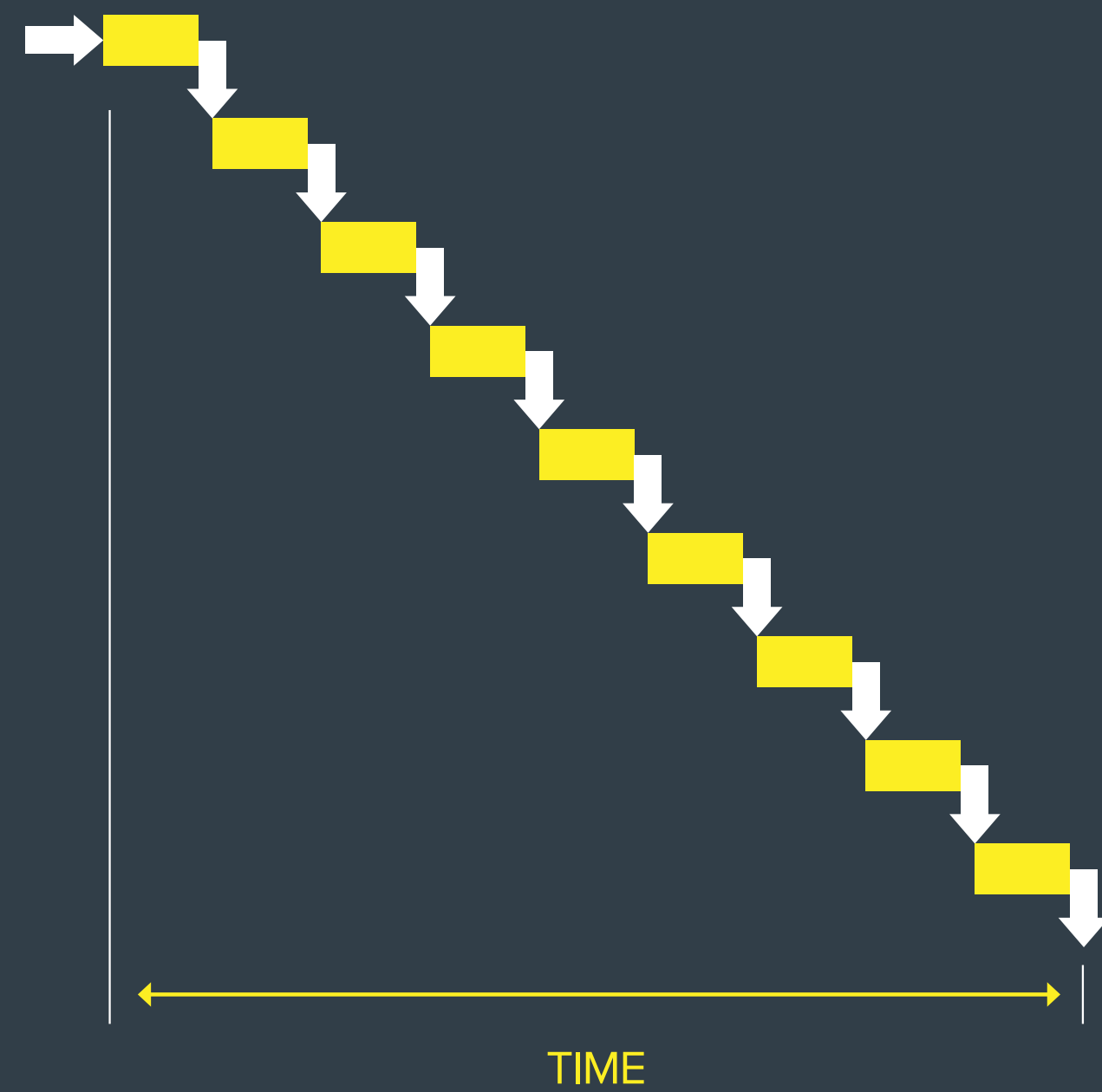
BRAINCHIP



THE BRAINCHIP CAR LEARNS THE TRACK IN **.89 SECONDS.**

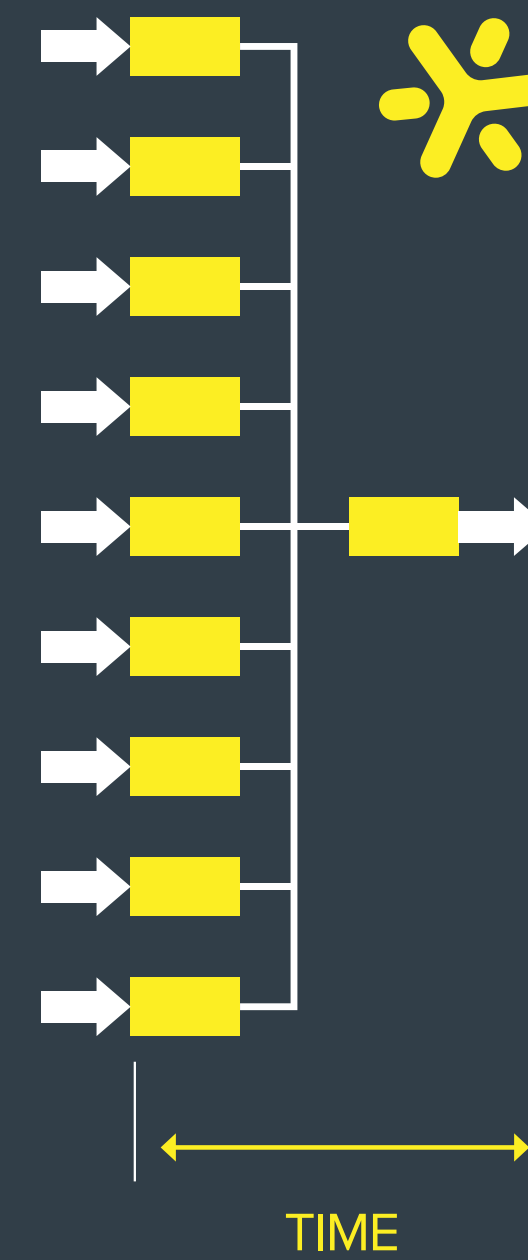
IN MILESTONE 2.0 WE PROVED  
**BRAINCHIP LEARNS EXTREMELY FAST.**

SIGMOID NEUTRONS – SEQUENTIAL PROCESSING



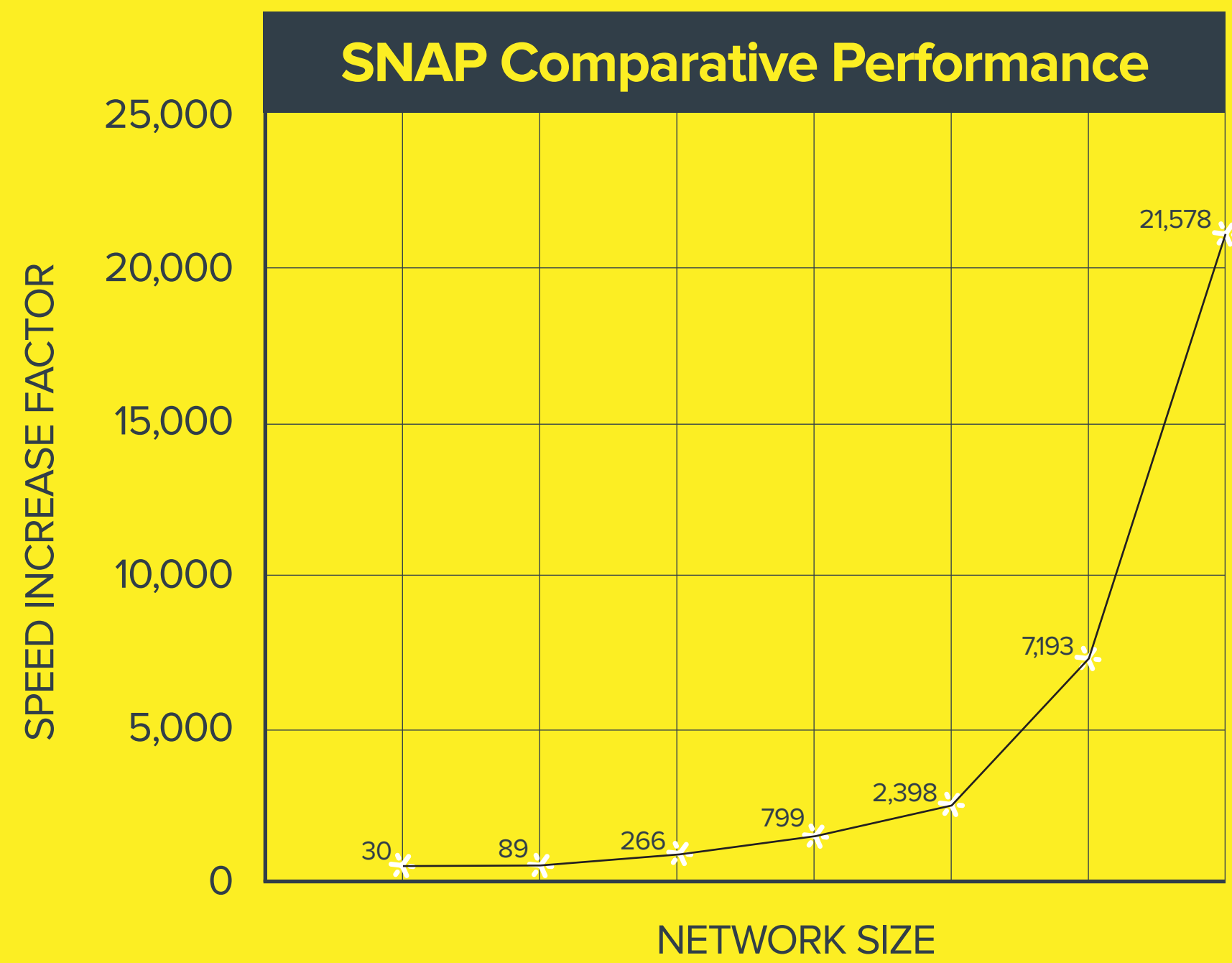
VS.

SNAP PROCESSING – PARALLEL PROCESSING



USING HARDWARE-BASED **PARALLEL PROCESSING.**

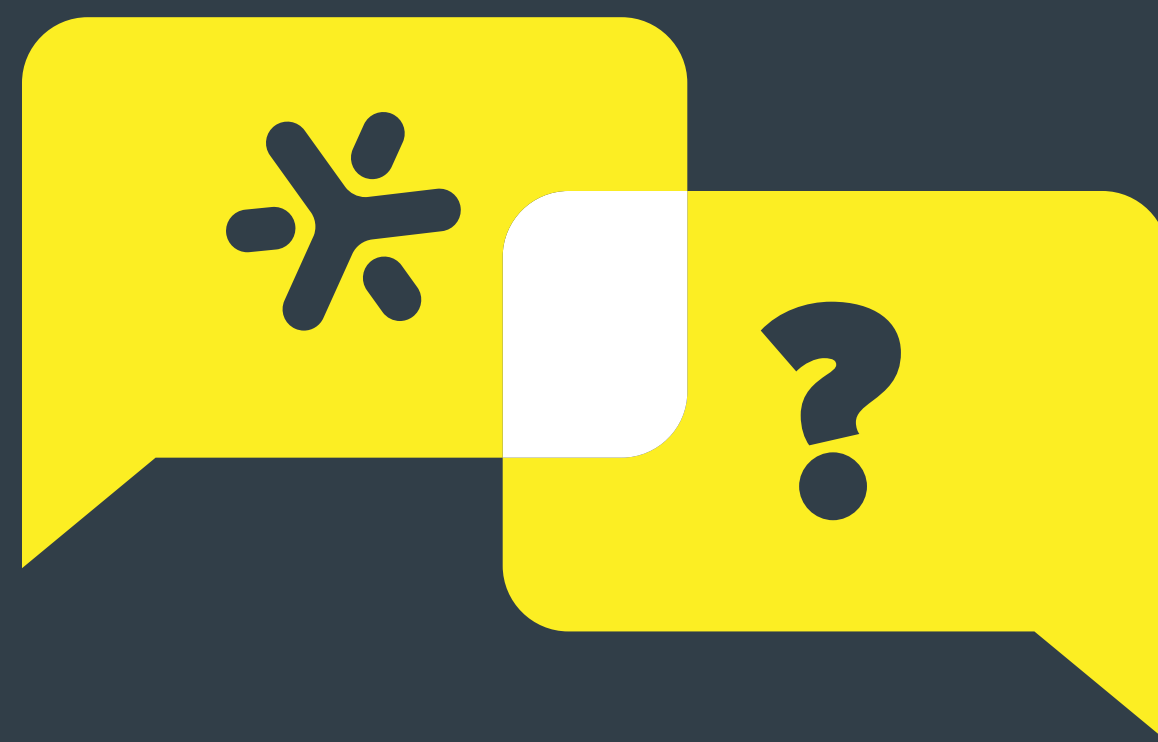
The simultaneous process isn't just fast, it also uses less power.



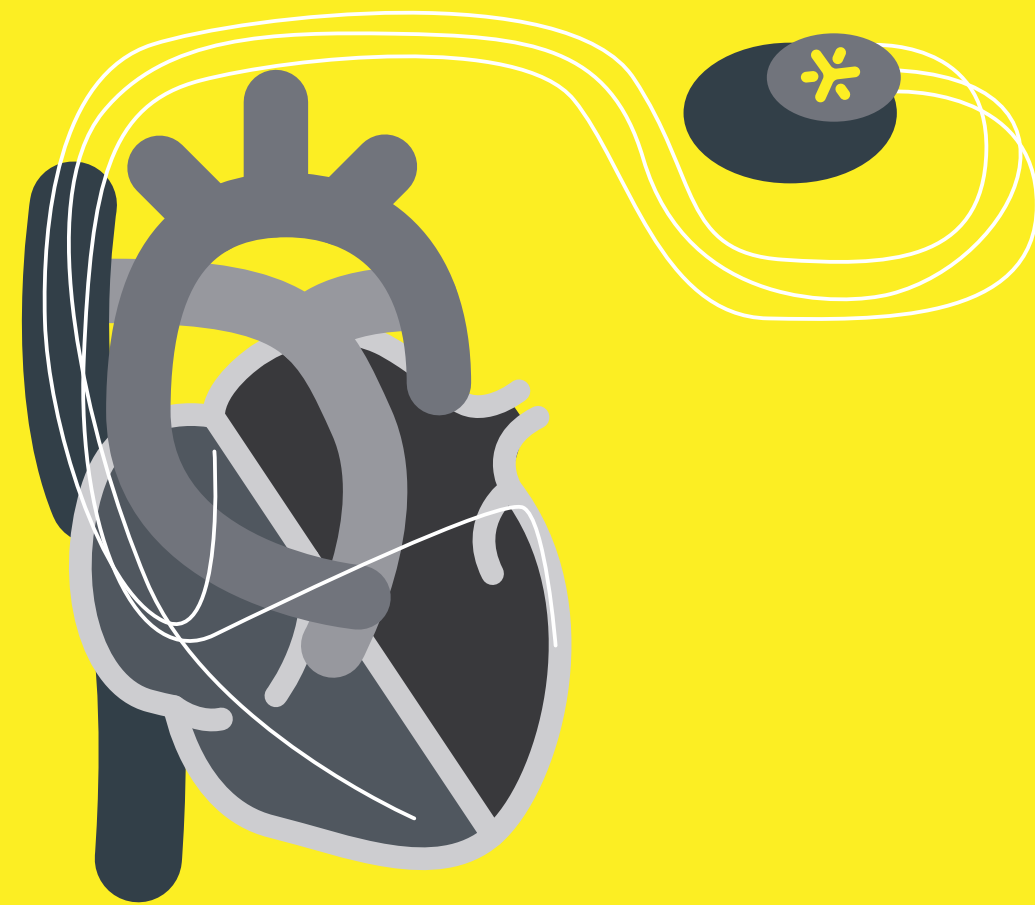
Scaled Size	Software time/cycle	SNAP incremental increase	Hardware time/cycle
25	0.0074	30	0.00025
75	0.0222	89	0.00025
225	0.0666	266	0.00025
675	0.1998	799	0.00025
2025	0.5994	2398	0.00025
6075	1.7982	7193	0.00025
18225	5.3946	21578	0.00025

SO NOW WE'VE PROVEN **SCALABILITY.**

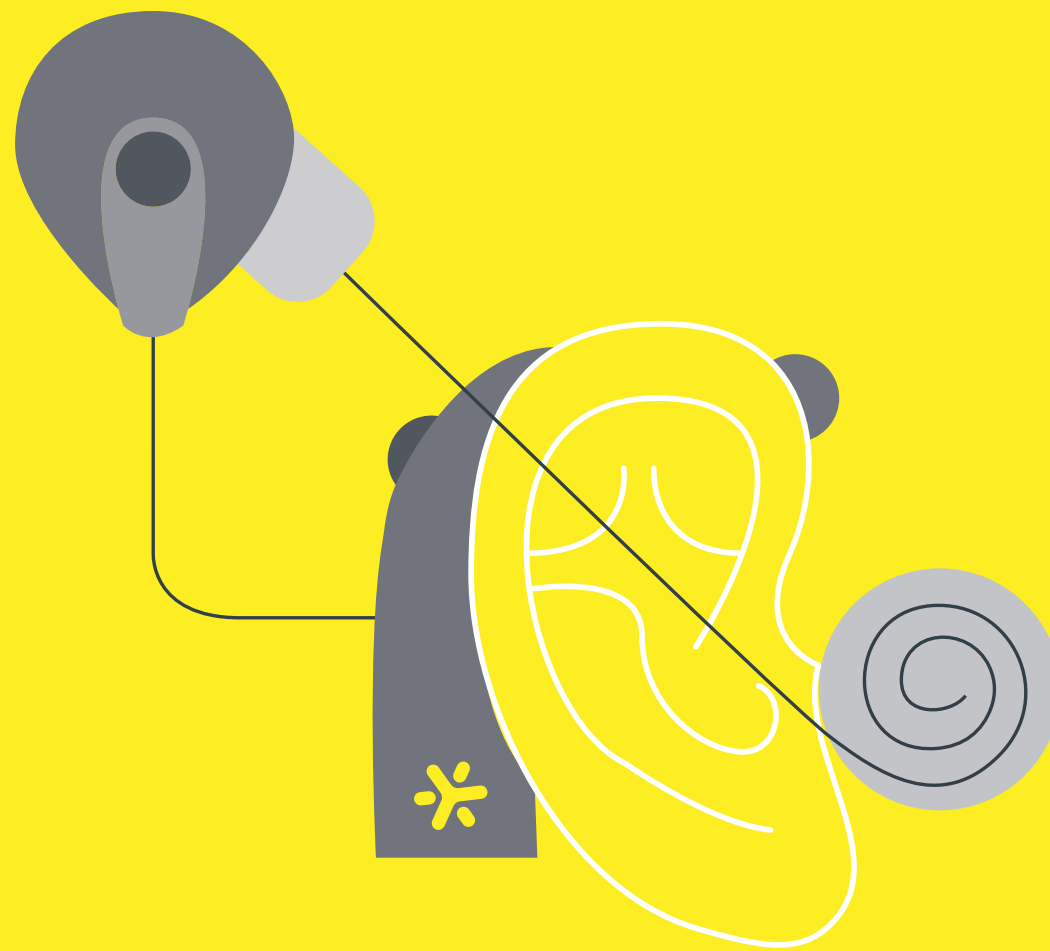
Speed is exponential. Power is linear.



AND WE'RE READY TO CHAT **WITH TECH PARTNERS.**



Pacemakers



Cochlear implants



Autonomous cars

IMAGINE THE **SPEED, EFFICIENCY** AND **LOW POWER** OF BRAINCHIP APPLIED TO REAL-WORLD PRODUCTS.

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NOW **THAT'S SMART.**

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