FRORE
SYSTEMS

AirJet: Solid-state active cooling helps maintain Moore’s Law

HotChips 2024

Moore's Law – Dead?

- Transistor counts increasing
- Die sizes are increasing
- **Power/transistor is stalling**
- **Total Heat is increasing**

Thermal envelope of devices must increase to maintain Moore's Law

The AI Revolution

Requires increased performance

Demand for AI Computing estimated to increase by over 300% by 2030

Increasing Heat

On-Device AI

Smartphones

Tablets

NoteBooks

Cameras

AR | VR

Mini PCs

- Copilot
- Photo Realistic Gaming
- Intelligent Video Editing and Image De-noising
- Real Time Video conferencing with Real-time Translation and Transcription
- Facial Recognition

Industrial Manufacturing

Smart City

Smart Retail

- Predict Maintenance, Remote Monitoring
- Automation, Robots, Asset Management
- Connected Public Transport and Traffic Management
- Video Surveillance
- Smart Shelves, Inventory Management
- Automated Checkout

This is Just the Tip of the Iceberg!

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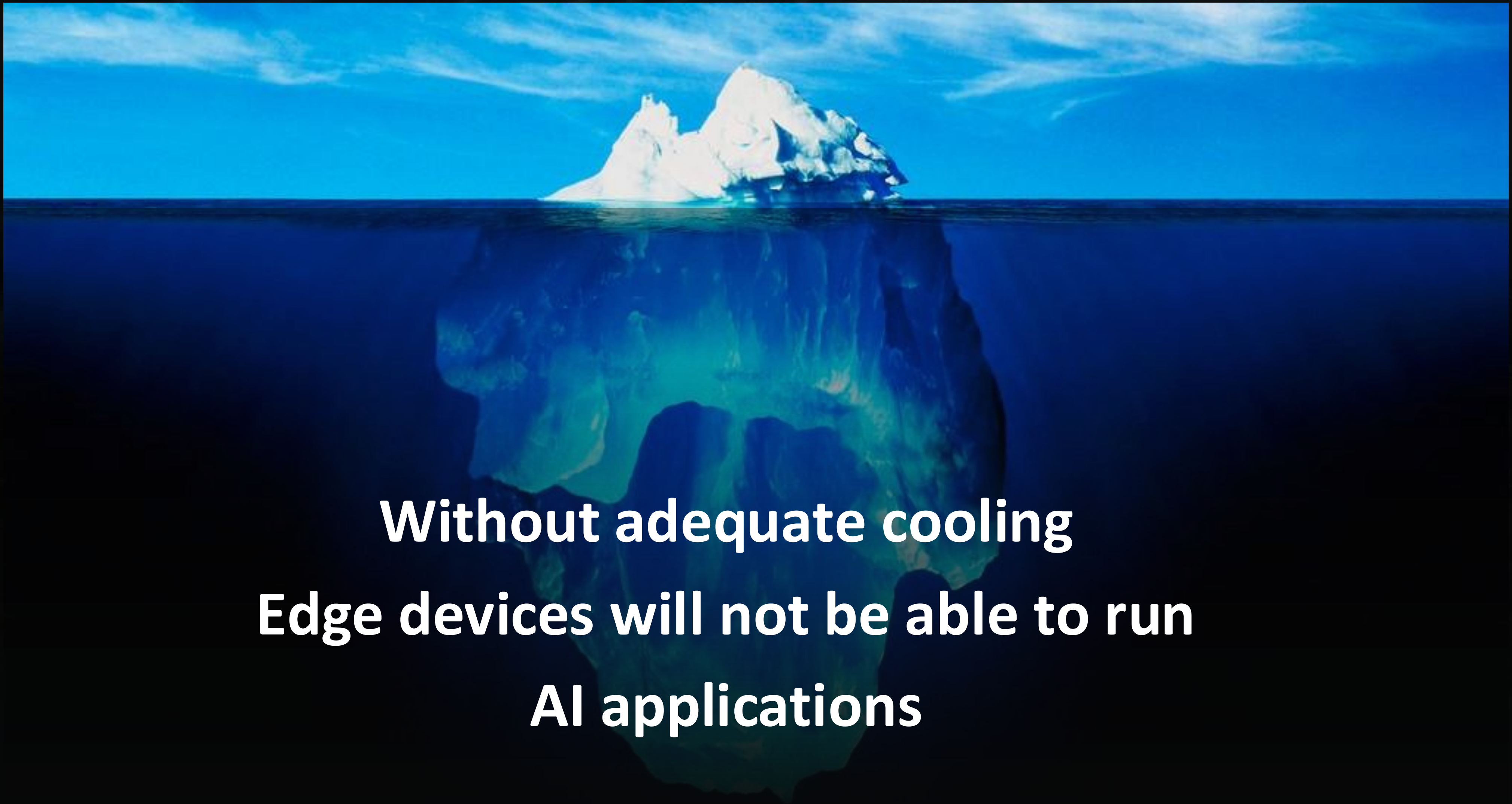


Without adequate cooling

Edge devices will not be able to run

AI applications

Inadequate Existing Thermal Solutions

Passively Cooled

Smartphones

Tablets

Fan-less NoteBooks

Smart Cameras

Streaming Devices

Fan-less Mini PCs

- Employ conduction and radiation to the environment
- Compact, thin device, highly packed with no space for fans
- Thermal envelope limited to 5-10W

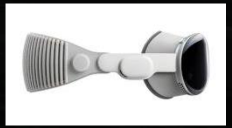
Actively Cooled

Industrial PCs

Gaming

NoteBooks

VR



- Employ heatsinks, heat pipes, fans, and blowers
- Bulky, noisy, heavy, reliability concerns
- Thermal envelope: 15-35W

What is the Ideal Thermal Solution?

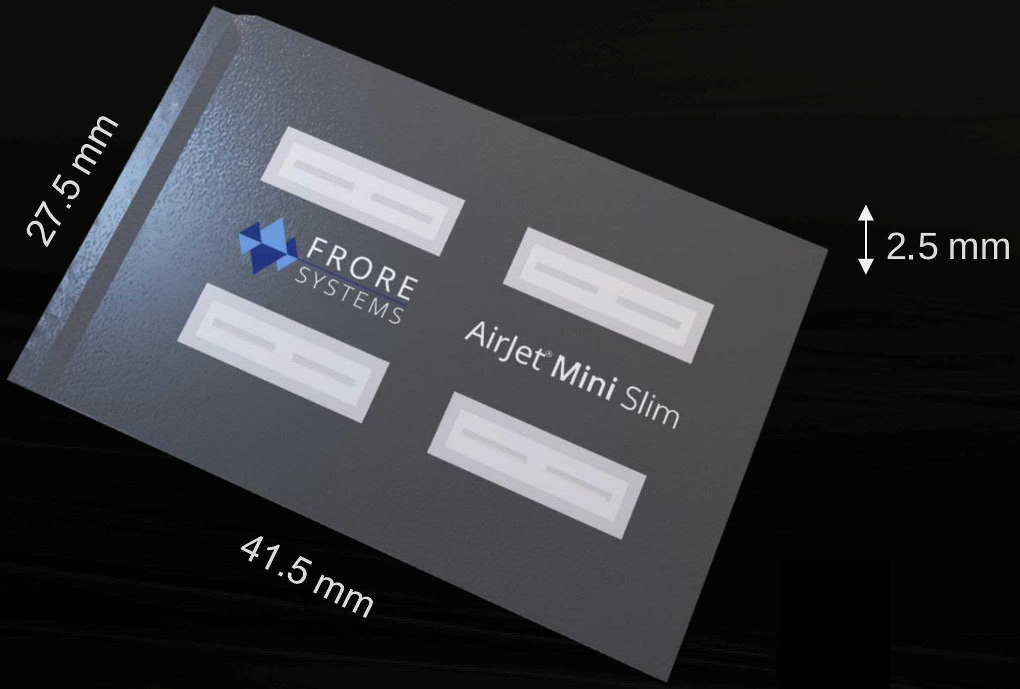
FRORE SYSTEMS

- High rate of heat removal
- Thin
- Light
- Silent
- Operate effectively in densely packed compact devices
- Dust proof
- Waterproof (IP68) compatible
- Reliable
- Scalable

Market Requirement Document for Frore Systems – 5 years ago!

Introducing AirJet® Mini

Solid-State Active Cooling Chip based on MEMS Technology



Weight **7g**

Heat Removal **5.25 W**

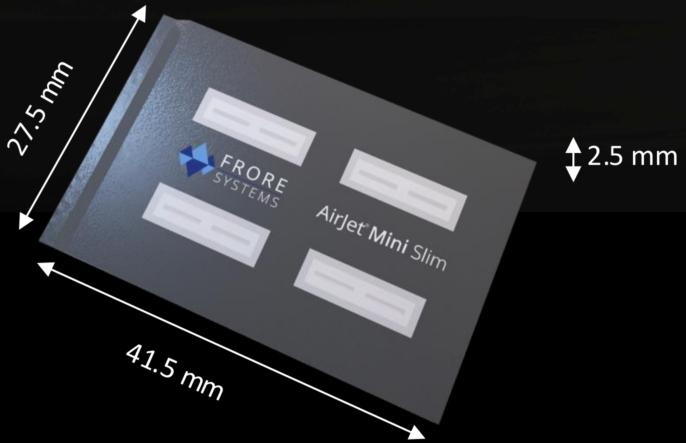
Back Pressure 1750 Pascals

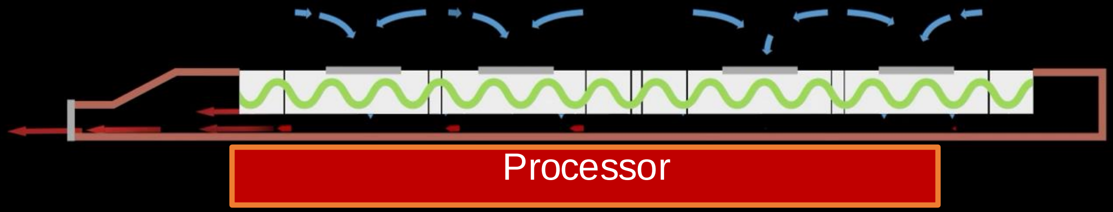
Max Power Consumed **1 W**

Making Devices: Faster | Quieter | Thinner | Lighter | Vibration Free | Dustproof

How AirJet® Works

Solid-State Active Cooling MEMS Chip





Exit Air Temperature ~ Processor Temperature

Jet impingement and high heat transfer

How AirJet® is Manufactured

Custom Semiconductor Process for Non-Silicon Wafer

Frore Systems Fab, Taiwan

An entirely new category of chip using unique:

- Materials
- Design
- Manufacturing

Who is Using AirJet Mini?

Ultra Thin Fanless Notebook with AirJet

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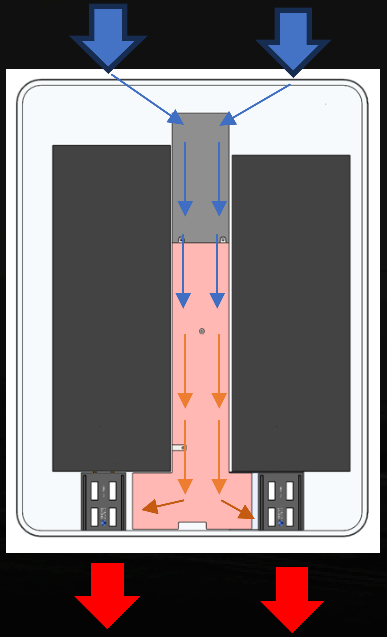
67% increase in CPU power
23% higher CPU performance
Silent

PERFORMANCE IMROVEMENT

	No AirJet	With AirJet
SoC Power:	**12W**	**20 W**

Premium Tablet with AirJet

On-device AI in mobile ultra-thin form factors



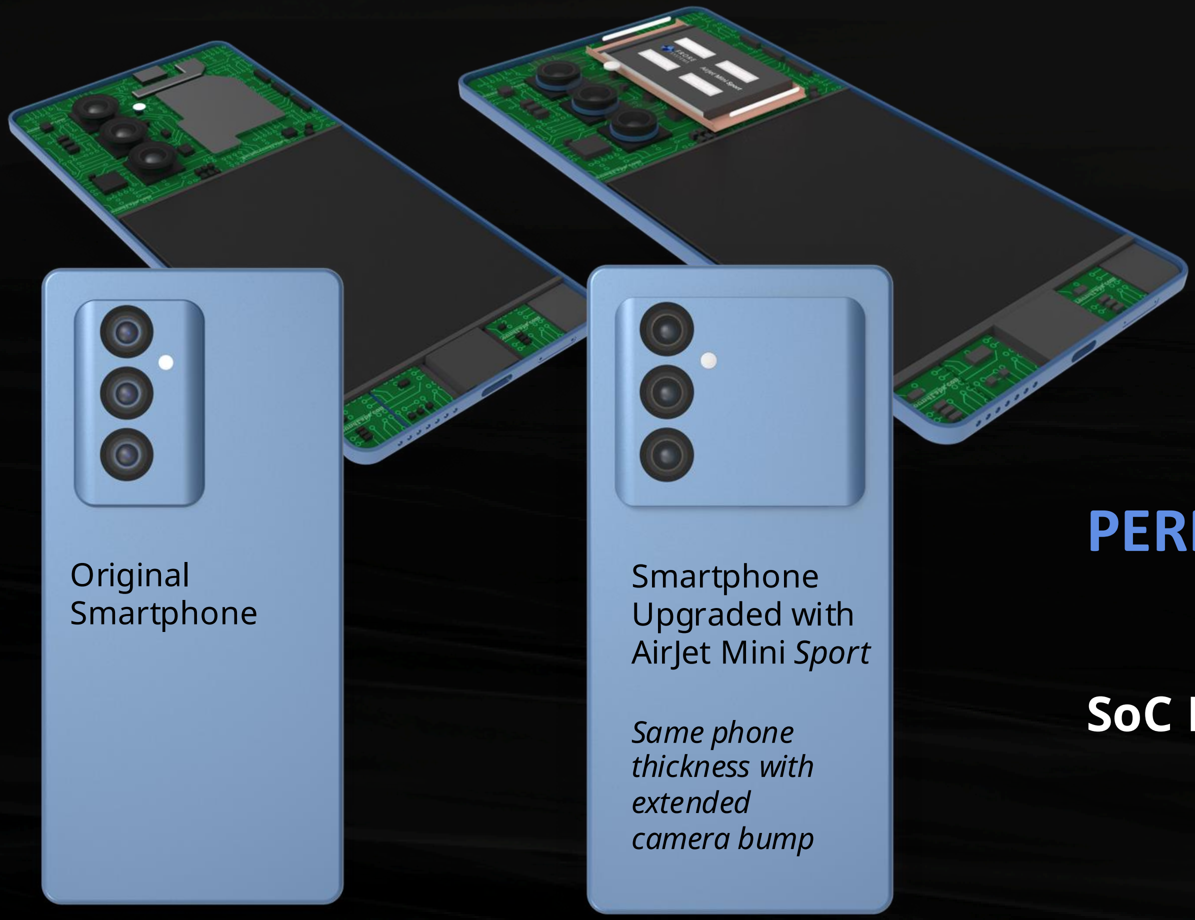
100% increase in sustained SoC performance

PERFORMANCE IMROVEMENT

	Commercial	With 2x AirJet Mini
SoC Power:	**5W**	**10.4 W**

AirJet Mini in Smartphones

Handle AI Workloads, IP68 Compatible, Same Thickness



Original
Smartphone

Smartphone
Upgraded with
AirJet Mini *Sport*

*Same phone
thickness with
extended
camera bump*

PERFORMANCE IMROVEMENT

	No AirJet	With AirJet	
SoC Power:	**5 W**	**7 W**	60 C

40% increased performance

Mobile SSD Accessory with AirJet

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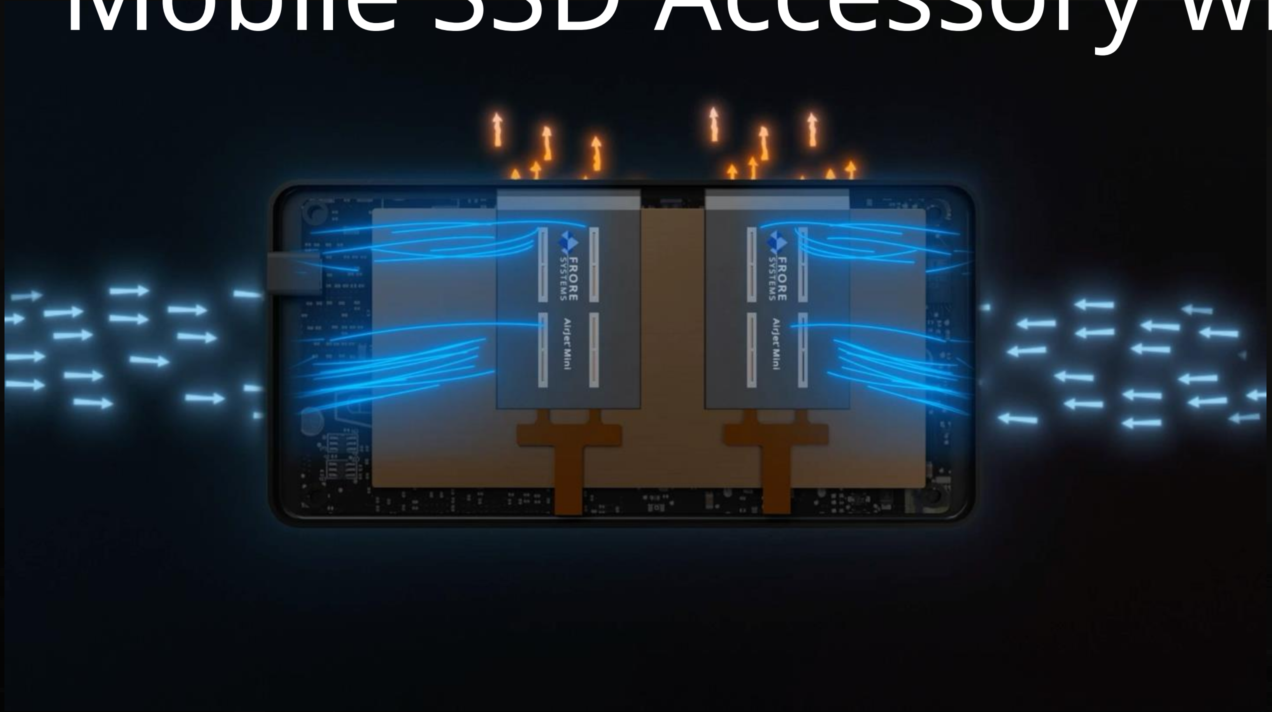
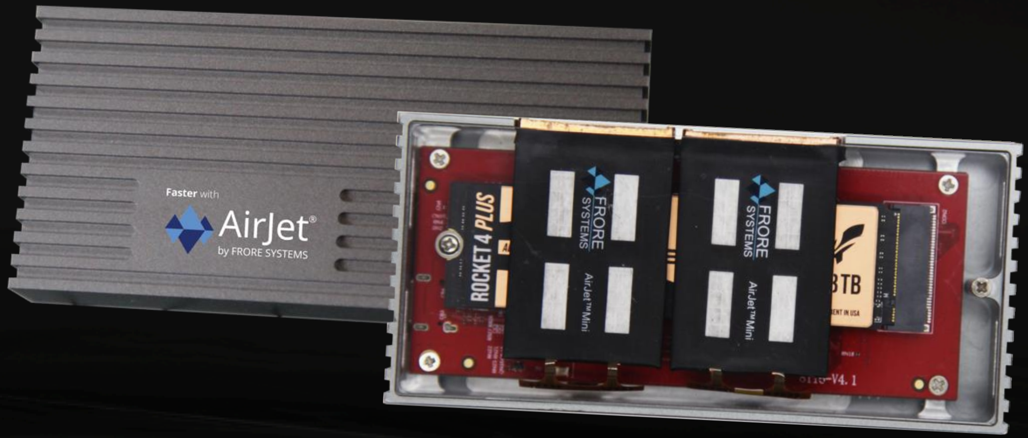




PERFORMANCE IMROVEMENT

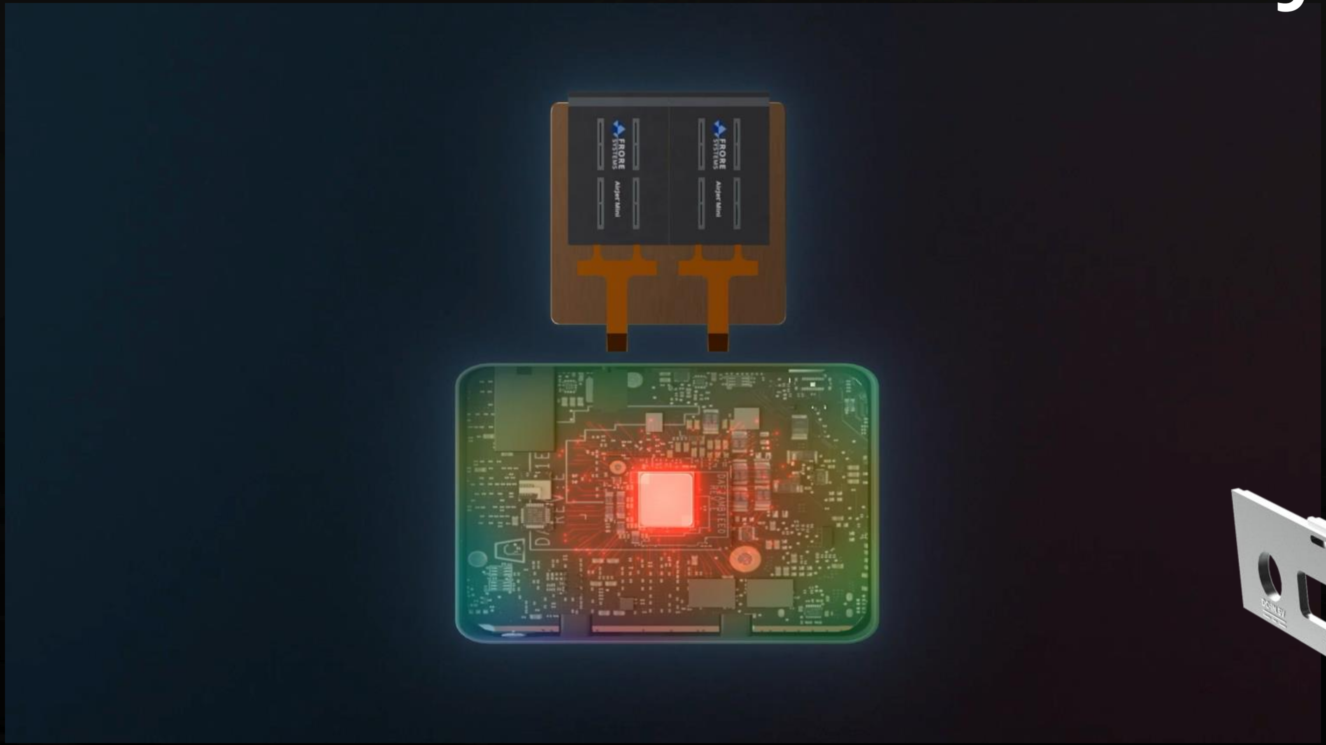
	No AirJet	With AirJet
Sustained Data Throughput:	700 MB/s	3000 MB/s
Skin Temperature:	62°C	42°C

3x Faster

20°C Cooler

Full sustained Thunderbolt speeds with no throttling

Industrial MiniPC with AirJet



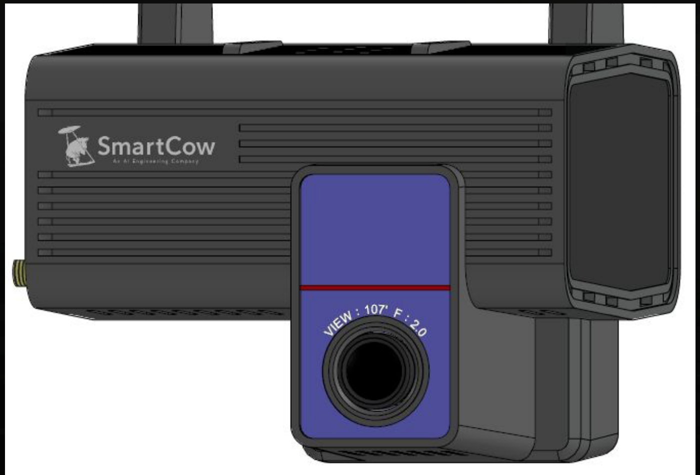
PERFORMANCE IMROVEMENT

	No AirJet	With AirJet	
System Power:	**14 W**	**24 W**	
Skin Temperature:	**72ºC**	**60ºC**	60 C

Fanless MiniPC with 2x AirJet Mini

Smart Cities Cameras with AirJet

Edge-devices in harsh environments



Smart Camera without AirJet

Smart Camera with AirJet

3x AirJet Mini cooling Nvidia Nano 8GB

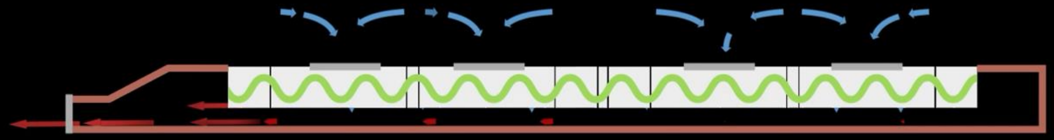
PERFORMANCE IMROVEMENT

	No AirJet	**With AirJet**
System Power:	**10W**	**22 W**

What’s Next ?

LiquidJet for Data Center

Solid-State Active Cooling MEMS technology applicable to all Fluids



Exit Fluid Temperature ~ Processor Temperature

What if we replace Air with Water?

THERMAL PERFORMANCE COMPARISON

	Air	Water
Thermal capacity	**1.2 x10^{-6} J/cc/C**	**4.2 x10^{-3} J/cc/C (3500x larger)**

Questions ?