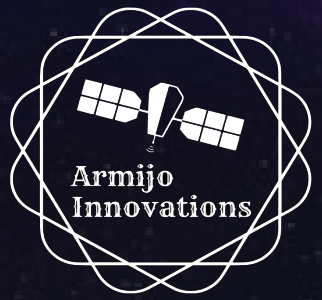
The Next Frontier of Scaling
Memory is Space

Paul Armijo

George Williams




Datacenters On Fire!
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tom's HARDWARE

AI industry needs to earn $600 billion per year to pay for massive hardware spend

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AI Model Training Costs Skyrocket

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GS

US Datacenters Will Represent ~10% of Total US Energy Demand By 2030

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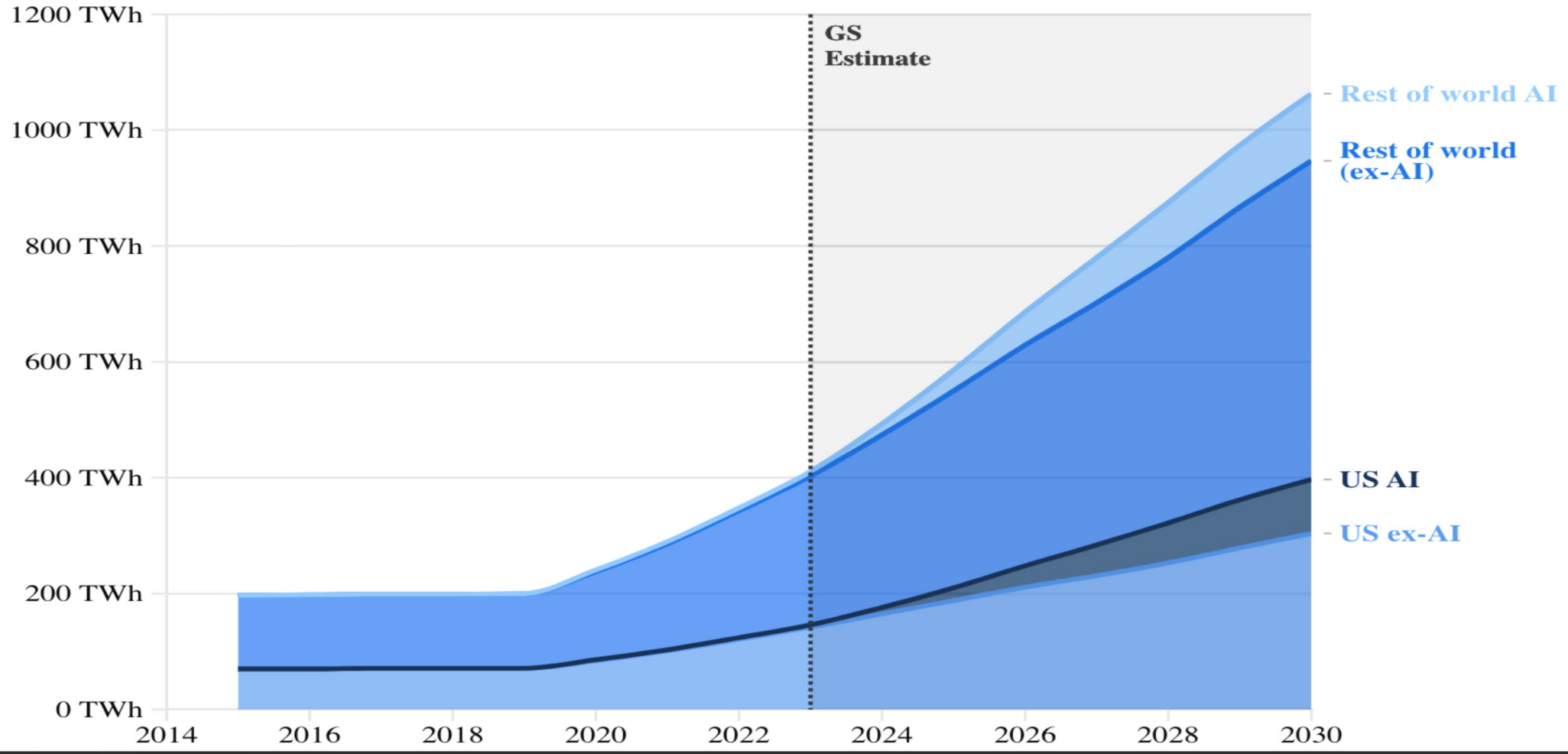
Data center power demand



Goldman Sachs, Generational Growth, 2024

"The only way to get more computing capacity today is to build bigger, more energy-consuming machines. If we're in an *AI arms race* with our adversaries, it could have a dramatically bad *impact on climate*."

-The Death Of Moore's Law, MIT

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Migrating
Datacenters Into
Space
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Power Generation & Consumption

- Every day the sun emits 44 Quadrillion (4.4×10^{16}) Watts of Power, while a large electric power plan produces about 1 Billion (1×10^{9}) Watts of Power. (1)
- About 30% of the solar energy that reaches the Earth is reflected back into space and the majority of the rest is absorbed by the Earth's atmosphere.

(1) - NASA - FS-2005-9-074-GSFC

Power Generation & Consumption

- Capture and Harness that energy for use in space systems
- Strategically plan constellations timing and use of that power
- Enable focused payloads with different type of memory and processors optimized for the type of sensor
- Transmit back and forth from specialized data centers rapidly and securely via laser communication

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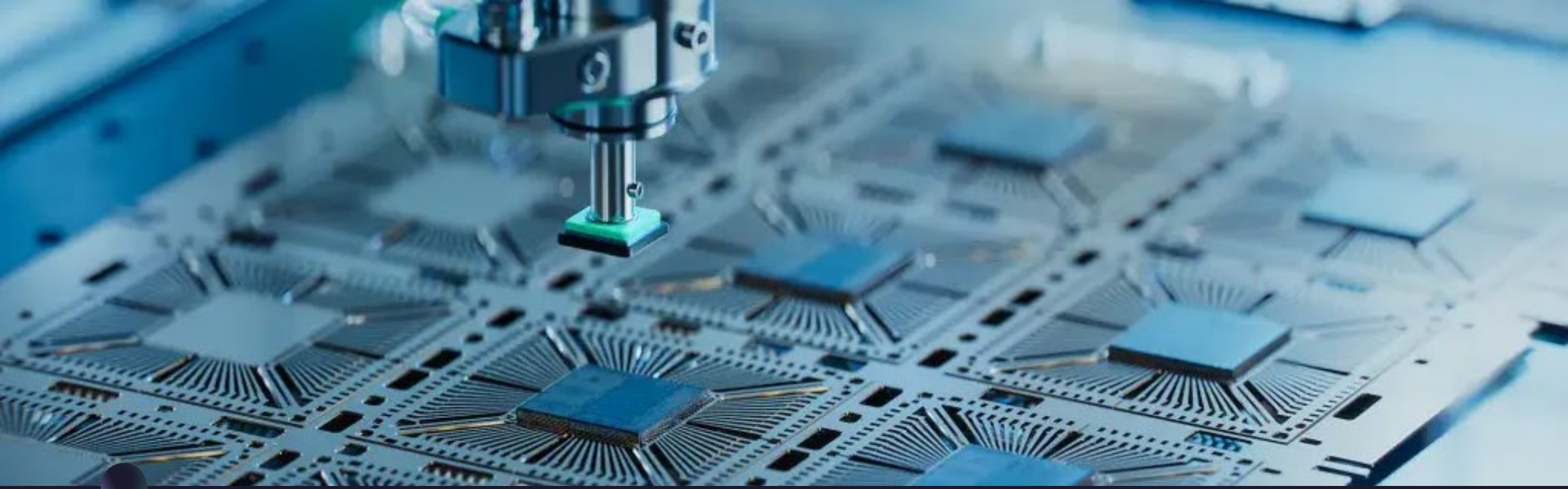

Fabrication and Material Science

- Ultimately with low-g fabrication in space down the line further opens the door for substantial use of wafer-level packaging of memories and processors that are a challenge today for mechanical/structural reasons as well as thermally to cool the product.

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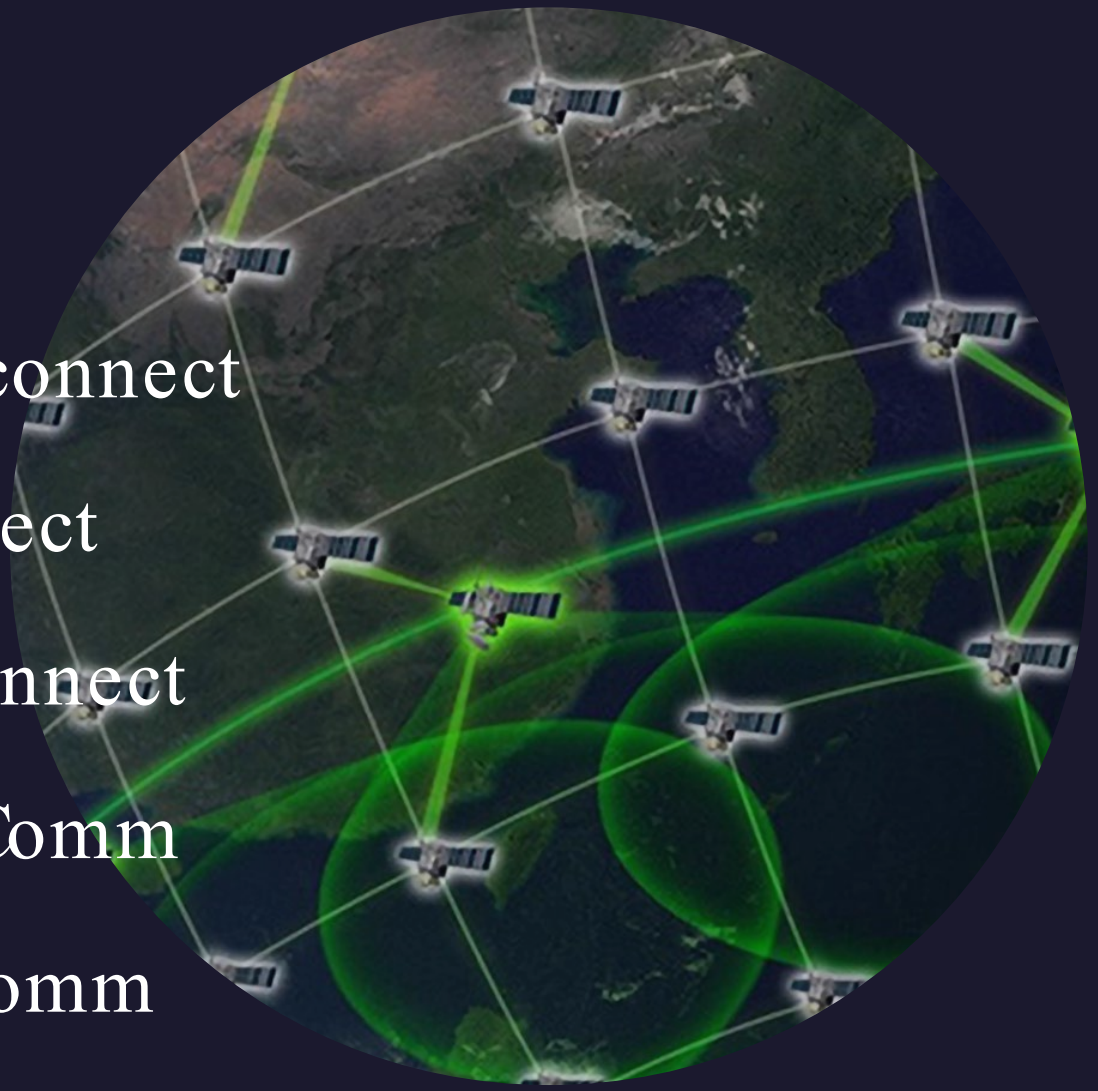
Interconnect With Photon Lasers

- Chip to Chip Silicon Photonic Interconnect
- Board to Board Photonic Interconnect
- System to System Photonic Interconnect
- Satellite to Satellite Photon Laser Comm
- Satellite to Ground Photon Laser Comm



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Cybersecurity

- Physical Security – Space Is Still Hard to Get To!!!
- Limited Entry Points to the Satellites via RF Ground Station Enterprises
- Extremely Limited Entry Points to the Satellite via Laser Communication Terminals to the Ground
- Additional Air-gap of Space Infrastructure with some satellites only making use of space-to-space laser communication, no satellite to ground connections.

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Challenges of
Scaling in Space
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Space Junk

SpaceX: 50K Collision Avoidance Maneuvers In The Past Year!

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Space Environment Challenges

- **Radiation**
  - **Total Ionizing Dose – TID – Gamma Rays – Cumulative Effect**
  - **Single Event Effects – Upsets, Transients, Latchup, Flip bits, Stuck Bits, Burnout, Gate Rupture – Cosmic Rays – Heav Ions & Protons**
- Plasma
  - Charging (exterior of satellite)
- Neutral Gas Particles
  - Drag, Surface Erosion, Structural Integrity Degradation
- Ultraviolet & X-ray
  - Surface Erosion & Structural Integrity Degradation
- Micro-Meteoroids & Orbital Debris
  - Structural damage decompression

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Construction and Supply Chain

- Traditional Satellite &Constellations Route
  - Full Satellite Bus Off-The-Shelf
  - Full Payloads Off-The-Shelf
- Space Stations
  - International Space Station
  - Lunar Gateway
  - Axiom Space
  - Orbital Reef
    - Blue Origin, Sierra Space, Redwire Space,
  - Starlab
    - Airbus, Voyager Space/Nanoracks,

- Space Worthy Resilience By:
  - RadHard Component Design
  - System Architecture
  - Component Redundancy
  - Constellation Satellite Redundancy
  - System Redundancy
    - Cold/Hot Spare
    - Triple Modular Redundancy
    - Quadruple Modular Redundancy
  - Error Detection And Correction

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Cost/Investment Examples

- CHIPS Act Aug' 22- $52.7B
  - American Semiconductor Research, Development, Manufacturing and Workforce Development
- Air Force Research Lab – **STAR-FISH** – Space Technology Advanced Research-Fast-tracking Innovative Software and Hardware
  - **ANGTRM** - Advanced Next Generation Strategic Radiation Hardened Memory Program
  - $35M Award to Western Digital in Nov' 23 - Contract provides for the evaluation development of strategic radiation hardened non-volatile memory devices with near-commercial state-of-the-art performance for space and strategic systems.

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Summary

- Scaling datacenters for next generation AI will face many *terrestrial* challenges
- Extending datacenters into space offers many advantages and opportunities for the microelectronics industry
- The hurdles are both technical and monetary, but there is a path...

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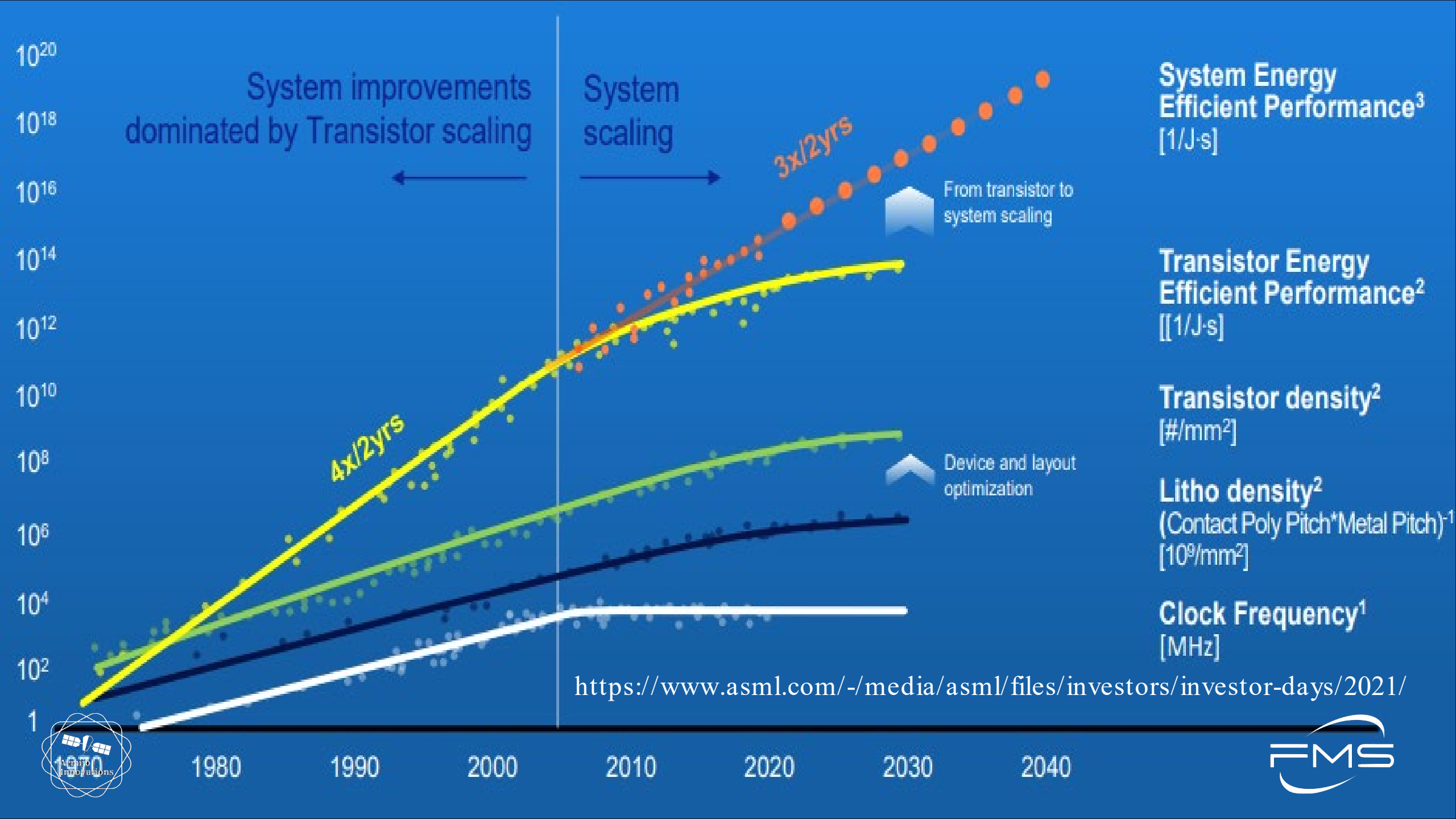
The End



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