

# **Exascale by 2021-2023**

## **—Truth or Myth?**

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**April 26, 2017**

(Abbreviated ECP Meeting Talk, Jan 2017)

# A Little Historical Perspective...

## Pundits—Exascale WG (2007-2009)



Power and energy  
Simplicity, accelerators, ...  
Data movement expensive  
Memory challenges  
>1000X parallelism than Peta  
New execution model

## Cowboys—The skeptics (2010+)



Tech advances will continue  
Historic benefits will continue  
No need for any alarms  
Disruptive tech not needed  
PPT based roadmaps rule!  
And we will deliver..

# "Capable Exascale", defined by ECP

## Application Performance Improvement in 20-30 MW

- Sequoia and Titan baseline
- 50x improvement in performance
- FOM = [Performance] × [Speedup]

17 PF (Rmax)

0.3 PF (HPCG)

8 MW

~ \$100 M

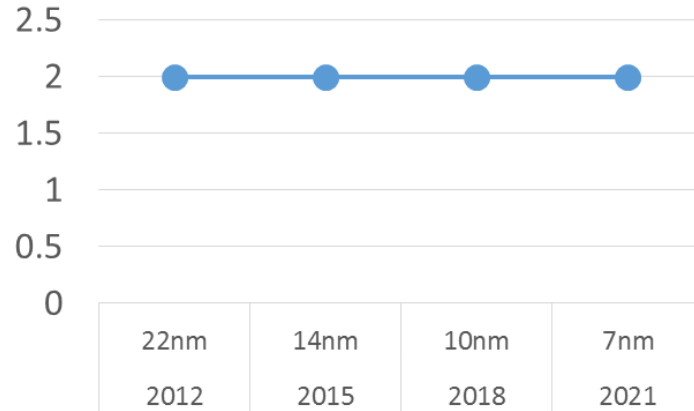
Source: Jim Anderson

meeting, April 6, 2016

Sequoia		Titan	
Performance	7.6 PF (Rmax)	17 PF (Rmax)	0.32 PF (HPCG)
HPCG/HPL	0.8%	0.2%	
HPCG/Peak			
Power	7.9 MW	8 MW	
Operational	June 2012	Operational	Early 2013

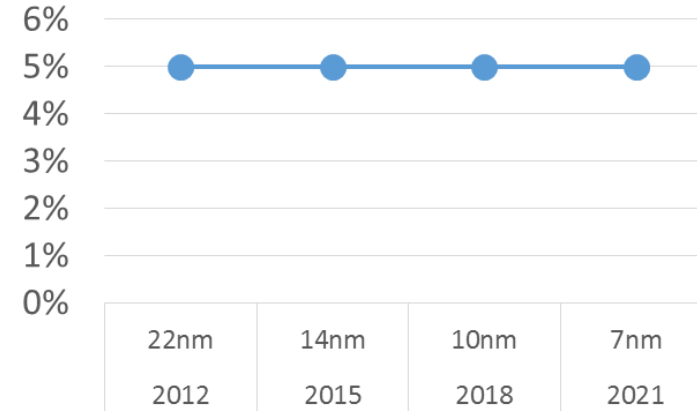
# Scaling Projections

### Transistors (X/Generation)



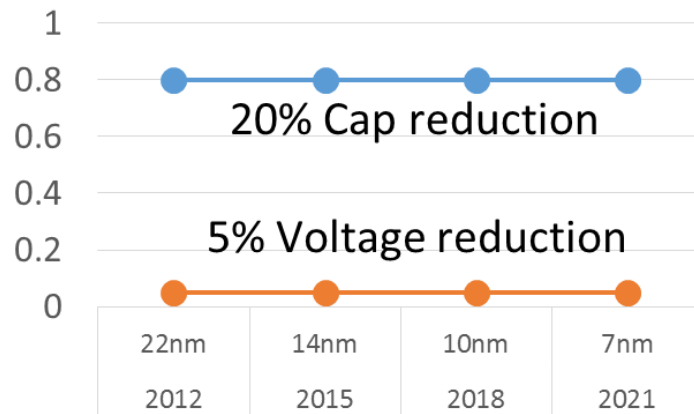
**Moore's Law, 2X Tr/Gen**

### Transistor Freq/Gen



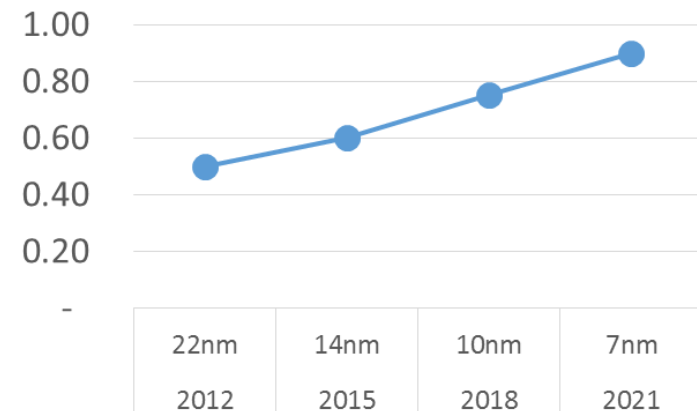
**Flattened, assume modest 5%**

### Node Cap & Voltage/Gen



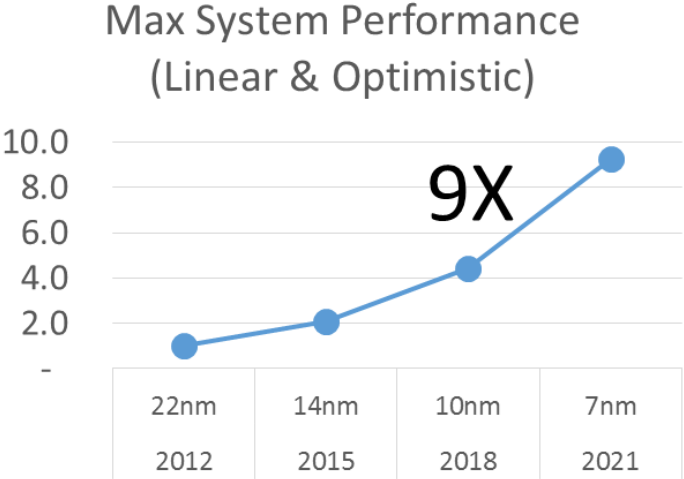
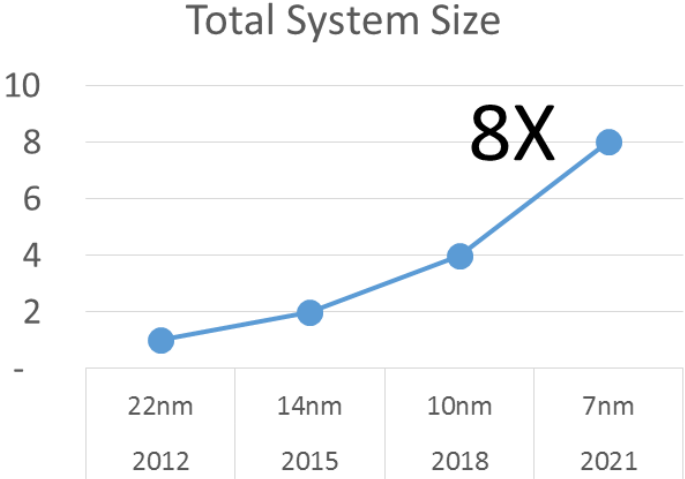
**Cap reduces, Vcc not much**

### Tran Cost Reduction (X)/Gen



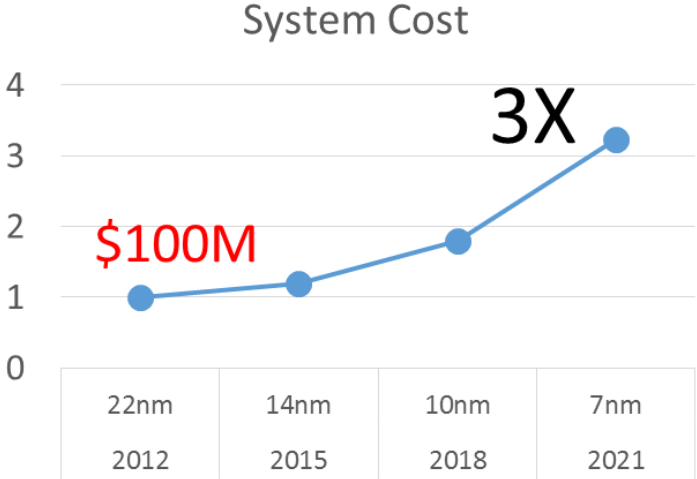
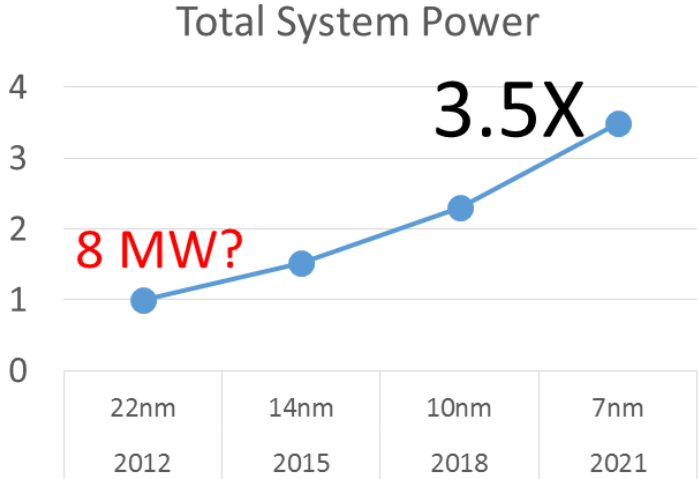
**Cost/Tr will not improve much**

# Sequoia/Titan Scaled System



**System size will grow...**

**Perf by an order of magnitude**



**Power within limit**

**And for exorbitant cost!**

# Projection

	Original	Scaled
Performance (Rmax)	17 PF	153 PF
Power	8 MW	28 MW
Cost		M

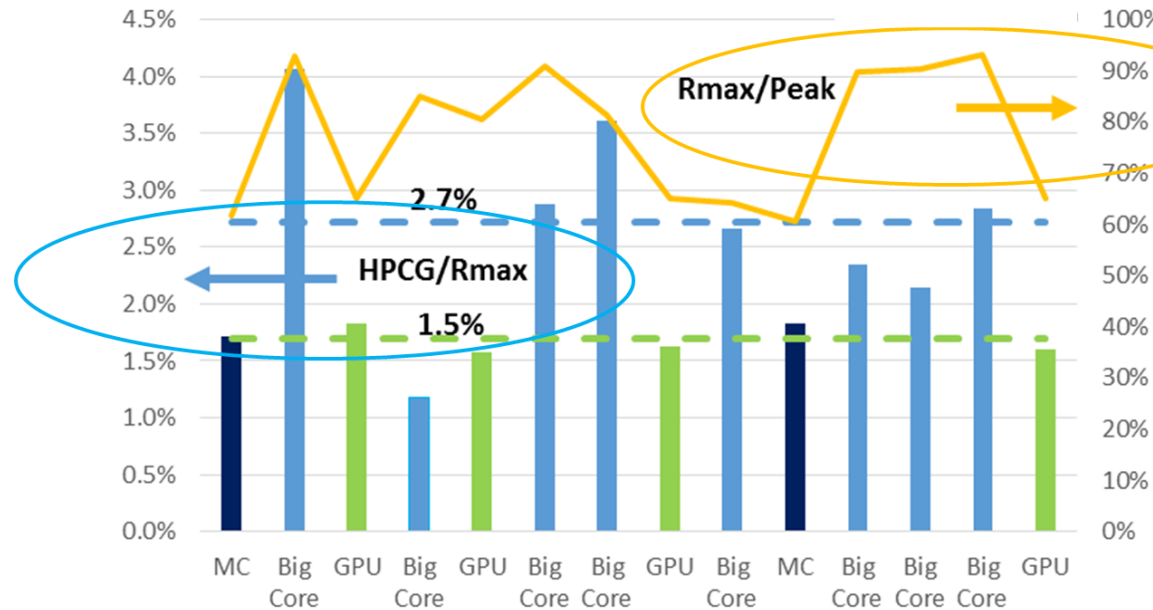
**1EF (Rmax)**  
**177 MW**  
**~ \$2 B**

*Ju... ng"...*

Power		25 MW
Cost		\$260 M

# Must Improve System Efficiency

Using HPCG as an example representative workload



**System efficiency = HPCG/Rmax**

**Today ~ 1.5-3%**

**System efficiency 39%**

Performance (Rmax)	49 PF
HPCG	19 PF
Power	<b>9 MW</b>
Cost	<b>\$100 M</b>

**System efficiency 13%**

Performance (Rmax)	141 PF
HPCG	19 PF
Power	<b>25 MW</b>
Cost	<b>\$290 M</b>

# Summary

- *Business-as-usual* is not an option
- Acknowledge past & upcoming shifts
- Embrace new promising approaches
- Must improve system efficiency

***Exascale by 2021/23 is a Truth or a Myth?***