

**Welcome To The 72nd
HPC User Forum
Meeting
April 1-3, 2019**



Introduction: Logistics

We have a very tight agenda (as usual)

- Please help us keep on time!

Review handouts

- Note: We will post most of the presentations on the web site

Dinner events

Thank You To Our Sponsors!

Platinum:

- AMD
- Dell EMC
- HPE
- Intel

Gold:

- ARM
- IBM
- Panasas

Silver:

- Altair
- XTREME-D

- Monday Dinner = Dell-EMC and Intel
- Tuesday Breakfast = Panasas
- Tuesday Lunch = IBM
- Tuesday Dinner = HPE and AMD
- Wednesday Breakfast = XTREME-D
- Wednesday Lunch = ARM
- Wednesday Break = Altair

Benefits Of Joining The HPC User Forum

**Access to a full information service:
20+ original Hyperion Research
documents/year (HPC, HPDA, AI,
cloud, quantum):**

- Market results, forecasts, vendor shares
- Analysis of market developments & trends
- In-depth profiles of leading sites and achievements

Inquiry time with Hyperion Research analysts

- Topics of your choice
- Custom cuts from our large data structures

For more information: <http://hpcuserforum.com/>



Benefits Of Joining The HPC User Forum

Additional Benefits:

- Hear about best practices (and lessons learned)
 - Mapping application to architectures
 - ROI from investments in HPC
 - Industry outreach
- Learn about future technologies and use cases
- Hear about best practices (and lessons learned)
 - Mapping application to architectures
 - ROI from investments in HPC
 - Industry outreach



Benefits Of Joining The HPC User Forum

For Vendors:

- Ability to show case your successes
- Access to HPC/HPDA/AI research reports
- Ability to start collaborations & meet others in the HPC community
 - And communicate your products and plans to major users, buyers and potential partners
- Key research questions addressed:
 - What's the future of the HPC market?
 - Where will HPC technology be in five years?
 - What role will HPC play in big data markets?
 - How can users and vendors collaborate better?
 - Where are the next high-growth opportunities?
 - What new requirements should vendors address?
- Inquiry time with Hyperion Research analysts



Important Dates For Your Calendar

2019 HPC USER FORUM MEETINGS:

- April 22 to 24, Santa Fe, New Mexico
- September 9 to 11, Chicago Illinois, Argonne National Laboratory
- October 7 to 8, Lugano, Switzerland at CSCS
- October 10 to 11, Edinburgh, Scotland at EPCC

And Join us for the Hyperion ISC19 Briefing:

- Tuesday, June 18, Movenpick Hotel, 7:45-9:30 am



CHAIRMAN'S WELCOME

HPC User Forum Mission

**To Improve The Health Of The
High Performance Computing Industry
Through Open Discussions, Information-
sharing And Initiatives Involving
HPC Users In Industry, Government And
Academia
Along With HPC Vendors
And Other Interested Parties**



The HPC User Forum: 71 Meetings Worldwide Since 2000

Amsterdam, Netherlands (SARA)

Annecy, France

Bangalore, India (Indian Institute of Technology)

Beijing, China (Chinese Academy of Sciences)

Bologna, Italy (CINECA)

Bristol, UK

Bruyères-le-Châtel, France (Teratec)

Canberra, Australia

Geneva, Switzerland (CERN)

Kobe, Japan (RIKEN)

Lausanne, Switzerland (EPFL)

London, UK (Imperial College)

Manchester, UK (Manchester University)

Melbourne, Australia

Munich, Germany (LRZ)

New Delhi, India (Indian Institute of Science)

Paris, France (GENCI)

Seoul, Korea (National Institute of Supercomputing & Networking)

Stuttgart, Germany (HLRS)

Warsaw, Poland (University of Warsaw)

Yokohama, Japan (Earth Simulator Center)

Zurich, Switzerland (ETH Zurich)

United States (many locations)

Introduction

HPC User Forum Steering Committee

Paul Muzio

Chairman, Industry Expert

Rupak Biswas

NASA Ames
Vice Chairman

Earl Joseph

Executive Director,
Hyperion Research

Vijay Agarwala

Virginia Tech.

Alex Akkerman

Ford Motor Company

Doug Ball

HPC Expert

Mike Bernhardt

Exascale Computing
Project

Steve Conway

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Hyperion Research

Steve Finn

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Moonshot Research

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INNOVATION
& ROI AWARDS

MEETING
PRESENTATIONS

FUTURE
MEETINGS

HPC Market Update

The Hyperion Research Team

Earl Joseph

Research studies & strategic consulting

Steve Conway

Strategic consulting, HPC UF, Big Data, AI

Bob Sorensen

Strategic research, government studies, QC

Alex Norton

Special studies, new data analysis, surveys

Mike Thorp

Global sales management

Kurt Gantrish

Global sales management

Jean Sorensen

Business manager

Tom Christian

Survey design & executive interviews

Nishi Katsuya

Japan research and studies

Hyperion Research HPC Activities

- Track all HPC servers sold each quarter
- 4 HPC User Forum meetings each year
- Publish 85 plus research reports each year
- Visit all major supercomputer sites & write reports
- Assist in collaborations between buyers/users and vendors
- Assist governments in HPC plans, strategies and direction
- Assist buyers/users in planning and procurements
- Maintain 5 year forecasts in many areas/topics
- A worldwide ROI measurement system
- **HPDA program (includes ML/DL/AI)**
- **HPC Cloud usage tracking**
- **Quarterly tracking of GPUs/accelerators**
- **Cyber Security**
- **Quantum Computing**

Top Trends in HPC



2018 was a very strong year with over 15% growth -- \$13.7 billion (US\$) in revenues!

- 2017 was also a strong year
- Supercomputers grew 23% = \$5.4 billion in 2018

The top systems have started growing again after over 4 years of softness

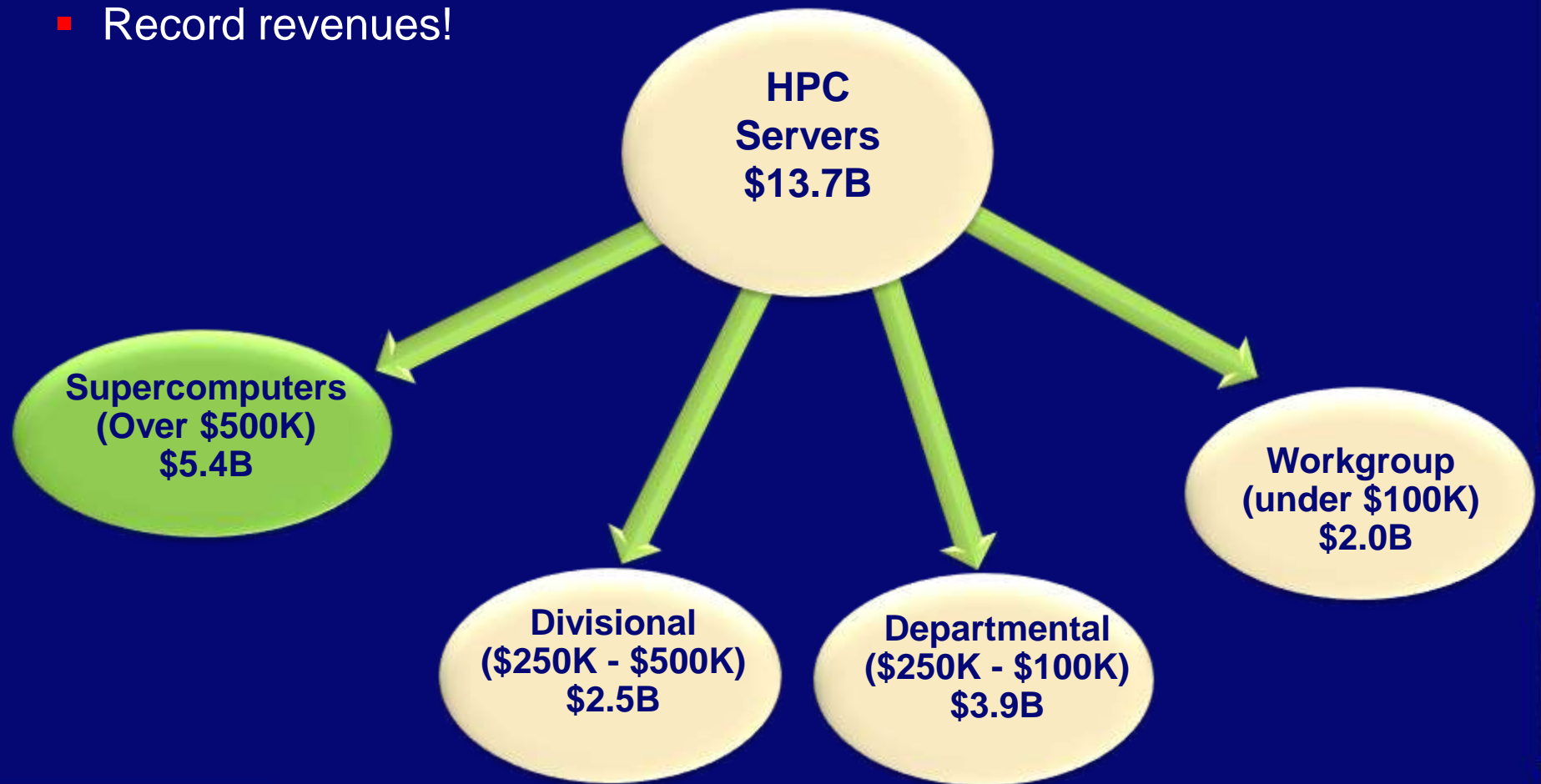
- The profusion of Exascale announcements are generating a lot of buzz

Big data combined with HPC is creating new solutions

- Adding many new users/buyers to the HPC space
- AI/ML/DL & HPDA are the hot new areas

The Worldwide HPC Server Market: \$13.7 Billion in 2018

- Record revenues!



2018 HPC Market By Verticals

WW HPC Systems Revenue by Applications	
	2018
Bio-Sciences	1,245,865
CAE	1,521,850
Chemical Engineering	205,891
DCC & Distribution	780,184
Economics/Financial	746,418
EDA / IT / ISV	984,887
Geosciences	1,029,041
Mechanical Design	63,137
Defense	1,403,164
Government Lab	2,616,822
University/Academic	2,420,440
Weather	560,631
Other	127,757
Total Revenue	13,706,088
Source: Hyperion 2019	-

HPC Market By Vendor Shares

OEM	2018 Sales (\$ Millions)	Share %
HPE/HP	4,766	34.8%
Dell	2,857	20.8%
IBM	971	7.1%
Lenovo	957	7.0%
Inspur	788	5.8%
Sugon (Dawning)	462	3.4%
Cray	313	2.3%
Fujitsu	269	2.0%
Penguin	244	1.8%
NEC	201	1.5%
Atos	150	1.1%
Other	1,728	12.6%
Grand Total	13,706	100.0%

New HPC Market Forecasts

Worldwide THPC Revenue Forecasts			
	2018	2023	CAGR 18-23
Supercomputer	5,361,603	8,029,838	8.4%
Divisional	2,449,270	3,527,414	7.6%
Departmental	3,879,445	5,536,962	7.4%
Workgroup	2,015,770	2,884,803	7.4%
Total	13,706,088	19,979,016	7.8%
Source: Hyperion 2019	-	-	

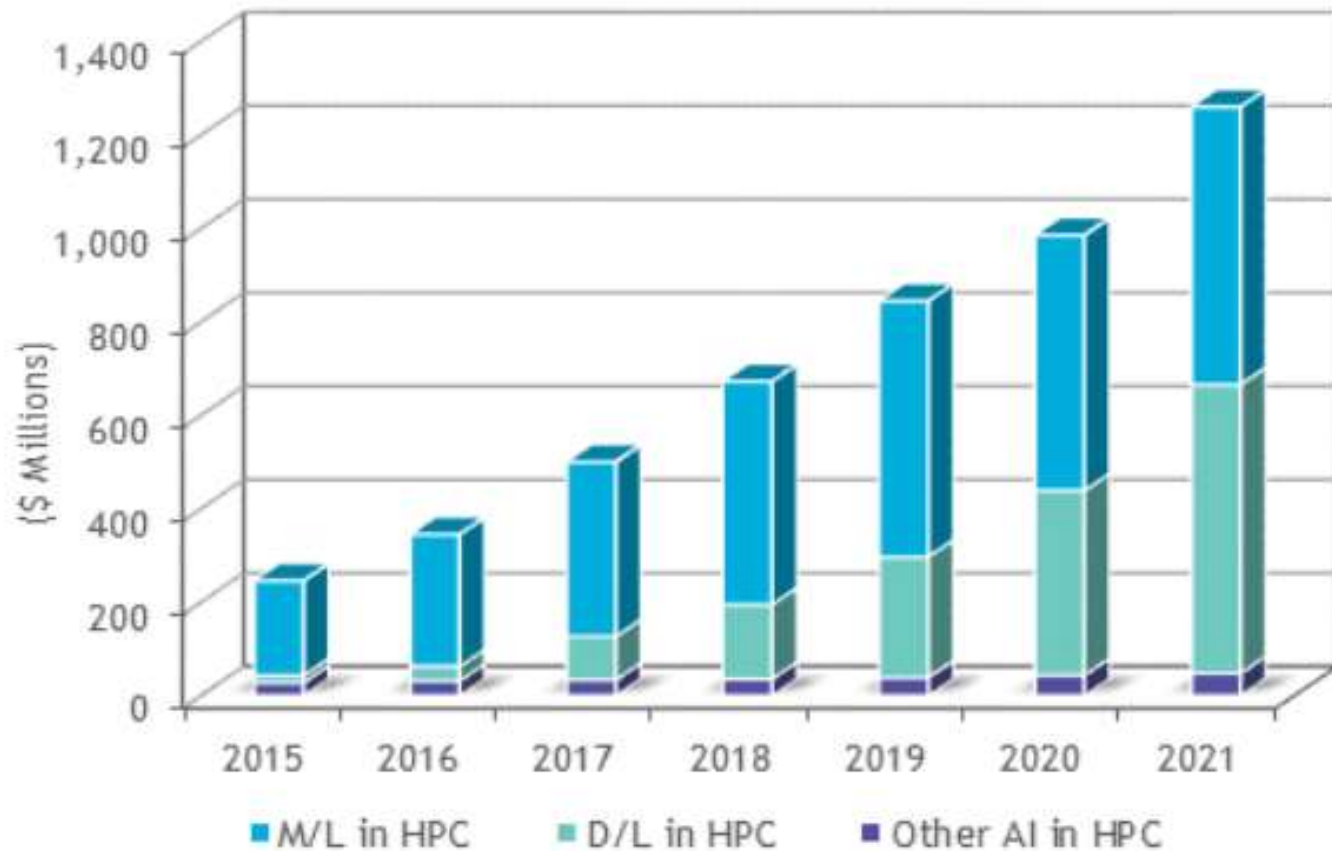
The Broader HPC Market Forecast

Revenues by the Broader HPC Market Areas			
	2018	2023	CAGR 18-23
Server	13,706,088	19,979,016	7.8%
Storage	5,547,188	7,771,184	7.0%
Middleware	1,582,892	2,217,801	7.0%
Applications	4,627,492	6,413,592	6.7%
Service	2,229,921	2,858,820	5.1%
Total Revenue	27,693,580	39,240,413	7.2%
Source: Hyperion 2019			

WW M/L, D/L, & AI Forecasts

FIGURE 2

Worldwide M/L, D/L & AI HPC-Based Revenues



Source: Hyperion Research 2017

EXASCALE UPDATE

Projected Exascale Dates and Suppliers

U.S.



Sustained ES*: 2022-2023

Peak ES: 2021

Vendors: U.S.

Processors: U.S. (some ARM?)

Initiatives: NSCI/ECP

Cost: \$500 to \$600M per system,
plus heavy R&D investments

EU



PEAK ES: 2023-2024

Pre-ES: 2021-2022

Vendors: Mixed US/EU

Processors: Commercial/ Arm, RISC-V

Initiatives: EuroHPC

Cost: Over \$350M per system, plus
heavy R&D investments

China



Sustained ES*: 2021-2022

Peak ES: 2020

Vendors: Chinese (multiple sites)

Processors: Chinese (plus U.S.?)

13th 5-Year Plan

Cost: \$350-\$500M per system, plus
heavy R&D

Japan



Pre-ES*: ~2021

Peak ES: ?

Vendors: Japanese

Processors: Japanese

Cost: \$800M-\$1B, this includes both
one system and the R&D costs

They will also do many smaller size
systems

US Exascale Plans

	A21	A22	Frontier (OLCF5)	EI Capitan (ATS-4)	NERSC-10	NSF Frontera Follow-on
Location	ANL	ANL	ORNL	LLNL	LBL/NERSC	TACC
Planned Delivery Date/ Estimated	2022 Q1	2022	2022 Q1	2022	2024	2024
Early Operation	2022, Q2	2023	2022, Q3	2023	2025	2025
Planned/Realized Performance (Pflops)	~1,000	1,300 or higher	1500-3000	4000-5000	8000-12000	500
Linpack Performance (PFlops)	800-900	780-1040	900-2100	2000-3000	2000-3000	
Linpack/Peak Performance Ratio (%)	80-90 (est.)	60-70 (est.)	60-70 (est.)	50-60	50-60	50-55
High Performance Conjugate Gradient (PFlops/s)	20.0-22.5	19.5-26.0	18-36	48-72	52-78	74
GF/Watt	40		60-100	134-200	266-480	

China Pre-Exascale Plans

	TianHe 2 A	Sunway Exascale Prototype	Sugon Prototype	TianHe 3 Prototype
Key User/Developer	NUDT	Sunway/ NRCPC	Sugon/AMD/CAS	NUDT
Planned Delivery Date/ Estimated	2018, 2H	8/2018	2018, 2H	05/2018
Planned/Realized Performance (Pflops)	100.67	3.13	3.18	3.14
Linpack Performance (PFlops)	61.45	2.55	2.27	2.46
Linpack/Peak Performance Ratio (%)	0.61	81.51	71.5	78.5
High Performance Conjugate Gradient (Pflops/s)	1.800	0.013	0.045	0.054
GF/Watt	5.27	11	11	15
Linpack GF/Watt	3.16	8.96	7.86	11.8

Chinese Exascale Plans

	Sunway 2020	Sugon Exascale	NUDT 2020
Key User/Developer	Sunway/NRCPC	Sugon/AMD	NUDT
Planned Delivery Date/ Estimated	2020, 4Q (could slip 1- 1.5 years)	2020, 4Q (could slip 1-1.5 years)	2020, 4Q (could slip 1-1.5 years)
Planned/Realized Performance (Pflops)	1000	1024	1000
Linpack Performance (PFlops)	600-700	627-732	700-800
Linpack/Peak Performance Ratio (%)	60-70	60-70 (est.)	70-80
High Performance Conjugate Gradient (Pflops/s)	6-7	9.4-10.1	14-16
GF/Watt	30	34.13	20-30
Linpack GF/Watt	20-23	20.9	23.3-32.0

Summary of Chinese Exascale Efforts

Development centered on non-commercial suppliers:

- NUDT
- Sunway
- Sugon

Noticeable and continued absence of major Chinese HPC suppliers:

- Lenovo and Inspur

Indigenous HW dependence deepens

No announced pre-exascale plans

Quick Diversion: HPCG/HPL Analysis

The High Performance Conjugate Gradients (HPCG) benchmark is intended as a complement to the High Performance LINPACK (HPL) benchmark

- HPCG is designed to exercise computational and data access patterns that more closely match a broad set of important applications
- The computational and data access patterns of HPL are still representative of some important scalable applications, but not all

The HPCG/Rmax Metric

HPCG/Rmax highlights the ability of an HPC to deliver balanced performance measured against LINPACK Rmax performance

- The higher the ratio, the better able a system is to deliver balanced performance against pure computational capability for a wide range of applications
- In addition, a higher ratio can signify a more balanced compute/interconnect system that is well suited to an HPC's overall computational capabilities

Select HPCG/Rmax

HPCG Rank Top 500 Rank		System	Rmax	HPCG	HPCG/Rmax
3	18	K Computer, SPARC64 VIIIfx 2.0GHz, Tofu interconnect , Fujitsu	10510	603	0.057
29	186	ARCHER - Cray XC30, Intel Xeon E5 v2 12C 2.700GHz, Aries interconnect , Cray Inc.	1643	81	0.049
19	34	Pangea - SGI ICE X, Xeon E5-2670/ E5-2680v3 12C 2.5GHz, InfiniBand FDR , HPE	5283	163	0.031
11	16	Tera-1000-2 - Bull Sequana X1000, Intel Xeon Phi 7250 68C 1.4GHz, Bull BXI 1.2 , Bull, Atos Group	11966	334	0.028
4	6	Trinity - Cray XC40, Xeon E5-2698v3 16C 2.3GHz, Intel Xeon Phi 7250 68C 1.4GHz, Aries interconnect , Cray Inc.	20159	546	0.027
32	69	TSUBAME 2.5 - Cluster Platform SL390s G7, Xeon X5670 6C 2.93GHz, InfiniBand QDR, NVIDIA K20x , NEC/HPE	2785	73	0.026
5	7	AI Bridging Cloud Infrastructure (ABCI) - PRIMERGY CX2570 M4, Xeon Gold 6148 20C 2.4GHz, NVIDIA Tesla V100 SXM2, InfiniBand EDR , Fujitsu	19880	509	0.026
10	12	Cori - Cray XC40, Intel Xeon Phi 7250 68C 1.4GHz, Aries interconnect , Cray Inc.	14015	355	0.025
1	1	Summit - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR InfiniBand , IBM	143500	2926	0.020
35	51	DGX Saturn V - NVIDIA DGX-1, Xeon E5-2698v4 20C 2.2GHz, Infiniband EDR, NVIDIA Tesla P100 , Nvidia	3307	67	0.020
2	2	Sierra - IBM Power System S922LC, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR InfiniBand , IBM / NVIDIA / Mellanox	94640	1796	0.019
13	9	Titan - Cray XK7, Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x , Cray Inc.	17590	322	0.018
7	3	Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway , NRCPC	93015	481	0.005
62	487	Lomonosov - T-Platforms T-Blade2/1.1, Xeon X5570/X5670/E5630 2.93/2.53 GHz, Nvidia 2070 GPU, PowerXCell 8i InfiniBand QDR , T-Platforms	902	2	0.002

Some Observations

The K Computer has the highest HPCG/Rmax (0.057) of any system on the list

- Its ratio is 2.85 times that of Summit, the current number one system on both the HPCG and Top 500 list
- The K Computer has an HPCG/Rmax ratio that is at least twice that of almost all other systems on the entire HPCG list
- **GPU-centric systems typically have an HPCG/Rmax ratio between 0.02-0.028**
- **The Sunway TaihuLight has one of the lowest HPCG/Rmax ratios on the list at 0.005**

Does this help us think about future systems design and target applications?

In Summary

HPC is still expected to be a growth market

- Growing recognition of HPC's strategic value
- HPDA, including ML/DL, cognitive and AI
- HPC in the Cloud will lift the sector writ large

Vendor share positions shifted greatly in 2015, 2016 & 2017 and may continue to shift

The HPDA, AI, ML & DL markets will expand opportunities for vendors

Questions?

Please email:

ejoseph@hyperionres.com

Or check out:

www.HyperionResearch.com

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Agenda: Tuesday Morning

- 8:15 AM Welcome: Paul Muzio, Rupak Biswas, Earl Joseph and Steve Conway**
- 8:20 AM HPC Global Market Update, Earl Joseph and Bob Sorensen
Morning Session Chair: Rupak Biswas**
- 8:30 AM Thermodynamics of Computation: Far More Than Counting Bit Erasure, David Wolpert, Santa Fe Institute**
- 9:00 AM Session: Exascale Computing**
- **Exascale Computing in Europe, Leonardo Flores, European Commission**
 - **Exascale Computing Project Software Activities, Mike Heroux, Sandia National Laboratories**
- 10:00 AM Networking Break**
- 10:30 AM Session: Exascale Computing**
- **CoMet Comparative Genomics Code: Gordon Bell Prize Winner, Wayne Joubert, Oak Ridge National Laboratory**
 - **Exascale Computing in the Life Sciences: Gordon Bell Prize Winner, Daniel Jacobson, Oak Ridge National Laboratory**
- 11:30 AM Vendor Technical Update: HPE**
- 11:45 AM Vendor Technical Update: Intel**
- 12:00 PM Networking Lunch**

**Please Return
By 1:00 PM**



Agenda: Tuesday Afternoon

1:00 PM Session: Exascale Computing

- ECP Co-Design Center for Machine Learning, Frank Alexander, Brookhaven National Laboratory
- Accelerating Therapeutics for Opportunities in Medicine (ATOM), Amanda Minnich, Lawrence Livermore National Laboratory

Session Chair: Paul Muzio and Henry Newman

2:00 PM Session: Metadata and Archiving at Scale: User Perspectives

- Security of Data at Rest, NIST standards, and NIAP/Common Criteria, Henry Newman, Seagate Government Solutions
- Moving from Extreme Scale Data to Extreme Scale Metadata Concerns: It's About Time! Gary Grider, Los Alamos National Laboratory

3:00 PM Vendor Technical Update: Penguin Computing

3:15 PM Vendor Technical Update: Dell EMC

3:30 PM Networking Break

3:45 PM Session: Metadata and Archiving at Scale: User Perspectives

- Amanda Tumminello, Navy DoD Shared Resource Center

4:15 PM Quantum Computing Research at ORNL, Travis Humble, Oak Ridge National Laboratory

4:45 PM Innovative Technologies Panel #1 (5 minute presentations on new technologies)

- Red Hat, Xtreme-D, AMD, Cray, Altair and DDC/ScaleMatrix

5:15 PM Meeting Ends

6:30 PM Special Dinner Event, A history of LANL Terry Wallace, Director Emeritus for Los Alamos National



Welcome To The Second Day Of The HPC User Forum Meeting



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Agenda: Wednesday Morning

- 8:15 AM** New AI Hardware Products and Trends, Alex Norton
Morning Session Chair: Paul Muzio and Henry Newman
- 8:30 AM** Personalized Healthcare with High Performance Computing in the Cloud, Wolfgang Gentzsch, UberCloud
- 8:45 AM** Session: Metadata and Archiving at Scale: User Perspectives
- Evolving NASA's Data and Information Systems for Earth Science, Rahul Ramachandran, NASA
- 9:15 AM** Vendor Technical Update: AMD
- 9:30 AM** Networking Break
- 10:00 AM** Session: Metadata and Archiving at Scale: Technology providers (15 minutes each)
- Data Movement and Tiering with DMF 7, Kirill Malkin, HPE
 - MetaOcean: Handling Massive and Sensitive Metadata from Precision Medicine, Frank Lee, IBM
 - iRODS Open Source Data Management Software, Terrell Russell, RENCi
 - Dealing with Extreme Requirements in HPC, Frank Herold, Thinkparq/BeeGFS
- 11:00 AM** Panel Session: Metadata and Archiving at Scale: Users will discuss vendor strategies and plans
- 11:30 AM** Vendor Technical Update: ARM
- 11:45 AM** Future High End Computing in Japan, Satoshi Matsuoka
- 12:15 PM** Networking Lunch

Please Return
By 1:15 PM



Agenda: Wednesday Afternoon

Afternoon Session Chair: Keith Gray

1:15 PM Innovative Technologies Panel #2 (5 minute presentations)

- **CPC, D-Wave, Tachyum (the first universal processor), ARM, IBM, and Panasas**

2:15 PM Session: Finding and Developing the Future HPC Workforce: STEM and HPC Workforce Issues

- **Education and Training for HPC, Keith Gray, BP and Melyssa Fratkin, Texas Advanced Computing Center**
- **The Computing4Change Program, Kelly Gaither, Texas Advanced Computing Center**

3:15 PM Networking Break

3:30 PM Session: STEM and HPC Workforce Issues

- **Computational Sciences and Educational Initiatives at the University of New Mexico, Patrick Bridges**
- **DoD STEM Activities Kevin Newmeyer, DoD HPCMP**

4:30 PM Panel Discussion: STEM and HPC Workforce Issues

5:15 PM Meeting Wrap-Up, Paul Muzio, Rupak Biswas, Earl Joseph and Steve Conway



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