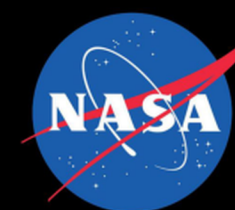




The Future of Supercomputing at NASA

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Abstract

Computers are a growing part of everyday life in many ways. For some of the biggest and most interesting problems, people have used some of the biggest and most interesting computers. This is the general area of High Performance Computing (HPC) or Supercomputing. One organization with a long and storied history with supercomputing is the National Aeronautics and Space Administration (NASA). The supercomputers at NASA have a variety of missions including weather forecasting to helping astronauts at the International Space Station. As problems continue to grow complex, the growth of supercomputing seems inevitable.

What are supercomputers?

As a general rule, a supercomputer is something substantially more powerful than what you might have on your desk today—at least a hundred times more powerful. The supercomputers of today can perform **trillions** of calculations in a manner of seconds. NASA's biggest supercomputer Pleiades has **935 TB total memory and can do up to 7.24 petaflops (10^{15})** computations in a second.¹

Supercomputers are everywhere in our daily lives. A modern iPhone has more computing power than **all of NASA** during the Apollo Mission in 1969. In other words, **your phone has the power to send a man on the moon.**²

	Dr. Tsengdar Lee	Dr. Stephen Wheat	Dr. Henry Neeman
Q1: Why are supercomputers important? How important is supercomputing in current and future NASA operations?	<p>"Supercomputers are considered a scientific instrument. It is important in the development of new theories (constructing models) and verify/validate the theory by comparing to observations.</p> <p>Not only supercomputing will be used for constructing the theories but also for multi-dimensional data analysis. design of space vehicle and airplane, Earth and space model and theory development and large scale data analytics. It's also being used to replace simulators of space environments."</p>	<p>"Supercomputers allow us to model, simulate, explore, and analyze phenomena at much greater level of scale at finer levels of fidelity than can otherwise be made possible with single systems. Supercomputers are valuable in getting things done that otherwise could not be done.</p> <p>Everything, and I mean everything!!, is modeled. These models are sufficient to replace all but a small part of experimentation and prototyping, thus enabling work to be done that otherwise could not be afforded."</p>	<p>"Supercomputers are used to solve some of the hardest problems, especially the hardest science and engineering problems... problems that simply won't fit on a regular computer. Here's how to think of it: Computational Science & Engineering makes the impossible possible, and supercomputing makes the impossible practical.</p> <p>For decades, NASA has had some of the fastest supercomputers in the world. Like any large science and engineering organization, they're hugely dependent on supercomputing, for research, design, visualization, and many other needs."</p>
What, in your opinion, is the biggest obstacle for NASA supercomputing currently?	<p>"Uncertain microprocessor architecture is becoming the biggest obstacle. NASA's legacy scientific and technical applications will need to be refactored to the new architecture. It would be very time consuming and manpower intensive. The uncertainty would create significant schedule delay."</p>	<p>"The largest limitation is always budget. The scope of the missions increase; the need for SC increases; etc. But the budget does not increase. Additionally, skilled scientists in the art of computational science. The pipeline of training such people is still too fragile."</p>	<p>"Budget. The supercomputing community knows how to make bigger supercomputers than we can afford."</p>
What is one thing NASA expects to learn from its supercomputers?	<p>"Can we improve our Earth observations so that we can extend the limit of weather forecast to many weeks (up to a season)?"</p>	<p>"Just about anything, from biology, to chemistry, to physics, to behavior, and well beyond."</p>	<p>"It's a very broad spectrum, and now that AI/ML/Deep Learning has been added into the mix, more than ever."</p>
What is the biggest advancement in the field of supercomputers?	<p>"I believe it is the development of the high bandwidth memory which allows more and faster data flow from the memory to the processor." (T. Lee, personal communication, February 11, 2019)</p>	<p>"NASA is already well-set for doing the work it needs to do. Computers aren't going to get appreciably faster, so the question is whether you can do more with more computers." (S. Wheat, personal communication, February 11, 2019)</p>	<p>"In the near term, the biggest recent change has been the incorporation of more and more AI/ML/DL capability into both CPUs and GPUs. In the longer term, as the current CMOS technology for making chips comes to the end of our ability to keep shrinking it, new computing technologies are needed" (H. Neeman, personal communication, February 17, 2019, 2019)</p>

Dr. Tsengdar Lee, Program Manager of the High-End Computing Division, NASA



Dr. Tsengdar Lee is the Program Manager of the High-End Computing Program at NASA. He is responsible for maintaining the HEC capability to support the agency's aeronautics research, human exploration, scientific discovery, and space operations missions. Lee is currently the NASA Weather Focus Area Lead.⁴

Dr. Stephen Wheat, Professor of Mathematics and Computer Science, Oral Roberts University



Dr. Wheat has spend 38 years in the High-Performance Computing (HPC) industry. Dr. Wheat is the recipient of a Gordon Bell Prize (1994) as well as the Intel Achievement Award (1997), both associated with his advancing the technology in HPC. A major HPC publication twice recognized him as a "Person to Watch". He was recognized as one of NASA AMES 25 most influential people in their 25-year history for his contributions to NASA's return to flight post the Columbia space shuttle disaster.⁵

Dr. Henry Neeman, Founding Director for OU Supercomputing Center



Henry Neeman is the founding Director of the OU Supercomputing Center for Education & Research (OSCEER), Associate Professor of Engineering, and Adjunct Associate Professor of Computer Science at OU. He also leads the Virtual Residency, which teaches research computing facilitation so far to over 400 research computing professionals. He received his BS in Computer Science and his BA in Statistics with a minor in Mathematics in 1987 from the University at Buffalo, MS in CS from University of Illinois at Urbana-Champaign (UIUC) in 1990, and his PhD in CS from UIUC in 1996.

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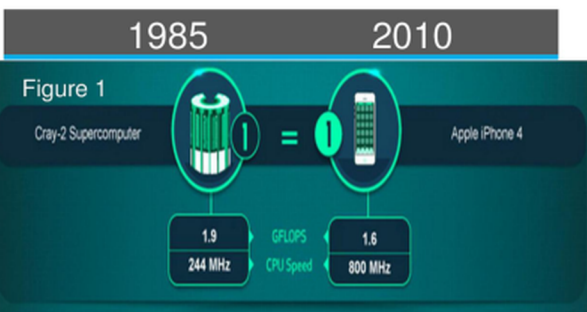


Figure 1-Comparison in processing power and speed between the Cray-2 supercomputer from 1985 and the iPhone 4 released in 2010³