**Dr. Arden L. Bement, Jr.**
**Director**
**National Science Foundation**

Thank you Mr. Chairman. Good morning ladies and gentlemen. I am greatly honored to be invited by the honorable Omi san to provide some comments on the future of science, engineering and technology in the global context.

One need look only at newspaper headlines to see that in almost every field of endeavor—from politics to economics—foreseeing the future is a risky proposition, but it's an essential exercise in these troubled times.

Experience has taught us that money invested in science and engineering research and education yields exceptional returns. Yet when we look to the future, we can legitimately ask, can science serve our global needs in the face of unprecedented change?

Here's one answer to that question that I find still apt and appropriate to the global S&T enterprise. The words were uttered more than a half-century ago. Quote - Science by itself provides no panacea for individual, social, and economic ills. But without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world[1] - unquote.
Those are the words of the visionary Science Advisor to President Roosevelt, Vannevar Bush. In the late 1940s, he saw that the way to improve civilian prosperity was to harness scientific and technological innovation.

The challenges before us once again require us to focus on how such discoveries can contribute to meeting vital national and international needs and objectives. Among these, three stand out as compelling, urgent—and, most significantly—ripe for progress. These are energy, environment, and

[1] Vannevar Bush, 1945

economy—or, the 3Es for short. As members of a global community, we all need to invest in and explore alternative energy sources to ensure continued economic prosperity and a rising quality of life for all people, most especially those in developing nations.

Today, the Earth's climate and life-support systems are changing in ways and at rates that both surprise and worry us all. We have yet to grasp the sometimes abrupt responses of these complex systems to external forces – both natural and human.

There can be little doubt that we have recently made advances in understanding each of these systems independently. It is when we attempt to establish sound policies for these three systems working in combination that we are confronted with their inherent interactive complexities. New information and communication tools can increase our understanding of these interrelationships. In this respect, today's interdisciplinary, international research teams require open access to a broad range of cyber resources to advance such understanding. Networking, open data protocols, and the development of virtual organizations are important ways to provide broad access to these resources across borders.

But we must look toward higher levels of computational capabilities to cut the Gordian knots of complex coupled systems. Petascale capabilities will permit researchers to develop the needed models that are intrinsically multi-scale or that involve multiple simultaneous reactions.

Moving on to address the third of the 3Es, the economy, we cannot forget that science and engineering are the engines of recent worldwide economic growth; that is, rising productivity and new jobs. We also know that sustainability means a sustainable economy, not just sustainable natural resources

And we must remember that issues and problems of today and tomorrow have not only technological and scientific dimensions, but also a human one. One example is the need to understand obstacles to the adoption of energy-saving behaviors by individual, groups, and organizations. What we should not sustain is inappropriate and wasteful energy use and the resultant degradation to the environment.

Researchers in the economic, social and behavioral sciences, in collaboration with their colleagues from other disciplines, should address these and other broad social and policy-informing challenges.

The ability to forecast trends based on coupled systems analyses at higher levels of complexity can facilitate:

- Advances in forecasting future trends at smaller spatial and temporal scales,
- Economically viable mitigation and adaptation strategies to global climate change and resultant ecological threats, and
- Improved tools for *science-informed* assessments and decision making, for examples.

These are grand challenges worthy of the global scientific enterprise. No one nation can solve these problems single-handedly. International collaborations among all nations will be necessary in any effort to develop new understanding and solutions.

The US National Science Foundation is investing in new scientific and engineering capabilities to enhance international collaborations in coupled energy, environmental, and economic systems, to include:

- The building of a petascale cyberinfrastructure that will enable converting massive data collections to knowledge and modeling coupled systems at higher levels of complexity,
- Establishing high-bandwidth network links with all regions of the world to enable sharing data and information in real time and establishing virtual communities that can conduct collaborative research at any time and any place,
- Complimenting our Long-Term Ecological Research sites with a National Ecological Observatories Network to observe ecological impacts caused by climate change, aridification, invasive species, and human and natural forcing functions,
- Joining with other Arctic nations to build an observing network to measure changes in climate, biota, and ocean circulation in the Arctic,
- Joining with the US Agency for International Development to facilitate research collaborations with developing nations in such areas as water, energy, food and nutrition, invasive species, and

disruptive events,

- Joining with NASA and NOAA and using our high-altitude instrumented aircraft to observe ice sheet stability and the effects of atmospheric aerosols and particulates on glacier melting and the Earth's albedo.

In most research areas, NSF is accustomed to working in partnership with private industry in transferring technology and reducing it to practice. Such partnerships need to be extended to our research collaborations with developing nations.

Finally, NSF has long linked the social and behavioral sciences with the physical sciences in exploring human factors in grand challenge problems of national and global scales. Such interdisciplinary research is critically needed to achieve the sustainability of complex coupled systems. We look forward to working with the global community in addressing these critical challenges.

Arigato gozaimasu