Science and Technology for National Security: The Next 50 Years Pioneering the Endless Frontier

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DISCLAIMER

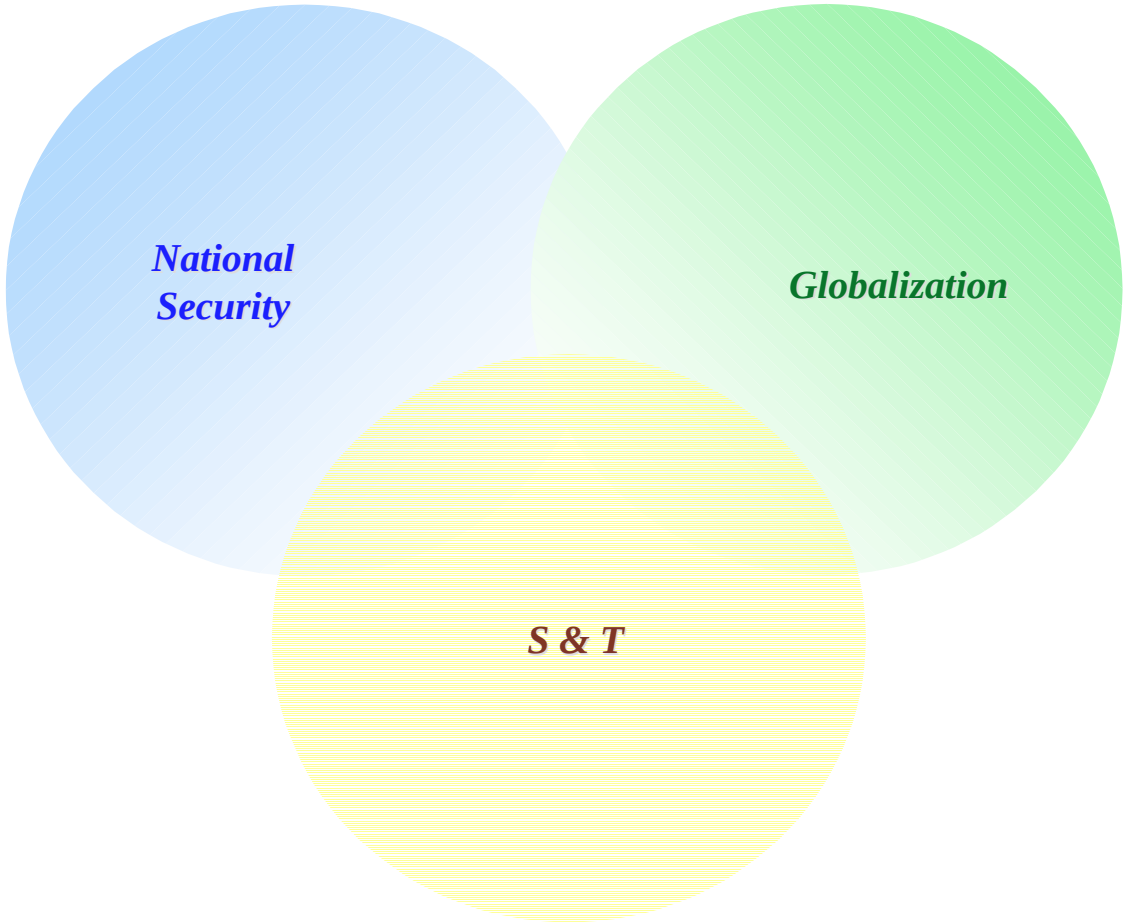
This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

What are the most important national security implications of long term S&T trends in an increasingly globalized, taking into account that our current concepts of "national security," "science and technology," and "globalization" may be transformed over time?

Through the Center for Global Security Research 2002 Futures Project, we are critically examining the role, in a globalized world, that science and technology will play in U.S. national security, as well as the threats science and technology might pose for national security. During the last 50 years, from the end of World War II through the end of the Cold War, science and technology played a significant role in U.S. national security through the development of nuclear weapons, the exploration of space, and breakthroughs in biotechnology and computations. During this time frame, the U.S. government invested heavily in military and civilian science research, development, and demonstration (RD&D) through both direct and indirect mechanisms. These investments supported RD&D in academia, industry, and the national laboratories and built the physical and intellectual infrastructure that contributes vastly to U.S. military and economic dominance. Science and technology continue to be heavily incorporated in the national security portfolio, as part of our conventional and nuclear deterrent, our defenses, our foreign policy, and more recently our homeland security. The funding and coordination are currently dispersed throughout numerous agencies and administrations, from DoD, to DoE, HHS, DoJ, DoC, DoI, DoA, and the new proposed Department of Homeland Security, to NASA, and NSF.

As we move into the first half of the 21st century, in a world reordered by new threats and challenges, we face new dimensions to science and technology, national security, globalization, and their interactions. The goal of our 2002 Futures project is to critically examine the science and technology requirements of national security, as well as the inherent challenges and constraints posed by science and technology, and globalization over the next 50 years. We want to understand these trends not--to predict the future, but to shape it. We want to outline the national security priorities in order to understand the root causes of stresses caused by population pressures, economic differentials, health, environment, zealotry and the willingness to accept change in order to address solutions to them. We need to understand the invariants and the indicators. Finally we want to acknowledge that this is not just about scientific and technical tools and solutions, but about people and human nature.

National Security, S&T and Globalization: Trends into the Future



Globalization

Globalization refers to the transnational flow of goods, money, ideas, lifestyles and cultural values. The term "globalization" is a relatively new phenomenon according to political scientists, who began using the term during the 1980s. Its primary significance is economic; it refers to the penetration into societies by economic/industrial/market-driven means. A major International Relations text defines it as "the integration of states, through increasing contact, communication and trade, to create a holistic, single global system in which the process of change increasingly binds people together in a common fate" (Kegley/Wittkopf, 2002). One key ingredient of globalization is the free flow of people worldwide. Transnational trade, the flow of ideas, and in particular, the migration of people are not new phenomena; they have occurred over many centuries. However, until the current era migration did not change the state-based basic structure of the international system. The reason why globalization is a new phenomenon is precisely because the various components of globalization, of which migration is one, are transforming the international system into a global one in which the role of the state is at best modified, and increasingly weakened. In addition, what has changed is the amplified rate and spatial scale of these processes, enabled, in no small part, by modern communication and transportation technologies. Modern communication technologies enable almost instantaneous transfer of ideas and capital to formerly remote locations while modern transportation technologies allow rapid concentration of raw materials and dispersal of manufactured goods. In some sense, access to these technologies and the empowerment they have provided to previously disconnected, small groups, has led to transformational change. We have identified some key factors for further examination: the new "multi-directional" migration, diasporas, changing demographics, and public response and reaction. Examining these changes may however require taking a long view in examining the trends.

While migration is not a new issue, it has taken on a new character in terms of a two-way, or even multi-directional, flow or connectedness, as opposed to a one-way ticket of movement. The past trend of one-way mass population movement (that is movement in the millions caused by underlying stresses such as environmental degradation.) is likely changed. The new trend is towards multi-directional flow, that is people, enabled by the ease of travel and communication as well as the ability to easily transfer funds. The "new" immigrants are maintaining their ties with their former homelands, socially, and emotionally, as well as monetarily. Additionally, people and capital are able to relocate with great ease based on response to new and changing opportunities. This is likely to have significant continuing impact on US national security as we look at the demographics of an aging workforce and in what ways the need for new workers will be met. The increased two-way flow of people, labor pools, capital, knowledge, ideas and culture are likely to have significant national security implications.

Diasporas are a special case of migration. Modern globalization has seen the creation of globally dispersed yet closely interconnected ethnic concentrations; information and communication technologies have facilitated the expansion of traditional local networks into a global "network-of-networks" by amplifying the power of small groups and enabling them to maintain connectivity while operating in small, geographically disconnected regions. Diasporas are increasingly responsible not only for the spread of social values but for distribution of wealth as well. This can be very powerful in enabling and financing cults and radicalized splinter sects. Again the risks this poses needs to be examined. Clearly more data is needed.

Demographic change is an area that requires much more data and study. In addition to examining the migrational pressures (for example, environmental degradation, public health, disease, lack of adequate food and clean water) it is critical to look at the changing workforce needs as well as the change in population balance and education. For example, are there new national technologic identification patterns in the world that will lead to new distributed centers of high-tech expertise, for example information technology or biotechnology in India? How and where will new specialists be trained and will there be a push for the development of new educational institutions? What will this mean for the system of higher education in the US that is increasingly dependent upon a base of non-US graduate students? Will this create new markets for technology in countries that did not previously have a technology market? Does this then introduce new diffusion pathways of concern to the US? Again more data is needed.

Finally a key issue to globalization will be the public response and reaction. It is likely that most large, successful organizations of the future will be multi-national and multi-cultural. Will this impede or enhance technology development and what will the public response to these changing demographics and evolving cultural values? Will it be uneven, for example due to cultural values and education? Will liberal democracies put prohibitions in place that will limit technologic development and force the technology offshore, thus introducing vulnerabilities (e.g. stem cell research)? How will nations that are defined by geography adapt to rapid geographical changes in concentrations of ideas, power, and wealth? Another topic worthy of the examination are elements of globalization that introduce stresses, and the possible technologic solutions to these stresses (e.g. reemerging disease and enhanced epidemiological surveillance, as well as environmental changes, both naturally occurring and human-induced).

Today we are seeing an increase in the struggle between cultures and their associated ideologies around the world. Though we recognize that interconnectedness does not necessarily mean blending of cultures, there is clearly an impact due to rapid communication and the mass media (including satellite communications). Are the struggles inversely proportional to the cost of communications and how does this impact globalization? Specifically we need to examine where the conflicts are occurring and the specific motivations for affiliation as well as how the new forms of communications cut across cultural boundaries. Do information and communication technologies indeed act as an equalizer, in essence enabling powerful leveling effects through globalization?

We live in an increasingly technologic society and the rapid transfer and concentration of technology can indeed pose a risk to US national security, and ultimately global stability. However having said this, the risks have not been quantified, nor balanced against the inherent benefits of diffusion. Thus during this project we will explore a wide number of pathways and mechanisms, in order to examine the ramifications, and assess strategies for mitigating the risks, and maximize the benefits. This is a very broad and unwieldy problem to tackle without boundary conditions. In the broadest definition technology diffusion refers to the flow of technology (including, but not limited to hardware, software, publications, as well as ideas, intellectual property, knowledge, scientific findings, etc.) either out of or through the U.S. (or other countries), both directly as well as indirectly. While we are fundamentally concerned with any negative impact to U.S. national security that is a direct result of diffusion, we all recognize that there are indirect pathways that could inadvertently lead to increased risk to US national security.

Globalization Trends

- **Younger population in developing world**
- **Opportunity or regulation increase pressure for people and capital to move**
- **Increased mobility of labor, capital, knowledge, technology**
- **Two-way flow likely to accelerate impact**
- **Successful organizations will be multi- national & multi-cultural**

Future Science and Technology (S&T) Trends

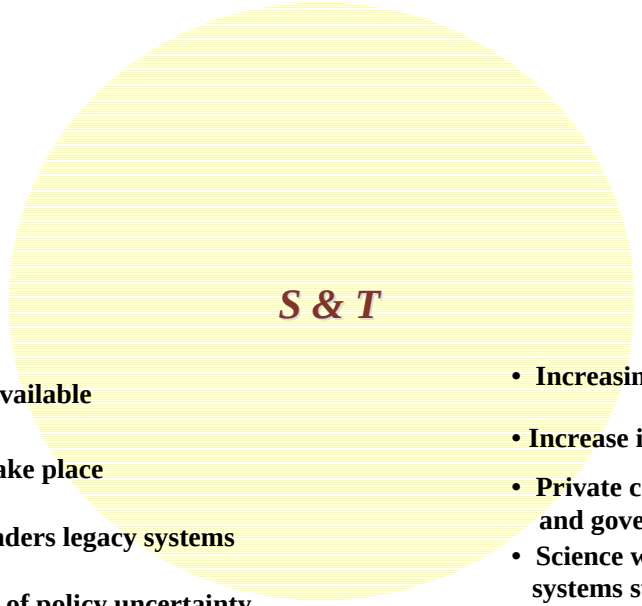
In an increasingly complex and globalized world, reordered by new threats, science and technology will play an increasingly important role. S&T will enable improved understanding of the complexity of natural systems and then aid in developing solutions to the threats by addressing their root causes. For example, we envision that the competition for healthcare resources between the aging populations in western countries and the challenges posed by rapidly spreading reemerging diseases in the developing world will greatly challenge both the private sector and governments. Understanding the impacts of global climate change will require modeling and understanding the anthropogenic and geogenic changes in the earth's systems. In particular, it will require drawing data from anthropological and archeological evidence and using this to contribute to aid in better understanding the future impact on societies and security. For example, the droughts of the 12th century likely meant the end of the Anasazi and Mayan civilizations. Can we model and understand such events in the future and in time frames where we can preclude introducing new sources of conflict or threats to security?

In looking towards future trends in science and technology it is critical that we look to the past and consider the trends occurring in the environment in which science is pursued, including the values and institutions engaged in pursuing science, as it is likely that these will have significant impact both on what is pursued and the way it is pursued. How does the culture of science impact national security? Open communication has been an important value yet could be destabilizing. How do you deconflict these? In the future, interdisciplinary science is likely to be increasingly important yet the system of scientific research and discovery is not currently structured to motivate interdisciplinary work. New reward mechanisms likely will need to be developed. In addition it is likely that new innovations and breakthroughs will increasingly occur at the boundaries between disciplines, for example information technology and biotechnology. Will this provide sufficient incentives for driving collaboration between the disciplines? Developing agility in science across and within market places will be key. Indeed if the rate of change within the scientific community isn't greater than the rate of change outside, there is likely to be conflict.

Equally important is the interaction between the science enterprise and scientific community with the rest of the world. It is clear that increasingly science and technology will be funded by the private sector and this private sector is increasingly internationalized. Private capital investment is likely to dwarf the government investments for science R&D. Additionally there will likely be an increase in the number of public and private partnerships. Thus this leaves large questions for the scientific community as these changes occur. Whose rules will be followed and how will this impact future S&T trends? Will increased security requirements imposed by terrorism be a publicly or privately funded priority?

In addressing the societal impact of science it is critical for the scientific community to engender public support for investment in areas that do not necessarily lead to financial profit, but will have significant intergenerational impact, such as addressing global warming. In addition, since the rate of changing technology is likely to continue it's acceleration, legacy systems are likely to become obsolete more quickly and public discomfort will likely continue. How can the scientific community help society adapt to these changes, and anticipate them, rather than merely responding?

S&T Trends



- **Great % of S&T innovation available and usable at smaller scales**
- **Innovation will increasingly take place between disciplines**
- **Pace of technology change renders legacy systems obsolete earlier**
- **Science moving in more areas of policy uncertainty**

- **Increasing impact of private sector**
- **Increase in public-private partnerships**
- **Private capital dwarfs government free energy and government lacks agility**
- **Science will deal with progressively more complex systems such as, biology, energy systems, information technology**

National Security Context and Architecture

To begin this discussion it is critical to define national security. It is likely that 50 years ago it would have been much easier to define security. The nation was more compact and security meant physical security. Today however, the concept of the nation state is evolving and more complex. Perhaps more importantly, protection of only the US borders and homeland is likely a necessary but not sufficient condition for maintaining security. Over the last 100 years national security has historically been coordinated at the federal level. Yet during the 19th century (and before) security was coordinated at the local level, at the "frontier". Are we reverting to this vision of security as "frontierism" with our current emphasis on homeland security and local protection, with coordination at the local level and what will this mean for the role of science and technology?

Following WWII there was great public faith in both the government and in the scientific community, expecting that good decisions would be made and good investments would provide good societal outcomes. Unfortunately the ensuing years, with events ranging from Viet Nam to the publication of Rachel Carson's "Silent Spring" and events such as Love Canal, Three Mile Island and Chernobyl, have changed public belief and trust in science and the government. Thus, public engagement and opinion has become much more critical and communication and engagement is key. Additionally the scale has changed, just as national security is dependent upon security outside US borders, science is increasingly dependent upon cooperation and partnership outside of the nations borders, as well as through public/private partnerships and this too will have significant impact on security

A place to begin the definition of security is provided in the Constitution, i.e.:

- Defense against external threats
- Preservation of the nation state
- Preservation of our way of life
- Guarantee of our well being and health

Yet outstanding questions remain, e.g. how do human and global security relate to national security, when dealing with issues such as poverty, disease, crime, global warming, and do these merge into national security?

Secondly there are some assumptions to be made with respect to the security architecture. We assume that conflict will continue to exist and that the international system will be increasingly interconnected and integrated (in part facilitated by technology). The nation state will continue to exist but will likely transform, in part due to questions of loyalties, allegiances and definition of citizenship and interests. It appears that we are less likely to be threatened by nation states; rather it is likely that sub-national organizations, empowered by technology, are likely to change the framework. Our defense base is likely to be increasingly dependent upon a commercial industrial base, including the utilization of commercial-off-the-shelf products and goods. How will this impact our security and will this introduce new vulnerabilities?

Economic stability too must be considered a national security issue and cannot be considered without examining trade partnerships, and alliances, as well as disparities. The relationship between security and stability needs to be examined and challenged.

Rather than examine national security through a window of scenarios or vulnerabilities, or attempt the difficult tasks of systems modeling, we are examining it through the lens of key drivers or forcing functions that will guide the future of national security. These can be split into three major areas: transforming events, political forces, and social forces.

Transforming events provide the opportunity to look at the varied response pathways of the socio-political system to often unexpected (though not unpredicted) events, as opposed to predicting the range of possible futures. Since the end of the cold war much of US foreign policy with Russia and the NIS has focused on preventing WMD proliferation, thus key events to examine include the intentional use or misuse of WMD or the proliferation of WMD. Both of these would likely have significant impact on US security concerns and likely would spur new S&T investment. Complicating this is the likelihood that law enforcement and the governmental controls on weapons systems is likely to be increasingly weak in fragile and failed states. Another transforming event likely to spur S&T investment would be a catastrophic planetary or environmental event, whether naturally occurring or man-made/induced.

Political forces include the ways in which institutions relate to one another, including the way power is allocated and traded, and are likely to have significant implication for US security and stability. These are likely to include the forces of integration and disintegration, including non-state systems and alliances. Centralization and decentralization and regulation are also likely to play key roles and must be factored into the security equation. Power realignment too is likely to involve both state and non-state actors, for example an ascendant China, and this is likely to place enormous pressure on the US to respond, though it is not clear what role S&T could play.

Increasingly, social forces are likely to have significant impact on the security architecture. Most certainly the reemergence of intolerance and the emergence of a compelling ideology could be quite destabilizing. Examining human motivations, sociology and psychology will be key. And while this is not a new phenomena, it is critical that we examine the role technology can play as an enabler and wildcard (mass media surely will play a role. Resource disparities, while also not new phenomena, can increasingly be enabled or mitigated by technology. A large number of civil wars and regional conflicts arise over competition for resources and it is likely technology could play both a stabilizing and destabilizing role in this arena.

Ultimately national security may depend in large part on those we work with regularly, with whom we have real-time electronic alliances, and those who produce goods we couldn't go to war without. These alliances, including security relationships such as NATO, scientific cooperative partners such as the EU, Russia, and trade partnerships such as NAFTA and ASEAN, need to be examined as perhaps the paradigm for our emerging security architecture.

National Security Trends

- **Threats will come from smaller nation states and sub-national organizations**
- **Defense base increasingly a commercial industrial base**
- **Threats will come from COTS systems**
- **Law enforcement & weapons controls weak in fragile & failed states**
- **Compelling ideologies likely to be destabilizing**
- **Security alliances and trade alliances form new base of emerging security architecture**

National Security

Intersection Between Globalization, Science and Technology, and National Security

The central focus of this project resides in examining the intersections between Globalization, Science and Technology and National Security. Technology, for example, can play a clear role in facilitating/enabling new threats. As described in the previous sections, the internet has been a powerful enabler in linking geographically dispersed groups who then are able to wage war without any new, significant expense through exploitation of the exiting technology. Will this continue? If so it is critical that we free ourselves from only expecting the threats to arise where the largest dollars are spent on large technology investments as opposed to use of existing in-hand technologies. We need to be sure we do not look through a lens that mirrors our own experiences.

There are numerous insights to be gained in understanding national security through breakthroughs in science and technology. Much of our current security has arisen from our ability to absorb and integrate technology into systems at a rate faster than anyone else and there is general agreement that maintaining this ability will be crucial to US national security. Thus the question arises as to what needs to be done to ensure superiority continues into the future? Equally challenging will be developing an understanding of the way in which new technologies might alter the balance of power. For example, what might the development of new, non-fossil fuel energy sources mean for the Arabian Gulf states and for stability in the Middle East? How might space travel impact life on earth? What are the security implications of the ability to rapidly transfer large amounts of data at increasing enormous rates, coupled with the ability to process this data into knowledge and wisdom, through the coupling of photonics and new information technologies? How indeed do we derive knowledge and wisdom from data? Will this enable us to make decisions faster and better than others or will we approach the limits of human tolerance and reach information overload? Will the inability of some to adapt to change introduce new conflicts in society?

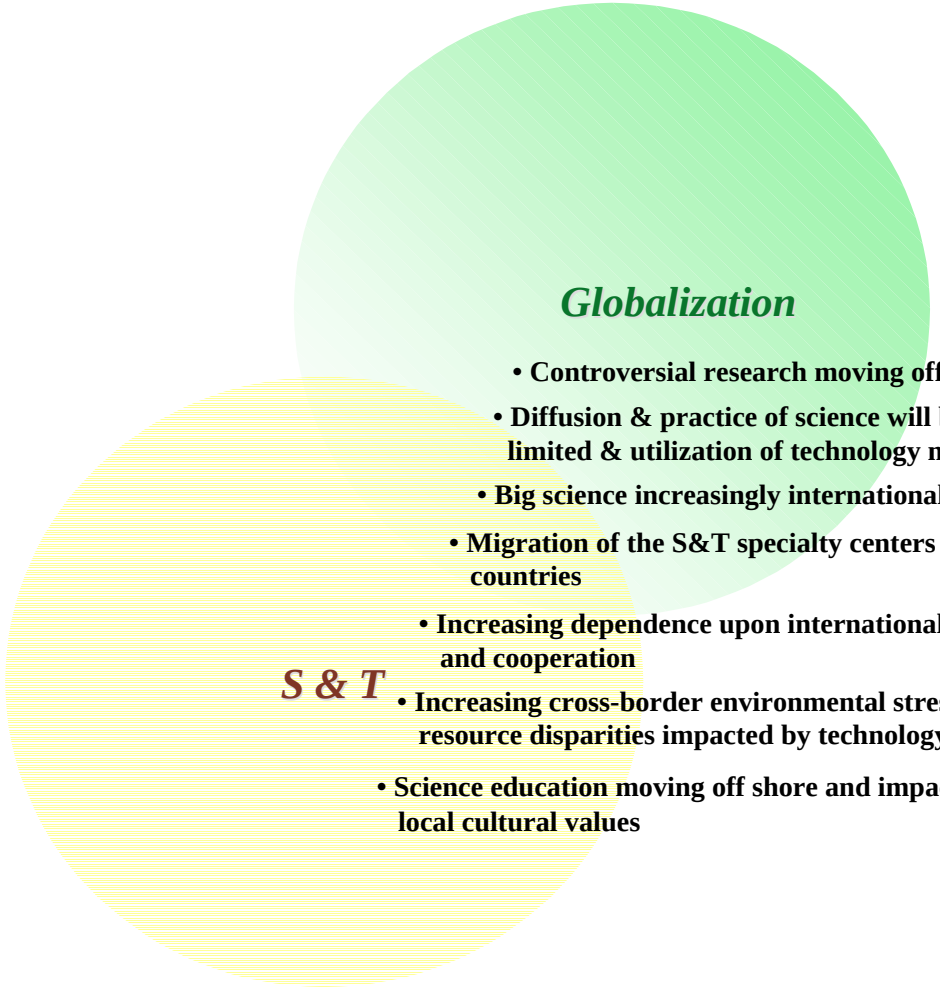
We need to explore whether globalization in the future will mean the same thing we mean today. Will the issues 50 years from now still be migration, demographic change and public response/reaction to globalization? For example does two-way, or multi-directional migration really mean more intense globalization and what are the implications for this, for example in terms of diffusion of ideas, culture and technology. Would one measure of the intensity of globalization include the number of Americans leaving and moving elsewhere and what are the long term implications for both national security and S&T for this trend, for example does it move beyond the individual to the development of common values and behaviors?

Understanding the natural tensions between science and security additionally will be key. Balancing the need export controls and controls on flow of information with the need to share information openly must be dealt with. In addition an increasing percentage of science funded by industry is not publicly open and this could have some significant security implications if the trend towards an increased investment in science continues to migrate from public to private funds. Global scientific collaborations are likely to undergo more scrutiny, likely introducing more vulnerability, while offering stronger likelihood of scientific breakthroughs and societal benefits. The benefits and risks must be balanced so as to minimize the risks while still reaping and maximizing the social and scientific benefits.

We recognize that with marginal effect we can control the flow of technology (for short time frames) but that the science cannot be controlled due to the inherent need to communicate and share within the scientific community. Thus the question arises as to whether select technologies should be controlled/classified and if so, for how long? Might a better strategy be to sprint faster to outpace others rather than to try and control that which cannot be controlled? At what cost and can this be done? Additionally most technologies are inherently dual use. In worrying about controls, we need to acknowledge that others may well choose a different technologic pathway and indeed choose solutions we could not possibly anticipate utilizing widely available technologies. Rather than arguing for more controls, perhaps we need to acknowledge that merely modeling technologic solutions will not be sufficient to understand our adversaries, rather we will need to address, in parallel, the sociological and psychological motivations.
There remain some outstanding issues at the boundary between globalization and science and technology that require further examination.

Predicting long terms technologic trends is clearly difficult, though not impossible. However in some key areas, biotechnology, information technology and energy, it is critical to examine the trends, recognizing that we are not predicting the future of the technology itself but only the trends. It is important to look not only at the malefactors who plan to use technology to malicious ends, but to look at the benefits of the technology as well. Perhaps an early warning system could be devised comprised of indicators that would point to possible misuse or malicious exploitation instead of the current system of export controls. Social demands in third world countries are likely to drive new investments in science and technology. Indeed multi- or trans-national companies may well be willing to invest in these countries if the profit margin, due to large populations and markets, are competitive with the US. What will this mean for commercial investments and developments in the US? Indeed to answer this question we must first answer the question of what is a transnational company. In an intensely globalized world where a premium is placed on scientific and technical creativity, do we know enough about the creative process to both stimulate it in the U.S. and harvest it around the world? In particular, when we need these skills to maintain our security, how do we foster them and utilize them in maintaining our scientific and technical dominance, key to our national security? And how do we refocus this skill base in addressing our broader national security needs, including homeland security?

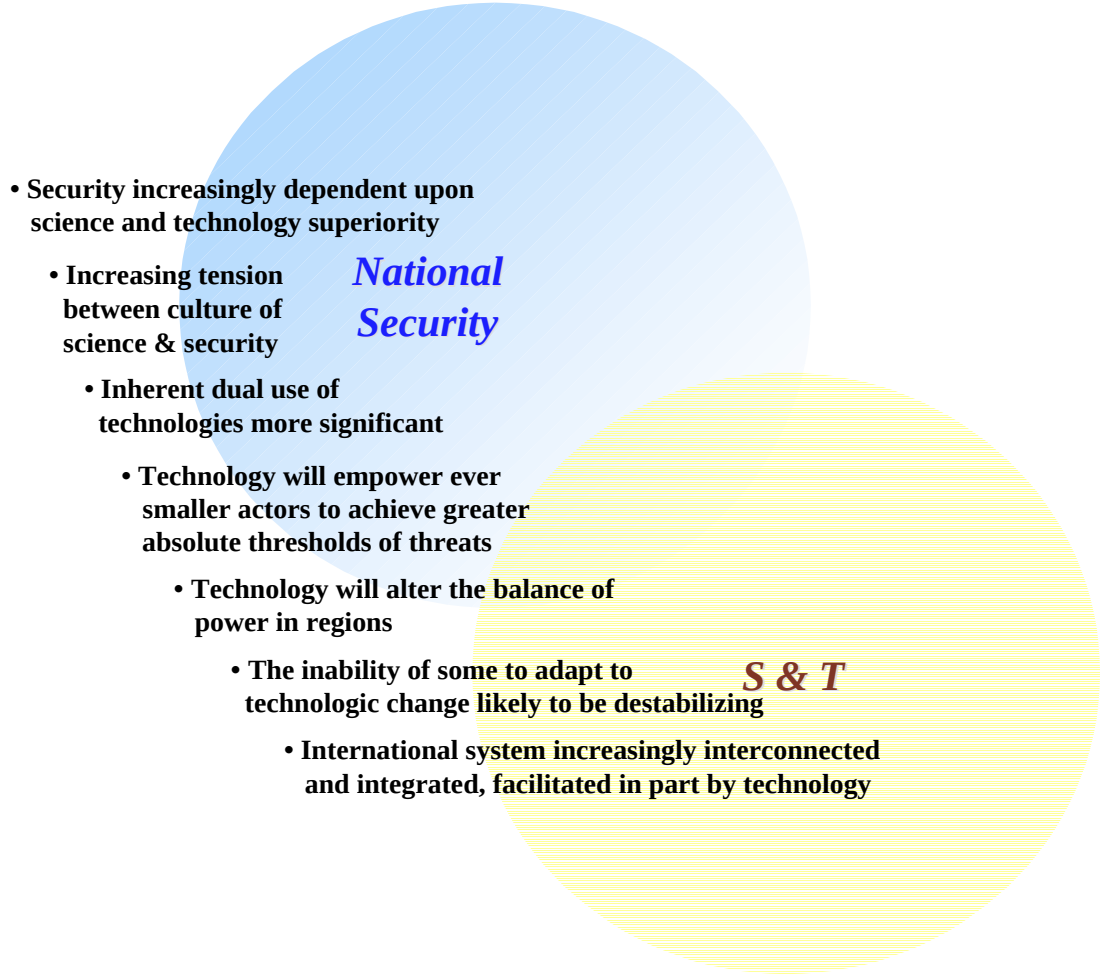
Trends at the interface of Globalization and S&T



- **Controversial research moving off shore**
- **Diffusion & practice of science will be culturally limited & utilization of technology may not be**
- **Big science increasingly international in search for talent**
- **Migration of the S&T specialty centers to developing countries**
- **Increasing dependence upon international collaboration and cooperation**
- **Increasing cross-border environmental stresses and resource disparities impacted by technology**
- **Science education moving off shore and impacted by local cultural values**

Trends at the interface of National Security and Globalization

Trends at the interface of National Security & S&T



- **Security increasingly dependent upon science and technology superiority**
  - **Increasing tension between culture of science & security**
    - **Inherent dual use of technologies more significant**
      - **Technology will empower ever smaller actors to achieve greater absolute thresholds of threats**
        - **Technology will alter the balance of power in regions**
          - **The inability of some to adapt to technologic change likely to be destabilizing**
            - **International system increasingly interconnected and integrated, facilitated in part by technology**

National Security, Globalization and S&T Interface