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Hearing on ARPA-E
before the
House Committee on Science
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Mr. Chairman and Members of the U.S. House of Representatives' Science Committee, I am pleased to have been asked to give my views on the pros and cons of creating an ARPA-E organization in the Dept. of Energy. I hope that this brief statement addresses your major questions.

At the outset, I need to tell you that, since I have spent most of my career in the defense R&D business, I am not an expert on energy matters. Nevertheless, I hope that my comments will be helpful to the committee.

For the past forty years I have worked with DARPA as a research contractor representing both small and large companies, as a Navy consultant, representing the Chief of Naval Operations, as Director of DARPA, from May1998-January 2001, and, most recently, as a consultant to the current DARPA Director. This variety of views of DARPA forms the basis for what follows.

In my experience, the fundamental reason for the existence of DARPA in the Department of Defense (DOD) has never really changed since 1958, when President Eisenhower created the Agency in reaction to the stove piped military services' disconnected space programs that led to America's Sputnik failure.

The reason for DARPA is a strong belief, currently held by both the executive and legislative branches of the government, is that, in order to maintain U.S. technological superiority over potential adversaries, the DOD needs a central organization, reporting to the Secretary, to create and fund high risk, potentially high return R&D projects. This is in addition to service funded R&D.

This belief is based on the fact that, regardless of intentions, within the DOD, organizational "stove pipes" develop and these "stove pipes" often have risk-averse, parochial views which can misjudge the potential for new, technologically enabled, opportunities and threats, especially if the technology is high risk.

The idea of a central agency, ARPA-E, may make sense if the DOE shares some of these organizational and management problems with the DOD.

DARPA's function is to work across and around these stove pipes for important, national defense problems.

Achieving this mission for almost fifty years has required that DARPA continuously adapt and to a defense environment that has undergone large change because of changing adversaries and, also, because of technology, much of which was the result of DARPA initiatives.

In order to accomplish its mission, DARPA employs a two pronged approach

It opportunistically, finds and funds long term, outcome focused R&D projects using the best talent in universities, laboratories and industry.
In parallel, it demonstrates and "makes a market" for these technologies by helping to fund developments needed for military and commercial adoption.

I think that this ability to, simultaneously, fund focused long term research and to act as a "market maker" with potential customers is a critical differentiator between DARPA and other DOD R&D entities.

DARPA is not bound by DOD acquisition requirements for technology or systems projects. DARPA often mixes basic research, applied research and advanced technology development in its projects to aid the transition of the understanding to war fighting capability.

It is this freedom to innovate that differentiates DARPA from the other DOD laboratories and funding agencies.
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This following list of characteristics that help DARPA operate at both the Institutional and personal innovation organization levels is largely drawn from DARPA's own descriptions of its organizing elements:[1]

Small and flexible: DARPA consists of only 100 to 150 professionals; some have referred to DARPA as "100 geniuses connected by a travel agent".
-        Flat organization: DARPA avoids military hierarchy, essentially operating at two levels to ensure participation.
-        Autonomy and freedom from bureaucratic impediments: DARPA operates outside civil service hiring and the limits of government contracting rules, which gives it unusual access to talent, plus speed and flexibility in organizing R&D efforts.
-        Technical staff drawn from world-class scientists and engineers: DARPA's talent is drawn from industry, universities, and government laboratories and R&D centers, mixing disciplines and theoretical and experimental strengths.
-        Technical staff hired or assigned for 3-5 years: Like any strong organization, DARPA mixes experience and change. It retains a base of experienced experts that know their way around DOD, but rotates most of its staff to assure fresh thinking and perspectives.
-        Project-based, organized around a challenge model: DARPA organizes a significant part of its portfolio around specific technology challenges. Although its

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[1] DARPA, DARPA - Bridging the Gap, Powered by Ideas (Feb. 2005); DARPA, DARPA Over The Years (Oct. 27, 2003)

projects typically last 3-5 years, major technological challenges may be addressed over much longer time periods, ensuring patient long-term investment, but only as a series of focused steps.

Necessary supporting personnel (technical, contracting, administrative) are used from other agencies on a temporary basis: This provides DARPA flexibility to get into and out of a technology field area without the problems of sustaining staff.

- Outstanding Program Managers are the heart of DARPA: In DARPA's words, "The best DARPA Program Managers have always been freewheeling zealots in pursuit of their goals." The DARPA Director's most important job historically is to recruit highly talented program managers and empower them to be creative.

- Acceptance of failure – DARPA, at its best, pursues a high risk model for breakthrough opportunities, and is very tolerant of failure if the payoff from potential success is great enough.

- Oriented to revolutionary technology breakthroughs – DARPA historically has focused on radical, not incremental, innovation, emphasizing high-risk investment, moving, as noted, technology advances from fundamental through prototyping, then handing off the production stage to services or commercial sector. DARPA often works on solutions to joint service problems which individual services traditionally are reluctant to pursue.

- Mix of Collaborators – DARPA typically has tried to build strong teams and networks of collaborators, bringing in a range of technical expertise and involving technology firms that are often not significant defense contractors with outstanding university researchers. The aim is to ensure strong collaborative "mindshare" on the challenge.

If the committee decides that ARPA-E is to be such a central organization, then, like DARPA, I think that it should have such a two pronged approach to its activities.

It must find and fund long term outcome focused R&D projects using the best talent in universities, laboratories and industry. In parallel, and often in conflict with the first part of the approach, it should convince selected parts of the energy industry that its technologies can radically and positively affect the energy business and that these technologies should be adopted. In addition, in partnership with industry, it should help fund the developments necessary to implement these technologies.

Balancing these, often conflicting, goals requires a special structure and operating style and DARPA is an example of something that works in the DOD

Like DARPA, I think that ARPA-E should be created as the central energy research and development organization in the DOE and should have a clear, national purpose for its projects that differentiates it from the laboratories and other agencies. It should have visibility and access to the top management of the Department and not be part of an established R&D beauracracy.

Like DARPA, I think that it should have a mandate to create, demonstrate and transition high risk, high return technologies that can dramatically change the U.S energy posture in the future

Like DARPA, I think that it should be funding agency, with very little infrastructure, a flat organization and a small, very competent, entrepreneurial, technical staff. Budget and program control should rest with the Director and the program manager and the agency should enforce constant turnover of both programs and staff.

Like DARPA, I think that it should have both the authorities and the resources needed to implement these authorities. For example, while flexible contracting and hiring authorities are necessary, implementing these authorities requires dedicated, in house, resources.

Unlike DARPA, however, ARPA-E will be in the energy business, not the defense business. Congress should not try to make this agency strictly mimic a defense agency that has and continues to evolve to accommodate a changing defense environment.

Instead, I think that ARPA-E should receive the funding, flexibility, leadership authorities and, most importantly, the time necessary to let it become the change agent for the DOE.
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I think that a DARPA like model makes sense even if the DOE is not the customer for the technology because this is not necessary for the transition of revolutionary technology.

The most famous example*

President Kennedy and Defense Secretary Robert McNamara were deeply frustrated with profound command and control problems during the Cuban Missile Crisis – the inability to obtain and analyze real time data and interact with on-scene military commanders. DARPA brings in Licklider to tackle the problem. It is the rare case of the visionary being placed in the position of vision-enabler. Strongly backed by noted early DARPA Directors Jack Ruina, Charles Herzfeld and George Heilmeir, Licklider finds, selects, funds, organizes and stands up a remarkable support network of early information technology researchers at universities and firms that over time builds personal computing and the internet.

At the institutional organization level, DARPA and Licklider become a collaborative force among the Defense Department research agencies controlled by the services, using DARPA investments to leverage their participation to solve common problems under connected science and challenge models. DARPA and Licklider also keep their own research bureaucracy to a bare bones minimum, using the service R&D agencies to carry out project management and administrative tasks, so that DARPA's efforts create co-ownership with the service R&D stovepipes. Institutionally, DARPA becomes more of a research supporter and collaborator, not a rival competitor to the DOD research establishment. DARPA provides an institutional example within DOD for a way to

create a flexible, cross-agency, cross-discipline model among stove piped U.S. R&D agencies. At the personal level of innovation organization, Licklider creates a remarkable base of information technology talent both within DAPRA and in a collaborative network of great research groups around the country.

Because it sees ongoing progress, DARPA is willing to be patient and look at long term investments in IT talent and R&D investments in a way that corporations and venture capital firms are not structured to undertake. Licklider's DARPA model is also not a flash in the pan. Internally it is able to institutionalize innovation so that successive generations of talent sustain and keep renewing the IT technology revolution over the long term. At the personal level of innovation, the great groups Licklider starts, in turn, share key features of the Rad Lab group previously discussed. Licklider's Information Processing Techniques group remains the first and greatest success of the DARPA model. But this success is not unique; DARPA is able to achieve similar accomplishments in a series of other technology areas.

One more key point: DARPA was willing to spawn technology advances not only in the defense sector but in the non-defense economy as well, recognizing that an economy-wide scale, as opposed to a defense sector-only scale, is needed to speed the advance. The Department of Defense (DOD) was able to take advantage of this technology evolution speed up, with its shared, and therefore reduced, development and acquisition costs, which enabled DOD to obtain the tools it needed to solve its initial command and control problem more quickly and less expensively.

The DOD was never as major market for personal computing or the internet.

Another example,

In 1987, faced with a competitor that threatened to control the semiconductor market, the SEMATECH venture was formed to improve domestic semiconductor manufacturing.. The federal dollars for SEMATECH were funneled through DARPA because semiconductor manufacturing was seen as vital to the defense technology base.

The success of the SEMATECH partnership in reestablishing US dominance in semiconductor fabrication was in part due to the fact that DARPA, in partnership with industry, was able to rapidly create and fund focused high risk, high return programs.

More importantly, the DOD profited from an industrial base that it could use without fear of control by a foreign power without having to make a market.

A final example *

When Andy Marshall, DOD's legendary in-house defense theorist, announced that U.S. forces were creating a "Revolution in Military Affairs", this defense transformation was built around many of the IT breakthroughs DARPA initially sponsored. Admirals Bill Owens and Art Cebrowski and others, in turn, translated this IT revolution into a working

concept of "network centric warfare" which enabled the U.S. in the past decade to achieve unparalleled dominance in conventional warfare.

In each of these examples, DARPA technology went, first to the commercial sector, then to the military, a transition path still followed at DARPA for many revolutionary technologies

*Provided by William Bonvillian, from a draft 02/19/06 "DARPA and the Connected Science Model For Its Innovation- Where Should It Go, Now?"
Finally, and with all due respect, even though I am extremely proud of my associations with DARPA, I think that it might be helpful if the committee considered a different name for this new organization, a name that reflects the uniqueness of the twenty first century energy needs of the nation.

Thank you.

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