S&T for National Security

JASON Study

Preliminary Results

Summer 2008

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Task Statement

How should DOD BASIC research be structured to best meet the challenges ahead?

- **Program**
  - Focusing on the right areas?
  - Well coupled to the forefronts?
  - Good coupling to applications?
- **People**
  - Is the workforce adequate and being used effectively?
  - How to generate, attract, and retain the best workforce?
- **Organization**
  - Proper relationship between DDR&E and Services?
  - Proper oversight and coordination?
  - Well-coordinated with other research activities?

Changes in DOD S&T Since the "Golden Age"

- **Shift in the scientific topics of greatest interest to society**
  - **<u>Then</u>: greatest threat = USSR military attack**
    - Science relevant to DOD was important (nuclear physics, aerospace engineering, electrical and mechanical engineering, etc.)
    - Attracted talented scientists to the DOD basic science community
  - **<u>Now</u>: Challenges are the needs of developing/developed world**
    - Issues are Energy, Food, Water, and Medicine, Education, Public Health.
    - Not immediately relevant to the DOD; tougher to attract talent
- **Decline of Industrial basic research**
  - **<u>Then:</u> Corporate support for basic research**
    - US manufacturing dominated and thrived post-WWII
    - US companies established basic research labs that benefited, and were synergistic with, DOD
  - **<u>Now:</u> Corporate basic research has all but vanished**
    - Global competition has streamlined many US industries with loss of basic research
    - DOD can no longer depend on this foundation of industrial basic research
    - Greater challenges in developing a DOD R&D workforce and transitioning the results of basic science to application

Another Change Since the "Golden Age"

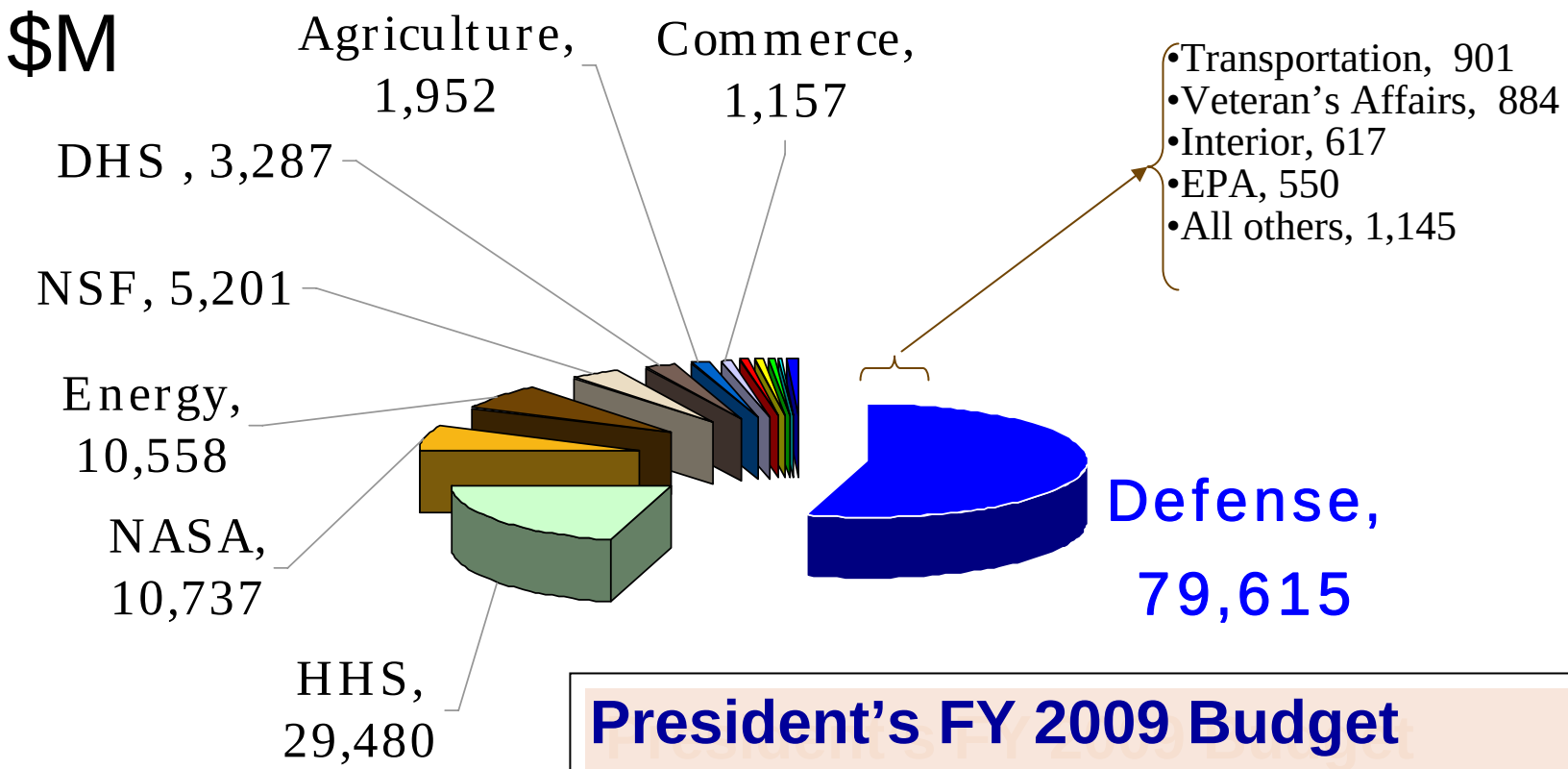
- **The expansion of US higher education**
  - Then: Science fellowships, independent of means, provided upward mobility for *any* talented student
    - Many were drawn into fields relevant to the DOD mission.
  - Now: *All* talented students have access to higher education
    - Growth of both public and private assistance programs.
    - Students often find much greater potential for upward mobility in non-science fields (finance/banking, business, medicine, law)
    - DOD support will continue to attract some, but a smaller fraction of the best and the brightest, who now have many other opportunities

Rationale for DOD Basic Research is still Valid

- **Some fields are (largely) DOD-unique**
  - hypersonics, underwater acoustics, rad-hard electronics, high power microwave generators, specialized detectors for remote-sensing systems, netcentric and distributed systems, precision navigation and geolocation systems, ….
  - ***DOD support crucial to new knowledge and researchers.***
- **Most basic research is not supported or guided by DoD (and much of it is abroad)**
  - DOD needs a cadre of basic researchers knowledgeable in DOD problems to scan and couple basic work to DOD applications; avoid technical surprise
- **Basic research helps attract and retain engineering talent crucial to the DOD mission**
  - Interest in advanced technology careers is waning
  - Basic research activities attract talented individuals, many of whom then migrate to more applied studies
  - Science is an entry point for young people to careers in technology development in DOD labs and in working towards the DOD's long range needs in the private sector

Federal R&D Funding

PBR FY2009



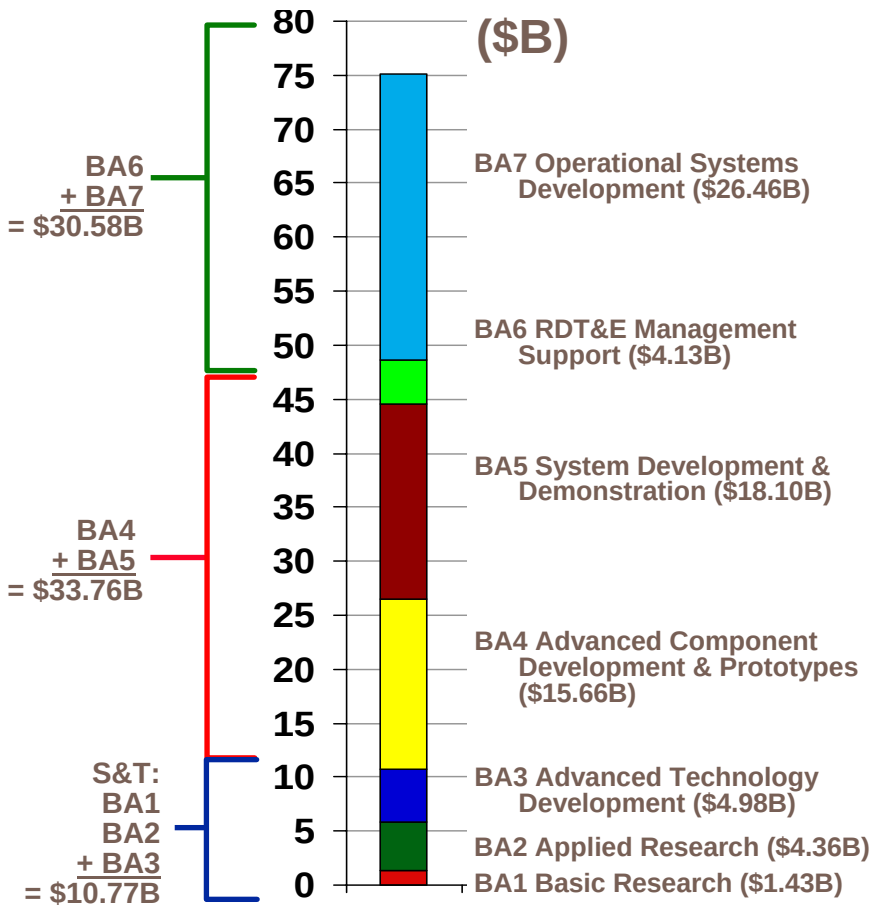
President's FY 2009 Budget showing Agency Federally funded Research and Development

http://www.whitehouse.gov/omb/budget/fy2009/pdf/apers/crosscutting.pdf. The DoD total is from the DoD Comptroller, FY09 R-1 page II

FY08 and FY09 RDT&E Budget Request Comparison

- in Then Year Dollars -

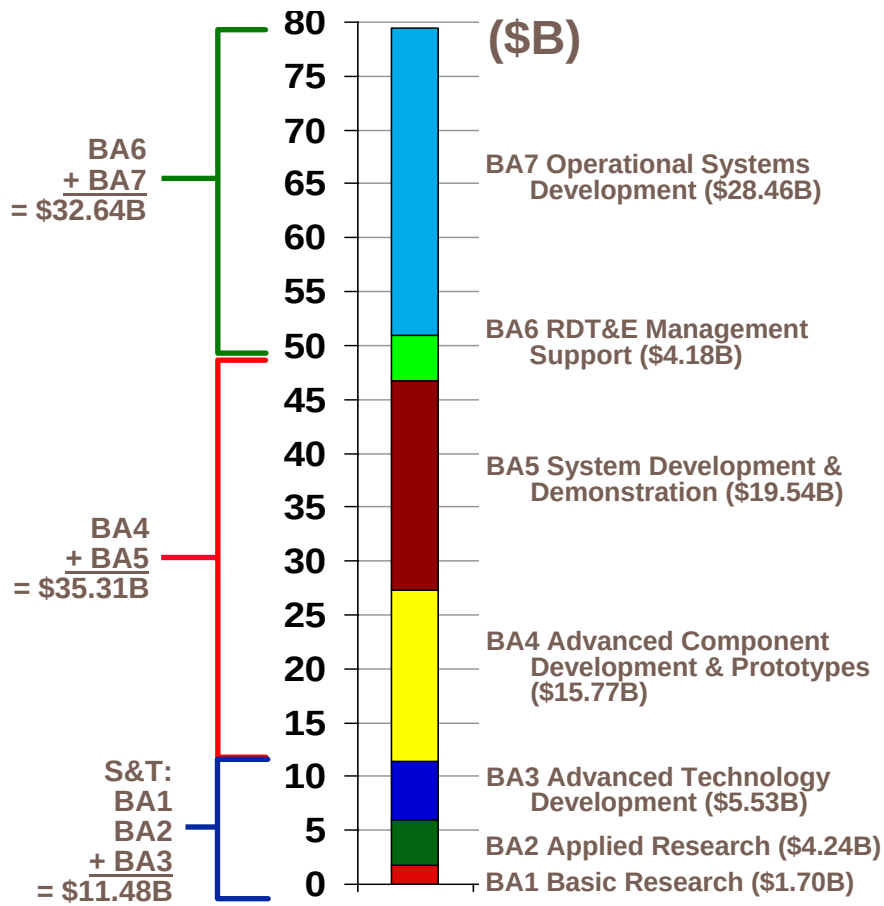
FY08 RDT&E request = $75.12B
(Budget Activities 1-7)



Technology Base (BA1 +BA2) = $5.78B

PBR08 S&T is 14.3% of RDT&E

FY09 RDT&E request = $79.43B
(Budget Activities 1-7)

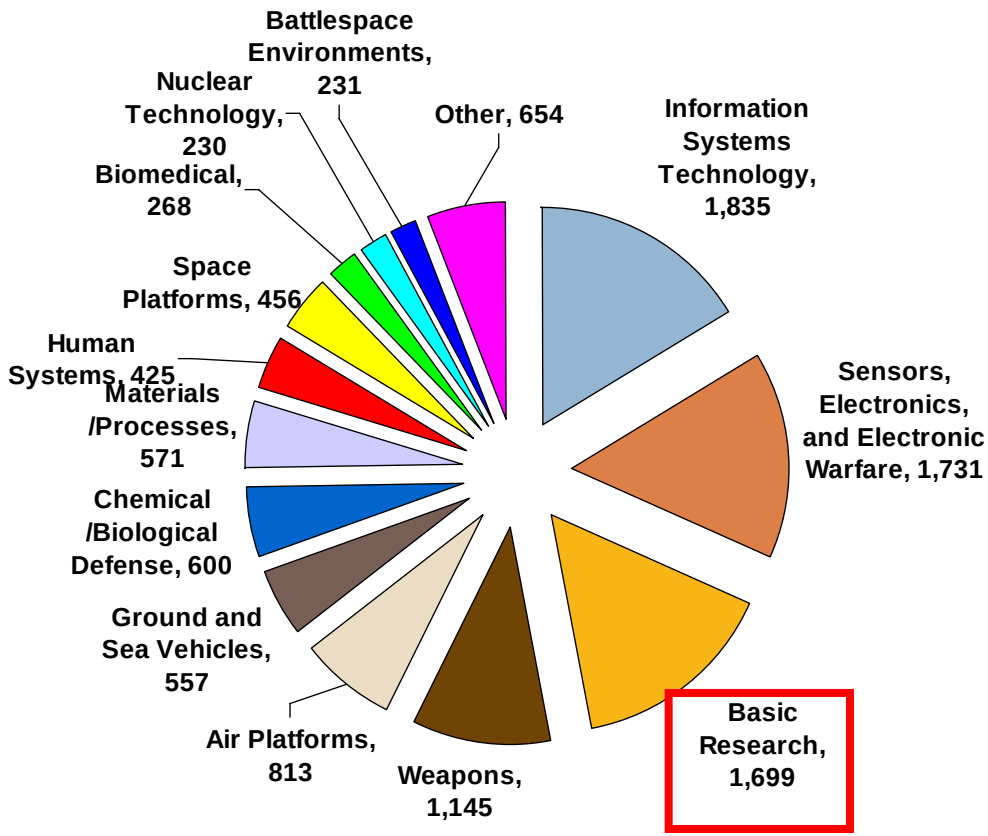


Technology Base (BA1 + BA2) = $5.94B

PBR09 S&T is 14.5% of RDT&E

Where is the DoD S&T money going?

- **Funding**
  - Current year S&T dollars: $10.77B FY08 to $11.48B FY09
  - Percent of DoD funding: 2.24% FY08 to 2.22% FY09
  - Over 50% of total investment in 4 functional areas:
    - Information Systems (1.8B)
    - Sensors, Electronics / EW (1.7B)
    - Basic Research (1.7B)
    - Weapons (1.1B)



DoD S&T program is focused on "sensing and shooting" But is changing……

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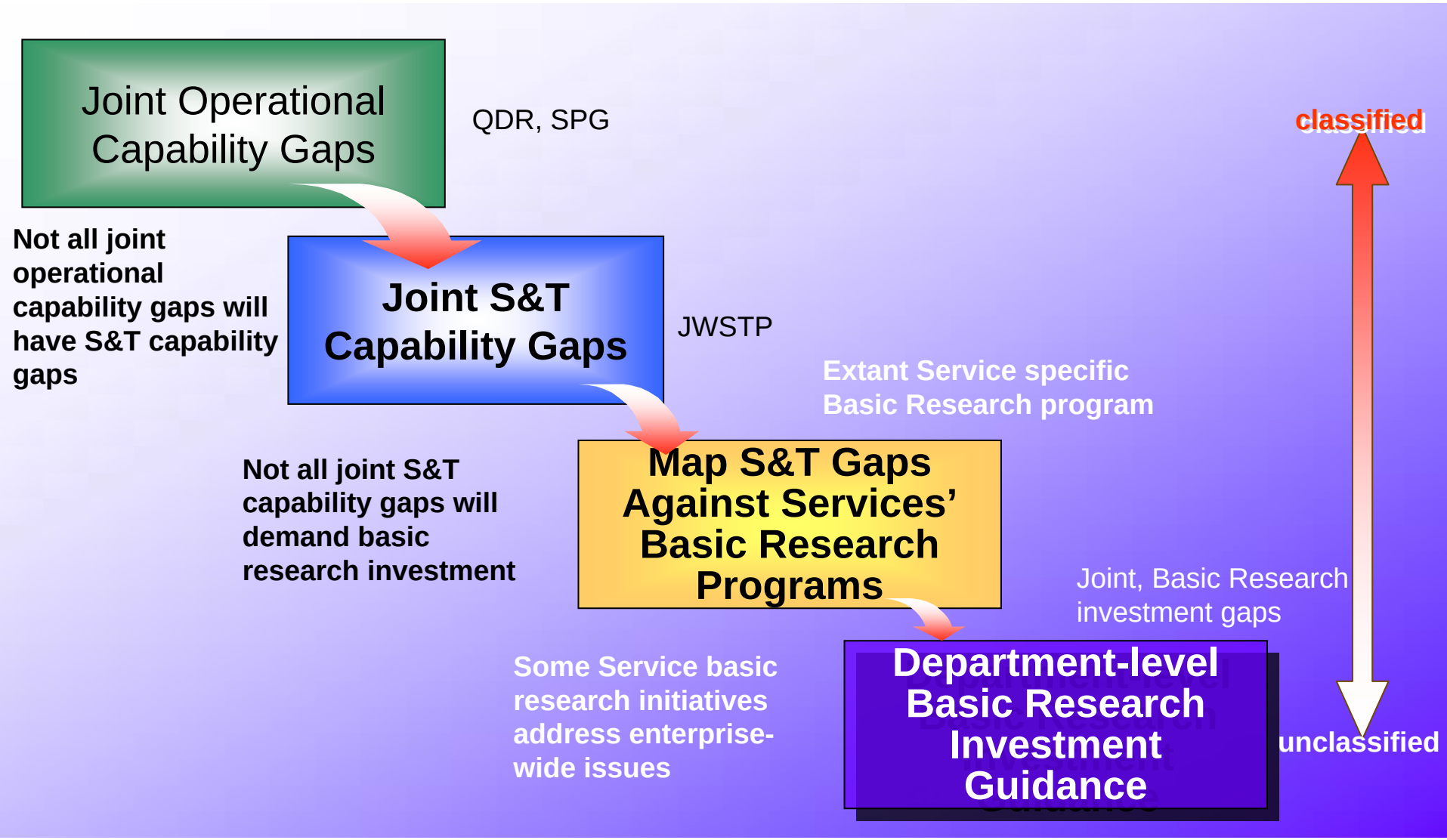
Conceptual Strategic Planning Process



JASON Observations (Program, Personnel and Organizational)

- **A healthy DOD basic research program is essential**

> ***"As changes in this century's threat environment create strategic challenges – irregular warfare, weapons of mass destruction, disruptive technologies – this request places greater emphasis on basic research, which in recent years has not kept pace with other parts of the budget."***
>
> ***Secretary of Defense Posture Statement on the FY09 Budget, February 2008***

- **But important aspects of the DOD basic research programs are "broken"**
  - Simple changes in procedures and definitions will not fix this important enterprise
  - Improvements must be institutionalized to endure the vagaries of the personnel involved at one time
- **Throwing more money at the problems will not fix them**

Program Observations

- **Relative to other S&T categories, basic research is longer-term, less immediately applicable, and a smaller amount of funds**
- **The DOD is not adhering to its own definition of basic research in its use of 6.1 funds**
  - **6.1 funding by the services has yielded to short-term pressures and drifted toward for more managed research relevant to direct service needs**
  - **Such drift has resulted in a net loss of bona fide 6.1 activities, inconsistent with DOD goals and directives**
- **Basic research funding is not exploited to seed inventions and discoveries that can shape the future; investments tend to be technological expenditures at the margin**
  - **A basic research program driven by operational requirements will produce only incremental advances of existing technologies**
- **The portfolio balance of DOD basic research is generally not critically reviewed by independent, technically knowledgeable individuals**
  - **ODDR&E has too little time, staff, and authority to do this properly**
- **Common management and reporting of 6.1 with 6.2, 6.3 funds is bad practice**
  - **Obscures the actual uses of 6.1 funds**
  - **As many 6.1 program managers also handle 6.2,3 activities, the smaller and less urgent 6.1 work gets less attention**

DDR&E's Grand Capability Challenges

- **Information Assurance**
- **Network Sciences**
- **Counter WMD**
- **Science of Autonomy**
- **Information Fusion & Decision Science**
- **Biosensors and Bio-inspired Systems**
- **Quantum Information Sciences**
- **Energy and Power Management**
- **Counter Directed Energy Weapons**
- **Immersive Science for Training & Mission Rehearsal**
- **Human Sciences**

- Without detailed review, this list looks about right
- But JASON would add "Dynamics of Oceans and Atmospheres"

Personnel Observations

People are the bedrock of a successful research effort, yet DOD research program is more about funding projects than supporting the best people. Symptoms of this are as follows:

Within DOD

- A career in S&T is not a path to the highest ranks in the uniformed services
- Civilian career paths in the DOD research labs and program management are not competitive to other opportunities in attracting outstanding young scientists and retaining the best people
- Program managers have too little time and incentive to maintain currency with, and connectivity to, the forefronts of their technical fields. Technical oversight of contractors is correspondingly handicapped

Personnel Observations

Within academia

- Although DOD 6.1 research has a significant presence at many of the nation's leading research universities, it is not effectively leveraging these contacts to solve DOD S&T problems

What universities do 6.1 research?

TABLE E-1 Top 50 University Recipients of DOD 6.1 Funding in Fiscal Year 2002

	Institution Name	State	Total 6.1 ($000)
1	**Massachusetts Institute of Technology**	MA	43,802
2	**Pennsylvania State University**, All Campuses	PA	35,357
3	**University of California, Los Angeles**	CA	31,784
4	**University of Washington**	WA	29,884
5	Stanford University	CA	25,811
6	**University of Southern California**	CA	25,758
7	Duke University	NC	25,607
8	**University of Michigan**, All Campuses	MI	24,245
9	University of California, San Diego	CA	24,117
10	**University of California, Santa Barbara**	CA	19,964
11	University of Illinois at Urbana-Champaign	IL	19,925
12	California Institute of Technology	CA	19,478
13	Georgia Institute of Technology, All Campuses	GA	19,098
14	Johns Hopkins University	MD	18,888
15	**University of Texas at Austin**	TX	17,044
16	Carnegie Mellon University	PA	16,527
17	**Cornell University**, All Campuses	NY	15,209
18	Princeton University	NJ	13,452
19	State University of New York, System Office	NY	12,598
20	Woods Hole Oceanographic Institution	MA	12,493
21	University of Pennsylvania	PA	12,282
22	Virginia Polytechnic Institute & State University	VA	11,476
23	**University of New Mexico**, All Campuses	NM	11,032
24	**University of Arizona**	AZ	10,977
25	University of Wisconsin - Madison	WI	10,389
26	University of Maryland System Administration	MD	10,334
27	University of Colorado, All Campuses	CO	10,303
28	Harvard University	MA	10,081
29	**Northwestern University**	IL	9,692
30	Purdue University, All Campuses	IN	9,479
31	**North Carolina State University at Raleigh**	NC	9,311
32	**Ohio State University**, All Campuses	OH	9,190
33	Arizona State University Main	AZ	9,051
34	University of Minnesota, All Campuses	MN	8,667
35	University of Virginia, All Campuses	VA	8,335
36	Rutgers, State University of New Jersey, All Campuses	NJ	8,262
37	University of Miami	FL	8,105
38	University of California, Davis	CA	7,776
39	University of California, Irvine	CA	7,672
40	Brown University	RI	7,491
41	Baylor College of Medicine	TX	7,040
42	Rice University	TX	6,918
43	San Diego State University	CA	6,893
44	University of North Carolina at Chapel Hill	NC	6,576
45	University of Pittsburgh, All Campuses	PA	6,305
46	New Mexico Institute of Mining and Technology	NM	6,129
47	Boston University	MA	6,005
48	University of South Carolina, All Campuses	SC	5,967
49	University of Florida	FL	5,947
50	University of Texas Southwestern Medical Center, Dallas	TX	5,862

Not a member of the Association of American Universities

SOURCE: Based on data provided in personal communication from Mark Herbst, Office of the Director of Basic Research, Office of the Secretary of Defense, Washington, D.C., to James Garcia, National Research Council, June 2004.

IEDs in Iraq - A telling example

- **Events on the ground demanded new tools and methods for counter-IED (a tough problem!)**
- **Early response focused on rapid deployment**
  - **Technical roadmap, training, and assessment functions when solving the IED problem became a national imperative**
  - **Premature introduction of hardware in theater generated backlash against promising technical directions**
- **JIEDDO has provided essential leadership and technical direction, but ...**
  - **It was formed and funded too late**
  - **Links to relevant research communities were not in place at the beginning; their establishment required major effort by senior JIEDDO staff, further delaying access to expertise**
  - **Funding drawn from existing programs**
    - Many activities were “re-labelling” of existing work, rather than coordinated efforts that could be directed toward most promising areas
    - Opportunity costs of continuing dead-end projects were substantial
- **Lesson: Well-established links between Acquisition and Research and between DOD and the research community might have:**
  - **Rapidly established a strategic plan necessary for an effective R&D effort**
  - **Enabled much needed triage of project ideas that had no serious chance of success**

Personnel Observations

Within academia

- Although DOD 6.1 research has a significant presence at many of the nation's leading research universities, it is not effectively leveraging these contacts to solve DOD S&T problems
- The DOD does not focus 6.1 funding on research of the highest caliber carried out by individuals with the potential to provide new paradigms for science and technology. DOD is getting what it asks for, but reducing the potential for true breakthroughs

Personnel Observations

Within academia

- Although DOD 6.1 research has a significant presence at many of the nation's leading research universities, it is not effectively leveraging these contacts to solve DOD S&T problems
- The DOD does not focus 6.1 funding on research of the highest caliber carried out by individuals with the potential to provide new paradigms for science and technology. DOD is getting what it asks for, but reducing the potential for true breakthroughs
- DOD is not adequately participating in the development and maintenance of the S&T educational pipeline
  - Relative to its size of basic research program, the DOD supports fewer pipeline activities than comparable NIH, NSF, DOE, … programs
    - NDSEG = 150/year *vs.* NSF = 1000/year

Organizational Observations

- **DOD is not effective in coordinating and overseeing the basic research program and funding across the department. In particular, OSD is structurally weak in determining and maintaining the quality and balance of basic research in DOD's intramural and external research programs**
  - The DDR&E is largely decoupled from the "cash flow" of the yearly budget process, both in the formulation of the research budgets proposed to Congress and in the direction of program funds appropriated by Congress
  - In some cases, the services have been able to redefine, or effectively eliminate, basic research activities within a single budget cycle
    - During the past decade, ONR has shifted its basic research toward a short-term focus inconsistent with DoD's definition
- **The bureaucracy associated with DOD research has grown to consume ever more time and has diverted program managers into administrative formalities at the expense of scientific program oversight**
- **The DOE labs (especially LLNL, LANL, and SNL) are similar to those of DOD in that they carry out basic research that ultimately leads to national security advances. They have a higher profile in basic research**

Program Recommendations

- **Focus on funding people and areas, not projects.**
  - The “payoff” to DOD is a cadre of people in the internal and external communities who are cognizant of both DOD needs and the forefronts of science, as well as the research itself
- **Ensure that 6.1 activities conform to the 6.1 definition**
  - Make the use of 6.1 funds transparent
  - The DDR&E should certify annually to the SecDef that 6.1-funded activities are basic research as defined by the DOD.
  - Non-conforming activities should be moved to other budget lines in subsequent years
- **Eliminate large fluctuations in 6.1 funding and schedules**
  - Long-term research efforts cannot be turned on and off with yearly budget cycles and service rotations
  - Stable funding is more productive than more funding
  - Avoid “War of the Month”

Personnel Recommendations

- **Establish a Research Corps within each Service**
  - Comprised of individuals from the military and civilian workforce who are involved in the research enterprise (DOD labs, DOD research agencies)
    - ***cf.* service medical corps or acquisition corps**
  - Professionalism, training, career paths, Defense-wide mobility, visibility, and esprit all help address the problems of research personnel within DOD
- **The DOD labs should house some researchers well-coupled to the broader communities**
  - DOD needs to develop a culture where in-house science and research is valued as critical to the long term health of the department
  - Lab focus should be on 6.2 and above, but they should house small cadres of high-quality basic researchers
  - Research leaves to academic / industrial / other USG labs could help toward these ends
  - Lab postdoctoral programs should be enhanced to attract young researchers

Personnel Recommendations (Universities)

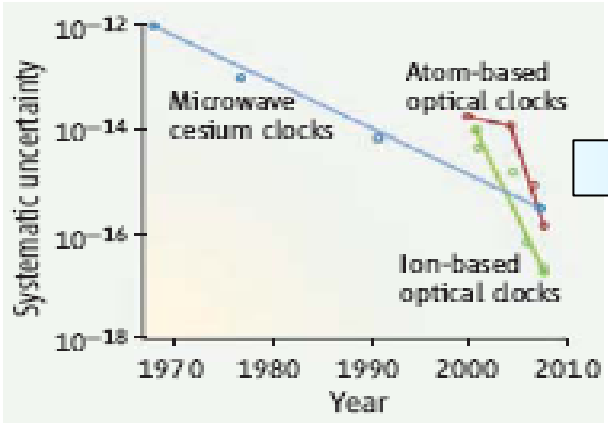
- **Undergraduates**
  - Consider outreach and summer internships rather than scholarships; (e.g., REUs)
  - DOD has many attractions to offer (field tours, explosives research, …)
- **Consider other models in addition to PI-driven graduate student and postdoctoral support:**
  - Graduate training grants (NSF, NIH, HHMI)
    - Integrate education and research (i.e., DOD labs)
    - Prestige is a very important element
  - Vertically integrated approaches
    - Postdocs + grads + undergraduate research experience
    - Teaching training
    - Creates broad network of researchers as graduates move on to industrial/academic/government positions

Organizational Recommendations

- **Protect 6.1 funding at the OSD level by strengthening and expanding the role of the DDR&E**
  - The Secretary of Defense should empower the DDR&E to substantively review and comment on the services 6.1 budget requests before these requests are sent to Congress.
  - The Secretary of Defense should empower the DDR&E to review and reprogram basic research funds appropriated by Congress before these funds are distributed to the services
  - Line acquisition and operational leaders should have input to, but not decision authority over, the 6.1 budget
- **Create a basic research advisory committee reporting to the USDATL**
  - DDR&E and appropriate service are members
  - Equal number of external members from academia, industry
  - Advises annually on health of DOD basic research (program, personnel, organization)

The way it's supposed to work

Atomic Clocks



GPS

JDAM

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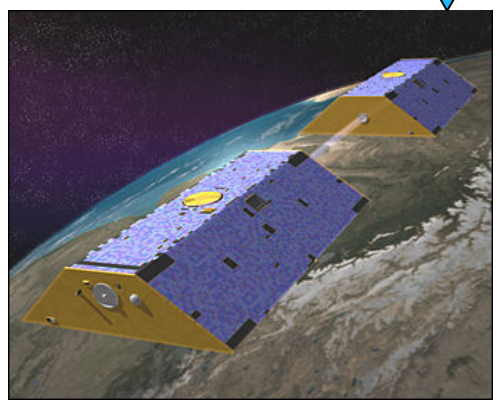

GRACE