Defense Advanced Research Projects Agency

Bridging the Gap

Dr. Anthony J. Tether
DARPA Director

DARPA Organization

Director, Tony Tether
Deputy Director, Bob Leheny

Information Exploitation
Ted Bially
Bob Tenney/Bob Popp

Sensors

Exploitation Systems

Command & Control

Tactical Technology
Art Morrish
Gary Graham/Stephen Welby

Air/Space/Land Platforms
Unmanned Systems
Space Operations
Laser Systems
Future Combat Systems
Planning / Logistics

Special Projects
Amy Alving
Joe Guerci

Chem/Bio Def Systems
Counter Underground Facilities
Space Sensors/Structures
Navigation/Sensors/ Signal Processing

Advanced Technology
Dave Honey
Larry Stotts

Assured C3ISR

Maritime

Early Entry/Special Forces

Joint Unmanned Combat Air Systems
Mike Francis

Common Systems & Technologies
 X-45 System
 X-47 System

Defense Sciences
Steven Wax
Brett Giroir

Bio Warfare Defense Technologies
Biology
Materials & Devices
Mathematics

Information Processing Technology
Ron Brachman
Barbara Yoon

Cognitive Systems
Computational - Perception
Representation & Reasoning
Learning
Natural Communication

MicrosystemsTechnology
John Zolper
Dean Collins

Electronics
Optoelectronics
MEMS
Combined Microsystems

DARPA Role in Science and Technology

DARPA Role in Science and Technology

DARPA Accomplishments

Saturn

1960

Vela Hotel

M-16 Rifle

1970

ATACMS

Ground Surveillance Radar

ARPANet

Stealth Fighter

1980

JSTARS

Sea Shadow

GPS

X-45

Mobile Robots

JSF Engine

2000

MEMS

Future Combat System

Global Hawk

Uncooled IR

1990

Predator

Taurus Launch Vehicle
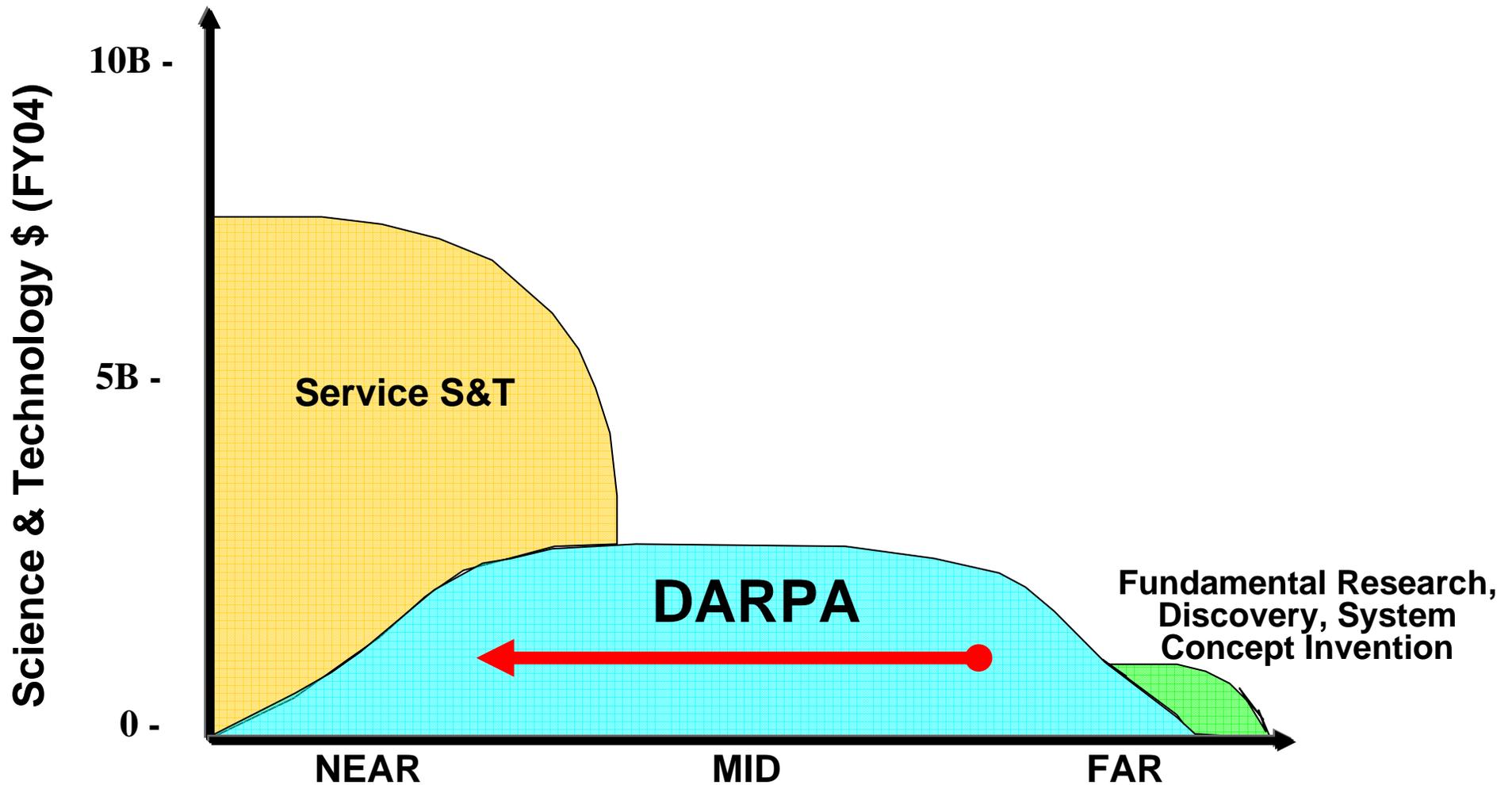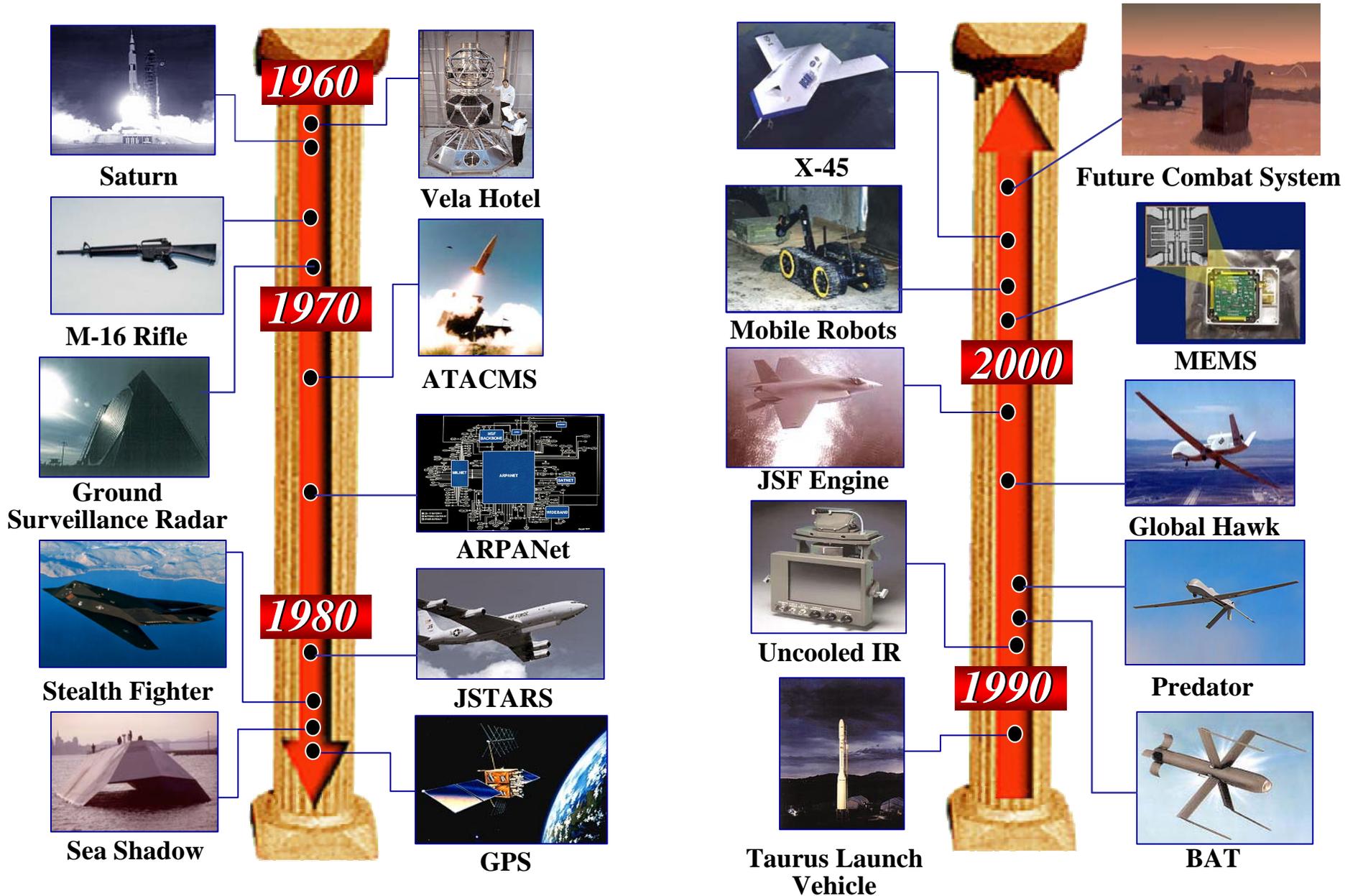
BAT

President's Budget

(Millions of Dollars)

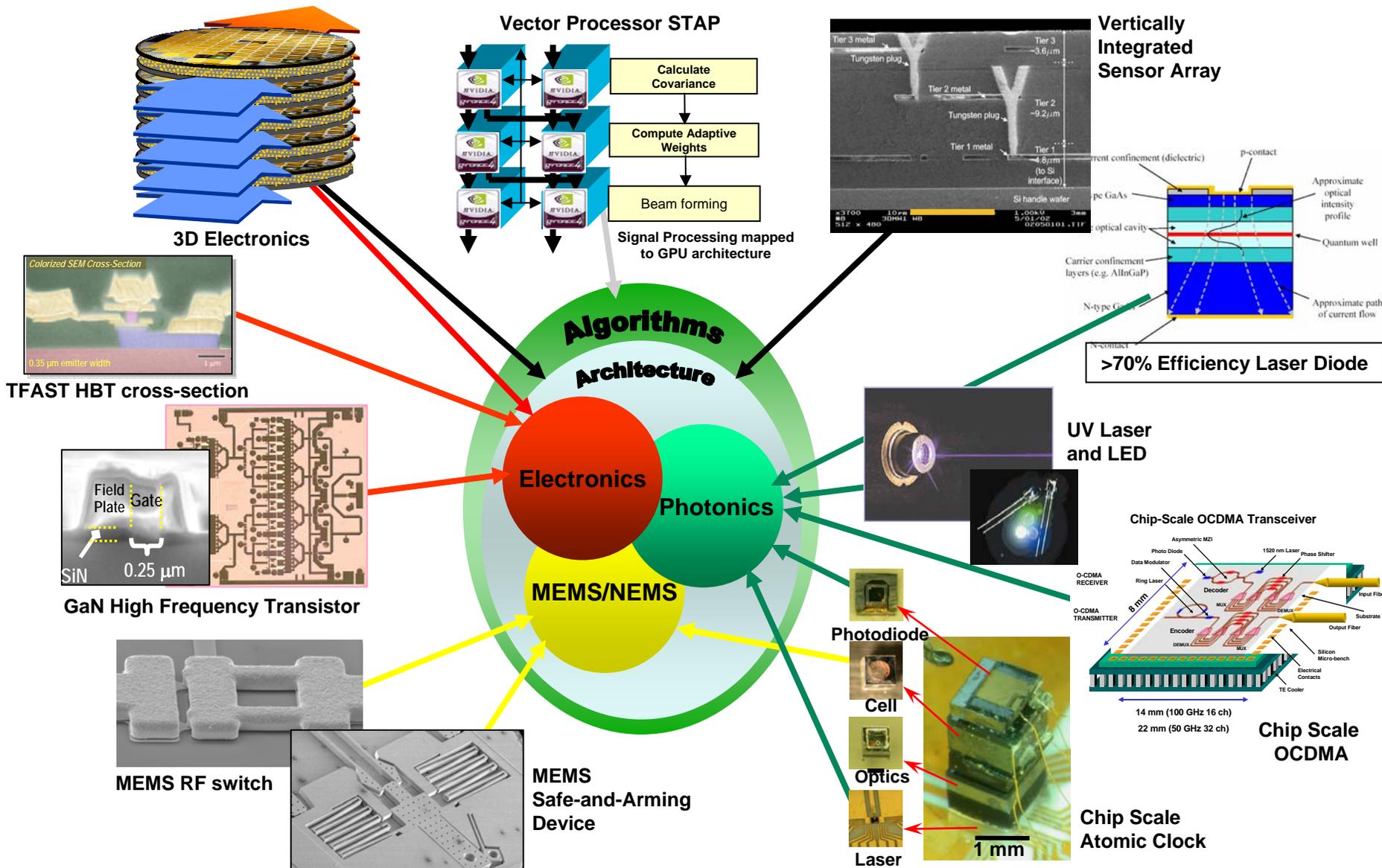| FY 2004	FY2005	FY 2006	FY 2007
2,815.4	2,976.7	3,083.8	3,358.6

QDR Operational Goals for Transformation

- **Protecting critical bases of operations** (U.S. homeland, forces abroad, allies, and friends) and defeating chemical, biological, radiological, nuclear, and enhanced high explosive (CBRNE) weapons and their means of delivery

- **Denying enemies sanctuary** by providing persistent surveillance, tracking, and rapid engagement with high-volume precision strike, through a combination of complementary air and ground capabilities, against critical mobile and fixed targets at various ranges and in all weather and terrains

- **Projecting and sustaining U.S. forces** in distant anti-access or area-denial environments and defeating anti-access and area-denial threats

- **Assuring information systems** in the face of attack and conducting effective information operations

- **Leveraging information technology** and innovative concepts to develop an interoperable, joint C4ISR architecture and capability that includes a tailorable joint operational picture

- **Enhance the capability and survivability of space systems** and protect the infrastructure that supports critical space capabilities

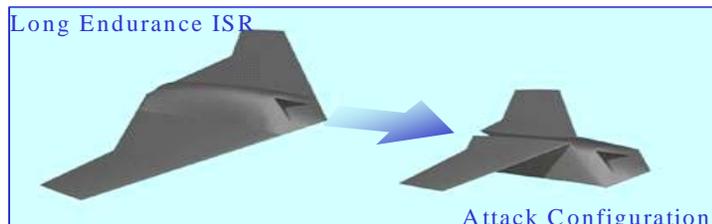# Budget by QDR Transformation Goals
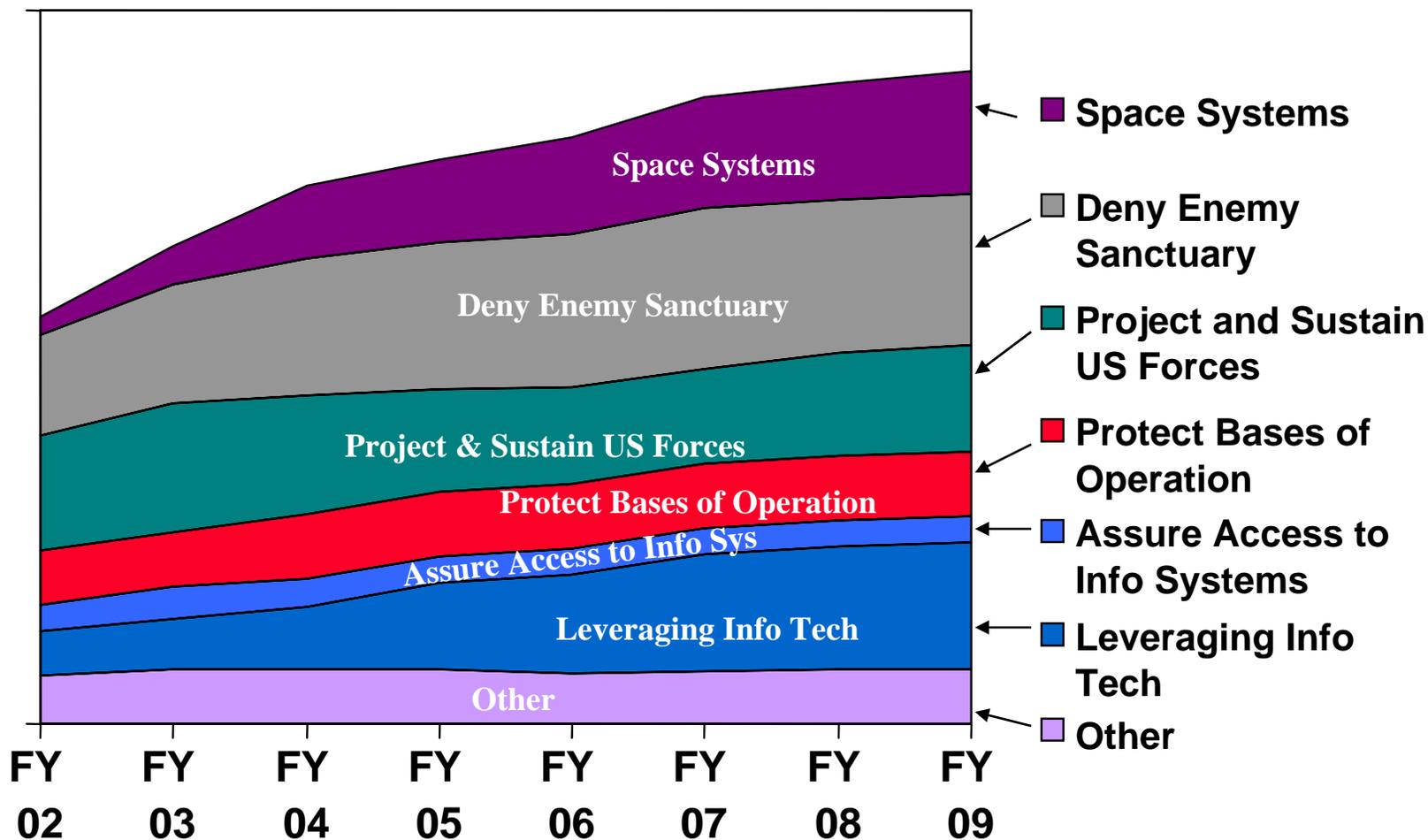
Core Technology - Electronics

DARPA

Vector Processor STAP

Calculate Covariance

Compute Adaptive Weights

Beam forming

Signal Processing mapped to GPU architecture

Vertically Integrated Sensor Array

Tier 3 metal | Tier 3 ~3.6 μm
Tungsten plug | Tier 2 metal | Tier 2 ~9.2 μm
Tier 1 metal | Tier 1 ~4.8 μm (to Si interface)
Si handle wafer

>70% Efficiency Laser Diode

3D Electronics

TFAST HBT cross-section

Colorized SEM Cross-Section
0.35 μm emitter width

GaN High Frequency Transistor

Field Plate | Gate
SiN | 0.25 μm

MEMS RF switch

MEMS Safe-and-Arming Device

Algorithms
Architecture

Electronics

Photonics

MEMS/NEMS

UV Laser and LED

Chip-Scale OCDMA Transceiver

O-CDMA RECEIVER
O-CDMA TRANSMITTER
8 mm
Photo Diode
Data Modulator
Ring Laser
Decoder
Encoder
DEMUX
MUX
Asymmetric MZI
1520 nm Laser
Phase Shifter
Input Fiber
Output Fiber
Substrate
Silicon Micro-bench
Electrical Contacts
TE Cooler

14 mm (100 GHz 16 ch)
22 mm (50 GHz 32 ch)

Chip Scale OCDMA

Photodiode

Cell

Optics

Laser

1 mm

Chip Scale Atomic Clock

Core Technology – Materials

DARPA

Smart Materials

Long Endurance ISR

Attack Configuration

Morphing Aircraft

EXOSKELETON
Soldier Support

Materials for Logistics

Water Harvesting
Obtain Water from Air

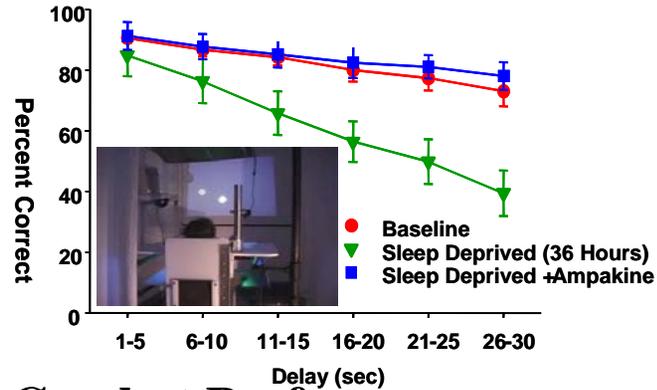New Energy Sources
To Replace Batteries

Structural Materials

0   3cm   30μm

Ti-6-4 Alloy

Baseline Ti alloy

1mm
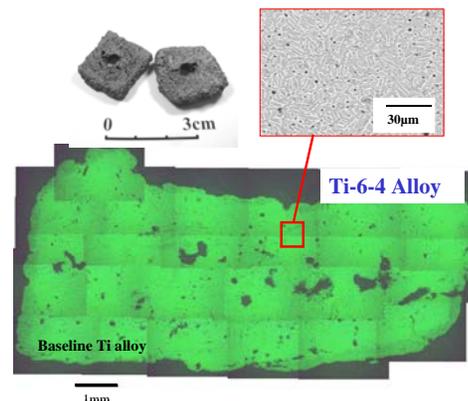
Low Cost Titanium
Less than $2 lb!

Multi-functional
Materials

Functional Materials

10x Reduction in UHF Antenna Size

Bio-Revolution

Maintaining Combat Performance

Revolutionizing Prosthetics

Bio-Inspired Robotics and Sensors
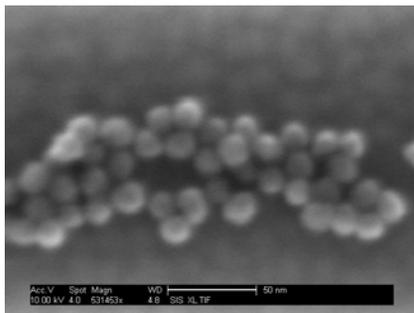
Bio-Magnetics Bio-Fabrication

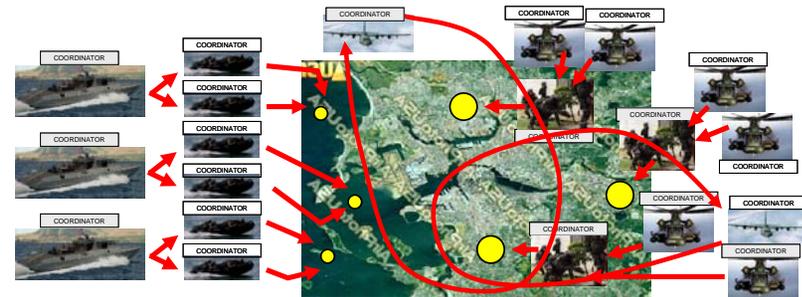**Biologically
Integrated, Fully
Functional Limb
Replacements
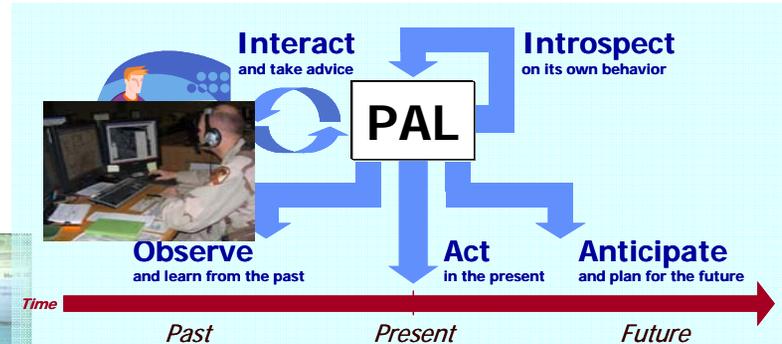Controlled by the
Brain**

Computer Science
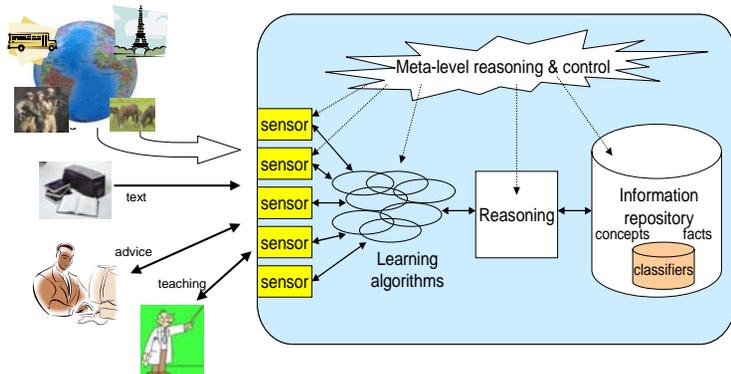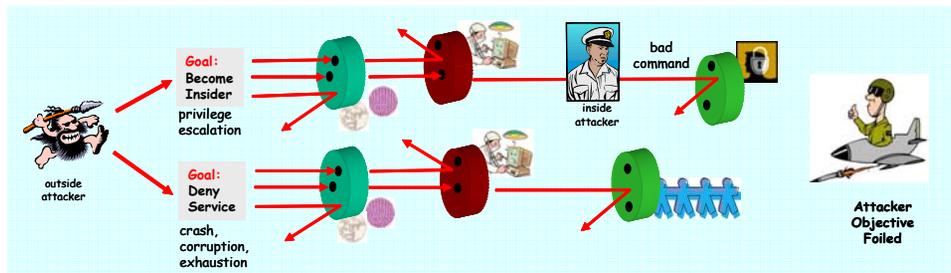
New ways for computers to learn

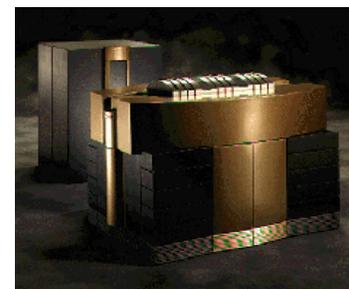Computer coordination managers to help adapt mission plans online

Ground robots that learn to navigate

Integrated cognitive assistants that perceive, reason and learn

Self-regenerative software systems

Radically new high-productivity computing systems

Upcoming Key Events

DARPATech 2005
24th DARPA Systems & Technology Symposium

August 9 – August 11, 2005

Anaheim, California

GRAND CHALLENGE

National Qualification Event
September 28 – October 5, 2005
Fontana Speedway

Grand Challenge Event
October 8, 2005
Southwestern United States
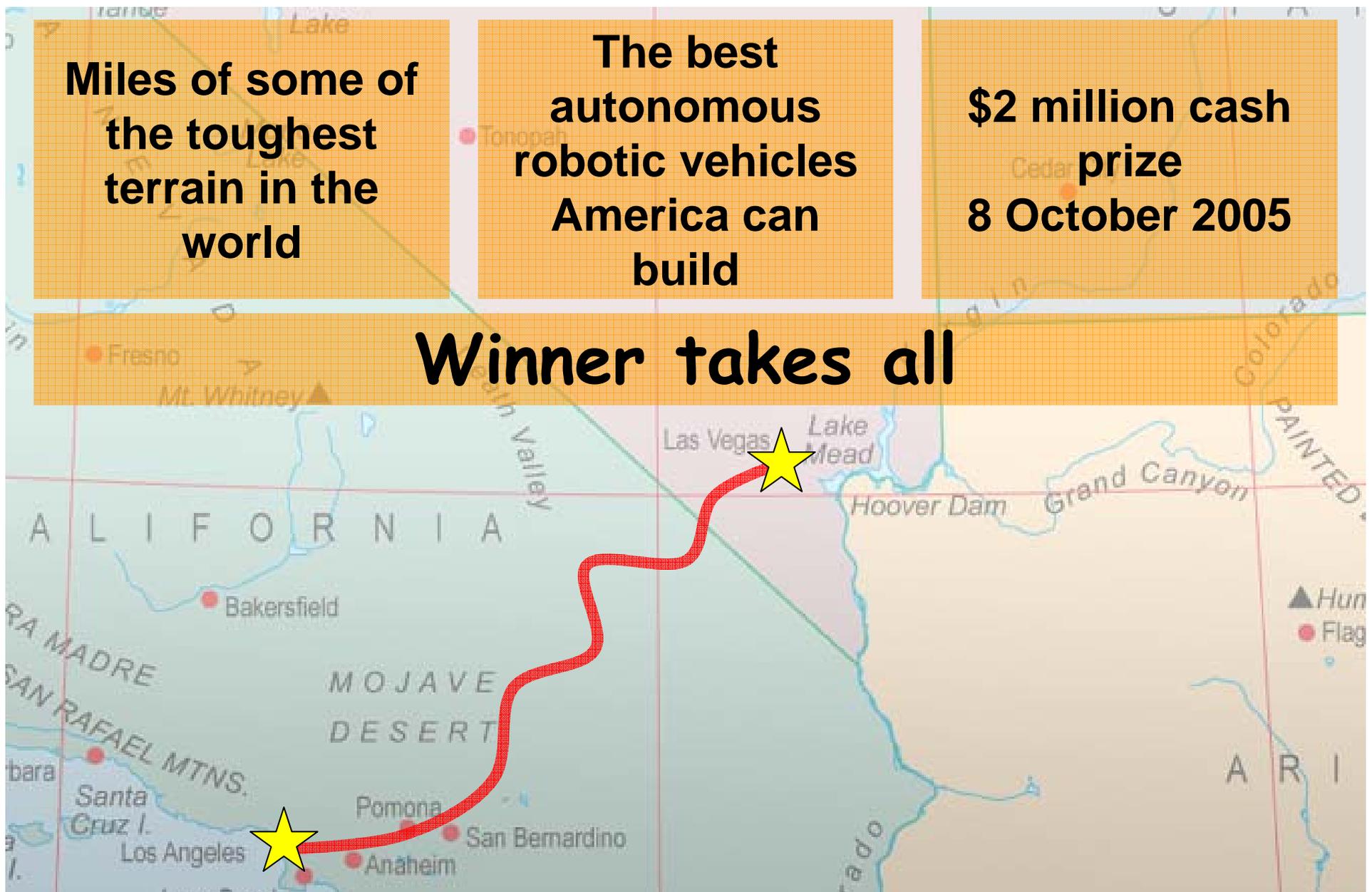
The DARPA Grand Challenge

Miles of some of the toughest terrain in the world

The best autonomous robotic vehicles America can build

**$2 million cash prize
8 October 2005**

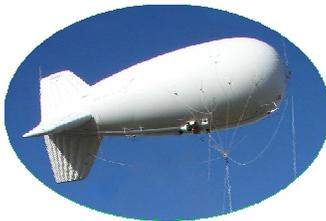**Winner takes all**

Grand Challenge Applicants for 2005 Event

195 teams from 36 states
3 High Schools / 35 Universities

Palos Verdes HS Road Warriors

Rapid Reaction Support to Warfighters

Gun Truck

**Marine Airborne
Re-Transmission System**

eTIRR

DARPA TIDES Iraq Reconstruction Report

Boomerang

Rapid Tactical Language Training

"DARWARS"
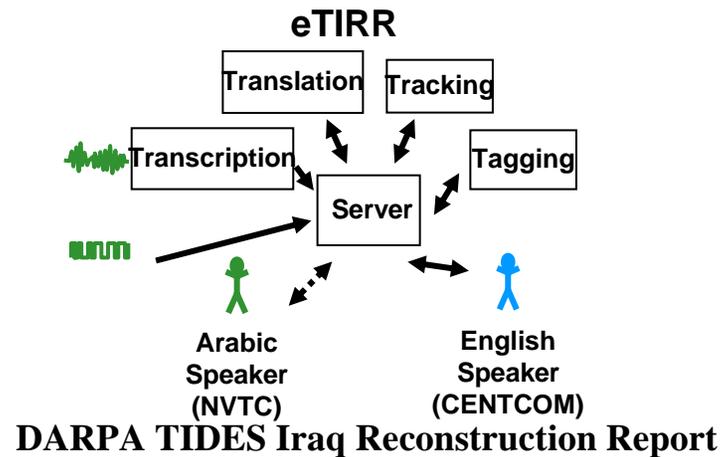
Phraselator – Translator

MIOX Disinfection Pen

Command Post of the Future (CPOF)

What Happened to University Funding (Especially Computer Science)?

DARPA Funding, Selected Universities FY99 - FY04

DARPA Funding of Universities and Computer Science

FY02 to FY04	Average Funds to University Performers*	Average Overall DARPA Funds	University Percentage
6.1 Basic Res	$90.1M	$150.3M	60%
6.2 Applied Res	$270.4M	$1,128M	24%
6.3 Adv.Tech. Dev.	$92.3M	$1,076.3M	8.6%
Total	$452.8M	$2,354.3M	19.2%

DARPA Computer Science Funding Trends ($M)

Average = $578M

FY 04 Constant Dollars
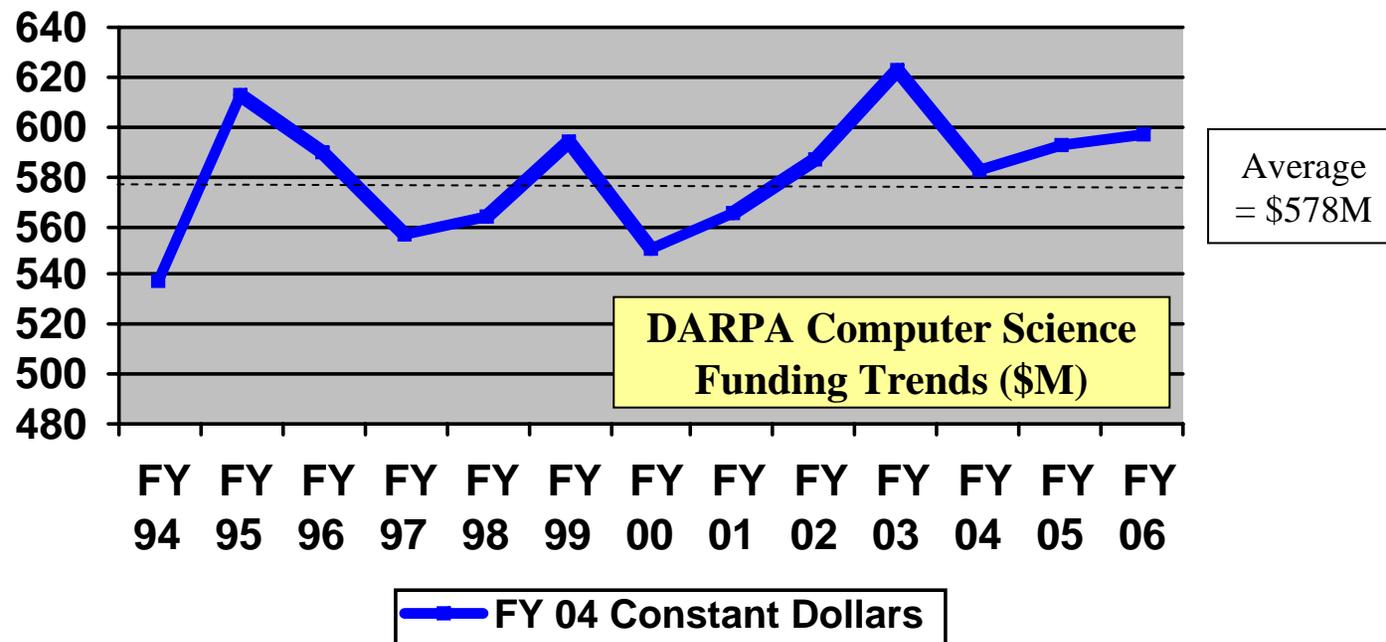
Summary

- Where did the money go since overall University funding has not gone down?
  - Accomplished survey of University websites
    - Discovered that multi-disciplinary efforts are the wave of the future

- We agree with the Universities

- But we also believe that the individual Disciplines need to be funded

  - Healthy funding of individual disciplines required to assure that multi-disciplinary efforts can be done

  - Block grant funding is a vehicle
    - All disciplines, not just Computer Science

- DoD is doing its part
  - National Defense Graduate Fellowship
  - Building on SMART program Congress established in FY05 (DARPA has 2 Interns)
  - Multi-disciplinary University Research Initiative (MURI)
  - Focused Research centers (Microelectronics, Nanotechnology, Cognitive?)

Focus Center Research Program (2004)

Sponsors:

SIA — SEMICONDUCTOR INDUSTRY ASSOCIATION

AMD
Analog Devices
Conexant
Cypress
IBM
Intel

LSI Logic
Micron
Motorola
National
TI
Xilinx

Air Products
Applied Materials
Cadence
Novellus
Teradyne

Department of Defense

DUSD (LABS)

DARPA

GSRC – Gigascale System Research Center

The University of California at Berkeley is the lead university for the System Design and Test Focus Center (Gigascale System Research Center--GSRC) and Prof. Jan Rabaey the center's director. The Design and Test Center's research agenda addresses the design, verification, and test of complex, heterogeneous (embedded) systems-on-a-chip/package, covering the complete spectrum from system specification to implementation on emerging circuit fabrics.

Prof. Jan Rabaey

C2S2 – Center for Circuits, Systems, and Solutions

The Focus Center for Circuit and System and Software (C2S2) is led by the Carnegie Mellon University. Professor Rob Rutenbar is the center director. The center's research focuses on inventing the circuit techniques and system concepts needed for integrating heterogeneous devices as well as converting end-of-roadmap devices and the promising post-CMOS devices into robust performance across the most diverse range of applications.

Prof. Rob Rutenbar

IFC – Interconnect Focus Center

The leadership for the Interconnect Focus Center (IFC) is based at the Georgia Institute of Technology. Professor James Meindl is the focus center director. The center's research teams examine high conductance nanoscale electrical interconnects, optical interconnects that will scale to meet the needs of future gigascale silicon electronic systems, novel thermal management solutions and interconnect driven circuit and system design.

Prof. James Meindl

MSD – Materials, Structures, and Devices

The Massachusetts Institute of Technology is the lead university for the Materials, Structures, and Devices (MSD) Center and Prof. Dimitri Antoniadis its director. This center will push CMOS scaling to its ultimate limit through advanced FETs incorporating novel materials and explore new frontier devices such as nanotube devices, molecular devices and spin based FETs, with due emphasis on coupling experiment with theoretical modeling and simulation .

Prof. D. Antoniadis

FENA – Functional Engineered Nano Architectonics

The University of California at Los Angeles is the lead University for the Center for Functional Engineered Nano Architectonics (FENA) and Professor Kang Wang the center director. This center will research into critical nanomaterials and process challenges that address the core problems of nanoscale device technology. FENA will examine novel nanoscale materials and structures, with potential to be incorporated in devices and architectures of the future

Prof. Kang Wang

UC-Berkeley

Caltech	Stanford
CMU	UCLA
Ga Tech	UCSB
Michigan	UC SC
MIT	UCSD
Penn State	UIUC
Princeton	**U T Austin**
Purdue	

CMU

Columbia	UCLA
Cornell	UCSD
Ga Tech	U. Florida
MIT	UIUC
Stanford	U Washington
UC-Berkeley	

Georgia Tech

CMU	U at Albany
Cornell	UCBerkeley
MIT	UCSB
NC State	U . Central Florida
RPI	**UT Austin**
Stanford	

MIT

Caltech	UC Berkeley
Cornell	UCLA
NC State	UC SB
Penn State	U Florida
Princeton	U Maryland
Purdue	**UT Austin**
Stanford	U Virginia
U at Albany	

UC-Los Angeles

Arizona State	UC Riverside
Caltech	U at Stony Brook
MIT	UCSB
NC State U	U Minnesota
UC Berkeley	USC
UCLA	

Questions?