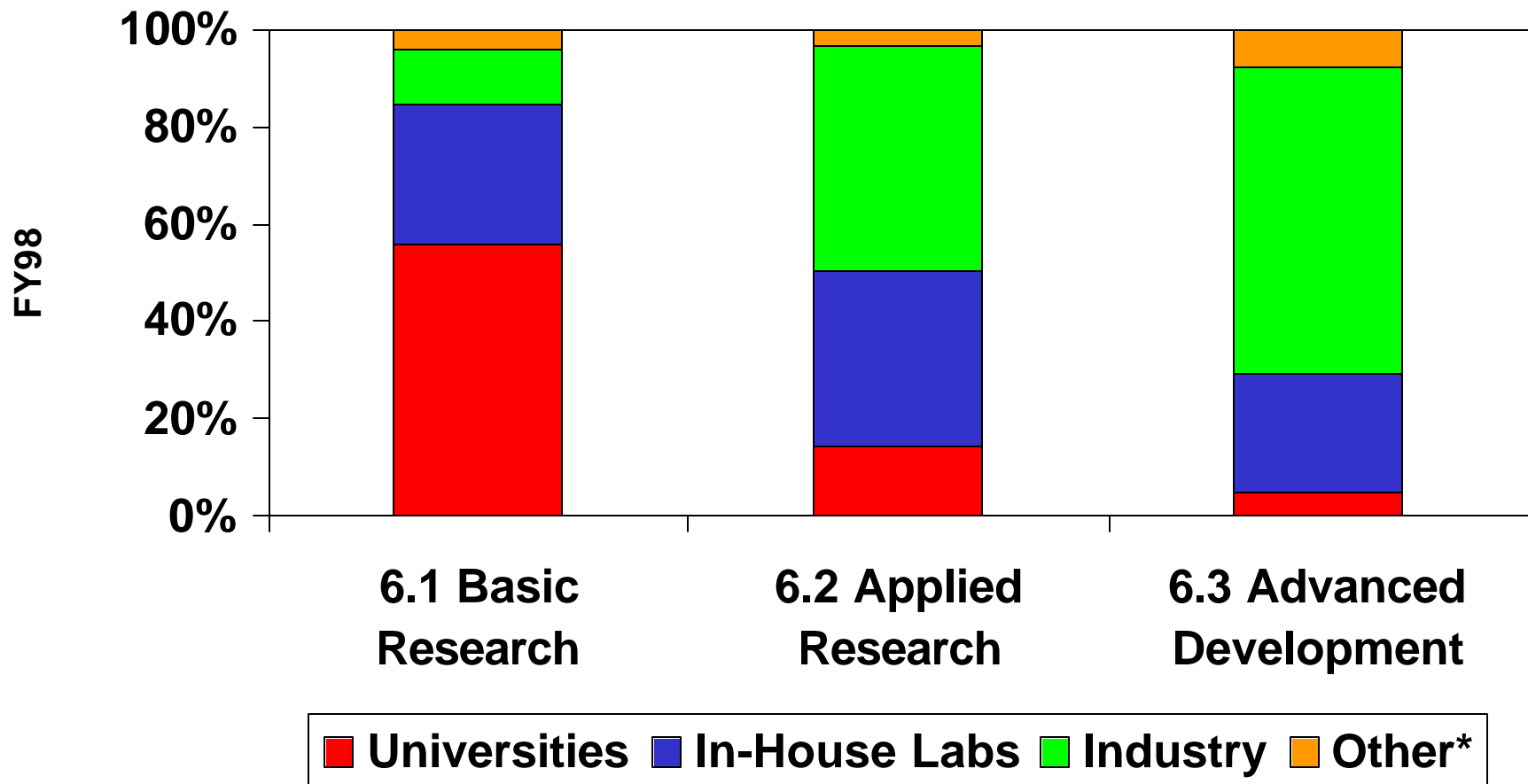# Computer Science
Research Directions
at the Office of Naval Research

12 February 2002

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Math, Computer, & Information Sciences Division

Office of Naval Research

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From Which DoD Accounts do Universities Receive Support?

FY98

100%
80%
60%
40%
20%
0%

6.1 Basic Research
6.2 Applied Research
6.3 Advanced Development

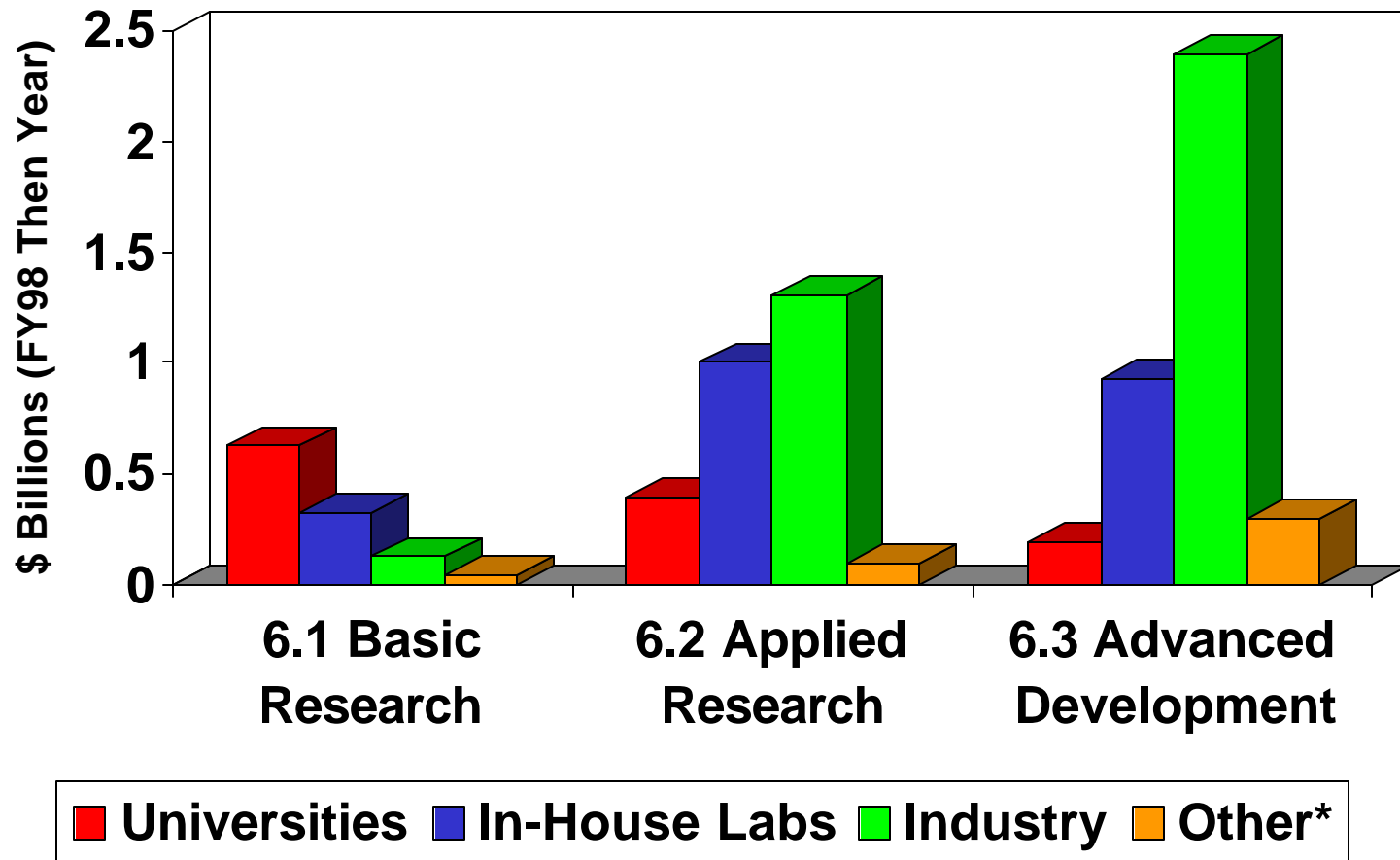■ Universities ■ In-House Labs ■ Industry ■ Other*

*Includes non-profit institutions, State & local govt., & foreign institutions
Source: National Science Foundation Report, NSF 98-332 (FY 1998)

How Much do Recipients of DoD S&T Funds Get?

Chart: $ Billions (FY98 Then Year) by research category

Legend: ■ Universities ■ In-House Labs ■ Industry ■ Other*

Categories: 6.1 Basic Research, 6.2 Applied Research, 6.3 Advanced Development

*Includes non-profit institutions, State & local govt., & foreign institutions
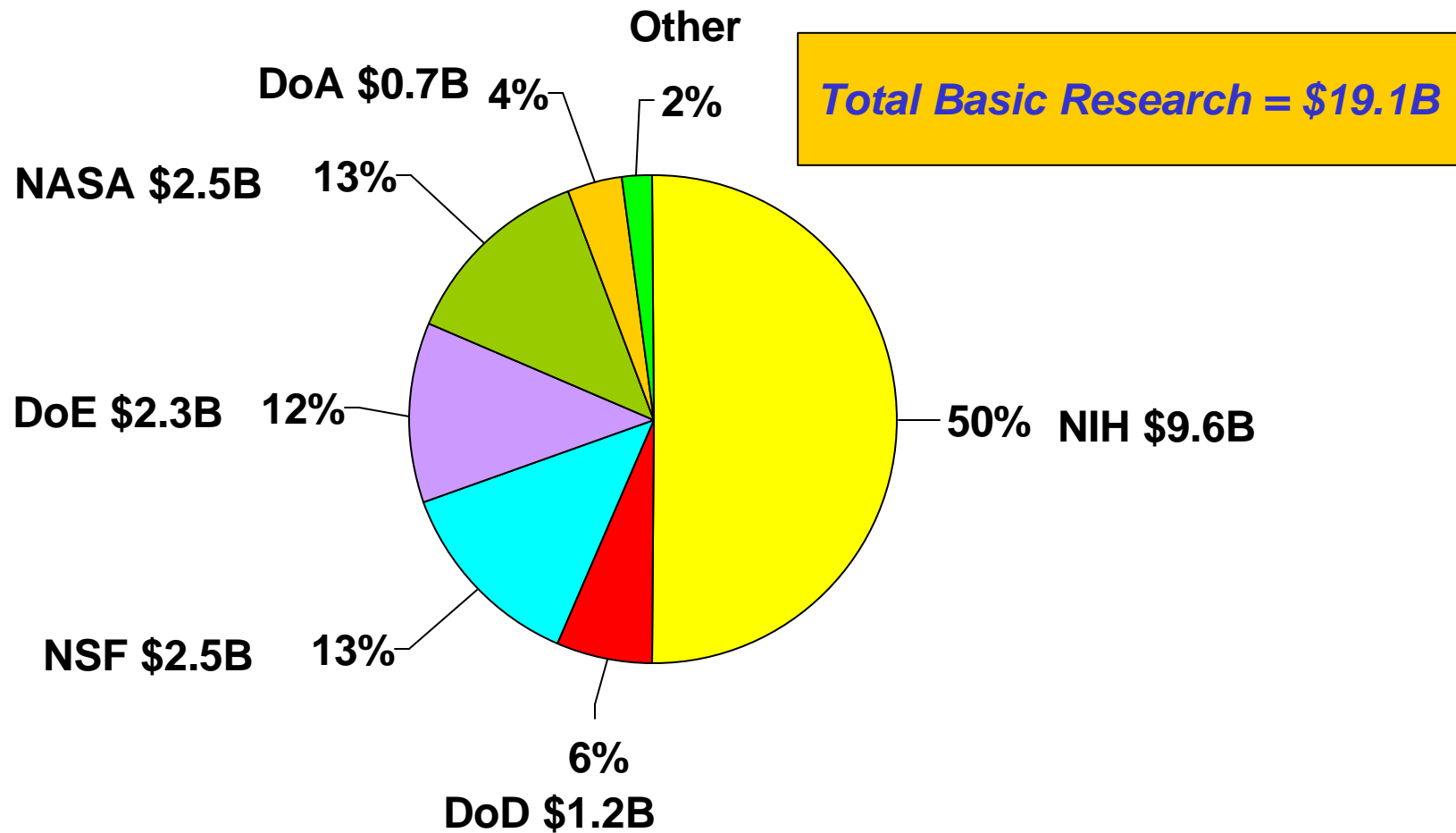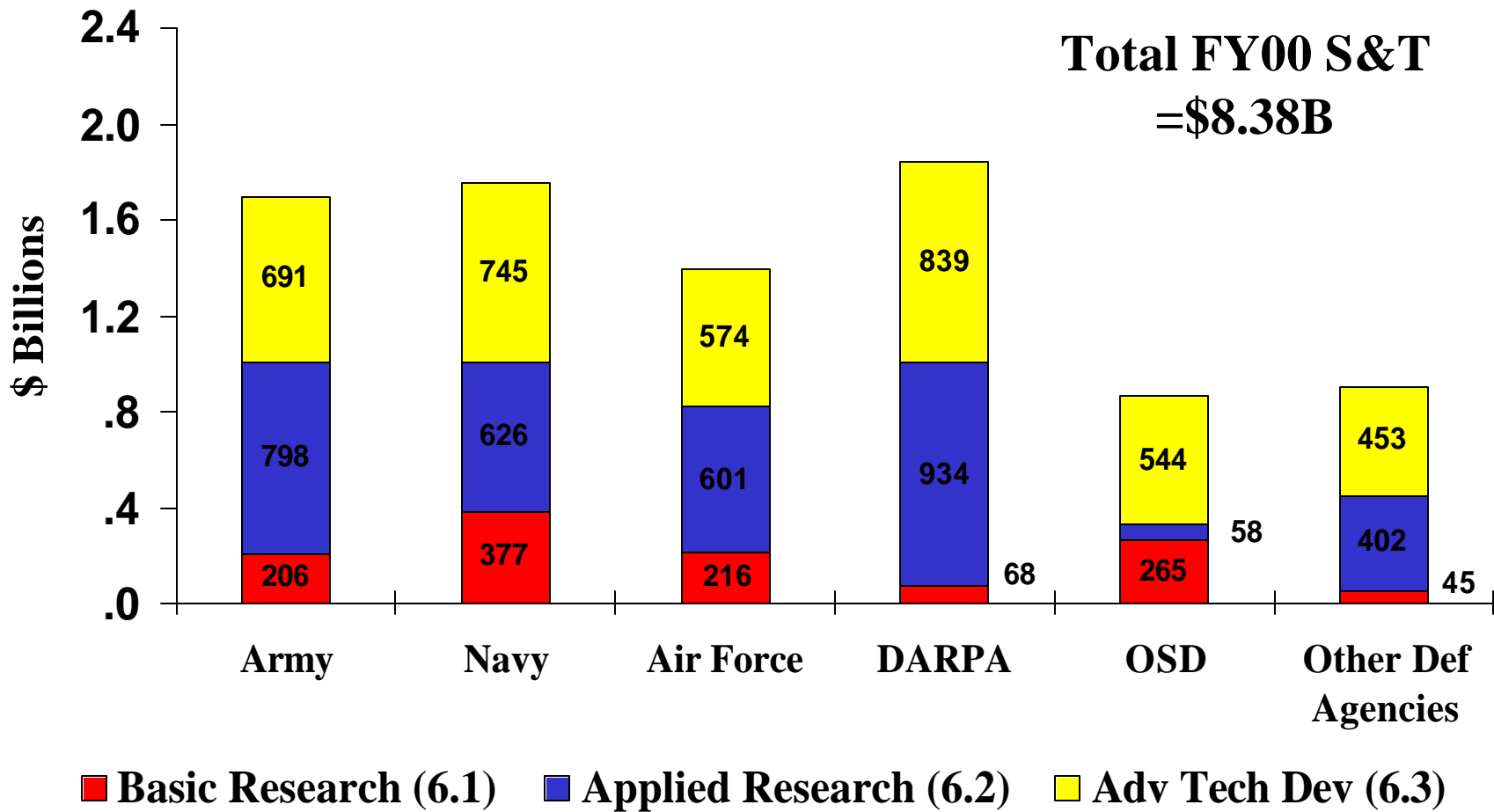Source: National Science Foundation Report, NSF 98-332 (FY 1998)

Federally Funded Basic Research Distribution by Source for FY00

Total Basic Research = $19.1B

Other 2%

DoA $0.7B 4%

NASA $2.5B 13%

DoE $2.3B 12%

NSF $2.5B 13%

50% NIH $9.6B

6% DoD $1.2B

FY00 DoD S&T Appropriations Budget

Total FY00 S&T = $8.38B

$ Billions

	Army	Navy	Air Force	DARPA	OSD	Other Def Agencies
Adv Tech Dev (6.3)	691	745	574	839	544	453
Applied Research (6.2)	798	626	601	934	58	402
Basic Research (6.1)	206	377	216	68	265	45

■ Basic Research (6.1) ■ Applied Research (6.2) □ Adv Tech Dev (6.3)

DoD Basic Research Funding by Discipline (FY99)

Cognitive & Neural Sci. 6%
Physics, 8%
Chemistry, 7%
Biological Sci. 13%
Mathematics, 5%
Atm. & Space Sci. 5%
Computer Science, 8%
Ocean Sci. 10%
Terrestrial Sci. 2%
Electronics, 16%
Mechanics, 10%
Material Sciences, 11%
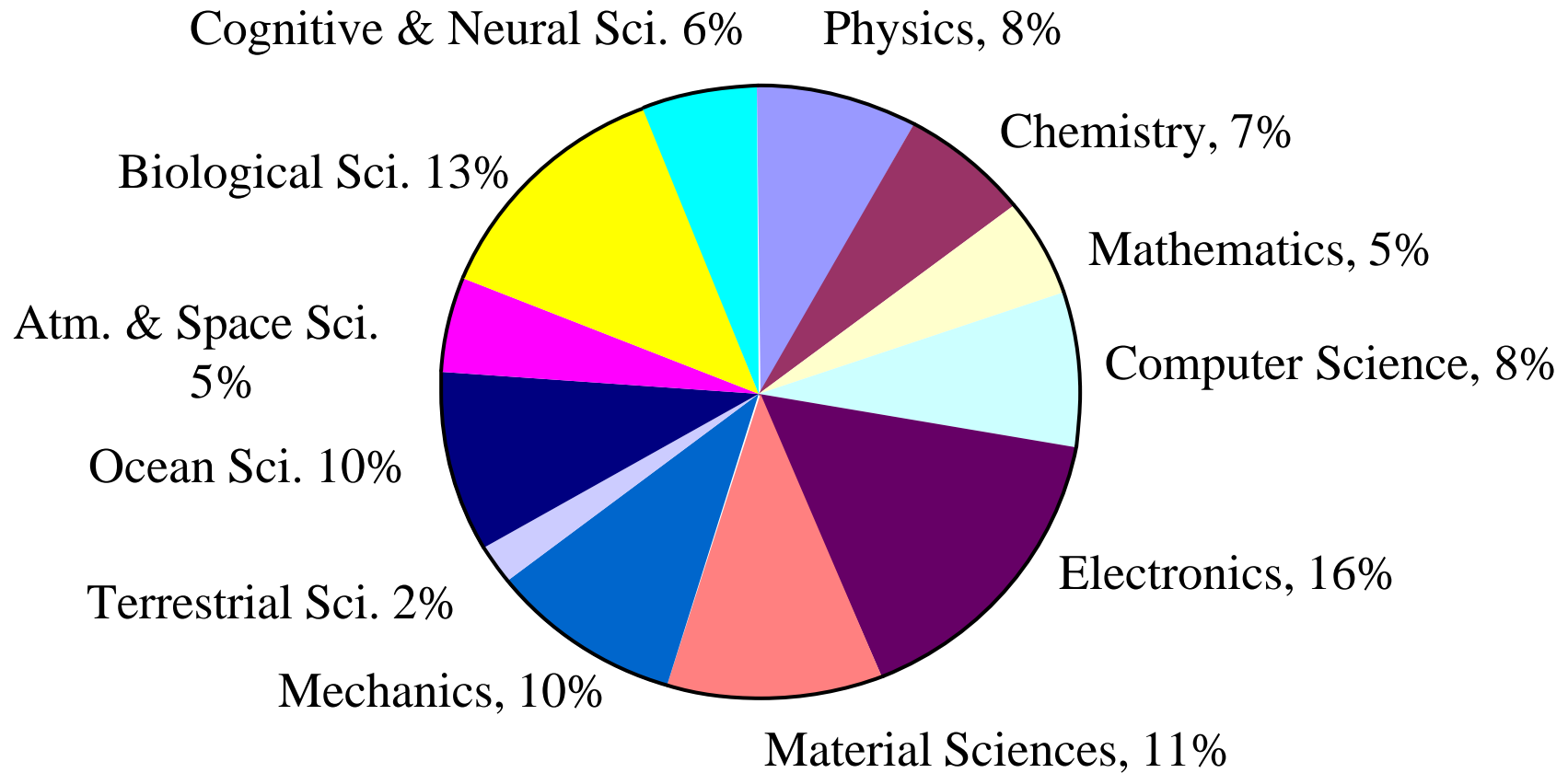
IT Technical Thrusts

- Networks and Communications

- Information Assurance

- Autonomous Systems

- Sensor and Information Integration

- Advanced Computing Architectures

- Foundations of Modeling and Simulation

ONR Organization

ONR 311

Information, Electronics & Surveillance

Mathematics
Computer Science
C² and Combat Systems
Electronics
Surveillance
Communications
Electronic Combat

Ocean, Atmosphere & Space

Oceanography
Atmospherics
Astrometry& Space
Undersea Sensor/
Surveillance
Mines/MCM/ EOD/SPECWAR
Marine Corps

Engineering, Materials & Physical Sciences

Physics
Chemistry
Environmental Quality
Materials
Mechanics
Energy Conversion &
Explosives
Ships & Submarines
Undersea Weapons

Human Systems

Biological, Health & BW/CW
Cognitive & Neural Sciences
and Human Factors
Biorobotics
Training & Training Devices
Bioremediation, Biofouling
Personnel & Clothing
Logistics/Shore Facilities/
Waterfront

Naval Expeditionary Warfare

Surface/Air
Weapons
Aircraft
Low Obs/Counter Low Obs
Marine Corps

Industrial & Corporate Programs

SBIR
MANTECH / MANSCIENCE
Navy Dual-Use
Technology Program
Tech Transfer/IR&D
Special Programs

ONR Math & CS Division Responsibilities

- **6.1 Basic Research (Funding level ~$36M)**
  - Applied & Numerical Analysis   **Dr. Wen Masters, Dr. Reza Malek-Madani**
  - Intelligent Systems   **Dr. Behzad Kamgar-Parsi**
  - Operations Research   **Dr. Donald Wagner**
  - Probability & Statistics   **Dr. Wendy Martinez**
  - Software & Systems   **Dr Ralph Wachter**
  - Autonomous Systems   **Dr. Behzad Kamgar-Parsi**
  - Visualization & Computer Graphics   **Dr Larry Rosenblum**

- **6.2 & 6.3 Applied and Exploratory Research (Funding level ~$51M)**
  - **Command & Control and Combat Systems**   **Mr. Gary Toth**
  - **CINC 21 ACTD**   **Dr. Susan Hearold**
  - **USMC C4I S&T**   **Mr. John Moniz, LtCol Gerry Nalepa**
  - **Natl Adv Telecommunications & Application Ctr**   **Mr. John Moniz**
  - **Battlespace Info Display Tech**   **Dr. Larry Rosenblum**
  - **Dominant Battlespace Command**   **LCDR David Jakubek**
  - **Navy Collab Integrated Info Tech Initiative**   **Mr. Gary Toth**
  - **National Technology Alliance**   **Mr. Ken Hamilton**
  - **Information Security Engineering**   **Dr. Ralph Wachter, Mr. Frank Deckelman**
  - **Virtual Operations Network**   **LCDR David Jakubek**

- **Future Naval Capabilities (Funding level ~$75M)**
  - **Knowledge Superiority and Assurance**   **LCDR David Jakubek**
  - **Missile Defense - Distributed Weapons Control**   **Mr. Robert Hicks, Mr. Roger Boughton**
  - **Time Critical Strike - Real-Time Execution Dec Sppt**   **Mr. BJ Ramsay**

Future Naval Operational Concept - FORCENet

The Vision

Forward-Deployed Forces (FDF) fully netted with hundreds of manned and unmanned air, sea and undersea vehicles coming in and out of areas of interest and adding to the actionable knowledge base
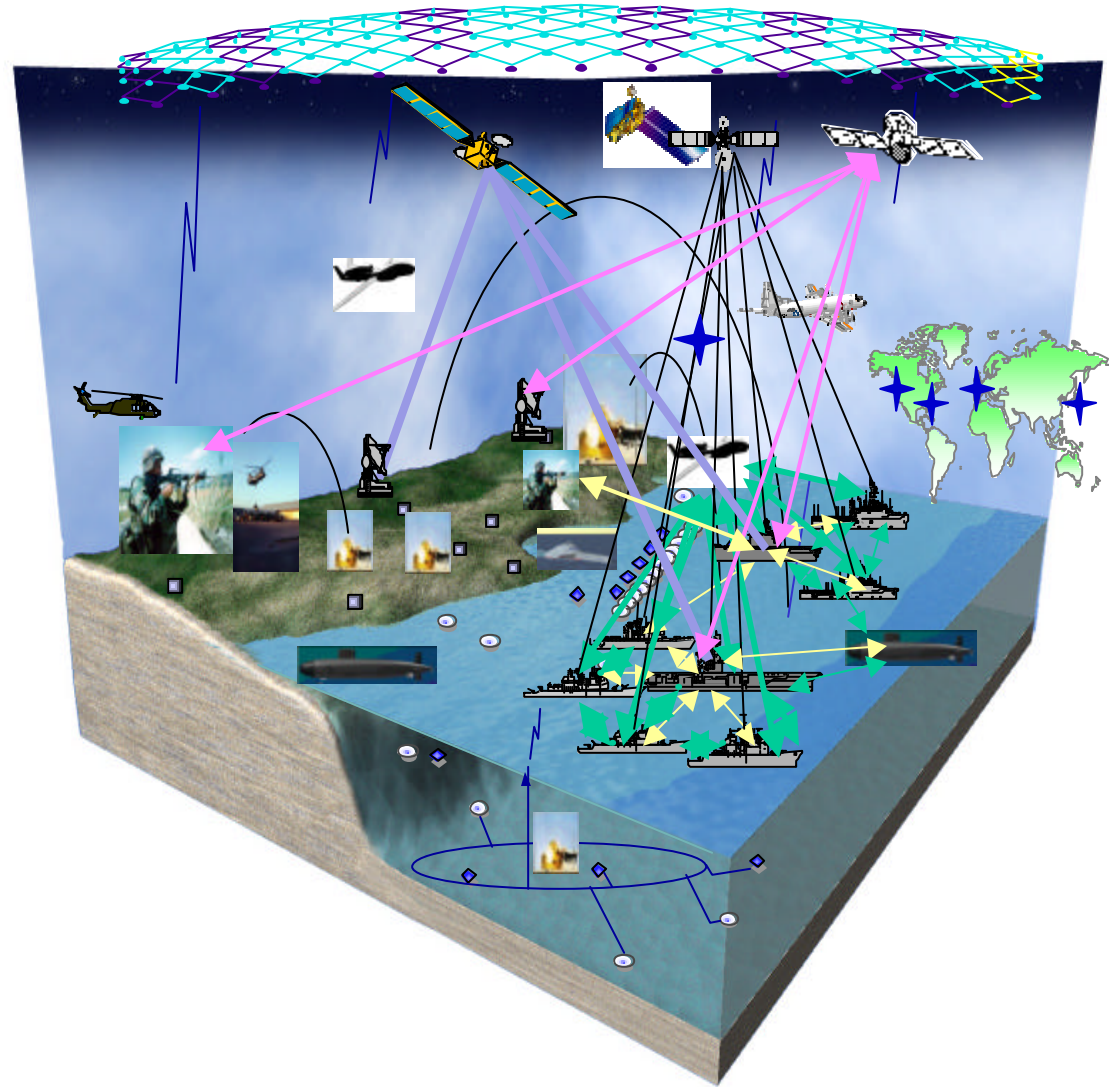
ONR Math & CS Division
Major Technical Thrusts

- **Robotic Sensors and Control**
- **Machine Reasoning and Planning**
- **Intelligent Software Agents**
- **Speech and Natural Language Processing**
- **Dependable Computing**
- **Real-Time Computing**
- **Virtual Environments for Training**
- **Software Development Methods and Tools**
- **Volumetric Visualization**
- **Networked Engagement and Operations**
- **Object Modeling Under Uncertainty for Image Analysis**
- **Target Tracking**
- **Information Assurance**

- **Augmented Reality**
- **Multi-Scale Image Processing**
- **Numerical Ocean Modeling**
- **Partial Differential Equations**
- **Dynamical Systems and Ocean Dynamics**
- **Fluid Mechanics**
- **Inverse Problems**
- **Wavelets and Images**
- **Mathematical Optimization**
- **Optimization and Computational Logic**
- **Common Operational Picture/Common Tactical Picture (COP/CTP) and Visualization**
- **Decision Support and Collaboration**
- **Interoperable Networks**

What are
the Research Products?

- **Theoretical foundations**

- **Practical algorithms**

- **Data representations**

- **Software prototypes**

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New and Better Algorithms
Enable Huge Technology Force-Multiplier Advantage
and
Create Technological Surprise

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The Traveling Salesman Problem

(or how to solve large, difficult combinatorial optimization problems)
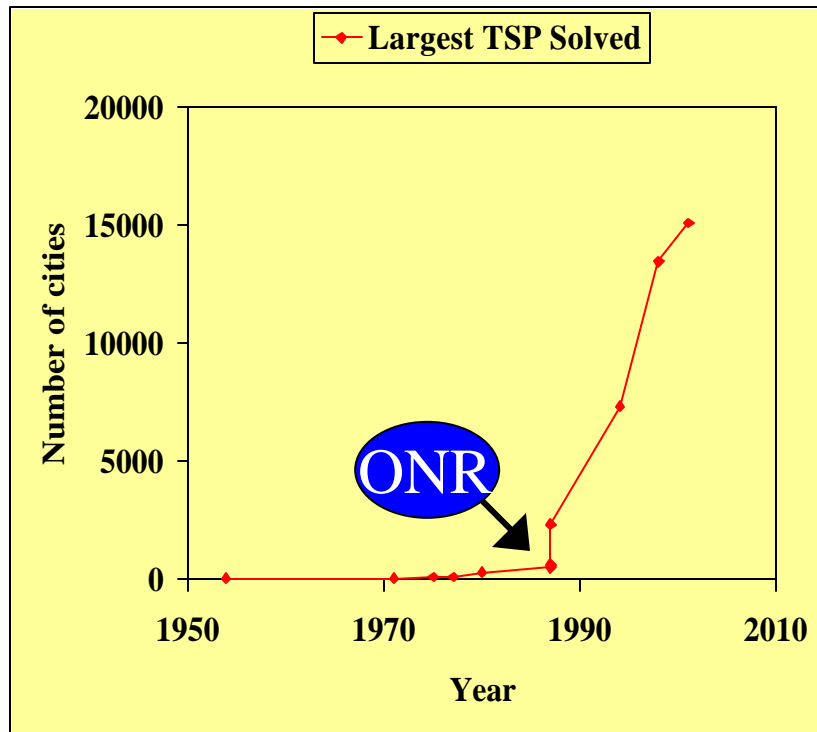
Technical Significance:

Ability to solve much bigger
  optimization problems

Major Performers:

Princeton

Accomplishment and Approach:

- Solved, *to provable optimality*, the largest TSP to date: 15,112 cities
- Developed heuristic algorithm capable of solving problems with up to 1,000,000 cities
- Approach based on "branch-and-cut" integer-programming technique

Impact:

- Transitioned techniques to best COTS integer-programming solvers; e.g., CPLEX
- CPLEX, in turn, is used in several DoD settings; e.g., JWAC

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Land Attack Predesignation

Technical Significance:

- Ability to assign missiles to targets so as to maximize mission success

Major Performers:

- NSWCDD, NPS

Accomplishment and Approach:

- Optimization model that incorporates mission priorities and timings, Vertical Launching System configurations, launch directions, follow-on capability.

- Heuristic and exact optimization algorithms

Impact:

- Much more effective use of expensive ($1M/missile) asset

- "Part 1 Weapon-to-Target" Transitioned to PMA 282/Lockheed for inclusion into TTWCS

- "Part 2 Target-to-Shooter" on track to be transitioned to PMA 281/ComGlobal for inclusion into PC-MDS

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Projected Future Naval Needs in Math and Computer Science

- Rule-based, knowledge-based, artificially intelligent systems
- Intelligent agents
- 3D visualization
- Interactive war game models
- Automatic programming
- Real-time distributed databases
- Automated knowledge capture
- Dynamic data probes
- Active databases
- Transaction-oriented protocols
- Real-time schedulers
- Deductive databases

- Formal verification tools
- Fault tolerance mechanisms
- Network-based simulation
- QoS for mobile environments
- Dynamic adaptive protocols
- Machine learning and planning
- Vision and image understanding
- Virtual reality
- Alternative computing paradigms
- High assurance computing
- HCI
- Operating systems
- Software formal methods

Primary Sources: *Defense Technology Area Plan, Joint Warfighting S&T Plan, Joint Vision 2010, Advanced Battlefield Information Systems Study*.

Significant S&T investments needed in:

- acquisition of data from and about the five battlespaces, especially the global marine environment, including particularly difficult areas like the Arctic, the sea-floor, and denied littoral regions

- compression, distillation, fusion, assimilation, reduction of data in the context of decisions to be made by machines or humans or jointly, plans to be drawn, training required and operations to be supported

- presentation of large amounts of complex data to decision makers

- decision making and cognition in distributed groups, including human-machine interactions

- uncertainty: how it is defined and calculated, how it propagates through models and data, how it is represented in machines and presented to humans, and how it affects decisions

About ONR Math & CS Awards

- ONR issues grants to institutions, not individuals.

- ONR Program Officer's job is to find and support research that might have Naval payoff.

- ONR Program Officer has wide latitude in deciding who gets grants; external peer review sometimes used.

- PI is rarely expected to know any specifics of Naval operations or organizations.

- ONR Program Officer is not hands-off; often PI is guided to interaction with Naval laboratories or acquisition programs.

Facts & Figures About ONR CS Awards

- Typical grant = ~$130K/year for 3 years.
- Typical grant is renewed once.
- Typical workshop/conference grant = ~$10K.
- Less than 5% of proposals result in award.
- Publication of results in scientific literature is encouraged.
- To have much chance of being funded in FY0N, proposal should be in hands of PO by May/June of FY0N-1.

How to Approach ONR

- Look at www.onr.navy.mil
- Be sure you have a novel approach or insight into a meaningful research problem.
- Start with a whitepaper sent via e-mail; send to most appropriate Program Officer, or to division director.
- Try to visit PO if possible.