TESTIMONY

Identifying Federally Funded Research and Development on Information Technology

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CT-229

July 2004

Testimony presented to the House Committee on Government Reform on July 7, 2004

Published 2004 by the RAND Corporation
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Before the Committee on Government Reform
U.S. House of Representatives

July 7, 2004

Mr. Chairman and Members of the Subcommittee, I appreciate the opportunity to testify here today on this most important topic. To support the work of the White House Office of Science and Technology Policy, in 1992, the RAND Corporation began to systematically gather information on all of the research and development (R&D) activities that are funded each year by the United States Federal Government. While this effort initially gathered information only on the R&D programs of federal agencies, it quickly became clear that the most readily available information on federal R&D activities was too aggregated to be of use in answering the many questions that were of greatest concern to the Federal Government.

Specifically, various agencies and offices of the executive and legislative branches of the Federal Government wanted to know how many federal R&D dollars were being spent on electronics, global positioning technology, preventing violence among at-risk youth, automotive-related technology, aviation safety, education technology, environmental change, and a host of other topics. To answer such focused questions, the RAND

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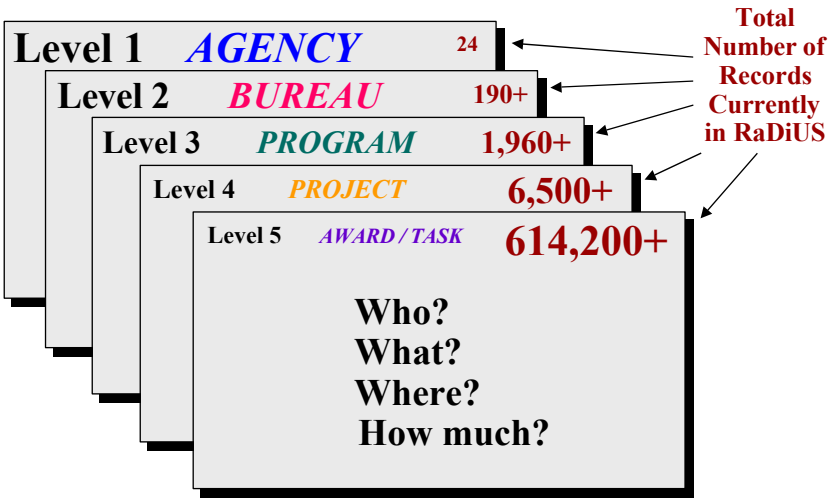
Corporation created the RaDiUS Database, which is the most comprehensive and detailed collection of information assembled on the R&D activities funded by the Federal Government.

The RaDiUS Database uses OMB's definition of R&D to systematically track the funds that federal agencies devote each year to R&D through the various bureaucratic levels of each agency to the point where they are actually spent to conduct R&D. As noted in the chart below, each increasingly detailed level of the RaDiUS Database provides users with information on who, what, where, and how much regarding federally funded R&D.

The Structure and Contents of the RaDiUS Database



Users of RaDiUS can search the database with any descriptive term(s) of their choosing to identify federally funded R&D activities in every field of science and engineering. In 1998, the General Accounting Office declared the RaDiUS Database to be a "Best Practice" of the Federal Government (GAO/NSIAD/RCED-98-23).

I have been the project manager of RaDiUS since its inception at RAND, and in that capacity oversaw the design and development of the RaDiUS Database a decade ago. I continue to make sure that the information in the RaDiUS Database is regularly updated and available for use. I am also the lead author of two reports that were made possible because of the existence of the RaDiUS Database. The first is "Discovery and Innovation," which was released in 2000 and which for the first time detailed all federally funded R&D activities by the state and city in which they actually occurred. In 2001, the Public Libraries Association and the American Association of School Libraries recommended that copies of "Discovery and Innovation" be included in all public and high school libraries in the nation. The second report is "Vital Assets," which was released just two months ago in April. It details the federal R&D funds that went to every university and college in the nation in the FY 2002. Among the notable findings presented in "Vital Assets" is the fact that only 80 of the more than 1,825 four-year accredited and professional degree-granting universities and colleges in the nation received 71 percent of all the federal R&D funds provided to such institutions in FY 2002. It also found that the nation's126 medical schools received 45 percent of all federal R&D funds provided to universities and colleges in FY 2002.

Today, the focus of this hearing is on information technology (IT) R&D. Specifically, the Subcommittee has asked the following questions:

- Which federal agencies fund IT R&D?

- How many federal dollars are spent on IT R&D?
- In what areas of IT are federal R&D investments being made?
- Who receives federal IT R&D funds and how much do they get?
- What is the federal government gaining from its investment in IT R&D?
- Why should the federal government continue to make these investments?

While I will draw upon the RaDiUS Database to provide answers to many of these questions, before I do so, I would first like to address an additional question – namely, to what are we referring when we use the term "IT R&D"?

What is IT R&D?

From the development of the transistor in the 1940's until today, the meaning of the term IT has changed dramatically, most especially in the past decade. And as the capabilities and pervasiveness of IT have expanded throughout society, the range and scope of IT R&D have also grown.

Initially IT R&D focused on the physical components of IT, encompassing both the physical sciences where research on hardware components was being conducted as well as mathematics where the foundation of rudimentary machine instructions or encoding was being laid. As research advanced our knowledge of specific physical components, new IT functionalities emerged, such as data storage, data processing, and data transfer, all of which became integral parts of computers and electronic devices. Consequently,

over time, IT R&D expanded to encompass research on physical IT components, as well as research on the higher-level functionalities that were enabled by the design and engineering of the underlying physical IT components. As a result, the focus of IT R&D expanded to include to fields of engineering and computer architecture design, as well as other disciplines that sought to explore and exploit the new higher-level functionalities.

Very quickly, it was discovered that these higher-level functionalities could be combined to create new applications and new infrastructures, spawning the field of software engineering as well as the development of new tools that allowed people to handle and manipulate both data and information. This era of IT R&D produced software for word processing, spreadsheets, databases, meteorological modeling, etc. IT R&D also produced a host of infrastructures including packet switching networks, as well as wireless base stations, cellular communication, and other similar innovations. Again, the scope of IT R&D expanded to include application and infrastructure design and development. These new IT applications and infrastructures allowed for the creation of new services, such as e-commerce, distributed computing, and the World-Wide-Web, all of which are new IT services enabled by combining IT applications and infrastructures. So the world of IT R&D expanded yet again.

In short, what began as R&D on the physical components of IT, has grown to include higher-level IT functionalities enabled by combinations of physical components, IT applications and infrastructures, and IT capabilities that are built on combinations of IT applications and infrastructures. As a consequence, the challenge today of identifying

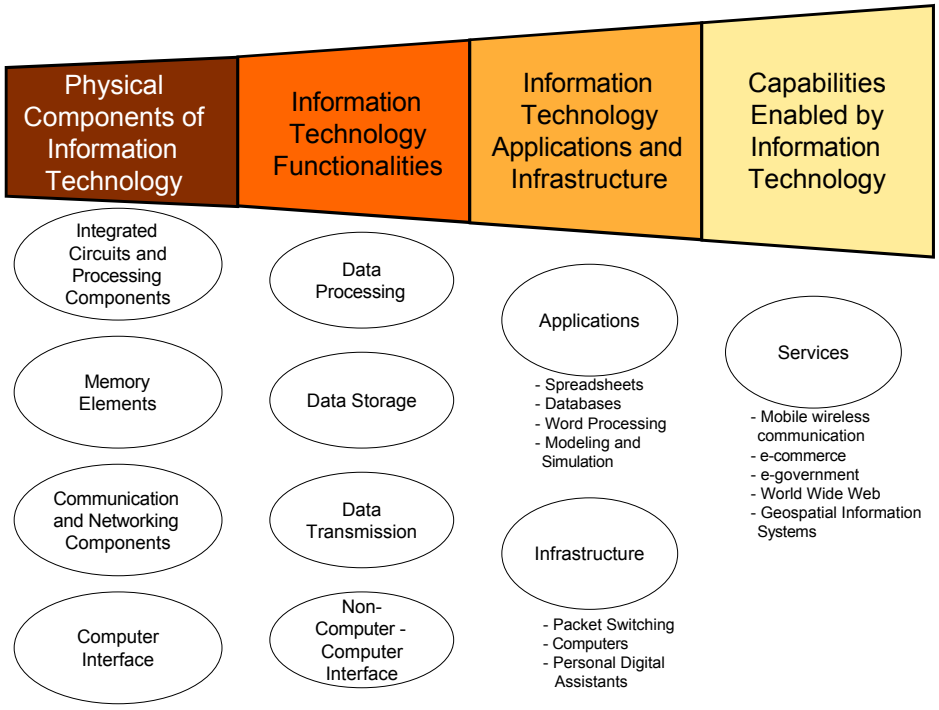
what is IT R&D, is not the equivalent of looking for a needle in a haystack as it was only a few decades ago. Rather it is the much harder task of identifying what is NOT encompassed by the term IT R&D, since virtually every field of science and engineering is now affected or has in some way become associated with IT. This challenge becomes even more difficult when one realizes that such seemingly non-IT fields as biology, chemistry, and optics, are now viewed as having the potential for revolutionizing how basic IT systems operate.

Further complicating this challenge is the fact that, as the focus of IT R&D moved from physical components to developing new applications and services, the types of problems solved by IT also changed. That is, early on, IT R&D focused on the emerging the field of electronics and electronic devices, and began by replacing mechanical devices with electronic ones, that merely provided an alternative method of solving simple problems. As IT R&D created new electronic devices, new combinations of IT were being discovered that allowed for new functionalities. Problems that once had to be solved by hand or mechanical devices could suddenly be solved faster and much more efficiently with the application of new IT devices. Eventually, by building on the new functionalities resulting from IT R&D, scientist and engineers began to create entirely new IT applications and infrastructures. The use of these new IT applications and infrastructures, in turn, allowed people to solve a whole new class of problems – complex problems encountered in the real world. However, to solve these real world problems using IT, it was still necessary to simplify the models of them in order for the IT to address them. Today, IT is able not only to solve the complex problems encountered in

the real world with little or no simplification, but also to interact directly with the world in such a way as to influence the very problems it is addressing. Consequently, as IT R&D has evolved over the decades, it has become increasing difficult to separate IT from the environment in which it operates.

Four Definitions of IT R&D

Based on the evolution of IT, the R&D related to IT can be defined in at least four different ways, all of which are illustrated in the chart below.



Depending on whether IT R&D is defined in terms of the physical components of IT, IT functionalities, IT applications and infrastructure, capabilities enabled by IT, or some

combination thereof, one will get a different answer regarding how much the federal government is spending on IT R&D and which federal agencies are funding it.

Clearly, much of the confusion that currently exists regarding how many federal dollars are being spent on IT R&D is a direct result of the fact that there is not a standard definition of what constitutes IT R&D. While the Interagency Working Group on Information Technology Research and Development of the National Science and Technology Council's Committee on Technology attempted to do this in its report, "Advanced Foundations for American Innovation," it does not appear to have succeeded for two reasons. First, the substantive definitions of IT R&D used by the Interagency Working Group were so expansive that it encompassed virtually every field of science and engineering. Second, the inclusion of the term "fundamental" in the discussions of the Interagency Working Group appears to have been taken as a signal by at least one major federal R&D agency that only "Basic Research" was of interest to the group. This meant that the vast majority of this federal agency's IT R&D was not included in this report.

Federal Funding for IT R&D

While the RaDiUS Database can answer a host of questions about IT R&D, the RaDiUS Database cannot define what IT R&D is – only people can do that. To ensure that this Subcommittee has some "hard" numbers on IT R&D, however, the RaDiUS Database was searched to identify all federally funded IT R&D using both a "narrow" and a

"broad" definition of IT R&D. Specifically, searches of the RaDiUS Database were conducted when IT R&D was defined narrowly as the "Physical Components of IT" only.[1] Searches of the RaDiUS Database were also conducted when IT R&D was broadly defined as the Physical Components of IT, and "IT functionalities" and "IT applications and infrastructure" and "Capabilities Enabled by IT."[2]

Federal Agency	Narrow Definition (Estimated FY 2002 Budget Authority in thousands)	Broad Definition (Estimated FY 2002 Budget Authority in thousands)
DOD	$1,137,154	$6,809,031
HHS	$47,518	$2,181,844
NASA	$21,756	$73,702
DOE	$148,370	$1,080,827
NSF	$65,129	$628,889
USDA	$1,880	$112,155
DOC	$94,921	$227,734
Other[3]	$351	$63,225
TOTAL	$1,517,080	$11,177,408

As the table above shows, using the "Narrow" definition of IT R&D, it was found that just over $1.5 billion, or about 2%, of all federal funds devoted to the conduct of R&D in FY 2002 were involved IT. Using the "Broad " definition of IT R&D, it was found that

[1] The specific terms searched were "(information technology) OR (integrated circuit%) OR (computer interface) OR (computer memory) OR (network component%) OR (processing component%)." Note that "%" is a "wildcard" that will retrieve any variation of the word specified.
[2] The specific terms searched were "(information technology) OR (integrated circuit%) OR (computer interface) OR (computer memory) OR (network component%) OR (processing component%) OR (data processing) OR (data storage) OR (data transmi%) OR (computer modeling) OR (computer simulation) OR (word processing) OR (database%) OR (spreadsheet%) OR (packet switching) OR (computer%) OR (personal digital assistant%) OR (mobile wireless communicat%) OR (e_commerce) OR (world wide web) OR (internet) OR (gis) OR (geospatial information system) OR (e_gov%)." Note that "%" is a "wildcard" that will retrieve any variation of the word specified.
[3] DOT and DVA for both definitions, as well as DOI for the "Broad" definition only.

just over $11 billion, or about 12%, of all of federal funds devoted to the conduct of R&D in FY 2002 involved IT. With both definitions, the federal agency providing the most funds for IT R&D was the DOD, while the second ranked agency was DOE for the "Narrow" definition and HHS for the "Broad" definition. Under both the "Narrow" and the "Broad" definitions, it was found that the vast majority of the IT R&D funds went to non-federal parties, most notably higher education institutions and private companies, where the federally funded IT R&D was actually conducted.

While there was not time before this hearing to systematically determine how many federal R&D funds were being spent on each specific IT areas such as integrated circuits, processing components, packet switching, etc., the records in the RaDiUS Database revealed that a wide range of IT challenges are being addressed with the help of federal R&D funds. For example, DOD's IT R&D awards/tasks included ones focusing on reconfigurable computers to reduce the size of strike aircraft and networked virtual environments to aid battlefield awareness and management. HHS's IT R&D awards/tasks included ones focusing on informatics-based data tools to link parent-derived information directly to the care process and the development of a wireless electrocardiogram chip. NSF's IT R&D awards/tasks included ones focusing on harnessing the power of IT to manage infrastructure systems and the use of computational intelligence to solve problems that defy solutions using traditional techniques. And DOC's IT R&D awards/tasks included one focusing on exploring the use of digital signal processing techniques, such as compression and error control

encoding, to improve the performance of IT applications that are carried over wireless communication systems.

Conclusion

As demonstrated above, the RaDiUS Database can tell us which federal agencies fund IT R&D, how many federal dollars are spent on IT R&D, and the areas in which IT are federal R&D investments being made. It can also tell us who receives federal IT R&D funds and how much do they get. The RaDiUS Database cannot tell us what the federal government gains from its investment in IT R&D or why the federal government should continue to make these investments, but it can provide the factual foundation on which to base an analysis of these types of questions.